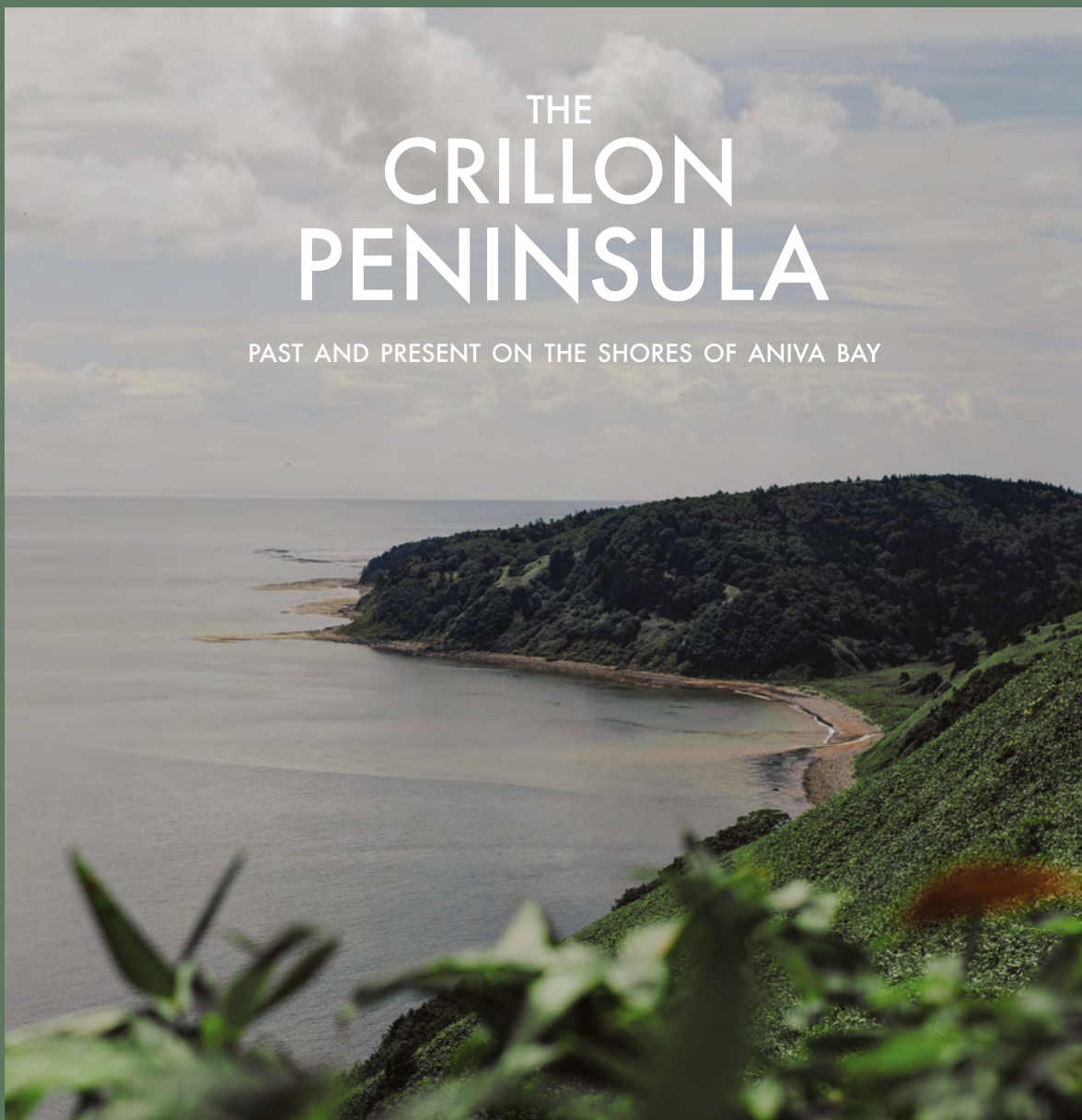


THE CRILLON PENINSULA

PAST AND PRESENT ON THE SHORES OF ANIVA BAY




VOLNOE DELO
OLEG DERIPASKA FOUNDATION

THE CRILLON PENINSULA:

PAST AND PRESENT ON THE SHORES OF ANIVA BAY



2026

Editor-in-Chief Ilya I. Gordeev

The Crillon Peninsula: Past and Present on the Shores of Aniva Bay / ed. by Ilya I. Gordeev. Moscow: Paulsen, 2026. 272 p. DOI: 10.61726/6265.2026.98.96.001

ISBN 978-5-6056034-0-5

The Crillon Peninsula, the southernmost region of Sakhalin, is distinct in climate and the composition of its vegetation and animal communities from both the northern part of the island and mainland Russia. Its eastern coast is bordered by Aniva Bay, whose unique features have shaped the history of local fisheries development and utilisation. This book summarises existing historical and modern information on the archaeological heritage and historical development of the peninsula's eastern part, as well as its agricultural development, hunting, fishing, mariculture, and plant communities, including rare and Red List species.

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Cover photo by A. Semenov;
part title page photos by A. Kim, A. A. Semenov,
A. G. Semenov, S. Semenova, D. Smykova, A. Fedorov.

Translated from the Russian original: Полуостров Крильон: история и современность на берегах залива Анива / отв. ред. И. И. Гордеев. — Москва: Паулсен, 2025. — 272 с. — DOI: 10.61726/3321.2025.77.37.001.
ISBN 978-5-98797-466-7.

Translated by UC Rusal
Maksim Isaev
Samira Abdurazakova

The comparison of Sakhalin to a sturgeon is most apt in the southern part, which resembles a fish tail. The left half of the tail is called Cape Crillon, the right, Cape Anivsky, and the semicircular bay between them, Aniva. Crillon, around which the ship makes a sharp turn to the northeast, looks like an attractive town in the sunlight and the solitary red lighthouse resembles an aristocratic villa. The large headland juts into the sea, which is green and smooth as a lovely water meadow. The earth is covered with velvety grass, and to someone on a sentimental journey all, it seems to lack is a herd of cattle wandering under the shade trees on the edge of the forest. But they say the grasses here are poor and that agriculture is barely possible because Crillon is hidden in salt-laden fog for most of the summer, and the fog is destructive to vegetation.

Anton Chekhov. Sakhalin Island (1895)
Translated by Luba and Michael Terpak

Dear Readers,

We extend our deepest gratitude for your interest in this research. The book you hold in your hands is the result of long and painstaking scholarly work that has brought together dozens of journeys, expeditions, and observations into a single coherent whole. Within its pages, a survey of the peninsula's flora and fauna is interwoven with the history of this unique place. The project is grounded in a love of science and in the aspiration to preserve the irreplaceable character of nature in its pristine state.

The beauty of the living world is profoundly fragile in the relentless tide of technological transformation — and so we sought to capture it within these pages. *Verba volant, scripta manent*. So that everyone might hear the living breath of this land, and touch its wild, singular spirit, growing ever harder to glimpse behind the veil of urban landscapes. It is our duty to care for the Earth: to preserve, to protect, to nurture. It was this sense of responsibility — and of love for the world around us — that became the wellspring of our work.

The pages of this publication will carry you to the southern reaches of Sakhalin — on a captivating journey along the quiet shores of Aniva Bay, to the place where the eponymous biological station was established. Here, researchers continue their comprehensive study of this remarkable territory, broadening the horizons of scientific knowledge and deepening our understanding of the peninsula's natural heritage and historical-cultural character.

May this book serve as a bridge between Crillon Peninsula and those who have yet to behold it with their own eyes. For those who have already been fortunate enough to visit the peninsula, may it remain a warm reminder of that time.

We sincerely thank Oleg Deripaska for his support, which has opened up the wonderful world of southern Sakhalin to every reader. His belief in the power of knowledge inspires and unites us in the pursuit of new discoveries.

**With love for the sea, science and people,
the team of the Aniva Marine Biological Station**

ANIVA





The Volnoe Delo Foundation, established by Oleg Deripaska, focuses on areas that shape the quality of life in the country — science, education, culture, healthcare, and sports. With its support, research centres, schools, and hospitals are being built. Alongside this, the Foundation works to protect the natural environment and preserve cultural heritage.

Oleg Deripaska, a graduate of the Physics Faculty at Lomonosov Moscow State University, has long believed that a rigorous scientific mindset is indispensable in any field — whether it's advancing industrial technologies or shaping regional development. This conviction lies at the heart of the Volnoe Delo Foundation, which helps schoolchildren and university students access a first-rate education and supports researchers working across both fundamental science and applied innovation.

The Aniva Project is part of this mission. With the support of Volnoe Delo, scientists are given the opportunity to explore the unique natural environment of Sakhalin and the Kuril Islands in greater depth, using modern tools and technologies. At the same time, the project creates a platform for international knowledge exchange — from educational programmes to research fellowships that strengthen Russia's ties with the global scientific community.

The Aniva Biological Station is envisioned as a nexus of discovery — a gathering place for scientists, engineers, technologists, and entrepreneurs bound by a common purpose: to push the frontiers of knowledge and make the world a better place.







INTRODUCTION

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The eastern part of the Crillon Peninsula is one of the most remote and sparsely populated areas of Southern Sakhalin. Despite this, it holds significant potential for economic development due to its vast natural resources. Located in the warmest climate zone of Sakhalin Island, the so-called 'snow tropics', the terrestrial ecosystems of the peninsula and the marine communities of the surrounding waters of Aniva Bay are very diverse in terms of species richness of flora and fauna. Here, one can find both valuable commercial species and vulnerable, endangered plants and animals. In addition to natural, pristine communities, the peninsula also contains secondary ecosystems that have formed as a result of modern historical human activity. The rich history of human economic activity of this place is marked by numerous historical and prehistoric sites. The physical and geographical features of the terrain,

archaeological sites and prehistoric settlements, the modern history of the peninsula, detailed descriptions of vegetation communities, the experience of agricultural use and potential development prospects, the animal world, hunting, fisheries, and mariculture of fish, invertebrates, and algae, all of these have found their place in the present book.

Since 2022, Lomonosov Moscow State University (MSU) and Sakhalin State University, in partnership with the Non-Profit Charitable Foundation 'Support for Bioresearch 'BIOME'', have been working to establish the Aniva Marine Biological Station at Cape Anastasia (Crillon Peninsula, Sakhalin Island). This project operates under the auspices of the Ministry of Science and Higher Education of the Russian Federation.

The official necessity of establishing a biological station at Cape Anastasia was noted by the President of



Aerial view of the port haven at Cape Anastasia and the mouth of the Anastasia River



Meeting of the President of the Russian Federation, Vladimir Putin, with participants of the III Young Scientists Congress. Sirius Educational Centre (Sochi). November 29, 2023

the Russian Federation, Vladimir Putin (Presidential Instructions following the meeting of the President of the Russian Federation with participants of the III Young Scientists Congress on November 29, 2023, dated January 24, 2024, Ord. No 131, para. 4), who pointed out the need to develop scientific research in the waters of the Far Eastern seas. To fulfil the Presidential instructions, para. 12 of the instruction from Deputy Prime Minister of the Russian Federation, D. Chernyshenko, dated February 5, 2024, No DCh-P8-3305, was issued. At a meeting of the Interdepartmental National Oceanographic Commission of the Russian Federation (Minutes No 8-pr/3-MNOK/2024 dated November 25, 2024), the 'Comprehensive Measures aimed at creating and developing a marine biological station at Cape Anastasia (Crillon Peninsula, Sakhalin Island) were approved, which also included the creation of the MSU-SakhalinTech Biodiversity Laboratory and envisaged work on studying the biodiversity of fauna and flora, including freshwater and marine communities of the Sakhalin Region.

Certain groundwork has already been laid during expeditions to the Crillon Peninsula in 2022–2024: new species of invertebrates have been described (Abato et al., 2024; Ekimova et al., 2024), the bryophyte flora has been documented (Yatsenko et al., 2023), the lichen flora has been described (Yakovchenko, 2024), a study of the ecological conditions and diversity of meadow vegetation on the peninsula has been conducted, including the influence of climatic and soil factors (Rozhkova-Timina, 2023; Rozhkova-Timina et al., 2024), new species of basidiomycete fungi for the Russian Far East have been recorded (Rebriev et al., 2024; Bukharova,

2024; Bukharova, Kochunova, 2024), and the level of tetrodotoxin in the peninsula's nemerteans has been analysed (Malykin et al., 2025).

The article on the results of the 'Crillon-2023' expedition (Gordeev et al., 2024) laid the foundation for the further comprehensive study of the marine, freshwater and terrestrial biota of the east coast of the Crillon Peninsula. It included the results of field work in ichthyology, invertebrate zoology, entomology, botany, lichenology, bryology, mycology, parasitology, microbiology and marine biology. More than 200 plant species, 101 lichen species, 127 moss species, 117 basidiomycete species, 119 invertebrate species, and 20 species of marine algae were recorded. Data on 20 fish species were collected, including information on their infestation with helminths. Parasitological work involved the detection of microsporidia in all available animal hosts, as well as the search for rhizocephalan crustaceans (parasites of arthropods). The species discovered—including animals, fungi, lichens, and plants—including rare and endangered species listed in Russian regional and federal Red Data Books, as well as species previously unrecorded on Sakhalin. These findings highlight the area's great potential for further biological research and underscore the promise of establishing a biological station here to support long-term studies and development (Gordeev et al., 2024).

Presented in a popular science format, this publication compiles published sources on the eastern Crillon Peninsula and the adjacent waters of Aniva Bay, assembled as work commenced on the Aniva Marine Biological Station at Cape Anastasia. It offers readers a chance to explore the past, present, and potential future



Cape Anastasia

of Sakhalin's southernmost tip. Richly illustrated and filled with factual data, the book appeals to a broad audience. Its preparation brought together specialists from diverse scientific fields, allowing this unique territory — and its inextricable link to Aniva Bay — to be examined through multiple disciplinary lenses.

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1 GEOGRAPHICAL FEATURES OF THE CRILLON PENINSULA

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Geographical Location

The Crillon Peninsula is one of the most significant features defining the geographical appearance of Sakhalin. The relatively straight western coast of the island, facing Eurasia, visually contrasts sharply with the east coast, which curves with large peninsulas bearing eponymous capes at their tips: the Schmidt Peninsula in the north, the Terpeniya Peninsula in the east, and the two peninsulas framing Aniva Bay, which opens to the south and along whose shores and nearby areas a significant portion of the island's population is concentrated, the Tonino-Anivsky Peninsula and the Crillon Peninsula, examined in detail in this book (Fig. 1.1).

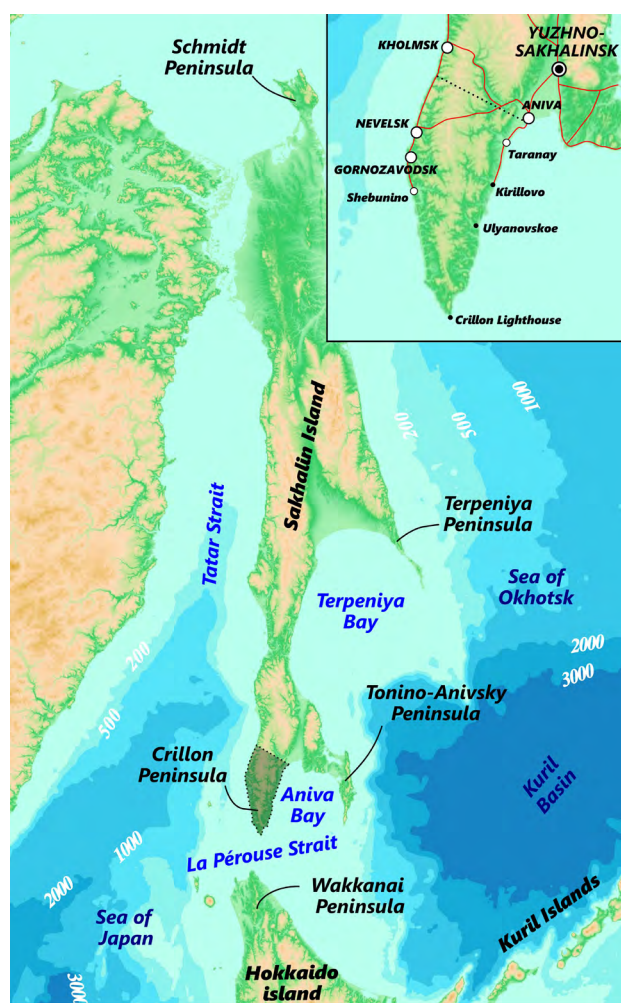


Fig. 1.1. The Crillon Peninsula and features mentioned in the text on a map of Sakhalin (sea depths and land terrain based on the GEBCO 2019 global terrain and bathymetry model)

The peninsula has the shape of an elongated triangle, about 110 km long along its axis and about 48 km wide at its base, gradually tapering towards the south. The area of the peninsula is approximately 3200 km². The tip of the peninsula, Cape Crillon, the extreme south-western point of Sakhalin (45°53'35" N, 142°04'51" E), serves as the boundary for several major geographical features. To the west, the cape and peninsula are washed by the Sea of Japan, and the cape itself marks the entrance to the Tatar Strait, which here is at its widest (approximately 300 km) and then gradually narrows to the north, connecting the Sea of Japan and the Sea of Okhotsk. The cape is also the location of another boundary between these seas: La Pérouse Strait, lying between the Crillon Peninsula and the Wakkanai Peninsula on the island of Hokkaido, Japan.

The Tatar Strait near Cape Crillon is quite deep (up to 1200 m in the basin); however, a shelf zone with depths up to 120 m extends up to 30 km from the Crillon Peninsula. At the same time, a sharp drop to depths of about 40 m is observed directly near the shore. La Pérouse Strait has a V-shaped profile with maximum depths of up to 120 m, located closer to the Hokkaido coast. The strait contains a chain of underwater and above-water rocks, including the Rock of Danger (Kamen Opasnosti), which complicates navigation. These being extensions of the geological structures that make up the peninsula. Closer to the Kuril Islands begins the Kuril Basin, reaching a depth of 3,916 m (the deepest point of the Sea of Okhotsk). Aniva Bay, washing the eastern side of the peninsula, is relatively shallow, with depths of up to 93 m.

The northern boundary of the peninsula can be approximately drawn along a line connecting the mouths of the Sova River (Tatar Strait, 46°53'54" N, 141°59'22" E) and the Lyutoga River (46°41'56" N, 142°31'54" E), which flows into Aniva Bay. The landscape boundary between the peninsula and the rest of Sakhalin is not clearly defined.

Human Impact

Human activity is primarily confined to the coast, while the central part of the Crillon Peninsula is minimally developed. The southernmost permanent civilian settlement is the village of Shebunino on the western shore; the road from it heading north passes through large population centres, the village of Gornozavodsk and the city of Nevelsk. In addition to the motorway, a



Rocks at Cape Anastasia (photo by A. Semenov)

narrow-gauge railway was laid along the coast as far as the settlement of Shebunino during the Japanese period of the island's development; it has now been reconstructed up to Gornozavodsk. The activities of these settlements are related to open-pit coal mining. During the Soviet period, underground mining predominated. In recent decades, the coal industry has again increased production volumes, but open-pit overburden removal has become prevalent, significantly transforming the landscapes of the mountainous part of the peninsula.

The east coast is much less populated than the west one. Currently, only the village of Taranay at the mouth of the eponymous river has a permanent population. Several settlements to the south (Kirillovo, Ulyanovskoye) are now abandoned. However, seasonal fishing camps operate at river mouths during

the summer. A significant number of facilities are associated with military infrastructure. In the south of the peninsula, near Cape Crillon, there is an active border guard outpost.

Terrain and Geological History of the Peninsula

Almost the entire territory of the peninsula is characterised by low-mountainous, highly dissected terrain. The mountains of the peninsula are a continuation of Sakhalin's main range, the West Sakhalin Mountains, which extend along the entire length of the island. Within the Crillon Peninsula, they are divided into two ranges. The main one is the Yuzhno-

Kamyshovy Ridge, which serves as the meridional axis of the peninsula. In the south, it divides the peninsula almost equally, and as it progresses northwards, it shifts closer to the coast of the Tatar Strait, forming a watershed between the relatively short and small-basin rivers of the eastern macro-slope and the more pronounced and larger rivers flowing into Aniva Bay (Fig. 1.2). The highest peaks of the range are located in one large massif near the city of Nevelsk. This includes the peninsula's highest point, Bambukovaya Mountain (588 m above sea level), as well as Granitnaya Mountain (575 m), Dobrolyubova Mountain (516 m), Kazachka Mountain (475 m), and Lesnaya Mountain (429 m). The largest peak north of this massif is Skalistaya

Mountain (560 m), while in the southern part of the peninsula, individual hills dominate: Komandnaya (446 m), Sivuha (502 m), Khmel'nitskaya (447 m), Storozhevaya (335 m), and Dal'naya (320 m). The Taranay Ridge, lying parallel to the Yuzhno-Kamyshovy Ridge along the shore of Aniva Bay and ending at the Tambovka River, is smaller in size and elevation. The highest mountains of this ridge within the peninsula are Taranay (518 m) and Perelesnaya (472 m). A separate Yuzhno-Pribrezhnaya (Southern Coastal) mountain chain lies along the coast north of Nevelsk (heights up to 424 m, Pervomaiskaya Mountain). The relatively low mountain ranges are nevertheless clearly defined and run parallel to each other; at the latitude of the settlement of

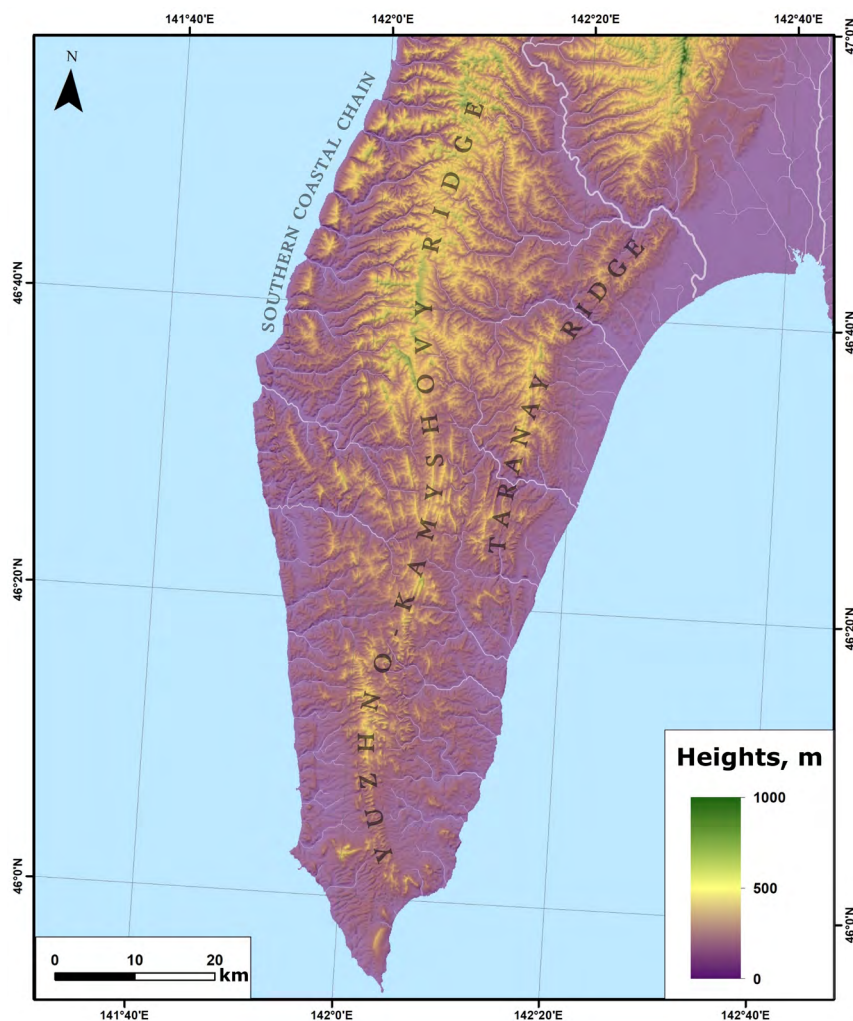


Fig. 1.2. Terrain of the Crillon Peninsula (using the SRTM digital elevation model)

Shebunino, their maximum number is noted to be about 20 (Guidebook ..., 1965). The ridge summits are sharp, often featuring rocky crests. Due to the predominance of ridges and flat uplands in the terrain, the average elevation of the peninsula is about 170 m.

Between the shores and the main structures of the ranges to the west lie wide plateaus, dissected by deep ravines and river valleys. These features are visible on the hypsographic curve of the peninsula's terrain (Fig. 1.3): 70 % of its area consists of low mountains (50–250 m). The sea shores are mostly steep cliffs, 20–100 m high, separated from the sea only by narrow strips of beaches (Fig. 1.4).

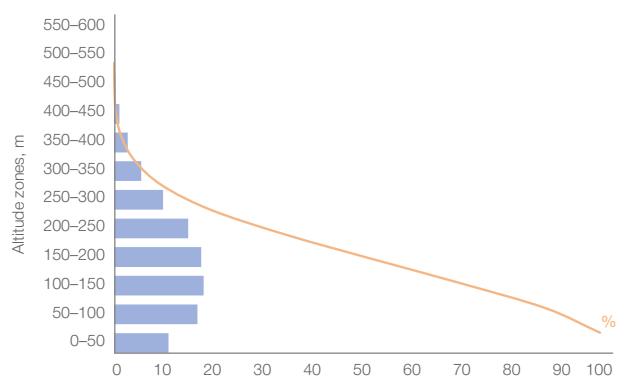


Fig. 1.3. Elevation histogram and hypsographic curve of the Crillon Peninsula



Fig. 1.4. Coastal cliffs on the eastern shore of the Crillon Peninsula near the Kalinovka natural landmark (photo by A. Semenov)

River valleys have a canyon-like shape with a deep incision and steep, sometimes vertical walls. Only the largest rivers (Lyutoga, Taranay) have well-defined valleys with flat bottoms; their width does not exceed 1–2 km. In the northern part of the peninsula, the mountains retreat from the coast of Aniva Bay by 10–15 km, where the Susunai Depression begins.

The morphologically complex appearance of the Crillon Peninsula's terrain is due to its formation history. The islands of Sakhalin, Hokkaido, and the Southern Kuril Islands are located in a transitional zone between continental and oceanic crust. It is in the area of the Crillon Peninsula that two major geological structures connect. The south of the peninsula and its eastern shore are a continuation of the Central Anticlinorium of Hokkaido Island, characterised by slow uplift. The western part of the peninsula and its main mountains belong to the West-Sakhalin anticlinorium. The large West Sakhalin Fault separates the West Sakhalin Anticlinorium from the Tatar Strait trough and extends from the southern tip of the peninsula approximately 550 km to the north (Geology of the USSR ..., 1970; Tectonic Map ..., 2000). Along the coast of Aniva Bay, the peninsula is also bounded by a system of faults and smaller-scale thrusts.

The modern Crillon is composed of ancient rocks, significantly altered by tectonic processes, as well as fluctuations in sea level over the last tens of thousands of years. For most of its geological history, the territory of Sakhalin was occupied by seas of varying depths, which is why the predominant rocks here are sedimentary: sandstones, argillites and siltstones. Their total thickness above the crystalline basement reaches several kilometres. The most intensive sediment accumulation occurred during the Cretaceous Period (145–66 million years ago), when, due to directed tectonic uplift, the area of the peninsula was a shallow shelf of a marginal sea.

The peninsula began to acquire the features and appearance of its modern terrain in subsequent geological periods (State Geological Map ..., 2021). Major faults run along both modern coastlines of the peninsula. As a result of tectonic displacements, Cretaceous deposits were folded into large folds, the modern axial elements of the terrain. Up to six meridionally elongated anticlinal folds, separated by synclines, can be identified on the peninsula. These folds are quite flat, with dip angles up to 15°. The main rocks at the outcrops of these folds to the surface are sandstones and siltstones of different ages, the grain size of which reflects the history

of sedimentation, its intensity, and temperatures in the aquatic areas. Tuffs from this period are also encountered, indicating the presence of submarine volcanism.

Extensive outcrops of Cretaceous rocks are observed throughout the entire extent of the West Sakhalin Mountains and are combined in regional stratigraphy under the name of Sakhalin's Main Cretaceous Field. On the peninsula, between the Anastasia and Ulyanovka rivers, lies its southern area, extending about 25 km from west to east and up to 70 km from north to south. This section differs significantly from the rest of the territory in the character of its terrain, which, due to its age, is much more smoothed out, dissected by a significant number of small and shallow incisions, and consists of individual hills. Across the rest of the peninsula's territory, Cretaceous rocks are also exposed in practically all river valleys; large fossilised ammonite shells can be found here (they are especially common in the valleys of the Gorbusha, Moguchi, and Naicha rivers).

During the subsequent Paleogene and Neogene Periods (66.0–2.6 mln years ago), the Crillon Peninsula also represented a shallow sea, periodically drying out and submerging again (Shelves ..., 1992). As a result, the troughs between the uplifts of Cretaceous structures and the uplifts themselves were overlain by a cover of new sedimentary deposits of varying thickness, predominantly argillites and sandstones. During this time, the territory experienced active deformation, during which the modern appearance of its individual parts took shape. In the Eocene (56.0–38.0 mln years ago), the most active processes were associated with the anticlinorium of Hokkaido Island, along whose axis a sharp uplift of the Aniva Bay coast occurred. In the Miocene (23.0–5.3 mln years ago), uplifts occurred in the extreme south of the peninsula at the junction of two tectonic zones, and in the Pliocene (5.3–2.6 mln years ago), ridge uplifts further folded sedimentary deposits of different ages.

The Neogene Period (23.0–2.6 mln years ago) covers the period of active submarine volcanism that engulfed the south of the modern peninsula (Grannik, 2017). Volcanic deposits are represented both by actual basaltic lavas, which outcrop on the west coast as individual extrusions onto the land surface (the most prominent are Mount Kovrizhka at Cape Vindis, Capes Kuznetsova and Zamiraylova Golova, and Cape Crillon itself), and by volcanogenic-sedimentary layers: psammite tuffs and tuff

sandstones, interbedded with ordinary sedimentary deposits up to 800 m thick. The largest mountain formations in this area (Konabeevka Hill and Mount Shchorsa) also represent basaltic extrusions overlain by later sedimentary cover. The northern boundary of volcanic deposit distribution is marked by the valley of the Nerestovaya River (in the area of the now-deserted village of Kirillovo).

By the onset of the Eopleistocene (780,000 years ago), the modern Crillon had finally risen above sea level and become part of a large peninsula connected to the mainland in the area of the modern Amur River mouth, encompassing all of Sakhalin and periodically Hokkaido Island (Shelves ..., 1992). In place of the present-day La Pérouse Strait, there was a lowland that subsided and rose during tectonic movements. This peninsula reached its greatest size in the Late Pleistocene (around 21,000 years ago) during the glacial maximum. The final flooding of the isthmus where the modern La Pérouse Strait is located occurred about 12,000 years ago. Less significant marine transgressions, which shaped the modern appearance of the lower parts of river valleys and their mouths, occurred throughout the Holocene (Mikishin et al., 2022).

The present-day terrain of the peninsula in its upper mountain belt is structural-denudational; here, as a result of the deformation of fold structure elements, slopes of mountain chains are formed. The main part of the peninsula is characterised by denudation-erosion terrain. Mountain structures are destroyed under the influence of various types of weathering, which has significant activity due to high precipitation and substantial temperature fluctuations throughout the year. This is also linked to the high degree of terrain dissection and the density of the erosional-channel network: 2.3 km/km², one of the highest across Russia (Atlas ..., 1967).

A relatively small part of the peninsula is occupied by areas of accumulative terrain, among which erosion-accumulative terrain of river genesis is distinguished (floodplains and bedrock terraces created by incision and deposition of river sediments) and abrasion-accumulative coastal areas (created by wave action: modern marine terraces and beach ridges 3–10 m high and a more ancient bedrock terrace 25–40 m high). Active vegetation and high biomass productivity led to the formation of mantle loams and a modern soil cover of significant thickness. The predominant soil type on the peninsula is acidic brown soils; in the foothill belt, humic-illuvial soils, unique to Russia and characteristic of bamboo-

covered areas, are widespread. Soddy-gley soils are abundant along the west coast. The boundary between the subtypes of brown soils, characteristic of broad-leaved forests and taiga, creates a natural boundary for the Crillon Peninsula, separating it from the rest of Sakhalin Island.

Compared to the rest of Sakhalin's territory, the peninsula is relatively poor in mineral resources (Atlas ..., 1967). A coal basin, associated with the formation of lake-lagoonal basins in intermontane troughs and consisting of 18 coal seams and 21 layers of carbonaceous-argillaceous rocks, is located in the basins of the Lopatinka, Shebuninka, Volchanka, and Amurskaya rivers in the west of the peninsula. It is currently actively mined. In the south of the peninsula, relatively small reserves of copper and lead-zinc ores, confined to volcanic zones, have been identified. Small concentrations of placer gold and silver are also noted along rivers there. In the area of the Uryum River in the north of the peninsula, there are very limited reserves of gas and peat. Amber is found in marine beach placers on the west coast.

Climate Characteristics

The atmospheric circulation regime over the peninsula is determined by Sakhalin's position near the continent and the Pacific Ocean, between which intensive air mass exchange occurs. The seasonal change in air currents is caused by the thermal contrast between the continent and the ocean: in winter, the currents move from the continent towards the Pacific Ocean, and in summer, from the ocean to the continent. The climate of the peninsula, according to B. Alisov's classification, is temperate monsoon; according to the more detailed W. Köppen classification, it belongs to the Dfb type: a temperate (humid) continental climate with cool summers and frosty winters. This is a humid monsoon climate with two monsoon seasons characteristic of temperate latitudes. In winter, the Siberian Anticyclone establishes itself over the continent, while the Aleutian Low prevails over the northern part of the Pacific Ocean, resulting in the dominance of north-westerly winds over Sakhalin in general and the Crillon Peninsula in particular; these winds bring cold air and cause a rather severe winter with frequent blizzards. In summer, a low-pressure area forms over the continent due to its gradual warming, while a high-pressure area forms over the colder Sea of Okhotsk. As a result, winds from south-easterly directions begin to predominate, bringing

cool, humid, rainy, and foggy summers (Scientific and Applied Reference Book ..., 1990).

Another defining climatic feature is the year-round approach of tropical cyclones to the island: up to 100 cyclones of various scales pass over it during the year, up to three per month in the warm season and up to six in the cold season. Precipitation, which can fall on this territory in large amounts in practically any month, is associated with their movement. The greatest amount of precipitation is brought by particularly powerful cyclones: decaying typhoons. They are characteristic of late summer and early autumn.

Another important factor strongly influencing the climate is the Soya Current passing through La Pérouse Strait (Fig. 1.5). This current is a residual branch of the warm Tsushima Current, constituting up to 30 % of its total power. Near the west coast of Sakhalin, it meets the cold Schrenck (Liman) Current coming from the Sea of Okhotsk and, under its influence, is directed through the strait into the Sea of Okhotsk, determining the climate of Southern Sakhalin, the Southern Kuril Islands, and the north coast of Hokkaido (Dubina et al., 2012). This current is strongest from June to November, when the water in Aniva Bay warms to +24 °C, and subsides from January to May. Along the west coast of Sakhalin Island, remnants of the current penetrate significantly north of the western shore of the Crillon Peninsula,

approximately to the city of Tomari. Consequently, Aniva Bay and La Pérouse Strait do not freeze in winter, and constant fogs are formed with increased humidity observed. Nevertheless, due to the influence of the Soya Current, the Crillon Peninsula is the warmest place on Sakhalin. In summer, there are fewer fogs and rains here, which provides increased insolation and, consequently, the possibility for subtropical species of flora and fauna to develop.

The adjacent waters are characterised by irregular diurnal tides (with the period between maximum levels varying from a day to half a day depending on the lunar declination). On the west coast, the tidal range does not exceed 0.5–0.7 m, increasing to the north as the Tatar Strait narrows. On the eastern shore, due to the configuration of the southern part of the Sea of Okhotsk, tides are higher and can reach 1.6 m.

Climate observations here are conducted at the island's oldest meteorological station, the hard-to-reach maritime coastal station at Cape Crillon. As early as 1787, during the La Pérouse expedition that opened this region to Europeans, a tide gauge for sea level observations was installed near its southern tip. La Pérouse gave the cape its name, which later spread to the entire peninsula, in honour of Viscount General Louis de Crillon, who lived in the 16th century and was known for his legendary bravery.

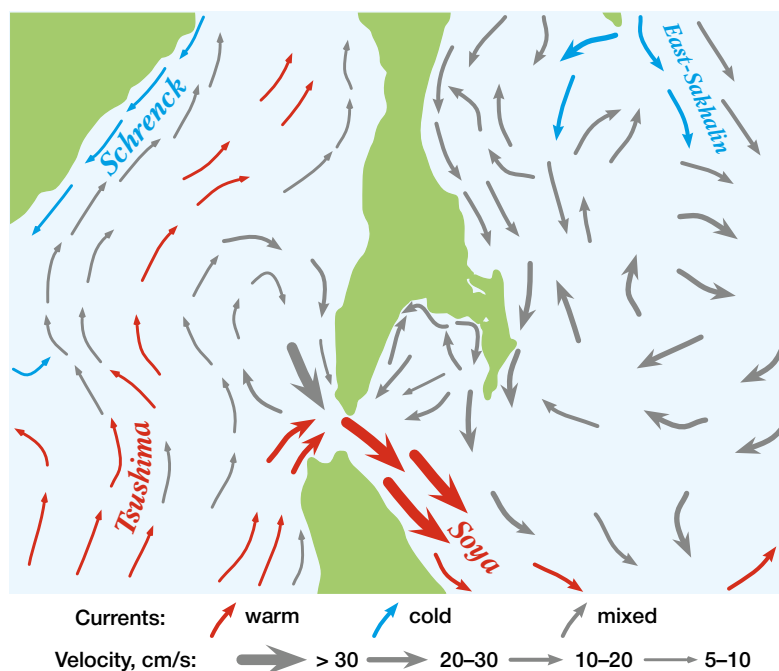


Fig. 1.5. Currents in the area of the Crillon Peninsula in summer

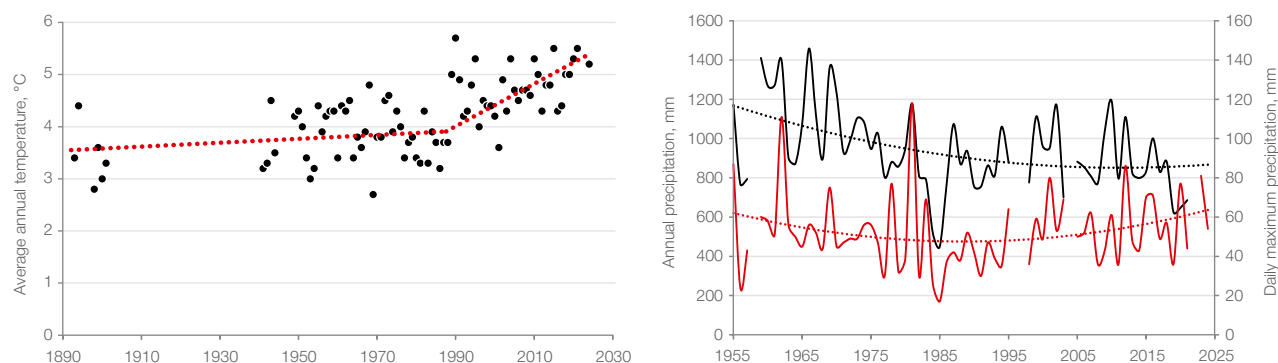


Fig. 1.6. Long-term trends in temperature, precipitation totals, and precipitation maxima at Cape Crillon (here and elsewhere, time series of meteorological characteristics published in the open-access scientific and applied reference book 'Climate of Russia' by the All-Russian Research Institute of Hydrometeorological Information (<http://aisori-m.meteo.ru/>) were used)

In 1883, construction of one of Sakhalin's first lighthouses began on the cape, and from 1892, the lighthouse keeper began conducting regular observations. Air temperature, wind direction and speed (by feel), and the state of the coastal sea were recorded. This station, the first to encounter tropical cyclones and typhoons, allows for timely notification of state services about their approach to the populated part of the island.

Many local climate indicators are record-breaking for all of Sakhalin. Air temperature here is significantly higher than in other regions of the island; the current average annual temperature is about $+5.7^{\circ}\text{C}$. It is worth noting modern climatic changes; for instance, at the beginning of the previous century, the temperature was 2.5°C lower. Throughout the 20th century, a gradual, slow increase in average temperatures was observed, accelerating over the last four decades (Fig. 1.6) starting from 1982.

The hottest month on Crillon is August, with an average monthly temperature of $+15.8^{\circ}\text{C}$ (Fig. 1.7). Maximum temperatures can reach $+30^{\circ}\text{C}$. The coldest month is January, with an average temperature of -6.7°C and minimums down to -24°C . The duration of the frosty period (with temperatures below -10°C) in particularly cold years is no more than 70 days; in many years, this period is absent. Annual temperature amplitudes are $20\text{--}40^{\circ}\text{C}$.

Winter on the peninsula is shorter than on the rest of Sakhalin and usually lasts less than five months (from November to March). Snow cover lies for 140–160 days. Due to significant terrain dissection and active blizzard transport, it is distributed extremely unevenly, accumulating in river valleys and glens. Because of the deep snow cover and its rapid establishment (a stable cover forms by the end of November and by December

can already reach 40 cm or more), the soil freezes relatively shallowly for these latitudes, on average 40–50 cm, and in certain years with little snow up to 100 cm (Kazakova, Lobkina, 2016). Permafrost is absent on the peninsula. The characteristics of winters are determined by the interaction of the Siberian Anticyclone and relatively warm southern cyclonic air masses. During the incursion of these air masses, which is observed most frequently on the island precisely on Crillon, thaws occur.

In late March to early April, the climatic spring begins on the peninsula: winds weaken significantly, and a slow temperature increase occurs with regular frosts. Snow cover in some shaded mountain areas can persist until early June. The duration of the frost-free period here is 150 days or more; however, the summer is relatively cool, and even individual frosts are possible. The relatively low summer temperatures are compensated by their low daily amplitude (in stable weather, from 2 to 7°C). Autumn is considered to be the most favourable season on Sakhalin. It sets

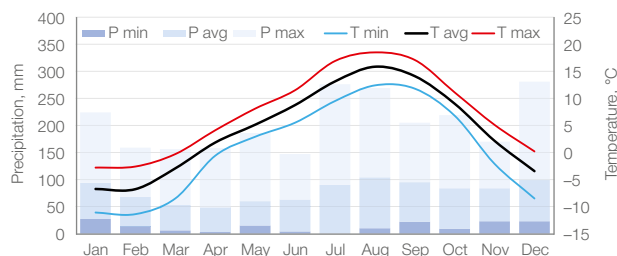


Fig. 1.7. Average, maximum, and minimum monthly temperatures and precipitation totals at Cape Crillon (1949–2024)

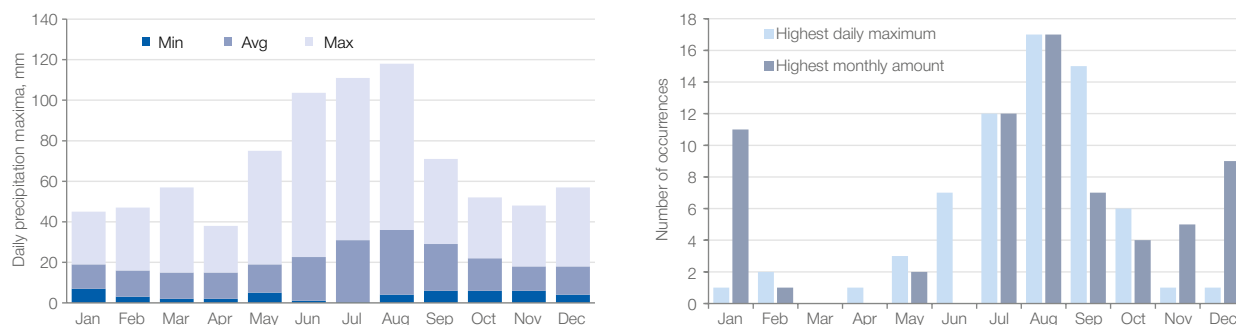


Fig. 1.8. Amplitude of daily precipitation maxima over the long-term period (left) and intra-annual distribution of precipitation maxima (right)

in gradually, and the more smoothly the temperature decreases, the more cloudless sunny days there are.

Annual precipitation totals on the peninsula average about 940 mm; however, they show significant variation over the long-term, ranging from 450 to 1460 mm. Changes in precipitation totals are usually cyclical, with several consecutive years of increased amounts observed, followed by a longer period of decreased amounts. The predominant part of precipitation (from $\frac{2}{3}$ to $\frac{3}{4}$) is liquid, falling mainly as torrential rains. More than half of the annual precipitation volume falls in July through September, the period of intensified cyclonic activity.

However, due to the peninsula's position, increased air humidity (over 80 %) is observed for most of the year (up to 250 days), associated with frequent drizzling rains. As a result, precipitation of varying intensity falls here for about 240 days a year. The minimum amount of precipitation is characteristic of April. Monthly precipitation totals demonstrate significant variation over the long-term period, associated with the uneven precipitation from passing cyclones. Daily maxima can reach 120 mm (Fig. 1.8); the greatest volumes fall when typhoons make landfall on the peninsula, and in such cases, extreme amounts of precipitation can fall here within a few hours. The distribution of maxima throughout the year has a complex structure. For instance, daily precipitation records have been set in every month except March; about two-thirds of all recorded daily maxima fall between July and September. Total monthly maxima are distributed slightly more evenly; however, in March, April, and June they were not observed at all, and after July and August their greatest frequency falls in December and January. Such cases relate to years with snowy winters, in which precipitation falls throughout the winter rather than in individual maxima (Bobrova et al., 2022).

The long-term variability of precipitation

characteristics for the peninsula is worth noting. Since the resumption of regular, full-scale observations in 1955, a gradual decrease in precipitation amount occurred over three decades, with the trend reversing in the mid-1980s (similar to air temperature). Since that moment, annual precipitation totals have on average become constant, while daily maxima have begun to gradually increase.

In the first summer months, the Crillon Peninsula, especially its coastal part, is characterised by regular fogs that persist for several days (maximum duration over 9 days). In August, fogs give way to clear and sunny weather, alternating with spells of torrential rain.

The wind pattern of the peninsula is determined by seasonal atmospheric circulation and is significantly altered by the mountainous terrain; however, the prevailing wind directions are meridional, corresponding to the direction of the coastal ranges. The windiest point on the peninsula is Cape Crillon itself, which is surrounded by the sea on three sides. Consequently, strong winds (over 13 m/s) are observed here for more than half of the year (Fig. 1.9). The highest annual wind speeds and wind gusts (40 m/s and more) are characteristic of the winter period and the landfall of typhoons. The average annual surface wind speed at sea level is 3.3 m/s.

The average proportion of sunny days in a year is small, only 23 %, and the total number of sunshine hours is merely 1650 per year. Cloudy or overcast weather is characteristic for most of the year. The peninsula's coasts, however, differ significantly: on the west, predominantly windward coast, cloud cover is the highest on all of Sakhalin due to the blocking effect of the mountains, while on the eastern slope the total number of cloudless hours is significantly greater.

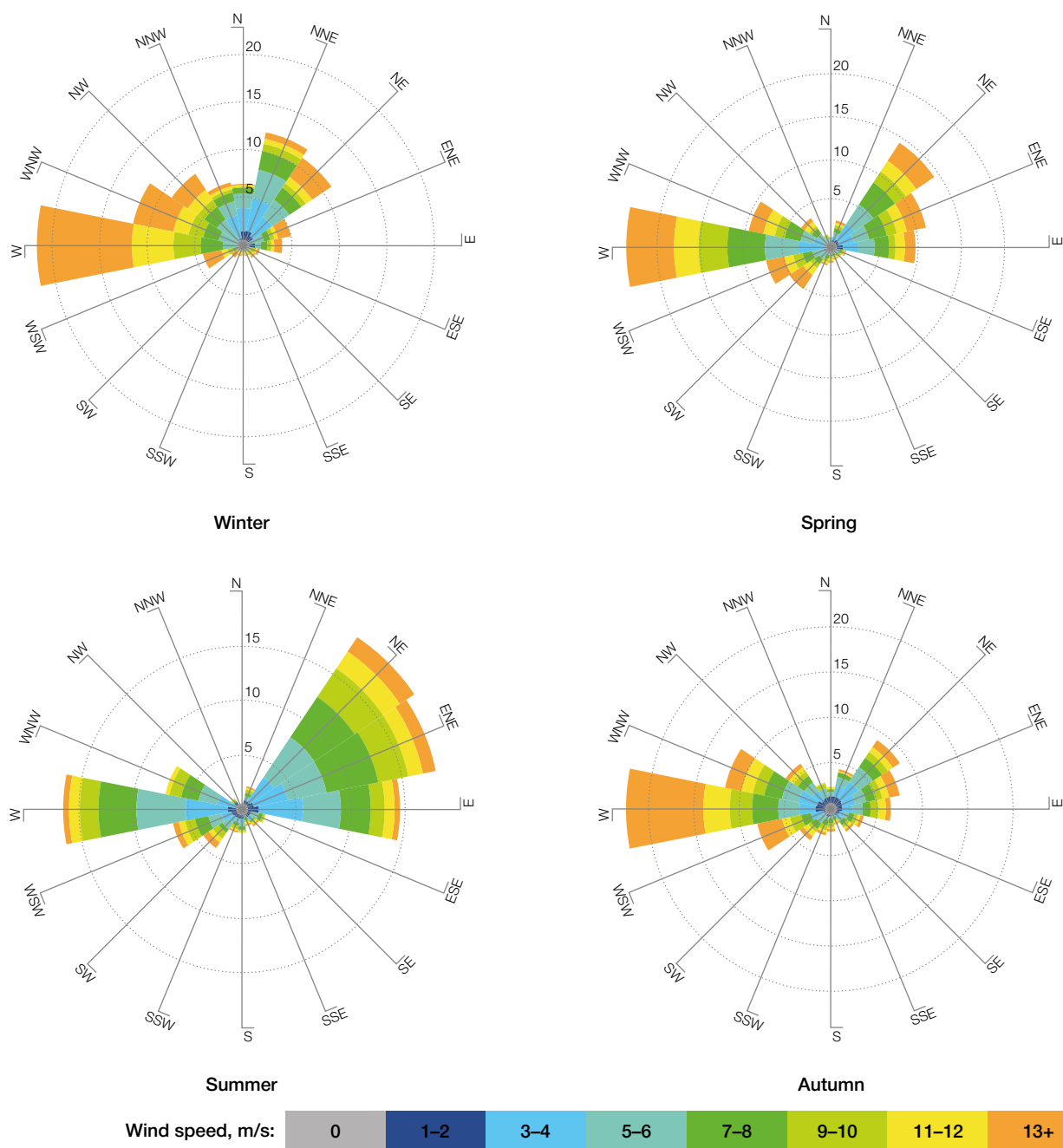


Fig. 1.9. Wind directions and speeds (as a % of total number of days) in different seasons for Cape Crillon (visualisation from <https://lakka-sails.ru/>)

Water Resources

Due to the peninsula's small width and the features of its terrain, watercourses are predominantly short, with small basins and an asymmetrical river network structure. High precipitation, significant channel slopes, and fissure groundwater associated with the aquifer complex of Upper Cretaceous deposits, fed by seeping atmospheric moisture, all contribute to transform even small streams into permanent watercourses with continuous groundwater recharge.

There are over a thousand watercourses on the peninsula, belonging to 178 drainage basins of various sizes (Fig. 1.10). A significant portion of these basins are those of the smallest rivers; more than half of the basins have an area of less than 2 km², and there are 32 rivers with basins larger than 20 km². The rivers

are distributed unevenly across the peninsula; there are half as many on the eastern side as on the western side, but they are on average longer and have a larger water catchment area. Of the eight largest rivers on the peninsula (over 30 km in length), only two lie on the western side, which is related to the greater height and dissection of the coastal mountains in the west of the peninsula.

The basins of the largest rivers on the peninsula (the Uryum, Taranay, Ulyanovka, Naicha, Kura, and Tambovka in the east, and the Lopatinka and Shebuninka in the west, as shown in table 1.1) have deep, well-developed valleys and a branched river network. In the valley expansions in the estuarine part, these rivers are of significant size: 20–30 m wide and over 1 m deep. In the mouths of such rivers, systems of bars and occasionally spits are formed,

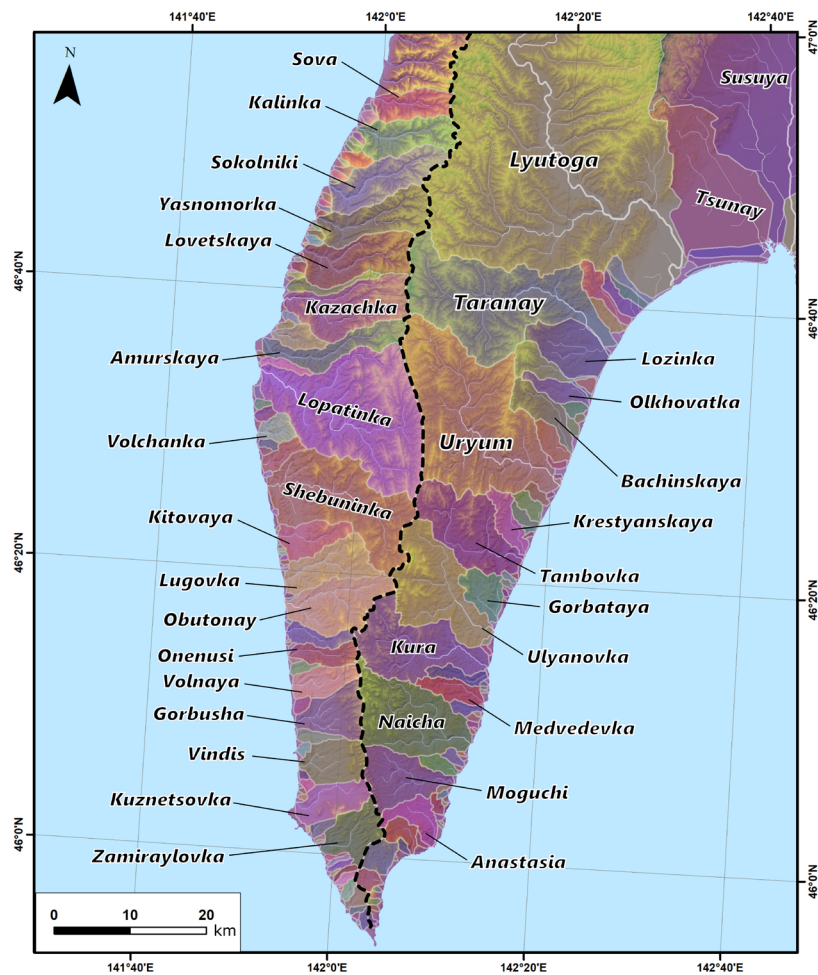


Fig. 1.10. Basins of the largest rivers of the Crillon Peninsula and the position of the main watershed



Fig. 1.11. A river valley in the lower reaches of the Anastasia River. In the background is Mount Bulat, 121 m (photo by A. Semenov)

which change position after major flash floods and storms. Most of the rivers are mountainous, with pebble and bouldery channel deposits, developed alluvial forms, and rapid flow, with speeds that can reach 3 m/s. Rivers in the upper parts of the catchments flow in narrow valleys with steep slopes. As the valleys widen and floodplains appear, the slopes of the rivers decrease, and their channels become meandering (Fig. 1.11). Small coastal rivers are characterised by rapids and waterfalls in their channels, and waterfalls 10–15 m high occur. There are no lakes within the peninsula's territory.

Due to the underdeveloped territory of the peninsula, hydrological observations on the rivers have been practically non-existent. In various years, according to the State Water Register, short-term observations were conducted on the Taranay and Uryum rivers. Separate observations have been

carried out since 1981 on the Lopatinka River (Tatar Strait basin). Despite its much larger catchment area, the Lyutoga River, the basin of which serves as the peninsula's northern border, can be used as an analogue for describing the discharge regime.

The type of river water source on the peninsula is mixed, with significant influence exerted by precipitation and its distribution throughout the year, as well as the geological structure of individual basins (Resources ..., 1973). In terms of water sources, snowmelt predominates (up to 60 % of the total runoff volume), with groundwater contribution playing a substantial role (25–30 %). Despite the significant number of cyclones and rainfall, the overall proportion of rain contribution is not high (up to 15–20 %), which is due to the high fracturing of the drainage basin surface. This fracturing allows a significant volume of falling precipitation to seep into the rock and recharge

Table 1.1. Largest rivers of the Crillon Peninsula (rivers of the western shore highlighted in green, eastern shore rivers in blue)

River	Catchment area, km ²	Length, km	Average discharge*, m ³ /s
Uryum	291	51	4.10
Lopatinka	267	30	3.63
Taranay	239	57	3.51
Shebuninka	166	33	2.93
Ulyanovka	119	34	1.84
Naicha	119	31	1.87
Kura	111	31	1.74
Tambovka	100	31	1.45
Kazachka	90	23	1.34
Lovetskaya	74	19	1.08
Obutonay	74	22	1.35
Sokolniki	70	19	0.99
Yasnomorka	67	20	0.92
Moguchi	60	22	1.15
Lozinka	56	13	0.55
Kalinka	53	15	0.82
Lugovka	53	18	0.91
Amurskaya	51	26	0.70
Gorbusha	45	12	0.89
Vindis	42	15	0.67
Zamiraylovka	41	15	0.81
Kuznetsovka	39	18	0.83
Sova	36	12	0.55
Kitovaya	33	13	0.52
Bachinskaya	31	18	0.72
Volnaya	28	14	0.49
Gorbataya	27	10	0.38
Anastasia	25	16	0.43
Olkhovatka	22	16	0.41
Krestyanskaya	22	14	0.33
Onenusi	22	12	0.42
Medvedevka	20	11	0.43

* Due to the lack of detailed observations, the water discharge data is sourced from the HydroRivers database (<https://www.hydrosheds.org/>) and has been modelled based on meteorological data and the landscape characteristics of the catch basin.

the underground aquifers. Three main phases of the water regime can be distinguished: the spring high water, which usually occurs from April to May; an extended summer-autumn flash flood period (in some dry years, a pronounced summer low water may be observed in June–August); and the winter low water from December to March. In terms of annual runoff volume, the high water dominates (55–60 %); 30–45 % occurs in the summer-autumn period, and 5–10 % in winter. On the east coast, the proportion of autumn runoff is higher, and winter runoff lower. On the west coast, due to atmospheric circulation features, the opposite situation is observed.

The peninsula's small but turbulent rivers exhibit considerable water level variability. During extreme precipitation events (especially when typhoons make landfall), water levels can rise by 3–5 metres in a matter of hours, even in small valleys. According to hydrological station data, the maximum observed amplitude was 4.5 m on the Lopatinka River in the settlement of Gornozavodsk. Such rises often flood the narrow floodplains of rivers, but the water recedes quite quickly. In normal years, high water levels exceed flash flood levels (including due to ice phenomena). However, the highest observed levels are precisely associated with flash floods (Fig. 1.12). Flash floods on the peninsula are short-lived, but due to the frequency of cyclones, their waves often follow one another.

The runoff modules (a characteristic reflecting water yield per unit area of the basin and allowing comparison of rivers of different sizes by their specific water content) here are among the highest on Sakhalin, amounting to 28 L/(s·km²) for the Lopatinka River, 34 L/(s·km²) for the Uryum River, and 29 L/(s·km²) for the Taranay River. For coastal small rivers, the annual runoff modules are about 23 L/(s·km²), with a vertical gradient of 3 L/(s·km²) per 100 m. During high-water phases, runoff modules increase significantly. For the spring high water, their typical values are 100–350 L/(s·km²). On the Uryum River in 1965, a flash flood with a module of 971 L/(s·km²) was recorded. Low water runoff modules are only 1–10 L/(s·km²). There is a direct relationship observed between the winter runoff module and average basin elevation due to groundwater accumulation. Small coastal streams almost dry up in winter.

Autumn ice run begins in the second decade of November and is observed only on the peninsula's largest rivers. Snow slush often appears, and accumulations of shuga ice into ice jams are possible, blocking the entire channel and accompanied by rising water levels. Freezing is often prolonged and can last from 5 to 45 days. Stable ice formation lasts

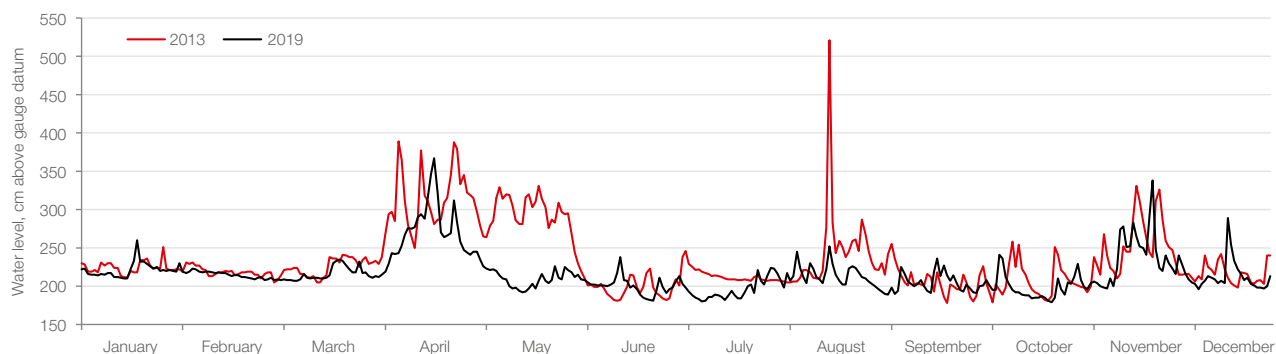


Fig. 1.12. Annual variation in the water level of the Lopatinka River (Tatar Strait basin) in a high-water year (2013) and a low-water year (2019)

about three months, while break-up and clearing occur quickly, within 3–6 days. The average annual water temperature is 11 °C and can rise to 15 °C in summer. Due to the cool climate, significant canopy shading of river and tributary channels, and their short length, the water does not have time to warm up more. The diurnal and annual course of water temperature is determined by fluctuations in air temperature; the peak water temperature during the day occurs several hours later than the peak air temperature.

Water mineralisation in the rivers is low, with the lowest levels during high water (up to 80 mg/L). Due to the characteristics of the rocks comprising the territory, a slight predominance of chloride (Cl^-), sodium (Na^+), and potassium (K^+) ions is observed during high water (Chudayeva, 1988). During flash floods, sulfates ($-\text{SO}_4^{2-}$) become the dominant anions, and during low water (when mineralisation is highest, up to 130 mg/L), hydrocarbonates ($-\text{HCO}_3^-$) prevail. The prevalent cation in both these seasons is calcium (Ca^{2+}). The pH value of the peninsula's river waters is less than 7, slightly shifted toward the acidic side.

The soil composing the river banks and floodplains is predominantly pebble, with sandy filler. During precipitation and snowmelt, significant surface runoff occurs; on low-lying sections, meanders actively develop and banks erode (Gensiorovsky et al., 2008). This leads to the transport of large volumes of material, forming turbid plumes in the sea. The average annual turbidity of river waters is 100–200 g/m³. The highest values are recorded primarily during high water, when maximum surface runoff occurs over frozen soil just beginning to thaw. In the Lyutoga River, the maximum turbidity observed during high water reached 4100 g/m³, suggesting that the water turbidity of the peninsula's smaller rivers may have similar values. The channels of many rivers are prone to debris flows, and

landslides regularly occur on high banks. Due to bank erosion, the channels are clogged with tree trunks and stumps, which complicates the passage of flash floods and leads to higher water level rises.

Natural Hazards

The peninsula's unique location and climate also conceal a large number of threats associated with natural hazards. Due to the presence of a fault system in this area, medium-magnitude earthquakes often occur, with their epicentres situated deep within the peninsula or in the nearby marine area. Over the last 20 years, three major events have occurred (Semenova, Safonov, 2022): the Gornozavodsk earthquake of August 17, 2006 ($M = 5.7$), earthquakes on November 25, 2013 ($M = 5.2$), and April 23, 2017 ($M = 5$). Following major earthquakes and aftershocks, a gradual decrease in seismic activity is usually observed until the next event. Tsunamis generated by both near and distant earthquakes can pose a danger to the coast; however, major Pacific events are significantly weakened by the time they pass through the straits of the Kuril Chain to reach Sakhalin. Tsunamis from nearby earthquakes do not have time to build up significant wave heights; for example, the tsunami wave height at Cape Crillon from the 1971 Moneron earthquake was 0.2 m, and from the 1963 Urup earthquake, it was 0.4 m.

The most hazardous and landscape-altering natural phenomenon is typhoons. Their landfall on the peninsula leads to powerful flash floods, floods, and landslides (Fig. 1.13); a significant increase in wind causes widespread tree blowdowns (Rybaltchenko, 2023). The most powerful typhoon in terms of impact over the last 80 years was Typhoon Phyllis, which

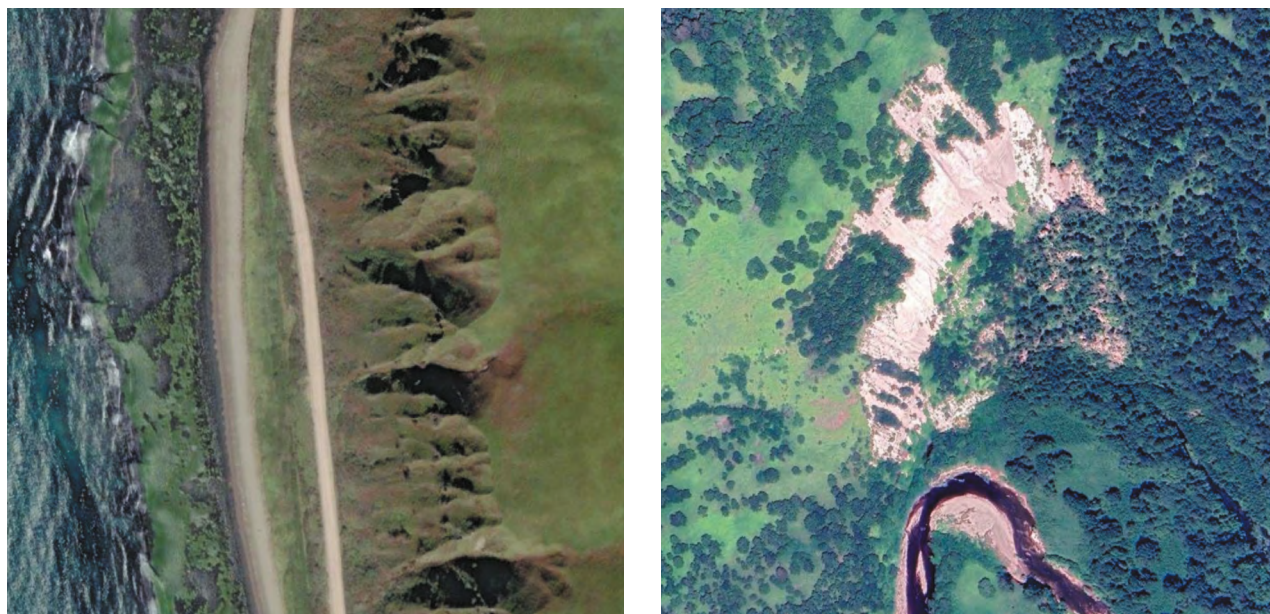


Fig. 1.13. Avalanche catchments on the west coast of Sakhalin Island (left) and a large landslide in the Uryum River basin (right)

struck southern Sakhalin in August 1981; its collision here with cold continental air masses resulted in hurricane-force winds and rainfall amounting to up to one-third of the annual total. All settlements on the peninsula were flooded and suffered significant damage; practically all rivers changed their course. Mudflows occurred, the deposits from which increased river turbidity for years to come. Other typhoons were not as severe but also led to significant changes in the natural environment. During the passage of a typhoon in September 1947, over 220 mm of precipitation fell in a single day. Typhoon Chaba (early September 2004) was marked by some of the strongest winds during the observation period. The peninsula was significantly affected by Typhoon Halong (August 2014) and Typhoon Jebi (September 2018).

The large amount of solid precipitation in winter and temperature instability lead to an increased avalanche hazard. Avalanches are characteristic of both the upper parts of basins and coastal areas, where glens with small catchment areas and steep slopes, opening directly onto the coast, act as avalanche catchments. Avalanches are particularly frequent on the west coast (Kazakova et al., 2022), where the Nevelsk–Shakhtersk and Nevelsk–Shebunino roads and settlements are at risk, necessitating regular controlled avalanche release.

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2 ARCHAEOLOGICAL SITES AND PREHISTORIC SETTLEMENTS

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State of Archaeological Knowledge of the Peninsula

As of 2025, archaeological periods, cultures, and their corresponding key archaeological sites have been identified and studied on Sakhalin Island, ranging from the final stage of the Early Paleolithic, dated from between 230,000 and 140,000 years ago, to the first quarter of the 20th century (Table 2.1). According to Russian legislation, the chronological boundary defining cultural layers, historical artefacts, as well as structures and remains of humans and animals found in the ground to the category of archaeological phenomena is set at 100 years before the present day.

As of January 1, 2025, scientific literature and registers of newly discovered archaeological sites on Sakhalin and the Kuril Islands have recorded

1,678 objects possessing the characteristics of archaeological heritage sites. Among these, 113 objects are reliably known within the boundaries defined as: the lower reaches of the Lyutoga River, the Bystraya River, Lovetsky Pass, the valley, the mouth of the Lovetskaya River, Cape Kuznetsova, Cape Crillon, the right bank of the Lyutoga River, both banks at its mouth. From this list, within the specified boundaries, 45 sites possessing the characteristics of archaeological heritage objects are known in the Anivsky city district, and 68 in the Nevelsky city district; these sites are listed in Table 2.2 and shown on the peninsula map (Fig. 2.1). In reality, the number of such objects is somewhat larger, as Crillon has been and remains to this day a very enigmatic and poorly studied territory.

The Crillon Peninsula is a place with a high concentration of archaeological sites from all archaeological periods, with the exception of the early Paleolithic period.



Excavation of a medieval Mohe dwelling, 10th–14th centuries. Shore of Aniva Bay, Solovyevka 5 settlement (photo by P. Pashentsev)

Table 2.1. Archaeological Sites of Sakhalin Island

Archaeological Period	Archaeological Culture, Stage	Key Archaeological Sites and Locations of Historical Military Events	Location
Early Paleolithic (230,000–140,000 years ago)	Final stage of the Early Paleolithic	Sennaya 1 campsite: a unique site; three campsites are known to be on the island	Sennaya River, Sovetskoye village
Late Paleolithic (23,000–13,000 years ago)	Middle and Late stages of the Late (Upper) Paleolithic	Ancient Ogonki 5 settlement; over 50 objects from the Late Paleolithic period	Anivsky, Dolinsky, Korsakovsky, Tymovsky city districts, Yuzhno-Sakhalinsk city
Neolithic 11,000–7,000 BC	Initial and Early stages of the Neolithic	The Takoye 2–6 campsites	Dolinsk city
		Taranay 1 campsite	Taranay village
		Slavnaya 5 campsite	Slavnaya River
		Crillon 1 campsite	Cape Crillon
6,000–4,000 BC	Middle and Late stages of the Neolithic: Sedykh, Imchin cultures	Kuznetsovo 3 settlement	Kuznetsovo natural landmark Kuznetsovo natural landmark
3,000 BC		Kovrizhka Refuge	Cape Vindis
		Sedykh 1 settlement	Okhotskoye village
		Levy Ruchey 2 settlement	Nogliki urban-type settlement Nogliki urban-type settlement
Transition from Stone to Metal: Paleometal 12th century BC – 5th century AD	Paleo-Ainu cultures ‘final stage of Jomon community genesis’ 12th–5th centuries BC	Yuzhnaya 2 settlement	Yuzhnaya natural landmark Yuzhnaya natural landmark
		Crillon 1 settlement	Cape Crillon
		Naicha 5 settlement	Naicha River
		Kuznetsovo 1 settlement	Kuznetsovo natural landmark
	Piltun, Nabil, Susuya cultures 5th century BC – 5th century AD	Chayvo 1 settlement	Chayvo natural landmark Chayvo natural landmark
		Dzhimdan 5 settlement	Dzhimdan River
		Susuyskaya campsite settlement	Susuya River
		Starodubskoye 2 settlement	Starodubskoye village
		Starodubskoye 3 settlement	
		Kuznetsovo 1 settlement	Kuznetsovo natural landmark
Medieval Period (6th century AD ~ 1650 AD)	7th–10th–11th–16th centuries AD. Kuwey, Emishi, Ainu; Mongols; Mohe–Jurchen; Jilemi, Paleo-Nivkh	Ozersk 1 settlement, Kuznetsovo 1 settlement and Small Wooden Fort	Ozersk village, Kuznetsovo natural landmark Kuznetsovo natural landmark
		Kuznetsovo 2 settlement	
		Sedykh 1 settlement	
		Crillon ancient settlement (Shiranushi) fortress	
Modern Era (~1650 ~1900)	Ainu, Nivkh, Uilta, Russian and Japanese culture 17th–19th centuries. Cultural layers of Russian and Japanese guard posts and villages of the 19th century	Promyslovoye settlement, etc.	Nevskoye Lake
		Ainu Kuznetsovo 1 necropolis	Kuznetsovo natural landmark
Contemporary Era (20th century), poorly studied from an archaeological perspective	Cultural layers of battles, military camps, burials, and fortifications of the Russo-Japanese War (1904–1905) and the Second World War (1945)	1905 Partisan Camp	Tunaicha Lake
		1905 Russian Military Camps	Aleksandrovsky, Tymovsky and Korsakovsky city districts
		Locations of battles and other military events of the Russo-Japanese War of 1905	Korsakovsky, Kholmsky, Dolinsky, Smirnykhovsky, Tymovsky, Aleksandrovsk-Sakhalinsky city districts, Yuzhno-Sakhalinsk city
		Locations of battles and military events of the Second World War (1945)	Smirnykhovsky, Uglegorsky, Poronaysky, Kholmsky city districts

Table 2.2. List of identified archaeological heritage objects of the Anivsky and Nevelsky Municipal Districts of Sakhalin Region within the Crillon Peninsula (List ..., 2025)

No	Archaeological Heritage Sites	No	Archaeological Heritage Sites
Anivsky City District			
1–6	The Ogonki 3–4 and Ogonki 6–9 campsites	21	Ostrovki 1 campsite
7	Ogonki 5 settlement (Ruchey Schastya)	22	Poyarkovo 1 campsite
8–10	Petropavlovskoye 5 settlement (Rodnik) points 1, 2, 3	23, 24	The Shebunino 1–2 campsites
11	Lyutoga 1 campsite	25	Reka Ivanovka 1 campsite
12–14	The Lyutoga 2–4 settlements	26, 27	The Reka Chkalovka 3–4 settlements
15, 16	The Taranay Village 1 and 7 campsites	28	Luzhki 1 campsite
17–20	The Taranay Village 2–5 settlements	29	Pereputye campsite
21	Yuzhnye Pochinki 1 settlement	30	Reka Onenusi 1 settlement
22	Pochinki 2 campsite	31	Reka Volnaya 1 campsite
23	Kirilovo 1 campsite	32, 33	The Kraynaya 1–2 campsites
24	Kirilovo 2 settlement	34	Reka Gorbusha 1 campsite
25	Zaberezhnaya 1 settlement	35	Reka Gorbusha 2 settlement
26	Reka Maksimkina 1 campsite	36	Reka Riflyanka 1 settlement
27–30	The Reka Ulyanovka 1–4 settlements	37	Mys Vindis 1 fortified settlement (Kovrizhka)
31	Reka Kura 1 settlement	38	Reka Vindis 1 campsite
32	Reka Kura 2 campsite	39	Reka Vindis 2 settlement (Reka Dubinka)
33	Reka Svatovka 1 campsite	40	Ruchey Sheptun 1 settlement
34	Reka Naicha 1 campsite	41	Multilayered Kuznetsovo 1 campsite and necropolis
35–37	The Reka Naicha 2–4 settlements	42	Kuznetsovo 2 small wooden fort
38	Reka Moguchi 1 campsite	43	Kuznetsovo 3 settlement
39	Reka Moguchi 2 settlement	44	Kuznetsovo 4 campsite
40	Reka Moguchi 3 settlement	45	Kuznetsovo 5 settlement
41	Mys Atlasovo 1 campsite (Reka Anastasia 1)	46–49	The Kuznetsovo 6–9 campsites
42	Mys Atlasovo 2 fortified settlement (Reka Anastasia 2)	50	Bukhta Kamoy 1 settlement
43	Reka Atlasovka 1 settlement	51	Mys Zamiraylova Golova fortified settlement
44	Reka Petrovka 1 campsite	52	Reka Neya 1 settlement
45	Mys Kostroma 1 campsite	53	Reka Zamiraylovka 1 settlement
Nevelsky City District		54	Reka Nishenka 1 settlement
1–4	The Lovetskoye 2–3, 5–6 campsites	55	Reka Rakitinka 1 settlement
5	Lovetskoye 4 fortified settlement	56	Reka Zvonarka 1 campsite
6	Nevelsk 1 settlement	57	Reka Zvonarka 2 settlement
7	Nevelsk 2 necropolis	58	Reka Fastovka 1 settlement
8	Gruntovy necropolis	59	Reka Bucha 1 campsite
9	Kazakevichi campsite	60	Reka Teterevka 1 settlement
10	Seleznevo 1 settlement	61–64	The Mys Maydelya 1–4 settlements
11	Mys Lopatina 1 campsite (Lopatino 1)	65	Mys Maydelya 5 fortified settlement
12	Zarechye 1 campsite	66	Shiranushi ancient settlement (Crillonskoye Gorodishche)
13–15	The Gornozavodsk 1–3 campsites	67	Shiranushi 2 settlement
16	Chaikino 1 campsite	68	Mys Crillon 1 campsite
17	Chaikino 2 fortified settlement (Uni Chasi)		
18	Orlovka 1 campsite		
19	Shtormovoye 2 fortification		
20	Volkovo 1 campsite		

Note: The names of the sites in the table correspond to commonly accepted toponyms: geographical names of settlements and rivers, which will facilitate their search for the reader.

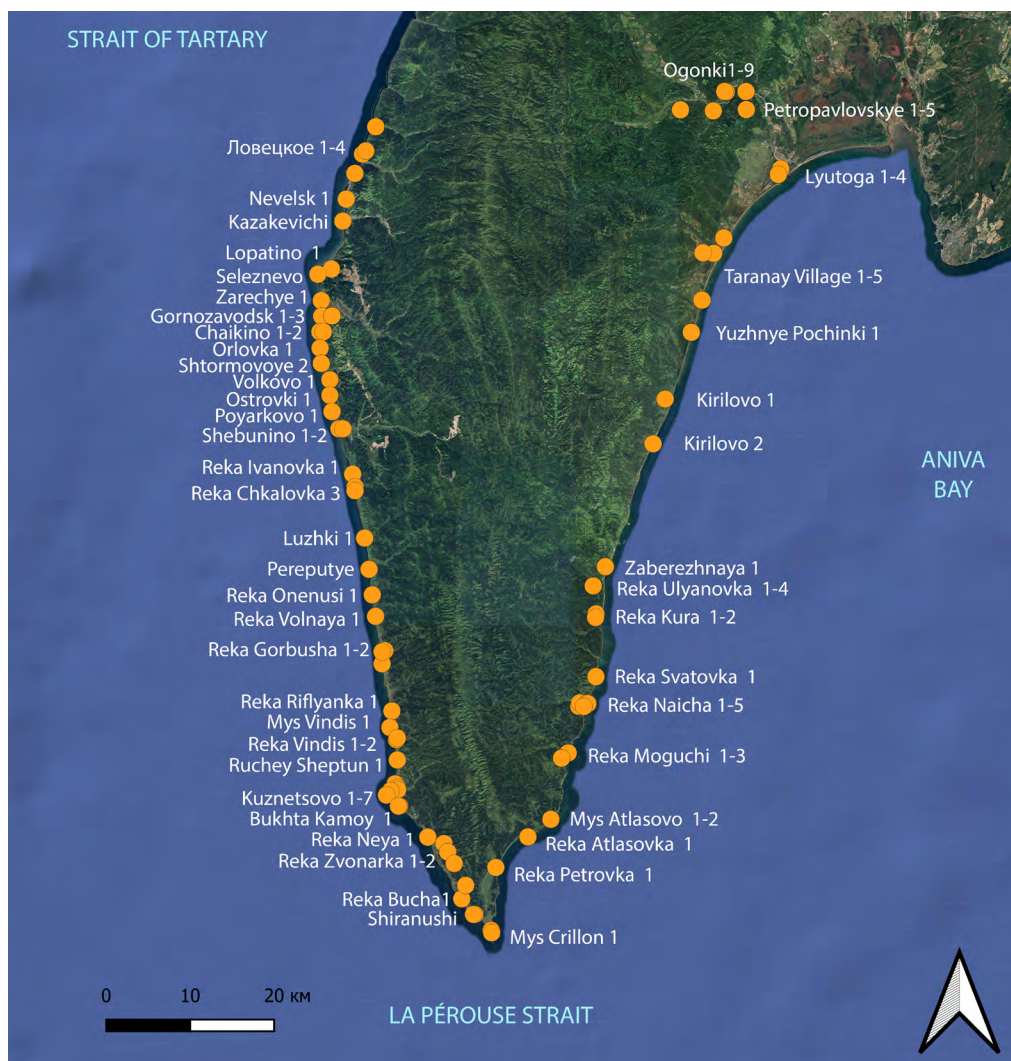


Fig. 2.1. Map of the main archaeological locations on the Crillon Peninsula

Due to the limited development and inaccessibility of the peninsula's territory, cultural layers and buried features on the peninsula have been preserved in satisfactory condition, but these same factors also hindered its systematic study. Nevertheless, in the 20th and first quarter of the 21st century, archaeologists have carried out a number of studies and made discoveries that allow for a broad characterisation of this territory's role in the early history of the island region.

The peninsula is exceptionally rich in archaeological sites: on every single river and almost every stream flowing into the sea, traces of habitation by people from distant epochs are preserved. Based on research from the 20th to the early 21st centuries, the following types of archaeological sites have been identified:

- seasonal campsites of hunters and fishermen; rarely, shell middens from the Neolithic, Paleometal Period, and Medieval Period without external features;
- settlements with clearly visible traces of activity on the land surface, such as depressions and hollows of dwellings;
- multilayered settlements in river mouth areas, containing cultural layers within the body of terraces and dunes, which include buried features such as necropolises, production areas, and dwelling complexes (e.g., the Kuznetsovo 1 settlement, from 2750 years ago to the 19th century);
- Ainu necropolises from the Modern Era, always located beyond a water barrier, to the north of their settlement;

- fortification objects, such as small wooden forts with ramparts and moats, and natural refuges used by local and incoming peoples during the Neolithic, Paleometal Period, and Medieval Period on impregnable capes (e.g., Mount Kovrizhka);
- other sites over 100 years old, including the remains of posts and settlements from the period of the island's development in the 19th century;
- underwater objects over 100 years old, such as shipwrecks, anchors, and individual antique items;
- sites of military archaeology from the 20th century (objects from the 17th–20th centuries AD are not considered in this chapter).

Of particular interest for archaeology on the peninsula is the Medieval Period site Shiranushi, or the 'Crillon ancient settlement'. This site is located on the eponymous cape and dates to the Medieval Period (12th–13th centuries).

Crillon in the Stone Age

The isthmus between the two territories of the Sakhalin-Hokkaido-Kuril palaeo-peninsula: the 'bottleneck' of the Ice Age (~30,000 – 23,000 – 12,000 years ago)

At all times, Crillon has been a territory of contact between the Eurasian continent and the island chains of the Japanese and Kuril archipelagos, a unique 'bottleneck' of the peninsula that united Sakhalin, Hokkaido, Kunashir, Shikotan, as well as the islands of Zelyony, Yuri, Anuchin, Tanfilyev, Polonskogo, Oskolki, Storozhevoy, Signalny, Rifoviy, Dyomin, and the cliffs of Peschernaya, Parus, and Svecha. In the north, near the Amur River mouth, the palaeo-peninsula was connected to the continent by an isthmus about 300 km wide (Fig. 2.2). The Late Paleolithic on the Sakhalin-Hokkaido-Kuril palaeo-peninsula is conventionally dated within the boundaries of 31,000–27,000 to 14,000 years before present, taking into account the event proven by radiocarbon dating: the settling of *Homo sapiens* across the entire area from the East Sakhalin Mountains to the Tokachi Plain (Vasilevsky, 2008; History ..., 2022; Sato, Morisaki, 2024).

To the east, the peninsula was washed by the waters of the Sea of Okhotsk, to the west by the Sea of Japan, and to the south, it was warmed by the Tsushima Current (Kuroshio). The width of the Crillon Isthmus during the

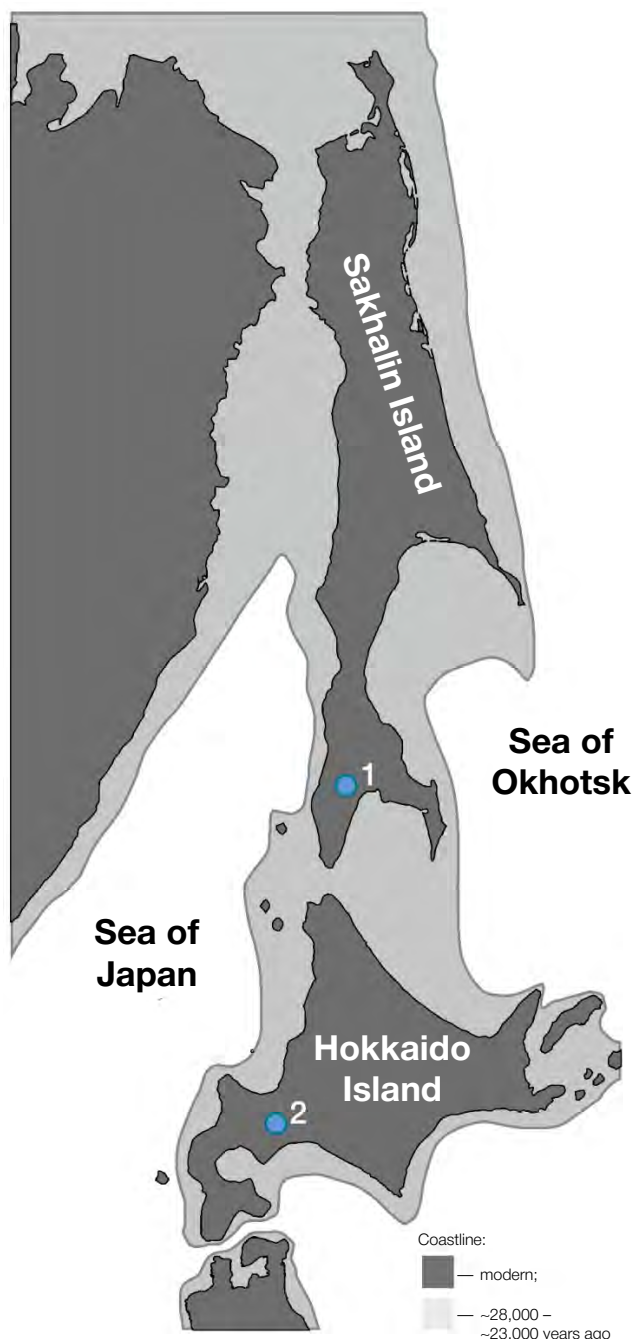


Fig. 2.2. Outline of the Sakhalin-Hokkaido-Kuril palaeo-peninsula during the Late Glacial Period and the last deglaciation on Hokkaido and Sakhalin islands in the northwestern Pacific Ocean ~28,000 – ~23,000 years ago, as well as the location of key Late Paleolithic sites of the peninsula: the Ogonki 5 settlement (1) and the Kashiwadai 1 settlement (2) (Igarashi, 2016; Vasilevsky, 2008; Sato and Morisaki, 2024, etc.)

coldest part of the glacial period exceeded the width of the modern Aniva Bay, fluctuating depending on changes in sea level, as is shown in Fig. 2.2 (Kinoshita et al., 2024). In the area of Cape Crillon, the terrain dropped sharply, beyond which a low-lying isthmus extended, now occupied by La Pérouse Strait. Climate fluctuations and environmental shifts gave rise to both the distinctiveness and the recurring historical-cultural transformations of this continental-to-island transition zone. Concurrently, in place of the disintegrated peninsula, the islands of Sakhalin, Hokkaido and Kunashir emerged (Ono, 1990; Igarashi, 2016). Periodic climate fluctuations and the accompanying transgressions and regressions of the World Ocean determined the meridional direction of the historical movement of peoples. Population changes in all historical periods, both on the isthmus and the peninsula, occurred at intervals from 30–40 to 300 years, which is characteristic of transitional territories. The Crillon Peninsula played the role of an isthmus in the region's history primarily during the era of the last (Sartan) glaciation, approximately 28,500 to 12,500 years ago, when *Homo sapiens* actively settled the Japanese archipelago and Sakhalin Island. The key cultural sites of Ice Age humans for the peninsula are the Ogonki 5 settlement on Sakhalin and the Kashiwadai 1 settlement on Hokkaido, which are undoubtedly linked by a unified Paleolithic tradition of material culture.

Evidence of stable winter habitation by human groups in the river valleys of the Crillon Peninsula as early as 23,000 years ago is provided by the Ogonki 5 settlement, located 5 km south of the modern village of Ogonki in Anivsky District, which gave its name to this location. The settlement is situated on a high ancient terrace on the left bank of the Lyutoga River, on a platform between two clear streams, one of which bears the remarkable name 'Ruchey Schastya' (Stream of Happiness). Ancient dwellings were discovered here (two contemporary and one later) in which people, members of a single primitive group or clan community, lived over an extended period. The dwellings were circular, 6–8 m in diameter, and can be classified as the 'chum' tent type. A chum is a conical, collapsible structure made of poles fastened together with straps. The chum frame was covered with bark, sometimes birch bark in particular, sometimes fabric made of fish skin, and animal hides, typical for taiga and Arctic hunters and fishermen of Siberian and Far Eastern rivers. Opposite the entrance, on a small elevation, a hearth was found, and not far from it, areas where men, by firelight, crafted stone tools, and women processed the skins of hunted animals and sewed clothing. Here, in a small space of 10–12 m², people spent much time: the floor in

the centre of the dwelling is particularly compact, black, with many finds trampled into the earth by the ancient people, for example, pieces of amber and obsidian flakes.

About 30–40 people, adults and children, lived together in the two dwellings. These people were undoubtedly a single community where everything belonged to all. Evidence of this was found during the excavations. Archaeologists managed to match and piece together dozens of broken and complete stone tool blanks, blades, flakes, and chips to their original size. The tools were made using the so-called blade technology (Fig. 2.3). From a large piece of raw material (a core, usually basalt, flint, or slate) the craftsman struck off long, even blades, which were blanks for future knives, scrapers, saws, piercing tools, points, etc. Their edges were then processed: the craftsman sharpened them by pressing off thin flakes from the blade using a horn (antler) tool, employing pressure flaking technique. Unlike the pebble tool technology of the Early Paleolithic, there was no longer a need to wastefully chip off a dulled knife edge; it was sufficient to simply resharpen it with a horn pith. The same technique was used by Upper Paleolithic people in France, Central Asia, on the Angara River, in China, Korea, the Japanese Islands, Primorye, and Kamchatka.

It cannot be stated with certainty that the people who lived at the Upper Paleolithic Ogonki 5 settlement



Fig. 2.3. Stone knives made using blade technology. Late Paleolithic. Ogonki 5 settlement

were relatives; there are no anthropological finds for this, and no possibility of conducting the appropriate genetic analysis in such cases. Presumably, the people of the Late Paleolithic lived in an early clan community based on kinship ties. According to modern understanding, this was a group of relatives living in one settlement and possessing collective ownership of everything around them, including hunting grounds and sources of stone raw material for toolmaking. Members of the community traced their descent from a common ancestor, usually a totem, a bear, a boar, or another animal or plant, which the people considered their progenitor.

A twin site on Hokkaido Island, characterised by a high degree of similarity to the Ogonki 5 settlement in the totality of features of its material culture, is the Kashiwada 1 settlement, studied by archaeologists during the construction of Chitose Airport. Radiocarbon dating of hearth coal from both sites, along with common features of toolmaking technology, allows us to attribute their lower layers, dwellings, and artefact concentrations around hearths to the same period, from 25,000–23,000 to 19,000 years ago. The biggest surprise at the Ogonki 5 settlement and in a whole series of early Late Paleolithic sites of the Japanese archipelago, which astonished European archaeologists, was the discovery of ancient adzes, tools for woodworking. Unlike the tundra regions of the European and Siberian Paleolithic, polished stone adzes appear much earlier in southern Sakhalin, as well as on the islands of the Japanese archipelago, during the early Late Paleolithic, starting around 30,000 years ago. They were all made by flaking and grinding the stone blade, a technique that would only develop in Europe 10,000 years later (Sekiya, 2006). In archaeological literature (Tsutsumi, 2007; Nobuyuki, 2015), this is explained by two circumstances. Firstly, scientists believe that it was here, in East Asia, that people mastered the art of seafaring very early, and polished adzes were needed for hollowing out boats. Presumably, the earliest rafts and boats appeared in East Asia, including the Sea of Japan basin, over 20,000 years ago. The early emergence of seafaring skills is also indicated by the history of stone raw material exchange between distant Upper Paleolithic settlements of the Sea of Japan basin mainland. Secondly, forests grew in this area, providing the opportunity to use timber for boats, not just bamboo or grasses. And, for that period of technological development, this was best done with an adze having a smooth, polished blade of semicircular or lens-shaped cross-section. The smooth surface of the polished blade did not tear the wood shavings, and its rounded shape concentrated the force of the blow in a

narrow area. Polishing and smooth surfaces were already known to people who could work bone. Transferring this skill to stone required time, but necessity compelled a transition eventually from flaked woodworking tools to polished ones. In Europe, the transition to polished stone tools would occur only in the Neolithic era, no earlier than 10,000–8,000 years ago.

High-quality, pliable raw materials (flint, jasper, and obsidian) were highly valued. For them, people undertook long journeys; hunters traded furs and bone, mammoth tusks, and reindeer antlers for them. The largest deposits of volcanic glass in Asia are located on Hokkaido. The closest is situated approximately 300 km south of Cape Crillon, in the Shirakawa locality (Japan). Research shows that obsidian from Hokkaido first appeared on Sakhalin as early as 23,000 years ago at the Ogonki 5 settlement (Vasilevsky, 2008). Scientists believe that already 20,000 years ago, craftsmen living near obsidian deposits prepared the stone specifically for exchange with neighbouring tribes that lacked access to this raw material (Reexamination ..., 1992). On Sakhalin, the point closest to the Hokkaido obsidian sources is Cape Crillon, 230 km away by azimuth. It was impossible to pass by it, so it is assumed that somewhere here, on the coast, there must have been meeting places, a sort of trading ground, where the exchange took place. The most distant proven point of distribution of Hokkaido obsidian is the lower reaches of the Amur River, located more than 1000 km away by azimuth from the deposits on Hokkaido (Kuzmin, Glascock, 2011). Most likely, Stone Age people, who led a mobile lifestyle, periodically visited the deposits or made special expeditions there, replenished their supplies, and took as much raw material as they could carry on themselves or, more likely, transport in boats. Regardless of how it happened, research shows that over the period from 23,000 to 2,000 years ago, people moved dozens of tonnes of this valuable mineral. This astonishing fact is confirmed by the mass finds of obsidian artefacts at Sakhalin campsites ranging in age from 18,000 to 2,000 years. It was during this time that the technique of splitting stone into blades ranging from 2–3 to 25 cm in length reached its peak in Northeast and East Asia. Microblades were used as blade inserts in bone knives and spears. This ancient technology allowed for maximum conservation of raw materials and reduced labour costs for preparing hunting tools. Since the best microblades were obtained precisely from volcanic glass, the development of this new technology also led to a flourishing of exchange in this material during the same period. The disappearance of the Crillon Isthmus did not sever the connections between people.

La Pérouse Strait reached its modern width of 42 km by about 7,000 years ago. Crossing it required stable skills and reliable means of navigation. The fact of the obsidian exchange persisting right up to the turn of the Common Era has been established, serving as proof of the existence of seafaring and the early adaptation of the region's population to insular living conditions.

The Crillon Peninsula in the Neolithic Period (12,000–3,000 years ago)

By the beginning of the Early Holocene, around 14,000 years ago, Sakhalin still remained a peninsula, connected in its northern part to the mainland by a broad, flat territory over 300 km wide. Its southern margin was most likely connected to Hokkaido Island by a narrow isthmus, 10–20 km wide, located where the central part of La Pérouse Strait is now.

The sea level at that time was 45–50 m lower than its present mark (Mikishin et al., 2010). Directly near the lighthouse on Cape Crillon lies the Crillon 1 campsite (Fig. 2.6), where researchers in various years have discovered evidence of visits to this place by representatives of different cultures and peoples. The oldest find is a burin on a small blade. Typologically, this tool can be attributed to the Final Paleolithic or Initial Neolithic within the range from 14,000 to 8,000 years ago, i.e., to the time when La Pérouse Strait formed into its modern shape (Fig. 2.4, 2.5). This find is not the only one on the cape, which contains at least five archaeological sites ranging from the Initial Neolithic to the Medieval Period, as well as the unique 13th-century AD Shiranushi ancient settlement, which will be discussed in the next part of this chapter.

In the 8th millennium BC, bearers of the blade point culture passed southwards through the Crillon Peninsula. They were migrants from the interior regions of Siberia (Transbaikalia and Yakutia) who spread in a short time across the entire north-east of Asia, including Sakhalin and the eastern regions of Hokkaido Island. The culture was named for the characteristic feature of its lithic industry: arrowheads fashioned from blades with trapezoidal or triangular cross-sections (see Fig. 2.7). Campsites of this culture, from the east coast of Hokkaido to the northern regions of Sakhalin, are inextricably linked to marine resources, obsidian, and a mobile lifestyle that included long sea voyages along the islands.

In the 6th millennium BC, the appearance of the Soni culture is noted, named after the Ainu toponym: the eponymous river and Ainu settlement of Soni in the Kuznetsovo natural landmark on the west coast of

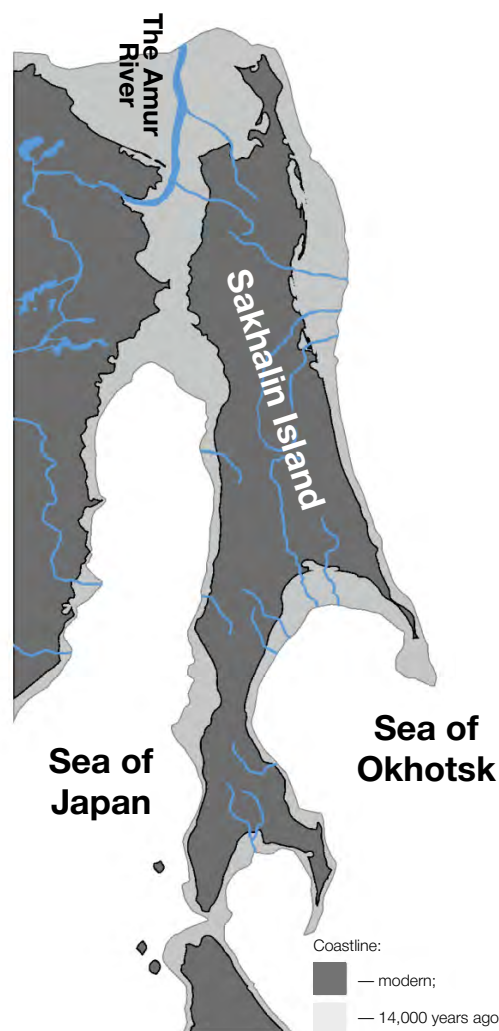


Fig. 2.4. Approximate outline of the Sakhalin coastline around 14,000 years ago (Mikishin et al., 2010)

the Crillon Peninsula. During this period, bearers of the Soni culture, with their unique tradition of making quadrangular vessels, settled not only on Sakhalin but also on Moneron Island. This culture had striking characteristics. Unlike the blade point culture, the Soni people led a sedentary life on the shores of sea bays; they were not nomads and lived not in collapsible dwellings but in permanent, solid log houses sunk up to a metre into the ground. In the lithic industry of the Soni culture, the use of obsidian, so characteristic of neighbouring cultures, unexpectedly ceased. Artefacts made of volcanic glass are extremely rare and may be explained by the secondary use of finds from an earlier period. Such fundamental changes in culture could only arise under the influence of two circumstances:

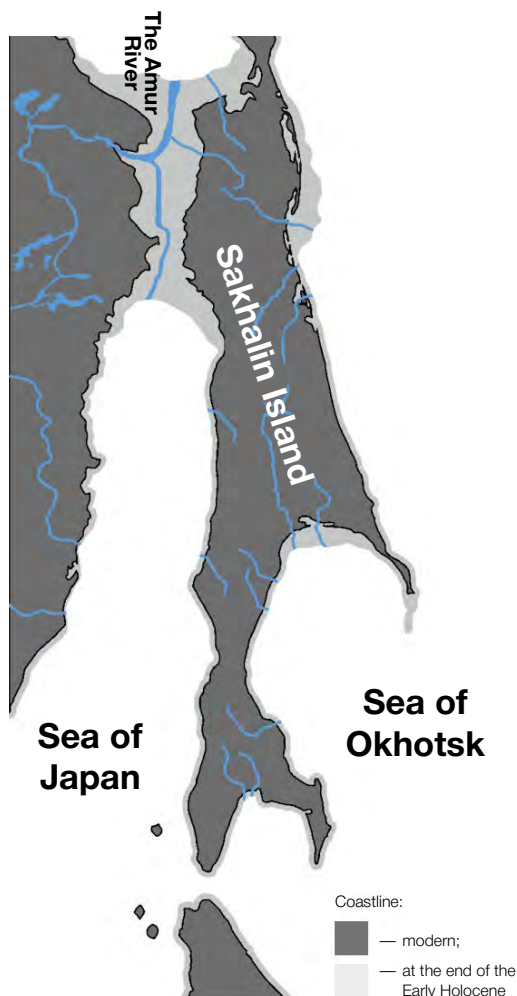


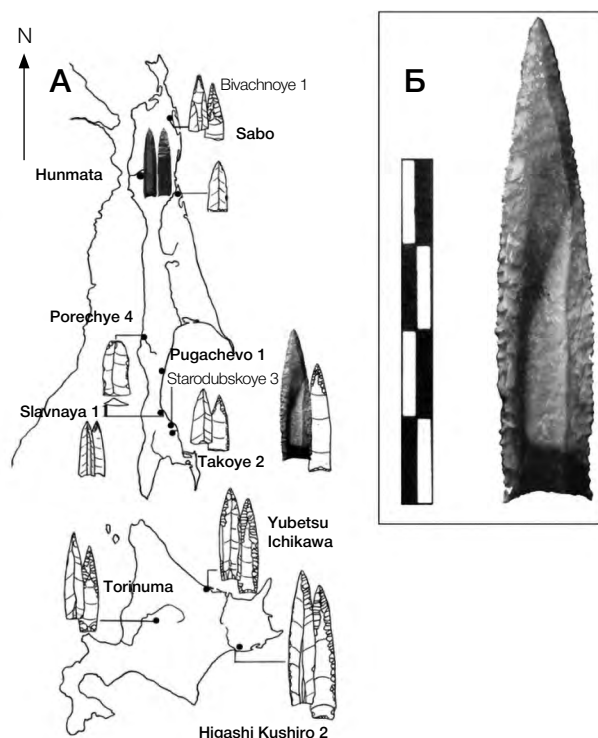
Fig. 2.5. The Sakhalin Peninsula after the flooding of the Crillon Isthmus and the emergence of La Pérouse Strait around 8,000 calendar years ago (*Mikishin et al., 2010*)

confrontation with tribes living across La Pérouse Strait on Hokkaido, Rebun, and Rishiri; and the abandonment of blade technology in stone processing. The latter could have been crucial, as the people of the Soni culture made excellent spearheads, arrowheads, knives, and scrapers from any rock, even of poor quality, using the bifacial pressure flaking method. This ended the raw material dependence of Sakhalin's peoples on sources of now-distant Hokkaido. Sedentary life required efforts to protect the lands. The people of the Soni culture fought with those coming from neighbouring islands. Evidence of such enmity was discovered by archaeologists at the summit of the impregnable Mount Kovrizhka on Cape Vindis (Fig. 2.8), on the west coast of the Crillon Peninsula, where, in addition to Medieval Period dwellings and finds from the Paleometal Period, a cultural layer was uncovered containing characteristic pottery, fragments of quadrangular vessels. Their rivals could have been both neighbouring tribesmen and bearers of the Jomon culture, the presumed distant ancestors of the ancient Ainu people. The latter lived directly across La Pérouse Strait on Hokkaido Island.

During the climatic optimum, in the warmest phase of the postglacial period in the 7th–4th millennium BC, marine bio-resources became a powerful source of food for the people living there. All-season sea fisheries provided an escape from the ecological crisis associated with abrupt warming, the extinction of so-called megafauna, rising global sea levels, the flooding of plains and isthmuses of the Sakhalin-Hokkaido-Kuril Peninsula, and the crisis of the hunting economy. At the same time, favourable areas (warm, shallow bays) formed at the mouths of most rivers, such as the Ulyanovka, Naicha, Moguchi, Anastasia, Kuznetsovka and similar ones. Neolithic settlements are associated with their terraces. The



Fig. 2.6. An Early Neolithic campsite on Cape Crillon (marked by arrow). View from the north-west



outlines of ancient bays are clearly traceable in the mouths of most rivers in Southern Sakhalin, including the Crillon Peninsula. Adaptation during the formation of a new coastal economy, based on the year-round, intensive exploitation of marine resources, constituted the essence of the last epoch of the Stone Age: the Neolithic, when an economic mode was established, founded on the active development of the resources of the seas washing the islands of the Far East (Vasilevsky, 2008; Grishchenko et al., 2022). It should be noted that in coastal areas such as the Crillon Peninsula, in rugged terrain, living space was limited to the coastal strip along the shores of bays and in the estuarine sections of rivers. Winter survival under deep snow cover was largely ensured by marine ice fishing. This is characteristic of all coastal cultures of North-East Asia and North-West America, where the transition was made from sea hunting from boats in winter months to ice fishing and seal hunting at the ice edge. This coastal economic mode, formed in the Neolithic era, was so effective that it was preserved in subsequent epochs, up to the Paleometal Period and the Medieval Period.

Fig. 2.7. Blade arrowheads culture. Sakhalin and Hokkaido Islands

Fig. 2.8. View of the multilayered settlement (a refuge from the Neolithic, Paleometal and Medieval periods) atop Mount Kovrizhka, on Cape Vindis, Crillon Peninsula. Photographed from the west (by P. Pashentsev)



The Paleometal Period, the Medieval Period and the Beginning of the Modern Era (11th century BC – 16th century AD)

The Crillon Peninsula at the crossroads of exchange routes in the ancient metal era (11th century BC – 5th century AD)

The end of the Neolithic period on the islands of North-East Asia, the 2nd millennium BC, coincides in time with the Bronze Age and the beginning of the Paleometal Period in China, Primorye, and Outer Manchuria. The significance of Cape Crillon and the Crillon Peninsula in the exchange trade between the tribes of the Far Eastern islands is beyond doubt for anyone. For the coastal areas of the World Ocean, the Neolithic period is characterised by a series of innovative solutions in organising life by the sea: the development of seafaring, marine harvesting utilising all possible resources, including gathering, fishing, sea mammal hunting, as well as active exchange, raiding expeditions, and resource-gathering voyages. On the west coast of Sakhalin, including the Crillon Peninsula, expeditions for hunting marine mammals, especially Steller's sea lions, to the islands of Moneron, Rebun, and Rishiri were important. For the inhabitants of Hokkaido and Sakhalin in various periods, including this one, access to the obsidian deposits of Hokkaido Island remained relevant. At the same time, there was a reciprocal interest of Hokkaido's inhabitants in the amber and bitumen of Sakhalin, which in the 2nd–1st millennia BC became objects of extraction and exchange operations across the area from the Tsugaru Strait to the Nutovo oil deposit in the extreme north of Sakhalin Island (Kato et al., 2008; Ogasawara, Kato, 2009; Deryugin, 2014; Ogasawara, Hara, 2022).

Of great interest is the amber exchange during the Paleometal Period between Sakhalin and Hokkaido. Firstly, because the movement in most cases must have followed the shortest route, through the Crillon Peninsula. Secondly, because two of the three currently known beaches where the sea constantly washes up amber (at Cape Kuznetsova and in Morzha Bay) are located not far from Cape Crillon. However, analytical chemistry methods have established that amber beads stored today in several museums on Hokkaido were made from raw material obtained from the beaches near the village of Starodubskoye (Ogasawara, Hara, 2022). This deposit is the most productive of the three, which probably explains its widespread distribution. In

addition, we note that years of excavation in the Kuznetsovo natural landmark area on the west coast of the Crillon Peninsula also yielded a collection of amber ornaments of a typical red colour from a Paleo-Ainu layer, radiocarbon-dated to between the 11th–5th centuries BC (Vasilevsky, 1995). This period corresponds to the chronology of the final Neolithic: the first phase of the Paleometal Period on Sakhalin and Hokkaido. The beach where the sea current brings a large amount of amber of a characteristic red colour is located directly next to the site studied by the author: the multilayered Kuznetsovo 1 campsite. The northernmost occurrences of Sakhalin amber exploited by ancient humans are associated with sites near Piltun Bay, while the southernmost points are linked to the Isikari River valley, closer to the southern part of Hokkaido Island. In terms of location, they coincide with the area of the Paleo-Ainu historical-cultural Jomon community in its final and post-stages across the wider region, in the range of the 11th century BC – 5th century AD, and with the Susuya culture of the 5th century BC – 5th century AD. The distance between the northernmost and southernmost points by azimuth is about 1200 km. The same applies to the routes along which not only amber was exchanged, but also Sakhalin bitumen, Hokkaido obsidian, and likely other, unknown to us, ancient goods.

The multilayered settlement of the Paleometal Period, the Medieval Period, and the Modern Era: the Kuznetsovo 1 settlement (11th century BC – 18th century AD)

One of the most indicative and studied sites of Paleo-Ainu culture on Sakhalin, including the Crillon Peninsula, is the settlement and necropolis from the Modern Era: the Kuznetsovo 1 settlement. This is a multilayered settlement located in the eponymous natural landmark, which has the Ainu name Soni and the Russian name Kuznetsovo, on the first marine terrace of the right bank of the Kuznetsovka River, directly above the breaker zone of the Sea of Japan. The cultural layer of the settlement, up to 3 m thick, consists of three major horizons, sequentially reflecting the life of the settlers of the Soni–Kuznetsovo natural landmark area over the last 3,000 years. One of the hearths from the lower layer of the Kuznetsovo 1 settlement is radiocarbon-dated to within the 11th–8th centuries BC (Vasilevsky, 1995). Finds from this layer belong to the final stage of the

northern variant of the Paleo-Ainu Jomon culture, the southern centre of which was located on Hokkaido Island, the north-eastern centre on the Kuril Islands, and the northern centre on Sakhalin. In the lower layer of the Kuznetsovo 1 settlement, flat-bottomed vessels typical of Hokkaido decorated with rope impressions 'jo' (Jap.: 'rope') were found, as well as pointed-bottom and round-bottom vessels known so far only on the Crillon Peninsula, with bodies fully decorated with cord impressions (Fig. 2.9). These finds directly indicate the mixing of cultural traditions, northern and southern, in the transition zone from Sakhalin to Hokkaido and emphasise the eclectic nature of the Crillon variant of the Paleo-Ainu culture of the 11th–5th centuries BC. The reason for this was the influence of the northern Nabilian paleometallic culture traditions, which spread to most of Sakhalin Island in the 11th–5th centuries BC and had a decisive impact on the local Paleo-Ainu cultures of the island at that time (Pashentsev, 2021).

During the transition from stone to metal, referred to in the scientific literature as the period of ancient (paleo) metal, the Crillon Peninsula became the area of the most intensive mixing of the indigenous population of the islands, Paleo-Ainu and carriers of the Nabil archaeological culture, natives of Transbaikalia and Southern Yakutia. Kuznetsovo 1 is an emblematic site, the materials of which illustrate the processes of counter-influence and mixing of northern Paleo-Asian and southern Paleo-Ainu Paleometal cultures.

The upper cultural layers of the Kuznetsovo 1 settlement date back to the Middle Ages and contain materials that make it possible to reconstruct the processes of settlement in southern Sakhalin by medieval migrants from the continent, the Mohe tribes.

Crillon Peninsula in the Medieval Period (7th–16th centuries). Crillon ancient settlement

A number of medieval works contain information about the country of Liuguei [liu:gui, lu:kuei], which, according to chroniclers, was located 'directly north-east... north of the North Sea'. 'People live scattered across the islands. The main occupations... are hunting and fishing. In summer they wore clothes sewn from fish skin, whereas in winter they used fur, and skins of dog, deer and pig. Neither vegetables, fruits, nor grain crops grew; people ate millet similar to chumiza. They did not know horses. There was no single ruler for the whole country. They had more than 10,000 troops. When invaders came to plunder, all were summoned. The bows are more than 4 chi long*, the arrows are similar to those in the Middle Kingdom (China), and the arrowheads are made of bone and stone' (Kurakiti, 1978; Wada, 1938; History..., 2008). In the 7th century, events occurred that determined the fate of Sakhalin and Hokkaido for a long time.

According to the 'Nihon shoki' chronicle, the famous naval commander Abe Hikita Omi Hiraifu in 658, 659, and 660 in the area of Watarijima (presumably Hokkaido), at the request of the Emishi, ancient Ainu, engaged in battle with foreign tribes three times. In 660 on the island of Hirabi in the Sea of Japan (probably today's Okushiri Island) he completely defeated them and took their fortress by storm. The events of the 7th century mark the beginning of the Middle Ages for the

* It is assumed that this is the chronicle name of the Sea of Okhotsk.

** Chi is an ancient Chinese measure of length equal to 32 centimetres.

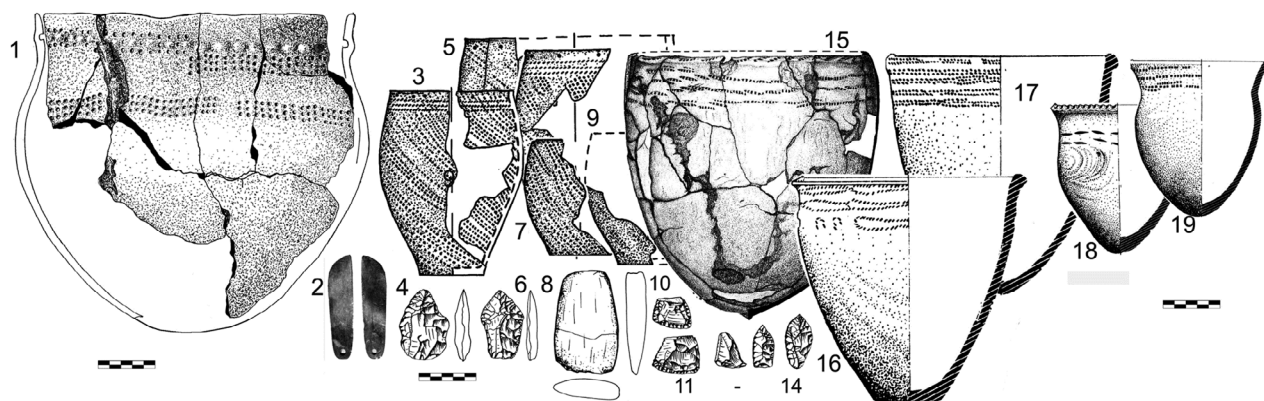


Fig. 2.9. Ceramics (1, 3, 5, 7, 9, 15–19) and stone tools (2, 4, 6, 8, 10–14) of archaeological cultures of the Paleometal Period (1st millennium BC). 1–2 — Piltun, 3–14 — Aniva (final Jomon), 15 — Nabil, 16–19 — Susu Paleometal culture

region, as a fundamentally new environment emerges on the islands, characterised by the active participation of island world tribes in global politics. Both the Hokkaido and Sakhalin tribes became active participants in wars, political relations and trade, finding themselves in the zone of interest of the states of Nihon, Bohai and Tang on the island arc from the mouth of the Amur to the Sangar Strait (Tsugaru). The expansion of new states has shaped new roles and realities in the system of relations.

In the 7th century, new migrants, the Mohe, arrived in eastern Hokkaido directly from the Amur regions via Sakhalin. Adapting to the new conditions, the Mohe took into account the experience of the conquered tribes and mastered maritime industries. As a result, their culture was modified. Archaeologists called it 'Okhotsk', taking into account the geographical factor, and considering the appearance of local variations in northern and southern Sakhalin, Hokkaido, and the Kuril Islands, these variations collectively became known as 'Okhotsk cultures'. The Mohe people of these cultures fought both among themselves and with the Proto-Ainu, as indicated by findings of skeletons with traces of wounds from arrows with stone and bone tips in the burials of Oomisaki and Moyoro on Hokkaido Island (Amano and Ono, 2006). Up to 60 % of the studied Okhotsk culture dwellings on Sakhalin bear traces of fires and destruction. Dwellings in the Okhotsk culture settlements of the 7th–10th centuries are pentagonal, larger than those of the Susuya culture, and have elongated proportions. All dwellings are oriented in the same direction, facing the prevailing sea winds in a particular area. The Okhotsk culture combines the traditional coastal economy of the island world with elements of productive agriculture brought from the continent: pig farming, dog breeding, poultry farming, and possibly horticulture (Watanabe et al., 2021). On Rebun Island, at the Kabukai A campsite, bones of domestic pigs as well as bones of wild Japanese and Mongolian boars were found. At the Ivanovka campsite on the western coast of the Crillon Peninsula, bones of domestic pigs are consistently found in the 7th–10th century strata together with bones of sea animals, numerous fish vertebrae, and mollusc shells. Many wooden figurines of pigs have also been found, emphasising their role in the Mohe economy.

In line with the general trend in archaeology toward the development of information systems, the diet of the Okhotsk culture population has been studied using isotopic analysis of collagen in the teeth and bones of medieval island inhabitants. In addition to pork, fish, and sea mammal meat, the diet of the 'Okhotsk

cultures' population included seafood and meat from forest animals, such as deer and bears, as well as herbs, tubers, and berries. An important aspect of the Okhotsk culture was barter trade in metal goods, weapons, textiles, furs, grains, and birds of prey, as documented in Japanese chronicles (Yoneda, 2006). Goods from the mainland spread to the islands in the 9th and 10th centuries AD. The earliest finds of parts of composite belts with plaques, military armament items, glass beads, etc., belong to this period. The most popular grains in trade were millet and barley. It was established that the Mohe people brought goods to Hokkaido from the mainland, while the Proto-Ainu brought goods from Honshu Island. Historiography has established that the strengthening of the Ainu component in the Okhotsk culture, and ultimately its decline, was due to the fact that the ancient Ainu had greater access to iron tools and trade than the tribes of the Okhotsk culture (Yamaura, 1983).

Ainu culture and the consolidation of the Proto-Ainu

In various sources, the Proto-Ainu of Sakhalin, Hokkaido, and the Kurils were referred to by several ethnonyms, including emishi, guwei, kuei, and kui. Their economy in the 7th–13th centuries was based on a combination of hoe farming, hunting, fishing, and gathering. They grew various cereals — millet, buckwheat, beans, hemp, and other crops. Blacksmiths made weapons, tools, and ornaments from iron and non-ferrous metals. Clothing was sewn from homespun cloth made from hemp, nettles, and animal wool. They lived in above-ground, four-sloped frame dwellings that contained fireplace-type furnaces and square hearths. In the 7th century, the northern and southern branches of the Proto-Ainu merged. The ideological basis for such consolidation could have been the concept of Ainumosiri: 'the land inhabited by the Ainu', commonly accepted in the Ainu oral tradition. However, the social structure of the Ainu did not develop beyond a tribal structure with a prominent role for tribal chiefs, whose power was hereditary. And the concept of Ainumosiri remained unrealised in both the early and late Middle Ages.

As mentioned above, from the 7th to 10th centuries, Sakhalin was dominated by the Mohe, migrants from the Amur region. They owned the island lands up to and including the 10th century. The migrants were ethnically heterogeneous. These were tribes displaced from the continental and coastal regions of East Asia to the islands, united in our time by one common conventional name, but different in their anthropological features. In

some groups, the Amur component prevailed; in others, anthropologists noted features of the Central Asian anthropological type. Living alongside the Proto-Ainu, the Mohe adopted from them features of economic organisation and elements of material and spiritual culture. Quite interesting in this sense is the Ivanovka 1 campsite (7th–10th centuries) on the Crillon Peninsula (Fig. 2.10). Among the large number of bone and wooden items are woodware with carved ornamentation directly resembling in style and form the Ainu *ikupasuy*, ritual sticks for supporting mustaches during sake drinking ceremonies, as well as wooden figurines of pigs, animals previously unknown on Sakhalin.

In the 10th–11th centuries, the Mohe on Sakhalin were replaced by the Proto-Nivkh, known under the ethnonym Jilemi, and the Proto-Ainu under the ethnonym Kuwei. Archaeological evidence of the Jilemi presence is found throughout Sakhalin, including on the Crillon Peninsula: dwellings with a characteristic hexagonal shape and pottery completely different from that of the Mohe appear in the cultural layers of the 11th–13th centuries. The Kuwei traditionally had square-shaped dwellings with small clay furnaces used for heating, cooking, and sometimes even blacksmithing. It is assumed that after the departure of the Mohe, the Crillon Peninsula became the first object of expansion by the Proto-Ainu, Kuwei, as early as the 10th century. Numerous small wooden forts testify to constant military clashes on the peninsula (Vasilevsky, 1996). The change of cultures is especially clearly recorded in the cultural layers of the Kuznetsovo 1 settlement, where the sequence of changes in the cultures of the Paleometal and Medieval Periods has been established.

In the Medieval Period, all major events on the mainland had, in one way or another, repercussions for the islanders, who were linked to the Amur-region tribes through trade relations. In the 10th–13th centuries, during the Song dynasty, products from the mainland, such as bronze composite belts, bells and mirrors, swords, wheel-made pottery, and other household items known to the Jurchens, became widespread on Sakhalin, Hokkaido, and the Kuril Islands (Kiruchi, 1976; Kiruchi, 2012).

The Jurchens on the Crillon Peninsula in the 13th century. Crillon ancient settlement

A new page in the medieval history of the island is connected with the military retinues of the Jurchens, Paleo-Nivkh (Jilemi, Iliyu, and Proto-Ainu Kuwei).



Fig. 2.10. Ritual items from the Ivanovka 1 campsite. The material is wood. Crillon Peninsula. Early Medieval Period. 7th–10th centuries (Nevelsk Museum of Local History)

After the troops of the Jurchen Jin state captured Bianliang (now Kaifeng), then the capital of China, in 1127, significant changes occurred in the international situation throughout eastern Asia, including in the Amur region and on Sakhalin. In the 12th century, the Jurchens founded three fortresses on the island: the military-agricultural settlements of Kalahoton, Neihoton, and Sirahoton, presumably the Black, Middle, and White (Yellow) Fortress, and several less important strongholds. This is confirmed by the partially studied Aleksandrovsk, Crillon, and Sedykh ancient settlements, as well as a series of small wooden forts. As mentioned above, ancient defensive structures, such as fortresses and small wooden forts, have been known for a long time on Sakhalin, Hokkaido and the Kuril Islands. They are distinguished by ramparts and moats, with legends and tales associated with them. As a rule, Russian old-timers nowadays attribute them to their predecessors, the Japanese. The Japanese, in turn, attributed some of

the structures to the Russians and some to the Ainu. In turn, the Ainu always clearly indicated which of the chasi were built by their ancestors, which by the tonchi, and which by other peoples. Archaeologists divide these defensive structures into those built by local peoples and those belonging to foreign conquerors.

The structures built by Sakhalin natives are usually small sites on mountain spurs or on steep sea headlands, protected on one or, more rarely, two sides by straight, or less commonly rounded, ramparts and moats. The small fortresses of local peoples are almost always accompanied by residential depressions. This indicates the long-term nature of medieval warfare, when people had to live permanently on high mountain precipices, behind fortress walls, to repel an attack at any moment. Their location in the region indicates that military conflicts occurred everywhere. But the fact that the greatest number of defensive structures were placed in contact zones between islands directly shows the main directions of expansion and expected adversaries. Such small fortresses usually belonged to a single tribe that gathered in them during wartime. Russian explorers of the 17th–18th centuries, during their advance to the Pacific Ocean and conquest of Siberian and Far Eastern tribes, encountered such fortifications everywhere. They called them *ostrozhki* (small wooden forts). The diminutive form indicated the imperfect design of these structures and their smaller size compared to Russian *ostrogi* (wooden fortress). More than 30 small wooden forts are known on Sakhalin and the Kuril Islands. Interestingly, they were mostly not adapted to repel large forces or withstand long sieges. Most likely, these fortifications were largely symbolic in nature, marking the residence of a chief with his retinue and a place for collecting tribute. The imperfection of fortification emphasises the lower level of military development among local tribes compared to the Jurchens and Mongols.

Foreign fortresses on Sakhalin, unlike these small wooden forts, were built according to all the rules of medieval eastern fortification. In Russian archaeology, such structures are called *gorodishcha* (ancient settlements). In addition to the Crillon fortress, several other settlements probably belonging to the Jurchen culture are known on Sakhalin: Aleksandrovsk, in the town of the same name, and Sedykh, on the lake of the same name, on Cape Atlasov. The Aleksandrovsk settlement was destroyed by construction in the growing city during the 20th century. Only descriptions and individual finds confirming the existence of this fortress have survived to our days. The remaining sites have yet to be studied.

The ancient settlement on Cape Crillon, although damaged by time, has been preserved quite well and is currently being studied by archaeologists. In Ainu it was called Toi-chasi, and in Japanese literature it has the names Gui and Shironushi (or Shiranushi). The Crillon ancient settlement is now a fortification consisting of ramparts up to 2 m high and surrounding moats up to 4 m wide and 1.5 m deep. The scale of the structure allows it to be called a fortress. Originally there were three ramparts, as the fourth, sea-facing side was protected by a cliff and either no rampart was built there or only a nominal one. An aerial view allows us to see fragments of a possible low barrier. The length of the three ramparts surrounding the ancient settlement site is 112–115 m. Thus, the area of the Crillon ancient settlement is almost 13,000 m². This is the largest artificial structure of the Medieval Period on Sakhalin Island. Today, two ramparts, the northern and southern, are well preserved. The eastern rampart was partially damaged and filled in along with the moat in the mid-20th century. In the middle part of each rampart, there are traces of gates, which in the early 20th century were about 5 m wide (Figures 2.11–2.13).

This implies a unified, highly developed fortification technology. The study of the Crillon ancient settlement showed that the fortress walls were built using the ‘*khantu*’ technology, characteristic of military architecture of that time but unknown to local peoples. The ‘*khantu*’ method in fortification is a way of building walls and ramparts in which layers of heterogeneous materials alternate, in this case loam, black soil, and mixed layers, compacted between the formwork made of fascines or logs. Walls built by this method are strong and durable, maintaining stability even after the formwork deteriorates. In addition, the walls, having a damping effect, were meant to absorb the blows of battering rams, and this principle was always part of the theory and practice of fortification in East Asian countries of that time. Even with the obvious absence of siege machines among the medieval population of the island, the engineers built the fortress conscientiously, according to the same principles as on the mainland. Earlier ramparts at other ancient settlements, including those at Lake Sedykh, were built without this consideration. The thoroughness with which the builders of the Crillon ancient settlement approached their task directly indicates their intentions to establish a foothold at this frontier. It must be remembered that the trendsetters in fortification in East Asia during the Medieval Period were Chinese engineers. Their knowledge and art were adopted by the fortifiers of the Jurchen states of Jin and Eastern Xia, who, in turn, built dozens of ancient settlements and redoubts in Primorye, the Amur region, and on Sakhalin.



Fig. 2.11. Bird's-eye view of the Crillon ancient settlement (*photo by P. Pashentsev*)



Fig. 2.12. A cross-section of the Crillon ancient settlement wall at the southeastern gate. View from the south



Fig. 2.13. A cross-section of the Crillon ancient settlement wall at the southeastern gate. View from the north

During the excavations of the Crillon ancient settlement, archaeologists were able to establish the stages of its construction. Having chosen the most suitable defensive site with a spring, the builders laid out the fortress on a plateau near the seashore in such a way that one side faced a cliff. Then they removed the turf around the perimeter of a square with a side of 115 m. The removed turf was used to lay the foundation of the future rampart. After that, judging by the location and shape of the layers in the cross-section of the rampart and moat, woven fascines were installed, a kind of formwork for the future structure. After filling the formwork with earth from the moat, the builders tamped it down, then built up the fascines, and the entire process was repeated about five times. In this way, a moat was dug, and a strong, high wall of tamped earth was built, forming a secure perimeter around the site.

The earthen wall was usually reinforced with wooden structures. The interior stairways allowed the fortress defenders to quickly climb the walls to repel an assault. On the exterior side, the rampart overhung the moat almost vertically. Because of this, enemies storming the fortress had to first descend to the bottom of the moat, and then climb up a five-metre height. But at the top, there was also a palisade, a fence made of sharpened logs. Under the protection of the palisade, the defenders shot at the enemy with bows. The fortress wall was added on, and archaeologists have revealed the backfilling of the rampart. It is clearly visible that the southern rampart is higher than the northern one.

In the excavations at the Crillon ancient settlement, archaeologists found wheel-made pottery typical of medieval Jurchen culture (Fig. 2.14), as well as a miniature fishing net weight and a whetstone characteristic of the Amur region peoples. The pottery found in the excavations at the ancient settlement is, without any doubt, of artisanal origin and manufactured according to a clearly defined standard. The fine sand admixture is well sorted, the vessels are made on a potter's wheel and fired evenly in a specialised kiln.

The pottery fragment is grey, uniform in thickness, surface treatment, colour, and clay composition. Judging by the fragments of different vessels found in the fortress, they had a distinct profile: an outward-flaring rim, a narrowed neck decorated with a thin, narrow, moulded arcaded clay ridge – a belt. The body is convex, and the bottom is flat. Most of the fragments bear traces of scraper work in the form of a grid-shaped impression, a typical feature of Jurchen ceramics (see Fig. 2.14). Interestingly, the same grid-shaped impression is also found on hand-moulded pottery discovered in the Poronai River delta area and at Lake Nevskoye (Middle

Sakhalin). Historically, this reticulated die inherits the grid-shaped (waffle) impressions of Amur Mohe pottery.

The ceramics from the Aleksandrovsk ancient settlement have a number of typological similarities and differences from the described ceramics from Crillon. What they have in common is the method of manufacture on the wheel, the high quality superior to all local samples, as well as the typical sorted impurity, and finally the use of a reticulated die. Imported ceramics, delivered via the trade route from the continent by the Jurchens and their vassals, the Jilemi, served as a model for the population of Sakhalin in the 12th–13th centuries.

We assume that the Aleksandrovsk and Sedykh ancient settlements were built earlier, and the Crillon ancient settlement later, respectively in the 11th–12th and 13th centuries. Research on the sites continues. All the above facts undeniably testify that at least two fortresses were built by the Jurchens in the early Medieval Period, but not later than the 13th century. Although archaeologists still face many questions, the research allows us to take a new look at the chronicles about the conquest of Sakhalin by foreign troops in the 13th century. The chronicles allow us to believe that the descriptions of Mongol punitive expeditions to protect Jilemi and punish Kuwei in the second half of the 13th and in the 14th centuries concern Sakhalin and the above-mentioned fortresses. This is described in more detail in books on the history of the island region (History ..., 2008; Vasilevsky, Potapova, 2017).

Late Medieval Period and Early Modern Era in the south of Sakhalin Island

In the historiography of the Ainu question, up until the last quarter of the 20th century, the entirely erroneous view prevailed that the Ainu appeared on Sakhalin relatively late, not before the 16th century. This opinion is most likely inspired by the great northern migration of the Ainu from Hokkaido under the pressure of Japanese colonisation, after the defeat of the anti-Japanese Ainu uprisings in the 15th–17th centuries. However, in fact, as early as the early 20th century, at least two researchers, Torii Ryuzo and Voldemar Jochelson, put forward the splendid idea of a wave-like northward movement of the Ainu (『千島アイヌ』吉川弘文館、1903年 – Ryuzo, 1903; Dikova, 1983; Vasilevsky, 2010). In fact, on Sakhalin, Hokkaido, the Kuril Islands, and Kamchatka, the Ainu, like their distant Neolithic ancestors in the Stone Age, Early Iron Age, and early Medieval Period, sought to extend northward the boundaries of their lands. This is primarily due to the

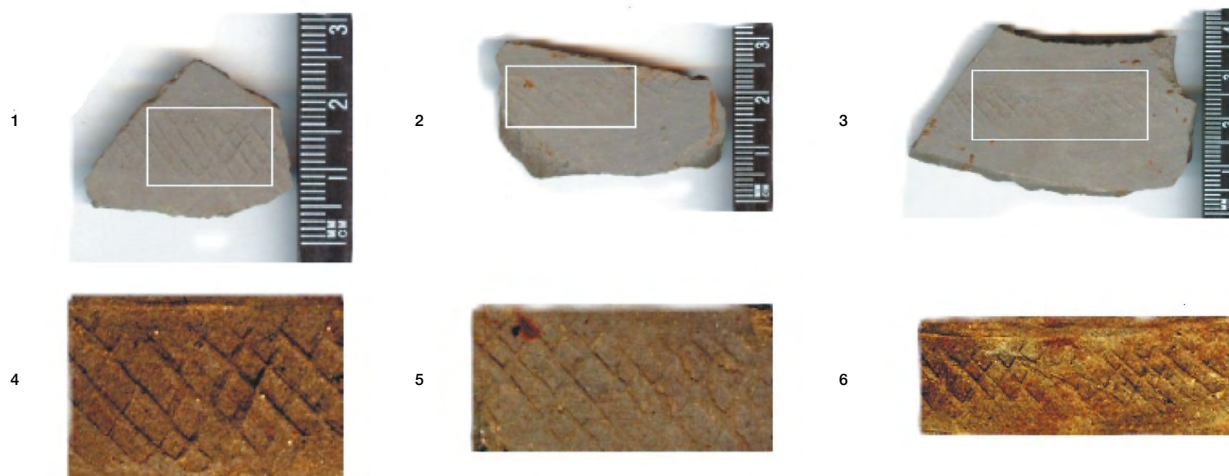


Fig. 2.14. Wheel-made ceramics of the Jurchens. Crillon ancient settlement. 1–3 — fragments of pottery; 4–6 — grid ornament on pottery

geographical factor. With pressure on the Ainu from other ethnic groups, abrupt climate changes, depletion of resources in their living areas, and the emergence of trading interest across the straits, the inhabitants of the island chains had no option but to migrate, either north or south. In other directions, the open sea awaited them. In this vein, the historical migrations of the Ainu and their ancestors at all times objectively saved them from destruction. The southern expansion of the Proto-Nivkhs—Jilemi, which took place on Sakhalin in the 11th–13th centuries, was most likely connected with the support of their advance to the south, first by the Jurchens, and then, in the 13th century, by the Mongols, as evidenced by historical chronicles. The construction of Sakhalin fortresses by the Jurchens and probably by the Mongols must have been directed against the Kuwei, the Proto-Ainu, who never submitted to the Mongol Yuan dynasty.

Within the framework of the Late Medieval Period, two stages are relatively clearly distinguished in the island region: the second half of the 13th century–14th century and 15th–16th centuries. The first stage is associated with the rise and fall of Mongol influence and the largest expansion of Ainu possessions in the history of the islands. In any case, when confronted with the Jurchen expansion, the extreme south of Sakhalin, the Tonino-Aniva Peninsula from Cape Rorey to Cape Aniva and the Crillon Peninsula from the Lyutoga River to Cape Crillon were areas of reverse movement of the Proto-Ainu population.

In the second period, in the 15th–16th centuries, the Ainu ethnos settled on a vast territory from the Amur River to the Ishikari River and from Saroma Lagoon in Hokkaido and from Kunashir Island to Nalychev Lake and Avacha Bay in Kamchatka. This period was associated with increased external influences on the peoples of the island region. In Hokkaido it manifested itself in the aggravation of Japanese-Ainu relations and a sharp strengthening of the positions of the new feudal clan Matsumae. At the turn of the 16th–17th centuries, the southern part of Hokkaido Island came under the jurisdiction of Japan. The Kakizaki clan successively received from the supreme rulers of Japan Toyotomi Hideyoshi and Shogun Tokugawa Ieyasu the name Matsumae, the princely titles ‘kami no shima’ (god of the island) and ‘kami no kuni’ (god of the principality, country) and credentials with ‘black’ and ‘red’ seals. At the same time, the peoples who inhabited Sakhalin, the Kuril Islands and the northern half of Hokkaido remained free. They were not subject to the authority of any state formations but also could not establish their own unified power; each tribe competed with its neighbours. However, the worsening situation in Hokkaido and the change of power in China had a great impact on the lives of the island peoples through interruptions in trade, changes in prices of goods, new trading partners, adversaries, etc. As a result, by the end of the Medieval Period, Sakhalin, Hokkaido and the Kuril Islands had the ethno-cultural environment that persisted here until the Japanese and Russians came to Sakhalin. The largest and strongest ethnic groups of the

region in the late Medieval Period were the Proto-Ainu: Kuwei, and their rivals and neighbours the Jilemi: Proto-Nivkhs. It is likely that other smaller ethnic groups also lived on Sakhalin and the Kurils and were absorbed by stronger ethnic groups by the Early Modern Era. Sakhalin, Hokkaido and the Kuril Islands were thus the site of active contacts between the peoples of the continent and the island world.

The Ainu culture passed through two major stages in its development: the Proto-Ainu ('Naiji'), covering the 13th–16th centuries, and the Neo-Ainu, considered within the framework of the 17th–19th centuries. In this case, we are interested in the first of these. Archaeologists have identified the following categories of sites of the Proto-Ainu Naiji culture, which spread across Hokkaido, Sakhalin, the Kuril Islands, and Kamchatka in the Late Medieval Period (13th–16th centuries): long-term settlements with dwelling remains; seasonal open-type coastal camps with temporary hearths; ground necropolises; and chasi — small forts with simple defensive structures. But the chasi is not only the chief's residence. It was also the site of political and religious ceremonies that reinforced the idea of unity and self-identification of societies scattered over a large area. The participation of island peoples in international trade during the Late Medieval Period gave them greater access to the cultural innovations of the advanced peoples of East Asia. Old traditions died out, became unnecessary. Essentially, pottery was degenerating. Self-made things disappeared from the household, they were replaced by handicrafts. Earthen furnaces, which appeared at a previous stage, as early as the 7th century, became widespread. There was a significant convergence of material and spiritual culture of the peoples of the region and the process of losing national features in many spheres of their life began.

The most vivid idea of the material and spiritual culture of the Ainu can be obtained from the Ainu ground necropolises. On Sakhalin, only necropolises of modern and contemporary times have so far been identified, dated by coins to no earlier than the 17th–18th centuries. Analysis of these necropolises in the landscape shows that they were located in an upland area near the sea to the north or west of the settlement. There are several sites within the Crillon Peninsula where finds of bronze items, as well as swords and smoking pipes, directly indicate burials of the Ainu people of the 17th–19th centuries. According to the most ancient rite, the deceased was laid on his side in a crouching ('embryonic') position, and in the Modern Era, on his back and covered with a wooden lid decorated with carvings and wooden figures. The depth of burial is minimal, about half a metre. Typical

inventory of these burials are single-bladed swords wrapped in birch bark with a bronze guard and in wooden scabbards, as well as narrow-bladed knives, beads of blue and yellow glass, compound bronze smoking pipes with a miniature cup for opium or tobacco, a pouch made of nettle fibers, silver temple rings with bead finials.

Based on the poor and rich burials in the necropolises, Ainu society was stratified during the Medieval Period. This is confirmed by both ethnographic data and historical documents. Each area where tribesmen lived was ruled by princes, *nispa*. They held trials of criminals, and in case of war they commanded combined detachments from several villages. They also received the lion's share of the spoils of war and of the tribute collected by the retinue. The role of the prince varied depending on the political situation, strengthening in wartime and weakening in peacetime. But, judging by ethnographic data, the prince's decisions were binding on his fellow tribesmen. At the same time, the power of the Ainu *nispa* was limited by the opinion of society, the main institution of clan democracy.

In the 20th century, under the leadership of V. Golubev and the present author, a valuable site of the Ainu culture of the Modern Era was studied in the Soni–Kuznetsovo area: a necropolis located within the medieval cultural layer of the multilayered Kuznetsovo 1 settlement. The finds (white metal temple rings, bronze jewelry, swords with guards, smoking pipes, knives, glass beads and tools for casting non-ferrous metals) make it possible to reconstruct the life of the Ainu settlement of Soni, which was located along a trade route known to the Japanese of the time as the Santan trade, running from northern China along the Amur River, through a trading post at Cape Maydelya and Cape Crillon, to the Matsumae domain in southern Hokkaido. As has been established, part of these goods remained in the Soni settlement and, according to the results of the excavations, is now housed in the collections of the Educational Archaeological Museum of Sakhalin State University.

The most valuable information obtained from the materials of the Kuznetsovo necropolis relates directly to the anthropological characteristics of the Ainu population of the Crillon Peninsula in the Modern Era, in the 17th–18th centuries (Vasilevsky et al., 2024). Anthropologists have described artefacts and reconstructed the physical appearance of the settlement's inhabitants, who probably lived in the small community of Soni. It turned out that relatives were buried in the necropolis. The peculiarity of this group is also revealed, which is relative shortness of the



Fig. 2.15. Reconstruction of the appearance of a man whose remains were found in burial No 4 of the Ainu Kuznetsovo 1 necropolis, excavation 1982. Reconstruction by R. Galeev, Center for Physical Anthropology, IEA RAS (after: Vasilevsky et al., 2024)

population living in the area in the 17th–18th centuries. Sculptural reconstruction of the face of an Ainu man was made by R. Galeev according to the method of M. Gerasimov (Fig. 2.15).

In all three cases of swords found at the site, they are very inexpensive pieces, with blades no longer than 60 cm, all assembled from inexpensive parts. It is noteworthy that one sword is an artisanal palash, and two others are katanas, obviously made in Japan, with narrow and weakly curved blades. The holes for connecting rods on the shanks are of early, conical shape, which allows us to attribute them to the 18th century. All metal jewelry from the Kuznetsovo necropolis is made of low-quality alloys of silver with zinc and lead. The lacquerware found in a half-destroyed state in the burials are the so-called lacquer bento boxes and sake drinking bowls, which were sold to the Ainu by two well-known lacquerware companies in Japan, Mimidarai and Hokkai. Lacquerware first arrived on South Sakhalin in the 18th century, which can be explained by the well-known large-scale northward migration of the Ainu. In the north of Sakhalin and on the Amur, lacquerware from Japan appears with the development of the Santan trade with the Manchus. Another observation is that weapons and guards, expensive durable objects, form a group of family heirlooms of the 18th century within the necropolis.

According to the diary of Cornelius Kuhn, the navigator of the Dutch expedition of Maarten Gerritsen Vries to Sakhalin, the Ainu in 1643 already used tobacco and had ‘copper pipes’ (On the 350th anniversary of the Dutch expedition ..., 1993). Smoking pipes from the Kuznetsovo necropolis are typologically referred to as the so-called long pipes (Fig. 2.16).

These are items of personal use, and an individual could possess up to a dozen of them during a lifetime. They most accurately date the necropolis to the 17th–18th centuries. The presence of a clay pipe may rather indicate not antiquity but poverty of the deceased. The inventory in the burials shows that there were no major differences in the set of things, but it is difficult to call the Ainu from the Soni area rich, judging by the finds in the necropolis (Vasilevsky et al., 2024). It is widely known that the 18th century, the middle of the Edo era, the reign of the House of Tokugawa, was not a good time in Japan. Indeed, a chain of catastrophic events befell the country during this period. The Ainu have always been characterised by large stature and greater body mass, but in this case anthropologists noted the following body length figures: 151.4, 156.4 and 162.9 cm for males and 148.1, 149.6 and 150.2 cm for females (Vasilevsky et al., 2024, p. 123). This, as well as other signs, may indicate not only insufficient nutrition but also the mixing of

this Crillon group of relatives with representatives of other peoples who were not distinguished by tall stature.

This archaeological and anthropological collection from the Crillon Peninsula is of great scientific importance as it preserves and objectively documents a complex period in the life of the Ainu population of the islands, including the Crillon Peninsula described in the book.



Accumulation of fragments of a medieval ceramic vessel in a cultural layer. Shore of Aniva Bay, Solov'yovka 5 settlement
(photo by P. Pashentsev)



Fig. 2.16. Artefacts from the excavations of the Modern Era Kuznetsovo 1 necropolis. Crillon Peninsula. Ainu culture. 17th–18th centuries. 1–3 — smoking pipes (bronze); 4, 5 — temple rings (silver); 6, 7 — sword guards (bronze). Note: guard No 6 is made from a copy of a mirror from the Muromachi era (1333–1582) (*Educational Archaeological Museum, Department of Russian and General History, Sakhalin State University*)

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3 MODERN HISTORY OF THE EASTERN PART OF THE CRILLON PENINSULA

I. SAMARIN

Pobeda Museum and Memorial Complex, Yuzhno-Sakhalinsk

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The eastern part of the Crillon Peninsula (from the Uryum River valley in the north to Cape Crillon in the south) has a unique history of its development due to its location: on one side, close to, and on the other, somewhat distant from the island's largest settlements, as well as due to its being 'sandwiched' between the Yuzhno-Kamyshovy Ridge and the waters of Aniva Bay. An important role in the region's history from the mid-19th to mid-20th century was played by its geographical features, as well as its proximity to Japan, which is separated from Sakhalin by the La Pérouse Strait (43 km). A distinctive feature of the landscape in this area is the narrow coastal strip, no more than a few dozen metres wide, interrupted by the valleys of several rivers, the largest being the Uryum, Tambovka, Ulyanovka, Kura, Naicha, Moguchi, Anastasia and Petrovka. The river valleys defined the network of temporary fishing sites that existed here before the Russo-Japanese War of 1904–1905, and subsequently the settlements with permanent civilian populations that emerged during the Karafuto Prefecture period (1905–1945). The residential and economic structure of this coastline, which had formed in the first half of the 20th century, remained intact in the early post-war period and was eliminated in the early 1960s.

East Crillon in the 19th – early 20th centuries

The first Russian to visit the south-east coast of Crillon was Lieutenant Nikolay Rudanovsky, a member of the Amur Expedition. He also gave the first Russian name on this coast. On January 14, 1854, he skied from the Shiranushi village (mouth of the Crillon stream) in the southwest of the peninsula to Aniva Bay. He ran out of food, so he named the first cape he had to bypass through the mountains Golodny ('hungry') (Rudanovsky, 2003, p. 150). This is now Cape Anastasia.

The next point he marked on the 'Map of the Southern Part of Sakhalin Island' was Cape Vennochi ('bad'). This is what the Ainu called Cape Kanabeevka. Today, it may be difficult to imagine, but the most populated and settled place on this coast was the now-defunct village of Tiyatomari (Riyatomari), located at the mouth of the Svatovka River (Fig. 3.1).

Following the establishment of penal colonies on Sakhalin and the gradual settlement of the shores of Aniva Bay, the development of Japanese and Russian fishing sites and the construction of a lighthouse on Cape Crillon (1883), the toponymic picture on the

south-east coast of the peninsula began to resemble a bizarre mosaic of Ainu, Japanese and Russian names. The second Russian name on this shore is Vodopadny cliff or cape, marked on the maps of 1870 and 1885 (see Fig. 3.1) in the area between the Tambovka and Ulyanovka rivers. Everyone who has visited these places knows that streams flow from clay cliffs here, cutting through bizarre canyons and forming small picturesque waterfalls. The author of this Russian toponym was probably Innokenty Lopatin, a mining engineer, who was the first to cross the peninsula along the valleys of the Gorbusha and Naicha rivers in September 1867.

The description of the walking journey to Cape Crillon, made in 1899 by Nikolay Kirilov, a doctor at the Korsakov prison infirmary, is indicative: '... the Uryum river (even with a small rise in water no longer fordable; one must go upstream about 5 verst^{*}). Only one verst from here is a spacious shore, and then a cliff approaches the sea, leaving a narrow path, 8 versts long, all the way to the Krestyanskie Rivers; there are two of them at a distance of 100 sazhen^{**}; the second, the southern one (Ainu name is Pistoro), is impassable by fording, one has to wait for the water to recede, because the rock from the south does not make it possible to turn towards the sea, even if one crosses the river at its upper reaches. The cliff, stretching to the next river for 9 versts, leaves a dry strip of shore only at the lowest water; therefore, in case of even a minor storm, one has to escape into the ravines along the way and wait out the weather; there are no less than 10 such crevices under this cliff; however, approaching the Malaya Maksimkina River, the road becomes more comfortable a verst away. One verst away, the Bolshaya Maksimkina River flows in; during high water it is dangerous to ford, while bypassing it upstream across a meadow overgrown with dense reeds (reaching human height) is difficult (and in places risky, for fear of encountering a bear). Then after 4 versts of relatively quiet road – the Tomari-onai River (one waits during high water); after 7 versts a small cliff (one and a half versts) with a stony base; after 4 more versts the Buchi River (small), after 1 verst the Rio-Tomari River (small); after 4 versts the Nayachi River (impassable in high water); after 6 versts the Moguchi River (also impassable during high water); after 2 versts the Kanabeevsky cliff, which must be bypassed through two gorges across a small ridge (the bypass line is 2 versts; it's only three-quarters of a verst to swim under the cliff). Further, there is a stony road for 5 versts; then a three-verst sandy path leads to the Two Brothers River

* Old Russian measure of distance equal to 1066.8 m.

** Old Russian measure of distance equal to 2.13 m.

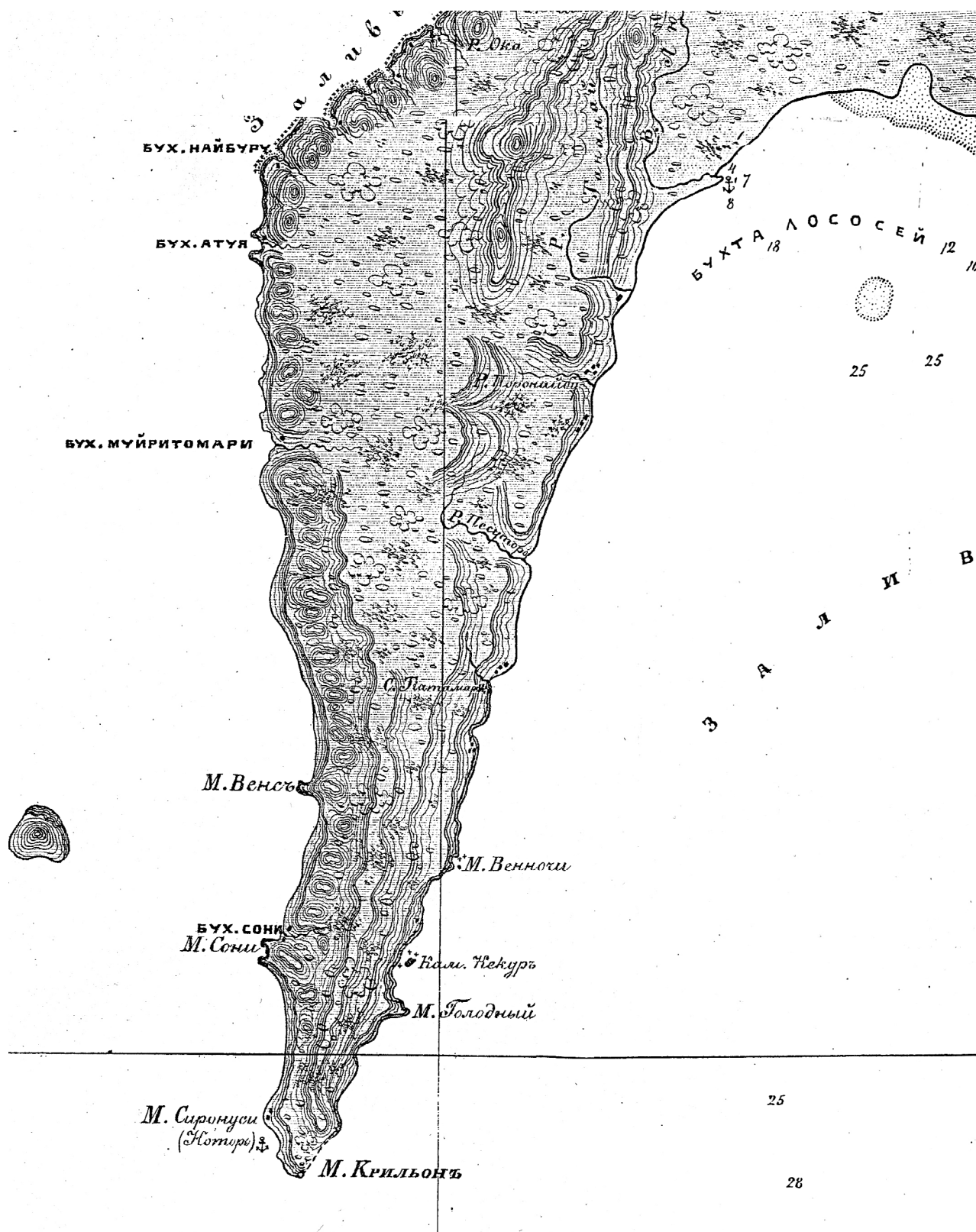


Fig. 3.1. Fragment of the 'Map of the Southern part of Sakhalin Island, from Cape Crillon to the parallel of Orokes Bay. Compiled based on the research of Lieutenant Rudanovsky and Second Lieutenant Orlov in 1853, 1854 and 1857'

(they do not ford during high water, but wait); from here 18 versts of stony road to the Crillon lighthouse' (Kirilov, 1899, pp. 144–145).

Such detailed descriptions and distances allow people to navigate quite freely through often unfamiliar names. The Krestyanskies rivers are the Malaya and Bolshaya Tambovka rivers; the Malaya Maksimkina is still called the Maksimkina River, but the Bolshaya Maksimkina is now the Ulyanovka River. Tomari-onai, located 4 versts (about 6 km) away, is the Kura River. Buchi, most likely Medvedevka, then the Svatovka River (RioTomari) and the names Nayachi and Moguchi are very similar to the modern ones (Naicha and Moguchi rivers). Kanabeev cliff can still be found on modern maps (spelled as both Cape Kanabeev and Cape Kanabeevka), and the Two Brothers River is now called Anastasia River, near the mouth of which stand two rocks.

The origin of the names of the Krestyanskies (Peasant) Rivers is difficult to determine. It can only be assumed that former convicts who had been exiled to the area and given fishing sites lived here. The names of the Maksimkina rivers are probably also associated with this episode of coastal history. The following table of fishing sites (Table 3.1) dates back to 1901 and was compiled by the ichthyologist P. Schmidt (Schmidt, 1905, pp. 267–268; Report ... for 1901) (Fig. 3.2). Table 3.1 uses modern geographical names for ease of perception.

There were different people among the Russian owners of fishing sites, and their goals were different too. Yegor Sukonnikov, a peasant and former exile from the settlement of Vtoraya Pad, and Mitrofan Nikonenko, a peasant from the Korsakov post, rented plots every year, but apparently the Sakhalin Administration put obstacles in their way when issuing licences, and they gave the catch from some plots 'to the treasury'. Thus, for state needs, Sukonnikov operated a fishery on the Uryum and Nikonenko on the Tambovka. Marfa Verisova, a settler from the Korsakovsky post, and Grigory Palgovsky, the keeper of the Korsakovsky lighthouse, were front men who took licences in their own names and resold them to the Japanese. It should be noted that this 'business' was widespread on South Sakhalin, and even people of 'noble origin' were not squeamish about it. For example, Maria, the wife of Lt. Col. I. Artsishevsky, the chief of the Korsakov local guard, also took a plot in her name and rented it out (Pozdneev, 1909, p. 407). Gavriil Kramarenko, a burgher from Astrakhan, started on Sakhalin as an overseer of fisheries and turned into one of the richest fishermen of the Far East.

Notably, Russian settlers only fished on their grounds, while Japanese industrialists used their catch more for making kasu (Japanese: 粕), pressed fish scrap, entirely exported to Central Japan. Despite the widespread belief that kasu was used to fertilise rice fields, it was actually used to fertilise fields planted

Table 3.1. Fishing sites of the west coast of Aniva Bay, according to data for 1901 (from Schmidt, 1905)

Ground name	Number of cauldrons	Number of workers	Establishment year	Pink salmon catch, kg	Fish scrap production, kg	Owner
Uryum	1	15	1891	12,800		Yegor Sukonnikov
Zlodeyka			1892	10,160		Yegor Sukonnikov
Tambovka		12	1894	6,400		Mitrofan Nikonenko
Ulyanovka			1895	7,400		Mitrofan Nikonenko
Kura			1895	2,270		Mitrofan Nikonenko
Kolkhoznaya	8	30	1899		81,520	Marfa Verisova
Untitled	10	50	1891		31,200	Japanese
Medvedevka	8	35	1895		43,000	Gavriil Kramarenko
Svatovka	8	35	1890	4,280	35,400	Gavriil Kramarenko
Naicha	8	30	1889	9,000	59,500	Japanese
Moguchi	5	10	1897	1,600	32,000	Kichita Ugiyama
Kanabeevka	10	15	1897	3,600	3,400	Kichita Ugiyama
Atlasovo	8	25	1896	6,000	26,700	Japanese
Atlasovka	9	30	1889		78,000	Japanese
Petrovka	1	15	1893			Irsha
Jacomini			1899	2,880		Marfa Verisova
Crillon	6	30	1898	15,200	65,300	Grigory Palgovsky

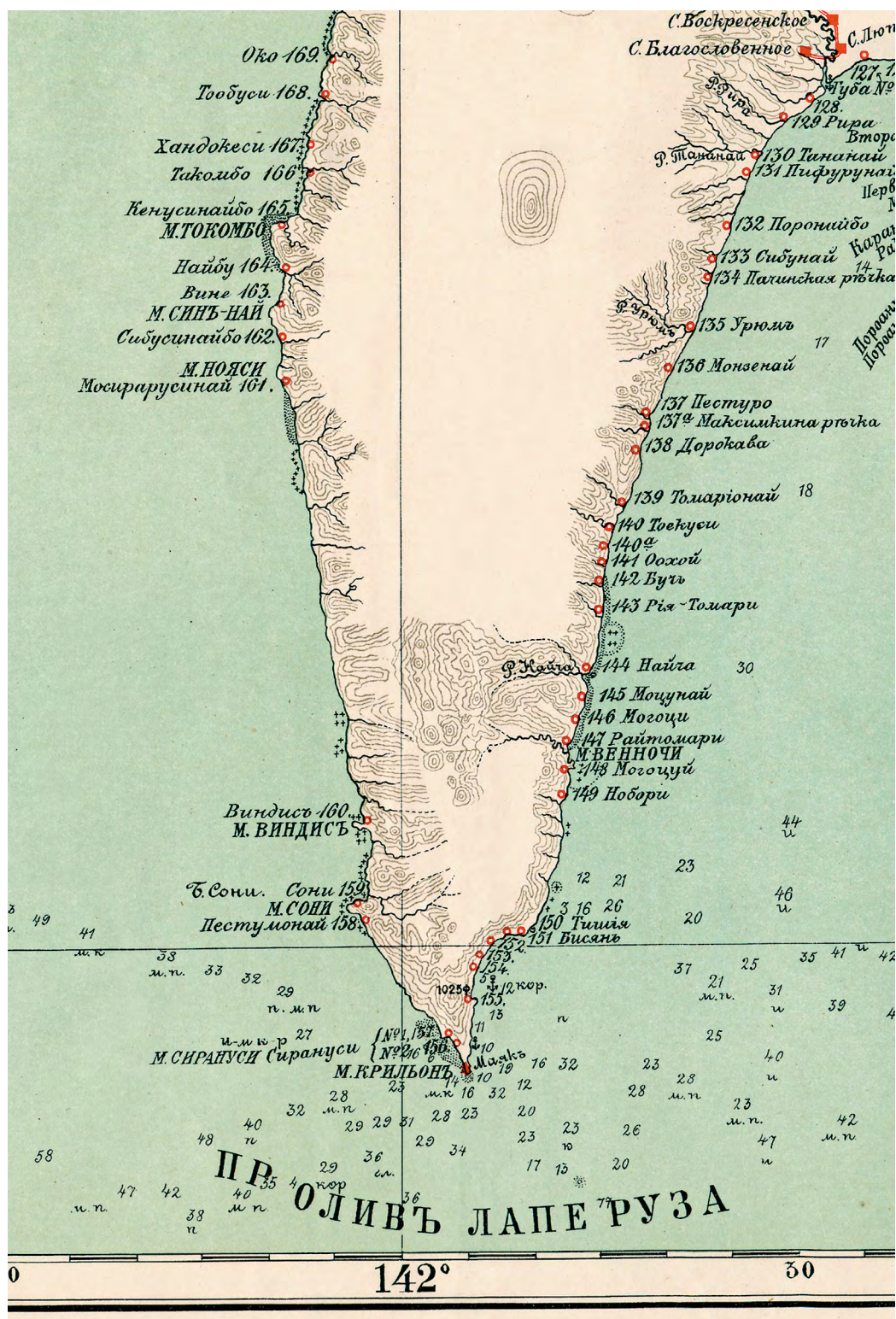


Fig. 3.2. Fragment of the 'Map of Marine Fisheries of Southern Sakhalin'. To the book 'Marine Fisheries of Sakhalin Island' by P. Schmidt. Compiled based on the map of the Main Hydrographic Administration of the Ministry of Agriculture and State Property and other sources. 1905' (Schmidt, 1905)

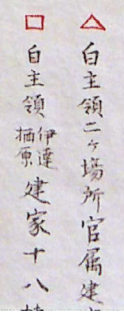


Fig. 3.3. Fragment of the map of South Sakhalin, 1857 (*Hokkaido University Library*)

with indigo, a plant used to produce the colouring material of the same name.

The Japanese settled on the east coast of Crillon quite early (Fig. 3.3). In 1809, the founders of the large fishing company Suhara (Japanese: 須原), Kakube Nobuyoshi and Date Rinenmon, established fishing sites on the Naicha, Svatovka and Uryum rivers, which existed here until the Treaty of Saint Petersburg on April 25 (May 7) 1875, when Sakhalin was ceded to Russia (Pozdnev, 1909, pp. 138–142). The Japanese then began to obtain fishing sites at annual auctions, catching mainly *Clupea pallasii*, or *nissin* (Japanese 鯵), Pacific herring that came in large numbers to the shores of Aniva Bay in spring to spawn.

The Japanese caught herring with seines near the shore directly from rowing boats, and the fish were brought ashore in special wooden boxes called *moko* that were worn on the back. There were so many herring piled up in the sheds that the lower layers were inevitably crushed (Fig. 3.4). Therefore, women and children continuously selected fresh and uncrushed fish that was the only kind used for salting. All the rest of the unfit herring, from which only roe and milt were extracted, went into *nisshin kama* (Japanese: 鯵釜) cauldrons. Stone, and later concrete, ovens with embedded cauldrons were built right on the shore. Cauldrons had various shapes, the most common one was *kabuto gata kama* (Japanese 兜釜), a helmet-shaped cauldron. Each cauldron was loaded with exactly 1,000 herrings, no more and no less. The herring was boiled in cauldrons for several hours to a mushy state, then was transferred to the nearby wooden presses called *shime dou* (Jap. 角胴) with special nets (Fig. 3.5). There, the mass was pressed in square presses by means of a long lever lowered



Fig. 3.4. Shed for caught herring (Schmidt, 1905)



Fig. 3.5. *Shime dou* presses and herring cauldrons (Schmidt, 1905)

using a hand-operated winch. Fish oil *abura* (Japanese 油) flowed into trays placed under the press. The dehydrated square-shaped flat pad was then knocked out of the press and laid out on a special, well-tamped and clean area for drying. The slightly dried mass was cut into small pieces using special two-handed knives called *kasu kiri hocho* (Japanese: 粕切り包丁), after which it was continuously stirred with wooden paddles *eburi* (Japanese: えぶり) for better drying. After this, the dried fish scrap was packed in jute bags, and it was ready for shipment.

East Crillon in the Karafuto Prefecture period (1905–1945)

During the Karafuto Prefecture period (樺太廳), from 1905 to 1945, this area was part of the Rutaka District (*gun*, Jap. 郡; Rutaka, Jap. 留多加, present-day Aniva) and included two *mura* townships («villages», Jap. 村), roughly comparable to Russian rural councils (Fig. 3.6). Initially, the southern part of the coast belonged to Notoro *mura* township (Japanese 能取村), including the villages of Tishia (Jap. 知谷多, later Atlasovo), Naisha (Jap. ナイシャ, Khvostovo) and Furue (Jap. フルエ, Krestyanovka). Further north was the Sango *mura* township (Jap. サンゴ村) with the villages of Uryu/Uryuu (Jap. ウリユウ, later Kirilovo/Kirillovo), Horonaiho (Jap. 幌内, Olkhovatka) and Tarannay (Jap. 多蘭内, now Taranay). Subsequently, from April 1925, Notoro *mura* township included villages south of Uryu settlement, where the township administration was located (Fig. 3.7). The township's name comes from Cape Crillon, labeled on Japanese maps as Nishinotoro-misaki (Cape West Notoro, Jap. 西能登呂岬).

The population growth dynamics of this section of coastline, not the most developed area of either Aniva Bay or the entire Karafuto Prefecture, are quite revealing. According to the 1920 general census of the Japanese Empire, Furue was the largest village at that time. It contained 97 households with a population of 726 people.

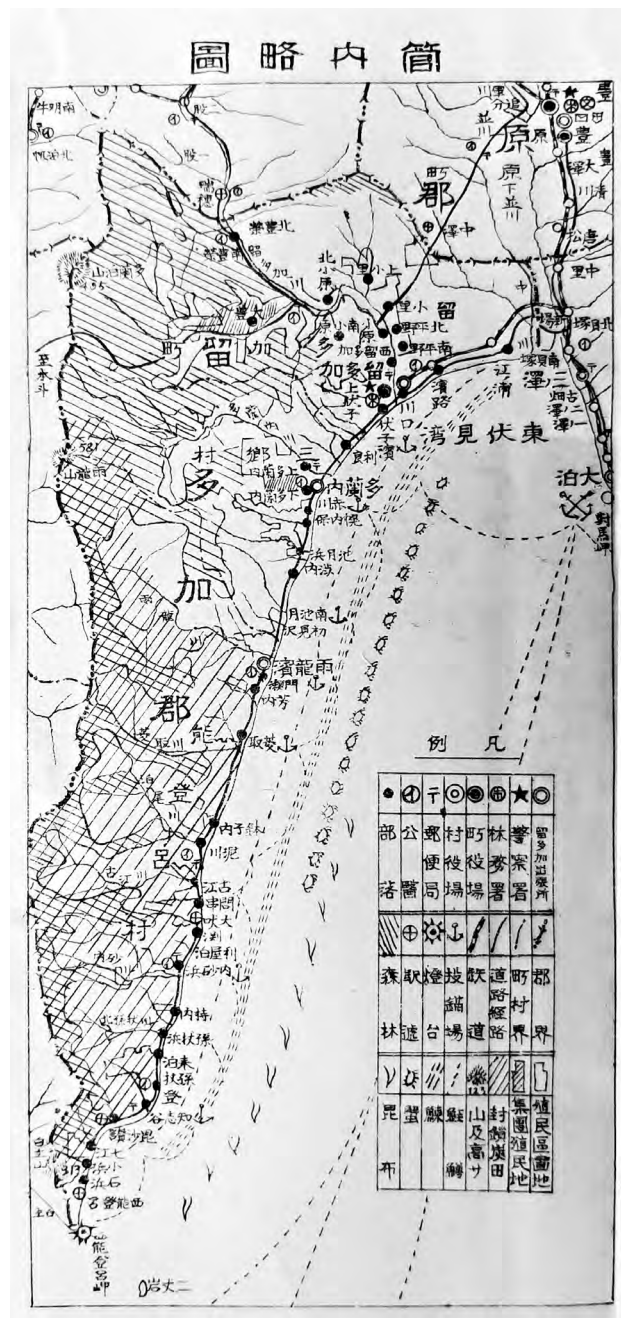


Fig. 3.6. Plan of Rutaka District. 1920s (Kannai yoran, 1935)

The next largest village was Naisha with 79 households and 382 people, followed by Tishia with 56 households and 356 people. Uryu village contained 64 households and 247 people (Census..., 2017, p. 94). Notably, the population was ethnically homogeneous at that time, with only seven Koreans living in Furue village. As of the end of December 1928, Notoro mura township had 769 households and 3,353 residents (1,933 men and 1,420 women) (Kannai yoran, 1929, p. 2).

A distinctive indicator of population growth in this township is the chronology of elementary school construction: in 1912 a school was built in Uryu (Kirillovo), in 1915 – in Naisha (Khvostovo), in 1917 – at the mouth of the Ulyanovka River, in 1922 – on the Kura River, in 1923 – on the Medvedevka River, in 1924 – on the Tambovka River



Fig. 3.7. Fragment of the map 'Karafuto Cho (Karafuto Prefecture), 2nd year of the Showa era' (1927)



Fig. 3.8. The Futatsu Iwa rocks ('Two Rocks'; now Twins) on Cape Tishia. There is a Shinto temple on the rock. Japanese postcard, 1920s

and in 1925 – on the Atlasovka River (Nishimura, 1996, pp. 268–277).

By 1929, the township had nine schools (six general public elementary schools and three elementary schools with expanded curricula), attended by 603 students (Kannai yoran, 1929, p. 2).

Employment in villages located in areas with wide valleys (Naisha, Furue) was equally divided between agriculture and fishing. The vast majority of residents in the village of Tishia, where such valleys did not exist, were engaged in fishing. Overall, the agricultural land area of the Noto mura township in 1929 totaled only 676 hectares (Kannai yoran, 1929, p. 4). In 1935, there were 600 developed agricultural plots, with areas available for settlers to develop an additional 1,039 plots (Kannai yoran, 1935, p. 54).

In 1935, the township's population owned 28 cows, 213 pigs, 262 horses, and 2,500 poultry. Some residents engaged in fur farming, with a small fox farm housing 14 foxes (Kannai yoran, 1935, p. 59).

A negligible portion of the township's population was employed in the mining industry. Gold, silver, copper and iron ore were mined here. For example, in the village of Naisha, Kishida Ryosuke company (Jap. 岸田涼介) from Akita Prefecture (Jap. 秋田県, Honshu Island) was active with a claimed mining allotment of 964,314 *tsubo* (Jap. 坪, 1 *tsubo* is about 3.3 m²), and Otsuchi Yuichi (Jap. 大槌雄一) from Otaru (Jap. 小樽市) on Hokkaido worked an allotment of 1,000,000 *tsubo* in the village of Tishia (Kannai yoran, 1929, p. 5).

The results of these operations are unknown. In 1935, high-quality coal deposits were discovered south of the Uryum River valley, but no data on their development is available.

Fishing played the primary role in the lives of the Japanese population along the south-east coast of the Crillon Peninsula during the Karafuto period. The herring industry stimulated life in what is now an uninhabited corner of South Sakhalin. Until 1932, Aniva Bay was the main herring fishing area. In 1931, 74 % of Sakhalin's total herring catch came from here. Fishing camps were scattered along the entire coastline, boats darted about, fish scrap boiled in large cast-iron cauldrons, oil was pressed out with wooden presses, and the resulting mass was immediately dried on special platforms. Now only cracked cauldrons and several *fuku roma* (Jap. 袋溜, 'sea pocket'), the Japanese term for shelters for fishing boats built into the rocky shore, remain from those busy days (Samarin, Shubina, 1997, p. 47).

Anticipating continued catches, the Japanese rapidly developed the necessary infrastructure. In 1934, a major concrete port haven project was launched in the village of Tishia (Fig. 3.8), as well as building a canning factory and widening the road laid by Japanese engineers back in 1906–1907 and running along the coastal slopes. In November 1933, a concrete bridge was built over the Kura River and another one was built over the Ulyanovka River in 1936 (Samarin, 2010, p. 231; 30 Years ..., 1936). Other rivers in the township, including large ones like the Uryum and Naicha, had wooden bridges (Fig. 3.9). As of 1935, the road surface up to Furue (Krestyanovka) settlement allowed cars to travel (Kannai yoran, 1935, p. 46).

Since 1933, Aniva Bay has no longer been the major spot for fishing on Sakhalin. Maximum catches in 1944 were only 42–45 % relative to 1931. The population mainly survived on small herring, while



Fig. 3.9. Naisha settlement
(mouth of the
Naicha River). Photo
from the 1930s

scallop fishing also began to develop. In general, it can be stated that the range of fish, invertebrates and processed products produced by the population of the Notoro mura township was quite representative (according to: Suisanbutsu kensa gaiyo, 1942):

- | | |
|----------------------------------|-----------------------|
| 1. Herring meal. | 17. Cod eggs. |
| 2. Fully dried herring. | 18. Flounder. |
| 3. Half-dried herring. | 19. Walleye pollock. |
| 4. Raw herring. | 20. Shark. |
| 5. Dried herring with bones. | 21. Capelin meal. |
| 6. Herring milt. | 22. Smelt meal. |
| 7. Herring eggs. | 23. Dried smelt. |
| 8. Herring for fertilisers. | 24. Greenling. |
| 9. Cherry salmon. | 25. Sea goby. |
| 10. Cherry salmon roe. | 26. Crab shell. |
| 11. Pink salmon. | 27. Dried skate. |
| 12. Pink salmon egg roe. | 28. Shrimp shell. |
| 13. Headed cod. | 29. Sea urchin shell. |
| 14. Headless cod. | 30. Cucumaria. |
| 15. Frozen headless cod carcass. | 31. Starfish meal. |
| 16. Cod liver oil. | 32. Cuttlefish. |
| | 33. Holothuria. |

Besides, as early as 1929, there were canning factories owned by the Tsuji Company (Jap. 辻) in Ohoe (Jap. 辻, later Medvedevka) and the Karafuto Sangyo Company (Jap. 樺太産業) in Nobori (Jap. 登), later

Kalinovka). (Kannai yoran, 1929, p. 5). Unfortunately, no documents about the products produced by these factories remain available.

The ups and downs in the economic life of the south-east coast are clearly reflected in the changing population of the Notoro township. Table 3.2 shows data on the total population of four settlements, consisting of several small farms and fishing villages in addition to the main settlement. Thus, the Uryuu settlement included villages located in the area from the Uryum River to the Tambovka River, Furue (from the Ulyanovka River to the Svatovka River), Naisha (from the Naicha River to the Moguchi River), Tishia (from the Kalinovka natural landmark to Cape Crillon).

Table 3.2. Population dynamics of the Notoro township
(Kannai yoran, 1935)

Village	1921	1925	1930	1935
Uryuu	242	1,546	1,201	1,115
Furue	726	1,865	1,180	1,136
Naisha	386	1,723	752	861
Tishia	356	622	840	1,055
Total:	1,672	5,756	3,973	4,167

Public services and social infrastructure in the Notoro township was quite developed. The supply of goods to people took place mainly during the navigation period, from April to December. Trade deals were

concluded in Odomari (Jap. 大泊, now Korsakov), then goods were transported along the coast to Cape Crillon. As of 1935, 152 salesmen and traders worked in 51 stores in the settlements of the township (Kannai yoran, 1935, p. 73).

The postal service was excellent. Post offices were opened in Uryu (June 1914), Dorokawa on the Ulyanovka River (December 1924), Naisha (October 1920) and Tishia (November 1930) (Fig. 3.10) (Nishimura, 1996, pp. 108–109). The volume of mail in 1935 is shown in Table 3.3.

There were four medical centres in the township, employing four physicians and three midwives. There was a branch of the International Red Cross (41 members), and in the village of Tishia there was a Sea Rescue Society consisting of a chairman, a medic and 25 lifeguards (Kannai yoran, 1935, p. 44).

The hotel business also flourished on the now empty coast. Early in the 20th century, there were ekitēzo (Jap. 駅) inns here to provide rest for travellers moving on foot or by boat. Such inns were opened on the Svatovka River (May 1910), Kolkhoznaya and Medvedevka rivers and Cape Crillon (June 1910), Ukrainka River (December 1911) and Ptichya River (December 1923) (Nishimura, 1996, p. 115). Subsequently, a comfortable hotel appeared in the village of Tishia (Fig. 3.11).

In 1943, the Karafuto Prefecture developed a perspective plan for the development of South Sakhalin for the next 15 years. Substantial capital investments were also envisioned for the east coast of the Crillon Peninsula. The plan for 1944–1945 was to build a 32-kilometre stretch of road from Moguchi to Cape Crillon, and a 36-kilometre pass connecting Ulyanovka and Pereputye in 1946–1947. However, Japan's catastrophic defeats in the war in the Pacific reduced the allocation for civil construction to a minimum, and September 1945 marked the beginning of a new era in the history of Sakhalin.

The population of the Crillon Peninsula was also drawn into the plans of the Japanese command for the defense of the island. From the end of 1943, Karafuto started getting ready for guerrilla and sabotage

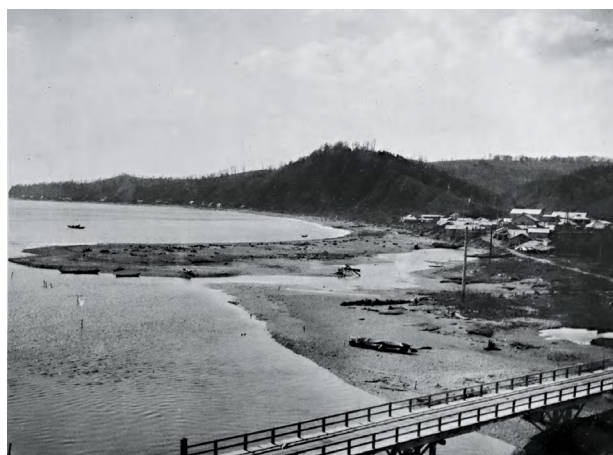


Fig. 3.10. The coast south of the village of Naisha. Photo from the 1930s

activities in case of a Soviet or American landing. In Kami-Sisuka (Jap. 上敷香事, now the village of Leonidovo in the Poronaysky District of Sakhalin Region), a school was opened for accelerated (10 days) training of sabotage groups recruited from the civilian population — reservists who had served in the army. In February 1944, one such squad was formed in the village of Uryuu (Kirilovo). It included 16 residents of settlements scattered as far as Cape Crillon. The task for detachments was to keep an eye on the coastline and, after the enemy landed, to carry out sabotage — taking out small squads, killing officers and blowing up bridges. Observation of the sea brought results: once a submarine was spotted opposite the village of Naisha, and they found a box from an American torpedo near the village of Tishia (Atlasovo). This information was reported to the sabotage squad centre located in Toyohara (Jap. 豊原, now Yuzhno-Sakhalinsk).

These were traces of the successful combat operations of the American submarine 'USS Barb', commanded by Captain Eugene Fluckey, which sank the Japanese ferry 'Sapporo Maru 11' with a torpedo attack on July 5, 1945, opposite the mouth of the Moguchi

Table 3.3. The volume of postal items in the Notoro township (Kannai yoran, 1935, pp. 51–53).

Place	Letters		Telegrams		Parcels	
	Accepted	Delivered	Accepted	Delivered	Accepted	Delivered
Uryu	154,207	133,841	2,181	2,408	621	2,225
Dorokawa	45,020	55,525	1,697	2,361	545	2,317
Naisha	23,196	144,350	1,752	4,062	454	1,659
Tishia	74,596	81,169			262	1,690

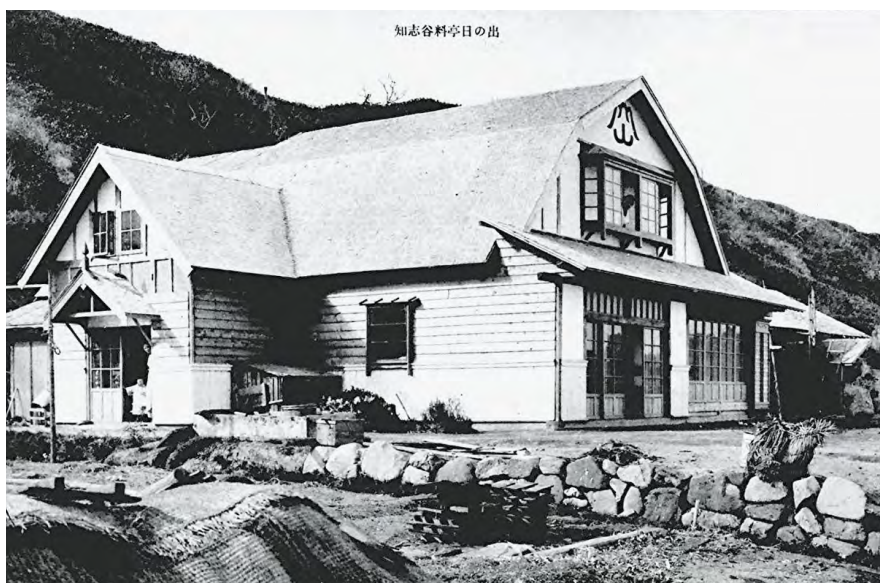


Fig. 3.11. Hotel in the village of Tishia. Japanese postcard from the 1930s

River and the escort ship CD-112 on July 18.

East Crillon in the first post-war decade

Right after the Second World War ended and South Sakhalin became an official part of the USSR, people living in coastal villages started working for the West Sakhalin State Fishery Trust, headed by M. Alperin, who died tragically during the November 1952 tsunami in the North Kuril Islands. There were established the Tishia fish processing plant, the Dorokawa fish factory and the Naisha fish farm (Fig. 3.12). The main body of fishermen at first were Japanese, gradually supplemented by immigrants from the western and central regions of the USSR. As a result, hydronyms brought in from the mainland (Tambovka, Ulyanovka) appeared on the coastal map, strongly recommended by the local population to the topographic officers of Major Koveza's 42nd Topographic Detachment, who were conducting a comparison of captured Japanese maps here.

The fishing season of 1946 was conducted under the banner of competition in honour of the day of victory over Japan. It is known, for example, that until August, the Tishia fish processing plant, headed by Director Denchenko, was lagging behind, ranking 13th or 14th among the trust's fish processing plants.

In 1946, the fishing collective farms (Russian for 'collective farm': 'kolkhoz') Pogranichnik with its central estate in Ulyanovo and a fish factory were established on the coast, as well as the Vozrozhdenie collective farm with its administration in the village

of Khvostovo. The village of Kirilovo (in documents and on maps, there are two spellings: Kirilovo and Kirillovo) was home to the estate of the Zabaikalets fishing collective farm and a fish factory. The Atlasovets collective farm was established in the village of Atlasovo (formerly Tishia). However, by the decision of the general collective farm meeting of August 1, 1949, the board of the collective farm was registered with the Khvostovo Village Council, and the collective farm itself merged with the Vozrozhdenie collective farm.

Initially, Japanese and Russian immigrants worked in the fishing squads. In July 1948, repatriation of the Japanese population began in the townships along the coast. A commission was formed in the Ulyanovo settlement to send Japanese peasants to Aniva and to receive the crops and property of repatriated Japanese farms. The commission included Zhuravlev (initials unknown), the chairman of the executive committee of the Ulyanovo Village Council, E. Vasilyev, the chairman of the Pogranichnik collective farm, Lieutenant I. Kamyshov, the head of the border guard post and M. Karmanov, the collective farm foreman. A squad was formed from among the collective farmers to cultivate the crops left by the Japanese, which immediately began weeding. The following areas (hectares) were assigned to the collective farm for subsidiary farming: wheat — 1.42; oats — 2.13; barley — 1.82; millet — 0.34; buckwheat — 1.7; corn — 0.13; peas — 0.45; beans — 0.12; broad beans — 0.44; potatoes — 4.15; vegetables — 1.65 (Minutes ... of the Ulyanovo Village Council ..., A-B, 1948–1952, pp. 18–18).

In September 1948, the commission inspected and

Table 3.4. Garden crops of houseowners from the village of Khvostovo

Houseowner	Family (number of people)	Grown crops								
		Potatoes	Vegetables (cabbage, etc.)	Legumes	Corn	Sunflower	Root vegetables (rutabaga, beetroot, etc.)	Buckwheat	Oats	Gourds
P. Guskov	6	0.70	0.10							
I. Zhukov A.	5	0.75								
N. Prutkov	4	0.13	0.02							
M. Rozhkova	4	0.30								
M. Kudryavtsev	7	0.10	0.03							
O. Guseva	2	0.08								
K. Kalashnikov I.	7	0.30	0.02							
G. Lyksov O.	4	0.70								
E. Zhurin A.	7	0.15	0.01							
M. Kravtsov	5	0.14	0.03							
V. Rusakova P.	5	0.20		0.20	0.10					
F. Zamiralov	3	0.20	0.01				0.01			
A. Degtyarev	4	0.14	0.04	0.01						
K. Rusakov	3	0.10	0.04	0.02			0.01			
I. Nekrasov	3	0.05	0.05	0.01			0.01			
I. Nikitin	3	0.40	0.01		0.01		0.02			
P. Tereshko	3	0.15	0.02		0.01					
Ya. Ostapenko	6	0.25	0.01	0.02				0.12		
T. Tigeeva	2	0.06	0.02	0.04	0.01		0.01			
F. Ermashev	3	0.18	0.03	0.01	0.03		0.01			
A. Usova	4	0.04	0.03	0.03	0.01		0.02			
K. Getalo	6	0.07	0.01	0.03	0.03	0.02	0.03			0.01
I. Kulik	4	0.03	0.05	0.07	0.06		0.04			
P. Kulik	4	0.07	0.05		0.09		0.01			
P. Kacherygin	6	0.03	0.02	0.03	0.03	0.03				0.03
I. Kartsev	3	0.07	0.01	0.01	0.02					
S. Shirshov	4	0.10	0.05	0.02	0.05		0.02			0.01
N. Yurchenko	3	0.05	0.04	0.02	0.02	0.04	0.05			
N. Volkov	2	0.07	0.04	0.01	0.02					
M. Barysheva, Medvezhka*	4	0.17	0.02	0.01						
S. Rychkov, Medvezhka*	3	0.17	0.04	0.01				0.03		
V. Syryatova, Medvezhka*	3	0.02	0.01		0.01					

* As in the text.

Polezhaev) and the Ulyanovo fish factory (managed by Druzhinin) were located in the Ulyanovo settlement.

The Pogranichnik collective farm was small, with only 6 people working on harvesting in the first quarter of 1959, 24 people (including 5 teenagers) in the second and third quarters and 16 people in the fourth

quarter. The 1959 fishing target was 1,900 centners of herring, 2,250 centners of salmon, 900 centners of cod and 550 centners of flounder. The collective farm had two vehicles: a GAZ-51 and a ZiS-5, as well as 11 horses.

The Pogranichnik collective farm maintained its

own subsidiary farm. 2 ha were plowed for potatoes in 1958 and 2.5 ha in 1959. There was 0.5 ha allocated for cabbage planting and a greenhouse with 40 frames for growing cucumbers (Production Plan ..., 1959).

The farmstead of the Zabaikalets fishing collective farm was located in the Kirilovo settlement (Table 3.5). The collective farm was assigned 500 ha (hectare) of land for perpetual use, including 3 ha of arable land, 8 ha for collective farmers' vegetable gardens and 60 ha of meadows. The collective farm consisted of 51 households and had 109 members — 60 men and 49 women. The territory of the collective farm included a border outpost and school No 7 (Fig. 3.13). The farmstead had no radio service or its own power station; electricity was supplied from the Aniva fish processing plant. The collective farm had three vehicles (GAZ-51, ZiS-5, and GAZ-AA) and eight draft horses. It operated its own brick factory with an output of 15,000 pieces of air bricks in 1954 and 5,000 pieces in 1955 (Acts, documents ..., p. 4).

One of the most common perceptions about post-war Crillon is the excellent condition of its roads. One often hears the claim that people in the past could travel by taxi or bus almost all the way to Cape Crillon. Documents provide evidence of how true this actually was. Thus, at the 3rd session of the Ulyanovo Village Council of Workers' Deputies on May 7, 1948, it was decided to adopt the document 'On the Road Construction Plan for 1948'. The document stated: 'In accordance with the decision of the Aniva District Executive Committee of Workers' Deputies No 170 dated April 22, 1948, the session of the Ulyanovo Village Council decided:

1. To repair the bridge over the Hotikonai River (Jap. ホチコナイ川, now Zlodeyka — *author's note*) and the washed-out road in the village of Krestyanovka with the labour and transport resources of the Pogranichnik collective farm, the fish farm and individual farmers. To repair the road: fill in potholes

Table 3.5. Plan of crop production of the Zabaikalets fishing collective farm for 1954–1955, ha (*Production plans ..., 1954–1959, pp. 8, 35, 60, 80, 135*)

Crop	1954	1955	1956	1957	1958
Oats	0.5	2	–	–	–
Potatoes	3	3	2.6	1.8	4
Vegetables (cabbage)	1	1	0.6	–	2
Annual grasses	2	3	–	1,4	2,3



Fig. 3.13. School in the village of Kirilovo. 1954 (photo by V. A. Tishkov)

and ruts with gravel from the village of Ulyanovskoye to the village of Novotambovka and from the village of Ulyanovskoye to the village of Krestyanovka inclusive, for which purpose to oblige: a) Comrade Vasilyev, Chairman of the Pogranichnik collective farm, to provide information by May 15 this year on the number of people and horses required to participate in road construction; b) Assign the section of road from the village of Kamenka to the village of Novotambovka to the Pogranichnik collective farm.

2. To oblige the head of the fish production base, Comrade Bocharov, to allocate the appropriate number of people and horses to repair the bridge and road' (Minutes ... of the Ulyanovo Village Council ..., V, 1948, p. 7) (Fig. 3.14).

The condition of roads in the Kirilovo Village Council area was no better. On February 20, 1951, at the third session, the Village Council decided on the

construction of bridges across the Uryum and Hishitoro Rivers (Jap. ヒシトロ川, now Tambovka — *author's note*). The participants stated: 'Due to the lack of bridges over the Uryu and Hishitoro Rivers, with the onset of thawing and ice run, horse and pedestrian travel may cease for an extended period. The population of our village council and adjacent village councils may be cut off from the centre for a long time.' It was decided:

'1. To construct footbridges to provide crossings over the Uryu and Hishitoro Rivers.

a) To oblige the chairman of the Zabaikalets collective farm Comrade Kolmykov to assign four men to build a bridge over the Uryu River.

b) To oblige the director of the fish factory Comrade Khromov to saw the necessary amount of timber for bridge plating and allocate funds from the available resources for road and repair work at the Kirillovo fish factory.

c) To oblige Comrade Khromov and Comrade Kolmykov to allocate the necessary horse-drawn transport for delivering materials to the bridge construction sites.

2. To use materials remaining from dismantled bridges on the Uryu and Hishitoro Rivers for the construction of new bridges.

3. To obtain technical materials such as cables and wire from the remaining property left after the repatriation of the Japanese population.

4. To assign the construction of a bridge across the Uryu River to the experienced carpenter of the Zabaikalets collective farm, Comrade Afanasyev (Minutes of the Kirillovo Village Council, 1949–1952, p. 21).

The rough roads in the village council area made it necessary to 'organise a two-day mass outing of the entire adult population with available transport to repair roads and bridges in June 1951' (Minutes ... of the Kirillovo Village Council ..., 1949–1952, p. 103). Obviously, even with such desperate measures, the small local population alone could not maintain dozens of kilometres of road, and the road gradually fell into complete disrepair.

The residential buildings inherited from the Japanese were also less than ideal, with a catastrophic shortage of space for the clubs, village libraries and village councils that were mandatory at the time. Often all of these were housed in former Japanese school buildings, as was the case in the village of Kirillovo, where the 'gymnasium' of the seven-year school was used as a club (Materials ..., 1948, p. 87).

The chronic lack of necessary building materials forced the use of local resources. In post-war construction in this area, shells were widely used to cover the roofs of

new houses built for Soviet settlers. The initiator of using shells as a roofing material was the previously mentioned local fisherman Kalistrat Afanasyev. In July 1949, he was appointed head of the squad building houses for collective farmers in the village of Kirillovo. The first house, built for the fisherman Sakharov, featured a roof made from this new material. Being sceptical, some people poured water from a bucket and attempted to slow down the flow by placing grass on the slope. By the beginning of winter, nine houses were covered with shells (Fig. 3.15). An ordinary worker could cover 10–12 m² of roof with this material per day. 100 shells were used per 1 m² (Fedorchenko, 1950).

Toponymic outline of the area

The modern geographical names of settlements in the former Crillon Nature Reserve (see below, chapter 'Hunting...') are the result of the work of employees

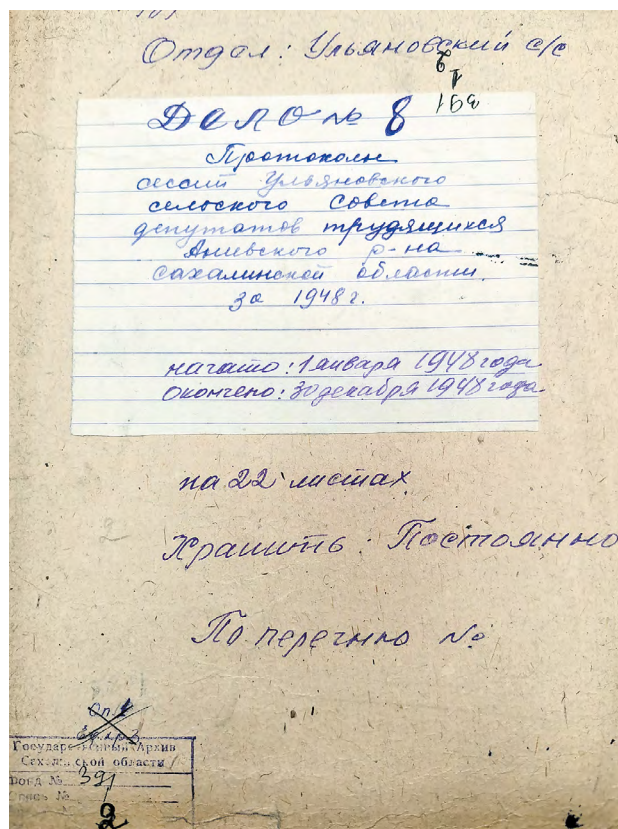


Fig. 3.14. Session minutes of the Ulyanovo Village Council of Workers' Deputies for 1948 (excerpt) (GIASO. Fund 391. Series 1. Record 2. Sheet 7)



Fig. 3.15. House in Aniva district with a shell roof. 2007

of the Civil Administration, a semi-military body that governed life in South Sakhalin and the Kuril Islands in 1945–1948. The renaming began in the spring of 1946 and was completed by the Decree of the Presidium of the Supreme Soviet of the RSFSR on the renaming of localities in the Sakhalin Region dated October 15, 1947 (Samarin, 2015, pp. 196–226) (Fig. 3.16). In addition, in 1946, officers of the 48th Topographic Detachment under the command of Major Koveza worked in the territory of South Sakhalin and gave names to most of the mountains, rivers, capes and bays.

Uryum, river, the russified Ainu name of **Uryuu**, means ‘river with many crows or guillemots’ (called sea crows by the Ainu) (Samarin, 2016, p. 46). This name first appeared on Japanese maps in 1790. In the course of renaming Japanese names, the district branch of the Civil Administration decided not to rename the river ‘as the old Russian name’ (? — *author’s note*). The river is mistakenly referred to as Ugryum on some maps from 1946–1947, apparently due to its association with V. Ya. Shishkov’s famous novel ‘Ugryum River’. The settlement of Uryukhama (Uryukhama Beach) was initially named Rybnovskoye at the suggestion of fishermen from Zabaikalets, a local fishing collective farm. At the same time, the Taranay village was named Kirilovskoye, but later it was decided to keep its Ainu name and to name the village of Uryuukhama after Dr. N. Kirilov. In October 1946, the settlement population was 423 people. It is important to note that the name of the village is spelled incorrectly on all maps, i.e. with two ‘i’s.

Zlodeyka, river. The Ainu name is **Iosinai** (‘a river with many bear tracks’). The small Japanese village was

erroneously named Krestyanskoye, as the Krestyanskie (Peasant) rivers mentioned by N. Kirilov are located further south. The origin of the modern name of the river was most likely chosen randomly.

Krestyanskaya, river. The name Malaya Tambovka is more commonly used.

Tambovka, river. The Ainu name is **Pesutoro** (‘place among the cliffs’). The Ainu used a similar-sounding name for another place on the west coast of the island – Esutoro, now the town of Uglegorsk. Following a suggestion by settlers from the Tambov region, the Japanese settlement was named Novotambovskoye. In October 1946, its population was 75 people.

Maksimkina, river. The Ainu name is **Hachikonai** (‘little river’). In October 1946, the settlement population was 57 people; at the suggestion of local residents, the village was named Kamenka based on the character of the beach.

Ulyanovka, river. The Ainu name is **Tomanay** (‘river carrying much silt and sand’) or Tomario (‘long spit forming a harbour’); the Japanese name is **Dorokawa** (‘muddy river’). In 1946, the Pogranichnik fishing collective farm was established here with a population of 195 people. In July 1947, local residents suggested changing the name Dorokawa to **Dorogaya**, based on the sound similarity, but it was later decided to name it Ulyanovka, in memory of the settlers from the Ulyanovsk Region. In the valley of the Dorokawa River, there was a small village called **Futamata**, renamed Serebryanaya Polyana (‘silver glade’), but almost immediately after the end of the war, the population left it, and it was not listed anywhere in the documents.

Kura, river. The russified Ainu name is **Furue** (‘low, gentle hill’). This probably refers to the gently sloping 5-metre terrace in the south-eastern part of the valley, which is home to an ancient campsite dating back around 2,000 years. Peasant settlers suggested naming the settlement Krestyanovka. In October 1946, its population was 87 people.

Kolkhoznaya, river. The Ainu names are **Toikushi** (‘a cliff sliding down to the road’) or **Toyokushi** (‘a place with edible clay’). At first, the name Netoskuy was suggested due to sound similarity, then the river received its modern name from collective farm fishermen.

Medvedevka, river. The Ainu name is **Ohoo** (‘deep place’ or ‘deep-entering place’). The village and the river got their modern name because of the large number of bears. The population of the settlement in October 1946 was 195 people.

Svatovka, river. The most famous and most frequently marked place on early Japanese maps along the entire coast. The Ainu name is **Riyatomari**



Fig. 3.16. Fragment of the map of South Sakhalin. 1950

(‘a place to live all year round’) (Samarin, 2017, p. 37). Lieutenant N. Rudanovsky in the winter of 1854 discovered here the largest Ainu settlement in the area from the mouth of the Lyutoga River to Cape Crillon: 14 dwellings inhabited by 60 Ainu people. In the summer of 1854, a Japanese guard post was established here by Hakodate Governor Hori Toshihiro. Soldiers from the Sendai, Akita, Nambu and Tsugaru clans performed guard duty. In addition to the barracks and administrative building, a Shinto shrine was constructed. The uniqueness of this area was clearly recognised by F. L. Kartavykh, a legendary gamekeeper and hunter from these lands, who had a house and a vegetable garden here. In October 1946, the local population was 30 people; at their suggestion, the settlement was named Chaika (‘seagull’) because of the bird market located nearby on the rocks. This was followed by the variant Ptichiy Bazar (‘colony of birds’); the name Kairino was adopted as a final name. The origin of the modern name of the river has not been established.

Naicha, river. The Ainu name is **Naisha** (‘village between river channels’); the Japanese one is **Naishahama**; renamed to **Khvostovo**, in honour of Lieutenant Nikolay Khvostov, commander of the Russian-American Company brig ‘Yunona’, who was considered by the Civil Administration workers as an explorer of Sakhalin. Population in October 1946 was 207 people; the Vozrozhdenie fishing collective farm was located here.

Riflyanka, river. The Ainu name is **Motinai** (‘small, muddy river’). In October 1946, 17 people lived at the mouth of the river.

Moguchi, river. The Ainu name is **Mogotinai** (‘winding river’). At the mouth of the river and to the south of it was the Japanese settlement of **Mokochi**. The population in October 1946 was 35 people. In the winter of 1946, there was an acute shortage of bread, which was usually delivered from the village of Naisha, but deep snow and lack of roads cut Mokochi off from the outside world. In the spring of 1947, the fishermen of the Tissei fish processing plant decided to build their own bakery. Carpenter Andrey Shur made wooden moulds, female workers Pegolitsina and Obrezan made 4,000 bricks to build an oven. They constructed a box for kneading dough, equipped the room, and baker Ivan Kosimovsky started baking his own bread.

Due to the nature of the terrain, the village was proposed to be renamed Utesovka.

Kanabeevka, cape. The Ainu name is **Vennochi** (‘bad’). The Japanese name for the cape and the rocky shoal off its coast is **Raytomari** (meaning ‘bay of death’ or

‘place where people got thrown out by the storm’). The cape deserved its name, as shipwrecks occurred here quite often. On October 30, 1949, the VO-130 boat crashed here, killing Captain Ovchinnikov and SakhtINRO (now the Sakhalin branch of the Russian Federal Research Institute of Fisheries and Oceanography) research assistant I. Varvarin. On April 15, 1956, the Sakhalin Shipping Company’s tugboat Stalingradets ran aground on the Raytomari shoal, crashed and sank. The modern name was given in the late 19th century in memory of warden Kanabeev, who was brutally murdered by escaped convicts in the area of the cape on October 3, 1885. Excerpt from the diary of the keeper of the Crillon lighthouse, Vasily Zharikov: ‘October 1. Today I saw off a guest, a certain nobleman Kanabeev, who came to the lighthouse from the Korsakovsky post to collect cattle left by my predecessor and sold by him to the district chief. No matter how much I tried to persuade Kanabeev to stay for today’s holiday, out of zeal for his service, he left. A nice fellow, a cheerful companion to talk to, a simple soul. I am surprised that an educated man from the nobility serves at the Korsakov prison as a simple warden. The only property he owns, as he states, is movable one. This is him, a Peabody rifle, a shotgun, a leather knapsack and spare moccasins. As you can see, he is a taiga man who likes to hike in the wilds of Sakhalin.’ The convicts slaughtered Kanabeev in his sleep at the lodging (Samarin, 2005, p. 14).

Ptichya, river. The Ainu name for this area is **Magotsue** (‘a cosy basin to relax in’). The population of the settlement in October 1946 was 125 people; however, no documents confirming its renaming could be found, and it was not listed among the settlements of Soviet South Sakhalin.

Kalinovka, natural landmark. The Ainu name is **Nupuri** (‘mountain’). The modern name was suggested because of many viburnum trees (‘kalina’ in Russian) that grew in this area. The population in October 1946 was 30 people.

Anastasia, river, **Atlasovo** natural landmark. The Ainu name is **Tishia** (‘two rocks’); the Japanese name **Futatsu iwa** means the same. The modern name of the river and cape was suggested by the Renaming Commission due to sound similarity with the Japanese name. The settlement, abolished in 1978, was named in honour of Vladimir Atlasov, an explorer of the Kuril Islands and a pioneer, but the justification for the name stated that it was ‘in honour of Atlasov, the first explorer of Sakhalin’. The population in October 1946 was 235 people.

Atlasovka, river. The Japanese name **Bisysan** (‘good descent from the cliff’) is more common on 19th

century maps. The Ainu name is **Peskorokotan** ('a place with rocks in the sea and on the shore, a rocky place'). In 1854, there was an Ainu village of three dwellings with 14 people living here. The population in October 1946 was 39 people. Initially, it was proposed to rename the village to Morzhovo after Morzh Bay, named in honour of the Siberian Flotilla gunboat 'Morzh'; then to Chekhovka. The final choice became the name Ukrainka. No reliable sources of its origin have been found. The river was named after the neighbouring village of Atlasovo; the Atlasovets fishing collective farm was located here and in the village of Utesovka.

Petrovka, river. The Ainu name is **Nanae** ('river with swampy banks'). When renaming the settlement, it was proposed to call it Petrovo, 'restoring the old Russian name', but no source recording the existence of a Russian settlement here prior to 1905 has been found. The population in October 1946 was 40 people.

Irsha, river. The Ainu name is **Baikarokotan** ('spring village' or 'village where many people gather to fish'); the Japanese name is **Kohama** ('narrow beach'). The population in October 1946 was 32 people. The origin of the modern name could not be determined.

Kostroma, cape. The Ainu name is **Chisuyankenai** ('a good place for landing boats'), and the Japanese name is **Ishihama** ('rocky beach'). The Russian name was given in memory of the volunteer fleet steamer 'Kostroma' which crashed near the south-west tip of Cape Crillon in May 1887.

Crillon, cape. The Ainu name is **Notoro** ('edge of the cape'). The Japanese called it **Nishi Notoro**, or West Notoro, as there were two other similar Ainu names on South Sakhalin, now Cape Slepikovsky and Cape Bykov. That is why the Japanese named the first one **Kami Notoro** ('Upper Notoro') and the second one **Higashi Notoro** ('East Notoro'). The modern name was given in August 1787 by Jean Galaup de La Pérouse (*Jean-François de Galaup, comte de La Pérouse*), the leader of the first French circumnavigation expedition, in honour of Viscount General Louis de Crillon, who lived in the 16th century and was known for his legendary bravery. Jacques Bodin, a retired 1st Rank Captain (commodore) and researcher of La Pérouse's life and trips, who visited Sakhalin in summer 2001, has his own version of the origin of this name. Indeed, La Pérouse's diary contains the official version of the name. However, the Crillon dynasty continued and continues to this day, and La Pérouse's circle of friends included a descendant of the famous general. Therefore, to conceal the true reason that prompted him to name the south-west tip of Sakhalin Island with this sonorous name, La Pérouse pointed to the legendary brave man. However, this is

nothing more than a hypothesis.

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4 VEGETATION OF THE EAST COAST OF THE CRILLON PENINSULA

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The peculiarities of Sakhalin's vegetation are determined by its geographical position and the geological history (Sochava, 1956). The island extends in a meridional direction for 948 km (Khomenko, 2003) providing the contrast in physical and geographical conditions along the island and resulting in different composition of vegetation in the North and the South. Due to the combination of lowland and mountain terrain, a diversity of ecotopes is presented providing a diversity of plants. Three groups of species can be identified within the flora of Sakhalin: first, plants widely distributed on the mainland, some of which occur only in the northern part of the island; second, plants that link the flora of Sakhalin with that of the Japanese archipelago; and third, island endemics. According to V. Barkalov and A. Taran (2004), 1,521 species of vascular plants, belonging to 575 genera from 132 families, including alien and escaped cultivated species, accounting for 18.9 % of their total number, were registered on Sakhalin. After 2004, new plants were discovered, and the list of vascular plants increased to 1,660 species, mostly due to the discovery of new alien species (Koroteeva, 2024). The level of endemism is weakly expressed. Thus, there are no endemic families on the island, and the status of the only endemic genus, *Miyakea* (*Miyakea* Miyabe & Tatew.), is disputed as it is very similar to the pasque flower (*Pulsatilla* Mill) genus. Sakhalin endemic species include 36 plants, most of which are quite rare and do not play any significant role in the island's vegetation cover. Many of them are narrowly localized, mostly correlate with the mountain part of Eastern Sakhalin (Barkalov, Taran, 2004), representing the most ancient flora elements. Due to the insufficient altitudinal range of mountain massifs, endemic species are absent on the Crillon Peninsula.

Natural conditions and historical factors influencing the formation of vegetation

Climate is a key natural factor shaping the island and is characterised by a pronounced monsoon regime. Due to the considerable length of the island, temperatures in the North and South differ significantly. The southern part of the island has an average annual temperature of +4 to +4.5 °C (Bogatov, 2004), compared to the northern part, where the average annual temperature is negative, reaching as low as -2.7 °C. A west-east temperature asymmetry is also evident across the Crillon Peninsula, reflecting the influence of the warm Tsushima Current in the Sea of Japan (Bogatov, 2004). During the cold

season, frequent cyclones prevail over Sakhalin, bringing heavy snowfalls. Snow cover thickness typically ranges from 50–60 cm and may occasionally reach up to 100 cm; this is likely a key factor promoting the development of tall-forb communities across Sakhalin. (Belaya, Morozov, 2000). In addition to sheltering plant buds and creating more comfortable and warmer conditions in winter, in spring during the snowmelt and after it, plants receive enough moisture for their entire growth period. The same mechanism may contribute to the active spread of bamboo thickets (represented by Kuril dwarf bamboo (*Sasa kurilensis* (Rupr.) Makino & Shibata) and other species of the dwarf bamboo genus (*Sasa* Makino & Shibata) (Tolmachev, 1956) (Fig. 4.1). The mean January temperature in southern Sakhalin ranges from -6.2 to -11.3 °C, while the winter period lasts for about five months, in contrast to the northern part, where winter lasts for about seven months. During the warm season, cloudy and foggy weather often prevails on Sakhalin due to the high-pressure zone over the Sea of Okhotsk. The weather becomes warmer and the sky is cloudless only in August and September. Summer lasts for about three months, with the mean August temperatures in the South ranging from +17.4 to +19.6 °C. It is noteworthy that precipitation is unevenly distributed both over the course of the year (with the greatest amounts falling in the summer and autumn months) and along the length of the island as a whole: the annual precipitation total in the southern part of the island may exceed that in the north by as much as three times, owing to cyclones and typhoons arriving from the east and southeast (Aleksandrova, 1982). Thus, the climatic conditions of the southern tip of the island result in warmer and more humid environments for vegetation, in contrast to the cooler and harsher conditions prevailing in northern Sakhalin.

The current-day appearance of Sakhalin's vegetation has not always been as we see it today: it has been changed by various geological processes and later by human activity. At the beginning of the Paleogene (65–55 million years ago), the north-eastern margin of the Eurasian continent and Sakhalin formed part of the Boreal phytogeographical region, the flora of which was rather homogeneous across a vast territory (Takhtajan, 1966). Due to the subtropical climate, numerous thermophilous plants grew in the forests; their modern representatives can now be found in subequatorial regions (Pletnev, 2004). During the early Eocene (54.9–38.0 million years ago), the climate on modern Sakhalin was the mildest and warmest throughout its entire geological history, with mean January temperatures never falling below +10 °C and mean July temperatures of +20...+22 °C (Velichko,



Fig. 4.1. Kuril dwarf bamboo (*Sasa kurilensis*). Left: bamboo leaf; right: typical dwarf bamboo growing areas



1999). During that period, the island was dominated by broad-leaved forests comprising chestnuts (*Castanea* Daubenton), walnuts (*Juglans* L.), representatives of the myrtle family (Myrtaceae) and other plant species. In the late Eocene, near the Eocene–Oligocene boundary, a period of significant cooling was recorded in geological history, when Sakhalin’s climate was changing from subtropical to warm-temperate (Fotyanova, 1987). Towards the late Eocene, an increasing contribution of plant species such as birch (*Betula* L.), alder (*Alnus* Mill.), and representatives of the pine family (Pinaceae) to the forest canopy was documented. At the Oligocene–Miocene transition, almost the entire territory of the island, except for the highest mountains, was covered by the sea, including the Crillon Peninsula (Gladenkov et al., 2002). In the Oligocene, severe cooling was recorded throughout the Russian Far East, leading to the dominance of cold-tolerant tree species in plant communities: shrub birch and alder were constantly present in the mixed pine and birch forests (Pletnev, 2004). By the middle Miocene (24.6–5.1 million years ago), the monsoon type of atmospheric circulation was established in eastern Asia. According to palaeobotanical data, the overall trend of climatic processes was similar to that of the Eocene: episodes of sharp warming were recorded against a background of progressive cooling. Global warming during this period caused sea-level rise due to melting ice – a glacioeustatic rise – which resulted in the flooding of most of Sakhalin. According to L. I. Fotyanova (1987), the broad-leaved plants reached their maximum development during this period. At this time, maples (*Acer* L.), chestnuts (*Castanea*), beeches (*Fagus* L.), wingnut trees (*Pterocarya* Kunth) and

representatives of the elm family (Ulmaceae) occupied the dominant role in communities.

It has been suggested that geological processes in the late Miocene led to the merging of Sakhalin and Hokkaido with the mainland, connecting them to the Korean Peninsula via present-day Honshu Island (Pletnev, 2004). During this period, intensifying temperature fall was recorded, and vegetation on Sakhalin was represented by coniferous-broad-leaved forests with elements of tundra communities in the north of the island. Later, in the Pliocene (5.6–1.6 million years ago), there occurred important geological processes that finally formed the West Sakhalin Mountains, and the overall outline of the island became largely similar to its present-day configuration. The Pleistocene (1.6–0.01 million years ago) corresponds to the largest changes in the development of Sakhalin’s natural environment due to repeated climate fluctuations, sea level fluctuations (from –110...–130 to +10...+15 m) and tectonic activity (Pletnev, 2004). In general, the climate has over time become more seasonal and cooler, as it remains to the present day. These events during the Eopleistocene caused extinction of the most thermophilous species from the genera hickory (*Carya* Nutt.), chestnut (*Castanea*), ginkgo (*Ginkgo* L.), swamp cypress (*Taxodium* Rich.), yew

(*Taxus* L.), gleichenia (*Gleichenia* Sm.), marsilea (*Marsilea* L.), etc.; a decrease in the diversity of such genera as hornbeam (*Carpinus* L.), spruce (*Picea* A. Dietr.), pine (*Pinus* L.), oak (*Quercus* L.), and the appearance of meadow plants from the grass family (Poaceae) and amaranth family (Amaranthaceae), as well as plants of the genus mugwort (*Artemisia* L.) (Pletnev, 2004). The further evolution of vegetation communities tended to reduce the participation of thermophilous plant species and increase the role of coniferous species such as spruce (*Picea*) and pine (*Pinus*). During the same period, as a result of the ongoing mountain formation (orogenic) process, the rivers of Sakhalin formed their present-day structure, resulting in the formation of a complex, jointed orthogonal drainage network (Pletnev, 2004).

In the Pleistocene, Sakhalin was likely once again connected with the Japanese island arc and the mainland, and during the periods of warming, thermophilous (heat-loving) plant species penetrated from Hokkaido through the southern tip of the island (Pletnev, 2004). These species do not occur in the northern part of the island, but they are currently present in the vegetation on the Crillon Peninsula. Thus, during the first significant Holocene

climate warming 10–12 thousand years ago, the first findings of Sakhalin fir (*Abies sachalinensis* (F. Schmidt) Mast.) (Fig. 4.2) appeared, which currently plays an important role in the forest communities of Sakhalin (Krestov et al., 2004). Closer to the present time, waves of climate warming were recorded, which witnessed cold-tolerant plant species migrating northward and heat-loving plants invading from Hokkaido Island and thereafter disappearing en masse from Sakhalin's flora during new cooling periods. As a result, the repeated climate fluctuations on Sakhalin have significantly enriched the flora with cold-tolerant representatives of East Asian flora (Krestov et al., 2004).

With regard to human influence on the island's vegetation, it should be noted that the first sites of *Homo sapiens* dated back to approximately 20–12 thousand years have been found in the middle and southern parts of Sakhalin (Rudaya et al., 2013). During the Neolithic period (10,000–2,500 years ago), the whole island was inhabited by people whose culture was based on fishing and hunting marine mammals. During the Medieval Period, the ancestors of the Ainu settled in the southern part of the island, maintaining contacts between Sakhalin

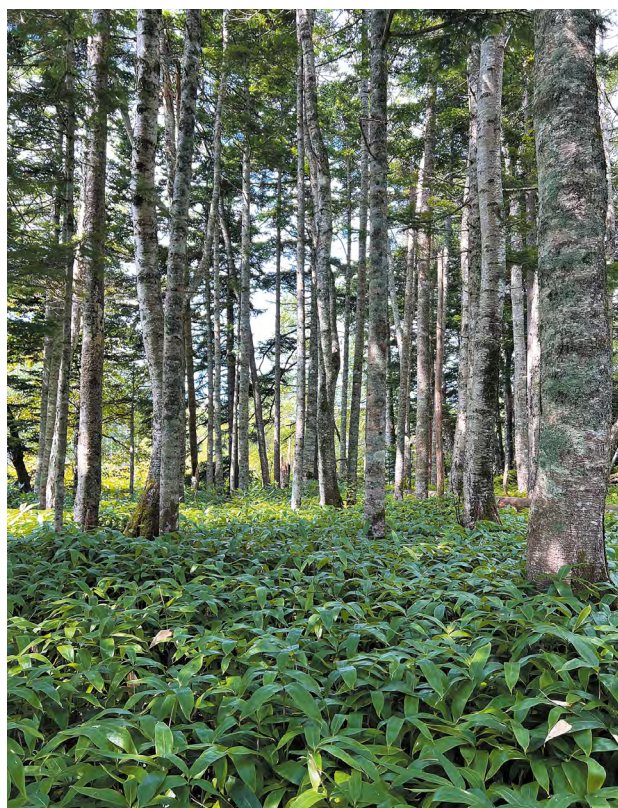


Fig. 4.2. Sakhalin fir (*Abies sachalinensis*) surrounded by Kuril dwarf bamboo

and Hokkaido. In contrast, the Nivkh people in the north were connected with the Lower Amur region through regular movements. The material culture of these groups was similar in many respects, and they obtained their sustenance through hunting, fishing, and gathering. These societies did not practice agriculture and did not create large urban-type settlements. Although the Ainu did not form a state, the structure of their tribes was well-defined (Akulov, 2007). This continued until the end of the 19th century, when Aleksandr II signed a decree establishing a penal colony on Sakhalin. The convicts were engaged in mining mineral resources (coal and iron ore), construction of households and administrative buildings, wharves, roads, laying telegraph lines, draining swamps, catching and salting fish, harvesting hay, loading and unloading sea vessels, cultivation of cereals and vegetables, raising livestock, poultry, and other work. With the onset of winter, all the convicts not engaged in compulsory labour were sent to the taiga for timber harvesting (Korablin, 2005). Large-scale logging initiated during this period significantly affected the vegetation of Sakhalin. In 1905, upon signing the Portsmouth Treaty between Japan and Russia, the part of Sakhalin, south of the 50th parallel, passed into Japanese possession and became known as Karafuto Prefecture. During the Japanese period, nine pulp and paper mills were built on Sakhalin, which processed mainly coniferous trees such as spruce and fir. Wood was also used for construction of railroads, bridges, residential, administrative and industrial buildings (Sabirov, 2022). During the Soviet period, industrial logging continued on Sakhalin. By the beginning of the 21st century, most of the production facilities had been decommissioned. As a result of intensive economic activity, by the present time, the areas of primary, intact forests have been preserved in hard-to-reach areas such as steep mountain slopes and headwaters of rivers, where logging was difficult or economically unprofitable. Many areas are now occupied by secondary forests, and a secondary origin can be assumed for some meadow communities as well as bamboo thickets

Vegetation of Sakhalin: general overview

Sakhalin is located at the junction of the Circumboreal and East Asian floristic regions (Takhtajan, 1978), which is reflected in the diverse and mixed character of its vegetation. Differences in plant species composition between the northern and southern parts of the island were specified by various researchers (Schmidt, 1868; Miyabe, Tatewaki, 1937). For example, the northern part is dominated by larch

forests formed by Dahurian larch (*Larix gmelinii* (Rupr.) Göpp.); its number decreases to the south, to the point of complete absence in the southern part of the island. Southern Sakhalin, where the Crillon Peninsula is located, is characterised by the absence of high mountain ranges and, consequently, the alpine zone vegetation, although the topography of this territory consists of interspersed low spurs of the West Sakhalin Mountains, river valleys and lowlands.

The territory of the Crillon Peninsula belongs to the subzone of dark coniferous forests with an admixture of broad-leaved species and, according to the classification of A. I. Tolmachev (1955), is assigned to the 14th floral region. This is a rather extensive area, including both the western (Nevelsky and Kholmsky, and partly Tomarinsky districts) and eastern (Anivsky district) coasts of the peninsula, as well as Moneron Island. It is in this area that the influence of the East Asian floristic region is mostly noticeable. In 2004, P. Krestov, V. Barkalov and A. Taran (Krestov et al., 2004) revised the botanical–geographical regionalisation of Sakhalin, proposing its division into six districts, with the boundary between the northern Circumboreal and southern East Asian floristic regions following the Schmidt Line—a major biogeographical boundary crossing the island diagonally in its central part (Tatewaki, 1958). M. Tatewaki used both physiognomic and floristic criteria to justify the designation of this line. To the north of this line, he recorded: 1) widespread distribution of larch forests; 2) increased role of spruce in dark coniferous communities; 3) decreased role of broad-leaved trees; 4) disappearance of the dwarf bamboo (*Sasa*) layer in forest communities; 5) disappearance of woody lianas; 6) appearance of Okhotsk floristic elements (Tatewaki, 1958). This line specifies the contrasting flora of Sakhalin. For example, in the central part of the island, where, according to the above-mentioned classification (Krestov et al., 2004), the East Sakhalin and West Sakhalin regions are located, the flora has a transitional character due to the presence of many northern and southern plant species; 46 % of all Sakhalin endemics grow here. In the West Sakhalin region, there is a southern border of northern genera spread, which do not cross the Belt (isthmus in the central part of the island, its narrowest part) within Sakhalin: needlegrass (*Achnatherum* P. Beauv.), arctic bell-heather (*Cassiope* D. Don), paintbrushes (*Castilleja mutis* ex L. f.), chrysanthemum (*Chrysanthemum* L.), scurvy grass (*Cochlearia* L.), hawksbeard (*Crepis* L.),

bleeding-hearts (*Dicentra* Bernh.), avens (*Dryas* L.), eremogone (*Eremogone* Fenzl), alpine forget-me-not (*Eritrichium* Schrad. ex Gaudin), dwarf gentian (*Gentianella* Moench), stickseed (*Hackelia* Opiz), bog adder's-mouth orchid (*Hammarbya* Kuntze), kitagawia (*Kitagawia* Pimenov), leibnitzia (*Leibnitzia* Cass.), avenella (*Avenella* Bluff ex Drejer), sandwort (*Minuartia* Loebl.), frog's reading lamp (*Moneses* Salisb. ex Gray), locoweed (*Oxytropis* D. C.), primrose (*Primula* L.), pasqueflower (*Pulsatilla* Mill.), glasswort (*Salicornia* L.), Sieversia (*Sieversia* Willd.), featherbells (*Stenanthium* (A. Gray) Kunth), synurus (*Synurus* Iljin), tansy (*Tanacetum* L.), pennycress (*Thlaspi* L.), valerian (*Valeriana* L.) and others. Most of the genera listed above are quite common at Hokkaido, so they are more likely to disappear from the flora due to the incomplete representation of altitudinal zones in the extreme south of Sakhalin (Krestov et al., 2004). According to this botanical-geographical classification, three regions are distinguished north of the Schmidt Line and three to the south, the southernmost being the Crillon District. It covers most of the Crillon Peninsula, part of the spurs of the West Sakhalin Mountains, and Moneron Island. The boundaries of the Crillon District coincide with the 14th region described by Tolmachev. Unlike other districts, only this one is characterised by the following plant species that link its vegetation with the flora of the Japanese Archipelago: tara vine (*Actinidia arguta* (Siebold & Zucc.) Planch. ex Miq.), porcelain berry (*Ampelopsis glandulosa* var. *heterophylla* (Thunb.) Momiy.), Japanese hart's tongue fern (*Asplenium scolopendrium* subsp. *japonicum* (Kom.) Rasbach), Miquel's leptorumohra (*Arachniodes miqueliana* (Maxim. ex Franch. & Sav.) Ohwi; syn. *Leptorumohra miqueliana* (Maxim. ex Franch. & Sav.) H. Ito), sea bindweed (*Calystegia soldanella* (L.) Roem. & Schult.), Maximowicz's swallow-wort (*Cynanchum maximowiczii* Pobed.), Japanese fairy bells (*Disporum sessile* (Thunb.) D. Don), gastrodia (*Gastrodia elata* Blume), castor aralia (*Kalopanax septemlobus* (Thunb.) Koidz.), Radde's lettuce (*Lactuca raddeana* Maxim.; syn. *Pterocypsela raddeana* (Maxim.) C. Shih.), triangular lettuce (*Lactuca triangulata* Maxim.; syn. *Pterocypsela triangulata* (Maxim.) C. Shih.), Ussurian scaly polypody (*Lepisorus ussuriensis* (Regel & Maack) Ching), Korean mulberry (*Morus indica* L.; syn. *Morus bombycis* Koidz.), Manchurian bird's-nest orchid (*Neottia papilligera* Schltr.), Asian royal fern (*Osmunda japonica* Thunb.), phacellanthus (*Phacellanthus tubiflorus* Siebold

& Zucc.), butterfly orchid (*Platanthera fuscescens* (L.) Kraenzl.; syn. *Tulotis fuscescens* (L.) Czer), Asian poison ivy (*Toxicodendron orientale* Greene) (Fig. 4.3) (Krestov et al., 2004).

Plant communities description of the east coast of the Crillon Peninsula

In general, the vegetation of the area comprises mountain and floodplain forests, dwarf bamboo thickets, coastal and floodplain meadows, marshes and lithophytic communities on coastal cliffs.

The main forest-forming species in the mountain forest are Sakhalin fir (*Abies sachalinensis*) and Ezo spruce (*Picea jezoensis* (Siebold & Zucc.) Carr.). Sakhalin fir (*A. sachalinensis*) growing on Sakhalin, the Kuril Islands and Hokkaido Island, is especially valued in Japan as a material for house decoration as well as a raw material for paper and turpentine production. It was first described by Russian geologist



Fig. 4.3. Asian poison ivy (*Toxicodendron orientale*)

and botanist Carl Friedrich Schmidt following his expedition to Sakhalin in 1866 (Schmidt, 1868). Sakhalin fir reaches up to 30 meters in height and may live up to 200 years, rarely up to 250 years. Ezo spruce (*P. jezoensis*) is a taller (up to 50 m) and long-lived (150–200 years) conifer with a broader distribution, occurring in Japan and the Russian Far East. The Latin name of this plant comes from the old name of Hokkaido Island, Ezo. Ezo spruce *P. jezoensis* is still subject to commercial logging as well, but not on Sakhalin territory. On the east coast of the Crillon Peninsula, rather large and old specimens of Ezo spruce (*P. jezoensis*) are found, mostly in inaccessible places, such as the slopes of steep hills. In addition to Sakhalin fir (*A. sachalinensis*) and Ezo spruce (*P. jezoensis*) (Fig. 4.4), the forest-forming species in the described area is Erman's birch (stone birch) *Betula ermanii* Cham (Fig. 4.5). Its contemporary range covers the south of Eastern Siberia, the Russian Far East (including Kamchatka, Sakhalin, and the Kuril Islands), China and Japan. A typical subspecies of

Erman's birch, *Betula ermanii* var. *ermanii*, grows on Sakhalin in mountain forests, Erman's birch *B. ermanii* preferentially occupies rocky substrates and reaches 15–20 m in height. It often forms open forests on elevated sites with dense and tall bamboo thickets. Stone birch (*B. ermanii*) prefers well-lit habitats, so it is rarely found mixed with coniferous tree species; it is also characterised by high resistance to wind exposure (Tolmachev, 1956).

Notably, Red Data Book plant species play an essential role in the formation of the tree layer in the vegetation communities of the Crillon Peninsula: Sakhalin cork tree (*Phellodendron sachalinense* (F. Schmidt) Sarg.), which is not now recognised as an independent taxon but is included within the broader taxon of Amur cork tree (*Ph. amurense* Rupr.) (Plants of the world...), and castor aralia (*Kalopanax septemlobus*), the only arborescent representative of the Araliaceae family in the Russian flora. In addition, Japanese yew (*Taxus cuspidata* Siebold et Zucc. ex Endl.) grows here under the forest canopy. It very rarely reaches the size of a full-grown tree due to its slow growth rate and historical logging activities. Another noteworthy woody species from the rose family, included in the Red Data Book of the Sakhalin Region (Red List..., 2019), occurs in mountain forests is the Hokkaido bird cherry, or Ainu cherry (*Prunus ssiori* F. Schmidt). It grows only on Sakhalin, the islands of the Japanese archipelago and the Kuril Islands. Owing to its spring flowering in the form of inflorescences composed of small white flowers and its pale, almost white bark, it is considered a promising ornamental plant for regions with suitable climates (Sargent, 1894). The autumn colouration of



Fig. 4.4 Ezo spruce (*Picea jezoensis*). Left: general view of a tree in its natural habitat; right: a fragment of a shoot



Fig. 4.5. Erman's birch (*Betula ermanii*)

these trees and their vividly coloured young shoots are particularly valued in horticulture.

To a lesser extent, Japanese rowan (*Sorbus commixta* Hedl.) (Fig. 4.6) and Korean cherry (*Prunus maximowiczii* (Rupr.) Kom.) participate in forming the tree layer. Korean cherry (*P. maximowiczii*) is quite widespread: it grows in South-eastern China, Japan, Sakhalin and generally in the Russian Far East. It is a small tree, reaching up to 7.5 m in height, with distinctive ornamental bark, beautifully blooming in spring and, in well-lit areas, bearing small edible but weakly flavoured fruits with large pits. Japanese rowan (*S. commixta*) grows in South-eastern China, Korea, Japan, and on Sakhalin. It is a tree 7–10 m tall with a beautiful silver hued bark; its pinnate leaves can reach 30 cm long. Its fruits are relatively large but have a bitter taste (Plant World of Sakhalin, 2014).

Quite often, dense bamboo thickets are found under the forest canopy as well as everywhere on mountain slopes and their summits. These

communities are very specific for Southern Sakhalin. According to modern data (Plants of the world ...), bamboo thickets on Sakhalin are represented by a complex of 10 species, nine of which belong to the genus of dwarf bamboo (*Sasa*): horned dwarf bamboo (*S. cernua* Makino), Kuril sasa or Kuril dwarf bamboo (*S. kurilensis* (Rupr.) Makino & Shibata), large-leaved dwarf bamboo (*S. megalophylla* Makino & Uchida), broadleaf bamboo (*S. palmata* (Burb.) E. G. Camus), running bamboo (*S. senanensis* (Franch. & Sav.) Rehder), northern dwarf bamboo (*S. septentrionalis* Makino), Tatewaki dwarf bamboo (*S. tatewakiana* Makino), Veitch's dwarf bamboo (*S. veitchii* (Carrière) Rehder; syn. *S. veitchii* var. *grandifolia* (Koidz.) Sad. Suzuki), Yahiko dwarf bamboo (*S. yahikoensis* Makino), and one species of another genus, northern bamboo (*Sasamorpho borealis* (Hack.) Nakai). The Crillon district is the area of utmost spread of bamboo thickets on Sakhalin. Here, they not only occupy the largest area as compared to the rest of the Sakhalin territory, but also reach their maximum taxonomic diversity. Northern bamboo (*Sasamorpho borealis*) and eight of nine species of the genus dwarf bamboo (*Sasa*) registered on Sakhalin (excluding Tatewaki dwarf bamboo (*S. tatewakiana*)) can be found in the Crillon district. It is noteworthy that Yahiko dwarf bamboo (*S. yahikoensis*) can be found only here. This fact highlights the exceptional development of bamboo thickets on the Crillon Peninsula, both in their extent and species richness. At the southern tip of Sakhalin, the height of Kuril bamboo in pure stands can reach heights of two meters or more. Under the forest canopy, bamboo grows in shaded conditions and remains much shorter. Bamboo plants retain green leaves throughout the winter and shed them in early summer, before new foliage appears (Tolmachev, 1956). Bamboo thickets play an essential role in protecting Sakhalin mountains from erosion during heavy rains and typhoons (Lashkov, 1965). They accumulate large amounts of dry plant material which makes them highly flammable and can promote the spread of wildfires. Bamboo rhizomes are not affected by fires, and bamboo thickets, unlike other vegetation communities, recover quickly and intensively invade the territories (Galanin and Galanina, 2008; Popov, 1969).

In some places along coastal slopes, sparse oak forests dominated by Japanese oak (*Quercus mongolica* var. *crispula* (Blume) H. Ohashi) (Fig. 4.7) with Meyer painted maple (*Acer pictum* subsp. *mayrii* (Schwer.) H. Ohashi) and Sargent's cherry (*Prunus sargentii* Rehder) can be found, but their spreading is rather limited. Sargent's juniper



Fig. 4.6. Japanese rowan (*Sorbus commixta*)

(*Juniperus chinensis* var. *sargentii* A. Henry; syn. *Juniperus sargentii* (A. Henry) Takeda ex Koidz.) is found on steep sea-facing cliffs. It is included in the Red Data Book of the Sakhalin Region (2019).

The lower layers of mountain forests include a wide variety of shrubs and lianas. Lianas in this area are prevalent due to the open tree canopy and humid climate, and they reflect the southern character of the local flora. Among them there are both quite large mature and young plants of species protected in the Red Data Book of the Sakhalin Region (Red List..., 2019), such as climbing hydrangea (*Hydrangea petiolaris* Siebold & Zucc.), kolomikta vine (*Actinidia kolomikta* (Maxim.) Maxim.) (Fig. 4.8), as well as crimson glory vine (*Vitis coignetiae* Pulliat ex Planch.) (Fig. 4.9). All the species above are widespread in horticulture, while the fruits of crimson glory vine (*V. coignetiae*) and kolomikta vine (*A. kolomikta*) are edible.

Among the shrubs of mountain forests, the most common species include Japanese angelica tree (*Aralia elata* (Miq.) Seem.), flat-stalked spindle tree

(*Euonymus planipes* (Koehne) Koehne), panicked hydrangea (*Hydrangea paniculata* Siebold), Sakhalin currant (*Ribes sachalinense* (F. Schmidt) Nakai), red elderberry (*Sambucus racemosa* L.), Japanese skimmia (*Skimmia japonica* var. *intermedia* Komatsu; syn. creeping skimmia *Skimmia repens* Nakai) (Fig. 4.10), tsuruholly (*Ilex rugosa* F. Schmidt), Small's blueberry (*Vaccinium smallii*) (Fig. 4.11), forked viburnum (*Viburnum furcatum* Blume ex Maxim.) and others.

The mountain forests have quite diverse herb layer. Due to the humid warm climate and sufficiently intense insolation, here as well as in the forests of East Asia, numerous various ferns are found: Japanese hart's tongue fern (*Asplenium scolopendrium* subsp. *japonicum*) (Fig. 4.12), mighty moonwort (*Botrychium robustum* (Rupr.) Underw), thick-stemmed woodfern (*Dryopteris crassirhizoma* Nakai), giant tapering glade fern (*Deparia pterorachis* (Christ) M. Kato; syn. *Lunathyrium pterorachis* (Christ) Kurata), Asian cinnamon fern (*Osmundastrum cinnamomeum* subsp. *asiaticum* (Fernald) Fraser-Jenk.; syn. cinnamon



Fig. 4.7. Japanese oak (*Quercus mongolica* var. *crispula*)



Fig. 4.8. Kolomikta vine (*Actinidia kolomikta*)

fern *Osmundastrum asiaticum* (Fern.) Tagawa), long beech fern (*Phegopteris connectilis* (Michx.) Watt.), Braun's hollyfern (*Polystichum braunii* (Spenn.) Fee), trifold holly fern (*Polystichum tripterum* (G. Kunze) C. Presl) and others. The following plants can often be found on mountain slopes: Japanese herbal aralia (*Aralia cordata* Thunb.), Canadian bunchberry (*Cornus canadensis* L.), umbrella leaf (*Podophyllum grayi* (F. Schmidt) Christenh. & Byng; syn. *Diphyllaea grayi* F. Schmidt), slender lily (*Lilium debile* Kittlitz), false lily of the valley (*Maianthemum dilatatum* (Alph. Wood) A. Nelson & J. F. Macbr.), May lily (*Maianthemum bifolium* (L.) F. W. Schmidt), Solomon's seal (*Polygonatum odoratum* var. *maximowiczii* (F. Schmidt) Koidz.; syn. *Polygonatum maximowiczii* F. Schmidt), arctic starflower (*Lysimachia europaea* (L.) U. Manns & Anderb.; syn. *Trientalis europaea* L.). Species of the tall-forb communities are often found on the mountain slopes: Ezo angelica (*Angelica ursina* (Rupr.) Maxim.), Kamchatka meadowsweet (*Filipendula camtschatica*



Fig. 4.9. Crimson glory vine (*Vitis coignetiae*)

(Pall.) Maxim.), giant butterbur (*Petasites japonicus* subsp. *giganteus* Kitam.; syn. broad butterbur *Petasites amplus* Kitam.) (Fig. 4.13), Aleutian ragwort (*Jacobaea cannabifolia* (Less.) E. Wiebe; syn. *Senecio cannabifolius* Less.) (Fig. 4.14), spear-leaved cacalia (*Hasteola robusta* (Tolm.) Pojark.; *Cacalia robusta* Tolm.) and heartleaf lily (*Cardiocrinum cordatum* (Thunb.) Makino; syn. *C. glehnii* (F. Schmidt) Makino).

In general, the tall-forb communities on the eastern coast of the Crillon Peninsula are found in river valleys (Fig. 4.15), in coastal meadows (Fig. 4.16) and, less frequently, on the slopes of coastal cliffs. In these communities, the height of plants exceeds 1 m, and in communities in the south of Sakhalin and in Northern Japan can reach 3.5–5.0 m (Belaya and Morozov, 2000). Such communities can exist due to several environmental factors. First, the mean annual relative air humidity is around 75–76 %, being lower at the beginning of growth period and increasing in the second half of the vegetation season. Second, a thick and persistent snow cover plays an important role of covering the buds of the plants during the winter. Typical species of tall-forb communities in the study area are: Ezo angelica (*Angelica ursina*), heartleaf lily (*Cardiocrinum cordatum*), Kamchatka thistle (*Cirsium kamtschaticum* Ledeb. ex DC.), Kamchatka meadowsweet (*Filipendula camtschatica*), American cow-parsnip (*Heracleum maximum* W. Bartram), spear-leaved cacalia (*Hasteola robusta*), giant butterbur (*Petasites japonicus* subsp. *giganteus*), Sakhalin knotweed (*Reynoutria sachalinensis* (F. Schmidt) Nakai.) and Aleutian ragwort (*Jacobaea cannabifolia*). Closer



Fig. 4.10. Japanese skimmia (*Skimmia japonica* var. *intermedia*).
Left: plant with fruits; right: specimen on a hillside in the
fir forest



Fig. 4.11. Small's blueberry (*Vaccinium smallii*)



Fig. 4.12. Japanese hart's tongue fern (*Asplenium scolopendrium*
subsp. *japonicum*)

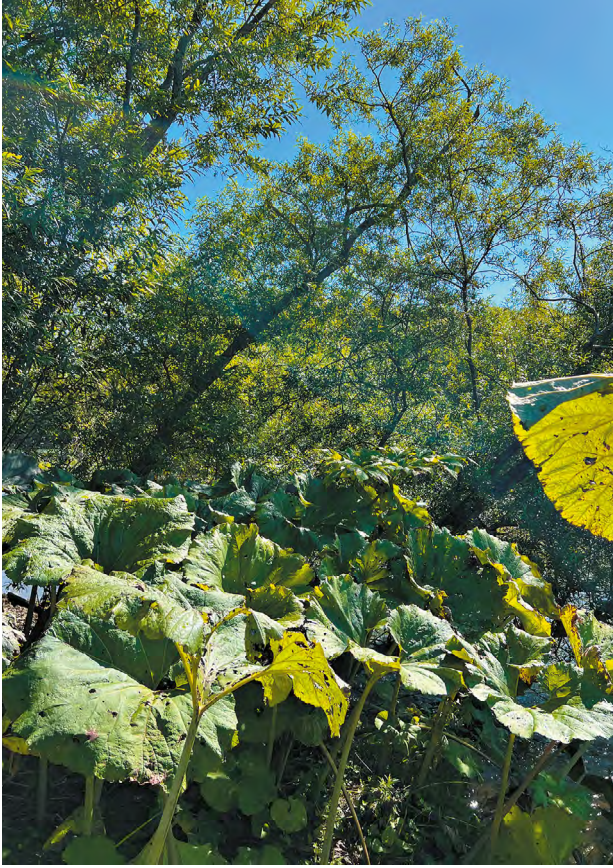


Fig. 4.13. Giant butterbur (*Petasites japonicus* subsp. *giganteus*)

to riverbanks, there are dense stands of purple reed grass (*Calamagrostis purpurea* (Trin.) Trin.) and reed canary grass (*Phalaris arundinacea* L.) (Stepanova, 1956).

Heartleaf lily (*C. cordata*) comes from the lily family (Liliaceae) that grows only in Japan, Sakhalin, and the Kuril Islands. It flowers in spring, producing inflorescences with large white flowers, and the flowering stalk can reach up to 2 m in height. The distribution of Ezo angelica (*A. ursina*) across Kamchatka, Sakhalin, and the Kuril Islands is not less spectacular. This perennial herbaceous plant, which flowers only once in its lifetime (monocarpic), is one of the largest representatives of the celery (Apiaceae) family; its height may reach up to 5 m. Ezo angelica has a powerful unbranched rhizome and a thick vertical root. Single hollow stems reach 8–10 cm in diameter at the bottom (Belaya, Morozov, 2000). The plant is consumed by both humans and bears. Wild species of giant butterbur (*P. japonicus* subsp. *giganteus*; family Asteraceae) are found only in Japan, Sakhalin, and the Kuril Islands; it forms powerful leaf stalks up to 2 m tall bearing enormous leaves with a surface area of up to 1.3 m².

In Korea and Japan young shoots of giant butterbur are used as a delicacy after processing to remove toxic alkaloids, its extracts have anticancer, antioxidant, and other properties (Seo et al., 2008; Lee et al., 2019). Sakhalin knotweed (*R. sachalinensis*) grows wild in Japan, Sakhalin, and the Kuril



Fig. 4.14. Aleutian ragwort (*Senecio cannabifolius*). Left: inflorescences; right: typical leaves



Fig. 4.15. Tall-forbs of the Crillon river valleys

Islands. This species was introduced to European countries and the USA (Pyšek and Prach, 1993; Šírka et al., 2013) and has since been actively invading and capturing new territories, causing significant economic and ecological harm (Lavoie, 2017). Sakhalin knotweed (*R. sachalinensis*) is included in the Black Books and lists of invasive species (Vinogradova et al., 2010). This plant vegetates through a branched network of powerful rhizomes, one of which can cover an area of up to 30 m² (Belaya, Morozov, 2000). Kamchatka meadowsweet (*F. camtschatica*) growing in Korea, Japan, Sakhalin, and the Kuril Islands, belongs to the rose family (Rosaceae). It also keeps up in size, reaching a height of 3.5 m; it blooms with large white panicle inflorescences from July to August. In general, all plants of tall-forb communities can vegetate rather rapidly, growing sometimes up to 10 cm per day (Belaya, Morozov, 2000). The tuber-bulbous orchid *Cremastra appendiculata* (*Cremastra appendiculata* var. *variabilis* (Blume) I.D. Lund; syn. *Cremastra*



Fig. 4.16. Tall-forbs of the Crillon coastal meadows

variable, *C. variabilis* (Blume) Nakai), included in the Red Data Book of the Sakhalin Region (2019), grows in small but frequently occurring groups on fertile soils in the lower layer of the described communities. Near the seashore, next to river valleys under the canopy of Ezo angelica (*A. ursina*) and other representatives of tall-forbs, there can be found another Red Data Book plant phacellanthus (*Phacellanthus tubiflorus* Siebold et Zucc.). It is the only species of the genus *Phacellanthus* Siebold & Zucc., herb parasitic plants of the broomrape family (Orobanchaceae). They are characterised by the absence of chlorophyll and leaves: their thick stem, hidden in leaf litter, is covered with colourless scales. Only inflorescences of tubular flowers rise to the soil surface, from which rounded fruits subsequently develop (Chung et al., 2010).

In floodplains and along riverbanks on the east coast of the Crillon Peninsula, willow stands of Schwerin's willow (*Salix schwerinii* E. Wolf subsp. *yezoensis* (C.K. Schneid.) Worosch) (Fig. 4.17),



Fig. 4.17. Uda willow (*Salix udensis*). Left: general view of the tree; right: the cracked bark of the willow

Uda willow (*Salix udensis* Trautv. & Mey.) and Manchurian alder (*Alnus hirsuta* (Spach) Fisch. ex Rupr.) can be found. In some of the most humid areas, thickets of Rough horsetail (*Equisetum hyemale* L.) can be found (Fig. 4.18), and in others areas can be found representatives of tall-forb communities that grow under the forest canopy: Sakhalin knotweed (*R. sachalinensis*), Kamchatka meadowsweet (*F. camtschatica*), robust cacalia (*H. robusta*) and others. Other moisture-loving plants also grow in these communities: cow parsley (*Anthriscus sylvestris* (L.) Hoffm.), broadleaf nettle (*Urtica platyphylla* Wedd.), ostrich fern (*Matteuccia struthiopteris* (L.) Todaro), yellow avens (*Geum aleppicum* Jacq.), largeleaf avens (*Geum macrophyllum* var. *macrophyllum* Willd.), creeping buttercup (*Ranunculus repens* L.), Glehn's aster (*Aster glehnii* F. Schmidt) and different species of monkshood *Aconitum* sp. The shrub layer is poorly represented in river floodplains, and red elderberry (*Sambucus racemosa*) is the most common here. Alder forests are characterised by purple reed grass (*Calamagrostis purpurea*) and different species of sedges (Stepanova, 1956).

Quite extensive waterlogged forests dominated by Sakhalin fir (*Abies sachalinensis*) with an extremely rare admixture of Dahurian larch (*Larix gmelinii* (Rupr.) Göpp.) may occur in river valleys (Fig. 4.19). Their undergrowth layer includes such shrubs as Japanese holly (*Ilex crenata* Thunb.), tsuru holly (*I. rugosa*), Labrador tea (*Ledum hypoleucum* Kom.), Japanese skimmia (*Skimmia japonica* var. *intermedia*), Sakhalin currant (*Ribes sachalinense*), Small's



Fig. 4.18. Manchurian alder (*Alnus hirsuta*) and thickets of Rough horsetail (*Equisetum hyemale*)



Fig. 4.19. Sakhalin fir (*Abies sachalinensis*)

blueberry (*Vaccinium smallii*). The following plants can be found among very diverse herbs of wetland forests: Kamchatka thistle (*Cirsium kamtschaticum*), creeping dogwood (*Cornus canadensis*), erect hosta (*Hosta rectifolia* Nakai), white skunk cabbage (*Lysichiton camtschatcensis* (L.) Schott), May lily (*Maianthemum bifolium*), Asian cinnamon fern (*Osmundastrum cinnamomeum* subsp. *asiaticum*), long beech fern (*Phegopteris connectilis* (Michx.) Watt.), Sakhalin butterfly orchid (*Platanthera sachalinensis* F. Schmidt) and arctic starflower (*Lysimachia europaea*). Eastern clubrush (*Scirpus orientalis* Ohwi) and bulrush (*Typha latifolia* L.) occur in open, more well-lit areas. Different species of sphagnum mosses *Sphagnum* sp. are not uncommon in swampy depressions in such forests (Fig. 4.20).

Meadow grassland communities of different formations are observed in open spaces near the seashore (Gordeev et al., 2024; Rozhkova-Timina, 2024). Coastal *Leymus*-dominated communities are among them, with the dominant species being sea-lyme grass (*Leymus mollis* (Trin.) Pilg.), while sea pea (*Lathyrus japonicus* Willd.) and other plant species occur less frequently. Other formations include mixed grass-forb and reed-bamboo communities, where the dominant species are Kuril dwarf bamboo (*Sasa kurilensis*) and common reed (*Phragmites australis* (Cav.) Trin. ex Steud.), as well as Glehn's aster (*Aster glehnii*), seabeach groundsel (*Jacobaea pseudoarnica* (Less.) Zuev) (Fig. 4.21) and other species of herbs, as well as a shrub of beach rose (*Rosa rugosa* Thunb.).

Another community in the described area is wet coastal meadows, combining a variety of plant species already mentioned in other communities: species specific of tall-forb communities that tolerate



Fig. 4.20. Spiky bogmoss (*Sphagnum squarrosum*)

significant moistening, for example, white skunk cabbage (*Lysichiton camtschatcense*) and other plants.

The lithophytic communities on coastal rocky outcrops should be noted separately (Fig. 4.22). These habitats are exposed to harsh conditions, which affect both species composition and plant appearance. These communities include almost no trees or shrubs, except for abundant thickets of beach rose (*Rosa rugosa*) (Fig. 4.23) as well as isolated plants of montane alder (*Alnus maximowiczii* Callier) and Sakhalin currant (*Rubus sachalinensis*), which can be found on gentler slopes. The herb perennial plants include goat's beard (*Aruncus dioicus* (Walter) Fernald), fringed pink (*Dianthus superbus* L.), Kamchatka plantain (*Plantago camtschatica* Link), goldenrod (*Solidago dahurica* (Kitag.) Kitag. ex Juz.), aizoon stonecrop (*Phedimus aizoon* (L.) 't Hart), Kamchatka sedum (*Phedimus kamtschaticus* (Fisch.) 't Hart) and lanceleaf thermopsis (*Thermopsis lanceolata* R. Br.). Brittle bladder fern (*Cystopteris fragilis* (L.) Bernh.), fragrant woodfern (*Dryopteris fragrans* (L.) Schott), Sakhalin saxifrage (*Micranthes sachalinensis* (F. Schmidt) S. Akiyama & H. Ohba) and polystichoid cliff fern (*Woodsia polystichoides* D.C. Eaton) (Fig. 4.24) can be found on the most humid parts of steep cliffs.

Overview of the bryophyte flora

Due to climatic and microclimatic conditions, bryophytes (mosses and liverworts) constitute a prominent component of the plant communities on the Crillon Peninsula. They are found on the tree bark, stones, soil, coniferous litter, fallen logs, moist



Fig. 4.21. Seabeach groundsel (*Jacobaea pseudoarctica*)

rocky screes, soil near streams, and generally on a wide variety of substrates (Fig. 4.25). Although the bryoflora of the area remains insufficiently studied yet, available evidence indicates that it shows rich diversity of species, including rare ones. Thus, as a result of the 'Crillon 2023' expedition (Gordeev et al., 2024), seven species of bryophytes not previously recorded on Sakhalin (Bakalin et al., 2012) were discovered: *Orthotrichum consobrinum* Cardot., *Brachytheciastrum trachypodium* Funck ex Brid.) Ignatov & Huttunen, Kono's schistidium (*Schistidium konoii* (Broth.) Ignatova & H. H. Blom), *Wiesnerella denudata* ((Mitt.) Stephani), *Frullania austinii* (J. J. Atwood, Vilnet, Mamontov & Konstant.), *Frullania takayuensis* Stephani, and *Taxiphyllum aomoriense* (Besch.) Iwats, included in the Red Data Book of the Sakhalin Region (2019). The most frequently occurring mosses in the surveyed area are: *Trachycystis flagellaris* (Sull. & Lesq.) Lindb., *Callicladium haldanianum* (Grev.) H. A. Crum, *Thamnobryum neckeroides* (Hook.) E. Lawton,



Fig. 4.22. Tall-forbs near rock communities

Myuroclada longiramea (Müll. Hal.) Min Li, Y. F. Wang, Ignatov & Huttunen), *Sciuro-hypnum reflexum* (Starke) Ignatov & Huttunen and *Aquilonium adscendens* (Lindb.) Hedenäs, Schlesak & D. Quandt. Sphagnum hollows containing *Sphagnum girgensohnii* Russow, *Sphagnum riparium* Angstr., and *Sphagnum squarrosum* Crome (Yatsenko, 2023, Gordeev et al., 2024) were found in wetlands under the fir forest canopy.

Alien plants of the east coast of the Crillon Peninsula

When describing the vegetation of any territory, it is important to consider the alien plant species of the area, which are not specific for the native communities. According to the Black Book of the Far East Flora (Vinogradova et al., 2021), Sakhalin Region ranks third among the subjects of the Far



Fig. 4.23. Beach rose (*Rosa rugosa*)

Eastern Federal District (FEFD) in terms of the invasive species amounting to 99 plant species, which is 85 % of all registered in the FEFD. According to another publication, Sakhalin counts 288 species of alien plant species (including introduced species and those that have escaped cultivation) accounting for 18.9 % of the island's vascular plant flora. Most of the adventive species have spread almost throughout its entire territory (Barkalov, Taran, 2004).

However, during surveys of the east coast of the Crillon Peninsula conducted in 2023, only five alien plant species were registered in native forest and coastal communities; only two of them were included in the Black Book of the Far East Flora (Vinogradova et al., 2021). The result is not surprising, as the main vectors of invasion are roads and railroads through which 96 % of invasive species disperse (Vinogradova et al., 2021); the area explored is currently almost devoid of transportation infrastructure. Moreover, many alien plant species are unable to establish within intact natural communities and prefer anthropogenic and affected habitats, however, in the recent past, the east coast of the Crillon Peninsula has been almost devoid of anthropogenic impact and synanthropic habitats. In natural communities, biological invasions are thought to occur most often in coastal, littoral, and riverine habitats (Vinogradova, Reshetnikova, 2016), and this pattern holds true for the east part of the Crillon Peninsula.



Fig. 4.24. Holly fern woodsia *Woodsia polystichoides*

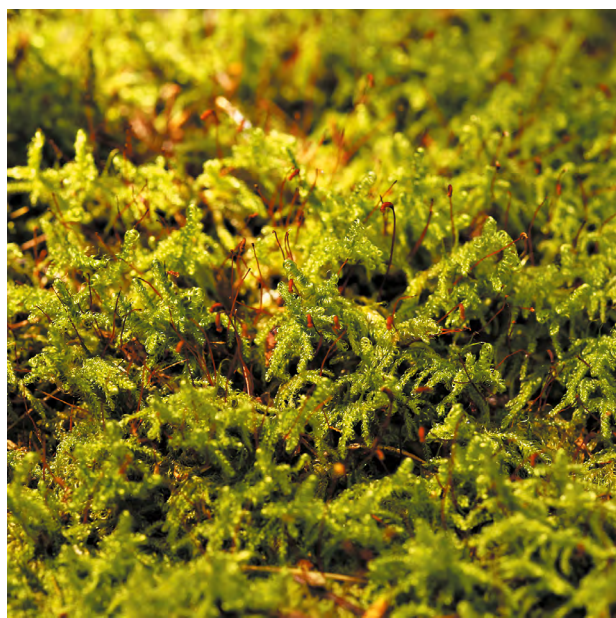


Fig. 4.25. *Sanionia uncinata*

The composition of alien plant species is of particular interest, as it can provide insights into their pathways of introduction to the island. Broadleaf plantain (*Plantago major* L.) is the most common alien species on the Aniva coast of Crillon (Fig. 4.26). It is a long-naturalised synanthropic plant native to Eurasia with an almost cosmopolitan secondary range. It rarely invades the unaffected natural communities, and it is therefore present at the described area either where there has been at least minimal anthropogenic impact during the period of absence of economic activity or in littoral habitats. Another species of this genus, ribwort plantain (*Plantago lanceolata* L.), originating from meadow communities in Europe, has been introduced and spread to North America (Hanley, 2012), as well as in Africa and East Asia. This species appeared in the south of Sakhalin in the first half of the 20th century, probably from Japan, where it was introduced a little earlier*.

American searocket (*Cakile edentula* (Bigelow) Hook.) of the cruciferous family (Brassicaceae) occurs naturally on the Atlantic coast of North America. Seeds of the searocket are spread by ocean currents, and therefore typical habitats of this species are supralittoral zones. This species can also grow on the shores of freshwater shorelines; for example, it is widespread along the shores of the Great Lakes. Outside its native range, the American searocket (*Cakile edentula*) has long been present. As early as the 19th century, it was apparently introduced unintentionally and subsequently spread along the Pacific coast of North America and the coasts of Australia, Tasmania, and New Zealand. In Asia, however, the species is a relatively recent arrival, with its first records in Japan dating to the 1990s (Ryu et al., 2018). The species was first recorded in Russia in the early 2000s, almost simultaneously in southern Primorye, Iturup Island, and Sakhalin (Korsakov District). There are no up-to-date data regarding the exact spread of the species on Sakhalin; it is not mentioned in the main floristic summaries (Barkalov, Taran, 2004), and the findings of 2023 (Gordeev et al., 2024) are probably the first records relating to the Anivsky District and Crillon Peninsula.

Red campion (*Silene dioica* (L.) Clairv.) from the pink family (Caryophyllaceae) is more often mentioned in the literature under older names

'*Melandrium dioicum*' or '*Melandrium rubrum*', as it was formerly assigned to the separate genus *Melandrium* Röhl. This species is specific for Europe, including the European part of Russia, where it is found in both natural and human-affected habitats. As an alien species, red campion (*Silene dioica*) is found in North and South America. The history of its naturalisation on Sakhalin is unclear. This species has been known in the flora of Japan since at least the middle of the 20th century, but it is not listed in most Sakhalin summaries. Only recently, with the development of the iNaturalist platform and other citizen science networks, available scientific data on the presence of this species on Sakhalin have begun to appear.

Chinese silver grass (*Miscanthus sinensis* Andersson) is a large ornamental grass (Fig. 4.27). In the Sakhalin Region, it occurs both as a native plant and as a wilding plant near the settlements of the Japanese period. The native habitats of this heat-loving species are often associated with areas of geothermal activity. Since Chinese silver grass



Fig. 4.26. Broadleaf plantain (*Plantago major*)

* GBIF.org (2025). GBIF Occurrence Download. <https://doi.org/10.15468/dl.3rvm47> (accessed 19 March 2025).

(*M. sinensis*) found in the described area occur without association with geothermal springs, but on an overgrown road near an abandoned Japanese port, it is logical to assume the cultural origin of this population.

The only places in the explored area where a variety of introduced species are found in large numbers are the abandoned settlements (Atlasovo border post, seaport on Cape Anastasia) and meadow communities where the economic activities were previously carried out. A large number of Eurasian meadow species grow here, such as orchard grass (*Dactylis glomerata* L.), meadow fescue (*Festuca pratensis* Huds.), red clover (*Trifolium pratense* L.), Kentucky bluegrass (*Poa pratensis* L.), fowl bluegrass (*Poa palustris* L.), timothy grass (*Phleum pratense* L.), etc. (Stepanova, 1956; Rozhkova-Timina, 2023; Rozhkova-Timina, 2024), which may be the result of the past economic use of the territory: grazing or hay production with overseeding of grass mixtures.

Plant species of the southern part of the eastern coast of the Crillon peninsula listed in the Red Data Books of the Russian Federation and the Sakhalin region

Given the overall natural distinctiveness of Sakhalin and the location of the study area at the southern tip of the island it is not surprising that the area is characterised by a considerable number of protected plant species listed in the Red Data Book of Sakhalin Region (2019) as well as the Red Data Book of the Russian Federation (Order ..., 2023). There are no endemic species in this area, all protected plant species of the east coast of the Crillon Peninsula occur outside Sakhalin as well, and they are mainly characterised by East Asian distribution ranges. In Russia, these species are located at the northern or north-eastern boundary of their range, which makes them vulnerable and one of the main reasons for their inclusion in protected species lists. Another, often additional, reason is the fact that these plants may have economic importance: they may be used for food, as sources of valuable wood, or as raw materials for conventional (scientifically based, practical) and alternative medicine. Populations at the northern limit of their range can be very unstable and cannot withstand the pressure from harvesting

even limited amounts of plant material; therefore, the plant species are assigned a conservation status for their protection. All protected plant species of the southern east coast of the Crillon Peninsula are also found outside Russia, on the Japanese island of Hokkaido, which is only 43 km south of Cape Crillon. In addition to Japan, the protected plant species of Crillon may grow naturally in other East Asian countries, most commonly in China and Korea, and two species, northern maidenhair fern (*Adiantum pedatum* L.) and Wright's filmy fern (*Hymenophyllum wrightii* Bosch), have ranges in North America as well. In Russia, the ranges of these protected species may cover either only the Crillon area (14th floral region (Tolmachev, 1955)), including Anivsky, Nevelsky, Kholmsky, and partially Tomarinsky administrative districts, or have a wider range within the island. These species are often found not only on Sakhalin but on Moneron and the Southern Kuril Islands as well. The protected species with extensive ranges may also occur in the southern continental Russian Far East.



Fig. 4.27. Chinese silver grass (*Miscanthus sinensis*)

Among the east coastal plants of Crillon listed in the Red Data Book of the Russian Federation and Sakhalin Region, only two species, heartleaf lily *Cardiocrinum cordatum* and *Ephippianthus sachalinensis* Rchb. f., have a Rarity Status Category 2 – ‘declining in abundance and/or distribution’; these species are in subcategory a) ‘taxon whose abundance is declining due to changes in subsistence conditions or habitat destruction’; most species have Rarity Status Category 3 – rare: ‘taxon with naturally low abundance, occurring in a limited area or sporadically distributed over significant areas, for the survival of which special protection measures are required’ with subcategories: b) having a significant range, within which they occur sporadically and with small populations; d) having a significant total range, but located within Russia at the border of distribution; and e) having a limited range, part of which is located in Russia. One species, woodland peony (*Paeonia obovata* Maxim.), has a Rarity Status Category 4 ‘species of uncertain status, taxa that probably belong to another category or require special protection measures’, while Japanese herbal aralia (*Aralia cordata*) is included in the Red Data Book of the Sakhalin Region with a Rarity Status Category 5, regenerating and regenerated species: ‘taxa which abundance and distribution area regenerate under the influence of natural causes or as a result of protection measures taken and approach the state of no necessity of special conservation and regenerating measures’ (Red Data Book..., 2019). However, at the federal level, the category of this species is rated differently: 3 – rare species.

The categories of threat status specified by the federal Red Data Book for Crillon plants are the following: EN – Endangered; VU – Vulnerable; and NT – Near Threatened (Order ..., 2023). All protected species belong to the same category of conservation status, i.e., the degree and priority of conservation measures taken and planned to be taken: Priority III. For this priority, the ‘general measures provided for by the regulations of the Russian Federation in the field of environmental protection, organisation, protection and use of specially protected natural areas and protection and use of wildlife and its habitat’ are deemed sufficient.

In the southern east coast of the Crillon Peninsula, 21 plant species included in the Red Data Book of the Russian Federation and Sakhalin Region vegetate.

1. Northern maidenhair fern (*Adiantum pedatum* L.)
Adiantaceae Family – Adiantaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

A fern up to 30 cm high, with a thin creeping rhizome. Fronds are solitary on shiny black-brown thin long petioles. Leaf blades are broadly fan-shaped, divided into two twice-pinnately dissected parts. It is registered only in the southern half of Sakhalin Island (Smirnykhovsky, Korsakovsky, Anivsky districts) and in the Russian Far East: Moneron, Kunashir, and Shikotan islands, Primorsky Region, Amur Region, and southern Khabarovsk Region. The general distribution is extensive: Himalayas, China, Japan, Korean Peninsula, North America (Alaska and eastern part). It grows in deciduous and coniferous and broadleaf forests, usually in semi-shaded areas.

2. Japanese herbal aralia (*Aralia cordata* Thunb.)
Ginseng Family – Araliaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: NT – Near Threatened.

Red Data Book of the Sakhalin Region: category and status within the Region 5: regenerating species.

Large herb perennial up to 2 m high. In Russia, it is found only in the Sakhalin region, where it is found at the northern boundary of its range: Sakhalin (in all administrative districts except Okhinsky, Noglikovsky, Tymovsky, and Poronaysky); in the southern part, it is observed everywhere; in the middle part, it runs to the coast of the Tatar Strait; Southern Kuril Islands. Outside Russia, it is spread in Japan, Taiwan, South and South-eastern China. It grows in mixed and coniferous forests, usually on forest edges, clearings, and cuttings, along roads, in shrubs and herbs, sometimes in bamboo thickets, often on coastal plateaus. The Red Data Book of the Sakhalin Region specifies the abundance of the species, stable population status, and possible restart of harvesting for medicinal raw materials and food purposes.

3. Japanese angelica tree (*Aralia elata* (Miq.) Seem.)
Ginseng Family – Araliaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

An erect, sparsely branched shrub up to 3 m high with brownish-grey bark covered with numerous

strong, sharp triangular spines and compound, twice-pinnate leaves up to 80 cm long. In the Sakhalin Region, it is found at the limit of spread only in the southern quarter of Sakhalin and the Southern Kuril Islands. In Russia, it is also observed in Primorsky and Khabarovsk Regions and the Jewish Autonomous Region. Outside Russia, it can be found in China, Japan, and the Korean Peninsula. It grows in sunny areas in coniferous and mixed, usually secondary forests, below slopes, on forest edges, clearings, and windfall sites.

4. Heartleaf lily *Cardiocrinum cordatum* (Thunb.) Makino (syn. *Cardiocrinum glehnii* (F. Schmidt) Makino)

Lily family – Liliaceae

Red Data Book of the Russian Federation: rarity status category 2, species declining in abundance and/or distribution; endangered status category: EN – Endangered.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

A large perennial monocarpic plant (Fig. 4.28), reaching 2.2 m in height. In Russia, it is at the northern limit of distribution. Found only in the southern half of Sakhalin (where the species was first described) and on the Southern Kurils, on Kunashir and Iturup islands. Outside Russia, it is spread in Japan (Hokkaido and Honshu islands). It is found in sparse deciduous and mixed forests along river valleys, on slopes of marine terraces, and in thickets of tall-forbs. It prefers nitrogen-rich, loose, constantly moistened soils, deep snow cover.

5. Coniogramme intermedia (*Coniogramme intermedia* Hieron.)

Pteridaceae Family – Pteridaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

A perennial fern with a long creeping rhizome. Fronds are slender, once or twice-pinnately dissected, up to 70 cm long on smooth dark brown petioles. In Russia, the species is found at the northern boundary of its range. It appears in the southern part of Sakhalin (Tomarinsky, Dolinsky, Kholmsky, Anivsky, and Nevelsky Districts). In Russia, it is also registered on the islands of Moneron, Kunashir, and Shikotan, in Primorsky and



Fig. 4.28. Heartleaf lily (*Cardiocrinum cordatum*)

Khabarovsk Regions. Outside Russia, it is found in Japan, China, the Himalayas, Indochina, the Korean Peninsula and the island of Taiwan. It grows in primary moist fir and mixed forests, alder forests and thickets of tall-forbs, usually in hollows near springs. Moisture- and warm-loving plant.

6. Cremastra variable (appendiculata) (*Cremastra appendiculata* var. *variabilis* (Blume) I.D. Lund; syn. *Cremastra variabilis* (Blume) Nakai)

Orchid family – Orchidaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: NT – Near Threatened.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

Perennial winter-green herb with a stem up to 40 cm high, thickened in the lower part into an ovoid false bulb, and a chain-shaped rhizome. In Russia, it is at the northern limit of its range, occurring only in the Sakhalin Region in the southern part of Sakhalin Island (vicinity of Yuzhno-Sakhalinsk, Uglegorsky, Tomarinsky, Korsakovsky, Kholmsky, Nevelsky, and Anivsky districts, in the latter it was found for the first time by the combined research expedition 'Crillon-2023') and

on Kunashir Island. Outside Russia, it is found in Japan and on the Korean Peninsula. It grows in fir, coniferous and broadleaf and deciduous forests, among tall-forbs, on loose, humus-rich, damp soils.

7. Umbrella leaf (*Podophyllum grayi* (F. Schmidt) Christenh. & Byng; syn. Gray's umbrella-leaf *Diphylleia grayi* F. Schmidt)

Barberry family — Berberidaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: NT — Near Threatened.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

Perennial herb with creeping rhizome and stem up to 100 cm high (a relict species first described from Sakhalin). In Russia, where the northern limit of its range lies, it occurs sporadically in the middle and southern parts of Sakhalin (all administrative districts except Okhinsky), on Moneron, and in the Southern Kurils (Iturup and Kunashir islands). Outside Russia, it is widespread in Japan. It grows in damp shady places, on fertile soils under the canopy of coniferous and broadleaved, spruce-fir and stone birch forests, in thickets of tall-forbs, from river valleys to the middle level of mountains.

8. *Ehippianthus schmidtii* Rechb. f. (syn. Sakhalin Saddleflower *Ehippianthus sachalinensis* Rechb. F.)
Orchid family — Orchidaceae

Red Data Book of the Russian Federation: rarity status category 2, species declining in abundance and/or distribution; endangered status category: VU — Vulnerable.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

A miniature perennial (10–20 cm) plant with a filamentous horizontal rhizome and single simple entire broadly ovate basal leaf up to 3 cm long, with clearly expressed reticulate venation. Flowers are small, yellow-green, arranged in a loose raceme of 2–5 flowers. It is found at the north-eastern boundary of its range. On Sakhalin Island it is found in Aleksandrovsk-Sakhalinsky, Smirnykhovsky, Uglegorsky, Makarovsky, Dolinsky, Anivsky, Korsakovsky and Nevelsky districts. In Russia, it is also observed in the Kuril Islands, Khabarovsk and Primorsky Regions. Outside Russia, it is found in Japan (Hokkaido Island).

9. Climbing Hydrangea (*Hydrangea petiolaris* Siebold et Zucc.)

Hydrangea family — Hydrangeaceae

Red Data Book of the Russian Federation: rarity

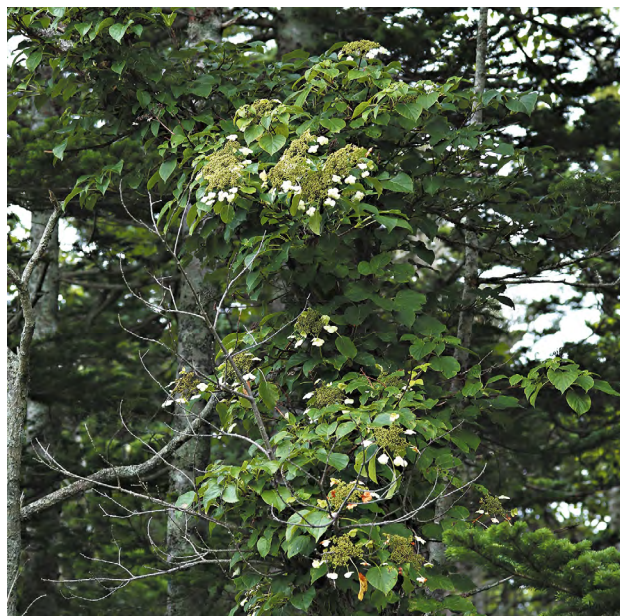


Fig. 4.29. Climbing Hydrangea (*Hydrangea petiolaris*). Left: adult plant; right: young plants



Fig. 4.30. Crenate holly (*Ilex crenata*)

status category 3, rare species; endangered status category: NT – Near Threatened.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region. Woody liana that ascends the trunks of coniferous and deciduous trees using thin aerial sucker roots to a height of up to 15 m (Fig. 4.29). In Russia, it occurs only in the Sakhalin region, at the north-eastern boundary of distribution: the southern half of Sakhalin Island and the Southern Kuril Islands. Outside the Russian Federation, it is widespread in Japan and the Korean Peninsula. It appears in fir-spruce, mixed, and stone birch forests, on light-brown forest moistened soils closer to the sea coast. In the absence of support, it can climb on rocks and stumps, and spread along the ground.

10. Crenate holly (*Ilex crenata* Thunb.)

Holly family – Aquifoliaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

Evergreen highly branching shrub with greyish bark, up to 1 m high on Sakhalin, up to 4 m, rarely up to 10 m high in more southern areas (Fig. 4.30). The species is common in the Southern Kuril Islands and

Moneron Island; on Sakhalin it is found rarely and only in the southern half of the island (Tomarinsky, Makarovskiy, Dolinsky, Kholmsky, Korsakovskiy, Anivskiy and Nevelskiy districts). Most of the range is located in China, Japan and the Korean Peninsula. It grows singly or in small groups in dark coniferous and stone birch forests, Sasa thickets, and among tall-forbs.

11. Sargent's Juniper (*Juniperus chinensis* var. *sargentii* A. Henry (*Juniperus sargentii* (A. Henry) Takeda ex Koidz.))

Cypress family – Cupressaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: NT – Near Threatened.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

An evergreen creeping dioecious shrub with a long main stem and ascending side branches (Fig. 4.31). It can reach 1.5 m in height in natural conditions. In Russia, it is found only in the southern part of Sakhalin Island (Aleksandrovsk-Sakhalinsky, Uglegorsky, Tomarinsky, Makarovskiy, Dolinsky, Kholmsky, Korsakovskiy, Nevelskiy, and Anivskiy districts, in the latter it was found for the first time by the combined research expedition 'Crillon-2023'), on Moneron Island and the Southern Kuril Islands. Outside Russia, it is found on the islands of Hokkaido and Honshu (Japan). It grows on sand dunes and rocky, often steep cliffs of the sea coast, less often in mountains, on slopes up to 600 m above sea level. A light-loving, highly ornamental shrub that prevents soil erosion.

12. Prickly castor oil tree (*Kalopanax septemlobus* (Thunb.) Koidz.)

Ginseng Family – Araliaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: VU – Vulnerable.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

Deciduous tree up to 20 m high, whose branches, as well as the trunks of young trees, are covered with thorns up to 2 cm long (Fig. 4.32). Leaves are simple, alternate, palmately lobed, up to 20 cm in diameter. Relict representative of a monotypic genus. In Russia, it is found at the northern



Fig. 4.31. Sargent's Juniper (*Juniperus chinensis* var. *sargentii*). Left: fragment of juniper and sedum shoots; right: general habit of the plant

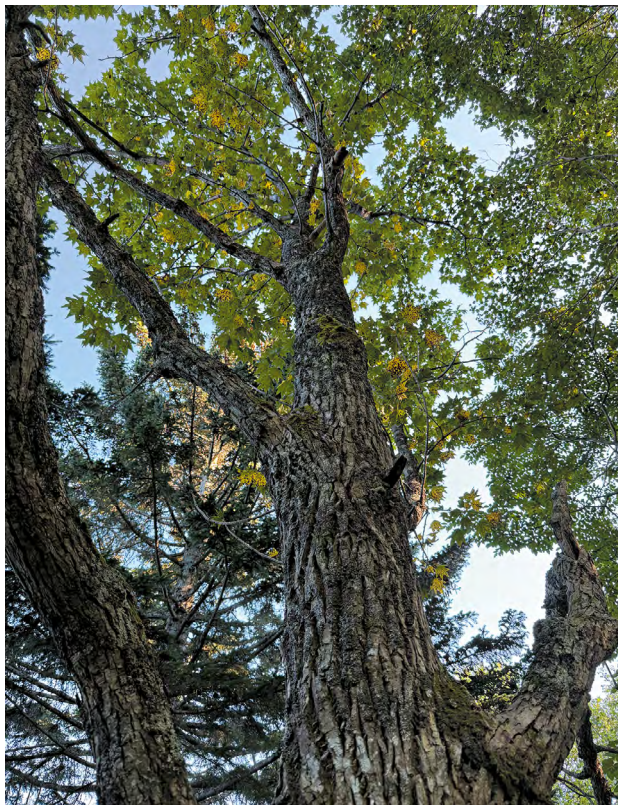


Fig. 4.32. Prickly castor oil tree (*Kalopanax septemlobus*). Left: crown of an adult tree; right: young plants



Fig. 4.33. Wright's filmy fern (*Hymenophyllum wrightii*)

boundary of its range. On Sakhalin, it appears only in the southwestern part of the island (Tomarinsky, Kholmsky, Anivsky and Nevelsky districts). In Russia, it is registered on Moneron Island and the Southern Kuril Islands, as well as in the south of Primorsky Region. Outside Russia, it is widespread in China, Japan, and the Korean Peninsula.

13. Wright's filmy fern (*Hymenophyllum wrightii* Bosch; syn. Wright's mecodium *Mecodium wrightii* (Bosch) Copel.)
Hymenophyllaceae Family – Hymenophyllaceae
Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: VU – Vulnerable.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3b: a rare species with a significant range, within which it appears sporadically and in small populations.

A small, graceful fern up to 4 cm high, often submerged in moss cover (Fig. 4.33). In Russia, it is found at the northern boundary of its range. It is scattered throughout Sakhalin Island, as well as in the Southern Kuril Islands and Primorsky Region. Outside Russia, it is widespread in Japan and North America. It grows in dark coniferous and mixed forests, usually in river valleys and strands, on moist shaded rocks and boulders, sometimes on stumps and tree trunks.

14. Hokkaido bird cherry (*Prunus ssiori* F. Schmidt; syn. *Padus ssiori* (F. Schmidt) C.K. Schneid.)

Rose Family – Rosaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

Deciduous straight-trunked tree up to 7 (12) m high with dark grey bark, dark brown shiny young stems and large entire elliptical leaves up to 15 cm long (Fig. 4.34). In Russia, Hokkaido bird cherry grows at the northern boundary of range, appearing only in the southern half of Sakhalin Island, where it was first described as a species, on Moneron Island and the Southern Kuril Islands, and in Japan. It grows in mixed, fir and spruce and stone birch forests, more often in the lower part of slopes, in sunlit areas. Light-loving mesophyte, mesotroph.

15. Woodland peony (*Paeonia obovata* Maxim.)

Peony Family – Paeoniaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: VU – Vulnerable.

Red Data Book of the Sakhalin Region: the category and the status within the Region 4: species of uncertain status.

A large perennial herb up to 60 cm high. The species is widespread in the southern and middle parts of Sakhalin Island, Kunashir, Iturup and Shikotan islands. In the Russian Far East, it is registered on Moneron Island, the Southern Kuril Islands, Primorsky Region, Amur Region, Jewish Autonomous Region, and in the south of Khabarovsk



Fig. 4.34. Hokkaido bird cherry (*Prunus ssion*). Left: foliage; right: tree bark



Fig. 4.35. *Phacellanthus tubiflorus*



Fig. 4.36. Sakhalin cork tree (*Phellodendron sachalinense*). Left: foliage; right: bark of an adult plant

Region. Outside Russia, it is found in China, the Korean Peninsula and Japan. It appears in spruce and fir, coniferous and broadleaved, secondary small-leaved forests, as well as in brushwood, clearings and burned areas. It is natural in river valleys and lower parts of mountains.

16. *Phacellanthus tubiflorus* Siebold et Zucc.

Broomrape Family — Orobanchaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3g: a rare species with a significant total range but at the limit of distribution within the Region.

A mycoheterotrophic, non-chlorophyllic perennial herb 5–15 cm high, with numerous scales instead of leaves and a shield-like, almost head-like inflorescence of 2–10 zygomorphic pale coloured flowers (Fig. 4.35). In Russia, it is found at the north-eastern boundary of its range. On Sakhalin, it was known only in the extreme south-western part of the

island in the Nevelsky District before the discovery of its additional growing areas on the east coast of the Crillon Peninsula, found by the combined research expedition 'Crillon-2023'. In Russia, the species is also found on Kunashir Island, in the Amur Region and in the south of Primorsky Region, while outside Russia it is widely distributed in China, the Korean Peninsula and Japan. It grows in thickets of tall-forbs along river valleys and slope ravines near the sea coast. It blooms in July, fruits ripen in August and September.



Fig. 4.37. Japanese yew (*Taxus cuspidata*). Left: plant with fruits; right: general view of vegetative shoots

17. Sakhalin cork tree (*Phellodendron sachalinense* (F. Schmidt) Sarg.); currently, most researchers do not recognise it as an independent taxon and include it in the Amur cork tree taxon *P. amurense* Rupr. (Fig. 4.36).

Rue Family — Rutaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

The species was first described on Sakhalin. In Russia, it appears only in the southern half of Sakhalin Island (vicinity of Yuzhno-Sakhalinsk, Smirnykhovsky, Makarovsky, Tomarinsky, Dolinsky, Kholmsky, Korsakovsky, Anivsky and Nevelsky districts), as well as on the islands of Moneron, Iturup, Kunashir and Shikotan. Outside Russia, it is registered in Japan. It appears in mixed and deciduous, less often in dark coniferous forests, usually in the lower part of slopes or river valleys, alone or in small groups. It is demanding of soil fertility and drainage.

18. Japanese hart's-tongue fern (*Asplenium scolopendrium* subsp. *japonicum* (Kom.) Rasbach; syn. *Phyllitis japonica* Kom.)

Aspleniaceae Family — Aspleniaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

A perennial fern with a short, stout rhizome bearing a rosette of overwintering fronds. Its entire leaf blades reach a length of 30 cm and a width of 6 cm. It appears at the north-eastern boundary of its range. It appears in the south-western part of Sakhalin (the vicinity of Yuzhno-Sakhalinsk, Kholmsky, Nevelsky, and Anivsky districts, in the latter it was found for the first time by the combined research expedition 'Crillon-2023'), Moneron and Kunashir islands. In Russia, isolated localities are also known in Primorsky and Khabarovsk Regions. Outside Russia, it is registered in Japan, Taiwan, Northeast China and the Korean Peninsula.

It grows in coniferous and broadleaved and deciduous forests, thickets of tall-forbs, usually in moist, shaded places, on slopes, near strands and rocks.

19. *Pterigocalyx volubilis* Maxim.

Gentian Family — Gentianaceae

Red Data Book of the Sakhalin Region: the category and the status within the Region 3b: a rare species with a significant range, within which it appears sporadically and in small populations.

Perennial herb with a slender stem twining around shrubs and large grasses, up to 1 m long. It appears only in the southern part of Sakhalin Island (Makarovsky, Tomarinsky, Anivsky and Nevelsky Districts). In the Russian Far East, it is registered on Iturup Island, Amur Region, Primorsky and Khabarovsk Regions. Outside Russia, it is found in China, Japan, and the Korean Peninsula. It grows in shrubs and reed thickets, Sasa thickets, and on damp soil.

the species is found at the northern boundary of its range. It appears in the south of the island (Kholmsky, Anivsky, Korsakovsky, Nevelsky districts). In Russia, it is also known on the Southern Kuril Islands and Moneron Island; the species is natural for the Primorsky Region, appears in the south of Khabarovsk Region, Amur Region and in the Jewish Autonomous Region. East Asian species is distributed in Japan, China, and the Korean Peninsula. It grows in deciduous forests on the basal parts of trunks and on fallen wood, in stream ravines on exposed rubbly-clay substrates and on fine soil on rocky outcrops.

20. Japanese yew (*Taxus cuspidata* Siebold et Zucc. ex Endl.)

Yew Family — Taxaceae

Red Data Book of the Russian Federation: rarity status category 3, rare species; endangered status category: VU – Vulnerable.

Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

A dioecious evergreen tree or large shrub (Fig. 4.37). Average height is 3–10 m, maximum height is up to 20 m, trunk diameter is up to 60, less often up to 120 cm. On the Sakhalin seashore, it often takes on a prostrate form, 1.0–1.5 m high. A relict ornamental species growing at the north-eastern boundary of its range. In Sakhalin, recorded in all administrative districts except Okhinsky and Nogliksky. In the Russian Far East, it is also found on Moneron and the Kurils, in Primorsky Region and in the south of Khabarovsk Regions. Outside Russia, it is widespread on the Korean Peninsula, in Japan, and in north-eastern China. It grows in dark coniferous forests as well as coniferous and broadleaved forests, shrubs and Sasa thickets, less often on slopes, rocks and sand dunes near the sea. It appears singly or in groups of different-aged sample, occasionally forming dense thickets.

21. *Taxiphyllum aomoriense* (Besch.) Iwats.

Plagiotheciaceae Family — Plagiotheciaceae

The Red Data Book of the Sakhalin Region: the category and the status within the Region 3d: a rare species with a limited range, part of which is located within the Region.

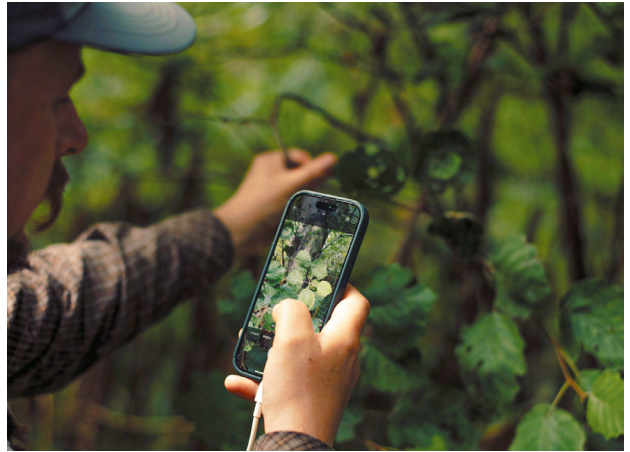
Medium-sized moss forms dense silky shiny whitish-green mats. In the Sakhalin Region,

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5 AGRO-CULTURAL UTILISATION OF THE REGION AND AVAILABLE DEVELOPMENT OPPORTUNITIES

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Sakhalin Island is conditionally divided into five agro-climatic areas, distinguished by different agricultural features and degrees of comfort for the population.

1. The northern part of the island (settlements: Okha, Rybnovsk, Pogibi, Chaivo, Nogliki) is unfavourable for living, recreation, and cultivation of agricultural crops; construction should foresee maximum heat, wind, and snow protection.
2. The west coast and the West Sakhalin Mountains (settlements: Alexandrovsk-Sakhalinsky, Lesogorsk, Ulegorsk, Krasnogorsk) are favourable for vegetable growing; the territory belongs to a moderately warm and humid agro-climatic area. Recreation can be arranged upon provision of protection from winter winds.
3. The east coast and the East Sakhalin Mountains (only the Pogranichny settlement is located on the coast) are unfavourable for living, recreation, and agriculture.
4. Tym-Poronaysk lowland (settlements: Ado-Tymovo, Tymovskoye, Kirovskoye, Onor, Smirnykh, Buyukly, Poronaysk). The agricultural conditions are more favourable in the central part of the Tymovsky Valley, less so in the Poronay Depression. Low winter temperatures combined with light winds and a large number of sunny days make the climate less severe and create comfortable conditions for residents and recreation. Locating large industrial facilities in this area

is inadvisable because the weakened wind pattern hinders the dispersion of pollutants, raising the risk of air contamination.

5. The southern part of the island (south of the isthmus) is the most developed (settlements: Yuzhno-Sakhalinsk, Dolinsk, Korsakov, Aniva, Kholmsk, Nevelsk, Gornozavodsk). The territory is most favourable for growing agricultural crops.

Depending on the agro-climatic areas, the territory of the island can be divided into agricultural zones (Table 5.1) (System..., 1989).

The southern zone is the most agriculturally developed part of the island. The Susunai valley forms its main part, with most of the area occupied by agricultural companies. The lower part of the Lyutoga River valley, well-developed as well, adjoins the Susunai valley. In addition, areas of the Korsakov Plateau and small river valleys on the Crillon and Tonino-Aniva Peninsulas, as well as part of the Okhotsk coast, are used as agricultural land.

The most developed complex of agricultural companies in the Sakhalin Region was formed within the southern zone in the 1970–90s: six state farms focused on dairy, potato and vegetable production (the largest among them are ‘Komsomolets’, ‘Anivsky’, ‘Yuzhno-Sakhalinsky’), a fruit and berry state farm, a specialised heifer breeding state farm, two pig breeding farms, a poultry farm, a greenhouse complex, a land reclamation centre, a number of subsidiary farms, and a regional complex experimental station (now the Sakhalin Research Institute of Agriculture), which provides scientific

Table 5.1. Agricultural zones of Sakhalin Island

Indicator	Agricultural zone					Average for the region
	Southern	South-Western	Western	North-Western	Eastern	
Mean annual precipitation, mm	800–1,200	760–840	580–600	510–620	800–950	500–1000
Sum of temperatures above +10 °C	1,580–1,630	1,480–1,830	> 1,600	1,110–1,470	1,300–1,400	700–1800
Duration of vegetation period, days	120–130	130–150	150–156	95–100	100–108	95–156
Duration of frost-free period, days	> 130	140–155	145	70–133	108–140	80–160
Prevailing soil types	Meadow-soddy, floodplain-alluvial	Mountain forest brown	Meadow-soddy, acidic forest-soddy	Marsh, peaty, meadow-soddy	Marsh, peaty, meadow-soddy	

support for the development of the island agro-industrial complex (Kozynyuk, 1975).

The most favourable conditions for agricultural production are on the south-western coast from Chekhov to Nevelsk and southwards, on the coast of Aniva Bay and in the south of the Susunai Depression.

The Aniva Bay coastline and inland areas are selectively suitable for winter recreation due to strong winds, frequent snowstorms and thaws, while parts of the south-western coastline are unsuitable due to unstable snow cover.

High relative air humidity throughout the entire growing season, combined with a prolonged and cold spring, along with frequent soil waterlogging, leads to vigorous development of diseases and active weed growth, resulting in decreased overall productivity of agricultural crops.

Natural and climatic conditions in the southern part of Sakhalin Region are favourable for livestock breeding, but wet and cloudy summers create difficulties for preparation of roughage.

Soils

The soils of the Sakhalin Region are very diverse: their formation and distribution across the island territory are directly dependent on the geographical and climatic conditions of the region. Variations in relief, parent materials and vegetation, along with differences in moisture levels and the intensity of decomposition and mineralisation of organic residues, give rise to diverse conditions for the development and course of soil-forming processes.

Sakhalin is classified as a distinct soil area within the Far Eastern soil facies (Gerasimov, 1945). The structure of the soil cover is represented by combinations of plain and mountain soil types.

According to the research of the prominent Sakhalin soil scientist A. Ivlev (1965, 1977), the classification comprised 15 soil types. Identification of a large number of soil types on the limited land located at the junction of continent and ocean indicates a great inhomogeneity of soil cover and natural conditions as a whole. Nevertheless, certain patterns in soil distribution over the territory of the island were observed, which allowed identifying the main soil provinces (Fig. 5.1a) and zones (Fig. 5.1b).

Sakhalin soils have different fertility, with all soil types characterised by the following attributes (Bogatyrev et al., 1960; Ivlev, Denisov, 1963; Ivlev,

1965; Denisov, 1968; Rozhkov, 1969; Ivlev, 1977):

- soils are predominantly infertile and low in nutrients;
- in the organogenic horizons, organic matter undergoes rapid mineralisation, with large quantities of fulvic humus being formed;
- all soils are leached, base-unsaturated, have an acidic reaction, and require liming;
- soils have a shallow humus horizon (0–18 (22) cm under arable land and 0–5 (15) cm under hayfields and pastures) and a truncated soil profile (especially in mountainous conditions);
- coarse fragments are common throughout the soil horizons; moreover, all mountain soils are characterised by a stony composition;
- soils are prone to excessive waterlogging,

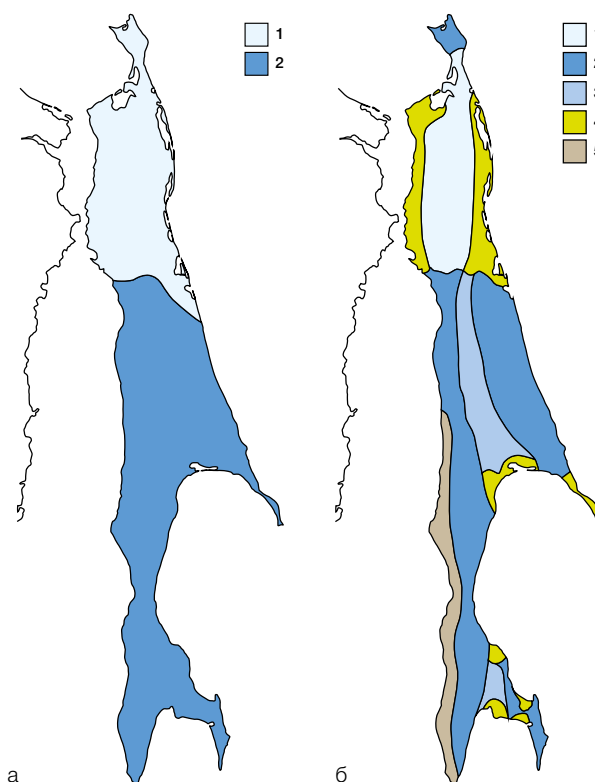


Fig. 5.1. For Sakhalin Island, the soil classification comprises: a) two soil provinces — (1) the North Sakhalin Province of Podzolic Soils and (2) the Sakhalin Province of Brown Forest Soils; and main soil areas — (1) podzolic soils, (2) mountain brown soils, (3) meadow and marsh soils, (4) marsh-podzolic soils, and (5) soddy-humus soils

which leads to the process of gleying; this, in turn, results in alterations to their physico-chemical properties.

The soil cover of Sakhalin is generally characterised by high spatial heterogeneity and a patchwork of small agricultural fields (averaging 5–20 ha in size). In terms of particle size distribution, the soils are mainly of medium and heavy loamy texture and contain abundant stone fragments.

The most promising soils for the development of island agriculture are soils above floodplain level, sea coasts and gentle watersheds.

Soil zoning of Sakhalin, proposed by A. Ivlev (Ivlev, 1965), has not lost its significance and application to date (Fig. 5.2). Within the Sakhalin soil region, he identified three subzones (northern podzolic-marsh, central soddy-podzolic, and southern brown-soddy), which together comprise 13 areas with different soil types.

The southern brown-soddy subzone occupies the whole of South Sakhalin, extending from the Poyasok Isthmus (47°59'11" N, 142°20'56" E). It encompasses both lowland and mountain soils and comprises six distinct soil areas.

On the south-western coast of the Crillon Peninsula, mountain forest brown soils and mountain forest soddy-humus soils predominate, with small patches of meadow and marsh soils. Despite the most favourable conditions in this part of the island for growing crops, there are no prospects for the expansion and further development of agriculture and crop production due to limited cultivated areas.

The southern tip of the Crillon Peninsula, the terminus of the Yuzhno-Kamyshovy Ridge in the West Sakhalin Mountains, features various soil types and subtypes associated with altitudinal zonation. These include acidic mountain forest brown soils with varying degrees of gleying and peat accumulation, while meadow and marsh soils occur locally in small river valleys. In terms of particle size distribution, the soils are classified as medium and heavy loams.

Fig. 5.3 shows a modern soil map of Sakhalin Island, and Fig. 5.4 shows a fragment related to the southern part of the island (National Atlas ..., 2011).

Agricultural land in southern Sakhalin is located mainly on meadow-soddy, brown forest and marsh soils, which account for 63, 19 and 18 % of the area, respectively (Vyatkina, 2017).

Meadow-soddy (Fig. 5.5) and soddy-gley soils (Fig. 5.6) are the main types of arable land in the Sakhalin Region. They are confined to river valleys and formed under meadow mixed herbs on alluvial

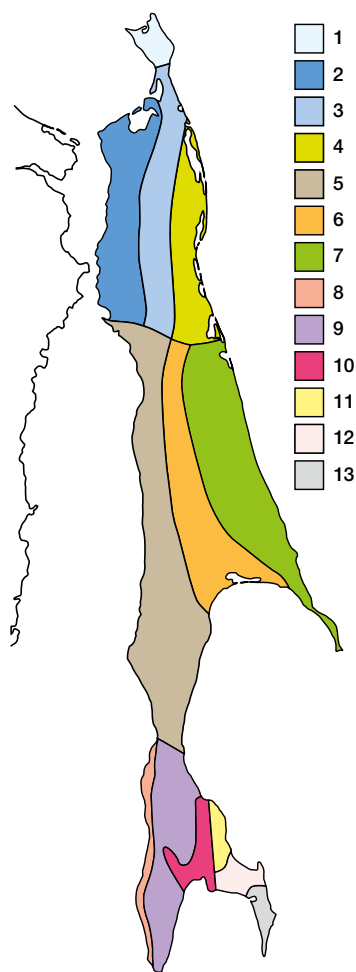


Fig. 5.2. Soil Zoning Map of Sakhalin Island. 1 — area of mountain podzolic soils of the Schmidt Peninsula; 2 — north-west area of marsh soils; 3 — area of podzolic soils of the North Sakhalin Depression; 4 — north-east area of marsh soils; 5 — area of mountain forest acid and mountain podzolic soils of the West Sakhalin Ridge; 6 — area of meadow and marsh soils of the Tym-Poronay Depression; 7 — mountain area of the East Sakhalin Ridge of mountain forest acid shallow-gleyed soil; 8 — area of mountain forest brown and forest soddy-humus soils of the south-western coast; 9 — area of mountain forest brown soils of the southern end of the West Sakhalin Ridge; 10 — area of meadow and marsh soils of the Susuya and Lyutoga river valleys (Susunai Depression); 11 — area of mountain forest brown soils of the Susunai Ridge; 12 — area of forest turf soils of the Muravyevskaya Depression; 13 — area of mountain forest brown soils of the Tonino-Anivsky Ridge



SOILS

Soils of taiga forests and mixed coniferous-broadleaved forests

- 5,6 Peaty gley-podzolic soils
- 0,9 Ferric illuvial podzols (low-humus illuvial podzols)
- 5,5 Humic illuvial podzols (humus-rich illuvial podzols)
- 6,5 Ferric illuvial and humic illuvial podzols, undifferentiated (including both low-humus and high-humus illuvial types)
- 0,9 Peaty-gleyic podzols, predominantly of the humic illuvial subtype
- 0,4 Dry-peaty podburs
- 27,9 Boreal brown humic illuvial soils (coarse-humic humic illuvial burozems, corresponding to Cambisols)
- 11,7 Boreal brown soils (coarse-humic burozems, corresponding to Cambisols)
- 6,3 Boreal brown humus-accumulative soils (humus-accumulative burozems)
- 2,9 Soddy-gley and humus-gley
- 1,6 Volcanic ash-layered
- 2,8 Volcanic dry-peaty
- 0,3 Volcanic peaty-humus
- 5,5 Volcanic ochreous, including podzolised ones
- 1,8 Volcanic ochreous-layered

Soils of broad-leaved forests and steppes

- 3,5 Acid brown forests (acid burozems)

Hydromorphic soils

- 7,3 Peat soils of raised bogs
- 0,3 Peat soils of fens
- 1,8 Peaty-gley marsh soils (including both moderately and highly organic gley soils)
- 0,3 Meadows (without subdivision)

Floodplain and marsh soils

- 1,6 Floodplain meadows

COMPLEX SOIL COVER

Soil complexes of Arctic, tundra and taiga

Ridge-hollow

- 3,4 Soil complexes of raised and transitional peat bogs
- 1,5 Water

Soil cover composition, %

SOIL-FORMING ROCKS

Loose soil-forming rocks

- Clayey and heavy loamy
- Medium loamy
- Medium loamy boulder and pebble
- Medium loamy rubbly
- Light loamy
- Sandy loamy
- Sandy
- Aerial, predominantly sandy and sandy loamy volcanic soils

Dense soil-forming rocks

- Acid metamorphic and igneous
- Main metamorphic and igneous
- Shales
- Sandstones

Fig. 5.3. Soil map of Sakhalin Island



Fig. 5.4. Soil map of the southern part of Sakhalin Island

soil-forming rocks. Depending on the degree and duration of moistening, the following subtypes are distinguished: typical (normal moistening), gleyed (short-term waterlogging) and gley (long-term waterlogging). In terms of particle size distribution, these soils are classified as heavy loams and clays. They exhibit high water-holding capacity, and when

excessively wet, develop poor water-air relations that lead to gleying processes. Stony varieties (weakly, moderately and strongly stony) are widespread. Despite relatively high natural fertility, agrochemical and water-physical properties of these soils are far from optimal and require liming, application of organic and mineral fertilisers.

Brown forest (Fig. 5.7) and forest soddy acid soils are formed under spruce-fir, secondary birch or birch-deciduous forests with well-developed herb cover in the lower third of mountain slopes, as well as on gentle hills and low watersheds, usually well drained and not subjected to flooding. The moistening regime is mainly determined by precipitation, which influences the formation of gleyed varieties. In terms of particle size distribution, the soils are classified as medium and heavy loams. Low base saturation of the soils indicates an acidic humus character; the content of available and total forms of potassium and phosphorus is low. Soils are water-absorbent and poorly permeable; in periods of rainfall they quickly become saturated with moisture, in dry periods they form a surface crust, which hinders air exchange. These soil types are involved in agricultural use but require liming and fertilisation. Measures to create optimal water-air conditions should focus on regulating and discharging excessive surface water by ridge or row planting of row crops, and periodic loosening of soil surface.

Marsh soils (Fig. 5.8) are widespread throughout



Fig. 5.5. Meadow-soddy (old-arable) soil



Fig. 5.6. Soddy-gley (old-arable) soil



Fig. 5.7. Brown forest soil



Fig. 5.8. Marsh soil

Sakhalin, including in the south of the island, and found on all landform elements and under various vegetation types; they are rich in organic matter but poor in ash elements. Marsh soils encompass peaty-gley, humus-gley, and peat soils, which vary in the depth of their peat layer. All marsh soils are inherently acidic, with low levels of available phosphorus and exchangeable potassium. After drainage and cultivation, these soils are used in agriculture for any kind of cultivated plants.

Agrochemical Service Centre ‘Sakhalinskiy’ FSBI calculated the fertility index of arable soils based on the results of agrochemical survey in 2012–2015 according to the generally accepted methodology. The fertility index is calculated as the average of the actual value ratio sum of four agrochemical indicators to their optimal values for all types of soils of crop cultivated areas (Milovskikh et al., 2019).

The total cultivated area of agricultural crops as of January 1, 2016, was 28.8 thousand hectares, including 21.6 thousand hectares of meadow-soddy soils, 2.4 thousand hectares of brown forest soils, 4.2 thousand hectares of marsh (peaty) soils, and 0.6 thousand hectares of floodplain-soddy soils.

The soil fertility index for each of these soil types was as follows: meadow-soddy, 0.65; brown forest, 0.65; marsh, 0.54; floodplain-soddy, 0.56. For the

Sakhalin Region as a whole, the index was 0.63.

Table 5.2 shows long-term averages of basic nutrient elements content in types of soils of agricultural use.

The soil and climatic (natural) potential of the agricultural territory of the Sakhalin Region is significantly lower compared with other agricultural areas of the Far East. Agriculture requires increased capital investments, a significant share of which is spent on eliminating and preventing the negative impact of natural and climatic factors.

Table 5.2. Average nutrient content in the main arable soil types of southern Sakhalin Island

Soil types	Humus, %		P ₂ O ₅ , mg/kg		K ₂ O, mg/kg		pH	
	opt	fact	opt	fact	opt	fact	opt	fact
Meadow-soddy	6.5	4.05	200	110.00	250	171	5.8	4.50
Brown forest	6.5	4.65	200	120.00	250	163	5.6	3.70
Marsh	15.0	10.00	150	43.20	170	82	5.0	3.70
Floodplain-soddy	6.5	3.98	150	83.60	170	68	5.0	3.45

Note: opt — optimum value, fact — actual value.

History of agricultural development in South Sakhalin in the 19th–21st centuries

Throughout the history of the development of Sakhalin and the Kuril Islands, one of the main objectives in organising the agricultural sector was to ensure food provision for the population. The development of agriculture on Sakhalin began more than 160 years ago, despite the extreme natural and climatic conditions of the region.

The indigenous people of Sakhalin (the Nivkh and Ainu) did not practice agriculture at all. The few Even and Orochen people who moved to the northern part of the island were engaged only in reindeer herding in limited numbers.

The first attempts of agricultural development of Sakhalin are usually attributed to the mid-19th century. During the period when Russian posts were being established, the surrounding territory was freed from the forest; there vegetable gardens were created, where potatoes, vegetables and peas were initially cultivated. The list of crops then expanded to include cereals, buckwheat, cabbage and other vegetables. Yields were low, amounting to tens, rarely hundreds of poods, cultivated areas were determined by the number of beds and individual plantings. Nevertheless, it signified the possibility of developing agriculture and growing some crops to support the small population of the time.

From 1859 onwards, convicts were engaged in land development, and in 1869, the peasants who voluntarily moved to Sakhalin were involved. In the 1870s, the amount of arable land on Sakhalin was only a few tens of desiatinas (1 desiatina corresponded to 1.09 ha) (Leonov et al., 1979).

In September 1871, agronomist Mikhail Mitsul arrived on the island as a member of a special state commission to study the prospects for its colonisation. The commission had to determine the

possibility of developing agriculture (farming and cattle breeding) in a territory remote from the centre of the Russian state (Mitsul, 1873) (Fig. 5.9).

‘As a result of surveying most of the island, M. Mitsul concluded that ‘it is possible to successfully cultivate economic plants and especially to develop cattle breeding’. The most favourable areas for agricultural development were in the southern part of the island, which had a milder climate and fertile soils suitable for growing cereals and vegetable crops.

According to rough estimates by M. Mitsul, at the initial stage of development (1872) there were

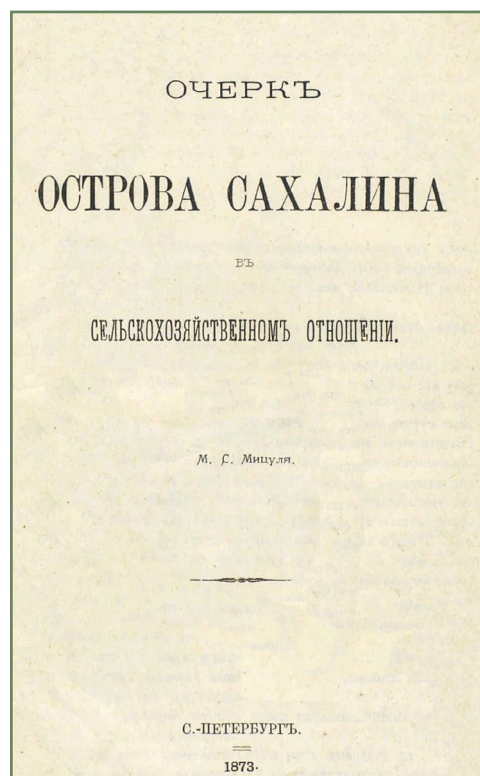


Fig. 5.9. The title page of M. Mitsul's book

Table 5.3. Summary of all sowings and harvests of agricultural crops for 1865–1872 according to settlers' information

Year	Crop	Sown in poods*	Harvested in poods	Average yield ratio (sam)***
1865	Winter rye (in autumn)	8		
1866	Wheat	4 f.**	–	–
	Barley	4	40	10
	Potatoes	10	200	20
	Winter rye	10	70	8¾
1867	Barley	6	65	10¾
	Potatoes	12	180	15
	Winter rye	12	100	10
1868	Barley	8	84	10½
	Potatoes	12½	150	12
	Winter rye	14	110	9⅙
1869	Barley	10	110	11
	Potatoes	9	120	7; 16****
	Winter rye	16	146	10½
1870	Barley	36	100	2¾
	Potatoes	10	100	10
	Winter rye	22	170	10¾
1871	Barley	10	60	6
	Potatoes	10	120	12
	Winter rye		28	1¼
1872	Barley	7	35	5
	Potatoes	70	Unknown	

Notes. *pood (p.) — 16.38 kg, **funt (f.) — 409.5 g (old Russian measures of weight); ***return ratio (sam) (obsolete) — 3 times more (1:3); **** as in the source.

about 420 thousand desiatinas of cultivated land on the island, mostly occupied by potatoes and vegetable crops (Vlasov et al., 2013). In the commission's report, and then in 'Sketch of Sakhalin Island in Agricultural Terms', published in 1873, he provided unique information received from peasants about crops and yields of cereals and potatoes for 1865–1872 (Table 5.3) (Mitsul, 1873).

To confirm M. Mitsul's conclusions about the suitability of soils for possible cultivation of various crops on Sakhalin, in 1880, V. Dokuchaev at St. Petersburg University conducted a laboratory study of the Sakhalin soil samples provided and determined their belonging to medium and heavy loams by mechanical and physical properties, containing a relatively rich set of nutrients in their chemical composition.

Despite the optimistic conclusions, agriculture developed at a very slow pace. Unfavourable climatic conditions, frequent crop failures, limited land suitable for cultivation, enormous human and material costs of clearing new plots, the lack of farming skills among convicts and exiles, and the forced nature of their labour all resulted in poor outcomes for the agricultural colonisation of the island. Nevertheless,

the work carried out was seen as a way of settling the area, developing it economically and increasing the rate of economic growth (Mitsul, 1873).

Over 20 years (1880–1900), 38 thousand settlers were brought to Sakhalin and more than 100 settlements were established. By the end of the 19th century, the cultivated areas reached over 4,000 ha by 1885 and 6,000 ha by 1886 (Tables 5.4, 5.5). Arable land during this period was used mainly for cereals (oats, wheat, rye, barley) (Table 5.6). Potatoes occupied only 10 % of the area, with even fewer vegetable crops (Korablin, 2005).

Agricultural settlements were very unevenly distributed. First, lands in the south of the island were developed: in the vicinity of the Korsakovsky post and in the Susunai valley around the village of Vladimirovka (now the city of Yuzhno-Sakhalinsk), in the valleys of large rivers, along the road from the Korsakovsky post to the Alexandrovsky post.

By the beginning of 1900, Sakhalin's land fund increased to 6.5 thousand hectares, with more than half allocated to cereals (wheat and rye), and the rest devoted to potatoes and vegetable crops. Thus, cereals farming was established (Fig. 5.10), with volumes that barely provided for the farmers themselves.

Table 5.4. Area used by exile settlers on Sakhalin Island for cereals and vegetables in 1885

Crop	District and area, des., sazh.*		
	Alexandrovsky	Tymovsky	Korsakovsky
Cereal crops	708 des. 1,767 sazh.	2,125 des. 450 sazh.	1,039 des. 679 sazh.
Vegetables and potatoes	182 des. 1,962 sazh.	294 des. 1,950 sazh.	333 des. 2,000 sazh.
Total	891 des. 1,329 sazh.	2,420 des.	1,373 des. 279 sazh.

* In 1 desyatina (des.) there are 2400 square sazhen, or 1.09 hectares. A sazhen (sazh.) is an old Russian measure of length equal to 3 arshins (2.13 m).

Table 5.5. Area exploited as agricultural by exile settlers on Sakhalin Island in 1886

District	Area, des.				
	for cereal	for vegetables	for arable land	for hayfields	total
Alexandrovsky	400	209	609	765	1,374
Tymovsky	387	266	653	1,687	2,340
Korsakovsky	113	23	136	265	401
Total	900	498	1,398	2,717	4,115

Table 5.6. Types and quantities of crops planted on Sakhalin Island in 1886

District	Types and quantities of crops, poods, funts				
	wheat	barley	rye	oats	potatoes
Alexandrovsky	2,154 p.	501 p. 30 f.	238 p. 20 f.	76 p. 26 f.	4,624 p. 30 f.
Tymovsky	1,169 p. 5 f.	745 p. 34 f.	797 p. 34 f.	7 p. 29 f.	4,637 p. 16 f.
Korsakovsky	368 p.	30 p.	400 p.	100 p.	1,840 p.
Total	3,691 p. 5 f.	1,277 p. 24 f.	1,436 p. 14 f.	184 p. 15 f.	11,102 p. 6 f.

In 1905, as a result of Russia's defeat in the Russo-Japanese War, the southern part of Sakhalin was lost and the northern part was temporarily occupied. In 1906, penal servitude was officially abolished, and the exiles were allowed to leave, which dramatically affected the island's agriculture. According to the 1905 census, there were 7,500 inhabitants in the Russian part of Sakhalin, including 2,000 members of local nationalities; 76 of 133 Russian settlements were completely abandoned (Kozynyuk, 1975). Agricultural activity nearly came to a halt.

In 1909, only about 2 thousand hectares were sown in Northern Sakhalin; in 1912, the cultivated areas increased to 4.2 thousand hectares, but by 1917 they decreased again to 3.3 thousand hectares. Cereal farming still dominated: the main crops were oats (29 % of the total area), wheat (27 %), rye and barley (29 %). The rest of the arable land was occupied by potatoes, peas and vegetables (Kozynyuk, 1975).

In 1925, Japan was forced to abandon the occupation of Northern Sakhalin, upon which the Soviet power was established there, and a new active

phase of settlement and socialist reorganisation of agriculture began.

In 1926–1927, another scientific expedition was performed, but under the leadership of A. Krasnyuk, to clarify the natural potential of the northern part of Sakhalin and its further settlement. Scientists identified 15.3 thousand ha of land not requiring improvement, 23.7 thousand ha requiring stubbing, 6.5 thousand ha requiring partial reclamation, and 28.4 thousand ha requiring radical reclamation (Isaikina, 2022b).

According to the 1926 census, 10,544 people lived in the Sakhalin District, of whom 8,022 lived in rural areas; there were 1,516 households (Isaikina, 2022a).

While in 1925–1928 agricultural production was based on individual peasant farms, in 1930–1931 the process of collectivisation began, which gave a noticeable boost to agricultural development. In 1932, 83 % of peasant farms in Northern Sakhalin were united into 12 collective farms, which were served by the first machine-tractor station (MTS); by 1938, these collective farms already included 96 % of peasant farms. In the pre-war period



Fig. 5.10. Threshing cereals by hand
(Karafuto ..., 1940)

(1940), 29 collective farms and 7 state farms were organised in Northern Sakhalin; during the war years, 21 collective farms, 8 state farms, and a number of subsidiary farms operated (Kozynyuk, 1975).

When the first state farms were established, cultivated areas increased by more than 800 ha, but within 1933–1938, an increase of only 8 % was recorded (Table 5.7). Average yields were low, especially for the cereals (from 5 to 12 centners/ha, and in some farms 3–5 centners/ha), which still dominated the agricultural structure and occupied 70 % of cultivated areas in collective farms. Potato yields ranged within 40–90 centners/ha and vegetable yields within 40–110 centners/ha (Table 5.8) (Isaikina, 2022a).

The first scientific knowledge about growing grain crops on the island dates back to the establishment of the Sakhalin Regional Complex Experimental Station in northern Sakhalin (1933), especially when D. Kryukov was appointed its director in 1935. It was he who laid the foundation for the complex approach: selection, study, development of agricultural techniques for cultivation, and even breeding new varieties (Isaikina, 2022b).

The agricultural techniques developed at that time made it possible to obtain 10–11 centners/ha of the promising ‘Garnet’ wheat variety and 12–15 centners/ha of the ‘Golden Rain’ oat variety, which was a significant achievement in the pre-war period (1936).

Table 5.7. Cultivated area and land development activities in 1933–1938

Crop	Cultivated area, ha					
	1933	1934	1935	1936	1937	1938
Cereals	1,637	1,505	1,645	1,820	1,641	1,588
Potatoes	372	447	405	467	423	330
Vegetables	83	135	189	109	101	201
Clover	–	8	19	25	91	212
Forage crops, etc.	196	95	74	106	38	143
Total cultivating	2,288	2,190	2,332	2,533	2,294	2,474
Fallow	–	–	–	–	148	445
Clover undersowing	–	8	19	25	111	403
Stubbing and development of virgin lands	–	38.4	20	79	175	400

Table 5.8. Yields of major crops in 1933–1938

Crop	Yield, centners/ha					
	1933	1934	1935	1936	1937	1938
Oats	9	10	9	6.1	7.1	4.8
Wheat	7	10	10.7	–	9.3	4.9
Barley	8	10	12.6	8	7.1	5
Potatoes	75	50	67	62	44	91
Vegetables	40	90	106	110	106	42

The climatic conditions of the island had an adverse effect on cereal cultivation, but work on the study and selection of spring and winter forms continued even after the liberation of the southern part of Sakhalin from Japanese militarists during the Great Patriotic War.

During the militarisation period of Southern Sakhalin (1905–1945), there was a drastic outflow of the Russian population and growth of migrants from Japan (Hokkaido Island); the number of peasant farms increased until 1936 (Fig. 5.11).

By 1918, the number of Japanese households and population had increased about 5 times, and by 1936, 11 times and 17 times respectively, likely linked to broader strategic interests.

During this period, new territories in the south of the island were actively developed and agricultural land was expanded through land stubbing and dewatering of wetlands (Fig. 5.12). Before the Second World War, there were 35 large farms of over 50 hectares each in South Sakhalin.

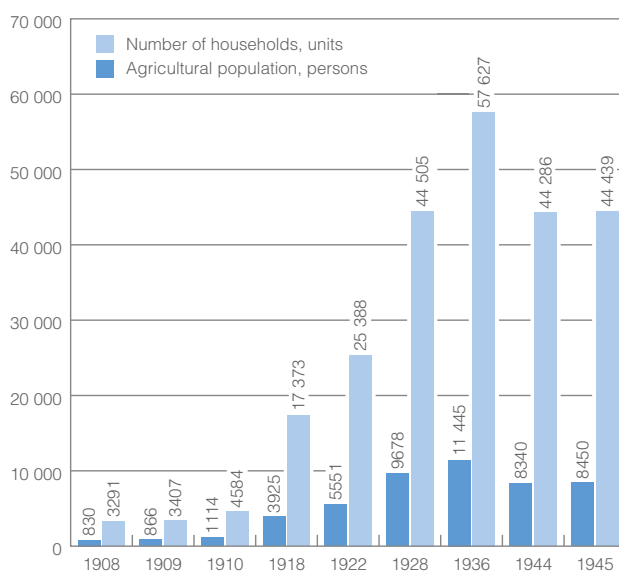
Agricultural lands and settlements did not form continuous areas, were characterised by small size, and varied in size from 3 to 15 ha. Despite the difficult climatic conditions (insufficient number of warm and sunny days, infertile soils, high moistening and waterlogged areas, heavy mechanical composition of soils), the Japanese cultivated a large variety of crops (Fig. 5.13): the cereals included spring wheat, barley, naked oats, winter rye, millet, and buckwheat; the leguminous plants included soybeans, beans, kidney beans, and peas; regarding the vegetables, preference was given to potatoes and cabbage (Chinese, white and red cabbage), they also planted green onions, radish, turnip, carrots, beets, pumpkin, and even heat-loving crops such as tomatoes, aubergines, and cucumbers; the industrial crops included corn, fodder rutabaga, beets, carrots, and turnips (Lopachev, 2002).

The Japanese considered the cultivation of sugar beet in South Sakhalin of great importance because

of the construction of the sugar production facility in 1934 in the town of Toyohara (now Yuzhno-Sakhalinsk). Yields of this crop were low (Table 5.9), but its cultivation did not stop until 1941, which was caused by the absence of sugar beet in Japan itself (Lopachev, 2002).

Agronomic knowledge and practice in Japan were still at an early stage of development. Knowledge of adaptive cultivation techniques was still lacking, mechanised tillage was not yet available, and the tillage depth was not more than 10 cm. All this contributed to the weed infestation of fields and destruction of the structure of Sakhalin's acidic soils.

By the end of the war and the stabilisation of the political situation, the number of peasant households and residents on Sakhalin decreased due to the outflow of the Japanese population. The workload

**Fig. 5.11.** Dynamics of peasant farm growth in Southern Sakhalin in 1908–1945 (Statistical Collection ..., 1943)

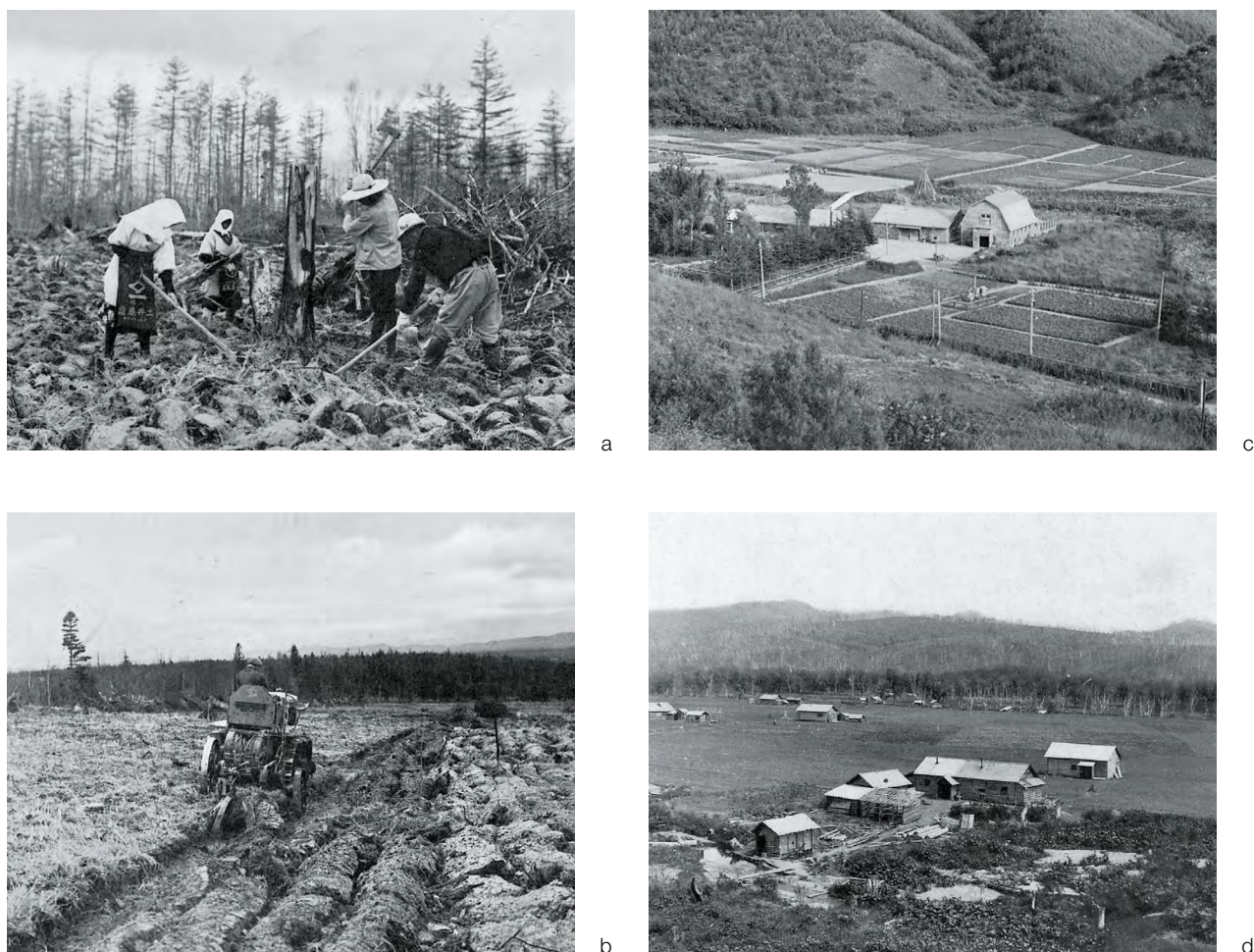


Fig. 5.12. Development of the territories in the south of Sakhalin Island: a — forest stubbing; b — autumn ploughing; c — general view of a large household; d — general view of a village (small peasant households) (Karafuto ..., 1940)

per able-bodied person increased from 0.35 ha (1932) to 0.98 ha (1945). The total post-war cultivated area was just over 26,000 hectares. Cereals, potatoes, and forage crops occupied more than three-quarters of the cultivated area (Fig. 5.14).

In the post-war period, by 1948, there were already 57 collective farms, 10 state farms, 4 MTS and more than 100 subsidiary farms throughout the island. Such a form of organising agricultural

production was inefficient. Most farms were small, with a cultivated area of no more than 100 ha, and crop production development was carried out without considering the peculiarities of the local soil and climate. The restored agricultural sector combined the unique farming systems of the Japanese and Korean populations, as well as domestic migrants.

It should be noted that the yields of all crops grown on Sakhalin experienced frequent and drastic

Table 5.9. Cultivated area and yield of sugar beets in 1934–1941

Factor	Farming year							
	1934	1935	1936	1937	1938	1939	1940	1941
Area under cultivation, ha	103.00	99.38	1,430.75	2,110.40	1,740.39	1,884.13	1,137.50	1,810.96
Yield, t/ha	25.7	27.7	15.8	12.7	17.9	15.8	9.1	5.7



a



d



b



e



c



f

Fig. 5.13. Cultivation of agricultural crops: a — cereals (barley in the foreground, then rye); b — sugar beet (cereals in the background); c — peas; d — soybeans; e — potatoes; f — white cabbage (*Karafuto ...*, 1940)

fluctuations from year to year and were constantly dependent on the severe weather conditions of the island region, which was one of the main reasons for the low production of the crops.

The most agriculturally developed area was the Susunai valley with floodplains of the large rivers Lyutoga and Susuya, where almost half of the cultivated lands in the southern part of Sakhalin were concentrated. Over 20 % of the cultivated areas were located in small valleys on the south-west coast (from Cape Crillon to Krasnogorsk) due to the fertile land and warmer climate. Nevertheless, even under these conditions, yield fluctuations were significant: for example, oat yield varied from 11 to 23 centners/ha, rye – from 7 to 16, potatoes – from 68 to 105, vegetables – from 10 to 150 centners/ha (Kozynyuk, 1975).

In this regard, under the leadership of D. Kryukov, Director of the Sakhalin Regional Complex Experimental Station, 12 mass experimentation support points were established in all the region's districts, where annual observations of growth and development of 20 to 40 varieties of different crops were conducted, with cereal variety testing being of primary importance (Isaikina, 2022b).

Breeding work on cereals was restarted in the 1950s: two varieties of oats, 'Sakhalinsky 1' and 'Sakhalinsky improved', spring wheat variety 'Sakhalinskaya 3', and barley variety 'Sakhalinsky local' were developed and submitted for state varietal testing. In the 1960s, the focus was already on selecting corn and Jerusalem artichoke. But the varieties created were not widely used in production.

The turning point for the structure of the cultivated areas occurred in 1957, when cereal growing gradually turned to potato-vegetable-forage production. Potatoes and vegetables began to occupy 50 % or more of the total area, but cereals were still given a significant place (in state farms, one-third of all arable land and in collective farms ('kolkhoz') half of lands) (Leonov et al., 1979).

Post-war experience showed that state farms were the most effective form of agricultural organisation on the island. In this regard, from 1958 to 1960, another reorganisation took place: enlargement of farms to 32 state farms (Kozynyuk, 1975), which made it possible to consolidate vegetable and potato specialisation and expand the forage base for the development of livestock breeding. State farms completely abandoned the cultivation of cereal crops in favour of expanding the cultivation of potatoes, outdoor vegetables, and annual and perennial grasses. During this period, agriculture in the region as a whole adopted modern organisational forms and sectoral specialisations, which had a significant impact on the development of farming and crop production on the island.

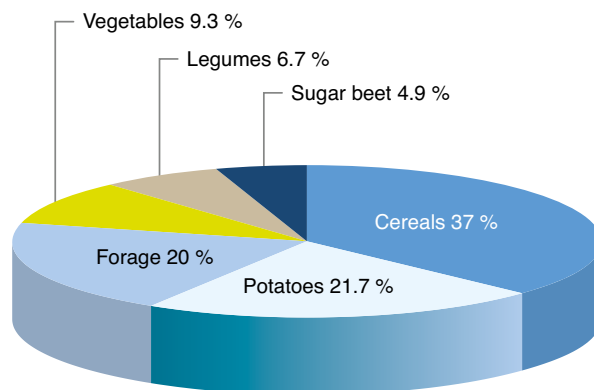


Fig. 5.14. Distribution of the cultivated areas on Sakhalin Island by crops in the early post-war years

In 1965, production at the state farm increased 2.4-fold; potato yields increased from 70 centners in 1960 to 107 centners in 1970, vegetables: from 78 to 194 centners/ha, respectively (Kozynyuk, 1975).

By the end of the 1970s, agricultural science, in close cooperation with production, had developed and mastered modern technologies to obtain 18–20 tonnes of potatoes, 40–50 tonnes of cabbage, 30–40 tonnes of carrots and beetroots per hectare despite extreme environmental conditions (Dryakhlov, 1993). 253 kg of potatoes and 69 kg of vegetables were allocated per capita (average per region); potato production exceeded consumption (Bagrova and Lukina, 1991). However, shortages of heat-loving crops such as tomatoes, cucumbers, peppers, and eggplants persisted. Only with the development of collective gardening and horticulture on the island and the expansion of greenhouse complexes in the cities of Yuzhno-Sakhalinsk and Krasnogorsk did this problem become less noticeable.

During perestroika (1989–1991), the agricultural sector faced an acute crisis; the number of livestock and cultivated areas decreased; the situation with the formation of state food resources became tense, and the pace of agricultural development began to decrease. Only 159 kg of potatoes and 55 kg of vegetables were produced per capita in 1989 (Bagrova, Lukina, 1991). In 1991, the volume of potato purchases was the lowest in the last 30 years and vegetable purchases were the lowest in 10 years. The share in crop production of products from private subsidiary farms increased. Thus, the share of the population in potato production increased from 34 % in 1990 to 36 % in 1991, and in vegetable production, from 16 % to 31 % (Dryakhlov, 1993).

Nevertheless, most agricultural products were still produced by state farms. As of January 1, 1991, there were 40 state farms including all systems of specialisation in crop and livestock production in Sakhalin Region (without the Kuril Islands) (Bagrova, Lukina, 1991). In 1992, some of them were reorganised again: 11 state farms (26 %) were re-registered, 9 were transformed into collective farms, 1 into a joint-stock company, and 1 retained the status of state farm.

The total area of agricultural land in all categories of farms during this period was 123 thousand hectares, of which arable land was 50, hayfields — 38, pastures — 31, and perennial plants — 4 thousand hectares (Shelepa et al., 2000).

Only by 2000, after a decade-long decline in the region's economy (Fig. 5.15), the agricultural sector seemed to be stabilising.

The main task set for the farmers of Sakhalin Region which determined their activities in the following years was to fully provide the population with basic foodstuffs: potatoes and winter-storage vegetables (cabbage, carrots, table beets), which could be produced in local climatic conditions in the open ground, as well as green and heat-loving crops in protected ground. In addition, various types of feed crops for farm animals must be grown in accordance with their numbers and productivity. This aim also determined the specialisation of modern farming in Sakhalin Region in the following years: the production of potatoes, vegetables and forage.

Over the last 20 years, scientific research by the Sakhalin Research Institute of Agriculture and the accumulated scientific and practical experience of interaction with agricultural producers in the region have contributed to the development of more advanced and effective approaches to crop production given the new economic conditions.

In 2017, a modern farming system for Sakhalin Region was developed, including a set of interrelated agronomic, reclamation, organisational, economic, and environmental measures aimed at the efficient use of the island's limited resources, and the preservation and improvement of natural soil fertility (Farming System ..., 2017). Each group of measures has an independent system of actions aimed at observing the laws of farming, obtaining maximum yields of good quality crops at the lowest costs, and preserving the ecological balance (Fig. 5.16).

The modern farming system forms the basis for crop production, which in turn is the foundation for all agricultural production in Sakhalin Region. It ensures high crop yields under the specific natural and economic conditions, maximising output per hectare while minimising labour and production costs per unit of output.

Adaptive, resource-saving, environmentally friendly technologies developed by scientists and introduced into production in Sakhalin Region allow high and sustainable yields of agricultural crops, including potatoes, vegetables and forage crops (Table 5.10).

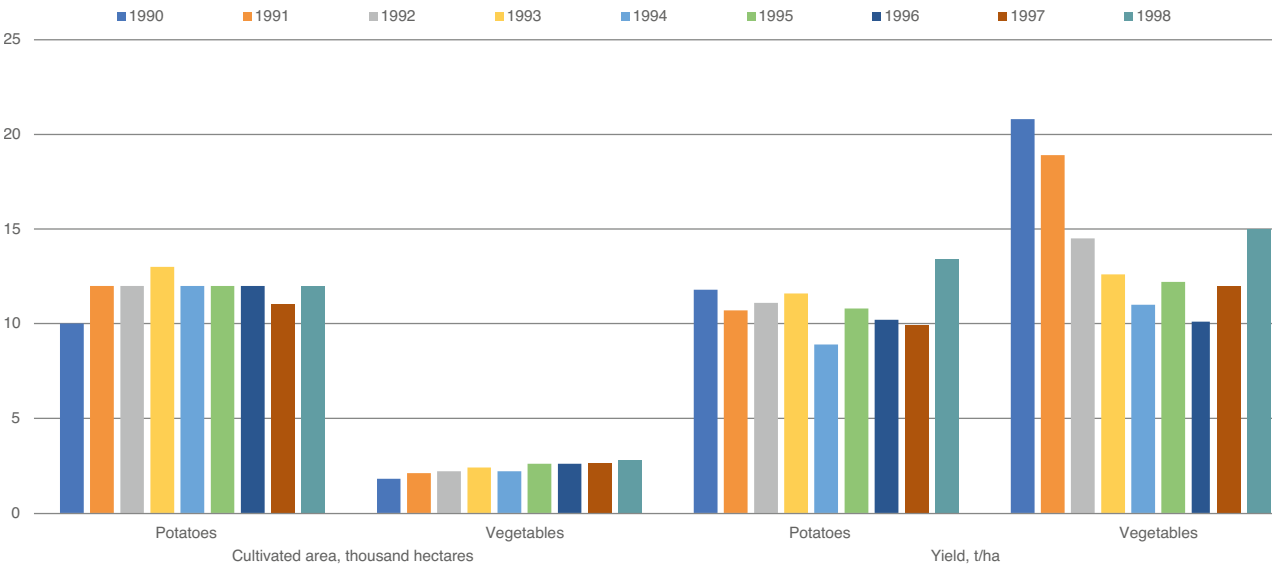


Fig. 5.15. Cultivated areas and yields of potatoes and vegetables in all categories of farms on Sakhalin Island, 1990–1998

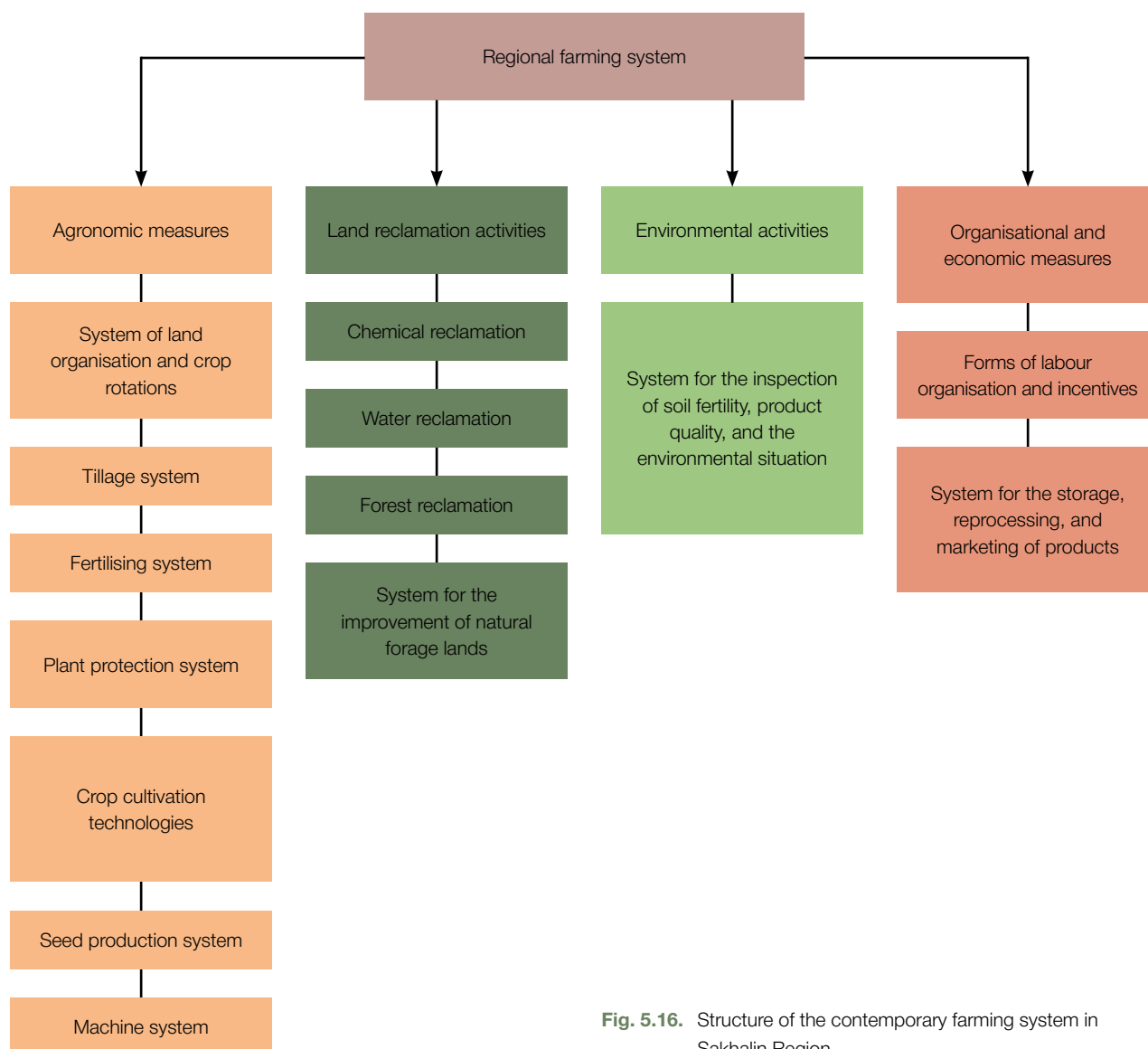


Fig. 5.16. Structure of the contemporary farming system in Sakhalin Region

Table 5.10. Cultivated areas and yields of potatoes, vegetables and forage crops in all categories of farms in Sakhalin Region, 2020–2024

Factor	Crop	Year				
		2020	2021	2022	2023	2024
Area, thousand hectares	potatoes	3.44	3.26	3.39	3.24	3.08
	vegetables	1.04	0.99	1.08	1.02	1.01
	forage	24.03	26.46	25.19	27.22	26.40
Yield, centners/ha	potatoes	190.80	187.40	191.90	190.90	145.00
	vegetables	292.70	298.30	284.60	270.80	235.20
	forage, including: • annual grasses	206.80	162.60	208.00	201.40	212.10
	• perennial grasses of previous years	129.00	163.50	196.50	113.10	101.40



Rocks at Cape Anastasia (photo by A. Semenov)

The Sakhalin Region Rosreestr Department registered 82.0 thousand hectares of agricultural land in 2017, of which arable land accounts for 35.7; hayfields — 22.7; pastures — 17.9; and perennial plantations — 5.9 thousand hectares. Over the past five years, there has been a tendency to expand the area under cultivation of major crops, improve hayfields and pastures, and increase collective horticultural partnerships. As of January 1, 2025, 101.6 thousand hectares of agricultural land were officially registered, of which arable land is 36.1 thousand hectares; hayfields — 32.8; pastures — 26.5; and perennial plantations — 6.2 thousand hectares.

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6 HUNTING AND A RETROSPECTIVE LOOK AT THE THERIOFAUNA OF THE CRILLON PENINSULA

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The large meridional extent of Sakhalin, the mountainous nature of the terrain, and the significant variability in the temperature of the Sea of Japan and Sea of Okhotsk around it create a wide variety of climatic conditions on the island. Thus, significant differences are observed between the north and south, east and west, and between the interior of the island and its coast. The presence of several climatic zones causes differences in the species composition and number of terrestrial animals. In general, while the fauna of Northern Sakhalin is similar (and of common origin) to the fauna of the nearby mainland, the fauna

of the Northern Kuril Islands is similar to the fauna of the Kamchatka Peninsula and the fauna of Southern Sakhalin and Southern Kurils resembles the fauna of the island of Hokkaido, Japan (Atlas ..., 2007). The species impoverishment of the fauna compared to the adjacent part of the mainland is explained by the insular character of the biogeotope. A total of 90 species of mammals (56 land-dwelling and 34 marine species), over 370 species of birds, 7 species of reptiles, 5 species of amphibians, 38 species of freshwater and migratory fishes, 2 species of cyclostomes and over 1,000 species of invertebrate animals have been recorded in Sakhalin Region (Scheme ..., 2023) (Fig. 6.1–6.4).

The natural distribution of animals in Sakhalin Region is also affected by anthropogenic factors. These

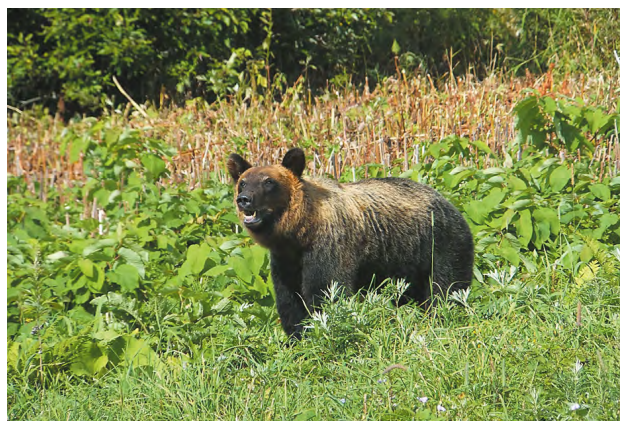


Fig. 6.1. Brown bear (*Ursus arctos*). Male, age 6 years. Sakhalin Region, Anivsky District, Uryum River, 2000



Fig. 6.2. Brown bear (*Ursus arctos*). Male, age 5 years. Sakhalin Region, Anivsky District, Ulyanovka River, 1998



Fig. 6.3. Gray heron (*Ardea cinerea*). Sakhalin Region, Anivsky District, Aniva Bay, 2023

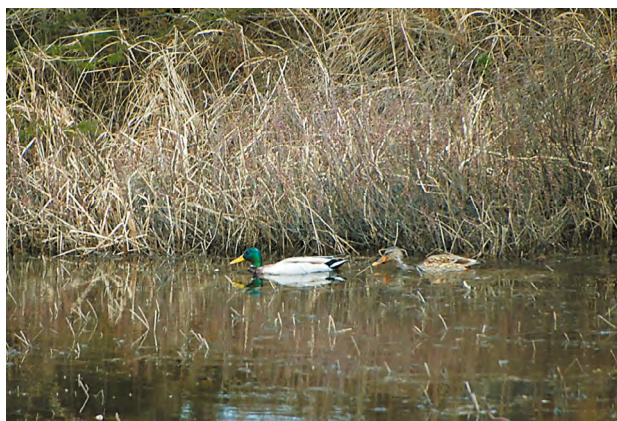


Fig. 6.4. Mallard (*Anas platyrhynchos*). Sakhalin Region, Anivsky District, Aniva Bay, 2023

can be either primary, i.e., direct (extermination, acclimatisation, introduction), or secondary, i.e., indirect (deforestation, fires, draining of swamps, plowing of lands, construction of major production lines and highways, etc.).

It is predominantly anthropogenic causes that have led to 157 animal species being listed in the Red List of Sakhalin Region (Red List ..., 2016; List of wildlife ..., 2021). They include:

- 15 species/subspecies of mammals (4 of which are in the Red List of the Russian Federation, 5 are in one of the 'threatened' categories of the 2014 Red List of the International Union for Conservation of Nature), including the Siberian musk deer (Sakhalin subspecies), reindeer (Sakhalin population), Eurasian lynx, wolverine, European mink, Steller's sea lion, sea otter, etc.;
- 93 bird species (of which 43 are listed in the Red List of the Russian Federation, 24 are in one of the 'threatened' categories of the 2014 Red List of the International Union for Conservation of Nature), including brant geese (Aleutian Canada goose and American brant), lesser white-fronted goose, swans (whooper, Bewick's and tundra swan), eastern spot-billed duck, mandarin duck, sea eagles (white-tailed and Steller's), Siberian grouse, black-billed capercaillie, etc.;
- 4 species of reptiles (2 of which are in the Red List of the Russian Federation): the Far Eastern skink, the Japanese striped snake, Japanese rat snake and the Japanese forest rat snake;
- 7 fish species (6 of which are in the Red List of the Russian Federation, 4 are in one of the 'threatened' categories of the Red List of the International Union for Conservation of Nature), including Sakhalin sturgeon, Kaluga sturgeon, Sakhalin taimen, etc.;
- 13 species of insects (7 of which are in the Red List of the Russian Federation), including ground beetles (Lopatin's ground beetle, Avinov's ground beetle and wrinkled ground beetle), swallowtail butterflies (Maack's swallowtail and blue swallowtail), Far Eastern stag beetle, etc.;
- 20 species of molluscs (2 of which are in the Red List of the Russian Federation), including pearl mussels (Dahurian freshwater pearl mussel (*Dahurinaia dahurica*), Tiunov's freshwater pearl mussel (*D. tiunovae*), Sakhalin freshwater pearl mussel (*Margaritifera middendorffi*) and Kuril freshwater pearl mussel (*D. kurilensis*);
- 5 crustacean species: Stanford's sinelobus

(*Sinelobus stanfordi*), Moneron sternomoera (*Sternomoera moneronensis*), relict pseudocrangonyx (*Pseudocrangonyx relict*), Susunai pseudocrangonyx (*Pseudocrangonyx susunaensis*) and Birstein's pseudocrangonyx (*Pseudocrangonyx birsteini*).

Thus, of the 157 animal species listed in the Red List of Sakhalin Region (Volume 'Animals'), 64 are listed in the Red List of the Russian Federation. 'The hunting grounds of Sakhalin-Crillon LLC, located in the southeast of Crillon Peninsula from the Uryum River in the north to Cape Crillon in the south and bounded by the coast of Aniva Bay to the east and Kamyshev Ridge to the west, with a total area of 93,350 hectares (hereinafter referred to as the 'Sakhalin-Crillon hunting grounds'), are home to 48 Red List species of animals, 17 of which are included in the Red List of the Russian Federation.

For some birds in the Red List, such as the gyrfalcon, the Sakhalin-Crillon hunting grounds serve as a migratory and wintering area. For such species as peregrine falcon, osprey, Japanese snipe, and Tengmalm's (Boreal) owl, this area is part of their breeding range, while the golden eagle, for example, is recorded in the non-breeding season. But perhaps the largest representatives of birds, quite often encountered by hunters, tourists, and fishermen, are the Steller's sea eagle and white-tailed eagle. Few remain unmoved at the sight of these titans from the order Falconiformes, whose wingspan can reach 230 cm with a body length of up to 90 cm and weight up to 7 kg (Nechaev, 1995, 2013).

Among the waterfowl belonging to the order Anseriformes which are present in the hunting grounds during spring and autumn migration periods, and accordingly during the permitted hunting seasons, the whooper swan, Tundra swan, mandarin duck and falcated duck have been recorded. Among mammals, the most striking rare representatives are the Sakhalin musk deer and Steller's sea lion; both of which are listed in the Red List of the Russian Federation. Many rare insects and plants are not so noticeable when visiting the hunting grounds, but they contribute to making it unique and distinct from other locations.

The conservation of the magnificent biodiversity of Crillon and the development of sustainable hunting on the peninsula require knowledge of all the animals above and the implementation of measures to conserve their numbers and habitats.

The full list of animal and plant species listed in the Red List of Sakhalin Region and the Red List of the Russian Federation and inhabiting the Sakhalin-Crillon hunting grounds is given in Table 6.1 (based

Table 6.1. List of animals in the Red List of Sakhalin Region and the Red List of the Russian Federation that live within the Sakhalin-Crillon hunting grounds

English species name	Binomial name	Comment
Mammals		
Steller's sea lion (Northern sea lion)	<i>Eumetopias jubatus</i> (Schreber, 1776)	
Sakhalin musk deer (subspecies of Siberian musk deer)	<i>Moschus moschiferus sachalinensis</i> (Flerov, 1929)	
Eurasian water shrew	<i>Neomys fodiens</i> (Pennant, 1771)	
Birds		
Gyr Falcon	<i>Falco rusticolus</i> (Linnaeus, 1758)	Migratory and wintering area
Peregrine falcon	<i>Falco peregrinus</i> (Tunstall, 1771)	Breeding range
Von Schrenck's bittern	<i>Ixobrychus eurhythmus</i> (Swinhoe, 1873)	Breeding range
Golden eagle	<i>Aquila chrysaetos</i> (Linnaeus, 1758)	Records outside the breeding season
Great bittern	<i>Botaurus stellaris</i> (Linnaeus, 1758)	
Oriental scops owl	<i>Otus sunia</i> (Hodgson, 1836)	Breeding area
Eastern marsh harrier	<i>Circus spilonotus</i> (Kaup, 1847)	Breeding range
Japanese green pigeon	<i>Treron sieboldii</i> (Temminck, 1836)	
Ruddy-breasted crake	<i>Porzana fusca</i> (Linnaeus, 1766)	Breeding area
Eurasian coot	<i>Fulica atra</i> (Linnaeus, 1758)	
Eurasian sparrowhawk	<i>Accipiter gularis</i> (Temminck et Schlegel, 1844)	Breeding range
Collared scops owl	<i>Otus bakkamoena</i> (Pennant, 1769)	Breeding area
Streaked shearwater	<i>Calonectris leucomelas</i> (Temminck, 1836)	
Long-billed murrelet	<i>Brachyramphus perdix</i> (Pallas, 1811)	Breeding range
Ross's gull	<i>Rhodostethia rosea</i> (MacGillivray, 1842)	
Russet sparrow	<i>Passer rutilans</i> (Temminck, 1836)	
Glaucous-winged gull	<i>Larus glaucescens</i> (J. F. Naumann, 1840)	
Osprey	<i>Pandion haliaetus</i> (Linnaeus, 1758)	Breeding range
Eurasian hobby	<i>Falco subbuteo</i> (Linnaeus, 1758)	Breeding range
Japanese cormorant	<i>Phalacrocorax capillatus</i> (Temminck et Schlegel, 1848)	Breeding range
Japanese quail	<i>Coturnix japonica</i> (Temminck et Schlegel, 1849)	
Red-billed starling	<i>Sturnia philippensis</i> (J. R. Forster, 1781)	
Whooper swan	<i>Cygnus cygnus</i> (Linnaeus, 1758)	
Tundra swan	<i>Cygnus bewickii</i> (Yarrell, 1830)	
Mandarin duck	<i>Aix galericulata</i> (Linnaeus, 1758)	
Falcated duck	<i>Anas falcata</i> (Georgi, 1775)	
Latham's snipe	<i>Gallinago hardwickii</i> (J. E. Gray, 1831)	
Snowy owl	<i>Nyctea scandiaca</i> (Linnaeus, 1758)	Locations of Records
White-billed diver	<i>Gavia adamsii</i> (G. R. Gray, 1859)	
Yellow-breasted bunting	<i>Ocyris aureolus</i> (Pallas, 1773)	
Common moorhen	<i>Gallinula chloropus</i> (Linnaeus, 1758)	
Boreal owl	<i>Aegolius funereus</i> (Linnaeus, 1758)	Records during the breeding season
White-tailed eagle	<i>Haliaeetus albicilla</i> (Linnaeus, 1758)	
Blue rock thrush	<i>Monticola solitarius</i> (Linnaeus, 1758)	
Japanese white-eye	<i>Zosterops japonicus</i> (Temminck et Schlegel, 1847)	Adjacent to the study area
Insects		
Maximowicz's ground beetle	<i>Calosoma maximowiczii</i> (Morawitz, 1863)	
Ramie moth	<i>Arcte coerula</i> (Guenee, 1852)	
Far Eastern musk beetle	<i>Aromia moschata orientalis</i> (Plavilsthikov, 1940)	
Avinov's ground beetle	<i>Carabus avinovi</i> (Semenov et Znoiko, 1932)	
Lopatin's ground beetle	<i>Carabus lopatini</i> (Morawitz, 1886)	
Molluscs		
Zatravkin's freshwater pearl mussel	<i>Kurilinaia zatravkini</i> (Bogatov, Prozorova et Starobogatov, 2003)	
Kuril freshwater pearl mussel	<i>Kurilinaia kurilensis</i> (Zatravkin et Starobogatov, 1984)	
Smooth striatura snail	<i>Striatura aperta</i> (Pilsbry et Hirase, 1904)	

on Voronov V., 1982; Voronov et al., 1980; Gizenko, 1955; Catalogue ..., 1983; Red List ..., 2016; Agency of Forestry ... [Electronic resource]).

Anthropogenic factors affect wildlife populations differently than natural factors (V. V. Voronov, 1982). While the latter are characterised by periodicity, which determines cyclical fluctuations in numbers, the so-called human factor is, as a rule, spontaneous. There are quite numerous areas of human economic activity that affect animal habitats. The main ones are forest management, reforestation, harvesting of the by-products (non-timber) of forests, development of lands by agricultural operations, development of mineral resources, water use, development of road networks, recreational use of forests and the associated forest fires.

As of January 2025, forest management in Sakhalin Region is carried out by five regional autonomous institutions subordinate to the Regional Forestry and Hunting Agency. Forest supervision is carried out by 17 forestries, and branches of the Sakhalin Forestry Department, also subordinate to the Regional Forestry and Hunting Agency. In the Sakhalin-Crillon hunting grounds, forest supervision is directly carried out by the Aniva Forestry. In Sakhalin Region, there are about 100 active operations in the timber extraction and processing industry (Scheme ..., 2023; Agency of Forestry ... [Electronic resource]).

Theriofauna of Sakhalin Island from the Paleolithic to the 18th–19th centuries

Due to the lack of specialised paleontological studies on the distribution and abundance of various ungulate species on Crillon Peninsula, this section contains overview data based on the 'Catalogue of Sakhalin Archaeological Sites with Shell Middens and Faunal Remains' and an analysis of more recent publications. Information on all faunal finds in ancient sites and settlements dating from the Paleolithic to the 18th–19th centuries has been studied. These are predominantly mollusc shells, often forming shell middens, and the preserved bones of fish, birds and mammals among them, which also include extinct species that no longer exist on Sakhalin, as well as those introduced to the island from distant locations (Alekseeva et al., 2004). The study of fauna from archaeological sites of Sakhalin allows us to understand the paleobiogeographical distribution of animals, the dominance of certain species in the diet of ancient people and characterises the paleoclimatic conditions

in different areas of the island. Based on these data, extrapolation to the Crillon Peninsula area was carried out. The following is a list of terrestrial mammals found in archaeological sites on Sakhalin:

- Mammals (class Mammalia)
 - Insectivores (order Insectivora)
 - Shrews (family Soricidae)
 - Far Eastern shrew (*Sorex gracillimus*)
 - Bats (order Chiroptera)
 - Vesper bats (family Vespertilionidae)
 - Daubenton's bat (*Myotis daubentonii*)
 - Long-fingered bat (*Myotis capaccinii*)
 - Ikonnikov's bat (*Myotis ikonnikovi*)
 - Brandt's bat (*Myotis brandtii*)
 - Brown long-eared bat (*Plecotus auritus*)
 - Northern bat (*Eptesicus nilssonii*)
 - Greater tube-nosed bat (*Murina leucogaster*)
 - Carnivores (order Carnivora)
 - Dogs (family Canidae)
 - Domestic dog (*Canis familiaris*)
 - Red fox (*Vulpes vulpes*)
 - Arctic fox (*Alopex lagopus semenovi*)
 - Raccoon dog (*Nyctereutes procyonoides*)
 - Bears (family Ursidae)
 - Brown bear (*Ursus arctos*)
 - Mustelids (family Mustelidae)
 - Least weasel (*Mustela nivalis*)
 - Steppe polecat (*Mustela eversmannii*)
 - Sable (*Martes zibellina*)
 - Yellow-throated marten (*Martes flavigula*)
 - Wolverine (*Gulo gulo*)
 - Eurasian otter (*Lutra lutra*)
 - Odd-toed ungulates (order Perissodactyla)
 - Horses (family Equidae)
 - Domestic horse (*Equus caballus*)
 - Even-toed ungulates (order Artiodactyla)
 - Pigs (family Suidae)
 - Wild boar (*Sus scrofa*)
 - Domestic pig (*Sus scrofa domestica*)
 - Deer (family Cervidae)
 - Siberian musk deer (*Moschus moschiferus*)
 - Sika deer (*Cervus nippon*)
 - Manchurian wapiti (*Cervus elaphus*)
 - Reindeer (*Rangifer tarandus*)
 - Elk (*Alces alces*)
 - Bovids (family Bovidae)
 - Snow sheep (*Ovis nivicola koriakorum*)
 - Cattle (*Bos taurus*)
 - Musk ox (*Ovibos moschatus*)
 - American bison (*Bison bison*)
 - Lagomorphs (order Lagomorpha)

- Hares and rabbits (family Leporidae)
 - Mountain hare (*Lepus timidus*)
- Pikas (family Ochotonidae)
 - Northern pika (*Ochotona hyperborea*)
- Rodents (order Rodentia)
 - Flying squirrels (family Pteromyidae)
 - Siberian flying squirrel (*Pteromys volans*)
 - Squirrels (family Sciuridae)
 - Eurasian red squirrel (*Sciurus vulgaris*)
 - Siberian chipmunk (*Tamias sibiricus*)
 - Long-tailed ground squirrel (*Urocitellus undulatus*)
 - Mice and rats (family Muridae)
 - Brown rat (*Rattus norvegicus*)
 - East Asian field mouse (*Apodemus peninsulae*)
 - Voles and lemmings (family Cricetidae)
 - Wood lemming (*Myopus schisticolor*)
 - Red vole (*Clethrionomys rutilus*)
 - Sakhalin vole (*Microtus sachalinensis*)
 - Collared lemming (*Dicrostonyx torquatus*)
 - Muskrat (*Ondatra zibethica*)

Quaternary mammals of Ostantsevaya Cave, 16–5 thousand years ago

Quantitative data on the composition and occurrence of ungulates were obtained during a survey of Ostantsevaya Cave, located in the central part of Sakhalin. Both similarities and differences between Quaternary mammals and modern mammals have been noted. Along with the reindeer currently living, Siberian musk deer, wolverine, fox, etc., the now absent Arctic fox, horse, roe deer, moose, snow sheep, long-tailed ground squirrel and other species were present (Kirillova et al., 2012).

The second most abundant group of animals found in the cave were medium-sized ungulates (snow sheep and reindeer). Most often their large tubular bones are fragmented, with mainly the articular and distal limb bones preserved intact. Many of the remains are heavily gnawed. Two calcaneal bones bear traces of specific breakage for bone marrow extraction, and the scapular bone bears traces of a tool blade. The fragmentation of some bones was clearly done to obtain food, meaning it was due to human 'kitchen' work. Sheep have been found in fossil form at many archaeological sites on Sakhalin. Forage competition between reindeer and snow sheep was minimal due to different pastures and partly due to different basic food sources (Popov, 1977; Danilkin, 2012).

Bone remains of large bovids (Bovidae) were also discovered. Representatives of this family are absent in the modern fauna of Sakhalin. Of the animals in this group that could have inhabited Sakhalin during the Quaternary period, the most likely are bison, yak, musk ox and aurochs. Species identification of these animals' bones is often difficult even with complete skeletons due to significant similarities in morphological features. They could also have been *Bos taurus*, cattle whose bones share several features with the large wild Bovidae species mentioned. However, cattle appeared on Sakhalin with Russian settlers in the second half of the 19th century, and no archaeological sites of this age are known near Ostantsevaya Cave. Additionally, the preserved condition of the specimens generally corresponds to that of the bulk of the material available. Considering these circumstances, even with insufficient diagnostic features, it is reasonable to assume that among these specimens are remains of one or more of the above-mentioned species of large wild bovids. Roe deer are absent from the modern fauna of Sakhalin (Kirillova et al., 2012). In a fossilised state, roe deer have been identified in archaeological sites of Sakhalin from later periods, at Ikonnikova Cave and Nevelsk-2.

The ratio of mammal bones of different species in the collections from the entrance area of the cave and the well differs markedly. In the entrance test pit, reindeer (40 %) and snow sheep (30 %) dominate in terms of the number of remains. The proportion of Siberian musk deer (22 %) is also significant. All other species account for 9 %, with bears comprising only 1 %. In the well, bear (up to 50 %) and hare bones consistently predominate. The proportion of reindeer and snow sheep is notable. Siberian musk deer are quite scarce. The well fauna does not include horses, but contains large bovids (Bovidae), roe deer, light-coloured polecats, large panthers, ground squirrels and hoofed lemmings, whose remains are not present in the test pit (Kirillova et al., 2012).

In the loose sediments of Ostantsevaya Cave, a process of transition from final Pleistocene animals to those of the first half of the Holocene, essentially modern animals, has been recorded. To date, these are the oldest deposits on Sakhalin that include both artifacts and numerous mammal remains together.

The importance of wild ungulates in the diet of the medieval population of the peninsula

The diet of the medieval population of the peninsula is best characterised by the contents of shell middens at sites on Aniva Bay in Southern Sakhalin. Analysis of material from 36 archaeological sites identified oyster and scallop shells along with the bones of herring, gobies, cod, halibut, whales and seals in the excavations; land mammal remains included pig jaws, dog skulls, deer antlers, boar and bear tusks (Archaeological Heritage ..., 2017). Based on the geographical and climatic conditions of this part of the island and the list of mammal species, it is reasonable to assume that most ungulate species recorded for Sakhalin were present in this area during the period under consideration. However, the protein diet of the bay's population was based on shellfish, fish and marine mammals, with ungulates playing only a minor role. This indirectly indicates low numbers of ungulates in Southern Sakhalin even during the Middle Ages; their main population was likely hunted out by indigenous peoples even in ancient times. Historical and current data and trends indicate that faunal impoverishment and decline in ungulate populations began on Crillon Peninsula, the part of Sakhalin Island closest to Japan, even before active economic development by humans there in the 20th century.

Currently, under the impact of significant anthropogenic habitat changes in Southern Sakhalin (reduction of forest areas, land development, industrial infrastructure expansion, etc.), the ranges and populations of most animal species continue to change. For example, just within the last century, reindeer have disappeared from the southern part of the island due to human influence (Smirnov, 2009b). Possibly due to human impact, species such as wild boar, moose, Manchurian wapitis and snow sheep have disappeared from the island's fauna in recent history (Voronov, 2003). The southernmost existing population of Siberian musk deer, inhabiting Crillon Peninsula, is very likely to disappear. Historically, relatively mild climatic conditions combined with transportation accessibility and the relative proximity of the peninsula to Sakhalin's largest settlement, Yuzhno-Sakhalinsk, create high anthropogenic pressure on the wild ungulate populations living there.

Modern forest management and its consequences for game species

In the early 1990s, due to the collapse of the previously established logging system, timber harvesting volumes in the Russian Far East decreased by at least threefold. Large logging operations that monopolistically exploited significant forested areas practically ceased to exist. In 1963, there were 13 such operations in Sakhalin Region, but after 1990, only two remained. They were replaced by dozens of small companies with various forms of ownership (Scheme ..., 2023).

Logging in the different geographical zones of Sakhalin Island has unequal impacts on forest communities. In the central part of the island, where dark coniferous forest stands predominate, almost all logging sites look like wastelands slowly becoming overgrown with deciduous tree species (succession). Under their canopy, if slope exposure and soil composition allow, dark coniferous forests consisting of spruce and fir subsequently form. Undergrowth on such logging sites develops in the year following the end of harvesting. The impact of logging on poorly drained soils of plains and highlands is also significant. Disturbance of water balance leads to waterlogging and the overgrowing of logging areas with grasses, which leads to increased fire safety hazards. Periodic fires in such areas complicate forest regeneration. As a result, such territories fall out of the ranges of most game species for quite a long period.

Another aspect of the negative impact of logging is the construction of many seasonal and year-round roads that accompany timber harvesting. Improved accessibility of lands, especially in the northern part of the island, has had a catastrophic effect on the reindeer population and leads to decreased sable population density.

Thus, the impact of logging is quite varied. It is a factor in both rapid and slow but inevitable transformations of wildlife habitats.

Considered in terms of total area, complete transformation of animal habitats at current clear-cutting rates would take long enough for the original forests to regenerate several times over. But the fact is that the most valuable forests in the southern and central regions, which have the highest productivity and biodiversity, are being cut down first. This causes a reduction in the area of lands inhabited by Siberian musk deer and a decrease in the population density of sable and squirrel. It can be assumed that there will be an increase in hare, fox and other

synanthropic species associated with habitat changes. Overall, as a result of logging, at least a 30 % reduction in land 'productivity' should be expected (Scheme ..., 2023).

In the near future, logging will continue to be concentrated in the southern and central districts of the region due to their transport accessibility. Other aspects of forest management during the revision period are unlikely to cause significant changes in game species habitats.

Wild plants are collected by local people in accessible places, and harvesting is now common mainly around settlements and along roads. In general, however, against the background of the low population density in the region, this type of forest use is practically unnoticed by wildlife.

Due to the fact that there are no residential settlements and virtually no road network within the Sakhalin-Crillon hunting area, there is no practical threat of deforestation or disturbance of wildlife by wild plant gatherers. At the same time, if the territory is developed, hunting and tourist infrastructure is arranged on the peninsula and the road network is expanded, the threat of negative anthropogenic impact on natural complexes will increase, which can only be mitigated by improving the efficiency of territory security and expanding biotechnical measures.

Artificial reforestation is carried out annually and has a positive impact on the habitat of game, red-listed and background animal species, as well as plants (Red List ..., 2005), but its scale is small; the most effective approaches include natural reforestation and the measures to promote natural reforestation taken by forestry operations and the tenants of the forest resource areas.

Impact of forest fires

Forest fires cause significant damage to wildlife habitat on Sakhalin. Due to the predominance of dark coniferous forests (69.5 %) and mountainous terrain, fires are difficult to extinguish. At the same time, the island's location and extensive network of rivers and streams prevent fires from spreading over large areas.

As a result of fires in coniferous forests, biocenoses are almost completely changed in burned areas, and the biocenotic and trophic chains are disrupted. Coniferous forests are replaced by small-leaved forests and become low-productive lands until coniferous forests form again under the canopy of the small-leaved trees. The most valuable species, such as squirrel and sable, are temporarily excluded from harvesting in burned areas (Eremin, 2005).

Burned areas of spruce-fir taiga stands typically occupy large areas; after fires of great intensity, they become open spaces. As a result, the established migration corridors are destroyed, leading to fragmentation of wildlife ranges, changes in seasonal vertical migration paths, deterioration of gene pool exchange and destruction of habitats that help animals survive the harshest winter months.

With less intense fires, soils do not burn out, but trees die, forming debris impassable to humans and large animals. Although the areas that burn annually on Sakhalin are generally insignificant, negative changes that are barely noticeable to one generation of people progress, shifting wildlife to higher elevation belts of mountain systems (600–800 m) less typical for them. The study of fire locations leads to another conclusion: the further north, the more forest fires. Here, they are destructive to reindeer and Siberian musk deer populations and reduce the productivity of sable habitats.

Ground fires are the most common. They cause the least damage, but even ground fires in forests do not pass without consequences, as the first annual wave of fires on the island coincides with the most critical wildlife breeding period (from May to June).

During the extensive fires at this time, the clutches and chicks of the vast majority of songbirds, young hares and small predators almost entirely perish. For the latter, the volume of food resources is drastically reduced. Sable, fox, raccoon dog and other species migrate away from the areas affected by fire. The burning of berry patches drastically reduces habitat attractiveness for bears, sables and berry-consuming birds for the entire duration of their regeneration. The wild reindeer population also suffers losses due to the reduction in reindeer moss areas.

Ground fires tend to recur periodically, which also leads to a simplification of the fauna composition. Fire recurrences are most frequent in meadows, marshes and agricultural lands, which, in the region, serve as migration routes for migratory birds, for the overwhelming majority of which, such lands also serve as nesting sites. Fires affect not only forest species but also waterfowl (Roslyakov, 1974), which are deprived of both nest-building materials and protected sites in which to build them. As a result, clutches become readily accessible to avian and terrestrial predators. Fires have the greatest impact on avifauna in floodplains and valleys. After them, a decline in wetland bird populations is clearly visible.

On average, grassland fires account for up to 10 % of the total annual fires, meaning that over

10–15 years, all previously burned territories burn again, destroying the undergrowth that has emerged by that time. As a result, distinctive pyrogenic landscapes form, with impoverished and unstable fauna. Crown and mixed fires, which account for 16–18 % of all fires, dramatically and permanently alter wildlife habitats. For Sakhalin Region, the impact of forest fires on significant fauna species can be expressed, according to expert assessment, as shown in Table 6.2.

The estimates given in the table reflect the opinion of an expert panel (Scheme ..., 2023) and are shown by us for further identification of priorities in planning activities for conservation of hunting resources and biodiversity in general.

The high level of fire danger in Sakhalin Region is a consequence of the numerous wastelands and burned areas overgrown with Kuril bamboo, which creates an extremely large and dense biomass of combustible material, and by the frequent winds that promote the rapid spread of fire. At the same time, the condition of the road network is not always suitable for delivering firefighting equipment.

This occurs differently in time across various geographic zones. In the northern part of the region, where larch forests predominate that are quite resistant to fire, the transformative processes occur more slowly, but there is a higher frequency of fire. In the central part, where dark coniferous forests predominate, fires gain greater speed and intensity, and even without the fire transitioning to the crowns, the death of the forest stand is significant. The situation is similar in the southern part of the region, where undergrowth density is high, the understory is well developed and the volumes of pyrogenic material are significant. However, in places where Kuril bamboo with poor water retention is widespread, fires in *Sasa* thickets can occur even 1–2 days after rain.

Road network and population impact

The negative role of roads is that they thoroughly destroy wildlife habitats. Considering there are 14,500 km of year-round roads in the region and their total length exceeds 25,000 km, in forest lands alone, the

Table 6.2. Expert assessment of the negative impact of forest fires on game animal resources on a 10-point system*

Species and species groups of animals and birds	Forest fire impact value				Average impact value
	Crown	Mixed	Ground		
			Spring	Autumn	
Sable	10	6	5	3	6.00
Red squirrel	10	7	4	3	6.00
Stoat	5	3	5	3	4.00
American mink	6	4	2	1	3.35
Otter	7	6	2	1	4.00
Muskrat	0	0	8	3	2.75
Red fox	3	3	5	3	3.50
Raccoon dog	0	5	4	4	3.25
Mountain hare	5	3	6	2	4.00
Brown bear	10	4	2	6	5.50
Moose	7	5	1	2	3.50
Manchurian wapiti	10	9	1	3	5.75
Reindeer	10	10	7	7	8.50
Grouse	10	4	8	2	6.00
Partridges	6	6	9	7	7.00
Wetland birds	0	3	8	2	3.25
Non-wetland birds	5	5	8	1	4.75
Including migratory species	5	5	8	1	4.75
Total average	7.37	5.74	4.9	3.28	5.41

* The assessment took into account the subsequent decline in animal population densities following fires and the time lag required to restore the species to their original abundance.

roadbeds and their ditches remove over 16,400 ha from animal habitats (Scheme ..., 2023). At least 50 m on both sides of seasonal roads and 100 m on year-round roads fall within the direct impact zone; consequently, at least 385,000 ha are excluded from full wildlife habitation.

In addition, the area of indirect influence should also be considered, where the population density of most wildlife decreases year after year due to the constant disturbance. With the commissioning of the Yuzhno-Sakhalinsk-Okha highway (830 km) and increased traffic flow due to industrial development, an additional negative effect arises as the main animal routes for seasonal vertical migrations to the coast are cut. The negative role of roads is further reinforced by the fact that they all run along easy landforms, areas with optimal conditions for wildlife habitats.

In general, population size and density are important indicators that determine the structure of territorial hunting management (Scheme ..., 2023). In southern Sakhalin, where most of the residents are concentrated, this is important to consider when organising new operations.

The existing human population density on the island does not have a decisive negative impact on animal populations. Nevertheless, it is well known that human presence pushes biocenoses toward impoverishment. Where the number of people per unit area increases and land security is inadequate, animal resources inevitably decline. Associated economic activities, forest fires caused by people and the disturbance factor, all combine to determine the composition and population density of fauna. The 5–10 km zone immediately adjacent to a settlement is within the area of direct impact; lands within a radius of up to 30 km can be categorised as indirectly impacted. As a rule, active economic activities tend to occur within 10 km of a settlement: cattle grazing, wild plant gathering, firewood preparation, etc. Local residents with transportation penetrate farther. The larger the settlement, the wider its zone of influence. The fact that settlements are overwhelmingly located along river valleys and seacoasts, areas key to the well-being of game animal populations, also negatively affects animal distribution.

History of hunting on Sakhalin

The distinctive feature of Sakhalin Island's hunting sector is that it covers the natural ranges of various animal species, causing the fragmentation of their habitats. The lists of animal species are constantly being updated, new invertebrate species are discovered, and information on their distribution is supplemented.

Hunting grounds occupy more than 90 % of the Sakhalin Region's area and serve as the basis for the productive activities of the 16 hunting providers constituting the industry (Agency of Forestry ... [Electronic resource]). Its economic importance is low, as the species composition of the region's resources is impoverished, with 12–13 mammal game species (Scheme ..., 2023). The main share of fur harvesting comes from sable pelts, with around 2,500 animals taken in recent years. Other fur species (squirrel, raccoon dog, otter, mink, muskrat, stoat and fox) are currently not in demand and their harvest is minimal (Fig. 6.5).

There is also practically no hunting for ungulates. The acclimatised Manchurian wapiti is few in number; its population in recent years remains at a consistently low level (100–250 individuals), and the moose population, which was reintroduced to Sakhalin, numbers only several dozen (Butkalyuk, 2012; Agency of Forestry ... [Electronic resource]); hunting for it in Sakhalin Region is prohibited. In addition, due to declining numbers, reindeer hunting was restricted in 2009–2012 by decision of the Sakhalin Region Administration, and completely banned in 2012–2015. In 2016, the eastern group thereof in Central Sakhalin was included in the Red List of the Sakhalin Region and from 2021, the species in full is listed in the regional Red List. Sakhalin is also home to the Siberian musk deer (Sakhalin subspecies), which is listed in the Red List of the Sakhalin Region and the Red List of the Russian Federation. It is noteworthy that the conservation strategy for Sakhalin musk deer in Russia, prepared with the participation of the A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, is dedicated to this species, and was approved in 2008 (Order of the Ministry ..., 2008). Therefore, among big game, the brown bear remains as a game species, and is quite abundant (4,200–4,500 individuals). In more limited numbers, in the Korsakovsky District, there is the red deer (Manchurian wapiti), most of which inhabits hunting grounds assigned to the hunting provider Svarog LLC (Scheme ..., 2023).

The total number of hunters in the Sakhalin Region is about 26,000 people (5 % of its population), which indicates a high level of enthusiasm for hunting (Scheme ..., 2023). The main activity of amateur hunters is bird hunting: it is waterfowl during autumn and spring migrations, and hazel grouse and willow ptarmigan in winter. In addition, unlike its neighbours (Primorsky and Khabarovsk Regions), hunting for mountain hare, including with hound dogs, is popular

on Sakhalin. The share of hunting in the regional economy is small: the value of harvested hunting products at average market prices is RUB 15–16 mln per year (Scheme ..., 2023).

Hunting is not of great economic importance for local residents: combined with agriculture and forestry, the hunting industry accounts for less than 2 % of the region's total production. Nevertheless, local hunters sell sable pelts alone for about RUB 10 mln per year on average, which provides significant support for pensioners and working enthusiasts.

Professional hunters now have amateur status. They obtain appropriate permits and go into the taiga to hunt fur-bearing animals, primarily sable. Such people are becoming fewer, the average age of the ever-diminishing 'caste' of commercial hunters is above 60 years, and today's youth is getting involved in commercial hunting less and less. At the same time, with the improvement in the general standard of living, the number of amateur hunters who prefer seasonal trips to hunting grounds for bird hunting is increasing. The share of recreational and commercial hunting in the production of hunting products in Sakhalin Region is 67.1 % and 32.9 %, respectively.

A hunter may take bear, Manchurian wapiti, sable and otter within the quota allocated for a specific area and hunting season. All other species, American mink, common squirrel, flying squirrel, fox, stoat, raccoon dog and mountain hare, are not subject to limits. The resources of upland, marsh-meadow and wetland game are fairly well utilised on Sakhalin (Fig. 6.6). The abundance of lakes, bays, lagoons and marshes, and the extensive river network allow Sakhalin hunters to connect with nature and taste freshly harvested game in two seasons a year (spring and autumn). Amateur hunters most often make soup from waterfowl, called 'shurpa'.

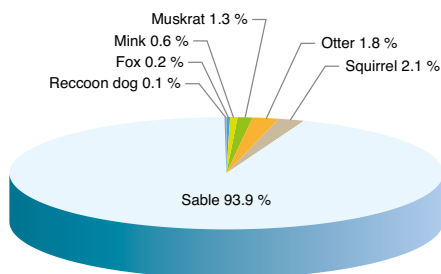


Fig. 6.5. Share of commercial species in fur production

Main game species and their numerical statistics

Hunting timing and restrictions are established as per the Hunting Rules (2021) based on data from state monitoring of game resources approved by the Ministry of Natural Resources and Environment of the Russian Federation. In Sakhalin Region, hunting times and restrictions are approved by decree of the Governor (On the determination of species ..., 2024). The limits and allocated quotas for the harvesting of hunting resources during the hunting season are approved annually by the regional Governor's decrees upon coordination with the Ministry of Natural Resources and Environment of the Russian Federation.

Hunting methods in the Sakhalin Region generally fall within the commonly accepted framework and exhibit no special features (Table 6.3), although the biological timing of breeding and seasonal migrations of most species is often shifted by 2–4 weeks relative to the mainland Far East due to the natural and climatic peculiarities of the island region.

Sport hunting is a type of active recreation (Federal Law ..., 2009). It fosters courage and resourcefulness, helps to become physically strong, agile, hardy and able to overcome difficulties and obstacles; develops love for nature. The hunter should be able to build a fire and arrange an overnight stay in the forest, find directions without a compass in rainy or winter conditions, be a good swimmer, operate watercraft, know how to protect themselves from thunderstorms and heat stroke, and provide first aid to themselves and companions if necessary. Hunting is allowed only for persons with hunting licenses. When obtaining a hunting license, a novice hunter is required to pass a hunting minimum exam: a set of basic knowledge covering firearms handling, hunting rules, seasons, and related matters. An experienced

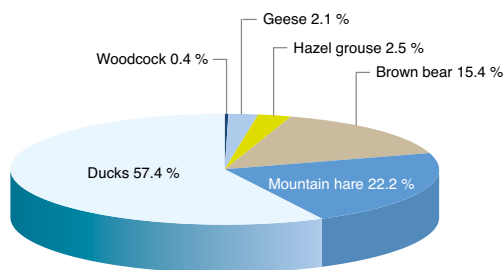


Fig. 6.6. Share of species in the harvest of amateur hunters

Sakhalin bear hunter, V. Mandritsa (Pasyukov, 2011) shared some basic safety rules for hunting.

‘Never forget safety precautions when hunting. When out hunting, never transport loaded firearms in cars, motorcycles, motorboats or other vehicles. When loading your gun, be careful not to point the barrel toward a companion. Hold the weapon with the barrel pointing at the ground. If you are stalking an animal and walking one behind another with loaded weapons, hold your gun slightly to the side with the barrel pointing up. Only take the safety off when you see a clear target; do not move any further. When climbing into a blind or hunting platform, your weapon should be unloaded. Never shoot at a poorly visible target; never shoot at noises in shrubs, burdock or bamboo. Never shoot if

you cannot see your target clearly due to fog or heavy rain. After shooting a bear, check to make sure that your weapon is unloaded, since due to the excitement of a successful hunt, young hunters often forget to do so and return home with loaded weapons, which is dangerous for family members and themselves. So despite the cold, fatigue or rain, the inevitable conditions of bear hunting, the weapon should be unloaded’.

The brown bear is the main game species for recreational hunting in the southern part of Sakhalin. It inhabits almost all forested areas of the region and can be found in almost all habitats during the warm season. Preferred habitats, where the species’ population density is higher than in other locations, are the floodplains of spawning rivers and seashores, including

Table 6.3. Timing and methods of hunting game in the Sakhalin Region

Game species	Hunting time	Methods of harvesting
Manchurian wapiti	All age and sex groups: from October 1 to January 10. Adult males: from September 1 to September 30. Adult males with unossified antlers: from June 1 to July 15.	Stalking; during the rut; using hunting towers and raised platforms. Poaching: shooting from vehicles using headlights on forest roads; pursuit using snowmobiles.
Wild reindeer	Hunting is prohibited; the species is listed in the Red List of the Sakhalin Region.	Poaching: pursuit using snowmobiles.
Moose	Hunting is prohibited.	Poaching: pursuit using snowmobiles.
Brown bear	Spring period: from April 20 to May 31. Autumn period: from August 10 to November 30.	Stalking; bait hunting from raised platforms; hunting with dogs. Poaching: snaring on trails near spawning grounds and bait sites; killing in dens.
Sable	From October 25 to February 28.	Harvesting with self-acting traps, other traps and humane trapping devices of various designs, baited or set on tracks. Shooting with the use of dogs. Poaching: standard steel-jawed leg-hold traps.
Eurasian otter	From October 25 to February 28.	Self-acting traps set on trails and in water at shallow riffles and at exit points onto land and ice. Poaching: standard steel-jawed leg-hold traps. Poaching: standard steel-jawed leg-hold traps.
Red fox	From September 15 to February 28.	Leg-hold traps. Stalking and shooting along the coast; shooting from vehicles in tundra areas.
Raccoon dog	From September 15 to February 28.	No targeted hunting is carried out. Poaching: standard steel-jawed leg-hold traps.
Least weasel	From October 25 to February 28.	Not harvested
Stoat	From October 25 to February 28.	No targeted hunting is carried out. Poaching: standard steel-jawed leg-hold traps. Use of long-barrelled rifled hunting firearms and rifled barrels of combination hunting firearms with a calibre exceeding 5.7 mm.
Mink	From October 25 to February 28.	Leg-hold traps set on trails and in water.

Game species	Hunting time	Methods of harvesting
Wolverine	Hunting is prohibited; the species is listed in the Red List of the Sakhalin Region.	Poaching: leg-hold traps set on trails.
Lynx	Hunting is prohibited; the species is listed in the Red List of the Sakhalin Region; only isolated records of lynx have been reported on Sakhalin.	In 2019, a lynx was recorded caught in a trap set for foxes in the Tomarinsky District. The animal was successfully released.
Flying squirrel	From October 25 to February 28.	No targeted hunting.
Mountain hare	From September 15 to February 28.	Snaring on trails. Rarely, shooting by tracking in snow, with hounds. Poaching: use of long-barrelled rifled hunting firearms and rifled barrels of combination hunting firearms with a calibre exceeding 5.7 mm.
Red squirrel	From October 25 to February 28.	Shooting with the use of dogs. Leg-hold traps set on trails. Rarely, driven hunting and box traps. Poaching: use of long-barrelled rifled hunting firearms and rifled barrels of combination hunting firearms with a calibre exceeding 5.7 mm.
Chipmunk	From September 15 to October 31.	No targeted hunting.
Muskrat	From October 15 to February 28.	Self-acting traps. Poaching: standard steel-jawed leg-hold traps. Rarely, basket traps. Use of long-barrelled rifled hunting firearms and rifled barrels of combination hunting firearms with a calibre exceeding 5.7 mm.
Black-capped marmot	From June 15 to September 30.	Long-range shooting with calibres from 5.45 to 7.62 mm.
Hazel grouse (upland game)	From September 15 to January 12.	Stalking. Use of calls in autumn. Poaching: use of calls in spring.
Partridges (upland game)	From the third Saturday in August for a duration of 150 calendar days.	Stalking.
Eurasian whimbrel (marsh and meadow game)	From the third Saturday in August to December 5. From the first Saturday in August to December 5: with gun dogs and birds of prey.	From hides with decoys; stalking.
Ducks (waterfowl)	From May 1 to May 10 inclusive (southern zone). From May 9 to May 18 inclusive (central zone). From May 15 to May 24 inclusive (northern zone). From April 15 to May 18: drake hunting using live decoy ducks during the spring season in the southern and northern zones. From the first Saturday in September to December 5 (for the entire Sakhalin Region).	Stalking in autumn. From hides at dawn and dusk, with and without decoys in spring. Use of mouth calls. With live decoys during the designated periods. Poaching: use of electronic sound-emitting devices imitating calls of Anseriformes. Use of motor vehicles.
Geese (waterfowl)	From May 1 to May 10 inclusive (southern zone). From May 9 to May 18 inclusive (central zone). From May 15 to May 24 inclusive (northern zone). From the first Saturday in September to December 5 (for the entire Sakhalin Region).	Stalking. Hunting from hides at dawn and dusk, with and without decoys, along migration and flight routes. Use of mouth calls. Poaching: use of electronic sound-emitting devices imitating calls of Anseriformes; use of motor vehicles.
Woodcock (upland game)	From May 2 to May 11 inclusive (southern zone). From May 10 to May 19 inclusive (central zone). From May 16 to May 25 inclusive (northern zone). From September 15 to January 12 (for the entire Sakhalin Region).	Shooting on the roding flight; rarely with dogs of appropriate breeds.
Turtle dove (field game)	From the first Saturday in September to December 5.	Stalking; shooting during migration on fields and forest roads.

coastal plateaus. On the littoral, the animals feed on sea deposits, especially when food is scarce after emerging from dens. Significant concentrations of animals can form there. In mid-May, with the appearance of the first vegetation, they move to river floodplains, as snow still covers the ridges at this time. By September, as berries ripen, the bears move to areas with blueberries, bilberries and lingonberries. They also actively visit the spawning grounds of migratory salmon. Generally speaking, the distribution patterns of bears are determined by food availability, the diversity and abundance of which contribute to a high population density (Glushkov, 2011; Danilkin, 2010; Sabaneev, 2008).

Brown bear numbers are determined through counts in the autumn, during the salmon spawning season, when bears concentrate near spawning grounds. Bears are also counted in spring on Sakhalin as they emerge from their dens. There are 3,800–4,500 bears on Sakhalin (V. Voronov, 1982; Agency for Forestry ... [Electronic resource]). The island's hunters currently harvest an average of 200–250 bears per year. In addition, any animals that approach human settlements and pose a danger to people are shot. Two to three bear attacks on humans are reported on the island each year.

Forced shootings refer to situations where no option remains except the physical elimination of the animal. Such situations may arise, for example, when an animal fed by humans loses its fear of them and begins to pose a real threat to human life and health. Since the entry into force of the federal law on hunting (Federal Law ..., 2009), the only legitimate mechanism for solving this problem is making decisions on population regulation regarding threats to the life and health of people and farm animals.

The average number of forced shootings per year over the past 10 years has ranged from 30 to 40. 2017 stands out from the overall statistics, when there were 120 forced shootings of 'troublesome' bears. At that time, weak salmon runs and poor wild berry harvests played a role against a backdrop of increased bear numbers and density in certain areas, causing the animals to approach settlements, garden plots and dumps in search of food. In addition, active cannibalism among bears was observed, a phenomenon quite common even in less austere years. Stronger individuals can easily kill weaker ones and consume them. This is why female bears often lead their cubs away to save them from large males, thereby approaching settlements on the periphery of their range.

Each forestry district has organised task forces consisting of game wardens, state forestry inspectors, foresters and public inspectors who are experienced

hunters. Sometimes they are assisted by police forces. Only in extreme cases does the Agency for Forestry and Hunting of the Sakhalin Region decide to regulate the bear population, and a task force carries out the forced shooting of an aggressive individual. Sometimes it is enough to scare the animal away and eliminate the bait that caused it to approach people. The main objective is to avoid casualties and damage to citizens, agriculture and other wildlife.

Introduction, acclimatisation and reacclimatisation of game animal species

Introduction, acclimatisation and reacclimatisation, which began in the 1950s, played a significant role in replenishing the species composition of the island. The region received muskrat, raccoon dog, American mink, European mink, Manchurian wapiti and moose. The attempts to repopulate South Sakhalin with wild boar and Canadian beaver were unsuccessful. In March 1980, six wild boars were brought to the island and released in the Korsakovsky District, near the Svobodnoye hunting base. In September 1979, 60 beavers were introduced and released into Lake Dobretskoe, into one of the rivers flowing into Lake Svobodnoye, and into the Moguchi River on the Crillon Peninsula. The causes of unsuccessful acclimatisation were high humidity, sudden water discharges in rivers during typhoons, the snowy Sakhalin winters and poorly chosen release sites.

Limited species include sable, Eurasian otter, American mink, brown bear, reindeer and Manchurian wapiti. Sakhalin musk deer, European mink and wild reindeer are listed in the Red Lists of various ranks of terrestrial mammals. From the hunting avifauna, the main game species are geese, sea and river ducks, hazel grouse, partridges, oriental turtle dove and waders (V. Voronov, 1982; Eremin, 2005).

Introduction is the movement of the individuals of a species of animals and plants outside their natural range to a place where they have not lived before.

The Manchurian wapiti is a subspecies of the wapiti. It inhabits the Russian Federation (Irkutsk Region, Transbaikalia and Far East) and China (Northern Manchuria), and occurs in Korea and Northern China. It was introduced on Sakhalin in 1965. The source individuals for the release were Manchurian wapitis from the Khabarovsk and Primorsky Regions. In the first 5 years after the introduction began, 56 animals were released.

They were released in the southern part of the island, in the vicinity of the Tonino-Aniva Ridge.

The further course of acclimatisation showed that serious mistakes were initially made in selecting the release site. First, there is the extreme isolation of the southern part of the island from the central and northern parts of Sakhalin; second, the depth of snow cover and the number of winter-spring cyclones in the south is twice as high as in the rest of the island; third, the southern part is the most densely populated part of Sakhalin. Deer counts were random in nature. The data from those years are inaccurate. In some places, there are not even ten sables, yet they move about so actively that it seems as if there are thirty of them ...

In March 1978, a one-day aerial survey recorded 25 Manchurian wapitis near Ptichie Lake in the vicinity of the Tonino-Aniva Ridge. From February to March 1980, the entire southern part of Sakhalin was surveyed for the first time by two groups of game wardens. The results exceeded our expectations. According to survey data, the number of Manchurian wapitis was 650–700 individuals. Manchurian wapitis are distributed along the entire length of the Tonino-Aniva Ridge and Susunaysky Ridge of the Korsakovsky District. In winter, deer stick to the eastern slopes (low-snow seashores) of the aforementioned ridges; in summer, throughout the forested part of the area.

From 1964 to 1986, the southern part of Sakhalin was exposed to powerful winter cyclones. In February and March, the snow cover height reached 2 m. Movement became practically impossible for Manchurian wapitis; the animals retreated into dense spruce forests and stayed there for 1–2 weeks. People could step right next to them. They stood in streams, eating straw and strip fodder. In order to support them, food was dropped from helicopters. The snow, melted and normal during the day, froze at night, becoming as hard as concrete. When traveling downhill, Manchurian wapitis would break through the crust, get stuck and break their legs ... In April–May 1985–1986, hunters and game wardens came across the corpses of Manchurian wapitis that had died from exhaustion. In short, the snow load was powerful, and the forage base was small.

Subsequent deer surveys showed that three snowy winters resulted in a halving of the animal population. Based on situational analysis, a decision was made to organise live capture and relocation of Manchurian wapitis to the central and northern parts of Sakhalin, which differ from the southern part by their more continental climate. This should have been done from the beginning. In February–March 1987, employees of the Hunting Department of the Sakhalin Region Executive Committee captured 23 Manchurian wapiti individuals (6 males and 17 females) in the Korsakovsky District and transported

them to the northern part of the Dolinsky District, 200 km from the capture location. The Izubrovoy Reserve was established at the release site (note: later renamed Dolinskiy Reserve, it received complex reserve status due to the absence of Manchurian wapiti and the presence of a large number of Red List species).

A distinctive feature of the chosen location is that the northern part of the Dolinsky District is part of the Kamyshovoy Ridge system, which runs across the island from south to north, meaning that animals released in the Dolinsky District can travel to the central and northern parts of Sakhalin. From 1967 to 1999, annual surveys for Manchurian wapiti were conducted in the Izubrovoy Wildlife Refuge. 25–30 individuals are permanently present, and animals were recorded to the north: Makarovsky District, 20 km from the release site; Poronaysky District, 200 km from the release site; Tymovsky District, 500 km from the release site. Considering the fact that Manchurian wapiti are gradually developing in the northern areas, 10 animals (1 male and 9 females) of different age groups were captured in 1999 in the south of the island.

All the individuals were brought to the Tymovsky District and, after a week's holding under good conditions, were released into areas that are inhabited by Manchurian wapiti that had previously come there on their own. Game wardens in the Tymovsky District noted the appearance of juvenile individuals in 2000. In March 2001, a further 10–15 animals were captured in the south of the island and released into Tymovsky District. In general, it can be said that the dispersal of Manchurian wapiti across Sakhalin has been successful. Alongside the introduction of Manchurian wapiti in the south, moose were introduced in the Smirnykhovsky District.

The hunting business should develop towards the introduction of large ungulates (Manchurian wapiti, red deer and moose) and other species interesting from the point of view of attracting tourists (sika deer, wild boar), which can be kept in the cordon of a subsidiary farm; or in the wild environment, the introduction of these species is extremely difficult due to depth of snow'.

A. Kostin (Kostin, 2000)

Sakhalin musk deer (subspecies of Siberian musk deer)

The Sakhalin (Siberian) musk deer (*Moschus moschiferus sachalinensis* Flerou, 1929) is a small ungulate of the musk deer family. Most of the Sakhalin musk deer's range is in Russia, from the Krasnoyarsk Region and

Irkutsk Region in the west to the Primorsky Region, Yakutia and Sakhalin in the east. The species is also common in Mongolia, China and Korea. Inhabiting a mountainous taiga landscape, the Sakhalin subspecies of Sakhalin musk deer is an important component of the island's balanced biodiversity. The current practice of human development of mountainous areas on the island leads to the loss of rare species (subspecies) and the destruction and destabilisation of the island ecosystem. The Sakhalin musk deer inhabits only Sakhalin Island; its subspecies status in the Russian Federation is Category 1, endangered island subspecies (Red List ..., 2016).

Distribution and habitats

The Sakhalin musk deer inhabits the middle belt of the island's mountain taiga, where it lives mainly in maturing, mature and overmature dark coniferous forests. The main habitats are the forests of Sakhalin fir (*Abies sachalinensis*) and Ajan spruce (*Picea ajanensis*). The habitats often include fir undergrowth and rocky outcrops. The favourite habitats for Sakhalin musk deer on the island are the slopes of ridge spurs stretching along rivers and strands. The animals have a clear preference for slopes littered with windthrow or overgrown with dense shrubs. In summer, the animals tend to stay in their northern and eastern exposures, while in winter they stick to the forested crests of ridge spurs.

In the western part of the island in winter, Siberian musk deer tend to inhabit green-moss forests, which occupy about 60 % of the area of the dark coniferous formations. They are distributed on slopes of different exposure and steepness, rising to a height of 400–450 m above sea level. On the Tonino-Aniva Ridge, Siberian musk deer inhabit fir fern forests found mainly on plateau-like overbank highlands up to 200–300 m above sea level. In the eastern part of Sakhalin, Sakhalin musk deer often winter in larch and spruce forests, where there are ground lichens under the canopy (Order of Ministry ..., 2008).

In summertime, Sakhalin musk deer tend to inhabit shrubby dark coniferous forests: bilberry, bilberry-moss, shrub-moss and shrub-grass forests. These forests occupy the middle parts of the mountains, their slopes, ravines, river terraces and sometimes plateau-like elevations. The dark coniferous forests extend along mountain strands up to 700 m above sea level, often forming high-altitude spruce forests.

Winter habitats of Sakhalin musk deer along the western macroslope of the Tonino-Aniva Ridge up

to the shore of Lake Tunaycha (Puzino Peninsula, Muravyevsky Isthmus) include larch forests (with spruce and fir), with wild rosemary or bilberry in flat and even swampy forest areas. These formations are atypical for the species. However, their colonisation by Sakhalin musk deer in recent years is due to the abundance of epiphytic lichens in these forests. Across all seasons, the spatial distribution of Sakhalin musk deer is closely related to the distribution of lichen forage on the ground. The main mass of lichens is concentrated in mature and overmature forests.

In central Sakhalin in the 1980s, Sakhalin musk deer inhabited extensive areas along the slopes of Kamyshev Ridge and the East Sakhalin Mountains. These two centres of habitat were geographically separated by the Tym-Poronai lowlands with floodplain forests and agricultural lands. The animals inhabited only certain parts of the mountain taiga within these areas. The northern boundary of their distribution in the eastern centre reached the Nogliksky District. Single animals were found on the Nabil Ridge (in the upper reaches of the Parkata River and Vezli River) and in the Pilenga River basin. Sakhalin musk deer were also recorded on the slopes of Mount Lopatina. Further south, they were found along the left tributaries of the Poronay River and in the Langeri River basin. The southern boundary of the eastern area of its habitat reached the headwaters of the Rukutama River. In western Central Sakhalin, Sakhalin musk deer had been recorded in the Alexandrovsk-Sakhalinsky, Smirnykhovsky, Ulegorsky and Makarovsky Districts. The northern boundary of their distribution in this part of the island extended to 51°N, while the southern boundary lay at 48°N. In the northern part of the Kamyshev Ridge in the 1980s, Sakhalin musk deer inhabited the tributaries of the Viahtu River, Grabchikha River, Khoe River, Bolshaya Tanga River and Aleksandrovska River in their upper reaches and some left tributaries of the Tymi River. Animals were also recorded along the Mangidai River, Malaya Machi River, Nai-Nai River and First River. To the south of Alexandrovsk-Sakhalinsk, traces of Sakhalin musk deer activity had been recorded along the Agney River near the Vladimirovka Village, along the Taulan River, Dadagan River and Agnevo River, and along the coastal rocks of the Tatar Strait from the vicinity of the Komsomolsky Village to South Shirokaya Padi Village. In the central part of the Kamyshev Ridge, Sakhalin musk deer were found in the tributaries of the Onorka River and Belkina River (Vesely and Sakharovka strands). To the south, it inhabited dark coniferous forest areas along the Ushakovka, Chernomorka and Leonidovka Rivers. Within the

Makarovskiy District, animals were found in the upper reaches of the Viktoriya, Kaluzhskaya (a tributary of the Makarova) and Goryanka Rivers. In the southern part of the Zapadno-Lisyanskiy Ridge, Siberian musk deer were regularly recorded at the watershed of the Markovka, Gornaya and Moskovka Rivers. The southern boundary of Siberian musk deer distribution on the Kamyshevoy Ridge should be considered the slopes of Mount Vladimirovka, from where these animals periodically migrated to Mount Tikhaya. In the southeast of Sakhalin, there were two more centres of residence: in the mountain taiga forests of the Susunayskiy Ridge (in the upper reaches of the Bakhura River, Anna River and Simau River) and Tonino-Aniva Ridge (from Cape Svobodny to Cape Velikan).

The range of the Siberian musk deer is currently divided into two main subpopulations, western and eastern; they are isolated from each other and are represented by seven groups (Strategy ..., 2010) (Fig. 6.7).

Group 1 is on the Tonino-Aniva Ridge, along its eastern and western spurs, from Cape Svobodny to Cape Velikan. To the south, isolated sightings of Sakhalin musk deer are recorded in the upper reaches of the Podsobnaya River and Evstafievka River, besides traces of its activity along the coastline from Cape Mramorny to Cape Aniva. During field surveys and counts, the presence of single Sakhalin musk deer individuals was detected on the Puzina Peninsula near Lake Svobodninskoye. The inhabited area is less than 100 km².

Group 2, on the slopes of the Susunai Ridge spurs in the upper reaches of the Bakhura River, Simau River, Zhukovka River, Krasnoselskaya River, Kolka River, Chusovaya River and Sokol River. Along the Anna River, the animals are found up to the middle reaches. In winter, Sakhalin musk deer enter the upper reaches of the Khomutovka and Ochepukha Rivers. The furthest points the animals visited in winter were noted to be in the middle belt of Mount Chekhov and Mount Pushkinskaya. The area of the inhabited territory is 30–35 km².

Group 3, on the eastern macro-slope of the South Kamyshevoy Ridge. The boundary of the isolated grouping covers the upper reaches of the Anastasia River, Utesovka River, Taranay River, Uryum River, Bryanka River and Tambovka River. The area of the inhabited territory is about 70 km².

Group 4, on the Shrenka Ridge, Mitsulsky Ridge and Bambukovy Ridge. It occurs only in the upper reaches of the Firsovka River, Krasnoyarka River and Kostroma River, in the vicinity of Sinegorye Village, in the basin of

the Novoselovka River, and at the foot of the Mitsulya and Bobryk mountains. The inhabited area includes three or four settlements and is about 100 km².

Group 5, along the spurs of the West Sakhalin Mountains. The northern boundary reaches 51°20'N, and in some years reaches the headwaters of the Viahtu, Grabchikha and Khoe Rivers. The southern group, up to 48°N, where animals are constantly present at the headwaters of the Ilyinka River and Tikhaya River. The range is highly fragmented and includes several disconnected subgroups. The most extensive subgroup is located in Makarovskiy District. The area of the inhabited territory does not exceed 300 km².

Group 6, on the southern and eastern slopes of Mount Vagis. There is no reliable evidence of a permanent grouping in the north of the island. Traces of Sakhalin musk deer activity have been recorded here since 1998. Field studies have shown that the potential area of the habitat suitable for Sakhalin musk deer here is at least 100 km².

Group 7, on the slopes of the East Sakhalin Mountains. The range has a small-focal structure with single individuals. Its boundary has not been explored. The main subgroup is located along the spurs of the Nabil Ridge. Single individuals are found on Luni Ridge. The second eastern habitat area covers the Central Ridge. To the north, the border extends to the upper reaches of the Vazi River and Kokubagieva

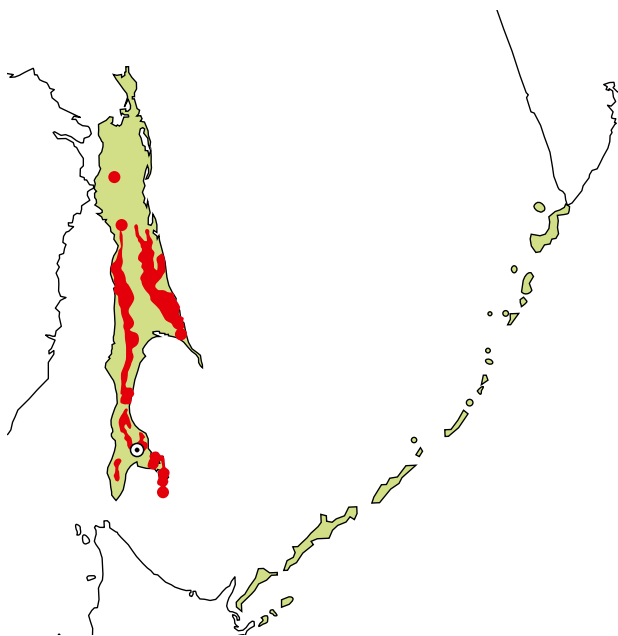


Fig. 6.7. Map of Sakhalin musk deer distribution in the Sakhalin Region (Red List ..., 2016)

River. In the Pursh-Pursh River basin, Sakhalin musk deer are recorded in the coastal rocky areas of the dark coniferous forest. The southern boundary of its distribution in the East Sakhalin Mountains runs along the Lake Dmitrievskoye-Lake Dolgoye line. In the 1990s, Sakhalin musk deer were seen near logging sites in the vicinity of the Trudovoye Village and Sobolinoye Village.

Animals were observed entering the Poronaysky State Nature Reserve. According to preliminary estimates, the inhabited area is 250–300 km² (Order of the Ministry ..., 2008).

Population size and dynamics

Population dynamics of the Sakhalin musk deer are conditionally divided into two periods: historical and modern. The first period, which began after the island's colonisation, was very long, lasting until the mid-19th century. It is assumed that the Pleistocene forests on the island were almost twice as large as the present-day forested area, reaching 10 million ha. On Sakhalin, as on the mainland part of the species' range, Sakhalin musk deer in the past gravitated to areas of dark coniferous taiga. Depending on the degree of relief dissection and food (lichen) reserves, Pleistocene island habitats are classified into two categories: suboptimal and pessimal, characterised by low density indicators and habitat capacity (Prikhodko, 2009). At an average density of 0.5 individuals/1,000 ha, the estimated maximum population of Sakhalin musk deer should theoretically have reached 5,000 individuals at the end of the Pleistocene. The specific, non-habitat-limited growth rate for the experimental group kept in captivity at the Chernogolovka Scientific and Experimental Base of IEE RAS, which increased from 9 to 53 individuals over a 10-year period, is 3.73 for Sakhalin musk deer. This low indicator suggests that, during the new-territorial development phase at the end of the Pleistocene, the growth of spatial groupings and then of the population occurred at a slow pace. After reaching a population approaching the upper limit, the growth rate periodically slowed down (Fig. 6.8). As it approached the upper asymptote in a changing environment, the rate not only slowed down but could exhibit negative values in some periods due to mortality exceeding the birth rates. Thus, the time interval required to reach the population limit (5,000 individuals) was calculated to be at least 130 years. Such an extended complete growth cycle is explained by the biological characteristics of the species, which has a moderate reproductive

potential and a short life span. The most important limiting environmental factors were and remain the successional cycles of fir-spruce forests, the climax stages of which occur after 90–120 years. It is not difficult to notice that the duration of demographic cycles slightly exceeds successional ones. This indicates a short-term inertial growth of the population after each transformation of the mountain-taiga landscape in the Pleistocene. It can only be assumed that during the growth phases, the Sakhalin musk deer population underwent a number of cyclical fluctuations with a decrease in the level of the upper asymptote. As a result of population fluctuations, there were gaps of time between when it reached 4,000 and decreased to 3,000 individuals even before intra-population factors came into play, such as territoriality, which limits the growth and density of animal populations. Available literature sources indicate a catastrophic decline in natural populations of Sakhalin musk deer in the northern part of the range in the late 19th century (Turkin and Satunin, 1902; Shcherbakov, 1959; Prikhodko, 2008), when the species was on the verge of extinction. Hunting was the cause of the catastrophic population decline. A characteristic feature of this period is a synchronous decline in the resources of the Sakhalin subspecies, comparable to mainland proportions of animal declines. The original population of these animals was about 3,000 in 1855, but as a result of hunting pressure, it had declined to 300–500 individuals by 1880. It took at least 100 years to restore the island population's resources to the original level.

Logging and forest fires caused another decline in the Sakhalin musk deer population in the late 20th century (Prikhodko, 2010). Despite the listing of the island subspecies in the Red List of the Russian Federation, a negative trend in population dynamics has been observed since 1998 and continues today. The decline has been monotonic over the past 17 years, reflecting the delayed extinction of the animals. According to the estimation of V. Prikhodko, by 2016 the number of Sakhalin musk deer had decreased to a critically low level of 250–300 individuals, so the subspecies' resources decreased by 5.5 times. Fig. 6.9 shows the exponential curve of actual population extinction plotted using empirical data (Prikhodko, 2016).

It is important to note that the data given by V. Prikhodko (probably the most authoritative expert on Sakhalin musk deer in Russia) contradicts data from the Agency for Forestry and Hunting of the Sakhalin Region. Thus, according to winter route surveys (WRS), the number of Sakhalin musk deer on

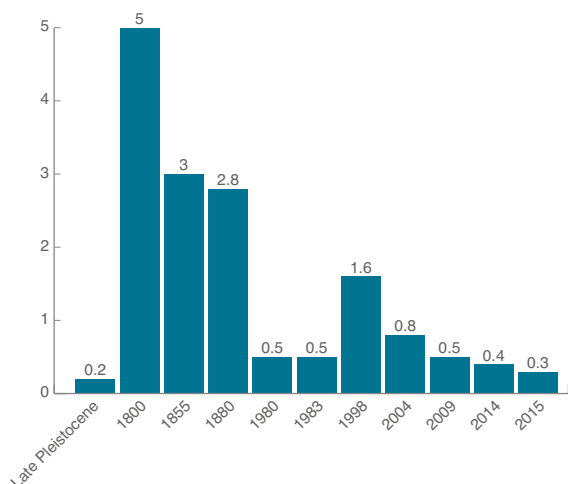


Fig. 6.8. Sakhalin musk deer population dynamics

the island in 2015 was 1,240 individuals, or, according to V. Prikhodko, 300 individuals. According to the Agency, having declined to 880 individuals by 2016, the Sakhalin musk deer population began to increase rapidly over the next 5 years, reaching 1,614 individuals by 2021 (Fig. 6.10).

The population dynamics of Sakhalin musk deer exhibit general patterns associated with periodic natural environmental changes. Throughout the Pleistocene and practically the entire Holocene, fluctuations in their abundance were synchronised with the successional cycles of mountain taiga forests, the main habitats of the species. Between the demographic cycles, if the birth rate exceeded the death rate, positive growth could occur, which in certain periods provided another wave of population numbers. Increases in animal numbers over the last two centuries have been followed by two waves of depression comparable to the beginning of the extinction phases.

In general, based on studies of the main types of forest landscapes in the Far East, it has been established (Bromley and Kucherenko, 1983; Zheleznov, 1990; Zaitsev, 1991) that in typical habitats Sakhalin musk deer rarely experiences food shortages. Even at the maximum known population density of Sakhalin musk deer (20 individuals/1,000 ha), the estimated amount of vegetation consumed by them is many times less than the available reserves, including during the non-growing season. There is absolutely no relationship between the Sakhalin musk deer population density and species diversity of forage plants of all available selectivity classes. Consequently, if these data are applied to the Sakhalin musk deer, it should be emphasised that the mass of plant food of this species in the mountainous

forest formations of Sakhalin is such that Sakhalin musk deer at the current densities cannot experience food shortages. Considering that the estimated consumption is less than 10 % of the available reserves, it can be argued that Sakhalin musk deer are not the cause of degradation of forage vegetation (Smirnov, 2009a).

Active human economic activity on the island since the late 19th century has led to the destruction of musk deer habitats and the displacement of the natural cycles that had existed for centuries. The current mosaic-like distribution of Sakhalin musk deer, caused by the patchiness of mountain taiga habitats, is now more pronounced compared to prehistoric times due to the anthropogenic factor in this process. The area of all focal zones of Sakhalin musk deer habitat continues to decline against the background of low numbers of intrapopulation groups.

Habitat area determines extinction

Small body size, trophic specialisation and stenobiomic nature have proven to be the features that hinder the long-term survival of the Sakhalin musk deer. The annual destruction of mature mountain taiga forests by logging causes the disappearance of epiphytic lichens which are the main source of food for Sakhalin musk deer and makes the logging areas unsuitable for animal habitation for an extended time. The Island's coniferous forests, as producers of epiphytic lichens, are vulnerable when exposed to even one abiotic factor, such as air pollution. Of all the industrial sources of emissions on Sakhalin, the

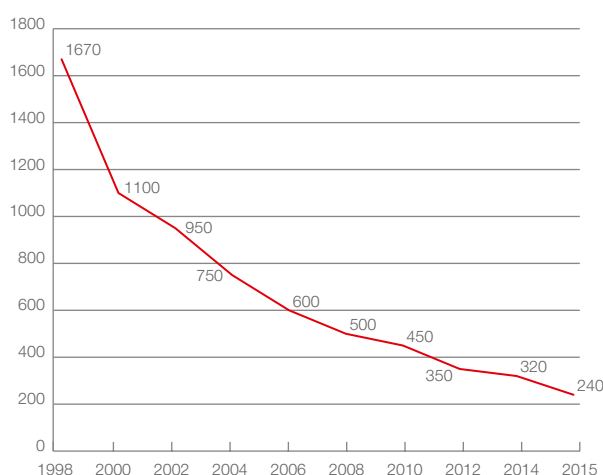


Fig. 6.9. Decline curve of the island population of Sakhalin musk deer over the last 17 years (1998–2015) (Prikhodko, 2016)

natural gas liquefaction plant is the primary producer of pollutants that are most dangerous in their long-term impact on the Sakhalin musk deer habitat. Its impact is selective, especially on epiphytic lichens, which may lead to the vanguard extinction of these ungulates in the southern and central parts of the island. The area of mature and overmature dark coniferous forests on Sakhalin that serve as preserved potential habitats of the island subspecies is currently about 650,000 ha. Each year, 2.5–3.0 % of Sakhalin musk deer habitat on the island is lost to forest fires alone, which ultimately leads to a reduction in the range of the individual spatial groups and their numbers (Prikhodko, 2010).

Genetic diversity

The observed decline in the abundance of the island subspecies in recent years and increased habitat fragmentation have led to a decrease in overall genetic diversity and, possibly, the occurrence of inbreeding depression in isolated local groups. A comparison of nucleotide variability of the studied mtDNA fragment of wild ungulate species showed that in Sakhalin musk deer the value of this index is at the average for the group of wild ruminants. However, the haplotypic diversity (H) and nucleotide variability (P) of the Sakhalin subspecies were two to three times lower than those characterising other subspecies of Sakhalin musk deer (Kholodova and Prikhodko, 2006). The decrease in diversity is not due to a reduction in the number of isolated local groups, but to a decrease in their population and their areas. None of the seven currently existing intrapopulation groups has an effective population size, equal to 102 breeding

individuals. In four groups, their resources do not exceed 30 individuals, in three, the number ranges from 30 to 125. The low and variable abundance of island groups, depending mainly on external factors, will continue to deplete the genetic diversity in successive generations.

Over the past 5 years, there has been a twofold decrease in the resources of the island subspecies of Sakhalin musk deer. The most productive part of this subspecies are middle-aged females, 3–5 years old. The average actual birth rate for Sakhalin musk deer is 0.1 fawns per female per year in favourable years. In all groups surveyed in the central and southern parts of Sakhalin, mortality has already exceeded the birth rates. Official records confirm the regular and significant population declines throughout the subspecies' range. Significant reductions in Sakhalin musk deer resources were recorded in 2007 and 2008 in Poronaysky (from 149 to 0 individuals), Smirnykhovsky (from 213 to 0 individuals), Tomarinsky (from 51 to 0 individuals), Alexandrovsk-Sakhalinsky (from 79 to 0), Korsakovsky (from 106 to 40 individuals) and Dolinsky Districts (from 138 to 15 individuals). The official counts were significantly higher than our quantitative data obtained from sampling during field surveys on Sakhalin (Prikhodko, 2009). Annual overestimations of the population growth rates reflected in official statistics and exceeding the reproductive potential of Sakhalin musk deer have been identified for all districts. The lack of group growth in the last 20 years can be explained by the high level of calf mortality during the winter period, critically difficult for the animals. Sakhalin musk deer also have a low percentage of reproducing females. Reproduction rates in the main Sakhalin musk deer groups are greatly influenced by the adult gender ratio. A predominance of females over males (3:1) was observed in all surveyed musk deer habitats, while in the stable mainland populations of the species, the gender ratio among adult animals is 1:1. The nature of the association between low offspring survival and gender ratio disturbance is explained by high male mortality due to different foraging strategies between the genders. According to our observations, females feed more often at wind-blown trees or in places with localised accumulation of lichen food, while males predominantly feed while moving through habitat areas (Prikhodko, 2002). The low reserves of epiphytic lichens (less than 1 kg/ha) in the habitats limit males' ability to gather sufficient food from fallen parts on the snow surface along their travel routes, causing them to die more often than females in winter. Sakhalin is characterised by a general low productivity of mountain taiga forests, especially in lichen reserves, which restrains musk

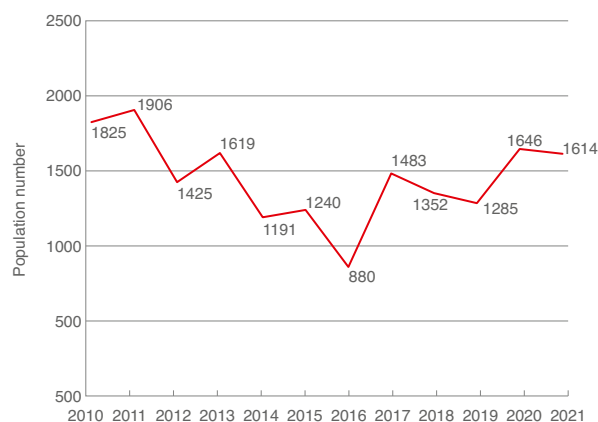


Fig. 6.10. Population dynamics of the Sakhalin musk deer according to the WRS from the Agency for Forestry and Hunting of the Sakhalin Region

deer from developing new forest areas and explains the patchy nature of animal distribution in the mountainous areas (Prikhodko, 2009)

Cause of Sakhalin musk deer extinction

The cause of the probable extinction of the Sakhalin musk deer is mainly human economic activities. The original pre-decline population was estimated at 1,670 individuals but has declined to 250–300 individuals over the past 17 years. The long-term negative trend indicates that at the final stage of the island population's decline, a mechanism of reduced reproductive potential is involved, including mortality exceeding birth rates, which has indirect links with habitat destruction processes. The current decline in numbers resembles the 19th century's depression, when Sakhalin musk deer resources declined from thousands to hundreds of individuals, but the decline did not cross the threshold of the irreversible extinction of the subspecies under conditions where habitats not yet destroyed by humans were still preserved. It is possible that extinction becomes irreversible when numbers fall below a threshold determined by both the biological characteristics of the species and environmental factors. As the current number of Sakhalin musk deer has approached the minimum viable population, the risk of extinction of the island subspecies will be determined by the longevity of all its groups, which are currently geographically isolated. Given the complex nature of wild ungulates' relationship with their habitat and the differences in longevity of individual species members, the Sakhalin musk deer is expected to persist for at least the next two decades.

Sakhalin musk deer grouping on the Crillon Peninsula

The only available up-to-date data on Sakhalin musk deer numbers on the Crillon Peninsula were also obtained by the Agency for Forestry and Hunting of the Sakhalin Region as a result of the WRS for the Nevelsky Urban District and Anivsky Urban District. As can be seen from the graph, in contrast to the generally optimistic data for Sakhalin, the Sakhalin musk deer numbers for this area continued their rapid decline (Fig. 6.11). If the results reflect the real picture, the remaining individual animals have either already disappeared or will disappear in the next couple of years. However, data obtained from WRS for Sakhalin

musk deer are often incomplete due to the difficulty of traversing the main winter staging areas of this species on foot or by snowmobile. During general WRS of game animals and birds, survey routes are often established (or traversed by unscrupulous surveyors) away from habitats used by Sakhalin musk deer during the winter. Additional dedicated research is needed to determine the presence, distribution, and abundance estimates of Sakhalin musk deer on the Crillon Peninsula. However, even with mass undercounting of animals during the WRS in the area under consideration, the number of Sakhalin musk deer is extremely low. Since the dark coniferous forests of the peninsula have been largely logged (Krestov et al., 2004), these habitats are not optimal, and even with careful protection, biotechnical measures, the breeding and release of Sakhalin musk deer, it will not be possible to achieve a high density of this species in the area in the short-term.

Reindeer

Today, the wild reindeer on Sakhalin Island are represented by the largest and most economically valuable but poorly studied subspecies of Okhotsk reindeer (*Rangifer tarandus phylarhus*, Hollister, 1912), which has two forms: forest and tundra (Eremin 1989, 2003). Wild reindeer have always lived on Sakhalin, but domestic reindeer appeared only in the 18th century, when Evenks and Uilta (Oroki) from the mainland migrated to the island with their herds. In the past, wild reindeer inhabited the entire territory of the island, with several tens of thousands of individuals, and such a state was preserved until the end of the 19th century (Eremin, 2003). Primitive reindeer herding, which appeared here in the middle of the 18th century, or according to other sources, a century later, initially did not cause serious negative changes in the number and distribution of wild reindeer. As before, its continuous intra-island range extended from the Schmidt Peninsula to Cape Aniva and Cape Crillon, which in the 19th century represented the southernmost habitat of the species (Eremin, 2003). A significant reduction in the number and distribution of wild reindeer on Sakhalin was observed in the first half of the 20th century. The main causes of this were, apparently, as for the mainland part of the species' range, unfavourable transformation of the natural environment, caused primarily by anthropogenic economic activity, and intensive destruction of wild reindeer by humans (Red List ..., 2016). Wild reindeer now inhabit Sakhalin Island north of the 48°N, and were also introduced to Shumshu Island from Kamchatka in 2005 and 2007. On Sakhalin, there are two isolated populations of wild

reindeer: the Shmidtovsky population, with a total area of 1,800 km², numbering up to several hundred individuals, occupying the mixed mountainous and taiga zone of the island, and the Nogliki population, numbering about 3,500 individuals, occupying the hilly and flat taiga part of the island, with a total area of 29,500 km². Within the latter there is a rather isolated population of the East Sakhalin Mountains, which already requires special protection measures. As a result, the number of wild reindeer has decreased here by almost 4.2 times over the last 22 years (by 19 % on average per year), primarily due to mass poaching, which has increased dramatically during the years when the hunting supervision service was reorganised and pipelines and the associated roads crossing animal migration routes were built. This resulted in the virtual disappearance of hard-to-reach areas suitable for the species' habitat. Their area has decreased by at least 10 times over the last 25 years (Eremin, 1989). Currently, the main causes of the low number of wild reindeer on Sakhalin and in the Nogliksky District in particular are as follows:

- Reduction of habitat suitable for wild reindeer due to its transformation into low-value areas due to anthropogenic impact from oil and gas extraction and the associated extensive infrastructure development, as well as offshore development resulting in the creation of new onshore facilities and pipeline routes in reindeer habitat, and consequently increased pressure on the population.
- Predation by brown bears, whose population density in calving areas is quite high and needs to be regulated.

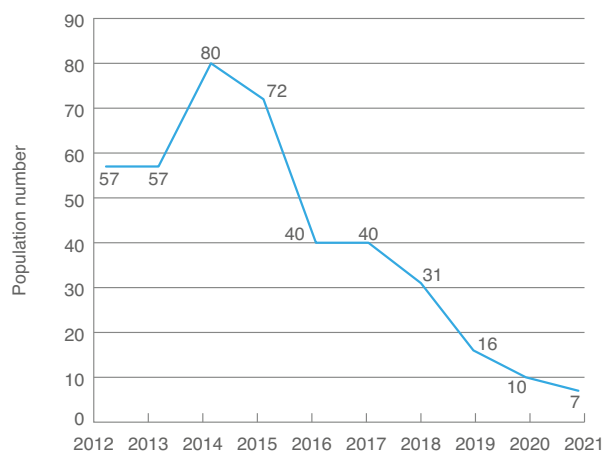


Fig. 6.11. Population dynamics of Sakhalin musk deer on Crillon Peninsula according to data from Agency for Forestry and Hunting of the Sakhalin Region's WRS

- Mass poaching, the level of which has increased dramatically during the years when the hunting supervision service was reorganised.
- Laying pipelines and the associated roads across animal migration routes.

Due to the fact that the wild reindeer on Sakhalin was practically the only hunted species of wild ungulates until its recent inclusion in the Red List, the commercial pressure on its population here has always been significant. The selectivity of hunting, which distorted the population structure, also contributed to the rapid decline of the wild reindeer population, as sexually mature animals, mainly males, were taken first, which led to a reduction in the proportion of young animals. Numerous studies have shown that reducing the proportion of adult males in wild reindeer population to 20 % or less leads to a significant increase in female infertility (Danilkin, 1999). Particularly dramatic changes in the conditions for the wild reindeer on the island have occurred due to industrial logging and forest fires. Thus, in dry years (1949, 1953, 1989), fires alone destroyed up to 20,000–300,000 ha of forests and deer pastures (Kolesnikov, 1955). As a result of many years of forestry activities and pyrogenic impact, the Sakhalin taiga is now represented almost everywhere by clear-cuts and forest clearings at various stages of reforestation. Progressive mining and shelf development on the east coast of the Nogliksky District, and the laying of the Chayvo-Khabarovsk Region oil and gas pipeline have led to the near extinction of reindeer in the coastal part of this territory. At the southern end of the range, there is also negative impact from logging and forest fires.

Collective reindeer herding has also played a very significant role in reducing the intra-island range and numbers of wild reindeer, the negative impact of which was already evident in the mid-1930s, when reindeer herding collective farms were first set up on Northern Sakhalin and thousands of herds of domestic reindeer were established. Their grazing required extensive pastures with high deer-feeding capacity, and with at least 10,000 wild reindeer present on the island at the time inhabiting the same areas, solving the grazing problem was only possible through the extermination and displacement of wild animals (Eremin, 2003). Domestic reindeer herds were located throughout much of northern Sakhalin at that time, with the heavily utilised coastal pastures on the west and east coasts of the island, between 52.0°N and 53.5°N, already severely depleted and in need of an 8–10 year recovery period. High-quality lichen pastures not used by domestic reindeer remained only in the middle,

more mountainous part of the island, in the upper reaches of the Nysh River, Evai River, Dagi River, Viakhtu River and Bolshaya River, as well as in the East Sakhalin Mountains and on the Schmidt Peninsula. The latter area was the main wintering ground for wild reindeer in the early 1950s; later, when reindeer herding on Sakhalin reached its peak development (1960–1975) and the domestic reindeer population numbered 13,000–15,000 animals, a significant portion of the lands in these areas was also incorporated into the pasture rotation. Having lost the main pastures vital for winter survival and still experiencing intense pressure from hunting, poaching and deliberate destruction by reindeer herders, the degradation of the wild reindeer population became particularly noticeable. As a result, its numbers decreased fourfold between 1950 and 1975, falling to a minimum of 2,800 individuals, and two years later (from 1977) a sharp decline in the domestic reindeer population was also observed (Fig. 6.12). The typical wild reindeer habitats on Sakhalin Island include sparse light coniferous forests, tundra and forest-tundra lands, including those with forests; high-mountain floodplain plateaus; in the southern tip of the island, reindeer are found in dark coniferous taiga with an abundance of terrestrial and arboreal lichens, fungi and other food sources. Wild reindeer also readily inhabit floodplains with abundant terrestrial and arboreal lichens, fungi and other food sources, larch and mixed forests, and frequently visit seacoasts and open spaces (tundra, bogs and coastal plains) in search of food (Eremin, 1989). Currently, most of the wild reindeer population (over 60 % of the population) is concentrated in the West Sakhalin Mountains, in the western part of the Okhinsky District and in the northern part of the Alexandrovsk-Sakhalinsky District. Overall, the southern boundary of this species' distribution is steadily shifting northward, although as recently as 1972, reindeer were found in the lands of the Anivsky State Hunting Operation and in the central part of the Kamyshev Ridge, where they were quite numerous. This species has always been present in the Turovka and Markovka river basins in the Makarovskiy District, but currently, almost no permanently residing reindeer remain there; only occasionally are single animals or groups of 2–5 individuals observed coming from the north during the second half of winter. The main cause of this is intensive shooting on peatlands (Eremin, 1989, 2003). The situation is equally complicated in the Tymovsky District, where wild reindeer were practically exterminated, with fewer than

100 individuals remaining by 2012, although previously 300–350 individuals fed in the Poronay tundra alone. Due to fires, habitats suitable for this species have been preserved only in the basins of the Belaya River, Korchevka River, Aleksandrovka River and Bubnovka River (Eremin, 1989, 2003). In the Poronaysky District, according to interviews with game wardens, the reindeer population is already beginning to recover; for example, their tracks have begun to appear even in the western part of the district, even though there were none at all about 10 years ago. A group of up to 150 individuals living in the Poronay Reserve likely plays a significant role in increasing the wild reindeer population here, with its main habitats being the tundras north of Lake Nevskoye. Since all potential reindeer pastures here are greatly affected by forest fires, and at a high intensity, both green and lichen forage are completely destroyed, with the lands losing their pasture properties entirely for a considerable period, it takes at least 25–30 years to fully restore even slightly burned lichen areas. The general pattern of reindeer distribution throughout the year is determined by the forage capacity and the accessibility of summer and winter pastures. The relatively short growing season in northern Sakhalin requires summer forage to be as nutritious as possible, which is achieved by reindeer migrating to areas with more young green vegetation. Therefore, in early summer, they follow temperature gradients to extend their feeding on young vegetation by migrating up mountain slopes or from inland areas to the seacoasts, causing the wild reindeer diet to change dramatically across seasons. In summer, reindeer consume more than 100 plant species (70–80 % green plants, 10–15 % lichens, with mosses and other materials making up the remainder). In spring, reindeer readily eat grasses and sedges, leaves of various willow species and dwarf birch and herbs. In autumn, lichens become more important in their diet, while green plants constitute 30–50 % of their total food intake by mass. In winter, lichens become the primary food source, comprising up to 70 % of stomach contents; the remainder consists of fragments of green plants preserved under snow, mosses and other materials. Thus, domestic reindeer herding, intensive industrial logging, and forest fires are the main factors causing the decline in wild reindeer numbers on Sakhalin Island, with the combined impact of other anthropogenic factors (construction, oil and gas development, agriculture, hunting, poaching, etc.) intensifying this effect. Poaching hinders the growth of the wild reindeer population on Sakhalin, but the main

cause likely lies in the reduction of the carrying capacity and winter pasture area due to anthropogenic and fire-related transformation, as well as prolonged overgrazing by domestic animals.

The following measures are necessary to restore Sakhalin's wild reindeer population:

- Completely eliminate domestic reindeer herding in wild reindeer habitats as a primitive and unprofitable form of economy that adversely impacts natural island ecosystems, including the continued existence of the wild reindeer population.
- Organise effective protection of reindeer in their autumn-winter concentration areas, especially during the breeding period.
- Stop the selective hunting of breeding males.

Manchurian wapiti and moose

The reintroduction of Manchurian wapiti to Sakhalin began in 1965. The species was found in archaeological sites but was completely absent from the island by the beginning of the 20th century. The animals reached their peak population in the early 1980s at 700 individuals, but in subsequent years, despite intra-regional relocation efforts, their numbers steadily declined (Eremin, 2013). The population decline was caused by poaching in southern Sakhalin, where deer are concentrated in a limited area and therefore become easy prey. Unfavourable weather conditions, high humidity and deep snow cover also have an impact. Cases of animal mortality due to deep snow were recorded. In the 1990s, Manchurian

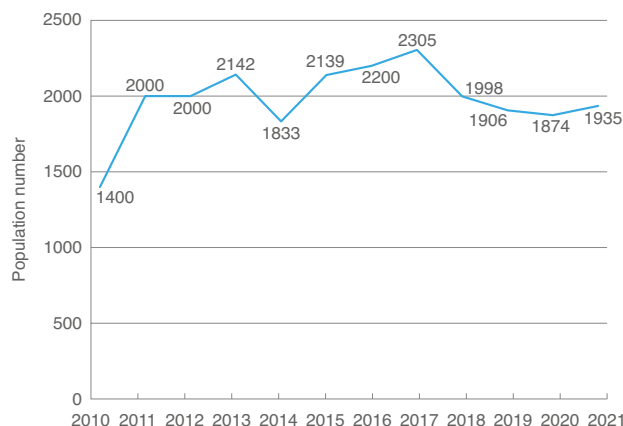


Fig. 6.12. Wild reindeer population dynamics according to WRS data and expert assessments of the Agency for Forestry and Hunting of the Sakhalin Region.

wapitis were relocated to the Tymovsky District (Palevskie Heights), where they have established themselves, with prospects for population growth due to the remoteness and inaccessibility of their habitat to poachers. To conserve and restore the Manchurian wapiti population in Sakhalin Region, a moratorium on hunting was introduced on September 15, 2009, and subsequently extended until 2015 (Eremin, 2013). According to the Agency for Forestry and Hunting of the Sakhalin Region, the Manchurian wapiti population has doubled since 2010, from 140 to 285 individuals. This allows for an optimistic forecast regarding the survival of this species if relocated to the Crillon Peninsula.

Moose were reintroduced to Sakhalin Island in 1988. Ten individuals were released in the Smirnykhovsky District. The Losiny wildlife preserve was established in their settlement area but was later disbanded. Currently, moose, including females with calves, are rarely seen in the Poronaysky and Tymovsky Districts (Eremin, 2013). According to the Agency for Forestry and Hunting of the Sakhalin Region, the moose population reached 50 individuals by 2015 and has remained stable over the past seven years (Fig. 6.13).

Veterinary evaluation: the realities of South Sakhalin

Due to the risk of contracting trichinellosis, consuming bear meat without veterinary examination is extremely dangerous to one's health. Trichinellosis is an acute febrile disease caused by the nematodes *Trichinella spiralis*, which in the adult stage inhabit the intestinal mucosa and in the larval stage inhabit the striated muscles of the host (Sabaneev, 2008; Agency for Veterinary ... [Electronic resource]).

Sakhalin is isolated from the introduction of infected animals; however, the spread of trichinellosis can be traced to the introduction of raccoon dogs to Sakhalin, omnivorous animals that frequently consume carrion.

One high-profile case of trichinellosis infection is described by well-known Sakhalin hunter V. Mandritsa. 'In 1979, they did not test for trichinellosis, they were in a hurry to prepare a ham for the celebration of another anniversary of the Great October Revolution. They cut pieces of 5–10 kilograms and smoked them. The larvae died

on the surface but remained alive inside. As a result of consuming this meat, 142 people fell ill, from game wardens to the District Committee Chairman, and nearly died. Luckily the worst didn't come to pass; it could have been much more dire' (Pasyukov, 2011).

Unfortunately, not all hunters report the detection of trichinellosis. According to D. Dudarev, who served as Deputy Head of the Forestry and Hunting Ministry of Sakhalin Region from 2017 to 2020, up to 10–20 % of bears on Sakhalin are infected with trichinellosis, depending on the area. The disease is more common in the south of the island and less common in the north. According to D. Dudarev, game hunters have always taken such cases seriously and implemented measures to destroy the carcass of an infected animal under the supervision of game wardens and representatives of the veterinary service. The latest case of trichinellosis detected in the Sakhalin-Crillon LLC hunting operation was recorded in September 2023 (according to the Agency for Forestry and Hunting of the Sakhalin Region).

Harm from trichinellosis can only be avoided with certainty through timely and competent veterinary evaluation (Agency for Veterinary ... [Electronic resource]). To that end, however, it is necessary to present the tear-off coupon of one's permit with a note that the animal was acquired legally. Bear skins and other derivatives cannot be exported from the island without this coupon.

Due to annual findings of an extremely dangerous parasitic disease, trichinellosis, in brown bears, the Agency for Forestry and Hunting of the Sakhalin Region has posted the following information. 'In order to ensure human health and safety, biomaterial from harvested game animals (brown bear) should be sent to the Sakhalin branch of FSBI Primorskaya Interregional Veterinary Laboratory for examination (693003, Yuzhno-Sakhalinsk, ul. Saranskaya, 17a)'. In practice, it takes 1 to 3 days to see the result.

Table 6.4 lists institutions subordinate to the Agency for Veterinary and Breeding Animal Husbandry of the Sakhalin Region that accept biomaterial for analysis. The result may not always be obtained quickly, as not all stations listed perform laboratory analysis for trichinella in muscle; some send the biomaterial to other places. The analysis is carried out most efficiently and quickly (1–2 days) at State Budgetary Institution Animal Disease Control Station No 3 (Sakhalin Region, Dolinsk, Sovetskaya St., 7).

History and prospects for the development of hunting on the Crillon Peninsula

The total area of hunting grounds in Sakhalin Region is 7,547 thousand hectares, including 86.76 % publicly accessible and 13.24 % assigned to hunting users. Hunting grounds occupy more than 87 % of the region's area and serve as a basis for the productive activities of 16 hunting providers forming the industry. At the same time, 85 % of hunting grounds are publicly accessible, in contrast to mainland Russia, where most of them are assigned to hunting providers (hunting agreements are concluded between a legal entity and the regional state body in the sphere of hunting; hunting is carried out under permits and vouchers issued by the legal entity) and only 10–20 % of hunting grounds are publicly accessible (hunting is carried out under permits obtained from the state body) (Butkalyuk, 2012; Scheme ..., 2023).

The development of hunting in the eastern part of the Crillon Peninsula began with the creation of a specially protected natural area. The Crillon Peninsula Reserve, with a total area of 62,000 hectares of hunting grounds, was established by the Hunting Administration under the Sakhalin Regional Executive Committee (Decision of the Sakhalin Regional Executive Committee 'On The Establishment of the Crillon Peninsula Reserve' No 142 dated March 14, 1972) as a reproductive area of the Anivsky State Hunting Operation. It was established to protect and reproduce rare and valuable wild animals, as well as

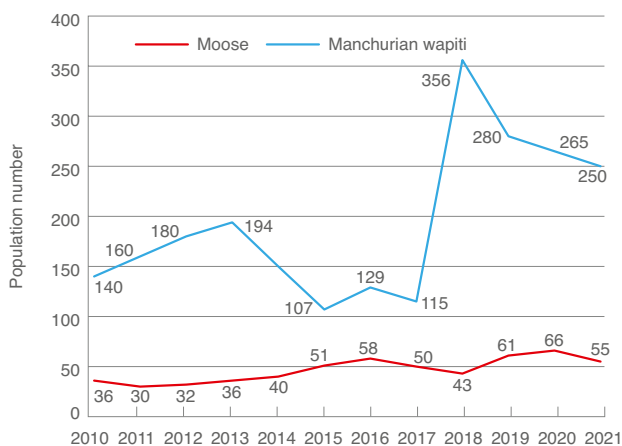


Fig. 6.13. Population dynamics of Manchurian wapiti and moose according to the WRS data and expert assessments of the Agency for Forestry and Hunting of the Sakhalin Region

to protect their habitat: sable, otter, brown bear, fox; Steller's and white-tailed sea eagles, hazel grouse; sea and waterfowl birds; taimen, cherry and pink salmon.

After the establishment of the Crillon Peninsula regional hunting reserve, the Sakhalin Meteorological Service Administration transferred a one-storey four-apartment building to the Hunting Administration under the Sakhalin Regional Executive Committee, for a gamekeeper's cordon for officials (gamekeepers, foresters) to be located. The building came with a set of auxiliary structures belonging to the former meteorological station in Kirillovo Village (now uninhabited), which had previously conducted meteorological and coastal sea observations.

Following the chronology of events, we should also mention the consequences of Typhoon Phyllis, the most destructive typhoon in the history of the USSR, passing over the southern part of Sakhalin. The typhoon reached Sakhalin on August 3, 1981 and raged until August 6 of the same year. The island received three months' worth of rainfall in just 24 hours. The southern part of Sakhalin actually turned into a swamp. Rivers overflowed their banks and roads were washed out. Of course, the wildlife suffered as well. For example, the Canadian beaver, which was brought to the Crillon Peninsula for acclimatisation, was completely washed into the Sea of Okhotsk by the powerful currents of the peninsula's mountain rivers that had overflowed their banks (Voronov G., 1982).

Later, activity in the specially protected natural territory was shaped by the Regulation 'On the State Complex Hunting Reserve on the Crillon Peninsula' No 216 of April 27, 1976 and its subsequent editions. Due to changes in federal environmental laws and the issuance of Sakhalin Region Administration Order No 716-ra dated December 24, 2002, 'On revocation of the status of the state hunting preserve of regional significance Crillon Peninsula in Aniva District', the preserve ceased to exist.

From then on, the transfer of hunting grounds of the eastern part of the Crillon Peninsula for use by legal entities began. Meanwhile, the Anivsky State Hunting Operation was abolished. As a result of the auction, Sakhalin-Crillon LLC became the owner of the aforementioned territory.

Sakhalin-Crillon LLC Hunting Operation is located in the southern part of the Anivsky Urban District, Sakhalin Region, in the southeast of the Crillon Peninsula from the Uryum River in the north to Cape Crillon in the south. The eastern boundary is the coast of Aniva Bay and the western boundary is the Kamyshovy Ridge. There are no population centres. Kirilovo Village at the mouth of the Uryum River is currently uninhabited. The area of the Sakhalin-Crillon hunting grounds is 93,350 ha (Fig. 6.14).

The procedure for the organisation of on-farm arrangement is determined by Federal Law (Federal Law ..., 2009). Intra-farm hunting arrangements are in place to plan for hunting and conservation of hunting resources and are aimed at defining the types of activities of individuals and legal entities in regard to the hunting business.

Table 6.4. List of institutions subordinate to the Agency for Veterinary Medicine and Animal Breeding of the Sakhalin Region (Agency for Veterinary ... [Electronic resource])

Organisation name	Areas covered
State Budgetary Institution Animal Disease Control Station No 1	Yuzhno-Sakhalinsk City Municipal District, Kurilsky Urban District, Severo-Kurilsky Urban District and Yuzhno-Kurilsky Urban District
State Budgetary Institution Animal Disease Control Station No 2	Anivsky Urban District
State Budgetary Institution Animal Disease Control Station No 3	Dolinsky Urban District, Tomarinsky Urban District
State Budgetary Institution Animal Disease Control Station No 4	Makarovsky Urban District, Poronaisky Urban District
State Budgetary Institution Animal Disease Control Station No 5	Alexandrovsk-Sakhalinsky Urban District, Smirnykhovsky Urban District, Tymovsky Urban District
State Budgetary Institution Animal Disease Control Station No 6	Nogliki Urban District, Okha Urban District
State Budgetary Institution Animal Disease Control Station No 7	Korsakovsky Urban District
State Budgetary Institution Animal Disease Control Station No 8	Nevelsky Urban District, Kholmskiy Urban District
State Budgetary Institution Animal Disease Control Station No 10	Ulegorsky Urban District

The accessibility of the grounds is satisfactory (it takes approximately 2 hours to travel from Yuzhno-Sakhalinsk airport to the boundaries of the Sakhalin-Crillon hunting grounds). The transport infrastructure within the boundaries of the hunting grounds is undeveloped. Since there are no automobile roads within the hunting operation, motor transport is only possible along the coastal strip (there are fragments of former Japanese roads along the coast) by cross-country vehicles at low tides. Among the all-terrain roads is one from Cape Crillon to the mouth of the Irsha River. The area of Atlasovo Village can only be reached by sea by small boats with outboard motors. Thus, many areas are only accessible by water transport. Nevertheless, it is possible to reach the mouth of the Uryum River from Taranay Village using a standard four-wheel drive vehicle. In winter, snowmobile travel is possible in the flat part of the hunting operation and along some relatively large rivers. The rivers are not navigable but are suitable for the use of airboats, such as the Sever model.

'Change is continuous.

Until the 1960s, clear-cutting was carried out by the Japanese, and then logging continued during the Soviet period. In those days, dams were used. Timber was stockpiled to later be released at the mouth of the river. Presently, there are no roads, only some reminders of the Japanese roads remain in the form of bridges over rivers, and landslides are frequent along the coast. Fish stocks in the rivers have declined significantly, as in the 1990s everything was being caught and roe was harvested by the tonne. Bears often pulled fish right out of the nets. Sometimes, it is very helpful to remember how things were, if only to realise what was lost and what was gained. Game wardens are now more mobile and better equipped, so the number of violations detected is increasing. Many graduates work as hunting inspectors, directors of wildlife sanctuaries or nature reserves and researchers. Game wardens may also work in public organisations, as well as hunters' and anglers' associations. A game warden should be able to take risks, show courage and ingenuity, be ready to meet wildlife, rely on his knowledge, experience, cunning and have good physical fitness'.

A. Kostin (Kostin, 2000)

Hunting tourism is related to the organisation and conduct of hunting tours in the hunting grounds. Photo hunting is gaining popularity, which does not harm nature and is no less a positive experience for the photo hunters than for those hunting with guns.

At the same time, hunting is of great recreational importance for Sakhalin. Not every resident of the region can afford a vacation abroad, which explains the high proportion of hunters among the population taking advantage of the recreational potential of the island's hunting grounds. In addition, hunting and fishing help significantly replenish the food supply for local residents. But the importance of hunting is especially great in educating, improving health and occupying the leisure time of local residents. Therefore, evaluating the hunting industry only by economic indicators isn't quite correct.

Game wardens keep records of commercial animals, conduct measures to combat the dangerous animals that pose a threat to human life and health, monitor the harvesting of animals that are allowed to be hunted, control and protect hunting grounds and conduct raids to control and protect the entrusted territory.

The Crillon Peninsula is characterised by a low diversity of large and medium-sized terrestrial mammal fauna. Currently, among wild ungulates, only the Sakhalin musk deer inhabits the area, and this red-listed subspecies is on the verge of extinction. There are unverified reports of occasional visits to the peninsula by Manchurian wapitis. Of the large land mammals, only the brown bear is common for the Crillon Peninsula. Background species include the fox, raccoon dog, sable, otter, American mink and squirrel. Of the species listed in the regional Red List, the common water shrew (*Neomys fodiens*, Category 4), Shikotan vole (*Microtus shikotanensis*, Category 4), Ussuri tube-nosed bat (*Murina ussuriensis*, Category 3) and Sakhalin musk deer (*Moschus moschiferus sachalinensis*, Category 1 in both the Red List of Sakhalin Region and the Red List of the Russian Federation) occur on the peninsula (Red List ..., 2016).

The following are attributes of promising areas of hunting in the Sakhalin-Crillon hunting grounds.

1. Trophy bear hunting. The density of animals, their forage base and protective conditions allow hunters to select the most desirable trophy. Both the weight of the bear and the dimensions of its skull can be counted as trophies, which can be sent to a trophy exhibition and compete for a prize. Parts of the animal (hide, bile, fat, claws and teeth) may be processed accordingly and given to the hunter for disposal at their personal discretion. At present, there are practically no professional taxidermists in Sakhalin Region who are able to dress animal skins or other derivatives qualitatively and according to the hunter's requests, so it is a good practice to

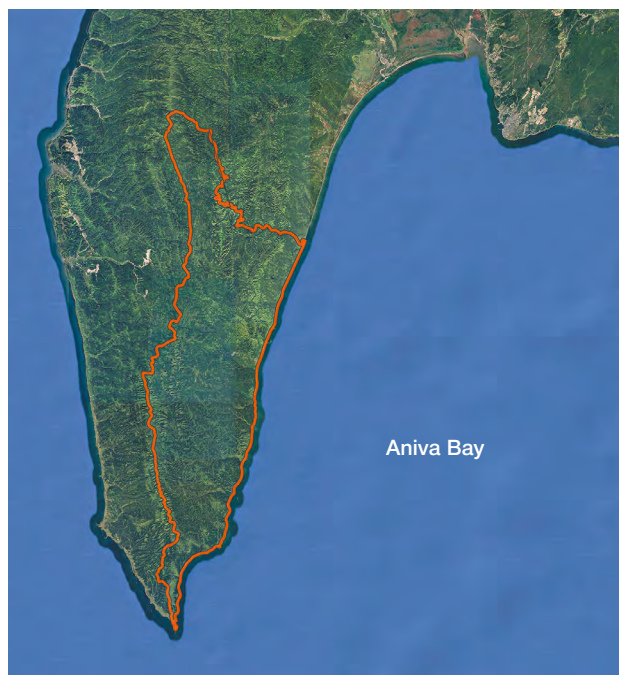


Fig. 6.14. Outline map of the hunting grounds of Sakhalin-Crillon LLC

have a professional taxidermist at the hunting operation. An alternative option is to cooperate with a professional taxidermy workshop in Moscow or in nearby Khabarovsk.

2. Enclosure hunting of large ungulates (red deer, moose). Due to the current absence of the listed ungulates within the Sakhalin-Crillon hunting grounds, it is necessary to prepare a programme for the relocation and acclimatisation of new species. The most promising area for the construction of an enclosure is the area at the mouth of the Naicha River with appropriate protective conditions and forage base. With a scientifically grounded enclosure arrangement, based on the biological needs of these ungulates and the arrangement of a set of biotechnical measures (feeding, settlement, prevention of death from natural disasters, population regulation, veterinary and preventive measures, etc.), a sufficient number of acclimatised animals will allow for the possibility of enclosure hunting.
3. Breeding of spotted (bamboo) deer in the enclosure is less helpful for the development of hunting itself, but quite realistic for increasing the operation's attractiveness for tourists, and

will require a large set of biotechnical measures. It is likely that spotted deer management in the snowy Sakhalin winter conditions will be reduced to a form of subsistence husbandry. In time, the animals will lose their fear of humans, and the hunting operation may become something like a small contact zoo for the guests of hunting bases and cordons.

4. An equally promising area is the development of amateur hunting tours for game birds, namely geese during their migration here twice a year, in spring and autumn. This would require the preparation of appropriate water bodies within the farm, forage fields, allocation of resting areas for game birds and setting up comfortable shelters (blinds) for hunters. The most suitable site (with accessibility and presence of an artificial water body) appears to be the northern part of the hunting grounds in the area of Kirilovo Village (uninhabited).

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7 THE MARINE FISH AND FISHERIES OF ANIVA BAY

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General characteristics of the ichthyofauna of Aniva Bay

Located between two seas, the Sea of Okhotsk to the east and the Sea of Japan to the west, Aniva Bay is the southernmost bay on Sakhalin Island. The hydrological regime of this water body is defined by the interaction of two currents, the cold East Sakhalin Current originating from the north and the warm Soya Current, part of which reaches the Sakhalin coast from the south, off the Japanese island of Hokkaido (Shelegova, 1958; Budaeva, 1980). The geographical location and oceanological conditions have a significant influence on the formation of the local marine ichthyofauna under consideration, which represents a high diversity of fish species compared with the northern parts of the Sakhalin shelf zone (Lindberg, 1959; Safronov and Khudya, 1981; Borets, 1997; Velikanov, 2002).

The taxonomic composition of the ichthyofauna of Aniva Bay includes 3 classes, 22 orders, 67 families and 161 genera. The total number of marine and anadromous fish species is 274, including species with disputed taxonomic status and those recorded in the adjacent waters of the southern part of the Sea of Okhotsk and the northern part of the Sea of Japan (Dyldin et al., 2020).

Thus, beginning with the results of the Kurilo-Sakhalin complex expedition of ZIN–TINRO (1947–1949), published by G. Lindberg in 1959, the list of known fish species of Aniva Bay has more than doubled. It should be noted that Aniva Bay is connected

to the Sea of Japan via La Pérouse Strait, where the ichthyofauna within Russian waters comprises 330 species. The bay also has an open connection to the Sea of Okhotsk, featuring 463 species of fish (Parin et al., 2014).

The species diversity of the ichthyofauna of Aniva Bay, when compared with that of Russian ichthyofauna as a whole, is comparable only to that of Peter the Great Bay (Sea of Japan) with over 300 species recorded (Sokolovsky et al., 2011). Overall, the ichthyofauna of Aniva Bay accounts for nearly 20 % of Russia's total marine and brackish-water ichthyofauna, which comprises up to 1,404 species (Parin et al., 2014).

Among the current ichthyofauna of the bay, representatives of the class Actinopterygii (255 species) are most prevalent; the second and third positions are occupied by representatives of classes Elasmobranchii (sharks, rays, 18 species in total) and Petromyzonti (lampreys, one species). Three quarters of the ichthyofauna of Aniva Bay are represented by three major orders, Scorpaeniformes, Perciformes, and Pleuronectiformes, which account for 207 species (over 75 %).

Of the 67 families, the most representative, accounting for 141 species (more than 50 %), are Cottidae (37 species), Pleuronectidae (25), Stichaeidae (22), Agonidae (16), Zoarcidae (16), Liparidae (14), and Sebastidae (11 species) (Fig. 7.1).

In general, the ichthyofauna of Aniva Bay is formed by fish belonging to various ecological and zoogeographic groups, as well as by species that undertake both short- and long-distance horizontal

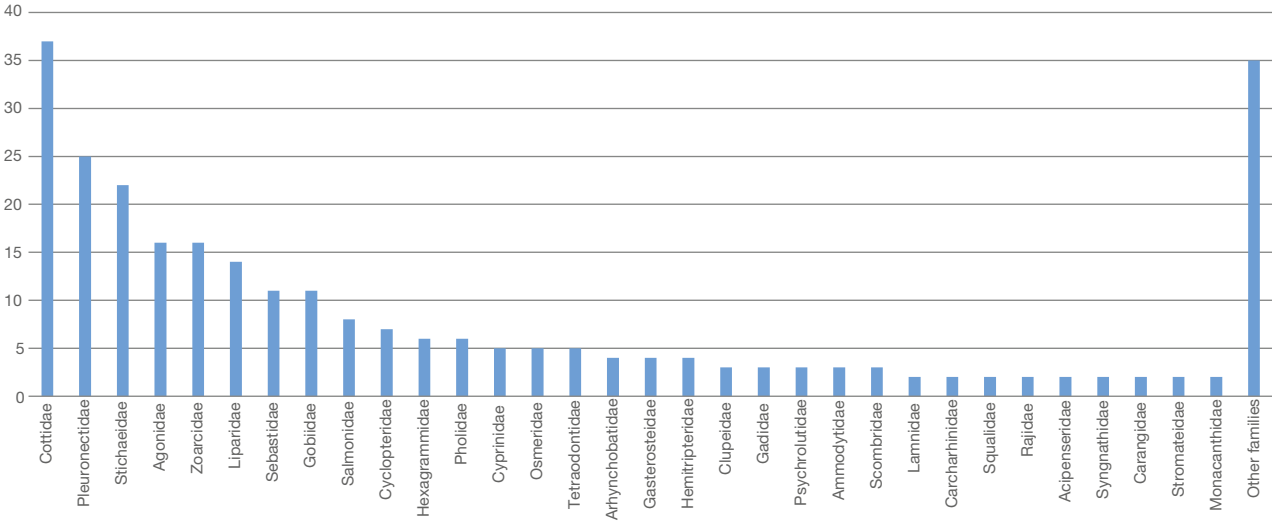


Fig. 7.1. Number of species by family of ichthyofauna of Aniva Bay (Dyldin et al., 2020). The horizontal axis shows the number of species



Fig. 7.2. Japanese amberjack *Seriola quinqueradiata* (hereafter in Chapter 7, photo by S. Anosov)

migrations, including transboundary species such as the Far Eastern sardine *Sardinops melanostictus*, the Japanese anchovy *Engraulis japonicus*, and the Japanese amberjack (also known as yellowtail), *Seriola quinqueradiata* (Fig. 7.2), among others. Perhaps one of the most important characteristics of the ichthyofauna of the study area is the constant variability of its species composition, including seasonal, interannual, and long-term aspects, driven by seasonal fish migrations, movement patterns, the population dynamics of fluctuating subtropical species such as sardine, anchovy and Pacific chub mackerel *Scomber japonicus*, as well as by interannual and long-term variability in oceanological conditions. All of the above applies to the commercial fish in the bay as well. The fish fauna of the bay is constantly undergoing changes due to periodic variability in the composition and structure of the fish communities. Perhaps the most important dynamic factors influencing this complex biological process are the oceanological regime, population dynamics and fish migrations.

Overview of cartilaginous fishes (class Elasmobranchii, elasmobranchs)

In Aniva Bay, 18 species belonging to this class have been recorded, including 10 species of sharks and 8 species of rays (Dyldin et al., 2020). Sharks and rays are cartilaginous fishes, one of the most ancient vertebrate lineages. This group has a number of differences in anatomical structure and metabolism from other fish, particularly bony fishes. Their skeleton is cartilaginous and partially calcified. The body is covered with special (placoid) scales or spines. The gill openings are separate (without an operculum), and a swim

bladder is absent.

The vast majority (over 83 %) of representatives of this class of fish are encountered rarely or very rarely in Aniva Bay, and the possible presence of individual species is regarded as hypothetical at this stage of research. Among these fishes, the great white shark (*Carcharodon carcharias*), one of the most famous species in the world, is of note; adult specimens have been caught twice by set nets in Aniva Bay, in 2007 near the Uryum River and in 2014 near Cape Crillon (Velikanov, 2010a; Velikanov et al., 2016).

Only three species of cartilaginous fish are common in Aniva Bay: the salmon shark *Lamna ditropis*, the Pacific spiny dogfish *Squalus suckleyi* (Fig. 7.3) and Smirnov's skate *Arctoraja smirnovi*. However, due to various circumstances, none of these species is of commercial interest in Aniva Bay (relatively low number, lack of demand and economic benefit, etc.).

At present, the salmon shark undertakes seasonal feeding migrations to the coast of Sakhalin, usually from June to August, following the movement of pre-spawning aggregations of pink salmon *Oncorhynchus gorbuscha*, which spawn in the rivers of the island. Aniva Bay is also within the salmon shark's range, which, like the Tatar Strait, it enters during the warm season. The greatest influx of salmon sharks into the Sakhalin-Kuril region is observed in years of abundant pink salmon, when catches of this predatory fish are most frequent. For example, in Aniva Bay, the salmon shark was recorded almost annually from 2002 to 2013. Unlike other epipelagic sharks, this species can come close to the coast. Previously, cases of this fish entering fixed nets in summer in Southern Primorye and Sakhalin were reported (Osipov, 1986). This shark has been recorded in Aniva Bay in various periods, in the late 1940s, from the 1950s to the 1960s and from the 1980s



Fig. 7.3. Pacific spiny dogfish *Squalus suckleyi*

to the 1990s (Lindberg, 1959; Osipov, 1986; Blagoderov, 1993; Fadeev, 2005), as well as in the first decade of the 21st century (Velikanov et al., 2005; Velikanov, 2006; Velikanov and Mukhametov, 2011).

Meanwhile, in several Southeast Asian countries, such as Japan and China, the species is actively fished using drift longlines at depths from 50 to 250 m; saury, herring, and squid are used as bait. The meat, fins, liver and skin are harvested. Using the liver of one salmon shark, up to 40 litres of oil rich in vitamins A and D can be obtained.

The Pacific spiny dogfish also undertakes seasonal migrations to the shores of Sakhalin during the warm season. From March to June, the stock of spiny dogfish in the East Japan Sea moves along the western coast of Hokkaido into the Sea of Okhotsk through La Pérouse Strait. During the first months of summer in Aniva Bay, this species is found at depths from 20 to 50 m, and a reverse migration takes place from August to December.

Generally speaking, sharks of this species are commercially important; the annual catch throughout their range is from 20 to 33 thousand tonnes. Set nets, bottom longlines, trawls and set seines are used for fishing. Among all sharks, this species ranks first in the value of its meat, which is about 12 % fat. The liver accounts for 22 to 25 % of the total body weight of the fish and has a high fat content rich in vitamins A and D (Gubanov et al., 1986; Osipov, 1986; Fadeev, 2005).

In Primorye and on Sakhalin, the annual catch of this fish reached several thousand tonnes before the 1940s. However, since the second half of the 20th century, there has been no domestic fishery for this species of shark. In Russia, commercial concentrations of this shark have been found off Sakhalin, the Kuril Islands and Southern Primorsky Territory. According to data from the Sakhalin Branch of Russian Federal Research Institute of Fisheries and Oceanography, in May 1975, unusually large aggregations of the shark were detected in La Pérouse Strait, adjacent to the southern boundary of Aniva Bay, where the catches by a domestic medium-tonnage vessel using a bottom trawl exceeded 1 tonne.

Smirnov's skate has a wide distribution. It is widespread in the Northwest Pacific and has been recorded in the Taiwan Strait (China), off the Pacific coast of Hokkaido, as well as in the Yellow Sea, the Sea of Japan, the Sea of Okhotsk and the Bering Sea (Dyldin et al., 2020). In the open waters of Aniva Bay, it is regularly recorded in bottom-trawl catches. Throughout its range, this species is most commonly fished at depths from 150 to 200 m; it reaches over 1 m in total length. Its biology is poorly understood. It has no independent commercial value, but is sometimes caught as a bycatch

in fisheries for other species (Dolganov, 1983; Dolganov and Tuponogov, 1999; Dyldin et al., 2020).

Overview of bony fishes (class Actinopterygii, ray-finned fishes)

According to current estimates, the ichthyofauna of Aniva Bay is largely dominated by representatives of the class Actinopterygii (255 species), the vast majority of which are bony fishes (Dyldin et al., 2020). As mentioned above, the fish fauna of the bay is primarily represented by three large orders: Scorpaeniformes, Perciformes and Pleuronectiformes. Most species within these taxonomic groups have a benthic or near-bottom lifestyle.

Representatives of all seven families that dominate the bay in terms of species diversity, as mentioned above (Cottidae, Pleuronectidae, Stichaeidae, Agonidae, Zoarcidae, Liparidae and Sebastidae), also inhabit the bottom or near-bottom layer of the sea.

Analysis of the published data shows that, of the impressive total number of bony fish species recorded in Aniva Bay, a significant proportion are so scarce that they exhibit low or even rare occurrence. In fact, this group makes up more than half of the total ichthyofauna identified, 139 species, or 54.5 %. It should be emphasised that among this large group of species, rare but valuable anadromous fish such as Sakhalin taimen *Parahucho perryi*, Sakhalin sturgeon *Acipenser mikadoi*, and kaluga *Huso dauricus* occur in the bay basin. During the summer months in certain years, southern migrant fishes also appear, including some subtropical and tropical epipelagic species such as Japanese sea bass *Lateolabrax japonicus*, yellowtail amberjack, common dolphinfish *Coryphaena hippurus* and Pacific bluefin tuna *Thunnus orientalis* (Velikanov, Stominok, 2004; Fadeev, 2005; Velikanov, 2010b; Velikanov et al., 2016; Dyldin et al., 2020; Velikanov, 2024a). All the fish species listed above, especially southern migrant fishes, are valuable commercial species in various regions and countries, and some are also valuable aquaculture species (sturgeon, kaluga and taimen in Russia; yellowtail amberjack in Japan).

The number of commonly occurring species that are present in the area and fished annually is 86, or 31.4 % of the total variety of species. Notable members of this large group of species include the Pacific redfin and big-scaled redfin (*Tribolodon brandtii*, *Tr. hakonensis*), three species of Japanese smelts (*Hypomesus japonicus* and others), Japanese icefish *Salangichthys microdon*,

southern Dolly Varden *Salvelinus curilus*, Far Eastern salmonids, chum salmon *O. keta* and masu salmon *O. masou* as well as a member of the cod family, saffron cod *Eleginus gracilis* (Fig. 7.4); among rockfishes, the three-banded rockfish *Sebastes trivittatus*, blue rockfish *S. glaucus* and minor rockfish *S. minor*, which prefers the near-surface layers of the sea. Of the 23 species of sculpin inhabiting the bay, the most striking external features are those of the helmet sculpins (for example, the broad-headed helmet sculpin *Gymnocanthus detrisus* and others), Irish lords, including the butterfly sculpin *Hemilepidotus papilio* (Fig. 7.5), the southern flathead sculpin *Megalocottus taeniopterus* and the sea raven *Hemitripterus villosus* (Fig. 7.6). Among the 15 species of poachers, the more notable ones are the sturgeon poacher *Podothecus accipenserinus* (Fig. 7.7), the dragon poacher *P. sachi*, the Pacific alligatorfish *Aspidophoroides bartoni*, the proboscis poacher *Agonomalus proboscoidalis*, as well as others. Among other genera, the following species are noteworthy: the flathead mullet *Mugil cephalus*, Pacific saury *Cololabis saira*, Tanaka's eelpout *Lycodes tanakae*, the elongated eelpout *Zoarces elongatus* (viviparous), the Bering wolffish *Anarhichas orientalis* (Fig. 7.8), the Japanese sandfish *Arctoscopus japonicus* (Fig. 7.9), and, among flounders, blackfin flounder *Glyptocephalus stelleri* and the Sakhalin sole *Limanda sakhalinensis* (Fig. 7.10), as well as others.

From the above list of species, the majority prefer coastal waters during the warm season: redfins, surf smelts, Japanese icefish *Salangichthys microdon*, southern Dolly Varden, certain species of rockfish, southern flathead sculpin *Megalocottus taeniopterus*, some species of poachers and agonids, flathead grey mullet, which undertakes seasonal feeding migrations from the waters of Primorye (the northwestern part of the Sea of Japan), elongated eelpout, Bering wolffish and Japanese sandfish. The remainder inhabit the upper shelf within the bay, where the water is cooler.

The proportion of relatively abundant species in the ichthyofauna of Aniva Bay is the lowest compared to the previous two groups, with no more than 30 species, or 11.8 %. These include the Pacific herring *Clupea pallasii* (Fig. 7.11), the Far Eastern sardine, the Japanese anchovy, the Sakhalin redfin *Tribolodon sachalinensis*, the capelin *Mallotus villosus* (syn. *M. catervarius*), the Asian smelt *Osmerus dentex*, the pink salmon, the white-spotted char *Salvelinus leucomaenis* (Fig. 7.12), the walleye pollock *Gadus chalcogrammus* (Fig. 7.13), the spotted greenling *Hexagrammos stelleri*, the Okhotsk atka mackerel *Pleurogrammus azonus* (Fig. 7.14), several species of sculpin including the jaok sculpin *Myoxocephalus jaok* (Fig. 7.15), the great sculpin



Fig. 7.4. Saffron cod *Eleginus gracilis*



Fig. 7.5. Butterfly sculpin *Hemilepidotus papilio*



Fig. 7.6. Sea raven *Hemitripterus villosus*



Fig. 7.7. Sturgeon poacher *Podothecus accipenserinus*



Fig. 7.8. Bering wolffish *Anarhichas orientalis*



Fig. 7.9. Japanese sandfish *Arctoscopus japonicus*



Fig. 7.10. Sakhalin sole *Limanda sakhalinensis*

Myoxocephalus polyacanthocephalus (Fig. 7.16), and Steller's sculpin *Myoxocephalus stelleri*, the Pacific sand lance *Ammodytes hexapterus*, as well as 15 additional species of flatfish, among which are the yellowfin sole *Limanda aspera* (Fig. 7.17), the yellow-striped flounder *Pseudopleuronectes herzensteini*, Schrenk's flounder *Pseudopleuronectes schrenki*, the starry flounder *Platichthys stellatus* (Fig. 7.18), three species of flathead flounders including the southern *Hippoglossoides dubius*,

the flathead sole *H. elassodon*, the northern *H. robustus*, and the southern rock sole *Lepidopsetta mochigarei*.

Most of the abundant species of the bay differ in the timing and locations of their reproduction, which is reflected in their seasonal movements. In particular, winter spawning is characteristic of sculpins (genus *Myoxocephalus*), the southern rock sole (December–March), the saffron cod (January–early February) and the Pacific sand lance (January–early May). In spring, Pacific herring and Far Eastern capelin, Asian smelt and smallmouth smelts spawn, as do the walleye pollock, Schrenk's flounder, the starry flounder and the flathead sole. Mass reproduction in the summer months is observed in anadromous species such as pink salmon and the Sakhalin redfin, in several flatfish species (yellowfin sole, blackfin flounder, etc.), as well as in the Japanese anchovy. Mass spawning of the anchovy was recorded in Aniva Bay in August 1999 (Mukhametova, 2004), although this phenomenon is not annual but occurs only periodically, when this subtropical fish migrates to the shores of Sakhalin.

The number of fish species spawning in Aniva Bay in autumn is significantly lower than in other seasons. Most predominantly, such anadromous species as chum salmon and possibly the southern arabesque greenling can be found here. Spawning of the latter species has been reliably documented off both south-western and south-eastern Sakhalin, in the area of Cape Svobodny. Aniva Bay has suitable habitats and conditions for such species to spawn, but no evidence of mass spawning has yet been recorded. On the other hand, according to pelagic trawl survey data, in June and July from 2002 to 2009, juveniles of the latter greenling species were distributed in the near-surface layer of the water column and were recorded in large numbers in the bay. There are grounds to assume that in the years in question, in June and early July, these juveniles undertook a feeding migration to Aniva Bay from Hokkaido, primarily from its western coast, where spawning of the West Hokkaido stock of arabesque greenling occurs, characterised by a high abundance and commercial catches of up to 200,000 tonnes (Velikanov and Fatykhov, 2021).

Although most fish species, including some anadromous ones, occur in the bay virtually year-round, a number of species undertake northward seasonal migrations only during the summer months. In addition to the arabesque greenling, during multi-year cycles of high abundance, aggregations of subtropical fish such as the Far Eastern sardine (iwashi) and Japanese anchovy move into the bay, and in some years, other southern migrants also appear, including subtropical and tropical epipelagic species such as Japanese mackerel, Japanese



Fig. 7.11. Pacific herring *Clupea pallasii*



Fig. 7.15. Jaok sculpin *Myoxocephalus jaok*



Fig. 7.12. White-spotted char *Salvelinus leucomaenis*



Fig. 7.16. Great sculpin *Myoxocephalus polyacanthocephalus*



Fig. 7.13. Walleye pollock *Gadus chalcogrammus*



Fig. 7.17. Yellowfin sole *Limanda aspera*



Fig. 7.14. Okhotsk atka mackerel *Pleurogrammus azonus*



Fig. 7.18. Starry flounder *Platichthys stellatus*

sea bass, yellowtail amberjack, dolphinfish, and Pacific bluefin tuna.

Overall, taking representatives of all classes occurring in the bay into account, the number of demersal fish species belonging to the eulittoral, sublittoral, and littoral groups is 195, or 71.2 % of the total fish and fish-like fauna. The number of species inhabiting the water column of the area under consideration, representing the neritic, epipelagic, and mesobenthic groups, is less than half that figure, at 79 species, or 28.8 %.

From the overview materials presented, it is evident that Aniva Bay serves as a permanent or temporary habitat for a large number of fish species. It should be borne in mind that the area under consideration plays an important role as a nursery ground for juvenile fish of various ecological groups. These include anadromous species that spawn in rivers (Pacific salmon, Asian toothed smelt and others); marine species that spawn in the coastal zone (herring, capelin, saffron cod, Schrenk's flounder); and species that spawn in the open waters of the bay (pollock, yellowfin sole, flathead flounder, Pacific sand lance). Juveniles of different fish species that spawn not in Aniva Bay but in other adjacent areas also periodically occur here for feeding, including the arabesque greenling and Japanese anchovy, among others. In certain years and seasons, aggregations of juvenile fish of various species in the bay are very numerous. For example, aggregations of capelin, herring and arabesque greenling recorded during pelagic research trawl surveys conducted in the early feeding season in the bay in summer 2003 consisted mainly of immature individuals. The trawl catch data indicated relatively high abundances of juvenile individuals of the species concerned (Velikanov and Stominok, 2004).

It should also be noted that the majority of the recorded list of fish species (25 species out of 31, i.e., 80.6 %) in pelagic trawl catches in July–August 2005 were predominantly juvenile and were characterised by small body lengths, mostly less than 10–15 cm, and in some cases less than 5 cm. Meanwhile, in addition to movements (migrations) and fluctuations in abundance, notable changes occurred in the size ranges of catches of several fish species over the entire observation period in the summer of 2005. In particular, the body lengths of capelin, arabesque greenling and Bering wolffish in pelagic trawl catches showed a significant increase from early July to the last days of the second ten-day period of August (Velikanov and Mukhametov, 2011).

Rare and Red List species

The information currently available makes it possible to provide a brief overview of the conservation status of all fish and lamprey species occurring in Aniva Bay and the adjacent waters (Table 7.1).

According to the IUCN Red List, 28 species are classified as Least Concern, 10 as Data Deficient, 6 as Vulnerable, 2 as Near Threatened, 3 as Critically Endangered, and 225 species (more than 82 % of the total list) as Not Evaluated. Only 49 species (less than 18 %) have some form of conservation status.

According to the Red List of Sakhalin Region, 3 species are included in the Red List: Sakhalin sturgeon, kaluga sturgeon, and Sakhalin taimen. The first species, *A. mikadoi*, is classified in the first category (endangered), while the remaining two, *H. dauricus* and *P. perryi*, are classified in the second category (experiencing population decline).

Overall, the fact that 225 of the 274 species occurring in Aniva Bay and adjacent areas lack any conservation status is of some concern. Many valuable commercial species of salmonids, rockfish, flounders, smelts, greenlings and other equally valuable species remain unaccounted for. This calls for the involvement of experts in the conservation assessment of a number of Far Eastern fish species found in the North Pacific (Dyldin et al., 2020).

Commercial species

Only 61 out of 274 species in Aniva Bay (about 22 % of the total) can be classified as commercial species. Note that this number includes fish species the stocks of which are exploited by fisheries both in the bay and in other regions and countries.

The commercial ichthyofauna of Aniva Bay is represented by a fairly broad range of fish species, including lamnids (salmon shark), squalids (Pacific spiny dogfish), clupeids (Pacific herring, Pacific sardine *Sardinops sagax*), engraulids (Japanese anchovy), cyprinids (redfins, silver crucian carp), osmerids (Far Eastern capelin, Asian toothed smelt, marine smallmouth smelt), salangids (noodlefish), salmonids (pink salmon, chum salmon, masu salmon, white-spotted char), gadids (saffron cod, walleye pollock, Pacific cod), scomberesocids (Pacific saury), rockfishes (*Sebastes* spp.; three-striped, blue, dark, eastern, etc.), hexagrammids (southern Atka mackerel), cottids (jaok sculpin, many-spined sculpin, helmet sculpins, etc.), Japanese sea bass *Lateolabrax japonicus*, carangids (yellowtail amberjack,

Table 7.1. List of fish and lampreys included in the IUCN Red List and the Red List of Sakhalin Region (RLSR). Aniva Bay and adjacent waters (based on Dyldin et al., 2020)

Lamprey and fish species included in the IUCN Red List				IUCN Red List and RBSR categories
Russian name	Latin name	Family	Order	
Arctic lamprey	<i>Lethenteron camtschaticum</i> (Tilesius, 1811)	Petromyzontidae	Petromyzontiformes	Least Concern
Bluntnose sevengill shark	<i>Notorynchus cepedianus</i> (Peron, 1807)	Hexanchidae	Hexanchiformes	Data Deficient
Great white shark	<i>Carcharodon carcharias</i> (Linnaeus, 1758)	Lamnidae	Lamniformes	Vulnerable
Salmon shark	<i>Lamna ditropis</i> Hubbs et Follett, 1947	Lamnidae	Lamniformes	Least Concern
Thintail thresher	<i>Alopias vulpinus</i> (Bonnaterre, 1838)	Alopiidae	Lamniformes	Vulnerable
Blue shark	<i>Prionace glauca</i> (Linnaeus, 1758)	Carcharhinidae	Carcharhiniformes	Near Threatened
Milk shark	<i>Rhizoprionodon acutus</i> (Ruppell, 1837)	Carcharhinidae	Carcharhiniformes	Least Concern
Smooth hammerhead shark	<i>Sphyrna zygaena</i> (Linnaeus, 1758)	Sphyrnidae	Carcharhiniformes	Vulnerable
Pacific sleeper shark	<i>Somniosus pacificus</i> Begelow et Schroeder, 1944	Somniosidae	Squaliformes	Data Deficient
Pacific spiny dogfish	<i>Squalus suckleyi</i> (Girard, 1855)	Squalidae	Squaliformes	Least Concern
Shortspine spurdog	<i>Squalus mitsukurii</i> Jordan et Snyder, 1903	Squalidae	Squaliformes	Data Deficient
Mottled skate	<i>Beringraja pulchra</i> (Liu, 1932)	Rajidae	Rajiformes	Vulnerable
Ocellate spot skate	<i>Okamejei kenojei</i> Muller et Henle, 1841	Rajidae	Rajiformes	Data Deficient
Smirnov's skate	<i>Arctoraja smirnovi</i> Soldatov et Pavlenko, 1915	Arhynchobatidae	Rajiformes	Least Concern
Aleutian skate	<i>Bathyrāja aleutica</i> (Gilbert, 1896)	Arhynchobatidae	Rajiformes	Least Concern
Bottom skate	<i>Bathyrāja bergi</i> (Dolganov, 1983)	Arhynchobatidae	Rajiformes	Least Concern
Violet skate	<i>Bathyrāja violacea</i> (Suvorov, 1935)	Arhynchobatidae	Rajiformes	Data Deficient
Short-tail stingray	<i>Bathytoshia brevicaudata</i> (Hutton, 1875)	Dasyatidae	Myliobatiformes	Least Concern
Japanese eagle ray	<i>Myliobatis tobijei</i> (Bleeker, 1854)	Myliobatidae	Myliobatiformes	Data Deficient
Sakhalin sturgeon	<i>Acipenser mikadoi</i> (Hilgendorf, 1892)	Acipenseridae	Acipenseriformes	Critically Endangered / 1
Kaluga sturgeon	<i>Huso dauricus</i> (Georgi, 1775)	Acipenseridae	Acipenseriformes	Critically Endangered / 2
Amur carp	<i>Cyprinus rubrofasciatus</i> (Lacepede, 1803)	Cyprinidae	Cypriniformes	Least Concern
Pond smelt	<i>Hypomesus olidus</i> (Pallas, 1814)	Osmeridae	Osmeriformes	Least Concern
Asian toothed smelt	<i>Osmerus dentex</i> (Steindachner et Kner, 1870)	Osmeridae	Osmeriformes	Least Concern
Sockeye salmon	<i>Oncorhynchus nerka</i> (Walbaum, 1792)	Salmonidae	Salmoniformes	Least Concern
Sakhalin taimen	<i>Parahucho perryi</i> (Brevoort, 1856)	Salmonidae	Salmoniformes	Critically Endangered / 2
Three-spined stickleback	<i>Gasterosteus aculeatus</i> (Linnaeus, 1758)	Gasterosteidae	Gasterosteiformes	Least Concern
Ninespined stickleback	<i>Pungitius pungitius</i> (Linnaeus, 1758)	Gasterosteidae	Gasterosteiformes	Least Concern
Schlegel's pipefish	<i>Syngnathus schlegeli</i> (Kaup, 1853)	Syngnathidae	Syngnathiformes	Least Concern
Japanese seahorse	<i>Hippocampus mohnikei</i> (Bleeker, 1853)	Syngnathidae	Syngnathiformes	Data Deficient
Snow rockfish	<i>Sebastes nivosus</i> (Hilgendorf, 1880)	Sebastidae	Scorpaeniformes	Data Deficient
Butterfly sculpin	<i>Hemilepidotus papilio</i> (Bean, 1880)	Cottidae	Scorpaeniformes	Least Concern
Yellowtail (Japanese) amberjack	<i>Seriola quinqueradiata</i> Temminck et Schlegel, 1844	Carangidae	Perciformes	Least Concern
Common dolphinfish	<i>Coryphaena hippurus</i> (Linnaeus, 1758)	Coryphaenidae	Perciformes	Least Concern
Red seabream	<i>Chrysophrys major</i> Temminck et Schlegel, 1843	Sparidae	Perciformes	Least Concern
Flathead mullet	<i>Mugil cephalus</i> (Linnaeus, 1758)	Mugilidae	Perciformes	Least Concern
Snyder's blenny	<i>Chirolophis snyderi</i> (Taranetz, 1938)	Stichaeidae	Perciformes	Data Deficient
Tidepool gunnel	<i>Pholis nebulosa</i> (Temminck et Schlegel, 1845)	Pholidae	Perciformes	Least Concern
Amur goby	<i>Rhinogobius brunneus</i> (sp.)	Gobiidae	Perciformes	Data Deficient

Lamprey and fish species included in the IUCN Red List				IUCN Red List and RBSR categories
Russian name	Latin name	Family	Order	
Frigate mackerel	<i>Auxis thazard</i> (Lacepede, 1800)	Scombridae	Perciformes	Least Concern
Japanese mackerel	<i>Scomber japonicus</i> Houttuyn, 1782	Scombridae	Perciformes	Least Concern
Pacific bluefin tuna	<i>Thunnus orientalis</i> (Temminck et Schlegel, 1844)	Scombridae	Perciformes	Vulnerable
Swordfish	<i>Xiphias gladius</i> Linnaeus, 1758	Xiphiidae	Perciformes	Least Concern
Starry flounder	<i>Platichthys stellatus</i> (Pallas, 1787)	Pleuronectidae	Pleuronectiformes	Least Concern
Alaska plaice	<i>Pleuronectes quadrituberculatus</i> Pallas, 1814	Pleuronectidae	Pleuronectiformes	Least Concern
Northern puffer	<i>Takifugu porphyreus</i> (Temminck et Schlegel, 1850)	Tetraodontidae	Tetraodontiformes	Least Concern
Tiger puffer (redfin puffer)	<i>Takifugu rubripes</i> (Temminck et Schlegel, 1850)	Tetraodontidae	Tetraodontiformes	Near Threatened
Spotted-back puffer	<i>Takifugu stictonotus</i> (Temminck et Schlegel, 1850)	Tetraodontidae	Tetraodontiformes	Least Concern
Ocean sunfish	<i>Mola mola</i> Bonaparte, 1835	Molidae	Tetraodontiformes	Vulnerable

common dolphinfish), mugilids (flathead grey mullet), pholids (Japanese pricklyback), ammodytids (Arctic sand lance), scombrids (Japanese mackerel, Pacific bluefin tuna), and pleuronectids (Pacific halibut *Hippoglossus stenolepis*, Greenland halibut *Reinhardtius matsuurae*, and 18 other flounder species, including yellowfin sole, cresthead flounder, blackfin flounder, etc.).

The commercial ichthyofauna of the bay includes anadromous, demersal and pelagic fish, including subtropical migrants. Fishery statistics and survey data showed that pelagic species were the most abundant at different times and were characterised by major long-term fluctuations in stock size.

It has previously been shown that the composition and relative importance of fish species dominant in terms of biomass along the west and east coasts of Sakhalin underwent significant periodic changes during the 20th century, which is characteristic of Sakhalin marine ecosystems as a whole (Velikanov, 2002b).

This characteristic is also typical of the commercial ichthyofauna of Aniva Bay. For example, from 1924 to 1934, herring catches in Aniva Bay reached 400 thousand tonnes per year (Probatov, Shelegova, 1968). However, since the late 1980s, commercial fishing for this species has been completely discontinued. The biomass of pink salmon during spawning runs to the rivers of Aniva Bay did not exceed 3.0 thousand tonnes in the 1960s (Kanidiev, 1973); however, in 1998–2002, the annual catch of this species increased markedly, reaching 32.8 thousand tonnes. In the 1950s, Japanese anchovy was extremely abundant in Aniva Bay; its aggregations were frequently mistaken by fishermen for herring schools (Darda, 1968). After 1960, this

species disappeared from Aniva and Terpeniya Bays for over 30 years (Velikanov, 2001). A subsequent mass occurrence of this species in Aniva Bay was observed from the 1990s to 2013 (Velikanov et al., 2025). In the 1970s, walleye pollock *Gadus chalcogrammus* dominated trawl catches in the study area, with its main aggregations distributed across the eastern part of the bay in summer. During those years, the biomass of feeding pollock off southeastern Sakhalin, including Aniva and Terpeniya Bays, was sufficient for catches of up to 30,000 tonnes (Pushnikov, 1975). At the beginning of the 21st century, walleye pollock occurred in very low abundance in the same areas and the adjacent waters (Radchenko et al., 2002). In La Pérouse Strait and the southwestern part of Aniva Bay in the 1970s, the Pacific sand lance was overwhelmingly dominant, with domestic (Russian) annual catches of about 13,000 tonnes, while catches by Japanese fishermen reached 165,000 tonnes (Velikanov, 1979). In the 1980s, exploratory fishing for Pacific sardine *S. sagax* (*Sardinops melanostictus*) was occasionally conducted in Aniva Bay in the summer (Zhigalin and Belayev, 1999). In 2002–2003, capelin was one of the most abundant fish species in the area, together with flounders, sculpin and saffron cod (Velikanov et al., 2005).

Thus, the composition of the commercial component of the ichthyofauna of the bay under consideration changes periodically in response to cyclical climatic and oceanographic conditions, which affect the reproductive success of abundant fish species both within the bay itself and in adjacent areas of the Sea of Japan, the Sea of Okhotsk, and the northwestern Pacific Ocean.

The history of fisheries

On the scale of Sakhalin Island, Aniva Bay and the adjacent waters of La Pérouse Strait to the south are an area of intensive coastal fisheries. Commercial fishing in the area has a long history, emerging in the late 19th and early 20th centuries with the development of fisheries based on Pacific herring and salmon.

According to P. Schmidt (1905), in the early period, the Sakhalin fishery was based on only seven species, including salmon (herring, cod, halibut, chum salmon, pink salmon, saffron cod, and the legendary Sakhalin sturgeon, which was caught in small numbers in Aniva Bay).

The process of development of marine biological resources in Aniva Bay, as in the entire Sakhalin-Kuril region, has proceeded in several stages. Until the mid-20th century, coastal fishery resources (Pacific herring, salmon, etc.) were intensively exploited. In the second half of the 20th century, with the industrialisation of marine fisheries, active vessel-based fishing using self-propelled fishing vessels (RB-75), small fishing seiners (MRS-100, MRS-225) and regular fishing seiners (RS-300) became increasingly important alongside coastal fisheries employing passive fishing gear such as fixed nets.

Studies of Russian fishery resources in the region under consideration, particularly around Sakhalin, were already underway in the early 20th century, practically simultaneously with the intensive exploitation of Pacific herring stocks (Schmidt, 1905). Over the past 120 years, the fishery resource base of the Sakhalin–Kuril region has increased significantly and now includes more than 90 species of fish, invertebrates and algae (Velikanov, 2021).

In Aniva Bay, Pacific salmon, primarily pink salmon, formed the basis of the fishery resource base until 2002. In the 1920s and 1930s, large quantities of herring were harvested in the study area (Probatov and Shelegova, 1968), while from the 1950s to 1970s, substantial catches of flounders (Pleuronectidae) and sculpins (Cottidae) were taken (Commercial Fishes ..., 1993; Zolotov et al., 2014). In the 1970s, expedition-based vessel fisheries targeting Arctic sand lance were conducted (Velikanov, 1979), while in some years of the following decade, similar fisheries targeted Far Eastern sardine (Zhigalin and Belayev, 1999). In the 1990s, fisheries targeting the coastal fish assemblage, including saffron cod, smelts (Osmeridae), redfins of the genus *Tribolodon* and White-spotted char *S. leucomaenis*, intensified in the area, while since the early 2000s Far Eastern capelin has also been exploited (Velikanov et al., 2003; Velikanov and

Stominok, 2004; Velikanov, 2024b). This was driven by both the natural and geographical conditions of the region, supporting a high biodiversity of aquatic organisms, and the rapid development of technology and research on Russian fisheries in the 20th century. Research into the fisheries' resource base off Sakhalin was particularly intensive and productive in the second half of the 20th century. Meanwhile, the resources of many commercially important fish, invertebrate, and algal species were intensively exploited, including those in Aniva Bay (Velikanov and Stominok, 2004; Velikanov, 2021).

The key features of fisheries targeting individual fish species in Aniva Bay are discussed below from a historical perspective.

Pacific herring

In Aniva Bay, this species ranks first in both annual and cumulative catches for the entire history of the fishery. By the late 20th to early 21st century, long-term data series had been compiled documenting the long-term changes in stock status and interannual catch dynamics of this species in Aniva Bay. The interannual dynamics of herring catches in the study area over different time periods have been documented in a number of publications (Rumyantsev, 1958; Probatov and Shelegova, 1968; Pushnikova, 1981, 1994). However, the most comprehensive account is provided by E. Ivshina (2021). Analysis of the available data has shown that two periods can be clearly distinguished across the long-term retrospective series of the annual herring catches in Aniva Bay. In particular, from 1906 to 1946, the herring fishery in this area was characterised by high fishing intensity and the highest annual catches, with peak annual landings exceeding 405,000 tonnes (Fig. 7.19). It should be noted that, as in other coastal areas of Sakhalin, the fishery in Aniva Bay during this period primarily targeted spawning herring. Catches were taken using large and small fixed (herring) seines.

In particular, in the area under consideration, in the first half of the 1940s, 250–290 fixed seines were set for the extraction of this highly abundant fish (E. Ivshina, 2021).

The fishery for mature feeding herring off Sakhalin was established by Japanese fishermen around the 1920s. Fixed and beach seines were used along with gillnets during the summer season. From 1924 to 1944, annual catches of feeding herring in Aniva Bay ranged from 0.01 to 29.32 thousand tonnes.

In addition, Japanese fishers actively exploited feeding immature herring in the marine waters of

Southern Sakhalin up until 1945. The fishery for immature herring began in the late 19th century, but large-scale catches were recorded from the 1910s onward. This young fish was most intensely caught in the 1930s. The main fishing area for this herring category was Aniva Bay, where the average annual catch from 1914 to 1944 was 21.1 thousand tonnes, while the maximum catch recorded from 1940 to 1941 was about 71 thousand tonnes.

Immature herring were defined as individuals with total lengths ranging from 9–17 to 24–25 cm (Probatov and Varvarin, 1951).

As a result of the irreversible depletion of herring stocks, including the excessive and unsustainable exploitation of spawning fish and their juveniles, annual catches in the subsequent, second fishing period in Aniva Bay (1947–1977) declined markedly, by more than an order of magnitude, with the maximum catch below 20 thousand tonnes. It should be noted that a pronounced reduction in catches of spawning herring in Aniva Bay became apparent as early as the mid-1930s (see Fig. 7.19). In the following decades, the condition of herring stocks in this area further deteriorated, resulting in a marked decline in annual catches (Fig. 7.20).

In the 1950s, the spawning herring fishery in Aniva Bay declined markedly in intensity due to declining abundance. The number of fixed seines deployed varied considerably from year to year, with the maximum number, 53, recorded in 1953; even at this peak level, fishing intensity had declined by a factor of 5.5 compared to the first half of the 1940s. In response to a significant decline in herring stocks off Sakhalin, a ban on the harvesting of spawning herring was introduced in 1960 across all major spawning areas, including Aniva Bay.

Fixed seines used to harvest spawning herring were mainly deployed in the major spawning areas. Pacific herring spawn off Sakhalin, as elsewhere within their range, at depths of 0.5–5.0 m within beds of macroalgae and seagrasses (*Zostera* and *Phyllospadix*), which serve as important substrates for spawned eggs (Fadeev, 2005).

The fishery for mature feeding herring in Aniva Bay continued from the late 1940s to the early 1960s. In this area, fishing for herring was concentrated mainly in the northern and eastern parts of Aniva Bay, where their principal feeding aggregations were located. Starting from 1949, vessel-based purse seine fisheries developed on Sakhalin. From 1954, hydroacoustic equipment was used to detect fish aggregations within fishing sites, and from 1955, aircraft were used to direct fishing vessels to fish schools. Meanwhile, catches of feeding, mature herring in the study area were low, with average annual

catches of 1.38–2.37 thousand tonnes, accounting for 10.1–17.5 % of the total catch of this herring category off the coast of South Sakhalin. After 1963, the specialised fishery for mature feeding herring in Aniva Bay was discontinued (E. Ivshina, 2021).

During the second period of the herring fishery in Aniva Bay, intensive harvesting of small-sized, immature fish (juveniles aged 0–3) also continued. The fishery for this herring category in Aniva Bay operated from 1947 to 1960 and, after a brief hiatus, resumed in 1968 and continued until 1977. From 1947 to 1960, the average annual catch of immature fish off South Sakhalin amounted to 5.64 thousand tonnes, accounting for 28 % of the total catch during the summer–autumn season. From 1968 to 1977, these figures declined markedly to 1.05 thousand tonnes, accounting for 14 %. The main fishing area for small-sized herring during the second period, as in previous decades, was Aniva Bay, which accounted for up to 90–100 % of the total catch across all areas of Sakhalin. During the summer months, Aniva Bay serves as the primary nursery area for juvenile herring of the Sakhalin–Hokkaido stock. During periods of high population abundance, high-density juvenile aggregations formed in the study area (Sokolov, 1963), facilitating efficient exploitation. In the 1940s and 1950s, juvenile herring were harvested mainly using fixed and beach seines, while in autumn, catches were taken exclusively with beach seines; in the 1960s and 1970s, purse seines were actively employed by small vessels (Druzhinin, 1957; Pushnikova, 1980).

Thus, due to stock depletion after 1977, commercial exploitation of herring resources in Aniva Bay was discontinued for several decades up to 2018.

Walleye pollock

The walleye pollock fishery in eastern Sakhalin waters began in the mid-1960s. The species was harvested by both Russian and foreign fishers (DPRK, Japan). The main fishing sites were off south-eastern Sakhalin, in Aniva and Terpeniya Bays. Fishing intensity in this area was low, with annual catches ranging from 1 to 10 thousand tonnes. Russian fishers operated mainly medium-tonnage vessels (SRTR, SRTM, etc.) using bottom trawls.

From 1976, the walleye pollock fishery shifted to the shelf off north-eastern Sakhalin, north of Terpeniya Bay, between 49° and 54° N, where fishing intensity increased rapidly (Fadeev and Vespestad, 2001). In subsequent years in Aniva Bay, walleye pollock were caught in small quantities only as bycatch during purse seine fisheries targeting demersal species (flatfish and sculpin).

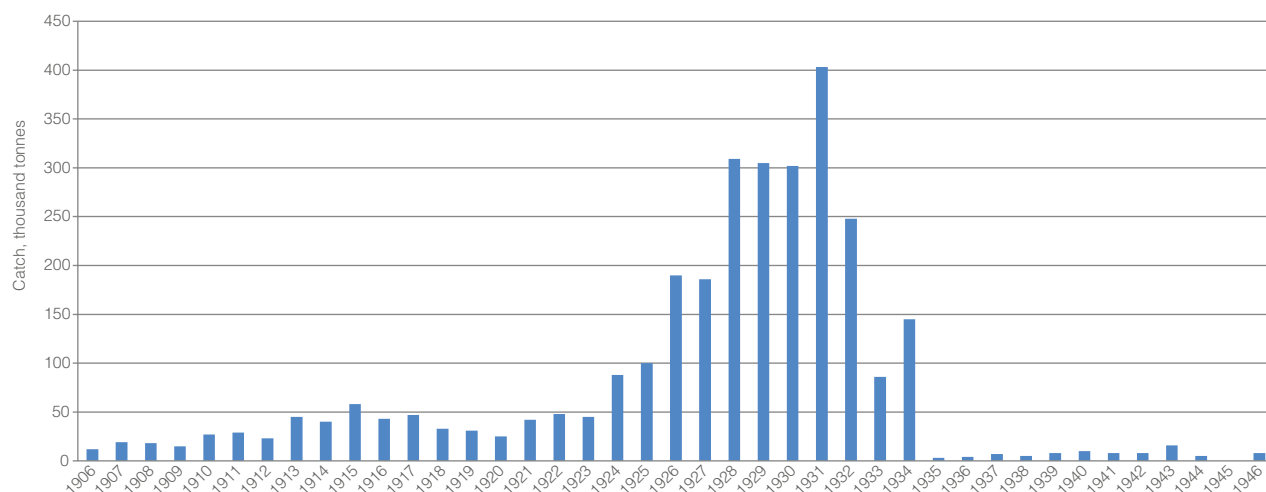


Fig. 7.19. Interannual dynamics of herring catches in Aniva Bay, 1906–1946 (*E. Ivshina, 2021*)

In the neighbouring, more southerly region of the Sea of Okhotsk, off the northern coast of Hokkaido, the walleye pollock fishery was already significant in the 1930s. From the 1950s onward, Japanese fishers annually caught about 100 thousand tonnes of walleye pollock in this area, occasionally reaching up to 200 thousand tonnes (Tsuiji, 1978; Shuntov et al., 1993). Subsequently, Japanese catches of walleye pollock in this area (Kitami Bank, west of the Shiretoko Peninsula) consistently declined, amounting to 117–142 thousand tonnes from 1983 to 1985, 47–50 thousand tonnes from 1986 to 1988, and only 10–14 thousand tonnes from 1991 to 1992 (Fadeev and Vespestad, 2001). Annual catches of walleye pollock in this area remained low from 1998 to 2002, ranging from 8.3 to 23.7 thousand tonnes (Fadeev, 2005). A long-term decline in walleye pollock catches was also observed off northern Hokkaido and

in its western sector, La Pérouse (Soya) Strait, where catches by Japanese fishers from the port of Wakkanai amounted to 28–63 thousand tonnes from 1960 to 1965, but declined to only 4–24 thousand tonnes from 1966 to 1975 (Kitaguchi, 1977). The above statistics indicate that, despite differing levels of fishing intensity, the long-term dynamics of walleye pollock catches in two adjacent areas, south-eastern Sakhalin, including Aniva Bay, and northern Hokkaido, were characterised by the same declining trend during the 1960s and 1970s.

Overall, the consistent decline in walleye pollock catches in the southern Sea of Okhotsk was driven by a substantial reduction in its abundance, not only during this period but also over several subsequent decades (Fadeev and Vespestad, 2001).

Surveys from scientific expeditions showed that, in the early 2000s, the main aggregations of walleye

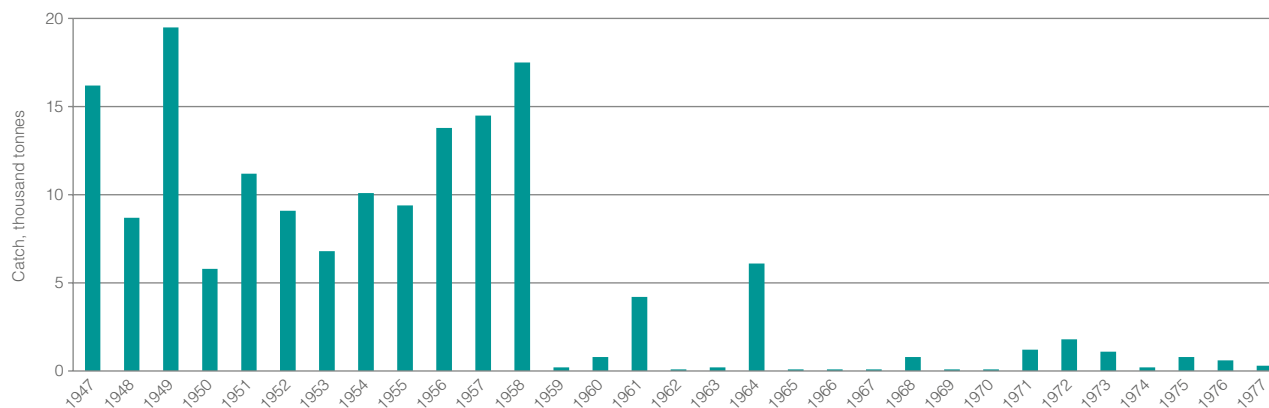


Fig. 7.20. Interannual dynamics of herring catches in Aniva Bay, 1947–1977 (*E. Ivshina, 2021*)

pollock in the Sea of Okhotsk off Sakhalin were confined to its north-east coast, whereas, off South-East Sakhalin and in Aniva Bay, these aggregations were sparse. In particular, published data (Velikanov, 2008) indicate that in late summer 2002, the density of walleye pollock aggregations in Terpeniya Bay was an order of magnitude lower than off north-eastern Sakhalin, and in Aniva Bay an order of magnitude lower than in Terpeniya Bay. This was reflected, among other factors, in the low occurrence frequency of the species, the limited spatial extent of its distribution, and low research survey catches. Low abundance of walleye pollock off south-eastern Sakhalin and in Aniva Bay was observed throughout the first decade of the 21st century.

In the first half of the 2000s, both spawning and feeding aggregations of walleye pollock in Aniva Bay and off south-eastern Sakhalin were very scarce. According to pelagic survey data (Velikanov et al., 2005; Velikanov, 2008), juvenile aggregations of walleye pollock in Aniva Bay and off south-eastern Sakhalin from 2002 to 2004 were also extremely scarce. The persistently low level of walleye pollock stocks in the study areas limits the development of an active, specialised fishery in these regions.

A slight increase in the biomass of the aggregations of this species has been observed only since 2011. In the near future, growth in walleye pollock stocks may lead to improved catches in the Sea of Okhotsk off southern Sakhalin.

Flatfishes (Pleuronectiformes)

According to current estimates, 18 species of flatfishes occur in Aniva Bay (Commercial Fishes ..., 1993; Dyldin et al., 2020). Some species occur occasionally, most are resident, and some are relatively abundant. Among the species rarely occurring in Aniva Bay are the Asian flounder (Bastard halibut) *Paralichthys olivaceus*, the slime flounder *Microstomus achne* and the stone flounder *Platichthys bicoloratus*. They are primarily distributed in the southern part of the Sea of Japan, but occasionally occur in the warmest areas off the southern Kuril Islands and Sakhalin, including Aniva Bay.

The second group belongs to the Kuril–Japan zoogeographic complex and includes up to eight species that occur year-round in Aniva Bay but are generally scarce. These include the scale-eye plaice *Acanthopsetta nadeshnyi*, blackfin flounder *Glyptocephalus stelleri*, the dusky sole *Lepidopsetta mochigarei* and the flathead sole *Hippoglossoides elassodon*.

The third group belongs to the Bering Sea zoogeographic complex. Representatives of this complex

exhibit greater ecological diversity. In Aniva Bay, this group includes spring-spawning species (Alaska plaice *Pleuronectes quadrituberculatus*, cresthead flounder *Pseudopleuronectes schrenki*, starry flounder *Platichthys stellatus*, flathead sole *H. elassodon*), summer-spawning species (yellowfin sole *L. aspera* and blackfin flounder) and winter-spawning species (Greenland halibut *R. matsuurae* and dusky sole *L. mochigarei*). Some representatives of this complex are relatively abundant (Commercial Fishes ..., 1993; Fadeev, 2005).

According to bottom trawl survey data collected on the Sakhalin Island shelf from 1976 to 1980, the total commercial stock of flatfishes in Aniva Bay amounted to 7.0 thousand tonnes. The Bering flounder *H. robustus* was dominant, with its stock estimated at 5.6 thousand tonnes, accounting for 80 % of the total recorded flatfish stock. Notably, in the second half of the 1970s, the maximum estimate of commercial stock in Sakhalin waters, 18.8 thousand tonnes, was also recorded for this halibut-like flounder species (Tarasyuk, 1983).

A trawl survey conducted by SakhtINRO (now the Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography) in October 1998 allowed researchers to encompass aggregations of cresthead flounder during their overwintering migration. The stock was estimated at 3.2 thousand tonnes. The highest concentrations (up to 26 tonnes per square mile) were observed off Cape Aniva at depths of about 50 m. In 2003, the stock of cresthead flounder was estimated at a similar level. This species, as well as several scarce flatfish species, was taken in small quantities in inshore fisheries using fixed gear.

From July to October 2000 TINRO (now the Pacific Branch of the Russian Federal Research Institute of Fisheries and Oceanography) conducted a bottom trawl survey on the shelf and the upper continental slope throughout the Sea of Okhotsk basin. According to the data obtained, the most abundant flatfish species in Aniva Bay are yellowfin sole and Bering flounder *H. robustus*; the density of aggregations of each species in the eastern part of Aniva Bay reached 100 kg/km² (Ilyinsky and Chetvergova, 2002).

The most pronounced flounder fishery in the study area, in terms of annual catches, occurred from 1947 to 1980; however, in different periods, different flounder species dominated purse seine catches. In the 1950s, dusky sole *L. mochigarei* and yellowfin sole were harvested. From the 1970s to 1980s, Bering flounder *H. robustus* (Fig. 7.21) and cresthead flounder dominated the same areas. The difficulty in harvesting cresthead flounder lies in the fact that the feeding aggregations suitable for trawl or purse seine fisheries occur at

depths of less than 20 m, where such fishing methods are prohibited by fisheries regulations. Therefore, it was recommended that harvesting be conducted using fixed seines, nets, or cast seines under scientific supervision.

In the first half of the 1980s, catches of up to one thousand tonnes of flatfishes, mainly Bering flounder, were recommended in Aniva Bay (Shuntov, 1985). Nevertheless, in the 1980s, no specialised fishery for Far Eastern flounders was conducted in Aniva Bay. Flatfishes were taken here mainly as a by-catch of the sculpin fishery. However, from the mid-1980s, the joint fishery for these two groups of demersal fish was discontinued due to declining sculpin stocks.

Thus, the flatfish fishery in Aniva Bay has consistently played a secondary role owing to low stock levels in this area. In Aniva Bay, as in Terpeniya Bay, the most productive period was from the 1950s to 1960s, with maximum catches recorded in 1954 (1.4 thousand tonnes) and 1956 (1.7 thousand tonnes).

On average, over the entire observation period, annual flatfish catches in Aniva Bay amounted to about 0.4 thousand tonnes, or approximately 9 % of the total catch in the East Sakhalin Subzone.

Although the transition from a Total Allowable Catch (TAC) regime to a Possible Catch (PC) format, with simplified annual catch control, slightly increased interest in flatfish harvesting in Aniva Bay, the area accounted on average for only about 11 % of annual catches of this species group off eastern Sakhalin from 2009 to 2013. The highest catches, amounting to 0.6–0.7 thousand tonnes, were recorded from 2009 to 2011, whereas in subsequent years, fishery was virtually discontinued (Zolotov et al., 2014).

Sculpins (Cottidae)

Long-term studies have shown that in Aniva Bay, among representatives of the family Cottidae, the numerically dominant species are the great sculpin *Myoxocephalus polyacanthocephalus*, the jaok sculpin *Myoxocephalus jaok*, the antlered sculpin *Enophrys diceraus*, Gilbert's sculpin *Hemilepidotus gilberti*, as well as the plain sculpin *Gymnocanthus herzensteini* and the threadfin sculpin *Gymnocanthus detrisus* (Fig. 7.22) (Commercial Fishes ..., 1993).

In June–July 1988–1989, research bottom trawl survey catches in Aniva Bay and the northern part of La Pérouse Strait were dominated by the same sculpin groups (scaly sculpins, helmet sculpins, jaok sculpins, and the antlered sculpin), with catches ranging from 0.1 to 7.0 tonnes per half-hour tow (Khudya, 1990b). Based on trawl survey data from Aniva Bay, sculpin

abundance increased up to 1994 as a result of the introduction of limited fishing. According to data from the 1994 integrated trawl survey, sculpin stock biomass in Aniva Bay amounted to 11.5 thousand tonnes. Based on bottom trawl results from the second basin-wide Sea of Okhotsk expedition in 2000, the most abundant sculpin species in Aniva Bay were the great sculpin and the jaok sculpin *C. jaok*. Aggregation density of these species in the study area reached 100–500 kg/km², whereas the abundance of helmet sculpins and scaly sculpins did not exceed 5–10 kg/km² (Ivanov, 2002).

Trawl survey data collected by SakhNIRO (now the Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography) specialists from 2001 to 2012 indicate that all of the sculpin species above still dominated in terms of biomass within the sculpin assemblage of the study area, despite a marked decline in abundance of the dominant species. In particular, the total sculpin stock in Aniva Bay in June 2011 amounted to 3.79 thousand tonnes. The plain sculpin dominated, accounting for 56.8 %, while the great sculpin accounted for 21.8 %. At the same time, the proportions of these species based on trawl survey data exhibit considerable long-term variability. In particular, in Aniva Bay the proportion of great sculpin ranged from 27.7 to 86.7 %, while that of the plain sculpin ranged from 13.3 to 72.3 %.

During the summer months, aggregations of sculpins in Aniva Bay are mainly confined to the shallower northern part. However, the distribution of these species in the study area is subject to considerable variability depending on seasonal and interannual oceanographic conditions.

Other abundant sculpin species (scaly sculpins, helmet sculpins and the antlered sculpin) are relatively small-sized and occur mainly in shallow waters, at



Fig. 7.21. Bering flounder *Hippoglossoides robustus*

depths not exceeding 100–200 m. In Aniva Bay, they are typically concentrated on the shelf in the south-western part of the bay and in adjacent areas of La Pérouse Strait, near Danger Rock.

From the 1960s to the 1980s, sculpin played an important role in the economy of Sakhalin Region. Catches of these species were in high demand during the development of two of the island's industries, fur and poultry farming. Sculpins were mainly harvested from April through October by small-tonnage vessels using purse seines. In the 1970s, sculpin stocks in the coastal waters off Sakhalin were intensively exploited, resulting in a significant decline in abundance during the first half of the following decade. In particular, owing to declining stocks of this group of demersal fish, a steady downward trend in annual catches on Sakhalin was observed, from 20.2 thousand tonnes in 1985 to 8.5 thousand tonnes in 1991 (Dudnik, 1985; Commercial Fishes ..., 1993).

In 2005, total sculpin catches off eastern Sakhalin decreased again and amounted to only 1.4 thousand tonnes, that is, 18.9 % of the forecast level. This pattern of sculpin stock exploitation became characteristic of subsequent fishing years. From 2004 to 2014, no specialised sculpin fishery was conducted in the main fishing areas of the East Sakhalin Subzone, which was the primary cause of the catch shortfall. In 2014, total sculpin catches amounted to only 0.25 thousand tonnes.

Fishery statistics indicate that in the second half of the 20th century, Aniva Bay remained the only area of the Sakhalin shelf where a specialised sculpin fishery was conducted until the early 1990s. Commercial sculpin catches were composed primarily of the above-mentioned species, accounting for up to 95–99 % of the total catch.

The catch of sculpins in Aniva Bay also remained small in the first five years of the 21st century. In particular, based on stock assessment results, the TAC for these fish in Aniva Bay in 2005 was 2.9 thousand tonnes. In subsequent years, sculpin abundance in Aniva Bay, particularly that of the dominant species, continued to decline steadily: in 2011, the total stock of these fish had declined by a factor of three since 1994, and the TAC in this area was set to only 0.74 thousand tonnes.

Arctic sand lance

The sand lance, an abundant small-bodied fish species, plays an important role in the shelf ecosystems of the Far Eastern seas. On the one hand, it is a major consumer of zooplankton; on the other, it serves as prey for many species of marine and anadromous fishes, as well as seabirds and marine mammals. However, as a target



Fig. 7.22. Threadfin sculpin *Gymnocanthus detrisus*

of domestic fisheries, this group attracted attention relatively recently, in the mid-1970s. A marked decline in the abundance and, consequently, catches of many important commercial fish species in the eastern seas of Russia in the 1960s forced the fishing industry of the Russian Far East to seek alternative, promising fishery targets (Velikanov, 2002a). Among the promising fish species characterised by wide distribution and high abundance was the Arctic sand lance, which in the 20th century was referred to as the Pacific multivertebrate sand lance and treated as a species complex. At that time, scientific knowledge of the biology of this species was extremely limited. Notably, until the mid-1970s, studies of the sand lance in the eastern seas of Russia were fragmentary and episodic, with the primary emphasis placed on the systematic position and distribution of the species (Schmidt, 1950; Andriyashev, 1954; Lindberg and Krasnyukova, 1975).

In 1976, off the coast of Sakhalin in the area of La Pérouse Strait, an expeditionary sand lance fishery was first undertaken by a group of Russian medium-tonnage trawlers, mainly vessels from the Nevelsk trawl fleet base. However, Japanese fishermen began harvesting sand lance in this area much earlier. In particular, off the coast of the northernmost Japanese island of Hokkaido, the sand lance fishery had a long history, although it became well established only in the early 1950s following a sharp decline in catches of herring of the Sakhalin-Hokkaido stock. In the 1930s and the first half of the 1940s, sand lance was also harvested using fixed seines off the coast of southern Sakhalin, which was under Japanese administration from 1905 to 1945. The intensity of the Japanese vessel-based sand lance fishery increased markedly from 1970 onward (Fig. 7.23).

With the establishment of a specialised fishery for this species, SakhtINRO, at the initiative of the Production Association 'SakhalinRybProm', also began systematic studies of the resource base and biology of the Pacific sand lance starting in 1976. Initially, from 1976 to 1980, studies of this species were mainly exploratory in nature. Expeditionary work, in which the staff of the SakhtINRO Laboratory of Marine Commercial Fishes participated annually, was conducted in close cooperation with the Operational Fish Exploration Administration of the Production Association 'SakhalinRybProm'. During that period, the study area was limited to the waters of La Pérouse Strait and the southern part of Aniva Bay. The spatial coverage of the observations was greatest in 1976, when exploratory surveys extended eastward as far as Cape Aniva and southward to the 12-mile fishing zone of Japan. From 1977 onward, similar observations, as well as fishing activities, were possible only up to the boundary separating the economic zones of the two states. The latter was due to the establishment of 200-mile exclusive economic zones (EEZs) by the governments of the USSR and Japan (Velikanov, 2002a).

Overall, during this period, it was established that, off the coast of Sakhalin, sand lance formed large annual commercial aggregations only in La Pérouse Strait and partially in the south-western part of Aniva Bay (Morzh Bay). From April through September, concentrations of this fish were observed mainly in the waters east of Danger Rock at depths of 30–100 m. It was found that during these months, sand lance engages in feeding, and its aggregations are confined to the upper shelf, associated with sandy substrates, strong near-bottom currents and relatively high zooplankton biomass levels. Analysis of data on the seasonal distribution patterns and changes in aggregation density suggests that during the spring–summer period, sand lance undertakes feeding migrations from southern areas, from the coast of Hokkaido into La Pérouse Strait, moving northward and northeastward. In August, sand lance began their return migration. In May, June, August and September, the densest aggregations were observed in the southern part of the area, whereas in July they occurred in the northern part (Velikanov, 1979).

The domestic sand lance fishery was conducted by medium-tonnage fishing vessels (SRTR and SRTM) using bottom trawls equipped with a fine-mesh (5 mm) insert in the codend, which helped to prevent extensive gilling of small fish in the trawl netting. An analysis of fishing operations in La Pérouse Strait showed that catch efficiency declined significantly at night, as Pacific sand lance occur predominantly on the seabed

or in near-bottom layers during daylight hours, where they aggregate into dense schools readily detected by hydroacoustic equipment. At night, as with other planktivorous fish, Pacific sand lance ascend to surface waters to feed, following diel plankton migrations (Velikanov, 1979, 2002b).

The extensive fishery and biological data accumulated by the late 1970s indicated a favourable stock status and high abundance of sand lance in La Pérouse Strait (Zverikova et al., 1982). This conclusion was supported by multiple lines of evidence, most notably the high intensity of fishing. For example, during the summer of 1976, up to 30–40 medium-tonnage vessels, including 7–10 domestic vessels, operated simultaneously within a relatively limited area of approximately 800 square miles. Russian (then Soviet) catches were relatively small and did not exceed 13,000 tonnes per year. By contrast, in the mid-1970s, sand lance catches by the Japanese fleet in the area reached 100–160 thousand tonnes (Kitaguchi, 1977).

In the 1980s, La Pérouse Strait and the adjacent southwestern part of Aniva Bay remained the only area in the Far Eastern fishery basin where the domestic fleet conducted annual sand lance fisheries, accompanied by intensive scientific studies (Hudya, 1985, 1990a, 1990b, 1993, 1994). However, amid a steady decline in sand lance stocks in the fishing area, combined with the absence of viable markets and limited development of processing technologies, the domestic fishery gradually contracted throughout the 1980s and was completely discontinued by 1990.

The Russian sand lance fishery in this area did not resume in the 1990s; however, Japanese fisheries continued to make annual catches. In some years, for example in 1997, Japanese fisheries also operated within the Russian exclusive economic zone under quotas allocated to foreign vessels. Sand lance catches by Japanese fisheries in the La Pérouse Strait area in the 1990s ranged from 23,000 to 56,000 tonnes.

An analysis of long-term fluctuations in sand lance abundance and catches in the La Pérouse Strait area during the second half of the 20th century showed that sand lance biomass in the area declined nearly sixfold over the preceding 25 years (Velikanov, 1999). Long-term changes in abundance were accompanied by similar synchronous fluctuations in the abundance and catches of other abundant fish species in the waters off Sakhalin, often in opposite directions. Specifically, periods of high sand lance abundance coincided with years of relatively low herring and pink salmon abundance. The emergence of large sardine aggregations in the southwestern Sea of Okhotsk during the late 1970s–early 1990s coincided

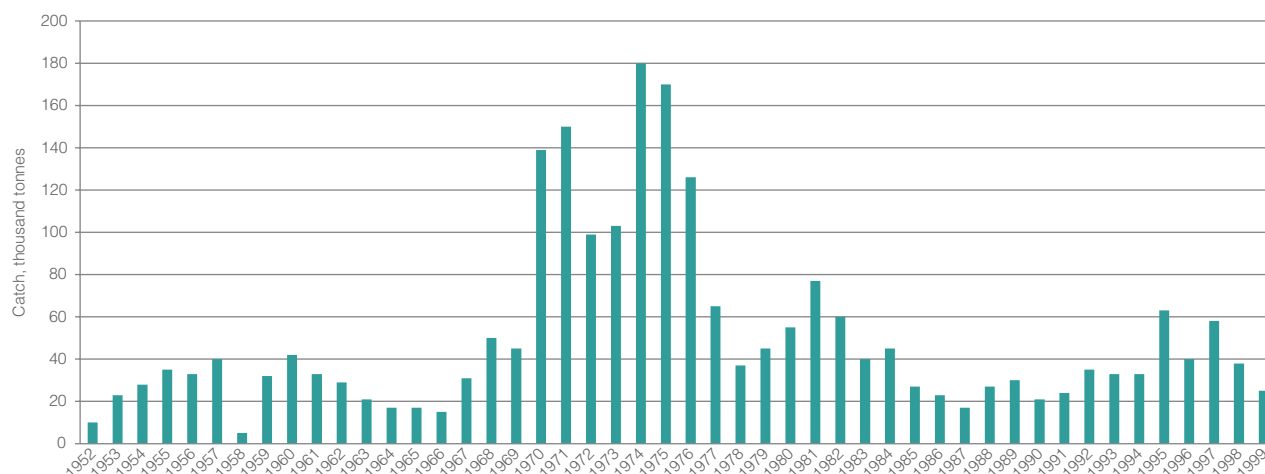


Fig. 7.23. Dynamics of annual sand lance catches by Japanese fishermen in the northern part of Hokkaido Island, including the La Pérouse Strait, in 1952–1999 (*Mizushima, Torisawa, 2005*)

with low herring abundance and marked declines in pollock and sand lance abundance. A period of low abundance of herring, pollock and sand lance in the 1990s coincided with increasing abundance of pink salmon, southern Atka mackerel and Japanese anchovy (Velikanov, 2008).

Formally, domestic sand lance fisheries in La Pérouse Strait resumed on a limited scale during 2000–2014. According to official statistics, sand lance catch quotas were allocated to only two or three fishing companies. Annual catches were low, ranging from 3 tonnes in 2014 to 448 tonnes in 2006. However, there are grounds to suggest that no actual fishing activity took place and that the reported catch figures merely reflected allocated quotas and were recorded for quota accounting purposes. From 2015 onward, sand lance fisheries by Russian fisheries were neither conducted nor recorded.

For these reasons, the domestic sand lance fishery in La Pérouse Strait has effectively not been conducted for about 35 years. A new phase of intensive sand lance exploitation by Russian fisheries in this area may emerge during a subsequent cycle of decline in major commercial fish stocks, under favourable conditions for the development of a specialised fishery for this species.

Current state of the fisheries

As shown in Fig. 7.24, in the early 21st century, the intensity of purse seine fishing in Aniva Bay was comparable to that on the shelves of southwestern and southeastern Sakhalin and the Southern Kurils, where mean catch densities of biological resources generally

did not exceed 100 kg/km².

At present, patterns of fishery exploitation of marine biological resources in Sakhalin and the Kuril Islands are shaped by the availability of a wide range of commercially exploited taxa, the diversity of fishing gears employed, and intensive exploitation across all the major fishing areas of the region. This was made possible by adequate knowledge of the fisheries' resource base, the implementation of diverse technologies for the exploitation of living marine resources, and access to broad domestic and international markets for fish products (Velikanov, 2021). This also applies in part to Aniva Bay, where fisheries exploit a broad range of marine living resources, encompassing up to 15–20 species (Velikanov and Stominok, 2004). By contrast, fisheries in this area have distinct characteristics. This reflects the generally limited abundance and biomass of the living marine resources in the bay, with the exception of infrequent episodes, such as high herring abundance and catches in the first half of the 20th century, as well as elevated abundance of sand lance and sardine during the 1970s and 1980s. Accordingly, fisheries targeting most living marine resources in the bay are predominantly coastal, employing appropriate coastal fishing gears; for fish, these include set nets, beach seines and purse seines operated from small vessels. Accordingly, many of these fish species are currently exploited in Aniva Bay either through specialised fisheries or as bycatch.

Pacific herring

Two stocks of Pacific herring occur within the East Sakhalin fishing subzone. In the northern part of

the subzone, there is a distinct local Northeastern Sakhalin herring population, whereas the southern part, including Aniva Bay, the southeast coast of the island and Terpeniya Bay, is occupied by the Sakhalin–Hokkaido population, formerly highly abundant, with maximum catches across its entire range reaching 1.0 million tonnes.

Stocks of the Sakhalin–Hokkaido herring population, supporting fisheries in the southern part of the island, have increased annually across their range since the mid-2010s, as evidenced by results from a suite of assessment surveys conducted at different stages of the species' life cycle. The current status of herring stocks supported a recommended catch of 18.70 thousand tonnes for 2023 in the southern part of the subzone.

The main herring fishing area off Sakhalin is along the southeast coast of the island; in recent years, the fishery importance of Aniva Bay has increased. Up to 80–95 % of all herring catches in Sakhalin Region are taken in these two areas (E. Ivshina, 2021). The fishery operates during the herring spawning season (April–June); the primary gear is small set nets. High catches since 2016 have been driven by two main factors: strong spawning runs of herring and increased industry interest in the fishery. In particular, catches amounted to 8.4 thousand tonnes in 2022 and increased to 9.4 thousand tonnes in 2023 (Fig. 7.25).

Far Eastern capelin

From the 1970s to the 1990s, capelin fisheries in the East Sakhalin subzone (Sea of Okhotsk waters off the island) were limited and largely sporadic. From 2000 to 2015, annual catches of this species off eastern Sakhalin ranged from 0.03 to 1.20 thousand tonnes. From 2016 onward, capelin catches increased markedly in response to emerging market demand.

From 2017 to 2018, capelin abundance off eastern Sakhalin was relatively high, allowing catches of over 4 thousand tonnes per fishing season (Velikanov, 2024b). However, a marked decline in catches followed (Fig. 7.26). In 2022, according to company reports, catches in the subzone amounted to 1.9 thousand tonnes, decreasing to about 0.6 thousand tonnes in 2023.

According to the annual forecast of the Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography, no signs of the emergence of new strong year classes of capelin off eastern Sakhalin are currently observed, and stock status is assessed as moderate with a declining trend. A published hypothesis suggests that low capelin abundance off eastern

Sakhalin may persist until the end of the current decade (Velikanov, 2023). In Aniva Bay, the share of capelin in the total catches in the Sea of Okhotsk waters off Sakhalin varied considerably among years. According to data from the Sakhalin–Kurul Territorial Administration of the Federal Agency for Fisheries (Russian Federation), from 2012 to 2019, the relative share of capelin catches in the bay ranged from 4.6 % (2013 and 2019) to 30.8 % (2016). However, in some years, capelin catches in the East Sakhalin subzone were equivalent to those recorded during the fishing season in Aniva Bay. For example, in 2002, according to official data, more than 1,327 tonnes were landed in the bay, with nearly 76 % of the catch taken in the western part of it, where the highest capelin catches were also recorded by research pelagic trawl surveys (Velikanov et al., 2003). The main areas for capelin fisheries in the East Sakhalin subzone are the southeast coast of the island and Aniva Bay, where capelin fishing along the Sea of Okhotsk coast of Sakhalin is largely concentrated. Fishing gear used for capelin off Sakhalin, including Aniva Bay, is predominantly small set nets (locally known as 'karavki'), beach seines, haul seines and dip nets. Depending on the strength of the spawning runs, between 16 and 59 fishing companies are involved annually in the capelin fishery along Sakhalin's coast on the Sea of Okhotsk (Fig. 7.27).

Other fish species

According to forecasts from the Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography, smelts are the traditional targets of coastal spring–summer fisheries on Sakhalin. Stocks of Asian toothed smelt off the east coast of Sakhalin

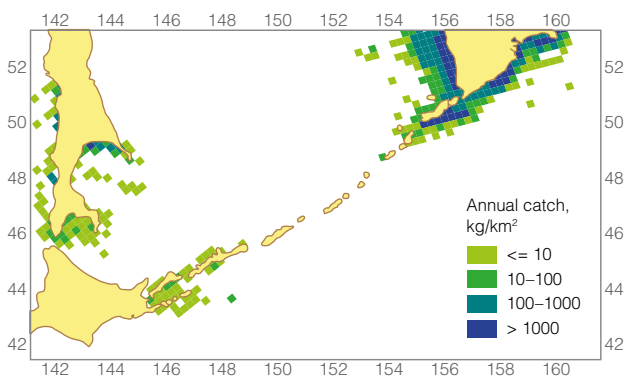


Fig. 7.24. Mean distribution (2003–2010) of marine living resource catches off Sakhalin Island and the Kuril Islands by purse seines (*Fisheries ...*, 2013)

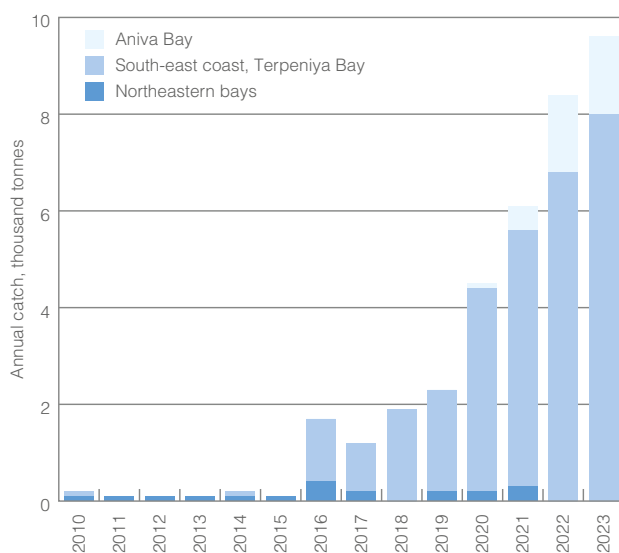


Fig. 7.25. Herring catch dynamics off the east coast of Sakhalin, including Aniva Bay, 2010–2023 (*E. Ivshina, 2021, with additions*)

are currently assessed as being in good condition. Each year, 20–40 companies in the region are involved in fishery, resulting in increased catches in the East Sakhalin subzone over the past decade, from 0.2 to over 1.0 thousand tonnes (Fig. 7.28). In 2023, catches of toothed smelt off eastern Sakhalin exceeded 1.3 thousand tonnes. Nearly a third of this volume was taken in Terpeniya Bay, where average catches amounted to about 60 tonnes per fishing area. Substantial catches of toothed smelt are also taken in Aniva Bay.

Marine smallmouth smelt was recognised as a separate fishery target from the smallmouth smelt group in 2012. The interspecific distinctness of three smallmouth smelt species, including Japanese smallmouth smelt and marine smallmouth smelt, was established by V. Klyukanov (1970); the presence of all three smelt species on Sakhalin was later confirmed by N. K. Zavarzina (2004). In 2017, mixed spawning grounds of capelin and marine smallmouth smelt were identified in Aniva Bay, near Prigorodnoye, the Gorelaya River and east of Ozerskoye (Mukhametova, 2020). In the same year, catches of marine smallmouth smelt in the East Sakhalin subzone exceeded 1.0 thousand tonnes; thereafter, catches declined markedly. In 2022, catches of this species off eastern Sakhalin amounted to only 191.4 tonnes, representing the lowest value recorded over the entire period of exploitation (Fig. 7.29). Signs of deterioration in the biological condition of marine smallmouth smelt resources were also identified from

2022 assessment surveys: a decline in aggregation density and a reduction in mean individual size were observed in Aniva Bay and off the southeast coast of Sakhalin.

From May to June 2023, catches of marine smallmouth smelt across the subzone amounted to about 370 tonnes, exceeding those of the previous year but remaining well below the long-term mean.

Most other fish species are taken in the bay as bycatch in fisheries employing set nets, beach seines, or purse seines. For example, redfin catches in the East Sakhalin fishing subzone, including Aniva Bay, ranged from 35 to 215 tonnes from 2012 to 2021, while the proportion of the recommended (scientifically based) catch utilised varied between 6.7 and 28.6 %. At present, potentially exploitable marine fish species in the East Sakhalin shelf zone include sculpins (*Cottidae*), particularly in Aniva and Terpeniya Bays, with a recommended catch of up to 1.12 thousand tonnes, as well as Arctic sand lance, for which commercial aggregations are known in La Pérouse Strait. However, stocks are currently low, with a recommended catch of 1.0 thousand tonnes in the Russian zone of La Pérouse Strait. The development of specialised fisheries for these species will be possible contingent on the emergence of market demand and the establishment of viable markets.

Thus, over the past 15 years, fisheries in Aniva Bay have primarily targeted Pacific herring and several smelt species, taken during spawning runs to the coast using coastal fishing gear.

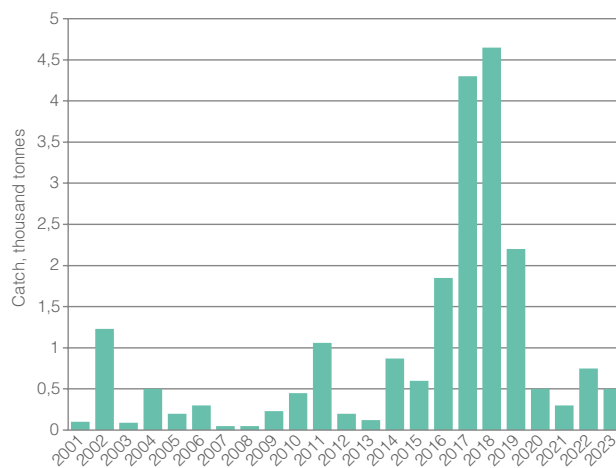


Fig. 7.26. Capelin catch dynamics in the East Sakhalin subzone, 2001–2023



Fig. 7.27. Capelin fishing during the spawning run on Sakhalin Island (*photo by the author*)

Prospects for fisheries

Fishery prospects are determined by the current status of stocks of various fish species and their long-term dynamics, as well as by economic factors shaping demand for particular species and the associated markets. Aniva Bay supports a number of fish species occurring either permanently or seasonally, whose reproduction and abundance are subject to pronounced long-term fluctuations. Such variability is reflected in annual catch levels as well as in the organisation and overall intensity of fisheries, which may range from complete cessation to renewed emergence and rapid development. Among commercially exploited fish species in the bay, several exhibit well-defined long-term cyclical changes in abundance and stock size, as demonstrated in fisheries studies. This category includes several species with a short life cycle (no more than 5–7 years), such as Arctic sand lance, Far Eastern capelin and Far Eastern sardine (Dudarev and Kenya, 1986; Khudya, 1993; Velikanov, 2018), as well as some species with moderate longevity, including Pacific herring and pollock (Fadeev, 2005).

Currently, following a prolonged period of depression of the Sakhalin–Hokkaido herring stock (Pushnikova, 1994; E. Ivshina, 2021), signs of recovery in reproduction and increasing abundance are evident both in Aniva Bay and off the south-western and south-east coasts of Sakhalin. This indicates that the observed improvement in herring reproductive efficiency in the study area is systematic and is likely to continue over the coming years.

A similar situation is observed in more southerly spawning areas of Pacific herring (E. Ivshina, 2021), including along the coasts of Hokkaido and the Korean Peninsula. The simultaneity and scale of this phenomenon suggest the likelihood of further increases in abundance and stock size of this species, including in Aniva Bay.

Low pollock abundance in southeastern Sakhalin and Aniva Bay was observed throughout the first decade of the 21st century. An increase in the biomass of its aggregations in these bays has been observed only since 2011. Results of trawl surveys regularly conducted by the Pacific and Sakhalin Branches of the Russian Federal Research Institute of Fisheries and Oceanography also indicate a constant steady increase in pollock abundance and biomass in the southwestern Sea of Okhotsk, including Aniva and Terpeniya Bays.

In this context, pink salmon abundance off eastern Sakhalin remains low (Velikanov et al., 2018; Kaev and Kolpakov, 2022), while herring and pollock stocks have not yet reached high levels. Nevertheless, a moderate increase in Arctic sand lance stocks cannot be ruled out over the next 5–7 years.

Given the continued increase in the abundance and stock size of the Pacific population of Far Eastern sardine (Yatsu, 2019), its strong seasonal migrations into the waters of the Southern Kuril Islands, and the substantial rise in annual catches by domestic fisheries (up to 500–580 thousand tonnes in recent years), the occurrence of sardine aggregations in Aniva Bay and adjacent areas of the Sea of Okhotsk cannot be excluded. During the previous cycle of high abundance of Far Eastern sardine (*iwashi*) in the 1980s to early 1990s, its aggregations were intensively exploited by domestic

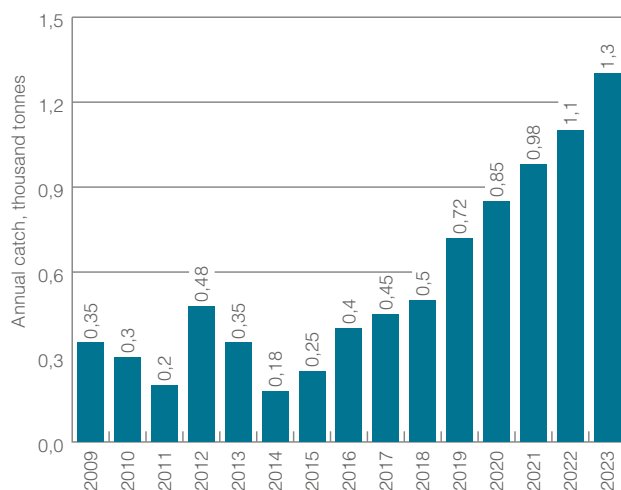


Fig. 7.28. Catch dynamics of Asian toothed smelt off the east coast of Sakhalin Island, 2009–2023 (data from A. Metlenkova, Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography)

fisheries in the southern Sea of Okhotsk, including, in certain years, Aniva Bay (Zhigalin and Belayev, 1999). According to data from the industry monitoring system of the Federal Agency for Fisheries (Russian Federation), between September and early November from 2021 to 2024, sardine aggregations regularly migrated through the straits from the northwestern Pacific Ocean into the southern Sea of Okhotsk adjacent to the Southern Kuril Islands, where they were intensively exploited by domestic fishing vessels.

As noted above, stocks of Far Eastern capelin off eastern Sakhalin are currently low. According to the published assessments, stocks of this species in Aniva Bay are not expected to increase before the end of the current decade or the beginning of the next (Velikanov, 2023). However, even during a low-productivity reproductive cycle and periods of low abundance, strong annual classes may emerge in some years, leading to short-term increases in spawning stock biomass and, consequently, to relatively high catches within a fishing season. Such episodes have already occurred in Aniva Bay in the 21st century, e.g., in 2002 (Velikanov et al., 2003).

Results of numerous trawl surveys indicate that commercial stock dynamics of sculpins (gobies) in Aniva Bay are also characterised by pronounced long-term fluctuations. Given the prolonged period of low stock levels of gobies in the region, the absence of intensive bottom fisheries and improving feeding conditions, stocks of this group in the bay are likely to increase.

Due to the relatively small shelf area in the bay, flatfish abundance is comparatively low (Zolotov et al., 2014), although stocks of individual flatfish species are also subject to pronounced long-term variability (Shuntov, 1985; Fadeev, 2005). Smelt stocks in Aniva Bay are also low (Shchukina, 1994; Zavarzina, 2004). In addition, the Asian toothed smelt assemblage in this bay is regarded as an independent stock of population rank, characterised by pronounced interannual fluctuations in abundance, while fishing pressure may substantially reduce spawning stock biomass under inadequate management (Shchukina, 1994, 1999).

Over the past two years, significant changes have occurred along the coast of Aniva Bay, associated with the development of modern fisheries infrastructure. Construction of a new deep-water port has commenced in the town of Korsakov. The project includes facilities for the fisheries sector, notably high-capacity refrigerated storage for the reception and storage of large volumes of fish landings. Construction of a new fish processing plant is underway in Ozerskoye, which will be equipped with state-of-the-art technologies. The infrastructure currently under construction will enable not only the processing of large volumes of fish landings delivered to shore from remote areas of the Far Eastern fisheries basin but also more intensive exploitation of local marine biological resources. Currently, fish products from cod and pollock are produced in this area at the existing processing facilities of the Kirov Collective Fishery, using raw material harvested in

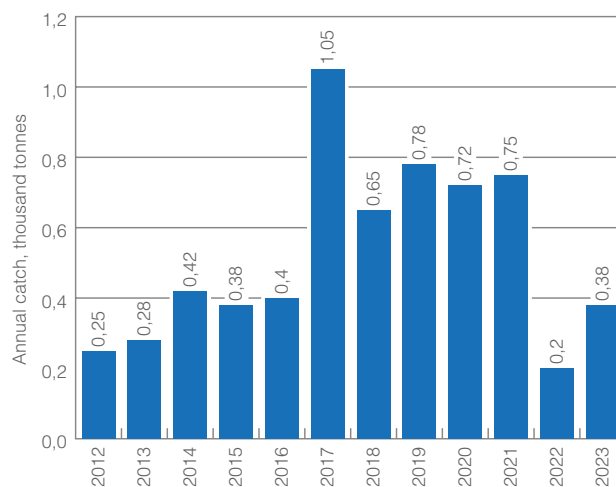


Fig. 7.29. Catch dynamics of marine smallmouth smelt off the east coast of Sakhalin Island from 2012 to 2023 (data from N. K. Zavarzina, Sakhalin Branch of the Russian Federal Research Institute of Fisheries and Oceanography)

other areas, including southwestern Sakhalin and the Southern Kurils.

On the one hand, the marine biological resources of Aniva Bay are characterised by high species diversity of commercially exploited aquatic organisms, including anadromous, marine, and coastal fish, commercial invertebrates and algae (Velikanov and Stominok, 2004). On the other hand, over the next 5–10 years, stocks of many commercial fish species, both local and transboundary, are expected to increase substantially in Aniva Bay and the adjacent waters of the Sea of Okhotsk. It is also important to consider one additional aspect. In Sakhalin Region, 78 salmon hatcheries are currently in operation; their juvenile salmon require large volumes of formulated feeds for rearing, which are still largely supplied to Sakhalin from distant western regions of the country. If a local feed production facility were established, part of the fish landings: particularly species currently underutilised or not exploited by fisheries, such as gobies, sand lance and others could be used as feed ingredients. Overall, given the temporal concurrence of the biological and economic factors outlined above, the region shows clear prospects for further fisheries development, with a more balanced level of fishing intensity and catch volumes.

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8 ANIVA BAY SALMON: FISHING HISTORY

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The pink salmon fishery in Aniva Bay has a long history. The first mention of it dates back to the early 19th century. I. Krusenstern noted that a Japanese settlement existed at the site of the Korsakov post, the inhabitants of which were engaged in salmon fishing (Schmidt, 1905). Until the late 1870s, fishing and seafood harvesting were mainly carried out by the Japanese. Under Article 2 of the Treaty of Shimoda, the shogunate granted the daimyo the right to fish along the island's shores. After the Meiji Restoration, feudal lords were replaced by merchant-industrialists, and maritime industries rapidly acquired the features of industrial production. From 1871 onward, the fisheries on Sakhalin came under the authority of the Japanese government. The first quantitative data on total salmon catches date back to 1876. The first Russian industrialist to begin fishing in Aniva Bay was the retired official A. Pletnev. He was mainly interested in the herring fishery and only partly in salmon.

From 1897 onward, statistics first reported separate catches of pink and chum salmon. In those years, the number of Russian industrialists increased. As reported by P. Schmidt (1905), these were mostly nominal owners acting on behalf of the Japanese. In 1900–1901, 20 fishing sites were registered in the Korsakov District in the names of Russian residents (Kostanov, 1991). Fishing regulations, approved in 1889 and enacted in 1890, excluded vast areas from the activities of Japanese industrialists harvesting salmon. This forced them to resort to using the Russian population as a cover to avoid customs payments to the Russian treasury. Local consumption of pink salmon was very low, and almost the entire catch was exported to Japan. From 1899 onward, fishing regulations were somewhat

relaxed, and the Japanese were again permitted to fish throughout Sakhalin. To ensure order in salmon fishing during this period, the distance between fishing gear along the shoreline was regulated (2 versts between seines and 2 versts in a straight line from river mouths).

The average annual catch of pink salmon from 1876 to 1902 amounted to 0.16 thousand tonnes. Apparently, catches during this period were limited less by abundance than by the capacities of industrialists. In the last five years of the 19th century, salmon catches on the island of Hokkaido declined sharply, which led to increased exports of fish from adjacent areas of the Russian Empire, including Sakhalin Island. During this period, salmon catches in Aniva Bay accounted for 2 % of the total catch on Sakhalin. Additionally, salmon fishing in the bay was conducted primarily in summer; therefore, catches consisted predominantly of pink salmon, which accounted for about 7 % of its total catches on Sakhalin.

After the transfer of Southern Sakhalin to Japanese jurisdiction, the intensity of fishing increased significantly. The total pink salmon catch in Aniva Bay from 1906 to 1941 averaged 2.8 thousand tonnes per year, ranging from 0.08 (1932) to 13.67 thousand tonnes (1907). Moreover, the 1907 catch remained a record until 1991 (Figure 8.1). Catches remained relatively high until 1912, after which they declined, while the frequency of returns of neighbouring generations increased. Thereafter, until the outbreak of World War II, despite occasional 'spikes' in catch dynamics, total catches remained low. In odd-numbered years, catches averaged 1.86 thousand tonnes, and in even-numbered years, 1.3 thousand tonnes. No fishery statistics are available for the war years.

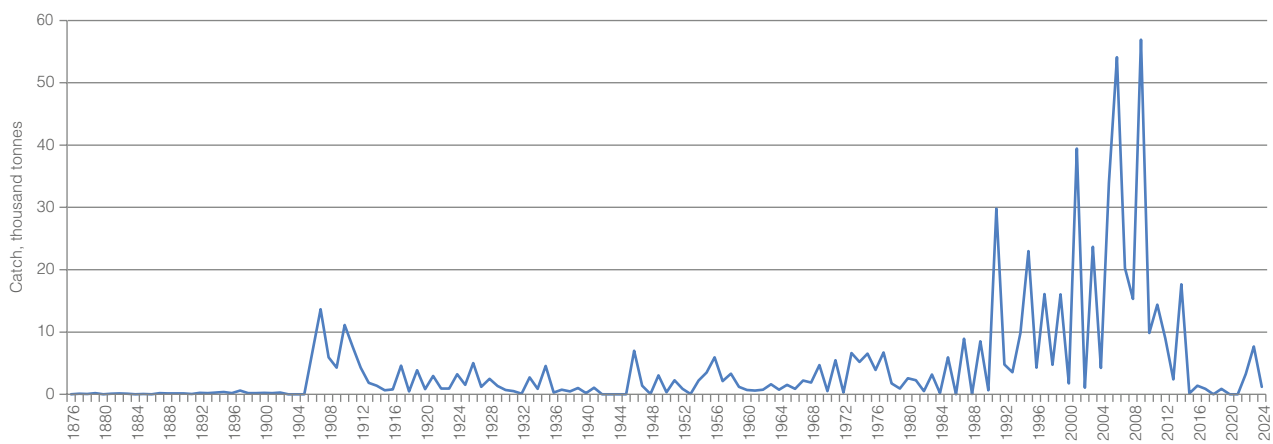


Fig. 8.1. Dynamics of pink salmon catches in Aniva Bay, 1876–2024



Black-tailed Gull (*Larus crassirostris*) (photo by A. G. Semenov)

After the war, the amplitude of catch fluctuations increased. The post-war period can be divided into three stages in terms of catch levels: 1947–1970, when the average catch amounted to 1.76 thousand tonnes; 1971–1990, with an average catch of 3.50 thousand tonnes; and 1990–2024, when the average annual catch reached 12.70 thousand tonnes, approximately 3.6 times higher than during the previous stage.

In the first post-war years, fishing was carried out mainly by small fishing artels that used set nets left by Japanese industrialists. This situation appears to have resulted in relatively low catches during this period, although they could potentially have been higher, as evidenced by the occurrence of abundance peaks with a periodicity of just over 20 years (see Figure 8.1).

In 1952, as a result of changes in the state's fisheries policy, small fishing artels were consolidated, and 10 large collective fisheries ("kolkhoz") were established from them (Leonov et al., 1979). The Kirov Collective Fishery was established at this time on the coast of Aniva Bay within the Korsakov Administrative District. In addition to this collective fishery, which had extensive fishing sites along the eastern and western coasts of the bay, the Priboy and Lenin collective fisheries operated fishing sites within the boundaries of the Crillon Peninsula and played a leading role in pink salmon harvesting in Aniva Bay in the 1960s and 1970s. They accounted for up to 90 % of the total catch. The output of state fishing enterprises and cooperatives, for which pink salmon was a secondary target (secondary producers), was used primarily for local consumption.

Until 1960, three quarters of the coastal waters of Aniva Bay were allocated to collective fisheries. However, the stock decline that occurred in the early to mid-1960s and was particularly pronounced along the western coast of the bay led to the abandonment of some fishing sites, where fishing thereafter took place only sporadically. During this period, unused fishing sites were transferred to secondary fish producers and to the State Reserve Fund. In 1972, the regional nature reserve 'Crillon Peninsula' was established on the western coast of the bay. As a result, about 50 km of coastline was closed to fishing. More than one third of the region's total salmon spawning grounds were located in rivers flowing through the reserve. Despite the protected status of the rivers within the reserve, the mean spawning-ground occupancy density during the period the reserve was in operation (1972–1995) was 1.7 individuals/m². In 1996, the reserve de facto ceased to exist. From that time, the second stage of commercial exploitation of pink salmon stocks on the western coast of the bay began.

In the late 1970s, three collective fisheries based on the south-western coast of the island and one, the Kirov Collective Fishery, on the east coast of the bay (the settlement of Ozersky), participated in the pink salmon fishery in Aniva Bay. The latter fished mainly at fishing sites on the east coast of the bay and in the estuarine zone of the largest river, Lyutoga. Moreover, fishing was carried out by secondary producers. Thus, in 1971, Anivsky State Hunting Operation, established in 1964, formed from the Krasnogorsk state fishing operation, was allocated the most extensive fishing sites

and processing facilities in the Anivsky Administrative District. However, since fishing was not the primary activity of this operation, the catches came to no more than several hundred tonnes, even in years of relatively high pink salmon abundance. The Yuzhno-Sakhalinsk consumer cooperative fishery operation, the Yuzhno-Sakhalinsk fish factory and the Korsakov cannery each had a small fishing site in the Korsakov and Aniva Districts and were able to deploy only 1–2 set nets. On average, these production facilities harvested between 30 and 200 tonnes of pink salmon.

The 1970s and early 1980s marked the peak of economic prosperity for the collective fisheries. In Aniva Bay, the average annual pink salmon catch by the Kirov Collective Fishery alone reached 2.0 thousand tonnes, with an average total catch of 3.47 thousand tonnes. However, during this period, the catches consisted mainly of late-run pink salmon, and a substantial proportion was harvested in the Korsakov District (the east coast of the bay). On the western coast (Aniva District), where catches consisted of pink salmon from the Sea of Japan stock and early pink salmon from the oceanic stock, collective fisheries and secondary fish producers harvested an average of 1.4 thousand tonnes. At the same time, salmonid spawning grounds in most rivers (especially on the Crillon Peninsula) were only 50 % occupied.

Changes in the state system were reflected in the changes in the structure of the fishing organisations. Once-large fishing organisations, which accounted for up to 90 % of the pink salmon catch in the bay, fell into decline. As a result, a large number of small private companies were established. Whereas before 1990 pink salmon harvesting in the bay was mainly carried out by four organisations, in 1991 there were 13. In 1991, the share of the total catch taken by the main fish producers (the Kirov and Priboy collective fisheries) fell to 62 %. In 1995, the number of operators harvesting pink salmon reached 37. Collective-fishery fishermen accounted for only 20 % of the total pink salmon catch in the bay. The increase in the number of operators involved in harvesting and processing pink salmon did not significantly affect the stock levels. The near-complete cessation of salmon harvesting in the open waters of the Pacific Ocean and the increase in survival rates during the marine phase of the life cycle over the last decade have made it possible to harvest record quantities of pink salmon from coastal waters without compromising reproduction (see Fig. 8.1).

Between 1995 and 2004, the number of operators involved in pink salmon harvesting in Aniva Bay varied from 29 to 64 (Fig. 8.2).

Subsequently, the number of operators involved in the pink salmon fishery in the coastal waters of Aniva

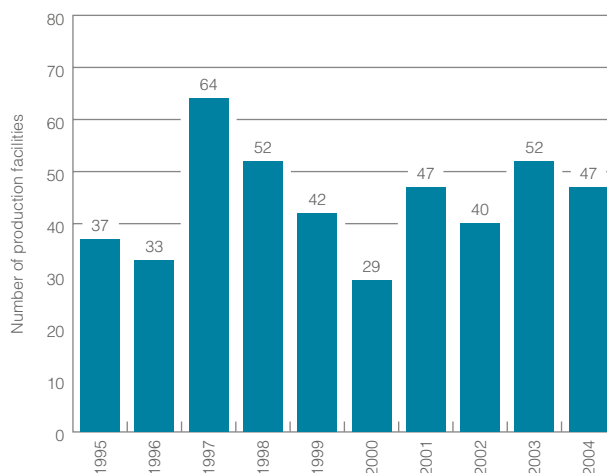


Fig. 8.2. Number of production facilities involved in pink salmon harvesting in Aniva Bay, 1995–2004

Bay remained virtually unchanged. However, there were changes in ownership. For example, the Kirov Collective Fishery based in Ozerskoye has changed ownership and is currently operated by Gidrostroy LLC. Moreover, a significant proportion of the companies harvesting pink salmon (Fig. 8.3) in the coastal waters of the western part of the bay also changed ownership, while the overall list of companies remained unchanged. A number of companies were consolidated.

Due to the decline in the pink salmon stock reproducing in the rivers flowing into the bay, most small companies were pushed to the brink of bankruptcy and were absorbed by the larger ones.

Fishing techniques include both the deployment of set nets near river mouths in other coastal areas where fishing sites are located, and the harvesting of pink salmon directly from the river mouths once the spawning grounds are full (Fig. 8.4–8.6).

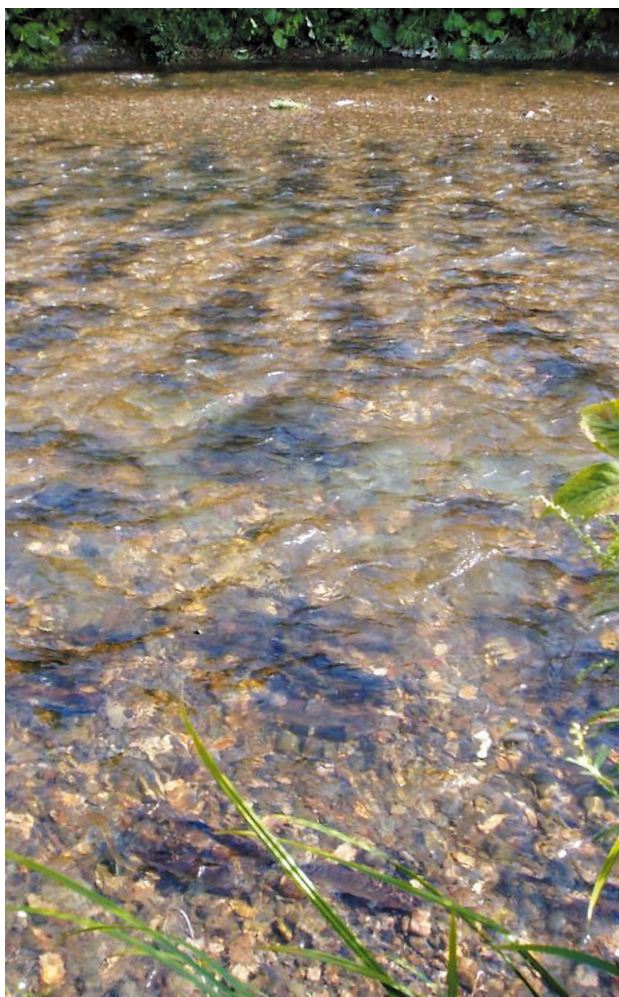


Fig. 8.3. Pink salmon in the Naicha River, 2008
(photo by S. Makeev)



Fig. 8.5. Fish-counting barrier on the Naicha River, 2008
(photo by S. Makeev)



Fig. 8.6. Unloading fish from nets on the Naicha River, 2008
(photo by S. Makeev)



Fig. 8.4. Salmon fishing in the Kura River, 2008
(photo by S. Makeev)

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9 ANIVA BAY SALMON: A HISTORY OF ARTIFICIAL REPRODUCTION

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The history of salmon farming in Sakhalin Region is conventionally divided into two stages: the pre-war stage, when the southern part of Sakhalin, demarcated by the 50th parallel, was under Japanese jurisdiction, and the post-war stage, when the USSR restored the historical integrity of Sakhalin and began to develop the southern part of the island.

The first fish hatchery on Sakhalin was built in the 1920s on one of the tributaries of the Tym River. It was small in capacity but played a significant role as the starting point of artificial fish farming.

In the southern part of the island, a large number of sometimes very small fish hatcheries were established by the Japanese.

A historical milestone was the establishment of the Sakhalin Fishery Protection and Fish Farming Department, based on Dalryba (Sakhalinrybvod). It was located in Yuzhno-Sakhalinsk and reported to the Main Basin Department for Fisheries and Conservation of Aquatic Biological Resources ("Glavrybvod") (Order No 186 of the Ministry of the Fishing Industry of the Eastern Regions of the USSR, dated 11.12.1946).

The scientific foundations of salmon reproduction were first laid as early as the 1920s and 1930s by I. I. Kuznetsov, F. V. Krogus, E. M. Krokhin, A. S. Baranenkova, P. A. Dvinin, R. S. Semko and many others. With increased knowledge on the biological characteristics of Far Eastern salmon, their patterns of dispersal, the efficiency of natural spawning, the characteristics of the spawning areas and their reproductive conditions and the reasons behind variations in abundance, it became clear that salmon exhibit considerable intraspecific morphobiological diversity. As shown by I. B. Birman, A. A. Svetovidova, B. Ya. Levanidov, P. A. Dvinin, R. I. Enyutina, S. M. Konovalov, B. B. Vronsky, S. P. Volovik, A. I. Smirnov, N. I. Kulikova and many others from the 1950s to the 1970s, intraspecific forms were identified and salmon populations were divided into local stocks differing in feeding grounds, spawning areas, anadromous migration routes and other adaptive features that should be considered in artificial reproduction (Sergieva et al., 2015).

The role and importance of fish hatcheries were clear, and Sakhalinrybvod immediately became involved in work at the remaining hatcheries after the liberation of southern Sakhalin. Two Japanese-built fish hatcheries were already operating in Aniva Bay, the Aniva and Taranay salmon hatcheries.

The Aniva Salmon Hatchery was built by the Japanese in 1939 to propagate chum salmon in the basin of one of the island's largest rivers, the

Lyutoga River. The production capacity of the hatchery was modest, at 3 to 5 million incubated eggs. The hatchery had a simplified water supply system, with a low spring discharge of about 5 L/s. In 1952, 1958 and from 1974 to 1975, the hatchery underwent major overhauls, including reconstruction of the water supply system, the incubator and the nursery, increasing capacity by up to 15.5 million downstream-migrating juvenile salmon released. During the same period, at the request of the fishing industry, the Aniva hatchery was reoriented towards the propagation of pink salmon as a more abundant and fast-maturing species. To improve the hatchery efficiency, a method for tagging released juveniles was developed.

In 1994, the hatcheries underwent comprehensive reconstruction, with the introduction of state-of-the-art fish breeding biotechnologies consistent with international standards in salmon culture. The hatchery capacity to release reared juvenile pink salmon was increased to 35.3 million pieces, with actual releases in recent years reaching 35 to 38 million downstream-migrating juveniles.

By combining water supply thermoregulation, juvenile rearing, and artificial propagation with regulated natural spawning, the hatchery team achieves highly efficient pink salmon production while also reproducing the low-abundance cherry salmon.

The second (and one of the oldest) hatchery was the Taranay hatchery. The hatchery was built by the Japanese in 1923 in the Taranay River basin, which flows into Aniva Bay. The hatchery was engaged in chum salmon production and initially had a modest release capacity of up to 3 million juveniles. It should be noted that chum salmon historically inhabited Aniva Bay but only in relatively small numbers, as the natural conditions for large-scale reproduction were lacking, whereas pink salmon were able to proliferate in all the rivers along the bay. This is why the Japanese focused on cultivating chum salmon.

In 1946, the Taranay hatchery became part of the Sakhalin Branch of the Main Basin Department for Fisheries and Conservation of Aquatic Biological Resources ("Sakhalinrybvod") Authority. From 1945 to 1948, Japanese specialists continued to work at the hatchery, sharing their experience. During these years, documentation in both Russian and Japanese was used (Fig. 9.1).

Salmon reproduction was adversely affected by loose timber rafting along rivers flowing into Aniva Bay

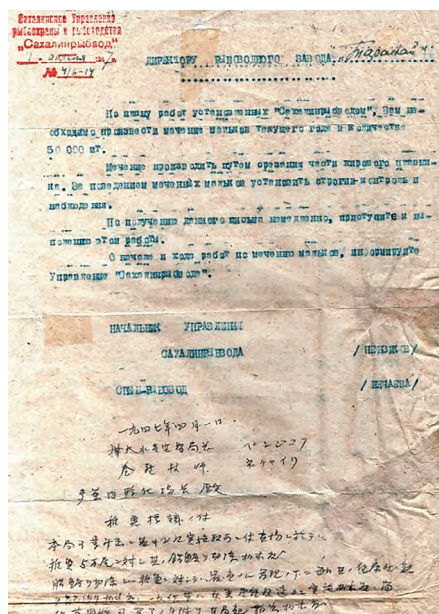


Fig. 9.1. Order issued to the Director of the Taranay hatchery regarding the tagging of juveniles in Russian and Japanese (photo from the website of the Sakhalin branch of Glavrybvod)

up to 1963. Therefore, during this period, the role of the hatcheries was particularly significant.

From 1947 to 1960, between 187,500 and 3,692,500 chum salmon eggs were collected annually in the Taranay River. The modernisation of the hatchery from 1954 to 1956 affected production facilities constructed of wooden structures. A drainage system for the removal of groundwater was built, as well as a fish trap, where, for the first time on Sakhalin, a system of suspended barrier panels was introduced based on designs developed by the hatchery specialist L. Pochuev.

In the 1950s, he worked on improving the technical layout of the hatchery and was the inventor of a modern fish barrier system with 'floating' panels (Fig. 9.2).

The hatchery capacity increased to 15 million juveniles released; however, egg collection from the Taranay River was insufficient for the full utilisation of the hatchery facilities. Therefore, chum and pink salmon eggs began to be imported from other rivers in Sakhalin Region, including chum salmon eggs from the west coast of Sakhalin, the Okhotsk and Sokolovsky hatcheries, and the Kuril Islands (1972). Chum salmon eggs were delivered from the Belaya, Uryum, Olkhovatka, Bryanka, Izluchnaya and Ochebukha rivers.

By the hatchery reconstruction in 1974, substantial experience in salmon aquaculture biotechnologies had been accumulated at all stages of the production cycle, making it possible to achieve a downstream juvenile yield of 93 to 95 percent from the incubated eggs. As a result of the construction of a second nursery facility, the production area was expanded, and juvenile output reached 42 million pieces. The hatchery switched to river water supply to specialise in pink salmon production, while the second nursery facility was supplied with spring water to incubate chum salmon eggs. During this period, the timing for juvenile release shifted to late May and the first ten days of June, while the body weight of the juveniles released remained low, 313 to 390 mg.

From the beginning of the 20th century until the 1960s, the Taranay River was dominated by chum salmon and was subject to commercial fishing. Catches of chum salmon in Aniva Bay in the 1930s reached 760 tonnes. During the Soviet period, the peak catch of chum salmon in Sakhalin Region took place in the 1950s. Changes in the river's hydrology, pollution of river waters from agricultural runoff, past overfishing and land reclamation, which resulted in the loss of the



Fig. 9.2. Fish barrier panels on the river of a modern design

right-bank tributaries Lozinka and Mariyka that had served as traditional spawning areas for chum salmon, reduced the chum salmon abundance in the Taranay River to a minimum. The overall situation with chum salmon stocks in southeastern Sakhalin was so severely depleted that coastal fishing in Aniva Bay ceased.

In 1981, Typhoon Phyllis caused substantial damage to salmon production, destroying the chum salmon production unit. The hatchery switched to strictly producing pink salmon.

To maintain chum salmon abundance, groundwater was supplied to one channel of the pink salmon nursery facility, where the catch of chum salmon collected in the main river consisted of 174,000 to 1,454,200 pieces. Feeding duration was increased, the feed composition was adjusted, and the body weight of released juvenile chum salmon increased to 590 mg. Feeding was carried out using both pollock roe and pelleted feed. From 1993 to 1998, only pelleted feed was used, and the average body weight of released juveniles reached 1.0 g.

After the completion of the fish-breeding complex, water temperature control became possible. At that time, in 1998, favourable temperature conditions were created for the formation of an artificial chum salmon stock in the Taranay River. For this purpose, eggs were imported from the Okhotsk hatchery, totalling 2,860,900 eggs, and from the Yasnomorsk hatchery, totalling 2,087,500 eggs, while 660,800 eggs were collected in the main river.

In 1999, 5,179,400 juvenile chum salmon, reared to a body weight of 800 mg, were released from the eggs collected. By 2002, the hatchery chum salmon broodstock had reached 15,000 individuals, bringing 8.4 million eggs

for incubation. This release marked the formation of a commercially exploited stock of Taranay chum salmon.

Since the mid-1990s, transfers of pink salmon eggs from other water bodies have ceased. The hatchery began efforts to increase return rates by applying targeted water temperature control and developing rearing schedules for aquaculture production. The results were soon evident, as the average return rate of pink salmon reached 4.9 %.

From 1995 to 1999, during the regulation of pink salmon passage to spawning at the mouth of the Taranay River, 6,750 tonnes of salmon were removed. The hatchery share of the fishermen's catches in the Aniva District was 10–25 %.

After the reconstruction in 2007, the Taranay hatchery (Figs. 9.3 and 9.4) represented a complex system of productive and auxiliary units, equipped with aquaculture equipment made of polymer materials and modern monitoring and control devices, and featuring an extensive network of pumping equipment. The hatchery's aquaculture capacity for releasing Pacific salmon is 37.5 million pieces, including 15.0 million juvenile chum salmon and 22.5 million juvenile pink salmon.

Before the reconstruction, the hatchery nursery units had the so-called Far Eastern type of longitudinal channels (Fig. 9.5).

After the reconstruction carried out in the 1990s, the nursery units were made of steel and concrete (Fig. 9.6), and the nursery channels became transverse rather than longitudinal, which significantly improved water exchange conditions for rearing salmon fry and juveniles.



Fig. 9.3. Chum salmon egg collection point at the Taranay hatchery after the 2007 reconstruction



Fig. 9.4. General view of the Taranay hatchery after reconstruction



Fig. 9.5. View of the hatchery nursery built in the 1970s

Prior to 1990, only state-owned salmon hatcheries operated in Aniva Bay, all of which were located in the Aniva District. With the start of perestroika, the Monetka hatchery was built at the confluence of the Monetka and Ostrovka rivers in Korsakov District by the Russian-Japanese joint venture Pilenga-Godo. The new hatcheries were built from technical designs used at Japanese aquaculture facilities and differed markedly in design from the existing ones. They featured a system of nursery channels arranged across the production unit rather than along it, in some cases extending up to one hundred metres in length, as well as shallow rearing sections measuring 18 m in length, 2 m in width and 0.25 m in depth, in accordance with the practices adopted in Japan. The hatcheries used plastic mesh substrates for holding larvae and trays for hatching them. The incubation units, made of PVC, were made in Japan. The reproduction technology differed slightly from the standards of the time, and the Russian-Japanese joint venture Pilenga-Godo used an instruction manual from Japan for its hatchery processes (Kobayashi, 1994). This manual later formed the basis for the operation of all the hatcheries built in Sakhalin Region.

The first batch of pink and chum salmon eggs set for incubation, totalling 11.5 million eggs, was placed at the Monetka hatchery in 1990.

In 1991, an open-air nursery was added to the salmon aquaculture hatchery on Chirkova Creek. The juvenile release capacity of the main production unit is 30 million downstream-migrating pink salmon per year, while the capacity of the open nursery on Chirkova Creek is 3 million downstream-migrating chum salmon.

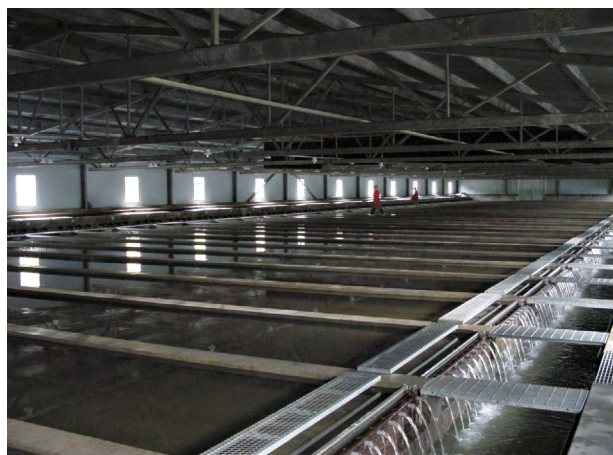


Fig. 9.6. General view of the salmon hatchery after reconstruction

Shortly after its launch, the hatchery was releasing an average of 10 to 17 million downstream-migrating juveniles per year. Since 1996, the number of juveniles released increased markedly and reached an average of 26.5 million by 2001 and 32.2 million in 2002, meaning that the hatchery was basically operating at full capacity (Sakhalin Branch ... [Electronic resource]).

In 2002, a nursery facility was built on the Igrivaya River near the Monetka salmon hatchery, and it began releasing juvenile pink and chum salmon.

In 2007, a salmon hatchery was built on the Olkhovatka River in Aniva District. Initially, it focused exclusively on pink salmon, but since 2009, it has been releasing both pink and chum salmon.

Since the early 2000s, it has become evident that chum salmon is a more promising commercial salmon species, as highly efficient facilities have started cultivating it (Samarsky, 2005). Importantly, chum salmon return with much greater accuracy to the river from which they migrated to the sea. Since 2003, when private salmon hatcheries began operating, the proportion of salmon species released has consistently shifted in favour of chum.

Table 9.1 shows the dynamics of changes in the release volumes of chum and pink salmon into Aniva Bay, 1970–2024.

Reform of the legislative framework, specifically the introduction of the possibility to establish aquaculture sites in rivers and at salmon hatchery locations, as well as to secure ownership rights to fishing harvests classified as commercial aquaculture products, stimulated the development of salmon aquaculture. However, despite the change in the legal status of

Table 9.1. Releases of juvenile chum and pink salmon from salmon hatcheries located in Aniva Bay

Year	Juvenile releases, million individuals	
	Chum salmon	Pink salmon
1970	1.20	40.50
1971	24.70	17.20
1972	4.30	36.40
1973	20.50	23.20
1974	0.00	42.09
1975	9.41	39.99
1976	0.00	53.76
1977	0.00	51.50
1978	21.12	35.68
1979	0.52	63.61
1980	21.60	42.70
1981	16.80	50.00
1982	25.20	17.70
1983	33.60	21.30
1984	0.10	52.80
1985	0.40	30.20
1986	0.00	53.40
1987	0.80	37.40
1988	3.70	40.60
1989	0.30	33.90
1990	0.00	50.13
1991	1.54	60.52
1992	3.30	80.73
1993	3.32	59.42
1994	0.81	51.37
1995	1.77	56.34
1996	1.59	100.95
1997	4.40	99.43

Year	Juvenile releases, million individuals	
	Chum salmon	Pink salmon
1998	3.42	96.24
1999	9.05	72.40
2000	9.26	86.60
2001	4.95	80.43
2002	2.77	95.30
2003	16.81	71.27
2004	20.13	47.77
2005	15.61	54.33
2006	12.50	88.54
2007	26.50	80.48
2008	30.74	85.10
2009	36.31	94.33
2010	36.89	90.90
2011	25.79	74.37
2012	35.32	55.88
2013	32.23	80.93
2014	27.42	89.42
2015	23.94	89.86
2016	42.13	31.28
2017*	32.97	56.29
2018*	19.99	34.81
2019*	28.18	65.06
2020*	39.98	60.43
2021*	49.74	51.68
2022*	47.16	49.78
2023*	48.31	46.09
2024*	47.96	32.44

* Starting from 2017, the releases are total: release under artificial reproduction and release under commercial aquaculture.

juveniles released from commercial aquaculture, the technological processes involved in rearing them do not differ from those for artificial reproduction. Thus, all the practices accumulated by specialists in aquaculture are being successfully applied and refined.

Because the rivers south of the Pochinka River in the Aniva administrative district on the Crillon Peninsula constitute excellent spawning habitats for pink salmon, a biologically justified restriction on the construction of salmon hatcheries is in force in this area.

In addition to chum and pink salmon, the salmon hatcheries of the Sakhalin branch of Glavrybvod have for many decades been engaged in the reproduction of another valuable salmon species, cherry salmon, a prized trophy for recreational fishing on Sakhalin. Cherry salmon requires support measures in areas where fishing pressure on the species is greatest. Cherry salmon egg stock volumes have never been large; however, several

hundred thousand cherry salmon eggs were regularly collected at the Aniva and Taranay salmon hatcheries. The principal difference between rearing cherry, chum and pink salmon is that cherry salmon juveniles must be fed at the hatchery for an entire year and released as larger, well-grown juveniles ready to migrate downstream to the sea.

Today, from all the experience of aquaculture specialists and scientists, it is clear that increasing fishery returns requires a systematic approach, including identifying the onset of favourable conditions for feeding the juveniles to be released and the importance of their physiological condition. It is not the number of juveniles released but the condition and quality of them that play a key role in improving the effectiveness of aquaculture (Samarsky, 2014; Beamish and Neville, 2021). Aquaculture specialists and scientists have travelled a long road to mastering the fundamentals

of Pacific salmon hatchery technologies that yield tangible results today. A substantial contribution was made by A. Kanidiev, A. Smirnov, E. Smirnov, E. Tarasyuk, S. Tarasyuk, T. Lyubaeva and V. Lyubaev (Smirnov, 1954, 1975; Kanidiev, 1967, 1984; Kanidiev and Gamygin, 1980; Kanidiev and Levanidov, 1968; Lyubaeva, Lyubaev and Sidorova, 2000; Tarasyuk et al., 2004; Tarasyuk and Tarasyuk, 2007, 2010).

Special credit is due to Gennady Kochetkov. He devoted more than 36 years to the fisheries sector of Sakhalin Region. He progressed from a hatchery specialist to Head of the Sakhalinrybvod Authority. Under his leadership, a programme for the construction and reconstruction of fish hatcheries in Sakhalin Region was implemented, and the present condition of these facilities is largely a credit to him.

Despite advances in aquaculture technology, the main stages of hatchery operation have changed little over the recent decades. The process begins with the collection of eggs from mature broodstock (Figs. 9.7, 9.8).

Females are processed on a special table, the receiving tray of which has a mesh bottom for draining the fluids. From the table, the eggs are transferred into a special basin, where the eggs from several females are combined (Fig. 9.9).



Fig. 9.7. Mature male (bottom) and female (top) chum salmon

The eggs are then fertilised with milt collected from the same number of males as females used (Fig. 9.10).

The milt is carefully mixed with the eggs, and a cupful of clean water is added to activate the sperm (Fig. 9.11). Fertilisation occurs within one to two minutes.

After fertilisation, the eggs are carefully washed and transferred to a special box, where they swell for



Fig. 9.8. Pink salmon spawners at the egg collection point



Fig. 9.9. Egg collection from female chum salmon



Fig. 9.10. Egg fertilisation process



Fig. 9.11. Adding water to activate sperm

several hours. The same box is used to transport them to the hatchery (Fig. 9.12).

After swelling, the eggs are ready for transport: water is carefully drained from the box, a foam pad is placed on top of the eggs, and the lid is tightly closed and secured with special locks (Fig. 9.13).

At the incubation facility, the eggs are carefully unpacked and transferred to incubators (Fig. 9.14). The most common incubators used at Sakhalin hatcheries are the Box type (Fig. 9.15) and the Atkins type (Fig. 9.16). The incubators operate on a similar principle: a stream of water flows through a special mesh bottom, washes over the eggs and, via a tray, enters the incubator installed below. Water that has passed through several incubators is discharged.

Egg collection begins in September and lasts about a month. The eggs in the incubators develop and, by November, reach a stage when they can be handled. At this time, the main task of hatchery staff is to separate the live eggs from the dead ones. During incubation, about 10 % of the eggs die for various reasons, mainly due to developmental abnormalities. Dead eggs become a breeding ground for parasitic fungi of the genus *Saprolegnia*. Previously, such eggs were picked out by hand. This was tedious and painstaking work: it is hard to imagine manually sorting through 20–30 million eggs. Today, the eggs are sorted using special egg-sorting machines (Fig. 9.17).

During this period, the developing embryos are clearly visible through the eggshell, and their eyes are especially noticeable. This phase of embryo development is known as the eyed stage among hatchery staff (Fig. 9.18).

By observing egg development, hatchery staff know exactly when the embryos will begin to hatch. A couple of days before this, the eggs are removed from the incubators and placed in nursery channels for hatching. The eggs are placed on special trays fitted with a mesh of elongated cells (Fig. 9.19). An egg cannot fall through such a cell, but a larva freely drops to the bottom of the channel and enters a special mesh substrate, where it will remain until it uses up all its yolk supply and needs to be fed (Fig. 9.20). This usually happens in April.

After a feeding period that lasts up to two months, chum salmon fry reach an average weight of about 1 g and are ready to be released into the sea. In Aniva Bay, this usually occurs by early June (Fig. 9.21–9.23). Special pelleted feeds are used.

After the release of the juvenile fish, the hatchery workshops are emptied, thoroughly cleaned, disinfected and prepared for the next production cycle (Fig. 9.24).



Fig. 9.12. Placing washed eggs into a box for swelling



Fig. 9.15. Box-type incubators in the hatchery incubation department

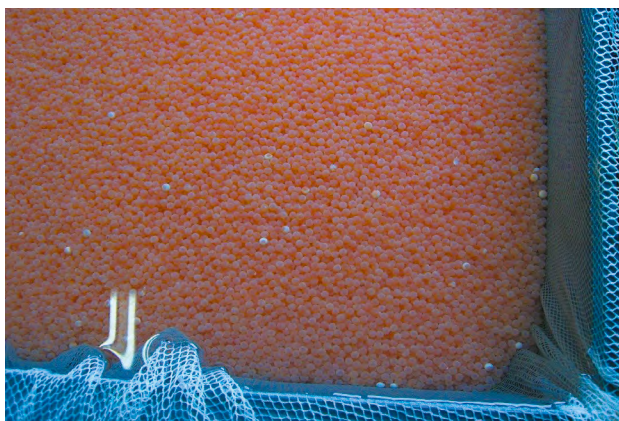


Fig. 9.13. Swollen eggs ready for transportation



Fig. 9.16. Atkins-type incubators in the hatchery incubation department



Fig. 9.14. Box-type incubator with incubating eggs



Fig. 9.17. Egg sorting using egg-sorting machines. Dead eggs are in buckets; live eggs, bright red in colour can be seen on the mesh tray



Fig. 9.18. Chum salmon eggs at the eyed stage after sorting on an egg-sorting machine. The black dots on the eggs are the embryos' eyes



Fig. 9.19. Eggs spread on trays for hatching



Fig. 9.20. Free chum salmon embryos immediately after hatching. A yolk sac reserve can be observed; it is far larger than the embryo's body

Overall, the technology of chum salmon breeding differs little from that of pink salmon; the main difference is that pink salmon require colder water during the winter period, with temperatures close to the freezing point, down to 0.1 °C. In addition, pink salmon juveniles do not need to be fed to the relatively large sizes required for chum salmon. Pink salmon fry only need to reach an average weight of 300–400 mg, which is sufficient to ensure their survival at sea. Together with the juveniles from the natural seaward migration, after feeding at sea, pink salmon return a year later to their natal areas, supporting the fishery (Fig. 9.25).



Fig. 9.21. Juvenile chum salmon with an average weight of about 0.6 g



Fig. 9.22. Juvenile chum salmon in the hatchery, ready for seaward migration



Fig. 9.23. Juvenile chum salmon released into the river for migration to sea feeding grounds



Fig. 9.24. Nursery facility of the hatchery after the release of juveniles



Fig. 9.25. A fixed seine installed in Aniva Bay for the pink salmon fishery



Cape Kanabeevka (*photo by A. A. Semenov*)

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10 SAKHALIN TAIMEN IN THE CRILLON PENINSULA

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The Sakhalin taimen, *Parahucho perryi* (Brevoort, 1856), is a representative of a monotypic genus within the family Salmonidae, with a relatively restricted range and scattered populations declining in abundance. The similarity of the anadromous Sakhalin taimen to freshwater taimen of the genus *Hucho* is purely superficial, convergent and is related to the ecological features of these large predatory fish.

Previously, the species was considered a relict species that has persisted to the present day without significant changes (Glubokovsky, 1995). The hypothesis that the species is the progenitor of all salmonids has been widely used in educational outreach to enhance its perceived value among recreational anglers who practice catch-and-release. However, numerous genetic and molecular studies have failed to support this morphology-based hypothesis. The genus *Parahucho* is currently placed between the genera *Salvelinus* and *Oncorhynchus* on the phylogenetic tree (Shedko et al., 2012; Zhivotovsky et al., 2015). In any case, the Sakhalin taimen differs from other species in having the highest number of plesiomorphic traits and is the most ancient of all extant salmonids (Zelennikov, 2025).

Along with the Siberian *Hucho taimen* (Pallas), the Sakhalin taimen is one of the largest salmonids and one of the largest anadromous fishes on the planet. The largest recorded length of a Sakhalin taimen exceeds 2 m: an individual measuring 210 cm was caught in the Tokatsugawa River on Hokkaido in 1937. The weight of the largest individuals has been recorded to reach 65 kg, and their age can exceed 30 years. At present, such individuals are no longer encountered, but the Sakhalin taimen remains a charismatic, ‘flagship’ species, as much a living symbol of aquatic ecosystems as the Amur tiger is a symbol of the taiga ecosystem.

Current conservation status

Thanks to the efforts of the Sakhalin Taimen Conservation Network, the species has been designated as a priority species requiring urgent recovery and conservation measures (Category 1 conservation status in the Red List of the Russian Federation) (Shilin, 2021; Makeev, 2022, 2023). Several versions of a Sakhalin

Taimen Conservation Strategy have been developed (Makeev et al., 2014; Makeev, 2022a), as well as an Action Plan for the conservation of populations in northeastern Sakhalin (Makeev). At present, the following sections of the Strategy have been implemented: ‘Legislative Measures’ and ‘Outreach Activities for Building Social Support for Species



Fig. 10.1. Sakhalin taimen

Conservation’; the remaining sections require updating and substantial support (Makeev, 2022).

In 2022, the Government of the Russian Federation adopted Resolution No 1322 ‘Rates for calculating the amount of damage caused to the marine biological resources listed in the Red List of the Russian Federation’. At present, the damage per specimen, regardless of size or weight, amounts to RUB 42,540 for the Sakhalin taimen (populations of Primorsky Territory and Sakhalin Region) and RUB 31,905 for the Siberian taimen (population of Sakhalin Island). At the same time, laws have been adopted to increase criminal liability under Article 258.1 of the Criminal Code of the Russian Federation for the illegal taking and trafficking of wildlife listed in the Red List of the Russian Federation. ‘Catch and release’ recreational fishing for the Sakhalin taimen occurs in Sakhalin Region (Fig. 10.1).

Species range and trends in its change

The range of the Sakhalin taimen is relatively small: it encompasses the basins of the northern Sea of Japan and the southern Sea of Okhotsk. The Sakhalin taimen is a restricted-range species with declining abundance.

In many rivers on Sakhalin Island, the Sakhalin taimen has almost completely disappeared. The list of rivers in which it has been recorded at least once over the past 50 years includes 122 rivers, although it has already disappeared from a substantial proportion of them (Zolotukhin et al., 2013; Makeev, 2023). On Crillon Peninsula, taimen have been recorded in seven rivers; the most abundant populations occur in the Ulyanovka and Moguchi rivers.

Modelling of the historical distribution of the Sakhalin taimen has revealed correlations with mean annual air temperature, precipitation, river basin area, mean basin elevation above sea level, the area of lowlands below 20 m above sea level and presence of lagoons (Fukushima et al., 2011). A prerequisite for

the habitat of the Sakhalin taimen is the presence of low-gradient reaches, large lakes or estuaries within a river basin.

Species abundance and trends in its change

Estimating the absolute abundance of specific fish species is notoriously difficult (Pavlov et al., 1994). This is especially true for rare species that are not subject to commercial exploitation. Most data were obtained through interviews with local experts, coastal fishermen and recreational anglers. The abundance and biomass of the Sakhalin taimen have always been relatively low, which is natural given the ecological niche that this species occupies.

The main method used to study the distribution and abundance of the species on Sakhalin was seining of suitable sites with small-mesh seines. This method primarily captured young-of-the-year and yearlings, as older juveniles are well sheltered among rocks and snags. Electrofishing has been used on many rivers. Naturally, for a protected species, only short-term removal from the wild is permissible, and utmost care must be exercised.

When sampling is conducted during monitoring in the same seasons and at the same sites, trends in the abundance of juvenile concentrations during the feeding phase in shallow areas can be identified (Zolotukhin, Semenchenko, 2008). According to A. Semenchenko and S. Zolotukhin (2011), the abundance of the Sakhalin taimen in Sakhalin's rivers is declining by approximately 15–20 % per year.

In Hokkaido, methods based on counting spawners during the spawning period or on counts of spawning mounds have often been used (Edo et al., 2000; Fukushima, 2001). However, in the Russian part of the range, spawning grounds are difficult to access during the spawning season, making indirect methods necessary.

The expert estimate of the total number of spawners in all rivers on Sakhalin is about 10,000 individuals. The estimated total abundance of early and late juvenile cohorts in Sakhalin's rivers is about 500,000 individuals (Nikitin, 2012).

Intraspecific structure

In terms of population structure, taimen are K-strategists with repeated spawning and a late age and large size at first maturation (Zolotukhin et al.,

2000). This is why they are particularly vulnerable to unregulated and unsustainable harvesting.

Throughout its range, the species has three ecological forms (Zolotukhin, Semenchenko, 2008; Nikitin, 2012).

1. Semi-anadromous form, entering coastal marine waters for feeding but not moving far from river mouths (predominant in rivers on Crillon Peninsula).
2. Lake–lagoon form, migrating within fresh and brackish waters.
3. Riverine form, completing its entire life cycle in large rivers.

There are also entirely freshwater populations inhabiting reservoirs isolated by dams. The only such isolated population in the Russian part of the range occurs in Lake Tainoye near Kholmsk in southwestern Sakhalin.

Genetic structure of populations

In fact, each isolated population of any species possesses a unique gene pool that requires protection. While this aspiration is justified, practical implementation is problematic.

For the long-term survival of the populations, it is important not only to maintain a minimum number of individuals but also to ensure sufficiently high genetic diversity. This is defined both by the number of genes with more than one allele (polymorphic genes) and by the number of alleles per polymorphic gene. As a result, heterozygous individuals appear in the population, inheriting the different alleles of a gene from their parents. Genetic variability allows the species to better adapt to environmental changes. In general, rare species exhibit lower genetic diversity than widespread species and are more vulnerable to extinction (Primack, 2002).

In Sakhalin, over a three-year period, a team from the N. I. Vavilov Institute of General Genetics (Moscow), under the leadership of Dr. L. A. Zhivotovsky, conducted a project titled 'Study of the population structure of the Sakhalin taimen aimed at developing measures to conserve its gene pool'. The main objective of the study was to determine the degree of genetic differentiation among Sakhalin taimen populations using DNA markers to assess their reproductive isolation from one another and to develop measures for conserving their gene pool.

Overall, the interpopulation component of the genetic diversity in this species proved to be the highest among all salmonids, ranging from 21.8 % (Edo et al., 2012) to 22.6 % (Yurchenko, 2015). It is believed that when the interpopulation diversity index exceeds

20 %, the exchange of migrants between populations is virtually absent.

Four genetic clusters of population samples can clearly be distinguished, representing geographically subdivided population groupings of the Sakhalin taimen on Sakhalin Island. These are taimen groups from the water bodies of western, northeastern and southern Sakhalin, as well as the Poronai River basin. The gene flow between populations is very limited.

At present, the Sakhalin taimen is represented by numerous relatively small, genetically weakly connected local stocks. These stocks, confined to individual river basins, persist under relatively stable conditions with low natural mortality (Zhivotovsky et al., 2015; Yurchenko, 2015).

Habitat characteristics and analysis

At different stages of its life cycle, the Sakhalin taimen uses a wide variety of habitats in the upper and lower reaches of rivers, estuaries, lagoons, lakes, bays and coastal waters. The taimen prefers watercourses within wetlands that have low gradients (gentle slopes), deep pools and forested banks. The most abundant populations inhabit rivers the basins of which contain large brackishwater lagoons.

The Sakhalin taimen spawns in upper tributaries with meandering channels and well-preserved riparian vegetation, in deep areas at the transition to shallow water (also referred to as the onset of shallow water). A typical spawning site is a small side channel of the main one, 3–4 m wide and about 1 m deep, with a current velocity of 0.3–0.5 m/s. The bottom is sandy–pebbly. Spawning grounds are located in areas where downstream river water infiltrates into the hyporheic flow (Parpura, 1991; Fukushima, 1994). As for their main characteristics, taimen spawning grounds are similar to those of chinook or pink salmon (Leman, 2003).

The spawning densities of taimen, as in other salmonids, are higher in areas with increased channel sinuosity (Fukushima, 2001). The number of redds does not depend on overhanging vegetation, but is higher in areas with woody debris and undercut banks (Mori et al., 1997).

Taimen larvae emerging from the redds, 27–29 mm long and weighing 140–290 mg, are carried downstream by the current. In late summer, fry inhabit the spawning grounds and areas several kilometres downstream. They form shoals in the warmed shallows near sandy and gravel spits, after the juveniles of other salmonids have already moved away from these areas. They remain in small pools among large cobbles, where the depth often

does not exceed 3–5 cm and the water temperature is 1–3 °C higher than in the main channel (Krykhtin et al., 1964; Gritsenko, Churikov, 1977; Gritsenko, 2002). For juveniles, the presence of slackwater areas in the side channels and backwaters is important, where they can take refuge during unexpected summer floods (Fukushima, pers. comm.).

In autumn, fingerlings and yearlings are most abundant in the thalweg of third-order tributaries. Fish size is positively correlated with water depth and shelter size. Juveniles occupy the same habitats as juvenile cherry salmon but consume different types of food (Sagawa et al., 2003).

From one year of age, juveniles inhabit large pools and relatively deep glides. A typical juvenile habitat is a pool 20–40 to 100–150 m long with a relatively slow current, a bottom of silted gravel or sand and overhanging or collapsed shrubs along an undercut bank. Juveniles avoid areas with frequent alternation between glides, pools and riffles (Gritsenko, Churikov, 1977; Gritsenko, 2002); instead, they occupy positions near the bottom in deep-water zones with slow flow, using shelters (Zhivoglyadov, 2004). They prefer lake-like complexes in meandering channels with dense riparian vegetation (Honda et al., 2010; Honda et al., 2012). In many rivers, only areas in the lower reaches are suitable for juvenile feeding. In general, in small rivers, the feeding area used by juvenile taimen is smaller than that used by juvenile Dolly Varden, whitespotted char, cherry salmon or coho salmon (Gritsenko, 2002).

The distribution of adult taimen in Hokkaido's rivers was studied using tagging and acoustic telemetry methods. In summer, taimen select large pools with slow currents and shade or shelter. The number of individuals shows a positive correlation with the percentage of shade or cover, while maximum body size correlates with pool bed area. These results highlight the importance of preserving large deep pools with shade or cover and allowing fish to migrate upstream and downstream within the river system (Sagawa et al., 2002). Adult taimen show high behavioural plasticity and can select habitats according to their specific requirements (Honda et al., 2012).

Sakhalin taimen do not migrate far into the sea, unlike Pacific salmon. Their movements between fresh and salt water resemble those of semi-anadromous char, Dolly Varden and whitespotted char. As a rule, at sea they remain close to the shore, sometimes forming loose aggregations in areas suitable for feeding.

In October, taimen begin to enter rivers for wintering. During the wintering period, the majority of taimen aggregate in pools separately from other fish



Far Eastern seal (largha), *Phoca largha* (photo by A. A. Semenov)

species (Gritsenko, Churikov, 1977; Gritsenko, 2002).

Characteristics and analysis of reproduction and mortality

In the rivers of Southern Sakhalin, Sakhalin taimen mature at the age of 6–8 years, reaching a length of 60–80 cm. Males begin to mature a year earlier (Gritsenko, 2002). The absolute fecundity of taimen in Aniva Bay has not been determined; however, by analogy with other areas of the Sakhalin Region, it is estimated to average approximately 10,000 eggs. There is a positive linear relationship between the body length of females and fecundity (Gritsenko, 2002).

All forms of taimen spawn in rivers in early spring. Spawning begins immediately after the snowmelt floods subside, from late April. The numbers of spawning adults were effectively estimated using sonar and video cameras (Rand and Fukushima, 2014; Fukushima and Rand, 2021).

Females are adapted to selecting suitable nest sites depending on river water level. The average daily water temperature during the spawning period reaches 4–7 °C (Krykhtin et al., 1964; Parpura, 1991; Fukushima, 1994).

Like all salmonids, taimen deposit eggs in the riverbed, forming spawning redds. Females bury the egg nest immediately after spawning, which aligns their behaviour with that of Pacific salmonids (Esteve et al., 2009). The tops of the egg nests are V-shaped. The number of nests, averaging 1.8–3.0 per redds, can be estimated from the shape of the redds. False redds of various shapes also occur. The number of nests and eggs, as well as the depth of egg placement in the substrate, correlates with female length (Fukushima, 1994).

An unusual observation was reported by O. Gritsenko (2002). In first-time spawners, the prespawning scales are not sufficiently embedded in the skin, making their ability to construct nests in the substrate questionable. In repeat spawners, the prespawning skin changes are pronounced and effectively protect the fish from injury during substrate digging.

Mature eggs are 4.0 to 6.4 mm in diameter and average 120 to 164 mg in weight (Krykhtin et al., 1964;

Gritsenko, 2002). The eyed stage and relative tolerance to physical impact occur at 200 degree-days. Egg development is rapid, with mass hatching occurring after about one month (320 degree-days) and emergence from the mounds at around 500 degree-days (Parpura, 1991).

Mortality of fingerlings in natural populations is likely to be extremely high. The survivors are individuals that have successfully overwintered and, by age 1+, from their second summer of life, have switched from benthic feeding to a predatory diet (Zolotukhin, Semenchenko, 2008).

Mobility, seasonal migrations

Fish migrations are usually explained by the differences in food availability between marine and riverine habitats. In rivers, taimen move downstream in spring, upstream in summer, and downstream in autumn. The effect of water temperature has been noted; the fish tend to move towards colder water (Honda et al., 2009; Honda et al., 2012).

The migration history was studied by analysing the Sr/Ca (strontium/calcium) ratio in the otoliths of adult fish (Arai et al., 2004; Suzuki et al., 2011; Zimmerman et al., 2011). To allow the identification of live individuals, guanine pigmentation of the scales at the base of the caudal fin has been proposed as a distinguishing feature of anadromous fish versus riverine forms (Edo et al., 2005).

Spawning in rivers of southern Sakhalin takes place from late April to early May. In early spring, sexually mature individuals migrate downstream to the sea for feeding and re-enter rivers for spawning in May (Gritsenko et al., 1974; Gritsenko, Churikov, 1977). However, other observations have not confirmed this short-term downstream migration before spawning.

The downstream migration of post-spawning fish usually occurs in July, and from September to November, they re-enter fresh water. After downstream migration, both juveniles and post-spawning individuals remain near river mouths or in lakes and estuaries. Taimen do not undertake extensive marine migrations, as evidenced by repeated returns to fresh water during the summer feeding period.

In large rivers, juvenile taimen feed and grow for up to 5–7 years, reaching a length of 40–50 cm. Limited feeding areas in small rivers facilitate downstream migration of juveniles at an earlier age (2–4 years) and at smaller body size (10–25 cm) (Krykhtin et al., 1964; Zavgorodnyaya et al., 1964; Gritsenko et al., 1974; Gritsenko, Churikov, 1977; Gritsenko, 2002). From late September to early November, taimen return to the

lower reaches of rivers or lakes for wintering. Only small individuals winter in the lower reaches of small rivers.

Unlike Pacific salmon, the connection of migratory taimen with the ocean is weaker; many fish enter river estuaries, lagoons and sea bays without reaching the open sea. Moreover, a significant proportion of individuals from populations of large rivers do not enter the sea every year but remain in fresh water throughout the summer. In terms of the duration and extent of migrations, Sakhalin taimen more closely resemble semi-anadromous chars such as Dolly Varden or whitespotted char than salmon.

Nutrition and growth

At early developmental stages, all fish are planktivorous, while at later stages predators initially feed on planktivorous juvenile fish. Growth of juvenile fish and of predators at the early stages of predatory feeding is determined by the quality and quantity of zooplankton. At later developmental stages, the growth of benthophagous fish and, to some extent, predators, is related to the quality and quantity of benthos. The growth of predatory fish mainly depends on the composition of the prey ichthyofauna, which in turn is determined by the quality and quantity of plankton and benthos. At different stages of individual development, the growth rate and condition depend on the state of the food base (Klyuchareva, Svetovidova, 1968).

Taimen are generalist predators adapted to consuming a wide range of prey. The diet of juvenile taimen is similar to that of juvenile salmon; however, because pink and chum salmon descend downstream early and cherry salmon move into the main river channel, the feeding periods of these species and juvenile taimen in the same habitats overlap only to a limited extent. Fingerling fish inhabiting shallow waters feed predominantly on benthos, with chironomid larvae and aquatic bugs dominating the diet. Juveniles, 9–20 cm long, consume larvae of caddisflies, stoneflies, beetles and chironomids. Aerial insects are consumed in negligible amounts.

Older juveniles feed on small fish. The species composition of prey is very broad, and the frequency of occurrence is closely related to the density of appropriately sized prey species.

Unlike other predators, a significant portion of the diet of taimen consists of benthic rather than pelagic fish; in all water bodies, these are the most abundant and often low-value fish species. As a predator, taimen preys on non-commercial planktivorous fish such as the nine-spined stickleback, benthivorous species such as Siberian stone

loach, and periphyton consumers such as the lake minnow, thereby increasing the availability of food resources for juvenile and adult commercial fish (Klyuchareva, Svetovidova, 1968).

Initially, a number of studies were aimed at determining the extent of the impact of taimen on juvenile Pacific salmon and commercially valuable cyprinids. It has been shown that taimen aged 1+ and 2+ consume juvenile chum and pink salmon; however, due to their low abundance, they do not exert a significant impact. Crucian carp and common carp are not consumed in lakes because of their deep-bodied shape. A small proportion of juvenile coho salmon is consumed, whereas juvenile cherry salmon have not been recorded in the diet. Complex biocenotic relationships develop in spawning rivers, in which taimen often play a positive role with respect to juvenile salmonids.

The growth rate of taimen at the early developmental stages is related to their feeding regime, the timing of the onset of predation, and the hydrological conditions in their habitats. Overall, island populations exhibited the lowest growth rates, whereas mainland populations showed the highest, which does not contradict the established ecological rules. Among the island and mainland populations of Sakhalin taimen, the more northern populations have higher growth rates than the southern ones (Zolotukhin, Semenchenko, 2008).

Natural enemies, parasites, diseases

Fingerlings are occasionally consumed in small numbers by older juveniles of the same species (Sagawa et al., 2003). Individuals up to 15 cm in length are occasionally recorded in the diet of Sakhalin otters (Vshivtsev, 1972). Taimen in Far Eastern rivers that have reached a body length of 20–30 cm have virtually no natural enemies except humans.

The species experiences little interspecific competition because the ecological niche it occupies differs from those of other apex predators spatially, temporally and trophically. The potential niche for the species is much larger than the realised niche (Giller, 1988).

Within host-parasite systems, ten parasites belonging to different taxa have been identified for Sakhalin taimen (Nagasawa et al., 1987). Among parasites, the copepod *Salmincola stellatus*, its infestation intensity, and attachment sites have been studied more extensively than those of other species (Nagasawa, Urawa, 1991; Shedko, Shedko, 2003).

Under hatchery conditions, the appetite of infected taimen individuals was reduced (Nagasawa et al., 1994).

A consolidated list of parasites of the genera *Hucho* and *Parahucho* has been published, and of 88 parasite species belonging to eight higher taxa, 18 have been recorded for Sakhalin taimen (Popiolek et al., 2013).

Protista: *Trichodina domerguei*;

Monogenea: Microcotylidae gen. sp.;

Digenea: *Azygla perryi*, *Bunodera luciopercae*;

Cestoda: *Bothriocephalus* spp.,

Diphyllbothrium nihonkaiense;

Nematoda: *Anisakis simplex*, *Cucullanus truttae*, *Philometroides masu*, *Rhabdochona* sp., Camalanidae gen. sp., Philometridae gen. sp.;

Acanthocephala: *Acanthocephalus* sp.,
Acanthocephala gen. sp.;

Hirudinea: *Limnotracheobdella okae*;

Crustacea: *Caligus orientalis*, *Basanistes woskoboinikovi*, *Salmincola stellatus*.

For most of these species, taimen serve as the definitive host. In general, parasitic infections are not among the main factors reducing the population size of the species. According to S. Utevsky (2003), even parasitic species should be protected, since in the event of host extinction, they would also disappear.

In summer 2021, mortality events involving Sakhalin taimen were recorded in Hokkaido due to abrupt increases in water temperature; no such events were observed in the Russian part of their area.

Sakhalin taimen on the east coast of the Crillon Peninsula

The status of the Sakhalin taimen population on Crillon Peninsula remains poorly studied, even though historically, this region has always been one of the main centres of its reproduction.

Accounts by early Russian explorers of the use of these fish by the indigenous inhabitants of southern Sakhalin, the Ainu, have been preserved. ‘The herald of spring is the *chevitsa* (*Salmo orientalis*), or, in the Ainu language, *chirai*, measuring from one to one and a half arshins; the *chevitsa* moves upstream from the first days of April ... in the same rivers. The arrival of the *chevitsa* is a real celebration for local people and, at the same time, marks the beginning of their summer work season. The tasty and hearty meat of the *chevitsa* is usually boiled in cast-iron cauldrons, and the roe is separated and prepared as a special dish that is no less delicious.

The skin, carefully removed from the fish, is dried and processed, and serves as the best material for summer footwear and outer garments that protect from rain' (Depreradovich, 2017).

The Crillon Peninsula Game Reserve, established in 1972, restricted public access, although it did not specifically protect fish. Once, fishery inspectors seized 36 large taimens caught in nets while wintering in the Moguchi River. After that, in 1987, amendments were introduced to the 'Reserve Regulations', allowing recreational fishing within the reserve. For the biological improvement of rivers and removal of so-called 'trash fish', the use of nets is permitted as an exception under permits issued by the hunting management authority.

Since the mid-1990s, commercial fishing for mixed species and pink salmon began to develop in the area; as a result, taimen entering coastal marine waters for feeding became subject to uncontrolled bycatch. From 1995 to 1996, attempts were made to catch adult specimens for Japanese fish farmers. Only two individuals were caught in the coastal marine area near the Naicha River. Spawners entering the Moguchi and Ulyanovka rivers in spring could not be caught; therefore, it was assumed that they migrate upstream during ice breakup without a short-term exit to the sea.

In the early 2000s, four rafting expeditions were conducted on the Uryum River; taimen were observed in spawning grounds during the first five days of May. Spawning individuals were recorded in the estuarine zones of tributaries with clear water (Istok, Pritochnaya, Kamyshinka, Yagodka). In late July 2010, juvenile taimen measuring 25–30 cm were found in poachers' catches in the uppermost reaches of the Uryum River.

In summer 2011, sampling was conducted under the 'Programme for the Study and Artificial Reproduction of Sakhalin Taimen *Parahucho perryi* (Brevoort, 1856)' in the water bodies of Sakhalin Region. In the Uryum River estuary, samples for genetic analysis were taken from three specimens measuring 23–32 cm. At km 2–9 of the Ulyanovka River, four specimens of different ages measuring 8, 11, 29 and 45 cm were collected. At km 3–5 of the Moguchi River, no juvenile taimen were recorded; in autumn, samples were taken from six specimens measuring 27–52 cm in the estuarine zone. All individuals were released into their natural habitat without injury.

In mid-July 2011, at the specified sections of the main channels of the Moguchi and Ulyanovka rivers, the species composition and station-specific density of the associated ichthyofauna were determined (pool, run, riffle). In the Moguchi River, the associated ichthyofauna comprised juvenile cherry salmon

Oncorhynchus masou at different life stages (0+, 1+, smolts, dwarf males), Far Eastern redfin *Pseudaspius* sp., Sakhalin sculpin *Cottus amblystomopsis* and whitespotted char *Salvelinus leucomaenis*. In the Ulyanovka River, the same species were recorded, along with southern Dolly Varden *Salvelinus curilus*, Siberian stone loach *Barbatula toni*, freshwater Far Eastern goby *Gymnogobius urotaenia* and Chinese ninespined stickleback *Pungitius sinensis*. The Japanese mitten crab *Eriocheir japonica* was also common in both rivers (Makeev, Report ... [Electronic resource]).

In autumn 2023, hydrological measurements were taken, geomorphological structures were examined, soil samples were collected for particle-size analysis, and hydrochemical parameters were recorded in the Moguchi River.

In the Ulyanovka River, the same species were recorded, along with southern Dolly Varden *Salvelinus curilus*, Siberian stone loach *Barbatula toni*, freshwater Far Eastern goby *Gymnogobius urotaenia* and Chinese nine-spined stickleback *Pungitius sinensis*.

During the survey, a Garmin Striker 4 fish finder, a FocusFish underwater video camera, a GoPro portable camera and a BLE-C600 digital tester were used. Due to technical problems encountered while operating the fish finder, the survey was limited to video camera observations. The method of drilling holes was selected, starting from a large pool at a sharp bend of the channel 700 m from the river mouth (point No 16) and gradually moving upstream. The uppermost point was located at a distance of approximately 1.4 km from the river mouth, in the area of a large woody debris accumulation. From this point (No 1), all holes were checked for the presence of fish using a video camera, and depth was estimated from markings on the cable.

Sakhalin taimen individuals were observed in pools with a total length of 200 m, an average width of 10 m, and a total area of 2,000 m². The viewing area of the video camera was accepted to be 50 m² (based on a circle with a radius of about 4 m). In total, approximately 108 individuals were observed; the total number of taimen was estimated at $2,000 \div 500 \times 108 = 432 \pm 20$ individuals. Deviations in either direction are attributable to the possibility of repeated counting of individuals and to unsurveyed sectors. Similarly, the number of whitespotted char individuals in a small area near the bend was estimated at 580 ± 20 individuals.

Taimen individuals measuring 30–80 cm in length, corresponding to an age of 4–8 years, were observed. As is known, in southern rivers, these fish begin spawning at an age of 6–8 years. No truly large taimen were recorded; presumably, they inhabit deeper areas where



Fig. 10.2. The Moguchi River

visibility is sharply reduced. No signs of male breeding coloration were observed. Given that Sakhalin taimen do not spawn annually and that 25–30 % of individuals participate in spawning, approximately 50 pairs could be expected to spawn in May 2024.

No wintering individuals were observed on the Ulyanovka River above the woody debris (near Point No 4); taimen were found along a 2 km stretch (compared to 0.2 km on the Moguchi River), with both taimen and whitespotted char in the lower section and only whitespotted char in the lowermost reaches. The largest taimen specimens were observed in the deepest pools. Overall, fish density was noticeably lower than in the Moguchi River; however, due to the larger extent of suitable habitats, the total estimated number of individuals was higher.

Taimen individuals were observed in pools with a total length of 2,000 m, an average width of 10 m, and a total area of 20,000 m². The video camera viewing area was also assumed to be 50 m²; taimen individuals were detected in 11 sectors. In total, approximately 42 individuals were observed; the total number of Sakhalin taimen was estimated at $20,000 \div 550 \times 42 = 1,527 \pm 30$ pcs. It can be assumed that the number of spawning pairs may reach 300. Similarly, taking the long estuarine section (600 m) into account, the number of whitespotted char individuals was estimated at $1,800 \pm 30$ pcs.

Observations confirm that the Ulyanovka and Moguchi rivers are extremely valuable for the reproduction of Sakhalin taimen and whitespotted char and, in this regard, are unique watercourses in southern

Table 10.1. Observations of wintering fish using an underwater camera in the Moguchi River

Point No (Fig. 10.2)	Depth, m	Substrate	Sakhalin taimen, ind.	Whitespotted char, ind.
1	1.0	sand. silt	0	0
2	1.0	"	0	0
3	0.8	leaf litter	1	0
4	1.5	pebbles. sand	2	0
5	1.5	"	20	0
6	1.5	fallen tree	0	0
7	1.5	small pebbles	10	0
8	2.0	large pebbles	20	0
9	1.5	"	20	0
10	2.0	small pebbles	5	0
11	3.0	large pebbles	15	0
12	4.0	"	0	0
13	1.5	"	15	10
14	4.0	not visible	0	100
15	5.0	"	0	50
16	4.0	large pebbles	0	10



Fig. 10.3. Ulyanovka River

Sakhalin. It is necessary to strengthen the targeted protection of the species by prohibiting any use of nets in the river and adjacent coastal waters, implementing a strict catch-and-release principle for recreational fishing, and establishing control over the taimen bycatch during commercial fishing for mixed fish species and salmonids.

In early July 2024, Sakhalin–Crillon LLC, jointly with the Sakhalin branch of the Federal State Budgetary Institution Glavrybvod, conducted the first experiment in inter-basin transportation of Sakhalin taimen yearlings from the Okhotsk Hatchery to the middle reaches of the Moguchi River. The experiment was successful; none of the 1,000 specimens were harmed during transit. In July 2025, such transportation was repeated and was also successful.

According to research (Zhivotovsky et al., 2015; Yurchenko, 2015), the Lake Tunaicha and Aniva Bay

basins form a single ecogeographic unit in Southern Sakhalin. Within zoogeographic regions, supportive translocations are possible to restore the genetic diversity of populations, which is especially relevant for populations with low levels of genetic diversity. That is, even though the Moguchi River has its own relatively robust population, transportation will not harm it and will only improve its condition. However, proper monitoring of water bodies and experiments to avoid domestication under fish farm conditions are not yet in place.

As a result, populations of a unique endangered species are preserved in the basins of the rivers studied. This allows promising areas of ecological tourism to develop while at the same time placing global responsibility for the state of this valuable resource on stakeholders.

Table 10.2. Observations of wintering fish using an underwater camera in the Ulyanovka River

Point No (Fig. 10.3)	Depth, m	Substrate	Sakhalin taimen, ind.	Whitespotted char, ind.
1	0.8	sand	0	0
2	1.0	“	0	0
3	1.0	pebbles	0	0
4	1.5	pebbles, sand	0	0
5	1.5	“	2	0
6	2.0	sand	5	0
7	2.2	“	5	0
8	1.8	pebbles	3	0
9	1.5	“	1	0
10	1.8	small pebbles	5	1
11	1.7	pebbles, sand	4	2
12	2.0	“	5	1
13	1.8	“	2	2
14	3.0	sand	6	2
15	2.0	“	4	1
16	1.5	pebbles	0	12

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11

COMMERCIAL RESOURCES AND MARICULTURE OF INVERTEBRATES AND ALGAE: HISTORY AND PROSPECTS FOR DEVELOPMENT

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Mariculture is aquaculture, or an activity involving the breeding, maintenance and cultivation of marine hydrobionts. As an economic activity, aquaculture aims to produce fish and other aquatic products, as well as to conserve aquatic biological resources (ABR) (Federal Law ..., 2013). There are two main areas of aquaculture that differ in their ultimate goal: commercial aquaculture and artificial reproduction. In turn, breeding, maintenance and cultivation can be carried out both in the sea and in inland water bodies, in artificial reservoirs, or under 'factory conditions', i.e., on land. Cultivation of hydrobionts in the sea appears to be a riskier activity than in inland water bodies or under 'factory conditions'. For successful mariculture in the sea, it is necessary to have a good understanding of biotechnological processes and to be able to make use of natural environmental conditions within the marine area used as the fish-farming site (within artificial reproduction, a fish-farming site is not required).

Traditionally, the enclosed and semi-enclosed water areas of bays and gulfs are used for commercial aquaculture (mariculture) (Temporary Instruction ..., 1984, 1987; Podkorytov, Maslennikov, 2008; Kondratieva, 2016; Gavrilova et al., 2019). In such areas, the results of many years of work can be preserved at lower cost than in open water. The preservation of cultivated products is one of the most important and, at the same time, complex tasks, since the loss of stock some time before harvest destroys several years of work and may lead to the bankruptcy of an uninsured company.

In many respects, the costs determine the first steps in starting up mariculture farms (sea farms). Within commercial mariculture, the pasture method is often used for the cultivation of benthic invertebrates. Planting material is purchased or produced in-house and then distributed within the boundaries of the fish-breeding site (FBS). Such a roadmap is fully justified provided that all the geomorphological and hydrological characteristics of the fish-breeding site are taken into account, as well as its carrying capacity for the selected mariculture species (Kovacheva, Chertoprud, 2014; Turabzhanova, 2016). Planned target indicators are usually formulated within an enterprise work programme and business plan. Similar assessments should be carried out as part of an Environmental Impact Assessment (EIA), which is usually included in the project documentation when establishing agricultural production facilities and is subject to State Environmental Expert Review (SEER). However, under the current regulatory framework,

State Environmental Expert Review is required for industrial aquaculture and is not required for pasture aquaculture (Order ..., 2020).

About 15 years ago, fish-breeding sites began to be established in the Sakhalin–Kuril region, including Aniva Bay, the Southern Kuril Islands and the southwestern coast of Sakhalin Island. Their boundaries have now been defined: 17 fish-breeding sites in Aniva Bay, four in the Southern Kuril Islands, and one off the southwestern coast of Sakhalin. All established FBSs are located in open water. According to current projections, the total production level at these fish-breeding sites (sea farms) in Sakhalin Region is expected to reach several thousand tonnes in the coming years. A biomass of this magnitude would be expected to be visible to the naked eye on the seabed adjacent to the fish-breeding sites. However, fisheries research has so far failed to detect any unnatural changes in biomass.

An overview of the benthic population of the coastal zone of Aniva Bay

The coastal zone of Aniva Bay is home to more than 450 species of hydrobionts, including invertebrates, algae and seagrasses that lead a fixed or low-mobility lifestyle. According to an analysis of the published data and our own research (Kanno, Matsubara, 1936; Vinogradov, 1950; Skarlato, 1960; Kulikova, 1973; Buzhinskaya, 1985; Vasilenko, 1974, 1985; Golikov, Skarlato, 1985; Golikov et al., 1985; Sirenko, 1985; Tsvetkova, Kudryashov, 1985; Kusakin et al., 1997; Dubrovsky, Sergeenko, 2002; Sergeenko, 2007; Galanin et al., 2011; Labay, 2015; Labay, 2016; Kim, 2020, 2021; Kim, Lozhkin, 2023), taking into account changes in taxonomy, the macrozoobenthos of Aniva Bay comprises 327 species. The species composition is comprised of three main groups of invertebrates: annelid worms Annelida (42 species), among which Polychaeta are the most diverse (40 species); mollusks Mollusca (187 species, including 106 Gastropoda, 72 Bivalvia and 9 Polyplacophora); and crustaceans overall (107 species), with the greatest representation of Amphipoda (68 species) and Decapoda (20 species).

The macrophytes of Aniva Bay are represented by 128 species, including four species of seagrasses, 22 species of green algae, 36 species of red algae and 66 species of brown algae (Kusakin et al., 1997; Sukhoveeva, Podkorytova, 2006).

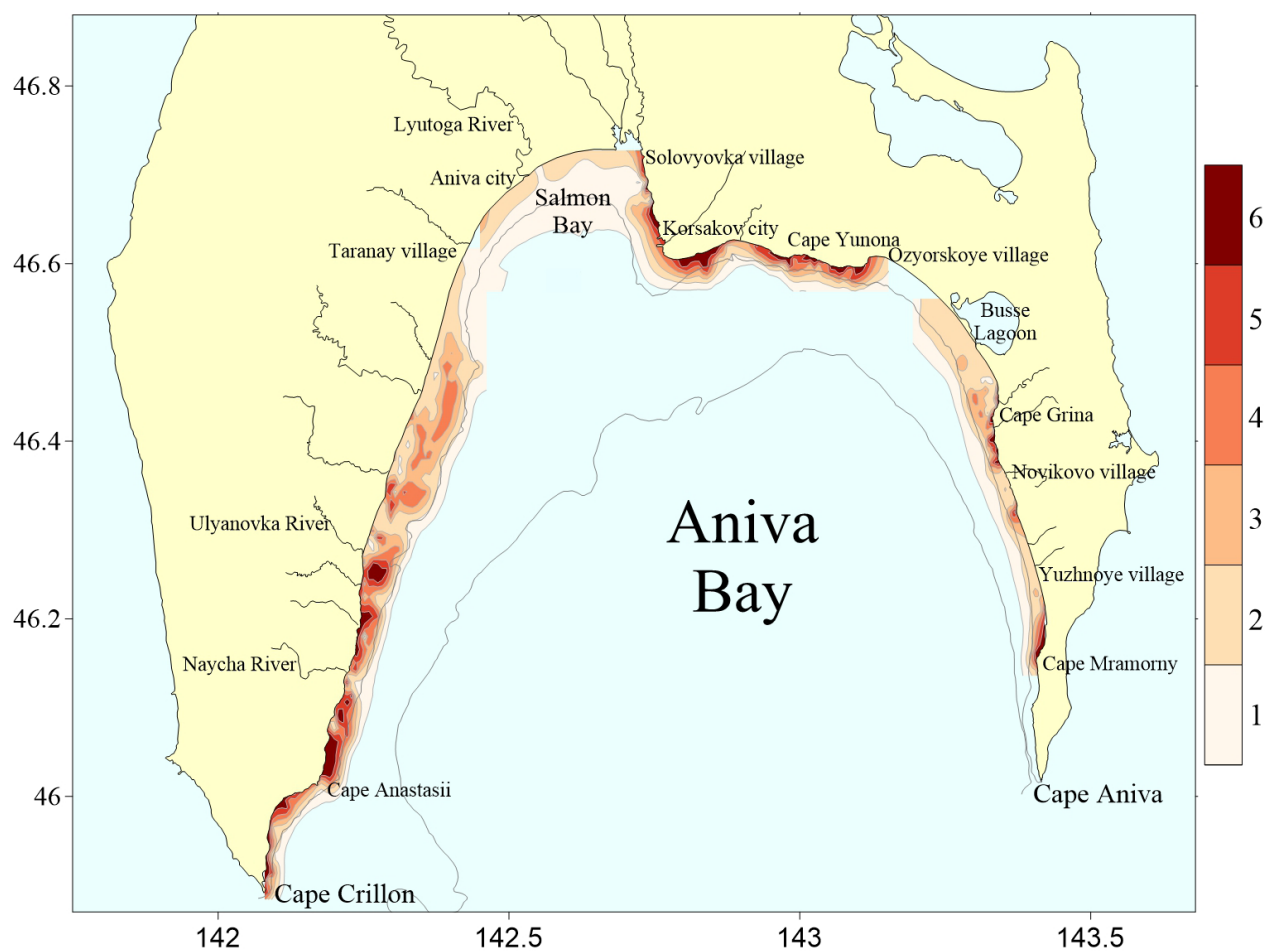


Fig. 11.1. Soil map of the coastal part of Aniva Bay: 1 silt; 2 sand; 3 gravel; 4 pebbles; 5 boulders; 6 rocky substrate

The coastal zone of Aniva Bay, within a 0–20 m depth range, is characterised by alternating hard and loose sediments, accounting for approximately 30 % and 70 %, respectively (Fig. 11.1). At depths of 20–30 m, the composition of bottom sediments can be highly diverse; however, the proportion of the solid fraction decreases to approximately 10 %. Below 40 m, various types of silt predominate, while stony and rocky substrates remain only in the vicinity of the outermost capes Aniva and Crillon (Tabunkov, 1974; Shchukina et al., 2003).

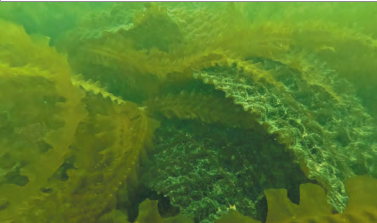
It is important to note that benthic communities, including commercially important hydrobionts inhabiting Aniva Bay, are highly diverse in composition, distribution and biomass, which tends to be a

consequence of the diversity of abiotic environmental conditions (Table 11.1) (Skalkin, 1970; Golikov et al., 1985; Yavnov, Pozdnyakov, 2000; Shchukina et al., 2003).

Commercial invertebrates and algae of the coastal zone of Aniva Bay

The taxonomic composition of hydrobionts authorised for commercial fishing in inland marine waters, including Aniva Bay, is determined by the 'List of aquatic biological resource species subject to industrial

Table 11.1. The most typical benthic landscapes of the west, north and east coasts of Aniva Bay

Depth, m	West Coast	North Coast	East Coast
1–5			
6–10			
11–15			
16–20			

and coastal fishing’ (Regulation ..., 2017). The List includes marine mammals, fish, invertebrates, algae and seagrasses. However, in a particular water body, several, one, or none of the species from the general List may be in demand for fishing; for example, in Aniva Bay, 13 such species are currently recorded among the representatives of benthic megabenthos (Table 11.2).

The most significant commercial invertebrates and algae currently harvested in the coastal zone of Aniva Bay, or harvested in the recent past, include the following: among echinoderms, the gray sea urchin *Strongylocentrotus intermedius* A. Agassiz, 1864; Far Eastern trepang *Apostichopus japonicus* Selenka, 1867; Japanese cucumaria *Cucumaria frondosa japonica* Semper, 1868; among gastropods, the trumpet shell *Buccinum bayani* Jousseume, 1883; among bivalves, the Japanese scallop *Mizuhopecten yessoensis* Jay, 1857; Sakhalin spisula *Spisula sachalinensis* Schrenck,

1861; and the Manila clam *Ruditapes philippinarum* A. Adams & Reeve, 1850; Pacific oyster *Magallana gigas* Thunberg, 1793; among crustaceans, the grass shrimp *Pandalus latirostris* Rathbun, 1902; horsehair crab *Erimacrus isenbeckii* Brandt, 1848; the Kamchatka crab *Paralithodes camtschaticus* Tilesius, 1815; among algae, Japanese kelp *Saccharina japonica* Lane et al., 2006, and Tobuchinskaya ahnfeltia *Ahnfeltia fastigiata* var. *tobuchiensis* Kanno et Matsubara, Skriptsova et Zhigadlova, 2022. The overall level of exploitation of these resources in Aniva Bay, expressed as catches, can be measured in hundreds and even thousands of tonnes per year. Over the entire history of the fishery, the highest annual catch of an aquatic biological resource, the red alga ahnfeltia, was recorded more than 100 years ago (Balkonskaya, 2000; Galanin, Prokhorova, 2023).

All benthic hydrobionts depend on specific environmental conditions, primarily on the nature of

Table 11.2. Significant commercial invertebrates and algae in the coastal zone of Aniva Bay and their highest distribution and biomass values at the present stage

No	Commercial species	Species	Depth, m	Substrate*	Area of commercial aggregations, km ²	Historical maximum biomass, tonnes
1	Japanese scallop	<i>Mizuhopecten yessoensis</i>	10–25	2, 3, 4	63	18,200
2	Sakhalin spisula	<i>Spisula sachalinensis</i>	1–15	2	29	12,630
3	Pacific clam	<i>Ruditapes philippinarum</i>	0–2	2	0.3	201.6
4	Giant oyster	<i>Magallana gigas</i>	0–5	5, 6	0.195	308
5	Whelk	<i>Buccinum bayani</i>	10–100	1, 2, 3, 4		1,700
6	Japanese cucumaria	<i>Cucumaria frondosa japonica</i>	10–30	5, 6	8,076	1,176.4
7	Gray sea urchin	<i>Strongylocentrotus intermedius</i>	2–30	4, 5, 6	1.55	662
8	Far Eastern sea cucumber	<i>Apostichopus japonicus</i>	0–20	4, 5, 6	6.2	90
9	Grass shrimp	<i>Pandalus latirostris</i>	1–12	2, 3	—	295
10	Kamchatka crab	<i>Paralithodes camtschaticus</i>	15–100	3, 4, 5, 6	2254 miles ²	749**
11	Horsehair crab	<i>Erimacrus isenbeckii</i>	10–80	1, 2, 3, 4	7,123	1,339**
12	Japanese kelp	<i>Saccharina japonica</i>	0–15	4, 5, 6	10.63	59,400
13	Tobuchinskaya ahnfeltia	<i>Ahnfeltia fastigiata</i> var. <i>tobuchiensis</i>	3–5	1, 2, 3	28	100.000

* Substrate: 1 silt; 2 sand; 3 gravel; 4 pebbles/rubble; 5 stones; 6 boulders/rocks.

** Commercial stock.

bottom sediments and hydrological factors such as salinity and water temperature. A common biological feature of the commercial invertebrates and algae presented in Table 11.2 is their low mobility or fixed lifestyle. At the same time, all of them have a life stage in their annual development cycle that facilitates their distribution: invertebrates have larvae, and algae have spores. Virtually all coastal areas of the Aniva Bay seabed are occupied by commercial accumulations of algae and invertebrates (Fig. 11.2).

It is well known that aquatic biological resources in general, and the commercial invertebrates and algae of Aniva Bay in particular, are not always in a stable state due to unsustainable exploitation or other factors (Gail, 1949; Klitin, 2002, 2003; Labay, Kochnev, 2008; Galanin et al., 2012; Nizyaev, 2022). When resources decline below a threshold level, their harvesting is suspended. However, aquaculture methods (artificial reproduction) can be used to maintain the abundance and biomass of intensively exploited species at a level corresponding to the maximum sustainable yield (MSY), while remaining within the carrying capacity of the environment (Galanin et al., 2006; Gavrilova, 2012; Turabzhanova, 2016). Some of the hydrobionts listed in Table 11.2 can be used for continuous cultivation under an agricultural production regime (commercial aquaculture, or mariculture when the target species is a marine hydrobiont) at volumes exceeding the

natural carrying capacity of their habitat, for example, in artificially created environments such as cages.

In theory, any hydrobiont – commercial or otherwise – whose natural populations are declining for whatever reason may be a candidate for artificial reproduction to support their replenishment. (Commercial Fishes ..., 1993; Klitin, 2002, 2003; Krutchenko, 2005). In Aniva Bay, the Kamchatka crab and the horsehair crab can be seen as objects for artificial reproduction. In such cases, biotechnology involves, for example, the dispersal of viable juveniles within the species' habitats (Fedoseev and Grigorieva, 2001, 2002; Tyrin et al., 2013). Another approach involves creating favourable conditions in the natural habitats of juveniles through the installation of artificial reefs, thereby increasing their survival rate (Gabaev, 2005).

In our opinion, primary objects of commercial aquaculture in Aniva Bay may include the Japanese scallop, the Far Eastern sea cucumber, the giant oyster and Japanese kelp (Sarochan, 1962; Kizevetter et al., 1981; Kucheryavenko et al., 2006; Regulev and Grigorieva, 2009; Brykov and Kolotukhina, 2009; Chernyshova et al., 2022). This choice is primarily associated with specific biological characteristics, including, in particular, hydrobionts native to the water body that exhibit sessile or weakly mobile lifestyles, among other traits. These characteristics promote the normal growth and development of the aquaculture

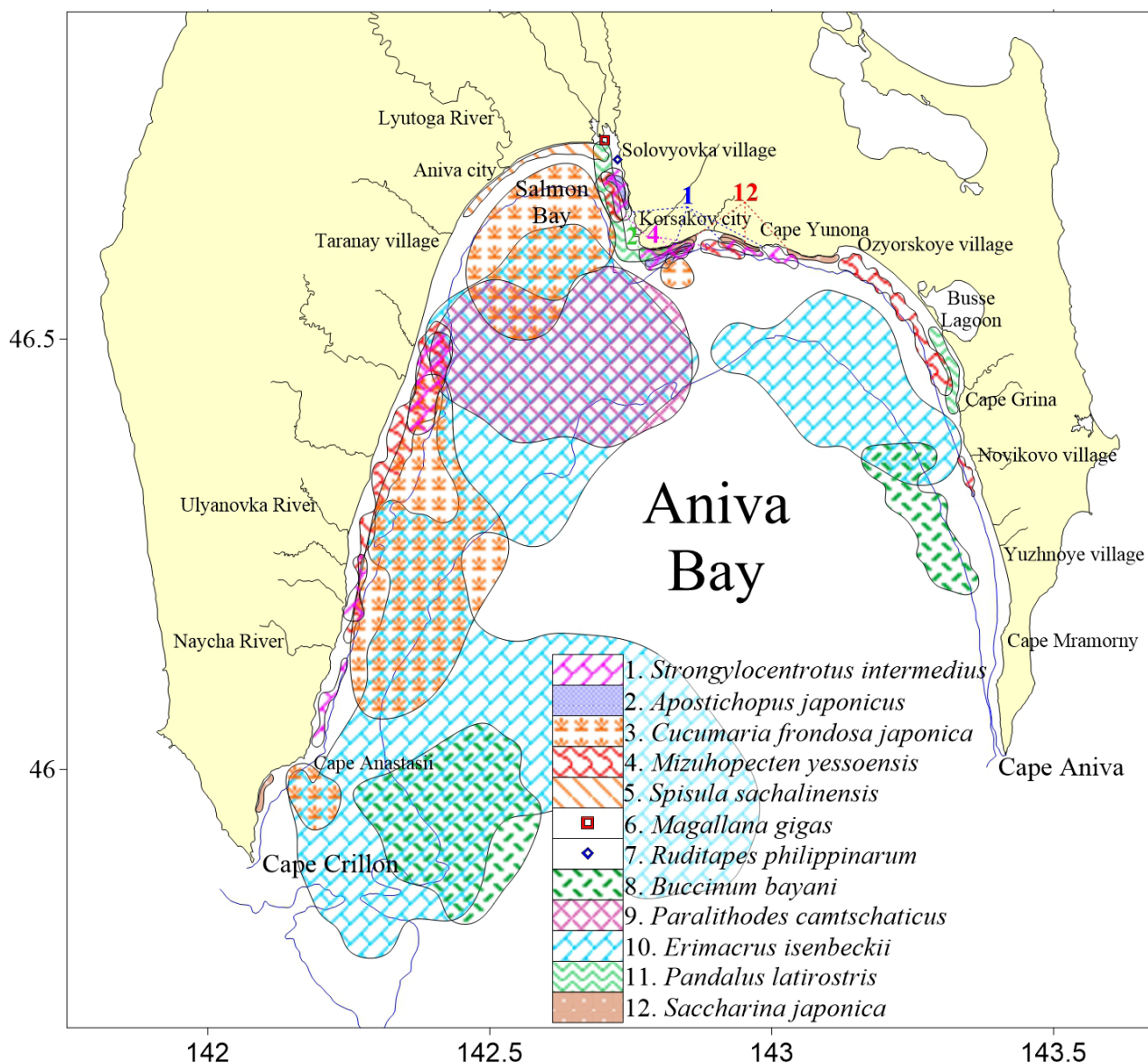


Fig. 11.2. Generalised map of the distribution of commercial aggregations of benthic invertebrates and algae in Aniva Bay (as per Table 11.2)

object, as well as its retention within the boundaries of the fish breeding site (Gail, 1949; Kulikova and Tabunkov, 1974; Levin, 1994; Gayko, 2004; Silina and Latypov, 2005; Silina and Zhukova, 2007; Podkorytov and Maslennikov, 2008). Key factors in selecting an object of mariculture include attractiveness and relatively low financial costs associated with implementing the cultivation biotechnologies.

Thus, it is important to note that the lists of commercial invertebrates and algae targeted by traditional fisheries and those targeted by mariculture

not only may, but should, overlap. Objects for commercial cultivation must be of native origin. The introduction of non-native hydrobionts for mariculture should be avoided. In addition, it is important to monitor the use of juveniles originating from other regions as planting material. For example, unwanted parasitic organisms or epibionts (polychaetes, sponges, etc.) may be introduced together with juvenile Japanese scallop.

History of invertebrate and algal fisheries and mariculture in Aniva Bay

The exploitation of aquatic biological resources in the coastal zone of Sakhalin Island is closely tied to the regional population that has inhabited the area for thousands of years. However, a sufficiently clear picture of target fishery species and dynamics is available only from the late 19th century to the present (Schmidt, 1905; Gail, 1949; Skalkin, 1966, 1969, 1971; Potapova, 2023). Until the 1960s, the mariculture of invertebrates and algae had not been documented either in Aniva Bay or in other areas of the Sakhalin–Kuril region (Saročan, 1962).

Scattered information on the exploitation of aquatic biological resources has been available since 1875, following the signing of the Treaty of St. Petersburg with Japan, after which the entire island of Sakhalin was incorporated into the Russian Empire. At that time, the island's fishery resources were exploited jointly. Each year, more than a thousand Japanese visited Sakhalin, caught fish, and exported marine products to Japan (Potapova, 2023). The provisions of the 1875 treaty and the actions of the local administration allowed Japanese entrepreneurs to maintain a virtually monopolistic position in the island's fishing industry for the following 30 years. The first Russian industrialist Ya. L. Semenov began harvesting kelp (*Laminaria*) on Sakhalin Island in 1878, and the first fishery enterprise was established in 1880. Around the same time, the exploitation of commercial hydrobiont resources in Aniva Bay began (Schmidt, 1905). The role of Russian fishery industrialists increased by the early 20th century. In 1880, harvesting was carried out by 25 Japanese and only one Russian, the aforementioned Ya. L. Semenov; however, by 1900 the number of domestic entrepreneurs had increased to 18, while the number of Japanese had risen to 38.

After the number of Japanese fishing sites on Sakhalin was reduced at the turn of the century, a new phenomenon, known as 'fictitious fisheries', became widespread: Japanese fishery industrialists effectively controlled most fishing sites through front men, Russian tenants. The difficult conditions for Russian business, caused by the remoteness and insularity of the island, were further exacerbated by the absence of protectionist measures combined with preferential policies towards Japanese businesses on Sakhalin, competition from Japanese industrialists, labour shortages, the lack of opportunities for

transporting products across Russia and insufficient financial resources among Russian entrepreneurs. All these factors resulted in the dependence of Sakhalin's fishing industry on the Japanese market.

By the early 20th century, Aniva Bay was one of five areas where Sakhalin's fisheries, both Russian and Japanese, were conducted, and it ranked third in terms of profitability. There were 93 fishing sites in operation in this area. The main objects of the fishery were herring, pink salmon and kelp. Neither molluscs nor crabs were specifically targeted; however, they were caught in nets and other fishing gear and subsequently consumed, although it was not a traditional food for the Russian population. In P. Schmidt's book 'Marine Fisheries of Sakhalin Island', an assessment is offered, in particular, of the oyster as a mollusc deserving special attention from the perspective of its potential for commercial harvesting and cultivation. The author assessed the organoleptic properties of the oyster and also noted the absence of a market for it (Schmidt, 1905).

In the 20th century, the history of fisheries in the coastal waters of Sakhalin, including Aniva Bay, can be divided into three periods: Japanese, Soviet and post-Soviet, each with its own specific characteristics.

The prolonged period of Japanese occupation of South Sakhalin (1905–1945) intensified the fishing pressure on coastal resources of commercial fish, invertebrates and algae. Using the fisheries for *Ahnfeltia*, Kamchatka crab and Japanese scallop as examples, it is possible to obtain a general understanding of the approach to the use of marine biological resources (Commercial Fishes ..., 1993).

With the development of industrial agar production technology, Japanese fishermen began harvesting *Ahnfeltia* in 1916 in Busse Lagoon, which is connected to Aniva Bay. The total stock of the alga at the onset of the fishery was approximately 100,000 tonnes. Catches of *Ahnfeltia* up to 1933 were not limited and varied from 12.0 to 23.7 thousand tonnes, exceeding its average annual growth of about 6 thousand tonnes. Under such exploitation, its total biomass declined to 70,000 tonnes by 1927, and to 19,000 tonnes by the end of the Japanese period of exploitation in 1943. In 1933, due to stock depletion, a catch of 9,000 tonnes per year was recommended, and in 1937, it was reduced to 4,500 tonnes (Balkonskaya, 2000).

The fishery for Kamchatka crab off the coast of Southern Sakhalin began in 1909. Between 1914 and 1944, 9,700 tonnes were harvested in Aniva Bay, averaging 291 tonnes per year, with a maximum

annual catch of 1,370 tonnes. One sign of resource depletion is the change in annual catch, which declined 2.5-fold over a 30-year period, from 674 to 265 tonnes per year.

At the same time, the annual catch of Japanese scallop in Aniva Bay was approximately 1,000 tonnes. Catches remained stable for a period of 10 years. It is likely that limitations of fishing gear and harvesting methods allowed sufficient natural replenishment of the Japanese scallop stock (Skalkin, 1966, 1969, 1971).

According to historical data on the Japanese fishery, the maximum catch of *Spisula* in Aniva Bay was approximately 1,500 tonnes in 1934. Following a period of intensive exploitation, stock depletion occurred, and in 1943, the catch in Aniva Bay declined to approximately 80 tonnes. In 1942, the stocking of juveniles from other areas was carried out in Lososei Bay.

Exploitation of the aquatic biological resources in the coastal zone was conducted under the Soviet regime for 45 years (1946–1991). During this period, no significant changes occurred in the composition or quantities of benthic invertebrates and algae harvested in Aniva Bay. Among algae, the species harvested included *Ahnfeltia* and Japanese kelp, while among invertebrates they included Kamchatka crab, Japanese scallop, trepang, cucumaria and several other species.

Domestic harvesting of *Ahnfeltia* in Busse Lagoon began in 1946 (Sarochan, 1950). In 1949, a six-section rotational fishing system was introduced. The entire lagoon was divided into six fishing sites, with each section harvested once every six years. For 16 years, the allowable removal amounted to 2,000 tonnes of *Ahnfeltia* (wet weight) per year. Unfortunately, these management regulations were not always complied with (Balkonskaya, 2000).

By 1970, the biomass of *Ahnfeltia* in the lagoon had decreased to 10,000 tonnes (Sarochan and Kudryavtseva, 1970). The integrity of the main productive layer was disrupted, and it became fragmented into separate algal aggregations. From 1971, due to a decline in algal stocks and their biomass to low commercial (and locally non-commercial) levels, as well as pronounced spatial fragmentation of the algal bed, it was proposed to impose a ban on the harvesting of *Ahnfeltia* in Busse Lagoon until 1975 (Sarochan, 1971).

According to studies conducted in 1999 and 2000, *Ahnfeltia fastigiata* var. *tobuchiensis* in Busse Lagoon was recommended for harvesting from 2002,

albeit in limited volumes (1,000 tonnes), and solely in connection with the need to support the restoration of the agar plant in the city of Korsakov. As the *Ahnfeltia* field in Busse Lagoon was still in the recovery phase, harvesting was carried out in small volumes and on an episodic basis.

The Russian crab fishery on Sakhalin began in 1946 (Commercial Fishes ..., 1993). The crab fishery initially accounted for no more than 1 % of the total fish and seafood catch and was centred around the Kamchatka crab. In Aniva Bay, the annual catch of Kamchatka crab averaged only 10 tonnes from 1944 to 1953, but over the next 20 years to 1973, it increased to 125 tonnes per year. This was followed by a decade-long period of reduced exploitation intensity, but from 1984 to 1991 the average annual catch of Kamchatka crab in Aniva Bay was 115.5 tonnes. The bycatch of spiny and horsehair crabs was not officially counted. The industry processed crabs into canned products, while cooked crab was consumed by the local coastal population.

Soviet fisheries for the Japanese scallop began only in the 1960s in Aniva and Terpeniya Bays, as well as in the shallow waters of the South Kurils (Skalkin, 1966, 1969, 1971). In the first year of exploitation, the scallop catch in Aniva Bay amounted to 1.8 thousand tonnes. In other areas, the annual catch was even larger, reaching several thousand tonnes. As a consequence, excessive fishing pressure on scallop aggregations had already led to a sharp decline in scallop stocks by the mid-1960s.

From 1970 to 1984, there was virtually no commercial exploitation of Japanese scallop resources in the Sakhalin–Kurul Region (SKR) (3 to 169 tonnes), and in 1985, fishing was banned. It took 15 years for Japanese scallop stocks to recover.

In the mid-1990s, the post-Soviet stage of coastal and commercial fishery development in Aniva Bay began (Commercial Fishes..., 1993). From this point onwards, fishing for aquatic biological resources (ABR) was divided into the coastal and oceanic fisheries. It took approximately 30 years to reach equilibrium, during which a composition of stakeholders was established and a balance of relations with regulatory bodies was achieved. During this period, further assessment of the aquatic biological resources available for fishing was carried out, and amendments were introduced to the Fishing Regulations to ensure optimal management conditions (Shchukina et al., 2003). Fishery monitoring made it possible to collect information on the biological condition of hydrobionts, while the vessel monitoring

system implemented by the Russian Federal Agency for Fisheries (Rosrybolovstvo) contributed to a reduction in illegal, unreported and unregulated (IUU) fishing. As a result, by around 2015, a sustainable and rational regime for the exploitation of aquatic biological resources had been established.

In the 21st century (2000–2023), the list of coastal fishery target species among benthic invertebrates and algae that were successfully harvested in Aniva Bay comprised 10 hydrobiont species (Table 11.3).

At different times, the intensity of fishing for many species fluctuated due to the influence of market demand and organisational constraints (Galanin et al., 2012). From 2000 to 2023, the fishery for the gray sea urchin, Japanese cucumaria, whelk, Japanese kelp and Sakhalin spisula continued, although not always on a sustainable basis and subject to market demand; at the same time, the status of these resources in Aniva Bay was and remains stable. During this period, the highest annual catches were recorded for Japanese kelp (2,150 tonnes), Japanese cucumaria (1,748 tonnes) and Sakhalin spisula (640 tonnes).

Other examples include the Japanese scallop, giant oyster, Pacific clam, horsehair crab, grass shrimp and trepang, the harvesting of which was suspended by the regulator in different years and for varying periods due to the depletion of these resources. The fisheries for the Japanese scallop and the horsehair crab provide the most illustrative examples: starting from favourable levels of commercial biomass, their stock in Aniva Bay was depleted in just 6–8 years as a result of IUU fishing. At present, only the trepang fishery remains closed, while the other resources on the list are once again available for harvesting.

Coastal fisheries in general, and fisheries targeting certain commercially harvested species (Japanese sea cucumber, horsehair crab, whelk and some others) in particular, will inevitably constrain the development of commercial mariculture, as these two types of economic activity often compete for the same coastal waters. We believe that a historical review of fisheries in Aniva Bay may help address any current and future disputes. In our opinion, well-organised fisheries based on the rational use of aquatic biological resources should take precedence over commercial

Table 11.3. Highest and lowest catch values for the most commercially important invertebrates and algae in the coastal zone of Aniva Bay, 2000–2023

No	Commercial species	Catch in Aniva Bay, tonnes	Total allowable catch / recommended catch in the East Sakhalin subzone, tonnes	Utilisation, %
		min./max. (relevant years)	min./max. (relevant years)	min./max. (relevant years)
1	Japanese scallop*	86.2/308.6 (2011/2004)	104/802 (2011/2016)	38.3/100 (2017/2002)
2	Sakhalin spisula	11.6/640 (2008/2015)	47/524 (2002/2023)	0/122 (2004/2015)
3	Pacific clam	18/53 (2011/2017)	8/22 (2017/2010)	82/671 (2011/2017)
4	Giant oyster	2.49/42 (2020/2013)	0.83/78 (2020/2012)	43/863 (2012/2017)
5	Whelk*	0.03/174 (2015/2018)	350/1,009 (2014/2023)	32/98 (2021/2018)
6	Japanese cucumaria	200/1,748 (2004/2020)	400/3,000 (2004/2017)	12/74 (2009/2020)
7	Grey sea urchin*	20/212 (1992/2022)	77/233 (2006/2000)	13/100 (2005/2013–2023)
8	Grass shrimp*	0.181/23 (2011/2021)	28/50 (2017–2023/1999–2002)	0/82 (2011/2021)
9	Horsehair crab	30/108 (2001/2023)	90/115 (2004/2023)	33/94 (2001/2023)
10	Japanese kelp	387/2150 (2022/2008)	2480/19,200 (2007/2023)	1.6/45 (2022/2009)

* Objects harvested not only within Aniva Bay, but also in other areas of the East Sakhalin Subzone.

mariculture, provided they are economically viable. If these conditions cannot be met, the sites should be allocated for use by mariculture farms.

The first experimental studies on the cultivation of invertebrates and algae in the Sakhalin-Kuril region were conducted as early as the 1960s–1980s. Japanese kelp and the Japanese scallop were among the first species used to develop mariculture techniques under local conditions (Sarochean, 1962; Data on foraging..., 1980; Chernyshova et al., 2022). However, the results of trials of scallop cultivation methods available at the time were never implemented on an industrial scale. Nevertheless, the study generated data that can be used to compare to current mariculture practices for the Japanese scallop and assessments of its biological condition (Chernyshova et al., 2022). The first experiments in Japanese scallop mariculture off the coast of Sakhalin Island coincided with similar studies conducted in neighbouring Japan.

The Japanese experience in mariculture of Japanese scallop off the northern coast of Hokkaido and possibilities for its adaptation in the Sakhalin-Kuril region

Japanese scallop in Japan (Hokkaido)

The exploitation of Japanese scallop resources in Japan has gone on for over 100 years (Northern Fishes ..., 2003). For a long time, the fishery was based on naturally occurring aggregations (Mottet, 1981). Until 1940, fishing operations in the Sea of Okhotsk were carried out manually using 'Kawasaki boats'; in 1942, dredges were introduced for the first time. Prior to 1943, scallop catches in the coastal waters of Hokkaido varied widely and averaged about 20,000 tonnes per year (Figure 11.3). Currently, in commercial operations, a single fishing schooner tows two scallop dredges known as 'hasyaku' with a total weight of less than 15 tonnes. The dredge is approximately 2.4 metres wide and has between 5 and 21 vertical 'teeth' measuring 50–60 cm. Such dredges demonstrate high fishing efficiency and do not damage the scallop shell. Intensive harvesting of scallops in Japan in the 1960s led to a decline in their stocks, prompting recovery measures, including the collection of larvae, rearing of juveniles and their release into the natural environment. For approximately 20 years, artificial propagation of the Japanese scallop was subsidised by the government. Scallop cultivation in Japan is now so well

developed that its production exceeds that of traditional fisheries. Experimental mariculture of the Japanese scallop in the coastal waters of Hokkaido began around 1960 in Lake Saroma and was being conducted on a commercial scale by 1965. In 1967, commercial cultivation of the scallop began in the marine waters of Funka Bay and, by 1970, had expanded to the west coast of Hokkaido. Between 1970 and 1990, production in the Hokkaido area grew rapidly.

By 1996, the volume of farmed shellfish had reached 150,000 tonnes. There were years of low production, for example in Funka Bay from 1977 to 1979 and in Lake Saroma from 1980 to 1982, due to mass mortality of farmed molluscs. At present, Japanese scallop mariculture in the coastal zone of Hokkaido (excluding the east coast) is one of the main economic activities for the local population. Nationwide, approximately 400,000 tonnes of scallop are produced, mainly around Hokkaido. Off the northern coast of Hokkaido alone, annual production amounts to 120,000 tonnes.

The mariculture technique for the Japanese scallop used in Japan is relatively simple and consists of two main stages. The first stage involves obtaining seed material, or juveniles, which are collected in their natural habitat using collectors. The second stage involves rearing molluscs to marketable size.

Collection of Japanese scallop juveniles is carried out from May to June. This is achieved by placing collectors in areas where spawning molluscs congregate. They were originally made from old bivalve shells. The modern collectors are polyethylene mesh bags filled with the same material as the outer

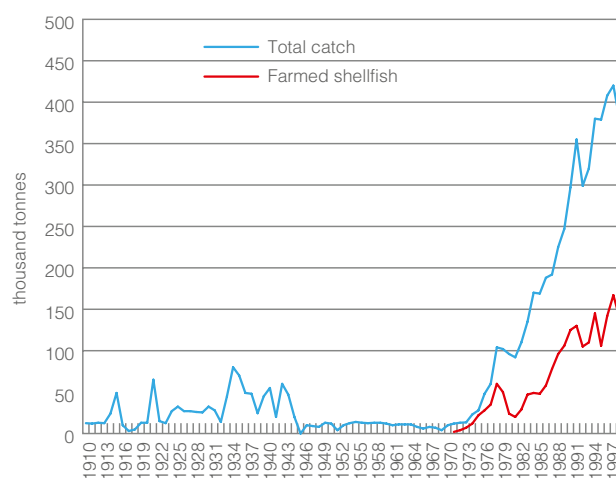


Fig. 11.3. Dynamics of Japanese scallop mariculture production in Japan (Hokkaido)

mesh, although other designs are also used. Collection of juveniles on collectors in the open sea typically varies greatly from year to year. In the semi-enclosed Funka Bay and the enclosed lakes Saroma and Notoro, juvenile collection has remained stable, except in certain years (1992, 1993, 1998 and 1999).

Intermediate cultivation is conducted until the following spring. If the collectors for juveniles become heavily overgrown with mussels and starfish, they are cleaned in July or August. To maximise survival, in September and October juveniles aged 3–4 months are transferred from the collectors to cages. The first experimental collection of Japanese scallop juveniles was carried out in Lake Saroma in 1934, thanks to the ability of young molluscs to attach to a substrate with byssal threads; old scallop shells were used as the substrate. In 1954, the work was expanded to Funka Bay. In 1964, spat began to be collected using onion mesh bags filled with conifer branches, improving collection efficiency. Over time, the techniques for collecting Japanese scallop juveniles improved, and as early as 1972, 57 million juveniles were released.

At the second stage of Japanese scallop mariculture, two methods are used: 'pasture' and suspended cultivation. The first method is as close as possible to the natural way of life of the Japanese scallop. 'Pastures', where juveniles are released, are areas of the seabed in the coastal zone with favourable environmental conditions. However, predators, for example, can negatively impact survival in such areas. The second method, suspended cultivation, is more technically complex and costly, as juveniles are placed in cages or other suspended systems within the water column. Relatively large cage installations have high 'windage' and are therefore most often located in closed or semi-enclosed water bodies (bays, inlets and lagoon-type lakes), for example in Funka Bay and Lake Saroma, or in areas where seasonal winds and hydrodynamic conditions allow suspended structures to remain stable for several months, such as along the western coast of Hokkaido (Fig. 11.4).

By the following spring, year-old Japanese scallop juveniles reach shell heights of 4–6 cm in Funka Bay and up to 10 cm in Lake Saroma. In these two areas, a permit system for cultivation is in place, which determines the number of shellfish to be grown based on their growth rates. Such juveniles are already bought and sold throughout Hokkaido and are used for stocking bottom areas. The main areas where scallops are stocked on bottom sites are located off the northern coast of Hokkaido. Stocking sites are usually located 5–7 km from the shore and extend for several

tens of kilometres along the coast. Water depth in the stocking areas is approximately 20–60 metres. Sea stars are usually removed prior to the release of juveniles. The entire area used for pasture cultivation is divided into four sections. At each site, one-year-old molluscs with shell heights of 4–6 cm are released in spring. Four-year-old molluscs are harvested at each site three years after 'stocking', and all sites are used in a four-year cycle. As a result, when juveniles are stocked at the fourth site, the first site is prepared for harvesting four-year-old molluscs. Released molluscs rarely move to neighbouring areas. As such, the individuals at a given site are of nearly the same age, and all are subject to fishery protection. In areas stocked with juvenile scallops, fish abundance increases from year to year. Large numbers of wild molluscs may also be present. In the Sea of Okhotsk, decreasing mollusc size has become an issue amidst stock enhancement programmes, and the Tokoro, Saroma and Yubetsu fishing cooperatives determine the number of molluscs to be released based on prefectural research (Kijima et al., 1984). In addition, many fishing cooperatives in this region constantly monitor mollusc growth and fishing conditions. To accurately estimate stock abundance, underwater photography has been employed.

Japanese scallop of Sakhalin Island

Along the coasts of Sakhalin Island and the Kuril Islands, there are areas where the mariculture techniques used in Japan, particularly on Hokkaido, can be applied. The similarity of the hydrological conditions and geomorphological features of the coastal landscapes in the southern waters of our region and northern Hokkaido makes it relatively easy to apply similar methods of Japanese scallop mariculture. However, in addition to the similarities, there are also differences. For example, owing to differences in temperature, spawning and the subsequent stages of the annual development cycle occur approximately 3–4 weeks later. In addition, stocking depths for scallop juveniles in Aniva Bay range from 15 to 30 m, whereas off the northern coast of Hokkaido, they range from 20 to 80 m. Such limitations in our waters are due to the silt widespread in the central part of the bay, as well as an arctic water regime, including a cold intermediate layer. Off the northern coast of Hokkaido, environmental conditions across a wide range of depths are shaped by the warm Soya Current, under which the bottom sediments are predominantly sand.

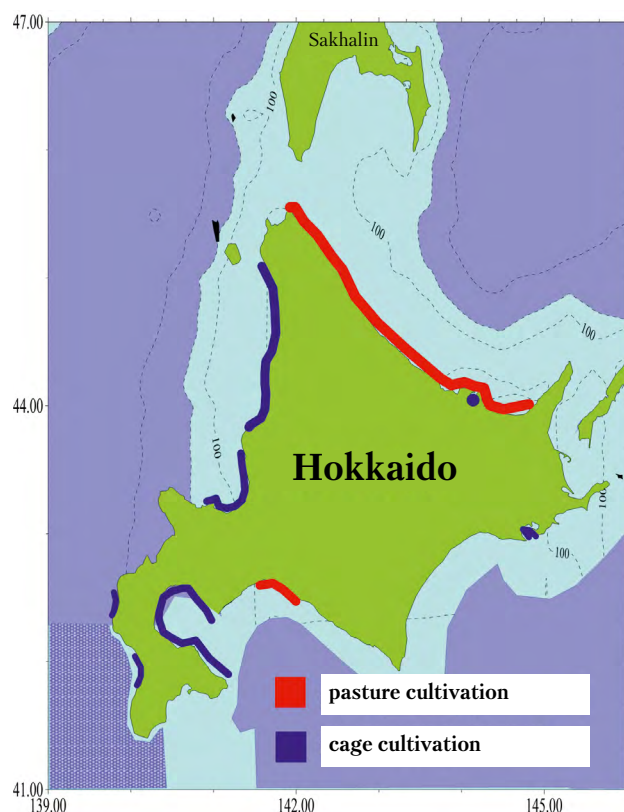


Fig. 11.4. Areas of pasture and cage cultivation of the Japanese scallop around Hokkaido

Current status of invertebrate and algal resources and fisheries in Aniva Bay

Our current understanding of the status of invertebrate and algal resources is based on fisheries research conducted from 2020 to 2023, as access to more recent data is 'For Official Use' only. Table 11.4 presents the current commercial concentrations of invertebrates and algae in Aniva Bay, as well as their estimated biomass (Abe, 1992; Commercial Fishes ..., 1993; Galanin et al., 2019; Kim, 2019, 2021; Klitin, Smirnov, 2021; Galanin, Prokhorova, 2023; Nizyaev, 2022; Bizikov et al., 2024). The assessment presented is based on the results of specialised resource studies and observations conducted during fishing.

Some commercial aquatic biological resources, such as Sakhalin spisula, whelk, Japanese sea cucumber, horsehair crab, grey sea urchin and Japanese kelp, are in satisfactory condition. A comparison of the current biomass of these species with their known historical maximum shows that, in most cases, the difference is

50–70 %. The distribution of commercial concentrations remains relatively unchanged, while abundance indicators are stable. It is noteworthy that the two commercial species, spisula and kelp, which have the highest estimated biomass, are the least exploited, indicating potential for increasing harvest volumes. At the same time, it has been established that, over the past 10 years, the distribution of Japanese kelp communities has decreased by 20 %, while specific abundance indicators have increased by 15 %. However, so far the estimated total biomass has remained the same.

Other species, by contrast, are characterised by relatively low current biomass compared with their known historical maximum, including the Japanese scallop, giant oyster, Pacific clam, Far Eastern sea cucumber and grass shrimp (Shpakova, 2004; Kim, 2021; Chernyshova, Prokhorova, 2018; Chernyshova et al., 2022; Galanin, Prokhorova, 2023). Experts believe that there are no natural factors that could explain their low abundance and biomass, only anthropogenic impact. All these aquatic biological resources have long been targets of IUU fishing due to high demand in domestic and foreign markets. Even when legal fishing is not possible, the stocks of the Japanese scallop, Far Eastern sea cucumber, giant oyster and Pacific clam (*Ruditapes*) either do not recover or recover very slowly. In our opinion, the explanation lies in their relative accessibility to recreational fishing, which often serves as a cover for poaching. As a result, more is harvested than can be replenished by annual recruitment.

Our understanding of the current status of benthic invertebrate and algal resources in Aniva Bay is complemented by recent fishing results (Table 11.5). A comparison of catches in Aniva Bay with those in the East Sakhalin Subzone as a whole, as well as with the total allowable catch or recommended catch for that subzone (the coastal zone off the east coast of Sakhalin), demonstrates the importance of this water body's invertebrate and algal resources. However, fishery zoning determines the format for statistical reporting on the use of aquatic biological resources. As such, catch information from Aniva Bay is combined with data from Terpeniya Bay and other areas of the East Sakhalin Subzone, which precludes the assessment of resources for a specific body of water.

The total catch of coastal fishery species in Aniva Bay in 2023 amounted to 2,500 tonnes: the largest contribution (1,456 tonnes) came from the Japanese sea cucumber fishery, followed by Japanese kelp (579 tonnes), while all other species combined accounted for 465 tonnes. Potentially, the harvest of Japanese kelp could be increased to 19,200 tonnes,

Table 11.4. Current status of the most significant commercial invertebrate and algal resources in the coastal zone of Aniva Bay

No	Commercial species	Species	Area of commercial aggregations, km ²	Commercial biomass, tonnes	Fishing/mariculture
1	Japanese scallop	<i>Mizuhopecten yessoensis</i>	58	3,453	no/yes
2	Sakhalin spisula	<i>Spisula sachalinensis</i>	29	10,470	yes/no
3	Pacific clam	<i>Ruditapes philippinarum</i>	0.0003	38.8	yes/no
4	Giant oyster	<i>Magallana gigas</i>	0.19	6.32	yes/no
5	Whelk	<i>Buccinum bayani</i>	–	1,613	yes/no
6	Japanese cucumaria	<i>Cucumaria frondosa japonica</i>	–	2,638	yes/no
7	Gray sea urchin	<i>Strongylocentrotus intermedius</i>	1.55	662	yes/yes
8	Far Eastern sea cucumber	<i>Apostichopus japonicus</i>	5.2	12	no/yes
9	Grass shrimp	<i>Pandalus latirostris</i>	–	140	yes/no
10	Kamchatka crab	<i>Paralithodes camtschaticus</i>	5,837.8	336.1	no/no
11	Horsehair crab	<i>Erimacrus isenbeckii</i>	7,122.6	1,145	yes/no
12	Japanese kelp	<i>Saccharina japonica</i>	10.63	59,400	yes/yes
13	Tobuchinskaya ahnfeltia	<i>Ahnfeltia fastigiata</i> var. <i>tobuchiensis</i>	3.27	9,150	no/no

while the catch of spisula could reach 524 tonnes. It is noteworthy that the two commercial species with the highest estimated biomass are the least exploited due to a lack of demand. The results of the grass shrimp fishery are consistent with the low level of recorded biomass for this species in certain areas of the coastal zone of Aniva Bay surveyed in 2022 and 2023.

It is important to note that the harvest potential for benthic invertebrate resources is an order of magnitude greater than the current catches. For economic reasons, their exploitation may never become profitable. In this situation, the development of mariculture becomes advisable.

In our opinion, among the coastal fishery targets of benthic invertebrates and algae in Aniva Bay, the Japanese scallop, Far Eastern sea cucumber, oyster and Japanese kelp have the greatest potential to become and remain targets for commercial mariculture, with scallop being the primary target species. We believe that the current status of resources and the habitat of mariculture species should be monitored annually, as the final outcome will depend on this, among other factors. For example, Japanese scallop resources remained scarce with low biomass levels for many years from 2010 onwards, yet over the past five years, juvenile recruitment has increased, which was unexpected, given that studies were not regularly conducted. At the time of the 2022 survey, specific abundance indicators were 2–3 times higher than in 2010, while the biomass differed by only about 50 %. In

our opinion, the total and commercial biomass of the Japanese scallop in Aniva Bay could increase by several times in the coming years, provided that efforts to combat IUU fishing continue.

According to the results of a diver survey conducted in Aniva Bay in 2022, the distribution area of the Japanese scallop was 58.1 km², which is close to the 2010 estimate (approximately 63 km²). The general pattern of shellfish distribution has not changed over a 12-year period due to the persistence of bottom sediment distribution and hydrological conditions in the near-bottom layer (Fig. 11.5). The density of mollusc settlements in 2022 and 2010 varied within approximately the same range (0.02–1.2 specimens/m²), but the mean values differed significantly (0.24 and 0.15 specimens/m², respectively) (Galanin et al., 2019; Chernyshova et al., 2022). Meanwhile, the average specific biomass values were practically identical: 45 and 45.8 g/m², respectively.

The total biomass of the Japanese scallop in Aniva Bay recorded in 2022 was 3,453 tonnes, while the commercial biomass was 2,498 tonnes. Compared to 2010, when the total biomass was 2,560 tonnes and the commercial biomass was 2,460 tonnes, an increase of about 855 non-commercial tonnes can be observed. The results of the 2022 analysis of the size composition of the Japanese scallop confirmed a high proportion of juveniles (42 %) in samples collected during the survey. The scallop shell height ranged from 67 to 181 mm and averaged 126 ± 1.54 mm. The mean height of commercially harvested individuals was 145.9 ± 1.07 mm. The frequency

Table 11.5. The catch and use of aquatic biological resources in the coastal zone of Aniva Bay and the East Sakhalin Subzone in 2023

No	Commercial species	Catch in Aniva Bay, tonnes	Catch in the East Sakhalin Subzone, tonnes	Total allowable catch or recommended catch in the East Sakhalin Subzone, tonnes	Use of total allowable catch or recommended catch, %
1	Scallop (Japanese scallop)	0	15	18.1	83
2	Sakhalin spissula	15.9	15.9	524	3
3	Pacific clam	0	0	0.221	0
4	Giant oyster	0	0	0.1	0
5	Whelk	107.2	745	780	95.5
6	Japanese cucumaria	1,456	2,057	2,868	72
7	Gray sea urchin	211	211	211	100
8	Far Eastern sea cucumber	SF*	SF*	0.2	0
9	Grass shrimp	22	22	28	79
10	Horsehair crab	109	109	115	95
11	Japanese kelp	579	579	19,200	3

* SF – fishing for scientific research and control purposes

distribution of molluscs by shell height indicates a high proportion of overgrown individuals, which, in 2023 and 2024, should add to the commercial portion of the aggregations (Figure 11.6).

Owing to its broad latitudinal distribution, the Japanese scallop inhabits a wide range of temperature conditions within its range. The distance from the southern boundary of the range near the northern coast of the Korean Peninsula to its northern boundary in the northwestern part of the Tatar Strait of the Sea of Japan is several thousand kilometres (Skalkin, 1966, 1971; Ignatyev et al., 1976; Kijima et al., 1984; Japanese Scallop, 1986; Shpakova, 2004; Dulenin, Dulenina, 2012). As a result, clear latitudinal zonation is observed in the distribution of settlements.

Water temperature in the northernmost habitats of the Japanese scallop, in Tabo Bay of the Tatar Strait, ranges from -1.7 to 16.1 °C (Pishchalnik, Bobkov, 2000). In the southern parts of the range (Mutsu Bay, Honshu Island), water temperature does not fall below $4-6$ °C in winter and rises to 24 °C in summer (Japanese Scallop, 1986). Off the coast of Sakhalin's Aniva Bay, the water temperature decreases to -1 °C in winter, while in August it warms to $7-10$ °C at depths of $15-20$ m.

The thermal regime of the water area affects the rate of biological processes (Sukhanov, Kafanov, 1983; Silina et al., 2000; Kim, Lozhkin, 2021), including growth rate and survival, especially in the first years of life (Tibilova, Bregman, 1975; Levin, 1986; Chernyshova et al., 2022). The Japanese scallop from the southern habitats is characterised by higher growth rates and larger

average shell sizes in the first years of life compared with individuals from the northern habitats. For example, the highest growth rates during the first year of life were recorded for scallops from Mutsu Bay (Honshu), reaching 84.3 ± 2.6 mm, and for scallops from Lake Saroma (Hokkaido), reaching 60 ± 4.6 mm (Table 11.6) (Japanese scallop, 1986; Northern Fishes, 2003).

In Sakhalin Region, the South Kuril Strait ranks first in terms of thermal conditions, followed by Alexandrovsky, Aniva and Terpeniya Bays (Pishchalnik, Bobkov, 2000). In Aniva Bay, the Japanese scallop is somewhat slow-growing and at age four may not reach the commercial size threshold of 120 mm in shell height (Table 11.6) (Sergeenko, Chernyshova, 2013; Galanin et al., 2019; Chernyshova et al., 2022).

The longer duration of the warm period in southern habitats also means that the Japanese scallop reaches marketable size earlier (Grigorieva, 2020). Whereas in the warm waters of South Primorye the scallop reaches commercial size in 2–3 years, in the colder waters of Aniva Bay, it takes 1–2 years longer (Grigorieva, 2020; Chernyshova et al., 2022). In South Primorye, the scallop grows by an average of 50 mm during its first year of life, whereas in Terpeniya Bay, the mean shell height of one-year-old juveniles is about 28.5 mm (Tibilova, Bregman, 1975; Japanese scallop, 1986; Chernyshova, Prokhorova, 2018; Chernyshova et al., 2022). Knowledge of the developmental features of the scallop inhabiting a particular area and influenced by local conditions becomes especially important when considering the possibilities for commercial cultivation of the mollusc.

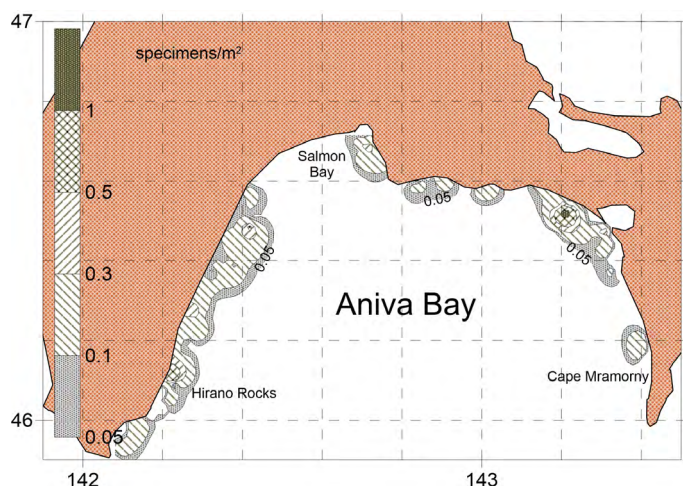


Fig. 11.5. Distribution of the Japanese scallop *Mizuhopecten yessoensis* in Aniva Bay, June–July 2010 (specimens/m²)

Given the changing thermal conditions in the coastal zone of Aniva Bay over the past ten years, the growth and development indicators of the Japanese scallop have been changing, which also affects production during commercial cultivation.

Mariculture of invertebrates and algae in Aniva Bay and its prospects

To date, 17 fish-breeding sites have been established in Aniva Bay and are under long-term lease (25 years) to several mariculture farms (Fig. 11.7). According to official information from the Sakhalin–Kuril Territorial Administration of the Federal Agency for Fisheries, only seven farms were operating in 2024, producing 287,097 tonnes of harvested products.

The species harvested at the fish-breeding sites included the grey sea urchin (85,632 tonnes) and the Japanese scallop (201,465 tonnes). During the first few years, mariculture farms focused on developing techniques for producing seed material, and from 2022 to 2024 they reached full production capacity. Over the past three years, an average of 42.45 million juvenile Japanese scallops and 0.51 million juvenile Far Eastern trepang have been released at the fish-breeding sites.

In Aniva Bay, this was the first harvest of mariculture products since the start of official operations in 2019, when the first official release of seed material took place (Table 11.7). Among the first cultivated mariculture species were the Japanese scallop and the Far Eastern trepang: 250 thousand and 90 thousand juveniles, respectively, were released at depths of 17–33 m at the fish-breeding sites.

In 2020 and 2021, the grey sea urchin and Japanese kelp also started to be cultivated. The amount of seed material released for these two species was two orders of magnitude greater than that for the Japanese scallop and the Far Eastern trepang. This was made possible by the specificities of the cultivation techniques permitted at that time. Its main distinguishing feature was the use of larvae or spores, rather than viable juveniles, as seed material, which settle on the bottom of the fish-breeding sites. However, as early as 2022, the practice of using grey sea urchin larvae as seed material was discontinued. As a result, since 2022, the grey sea urchin has no longer been a priority mariculture species at mariculture farms in Aniva Bay. Standard biotechnological methods for

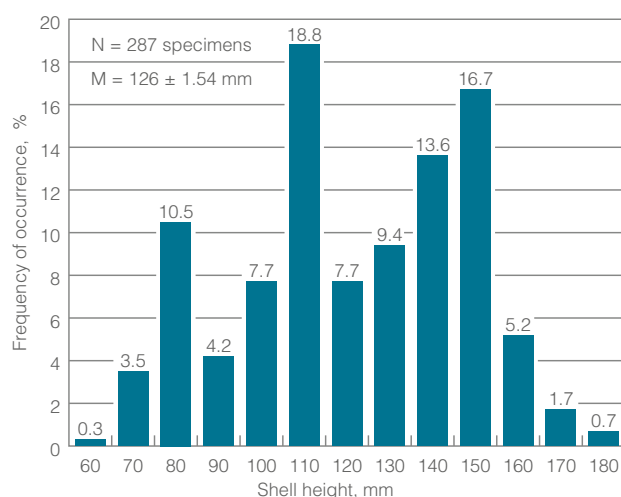


Fig. 11.6. Frequency distribution of the Japanese scallop *Mizuhopecten yessoensis* by shell height in Aniva Bay in 2022

Table 11.6. Growth indicators of the Japanese scallop during their first years of life in the Sakhalin–Kuril region based on 2012–2020 data

Age, years	South Kuril Strait (2000–2011 data)	Alexandrovsky Bay	Terpeniya Bay	Aniva Bay (2000–2011 data)
1	$\frac{39.6 \pm 2.5}{39.6}$	$\frac{37.5 \pm 0.5}{37.5}$	$\frac{28.5 \pm 2.1}{28.5}$	$\frac{30.1 \pm 2.3}{30.1}$
2	$\frac{78.3 \pm 2.8}{38.7}$	$\frac{69.4 \pm 0.4}{31.9}$	$\frac{68.9 \pm 0.9}{40.4}$	$\frac{61.4 \pm 0.8}{31.4}$
3	$\frac{109.2 \pm 1.5}{30.9}$	$\frac{98.2 \pm 0.3}{28.8}$	$\frac{102.3 \pm 1.3}{33.4}$	$\frac{89.4 \pm 0.9}{28.0}$
4	$\frac{132.4 \pm 1.2}{23.2}$	$\frac{119.2 \pm 0.4}{21.0}$	$\frac{123.3 \pm 0.6}{21.0}$	$\frac{114.3 \pm 0.5}{24.9}$

Note: the values above the line indicate average shell height (mm), values below the line indicate annual increase in shell height (mm).

producing viable juveniles of echinoderms (trepang and the grey sea urchin) require substantial investment in the construction of industrial facilities with controlled conditions. Therefore, the cultivation of the grey sea urchin and trepang has not yet been developed in the Sakhalin–Kuril region (Instructions on Technology ..., 2011). The mariculture experience with Japanese kelp in Aniva Bay is similar to that of the grey sea urchin. From 2020 to 2023, a method applied in Primorsky Region to restore kelp fields in areas where they had previously existed but subsequently declined was used (Krupnova, 2011, 2022, 2024). Recent testing of mariculture results for the grey sea urchin and Japanese kelp at a reference fish-breeding site in the northern part of Aniva Bay showed the ineffectiveness of using the larvae and spores of these species as seed material (Galanin et al., 2025). A similar situation is likely at other fish-breeding sites, as releases indicate that several hundred tonnes of Japanese kelp should be produced annually and potentially harvested between 2022 and 2024. However, the statistical data do not confirm this. We believe that errors were already made at the organisational stage in selecting species and cultivation techniques that were not aligned with the environmental conditions of specific fish-breeding sites. For example, Japanese kelp cannot be cultivated at a depth of 30 m; the grey sea urchin, released for pasture cultivation within a fish-breeding site at the larval stage, will be found far beyond them by the time of settlement (after 30 days) (Buznikov, Podmarev, 1975; Buyankina, 1977; Viktorovskaya, Sedova, 2000; Dubrovsky, Sergeenko, 2002; Kulikova, 2003; Gabaev, 2008; Ponyrko, Krupnova, 2021). Less obviously, but with similar outcomes, viable juveniles of the Japanese scallop, trepang, or the grey sea urchin may be released; however, if they are not provided with sufficient food in a fish-breeding site, they will either

perish or attempt to migrate elsewhere (Temporary Instruction ..., 1987; Silina et al., 1994; Gayko, 2004; Kovacheva, Chertoprud, 2014; Turabzhanova, 2016).

It is important to emphasise that, in accordance with scientific recommendations, all fish-breeding sites in Aniva Bay were established for the commercial cultivation of the Japanese scallop using industrial or pasture-based methods. This was partly due to the fact that the entire coastal zone from the shoreline to 2–3 km offshore is occupied by fishing sites. Under the current legislation, the overlapping of sites is not permitted. Cultivation of the Far Eastern trepang and the grey sea urchin, the mariculture biotechnological methods for which require the creation of artificial conditions in recirculating aquaculture systems for broodstock spawning and for obtaining and rearing larvae and juveniles to a viable state, is an effective but costly technique (Sukhin, 2006, 2008). In our region, the cost of heating water to 16 °C, required for broodstock spawning and juvenile rearing, is extremely high due to the high cost of energy. The Japanese scallop, the giant oyster and Japanese kelp do not require such conditions (Shpakova and Galanin, 2008; Brykov and Kolotukhina, 2009; Kondratieva, 2016; Savchuk, 2023). At the same time, biotechnological practices in oyster and kelp mariculture continue to develop, and in order to increase the predictability of farm operations, it is also advisable to transfer certain stages of their cultivation to recirculating aquaculture systems.

At present, the actual use of fish-breeding sites in Aniva Bay for the cultivation of Japanese kelp and the grey sea urchin is opportunistic, as current legislation makes it difficult to ensure minimum cultivation volumes. In the absence of a sufficient amount of available seed material in the form of juvenile Japanese

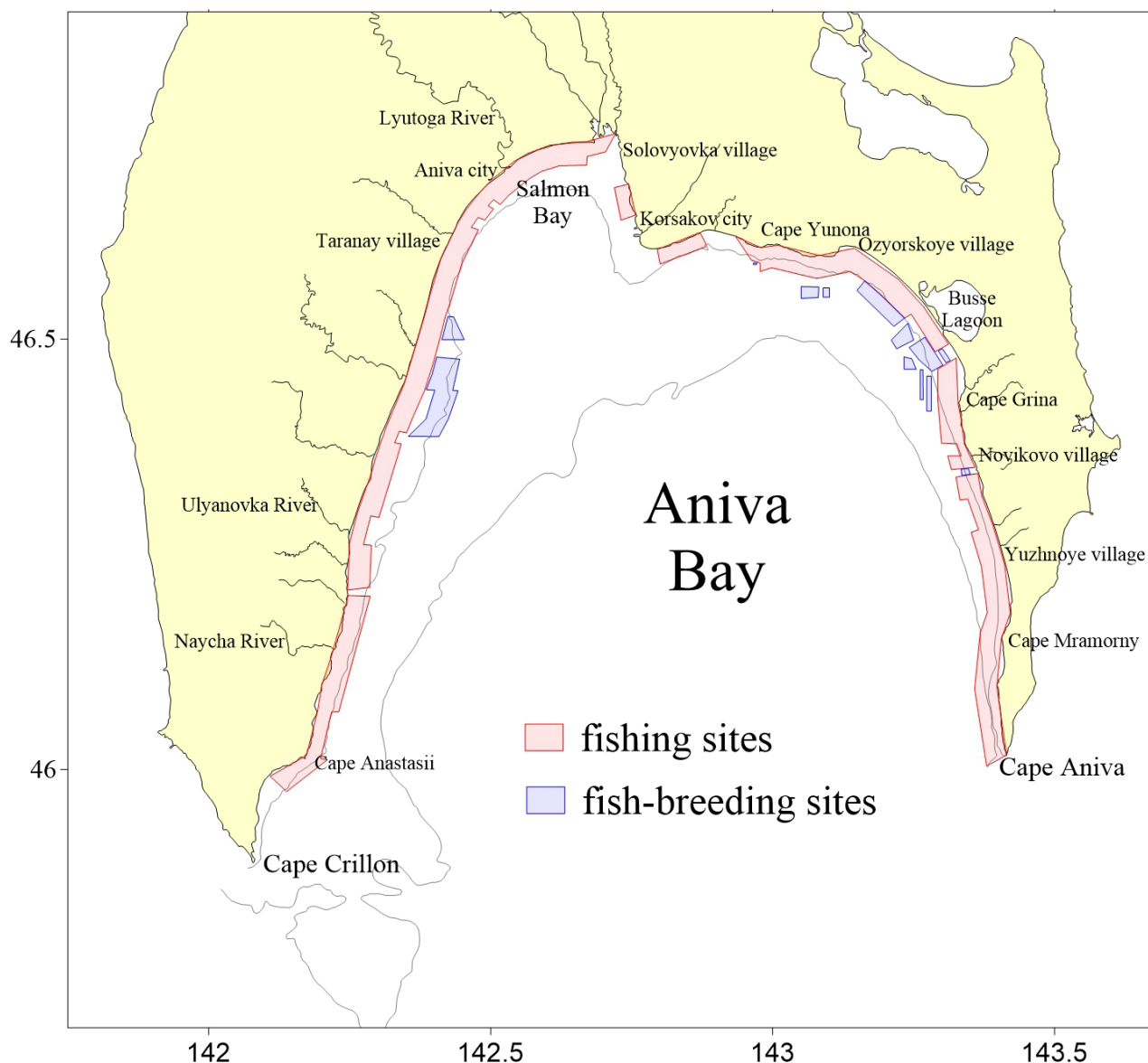


Fig. 11.7. Distribution of fishing and fish-breeding sites in Aniva Bay

scallop, mariculture farms, in an effort to sustain operations, engaged in inefficient activities from the standpoint of production, at their own risk.

The general scheme of commercial cultivation of the Japanese scallop in the Sakhalin–Kuril region in general, and in Aniva Bay in particular, is shown in Fig. 11.8. This scheme is largely based on the experience of Japanese and Chinese mariculture operations (Northern Fishes ..., 2003; Chen et al., 2006).

Cultivation of the Japanese scallop is usually carried out using either cage-based or bottom (pasture-

based) methods (Temporary Instruction ..., 1984, 1987; Brykov, Kolotukhina, 2009; Instruction on Technology ..., 2011). Although more costly, cage-based cultivation has advantages over bottom farming, including higher survival rates of cultured organisms and greater product availability compared to pasture-based cultivation. The latter method is less costly and does not require constant efforts to protect the crop, except in cases of poaching. Juveniles of natural origin (collected in their natural habitat using collectors) or artificial origin (obtained from broodstock under controlled conditions in recirculating aquaculture

Table 11.7. Release of mariculture (aquaculture) species at fish-breeding sites in Aniva Bay, million individuals

No	Facility	2019	2020	2021	2022	2023	2024
1	Japanese scallop	0.25	0.02	0.00	63.06	36.63	27.67
2	Gray sea urchin	0.00	2,100.00	9,660.70	0.00	0.00	0.00
3	Far Eastern sea cucumber	0.09	0.00	0.00	0.55	0.68	0.30
4	Japanese kelp	0.00	73,500.00	2,994.00	573,648.00	204,290.64	0.00

systems) are released either onto the bottom within fish-breeding sites or into cages installed in hydrotechnical structures at sea (Fig. 11.9).

At the end of the cultivation cycle, defined by the available cultivation technologies and economic feasibility, the product is harvested and can be marketed commercially.

Overall, the general scheme for organising commercial mariculture of the Japanese scallop appears relatively simple. However, the individual stages are always modified depending on specific environmental conditions and the biological characteristics of the cultured species. For example, in Aniva Bay, which can be considered an open and relatively cold-water area, spawning of the

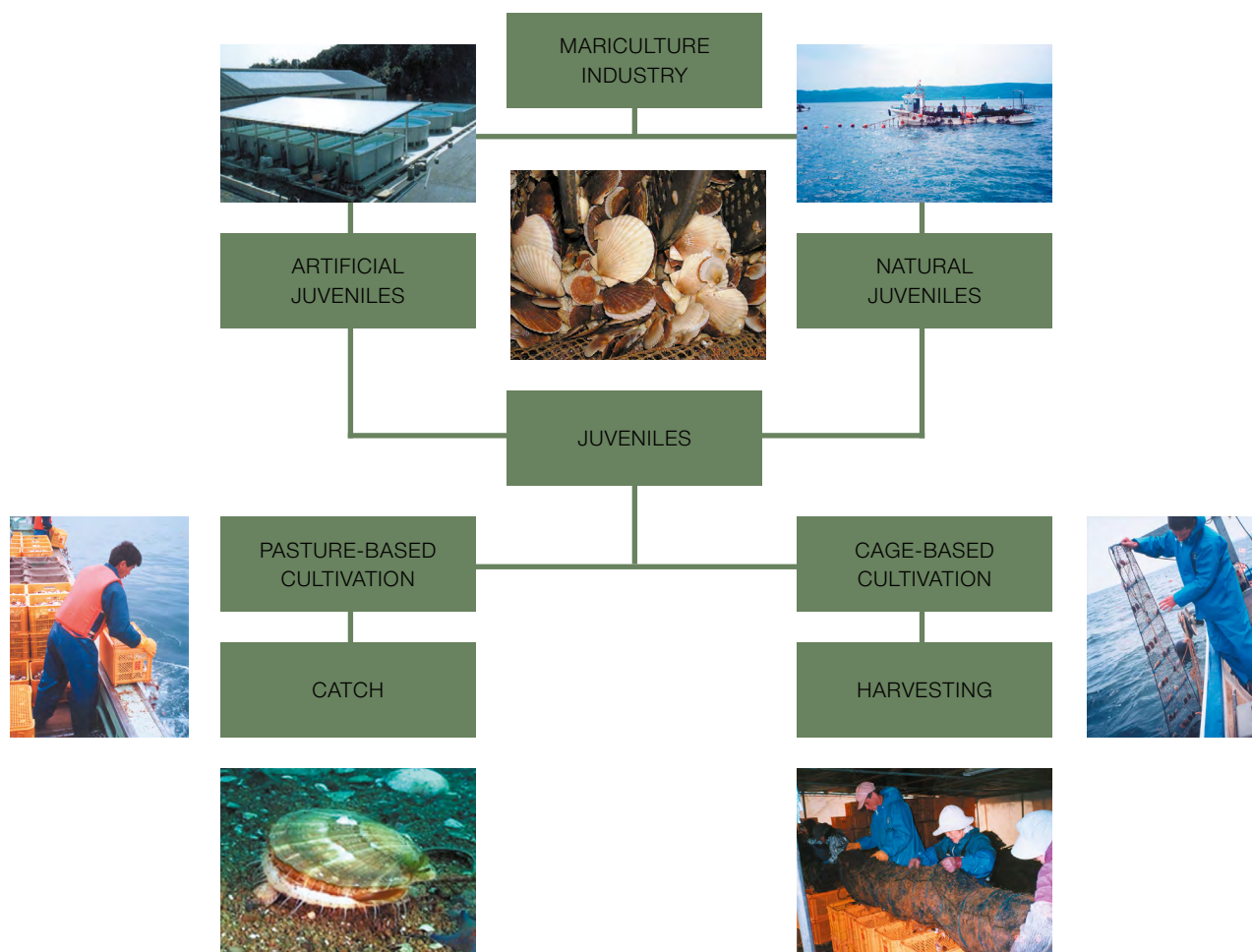


Fig. 11.8. General scheme of commercial mariculture for the Japanese scallop

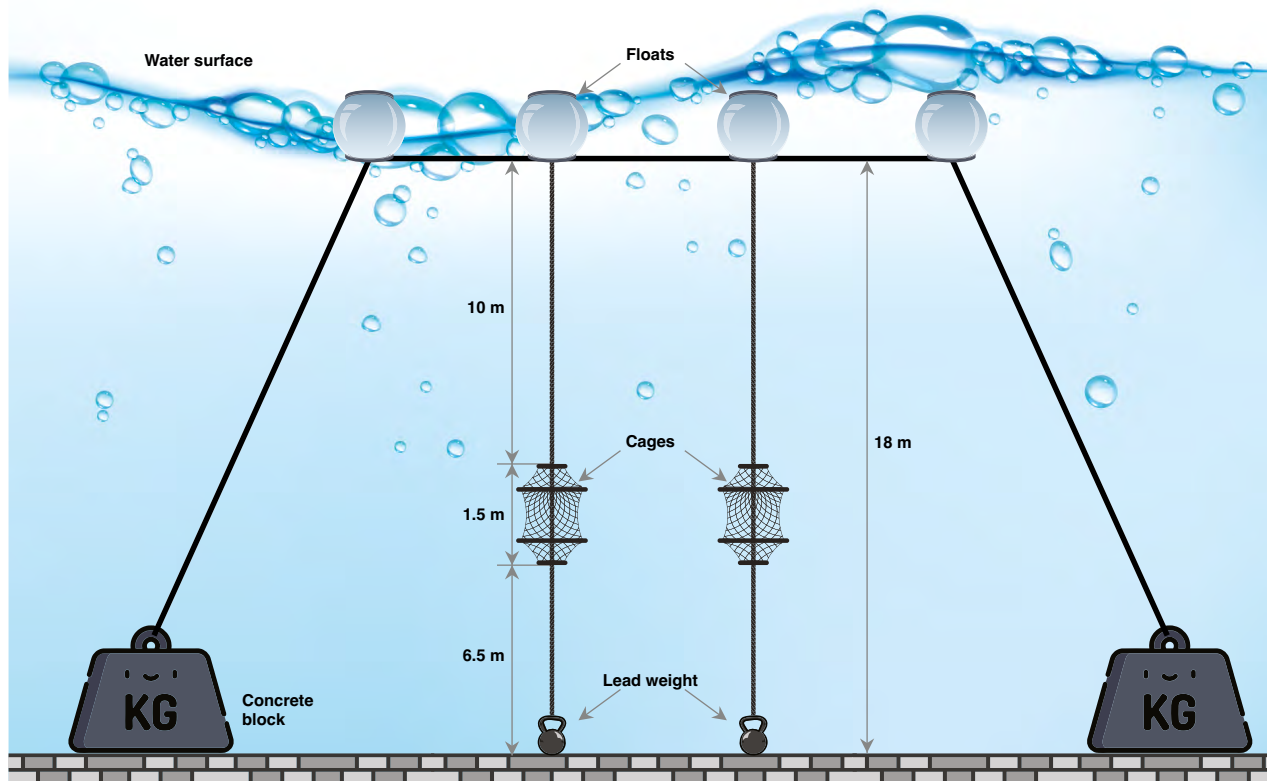


Fig. 11.9. Schematic diagram of a hydrotechnical structure with cages

Japanese scallop occurs approximately one month later than off the northern coast of Hokkaido Island and in Primorsky Region (Prokhorova and Galanin, 2016; Chernyshova and Prokhorova, 2018; Galanin et al., 2019; Chernyshova et al., 2022). Spat collectors are deployed in June, and in August mass settlement of Japanese scallop larvae occurs on them. By mid-October, the spat reaches an average size of about 10 mm, which necessitates continued rearing right in the collectors, usually until the following June. Seed material (in the form of viable juveniles) can be obtained within each fish-breeding site established in Aniva Bay; however, the quality and quantity of these juveniles may vary considerably. It is important to note that the amount of spat settling on the collectors at one location is variable and strongly depends on prevailing environmental conditions (Prokhorova and Galanin, 2016; Chernyshova and Prokhorova, 2018). Our experience indicates that between 50 and 1,000 spat specimens may be collected per bag-type collector (approximately 1 m²); however, the highest-quality juveniles are obtained in Busse Lagoon and in the estuarine waters of Aniva Bay (Fig. 11.10).

According to long-term data, the average number of spat per collector (bag) in the lagoon is about 250 specimens, and by November 1, the juvenile shell height reaches a conditionally viable size of 15–20 mm, rather than 8–10 mm, as observed in Aniva Bay (Prokhorova and Galanin, 2016; Chernyshova and Prokhorova, 2018). The possibility of dispersing juveniles at an early juvenile stage reduces production costs, since leaving collectors in place until the following spring would require additional maintenance expenditures.

In the future, juveniles collected in Busse Lagoon should be partially used to maintain the lagoon's broodstock, while the remainder should be distributed within Aniva Bay in areas suitable for pasture-based cultivation (Prokhorova and Galanin, 2016). We believe that, to maintain natural reproduction of the Japanese scallop in Busse Lagoon, it is sufficient to disperse 500,000 spat specimens aged 3–4 months or 300,000 one-year-old juveniles. The majority of Japanese scallop juveniles collected on the collectors in Busse Lagoon should be used as seed material to

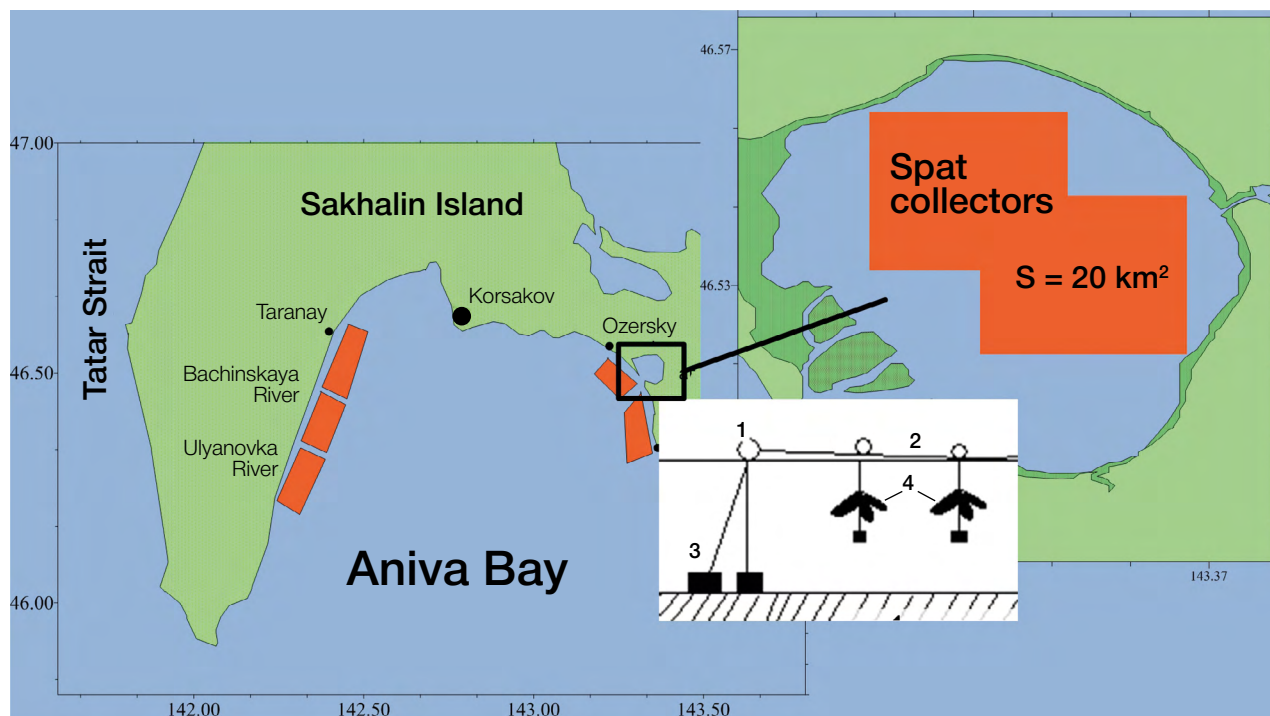


Fig. 11.10. Quantitative potential for producing Japanese scallop juveniles in Busse Lagoon using bag-type collectors Elements of the hydrotechnical structure: 1 buoy (control and monitoring element), 2 'backbone' rope with floats to keep the installation afloat, 3 weight to secure the installation in place, 4 bag-type collectors connected in groups of three

support commercial mariculture objectives within pasture-based or cage-based cultivation systems. Then, 10 km² of pasture area would be required to settle the remaining 99.5 million juveniles at a density of 10 specimens/m². Considering the four-year cultivation cycle, pasture-based cultivation areas would need to be increased fourfold (as juveniles are dispersed in a new area each year), resulting in a total area of approximately 40 km².

At present, the total area of fish-breeding sites in Aniva Bay is approximately 100 km², which, in our view, is already close to the upper acceptable limit. This means that the production of seed material must be increased either through the installation of new collectors in Aniva Bay or by sourcing it from other areas.

Assuming that the entire area is used and planned for pasture-based cultivation of the Japanese scallop, juveniles would need to be dispersed annually over an area of 25 km². Based on the minimum stocking density, approximately 250 million juveniles would be required for a single stocking of this area. At higher stocking densities of 50 specimens per m², as practiced in Primorsky Region, the demand for seed material will increase (Brykov and Kolotukhina, 2009). Using

one-year-old juveniles as seed material would increase survival rates, but production costs would also rise. It is important to emphasise that the annual dispersal of juveniles over one quarter of the total area of a hypothetical mariculture operation must be ensured. A rough calculation indicates that the annual minimum production of the Japanese scallop in Aniva Bay could already reach 2,500 tonnes. In reality, only 201 tonnes were harvested in 2024.

Thus, we believe that the current stage of mariculture in Aniva Bay represents a formative period of trial and error, after which only those with sufficient expertise will remain among the initial participants. In our view, commercial mariculture of the Japanese scallop remains a priority, without precluding the successful testing of other approaches.



Divers at Cape Anastasia (photo by A. Semenov)

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APPENDIX

Crillon Peninsula (eastern part). A Photographic Chronicle of the Twentieth Century 254

(from the collection of I. Samarin)

The photographs presented reflect life on Crillon throughout the twentieth century, from the period preceding the Japanese occupation of Sakhalin, through the era of the Karafuto governorship (1905–1945), and into the subsequent years when the southern part of the island became part of the Soviet Union.

A special place is given to images depicting the working lives of the residents, their everyday activities and crafts. Photographs taken in the city reveal streets and courtyards from a period when Japanese culture and infrastructure gradually came to shape the appearance of the region.

The collection also includes photographs from the Soviet period, capturing a new chapter in the history of Crillon and the southern part of the island, a time of reconstruction and development that followed the years of war and devastation.

Cape Anastasia also appears among the photographs. Its outlines, fading into the haze, seem untouched by the passage of time. Everything appears unchanged, the slopes, the sea, the horizon. Here time itself moves more slowly, carefully preserving the memory of people and events that have left their mark on this land.

Crillon Peninsula (eastern part). A Photographic Chronicle of the Twentieth Century



Bridge over the Rutaka River, now Lyutoga River, in the town of Rutaka, now Aniva. 1926 to 1927



A street in the town of Rutaka (now Aniva).
Date unknown



A school in the town of Rutaka (now Aniva).
1915–1925



A street in the settlement of Dorokawa, later known as Ulyanovskoye during the Soviet period.
1925



A street in the village of Uryu/Uryuu (later Kirilovo). 1925



Coastal fishing at the mouth of the Tisia River (now Anastasia River). 1933



Carrying fish in moko boxes. 1901



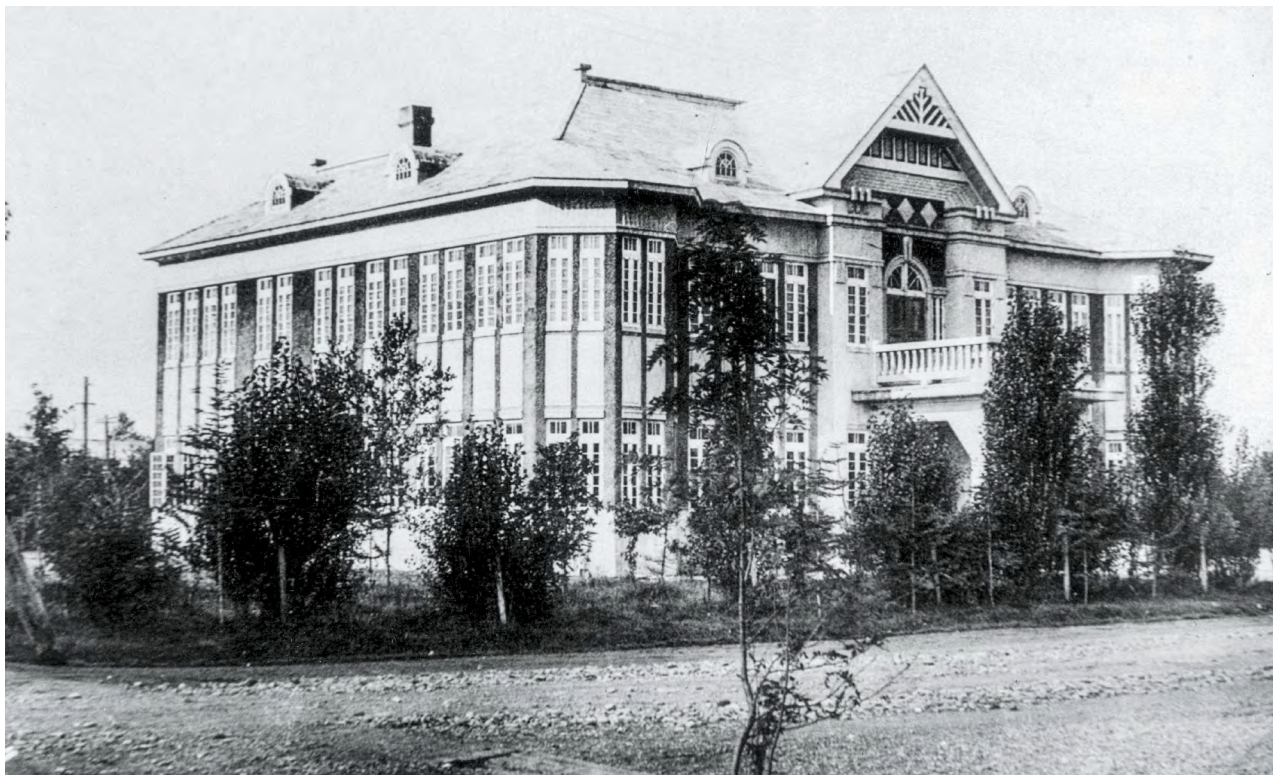
Shime-dou press for fish fertiliser. 1901



A street in the town of Rutaka (now Aniva). 1933



A hiking trail on Cape Vennoch (Kanabeevka), built by Japanese sappers in 1906 to 1907. Photograph from the 1930s



City Hall of Rutaka, now Aniva. 1920–1945



Brick oven and cabbage drying shed. 1901

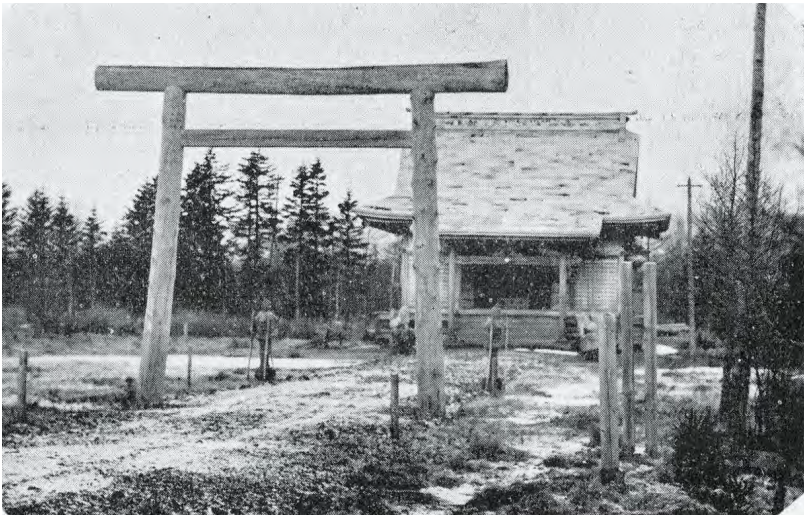
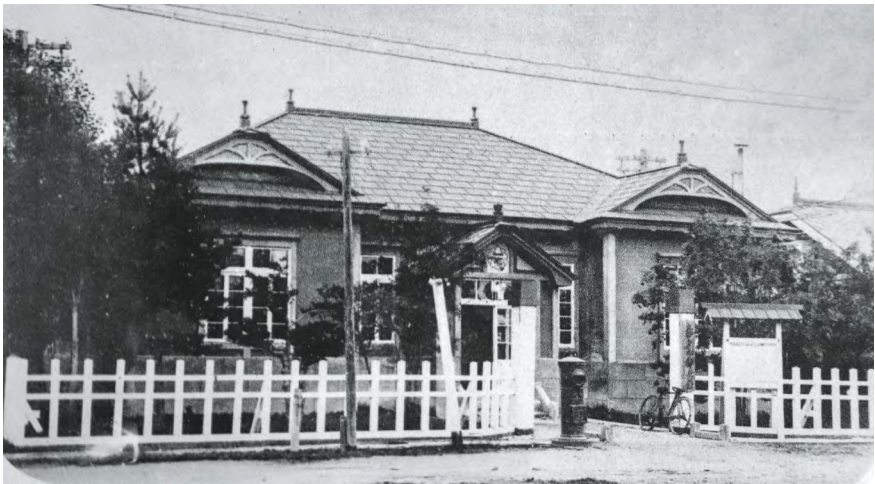


A stack of logs on the Rutaka River, now Lyutoga River, intended for shipment to paper mills in Toyohara, now Yuzhno-Sakhalinsk, and Odomari, now Korsakov. Date unknown



Log transportation at logging sites. Date unknown

Post office in the town of Rutaka
(now Aniva). 1920–1925



Rutaka Hachiman Jinja Shinto temple
dedicated to Hachiman, god of war, in Rutaka
(now Aniva). 1930–1934



Timber rafting on the Rutaka River
(now Lyutoga River). Date unknown



Coast south of the mouth of the Tisia River
(now Anastasia River). 1930–1935



The coast of 'Western Vannaya'
near the mouth of the Tisia River,
now Anastasia. 1933



A street in the town of
Rutaka (now Aniva).
Date unknown



Timber rafting on the Furue River (now Kura River). 1925–1930



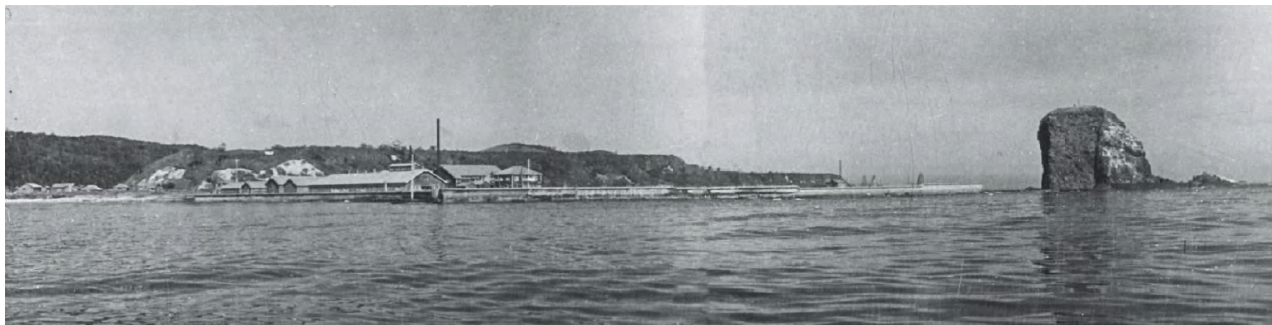
A dam for timber rafting on the Furue River (now Kura River). 1924



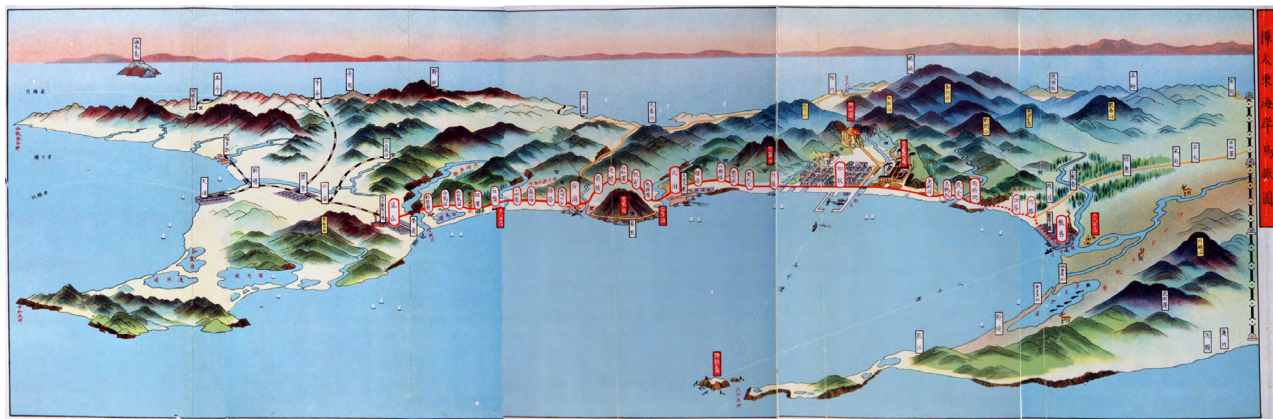
Logging in Karafuto. 1920s (Yoichi Library Collection, Hokkaido)



Memorial stone 'shotokuhi' near the mouth of the Naicha River. Erected in recognition of the merits and in honour of Eguchi Harunojo. Date on the stone: June 1934. *Contemporary photograph*



Cape Anastasia. Soviet times. 1945–1950



Japanese map of the Karafuto governorate. Birds-eye view of Terpeniya Bay. Aniva Bay on the left. Date unknown



A fishing schooner in Morzh Bay. Nishi Notoro Misaki (Crillon) lighthouse in the distant background. 1930s (*Yoichi Library Collection, Hokkaido*)



Boiler for cooking fish fertiliser 'kabuto gata kama' (helmet-shaped boiler) in the Krestyanovka tract in the Kura River valley. 1988. (*photo by A. Samarin*)



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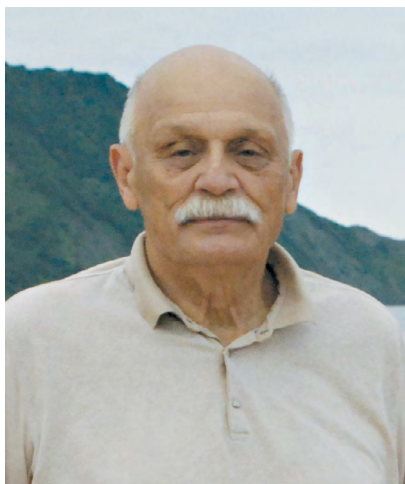
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The Crillon Peninsula:

PAST AND PRESENT ON THE SHORES OF ANIVA BAY

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Layout, design A. Alekseev

Translated from the Russian original: Полуостров Крильон:
история и современность на берегах залива Анива / отв. ред. И. И. Гордеев. —
Москва: Паулсен, 2025. — 272 с. — DOI: 10.61726/3321.2025.77.37.001.
ISBN 978-5-98797-466-7.

Translated by UC Rusal
Maksim Isaev
Samira Abdurazakova

The book has been prepared by Non-Profit Charitable Foundation “Support for Bioresearch ‘BIOME’”

Signed for printing: April 30, 2026. Format 84 × 108/16.
Coated paper. Print run: 50 copies.

ISBN 978-5-6056034-0-5



9 785605 603405 >

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