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Original article

Impact of Tide on Hydrological Conditions near the La Perouse Strait Based on Instrumental Measurements

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Abstract

Purpose. This study aims to investigate the influence of the tidal-driven Okhotsk Sea water inflow through the La Perouse Strait on the hydrological conditions along the western coast of the Krillon Peninsula (Southwestern Sakhalin) during the warm season.

Methods and Results. The material for investigation is based on the instrumental measurement data on sea current velocities, sea level fluctuations, and seawater temperature and salinity near the Gorbusha River mouth collected in May – October 2024. The results of oceanographic surveys performed in the coastal zone (up to the 20 m isobath) along transects perpendicular to the coast were also used. Additionally, the data on current velocities, water temperature, and salinity collected at the autonomous buoy station “Astarta”, located in the central part of the La Perouse Strait (May – June 1999), as well as the meteorological observation data from the Nevelsk weather station (May – October 2024) were utilized. Against the backdrop of diurnal fluctuations, a semi-monthly cyclicity of the Okhotsk Sea water intrusion was identified: a 10–11-day phase of intensified inflow to the Southwest Sakhalin shelf during periods of tropical tides, followed by a 3–4-day period of marked weakening during equatorial tides. Standard methods of statistical and harmonic analysis were applied to the observation data.

Conclusions. The area off the western coast of the Krillon Peninsula is significantly influenced by the Okhotsk Sea water entering through the La Perouse Strait, driven by strong diurnal tidal currents. The diurnal temperature fluctuations can reach 10 °C, and salinity variations can reach 2 psu. An unexpected finding of this study was the identification of not only lower salinity but also higher temperature in the Okhotsk Sea water compared to those of the West Sakhalin Current, which flows southward along the southwestern coast of Sakhalin.

Keywords: La Perouse Strait, water exchange, cold water belt, seawater temperature, salinity, current, tide, West Sakhalin current

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Introduction

Water exchange through the La Perouse Strait (defined here as the strait between the southwestern tip of Sakhalin Island, Cape Krillon, and the northernmost point of Hokkaido Island, Japan, Cape Soya) plays a crucial role in shaping the hydrological regime of the adjacent waters of the Sea of Japan and the Okhotsk Sea. During the warm season, warm, saline water from the Sea of Japan flow through the strait, giving rise to the Soya Current (an Okhotsk branch of the warm Tsushima Current). In contrast, during the cold season, an inflow of the Okhotsk Sea water is observed along the western coast of the Krillon Peninsula, characterized by lower temperatures and salinity compared to the Sea of Japan waters [1].

Water exchange processes through the La Perouse Strait, characterized by significant seasonal variability, are strongly influenced by tidal currents, which reach anomalously high velocities of up to 3 knots [2–4]. In study [5], analysis of seawater temperature measurements, obtained by attaching an instrument to a set net near Cape Kuznetsov, revealed significant fluctuations in this parameter caused by tidal influences. Studies [5, 6] established a correlation between the extent of the cold water belt off the western coast of the Krillon Peninsula (sometimes referred to as the "Makarov Spot", named after the renowned Russian naval commander and oceanographer who first described its formation mechanism) and tidal phases, with notable expansion during tropical tides and contraction during equatorial tides. In regions dominated by diurnal tides, semi-monthly variations in sea level fluctuations are linked not to the relative positions of the Moon and Sun (as during syzygy and quadrature) but to changes in the Moon's declination as it approaches the tropics or the equator.

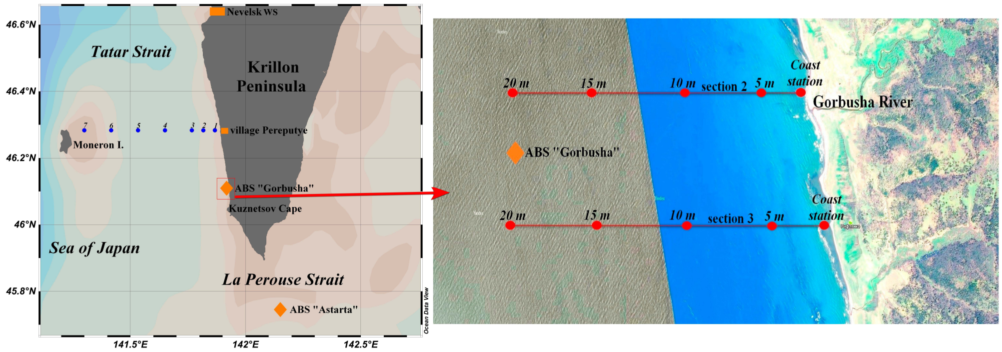
Until recently, the specific pathways of the Okhotsk Sea water propagation along the southwestern coast of Sakhalin Island under tidal influence, as well as its characteristics and differences from the surrounding Sea of Japan waters, had not been described. Instrumental measurements of sea current velocities, water temperature, and salinity, conducted by the Sakhalin Branch of "VNIRO" from May to October 2024 near the Gorbusha River mouth (approximately 10 km north of Cape Kuznetsov and 30 km from the La Perouse Strait; Fig. 1), have provided new insights into these processes.

Thus, the study aims to investigate the influence of the tidal-driven Okhotsk Sea water inflow through the La Perouse Strait during the warm season on the hydrological conditions along the western coast of the Krillon Peninsula, Southwestern Sakhalin.

To achieve this goal, the following tasks were addressed:

– analyze instrumental measurements of sea level fluctuations and current velocities near the Gorbusha River mouth (western coast of the Krillon Peninsula) to determine the role of tidal components in their variability;

– examine variations in temperature and salinity during ebb and flood tides using instrumental measurements and coastal oceanographic surveys to identify the role of the Okhotsk Sea water in shaping hydrological conditions in the area;



F i g. 1. Map of the study area. Diamonds indicate the locations of autonomous buoy stations, and dots represent stations along the standard oceanographic section from Pereputye village to Moneron Island (*on the left*) and coastal sections 2 and 3 (*on the right*)

– analyze historical instrumental measurements to identify the presence of the Okhotsk Sea water in the La Perouse Strait during tides and compare its temperature and salinity with oceanographic parameters along the western coast of the Krillon Peninsula;

– determine the thermohaline characteristics of the West Sakhalin Current (WSC) and compare them with those of the Okhotsk Sea water entering the southwestern shelf of Sakhalin Island during tides.

Observational data and analysis methods

The primary data for this study consisted of sea current velocity vectors, bottom hydrostatic pressure (sea level fluctuations), and seawater temperature and salinity recorded at the autonomous buoy station (ABS) “Gorbusha”, deployed near the mouth of the Gorbusha River (coordinates: 46°07′N, 141°54′E; location is shown in Fig. 1). The sea depth at the deployment site was approximately 20 m, with measuring equipment positioned in the bottom layer at approximately 18 m. The station was deployed from a motorboat on May 14 and retrieved on October 18, 2024, covering almost the entire warm season. The ABS was equipped with a Doppler acoustic current meter (Argonaut MD) and a SeaBird hydrological mini-probe. Hydrophysical parameters were recorded hourly, yielding 3,765 data points.

Harmonic constants for the amplitudes and phases of the main tidal waves (four diurnal: $Q1$, $O1$, $P1$, $K1$; and four semidiurnal: $N2$, $M2$, $S2$, $K2$) were calculated using the least squares method [7]. The length of the data series enabled direct computation of all harmonic parameters without corrections. A similar procedure was applied to the projections of measured current velocity vectors onto the parallel and meridian axes. Residual components of sea level fluctuations and currents were determined by subtracting the predicted tide from the original sea level or current velocity projection series. Tidal, residual, and total fluctuations were analyzed using standard statistical methods.

Additional data included measurements of current velocities, water temperature, and salinity from the ABS “Astarta”, deployed in the central part of the La Perouse Strait in 1999. The station was equipped with two AADERAA RCM-4 meters installed at depths of 15 m and 45 m (location is shown in Fig. 1). These data were previously analyzed [3, 8], but salinity was not examined in those studies. In this study, significant attention was given to salinity variations (or synchronous variations in temperature and salinity) to compare the thermohaline characteristics of the Okhotsk Sea water near the Gorbusha River mouth with those in the La Perouse Strait. Hourly measurements at 15 m depth from May 1 to July 15, 1999, were analyzed.

To investigate the water structure characteristics in the study area, oceanographic soundings were conducted along four cross-shore sections (from the shore to the 20 m isobath, approximately 2.4 km from the shoreline). Measurements were obtained using a portable ACTD-CMP probe deployed from a motorboat. Vertical sections were constructed using Surfer software. Results from two sections (2 and 3) near the Gorbusha River mouth (Fig. 1) are discussed below.

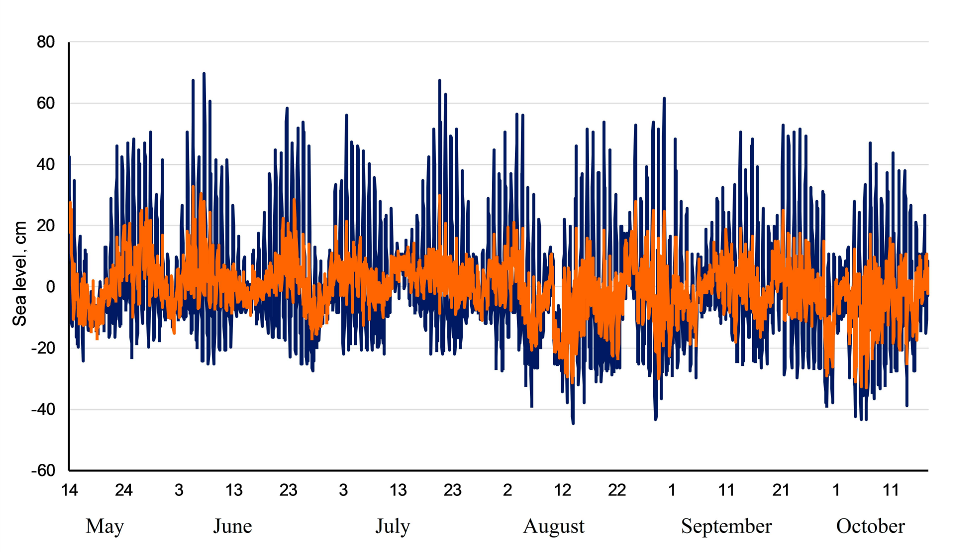
Meteorological conditions during the measurement period were characterized using data from the Nevelsk coastal weather station (May – October 2024), accessed from www.rp5.ru. Although the station is approximately 60 km north of the Gorbusha River mouth, it lies within the same orographic sector of the mountain range, suggesting similar wind flow characteristics. In contrast, the closer Cape Krillon weather station (20 km south of the study area) is separated by this range, resulting in different airflow patterns. Consequently, data from the Nevelsk station were preferred.

The characteristics of the WSC water were determined using long-term average temperature and salinity values along the standard oceanographic section from Pereputye village to Moneron Island (Fig. 1) for various months (March – December) [9, 1].

Results and discussion

Variations in hydrophysical parameters near the Gorbusha River Mouth. Fig. 2 represents graphs of total (measured) sea level variations and their residual component, obtained by subtracting the predicted tide from the original series. Tides play a dominant role in sea level fluctuations, accounting for over 76% of the variance (energy) of the measured series. Diurnal tides predominate in the study area, with the tidal character index, defined as the ratio of the summed amplitudes of the two main diurnal waves and two main semidiurnal waves:

$$R = (HO1 + HK1)/(HM2 + HS2) = 2.1.$$

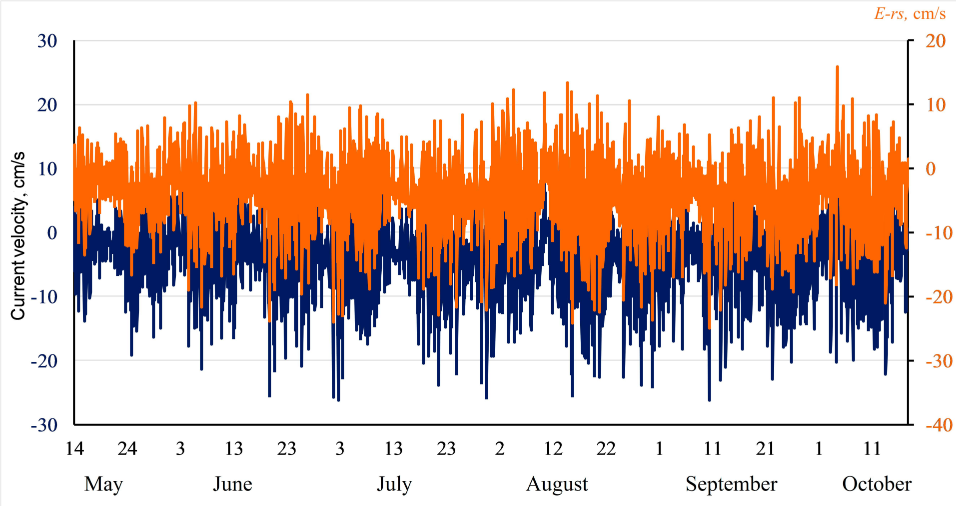


F i g. 2. Fluctuations of total level *L* (blue curve) and its residual component *L-rs* (orange curve) based on the ABS "Gorbusha" data, May – October 2024

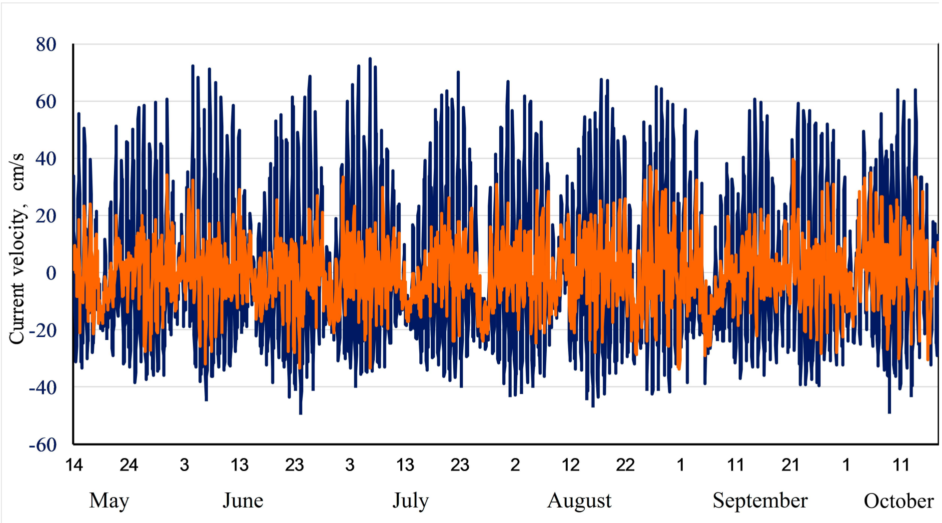
The *O*1 wave exhibits the highest amplitude (approximately 14 cm), which is unusual as the main diurnal *K*1 wave typically dominates. Extreme tidal fluctuations were estimated by predicting a 100-year tidal series, revealing a maximum positive deviation of +49 cm and a negative deviation of −30 cm from the mean sea level, with a total fluctuation range of 79 cm – nearly twice that observed at the Nevelsk tide gauge station. This asymmetry between positive (flood) and negative (ebb) deviations indicates a shorter flood duration compared to ebb. Notably, the amplitude of the main diurnal *K*1 wave is smaller than that of the *O*1 wave, a rare observation.

Residual fluctuations are also significant, with extreme deviations from the mean sea level reaching ±33 cm. Synoptic-scale variations with a period of approximately two weeks and a notable presence of long-wave noise are evident in these fluctuations.

Fig. 3 shows graphs of total current variations and their residual component (projected onto the parallel). The shoreline in the study area is nearly meridional, resulting in relatively small zonal current components, particularly for eastward flows (maximum eastward flow velocity: 15 cm/s; westward: 26 cm/s). The tidal component's contribution was minimal, with wind-driven drift currents dominating. Synoptic-scale fluctuations (approximately two weeks) and long-wave noise are evident, consistent with the residual sea level component.



F i g. 3. Variations of projections of the vectors of total current *E* (blue curve) and its residual component *E-rs* (orange curve) onto the parallel based on the ABS "Gorbusha" data, May – October 2024

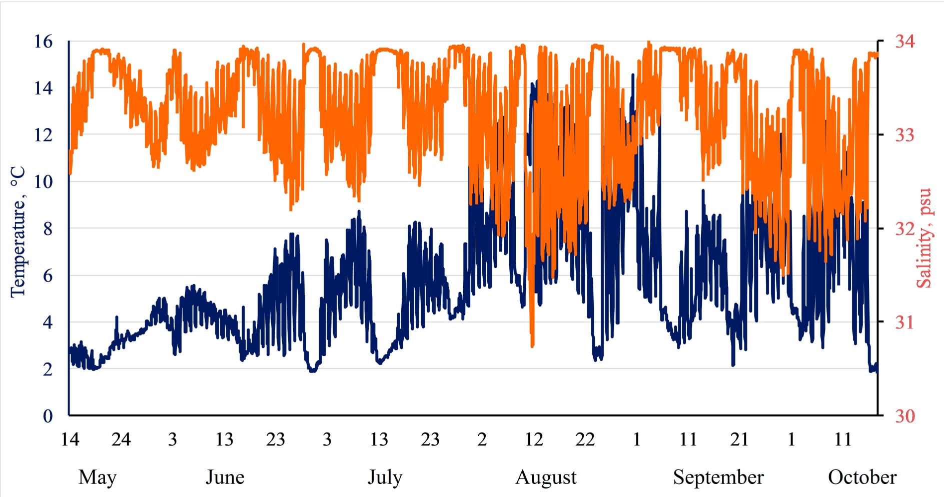


F i g. 4. Variations of projections of the vectors of total flow (blue curve) and its residual component (orange curve) onto the meridian based on the "Gorbusha" ABS data, May – October 2024

Fig. 4 presents similar graphs for the meridional current component. Total current velocities here are much higher than those of the cross-shore zonal component: the maximum northward velocity reaches 75 cm/s, and the maximum southward velocity reaches 49 cm/s. The alongshore component is dominated by tidal currents, accounting for over 82% of the time series variance. Diurnal waves play the predominant role in tidal currents: the amplitudes of the main diurnal waves are 18 cm/s for *K*1 and 21 cm/s for *O*1, with an amplitude ratio *R* = 4.4 (twice that for sea level). Tidal currents are reversible, with ellipses of the main waves compressed and elongated along the meridian. The asymmetry between northward and southward currents is similar to that between positive and negative tidal level deviations: northward currents are stronger, while southward currents last longer.

Residual currents are also intense, with maximum northward and southward velocities of 40 cm/s and 34 cm/s, respectively. The observed variations additionally exhibit a synoptic component with a period of approximately two weeks, along with high-frequency noise producing distinct spikes. The frequency of these spikes increases notably during the autumn period.

The most unexpected result was the exact correlation between the maximum tidal level and the maximum northward current velocity (correlation coefficient between the total level series and the original meridional current component series: 0.78; for tidal components: 0.97). Unlike typical dynamics where the maximum level corresponds to weak currents ("still water"), an anomalous persistence of flow was observed near the Gorbusha River mouth. This phenomenon currently lacks a convincing explanation but suggests northward tidal energy transport, which is characteristic of areas with significant dissipation, highlighting the unique nature of tidal processes along the southwestern coast of Sakhalin.



F i g. 5. Variations in seawater temperature (blue curve) and salinity (orange curve) based on the ABS "Gorbusha" data, May – October 2024

From the perspective of assessing the assimilative capacity of the water body, the most significant parameters of interest were the variations in seawater temperature and salinity (Fig. 5). These variations were substantial and complex. Temperature generally increased from May to late August or early September (the peak warming period) and then declined gradually. No similar variations were observed in salinity. The remaining oceanographic parameters exhibited diurnal fluctuations that were strictly antiphased (correlation coefficient: −0.88).

The inverse relationship between temperature and salinity is surprising, as conventional wisdom states that water from the Okhotsk Sea entering the southern part of the Tatar Strait through the La Perouse Strait has lower temperature and salinity [1–4, 10–12]. We consider this in detail below.

Diurnal fluctuations in temperature and salinity, similar to variations in sea level and the meridional current, indicate a link between oceanographic parameters and tides. Semi-monthly fluctuations are also evident, with temperature rising and salinity decreasing during stronger tides (tropical tides). This reflects the semi-monthly cyclicity of the Okhotsk Sea water intruding into the ABS deployment area – a 10–11-day phase of intensified inflow onto the Southwest Sakhalin shelf during tropical tides, followed by a sharp weakening phase lasting 3–4 days during equatorial tides. During the latter period, the temperature decreases and the salinity increases, indicating a reduction in the impact of the Okhotsk Sea water. The station is usually affected by the WSC, so its characteristics should be examined in more detail. The most reliable data for this analysis are the long-term average temperature and salinity values at depths of 0, 10, and 20 m at station *1* (coastal) of the standard oceanographic section from Pereputye village to Moneron Island. Data from May to October, when the WSC is most active [1, 9], were selected (see Table). To compare with oceanographic conditions at the ABS deployment site, values at a depth of 20 m are relevant. As shown in the table, the WSC water temperatures can be very low, increasing from 2.7 °C to 3 °C from May to July and reaching only 4 °C in August. Higher values occur in September and October when the shift from summer to winter monsoons significantly alters coastal oceanographic conditions.

The WSC water is not only cold but also salty, with salinity increasing from 33.74 psu in May to 33.9 psu in August before returning to initial values by October. During equatorial tides, when tidal currents are weaker, salinity measurements at the ABS remain stable at 33.8–33.9 psu. Over the same period, temperatures ranged from 2 °C in May – June to 4.7 °C in August. These values indicate that the ABS was influenced by the cold WSC, while less salty and warmer Okhotsk Sea water entered the study area during tides. Diurnal variations in oceanographic parameters lagged behind the meridional current component, and this lag varied over the time interval under consideration. It was relatively stable within each two-week cycle, with salinity minima typically lagging behind peak northward currents by 2–4 hours. In some cases, however, the lag reached 6 hours, suggesting highly unusual water movement patterns under tidal forcing.

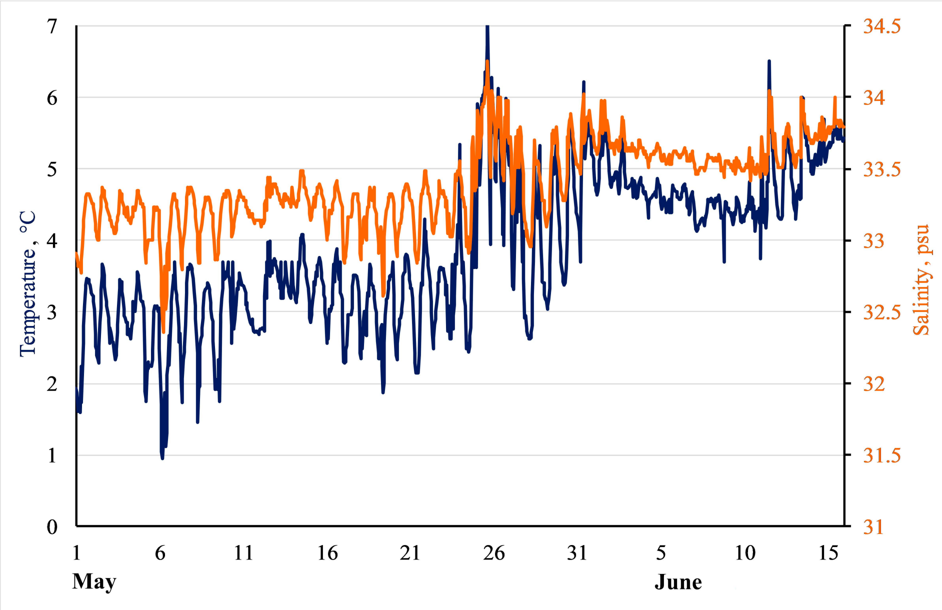
Diurnal temperature and salinity fluctuations varied throughout the measurement period. For example, salinity variations during the first month of observations were relatively small, at about 0.5 psu, but later increased to 1.5 psu. Large amplitude variations were observed for about 10 days during the period of decreasing tides (equatorial tides), after which they decreased almost to zero. Maximum fluctuation values (approximately 2 and up to 2.4 psu) were recorded from August 12 to August 22. After this period, the clear two-week cyclicity was disrupted. In particular, during the period of decreasing tides, the amplitude of diurnal salinity variations was no longer close to zero.

Long-term average values of temperature *T* (°C) and salinity *S* (psu) on 0, 10 and 20 m horizons at station *1* of standard oceanographic section Pereputye village – Moneron Island (according to data from [9])

h, m	*T*	*S*	*h*, m	*T*	*S*
May			*August*		
0	3.51	33.41	0	13.61	33.44
10	2.85	33.50	10	6.65	33.67
20	2.69	33.74	20	4.13	33.90
June			*September*		
0	6.07	33.53	0	14.22	33.39
10	3.32	33.63	10	8.14	33.67
20	2.74	33.86	20	4.63	33.87
July			*October*		
0	9.41	33.48	0	7.88	33.15
10	4.71	33.64	10	6.62	33.49
20	3.08	33.88	20	5.28	33.74

The diurnal temperature variations were similar. At the initial stage, their magnitude was relatively small, at about 2 °C during tropical tides and nearly zero during equatorial tides. Then, the variations increased to 4 °C during large tides, remaining almost unchanged during weak tides. In August, the amplitude increased to 10 °C, and the duration of low values decreased. The intensity of daily variations decreased in September and increased again in October.

Semi-monthly variations linked to the "pumping" of the Okhotsk Sea water onto the southeastern Sakhalin shelf were also significant. The expansion and contraction of the cold "Makarov Spot" during tropical and equatorial tides was described earlier [6]. This occurs because not all of the Okhotsk Sea water entering the shelf during flood tides returns during ebb. Instead, some WSC water is exported through the La Perouse Strait. This effect strengthens and weakens with increasing and decreasing tidal currents, respectively. Two-week salinity variations were more stable, with a range of approximately 1 psu throughout most of the observation period. The temperature variability demonstrated a more complex pattern. During the first month, temperature fluctuations were relatively moderate, ranging from 2 to 4 °C, later increasing to 6°C. By August, both lower (up to 4 °C) and, particularly, upper temperature extremes (10–12 °C) intensified significantly, accompanied by a notable loss of stability that persisted until autumn. From September to October, the range stabilized, with lower values around 4 °C and higher values around 8–9 °C.

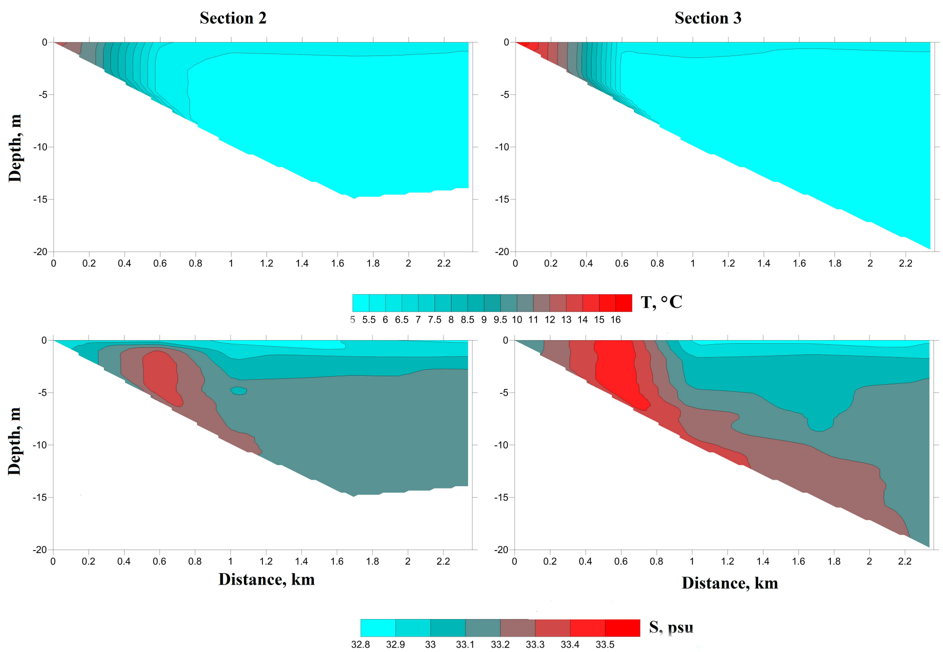


F i g. 6. Variations in seawater temperature (blue line) and salinity (orange curve) based on the ABS "Astarta" data, May – June 1999

For comparison, we are to examine the variations in seawater temperature and salinity recorded at the ABS "Astarta" mooring in the central part of the La Perouse Strait from May 1 to June 15, 1999 (Fig. 6). In May, the diurnal variations of both temperature and salinity were pronounced, with characteristic ranges of approximately 2 °C and 0.5 psu. Semi-monthly variations were also clearly evident, detected as weakened diurnal fluctuations during equatorial tidal phases – a pattern similar to that observed at the ABS "Gorbusha" station. A distinct relationship between hydrological parameters was observed exclusively in the strait: saltier water corresponded to higher temperatures, while fresher water corresponded to lower temperatures. This reflects the typical interaction between the Japan Sea water, carried here by the warm Soya Current, and the Okhotsk Sea water entering from the southwestern part of Aniva Bay. The characteristic values for the latter were 2.5 °C and 32.7 psu, closely matching the salinity readings recorded at the Gorbusha River estuary in May during periods of lowest salinity.

Pay attention that diurnal variations in oceanographic parameters decreased in June, likely due to seasonal strengthening of the Soya Current displacing the Okhotsk Sea water to the northern part of the strait, where it was no longer detected by the ABS "Astarta". Notably, the temporal patterns of oceanographic parameter variations at the ABS "Gorbusha" in May were similar to those in the La Perouse Strait, highlighting the role of tides in temperature and salinity variations near the study area. The thermohaline characteristics of the Okhotsk Sea water in the strait and off the Krillon Peninsula were also similar, despite measurements being taken in different years.

Oceanographic soundings. The first oceanographic survey of four sections was conducted in mid-May 2024. Soundings at each section were taken at five stations: near the shore and at the 5, 10, 15, and 20 m isobaths. Near the shore, spring warming was evident, with water temperatures > 7 °C. At other stations, however, the water was much colder, ranging from 3 to 3.5 °C. Section 2, especially station *2* at a depth of 5 m, experienced sharp local salinity drops due to spring freshet. The lowest salinity was observed in the bottom layer: < 2 psu at station *2* and ~ 10 psu at station *3* at a depth of 10 m. A strong (5–8 m/s) southerly wind on May 14–15 may have contributed to the descent of freshened water.

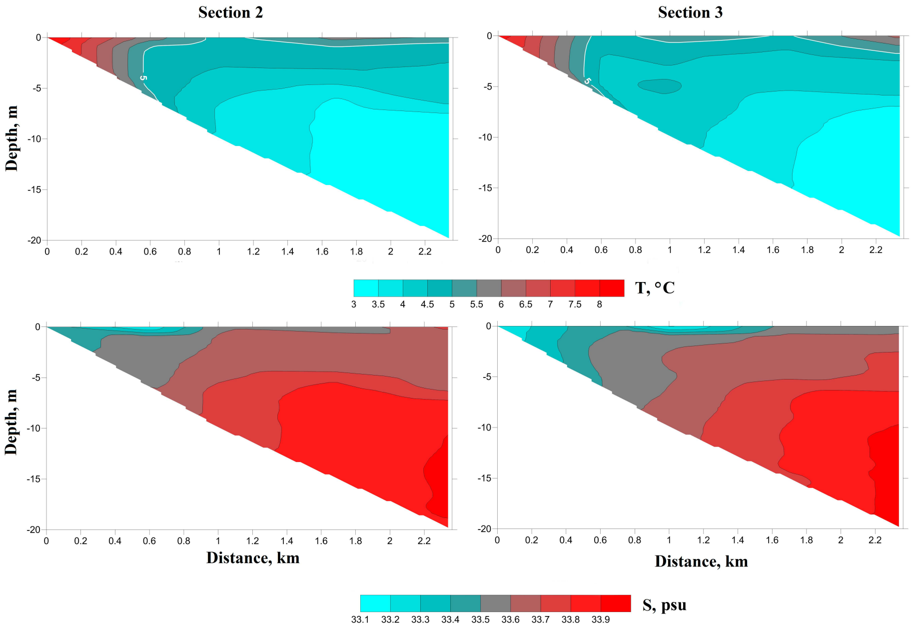


F i g. 7. Vertical distributions of temperature (*top*) and salinity (*bottom*) on sections 2 and 3 based on the results of oceanographic survey conducted in the first decade of June 2024

At other sections, salinity varied minimally (32.1–32.4 psu), which is a low value for Sakhalin's southwestern coast (see Table). This indicates the influence of the Okhotsk Sea water, which is transported by tidal currents to the mouth of the Gorbusha River.

In early June (Fig. 7), the temperature of the coastal water increased significantly compared to May, reaching 12.8 °C at section 2 and 16.3 °C at section 3. At other stations, temperatures were uniform, ranging from 6 °C at the surface (5-m isobath) to 5.1 °C near the bottom at the offshore stations. Salinity ranged from 32.8 psu at the surface to 33.3 psu near the bottom. However, at station *2* on both sections, values were higher at ~ 33.4 psu at section 2 and 33.5 psu at section 3. The distribution of temperature and salinity suggests an effect of the Okhotsk Sea water over the shelf with a lesser impact on coastal shallows.

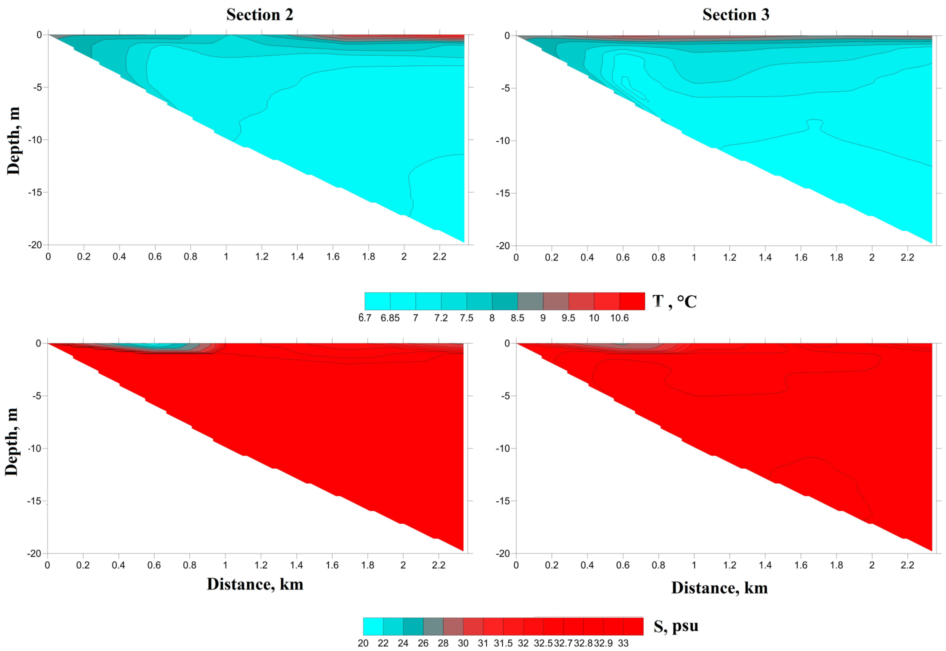
In mid-June (Fig. 8), temperatures were lower than two weeks earlier (~ 8 °C near the shore, 4.7–5.7 °C at the surface offshore, ~ 4 °C at 10 m, and ~ 3 °C at 15–20 m). Deep-water salinity was high (~ 33.9 psu), indicating a strong impact from the WSC water. This aligns with the graphs showing weak tidal and the Okhotsk Sea water influences, as well as temperature, salinity, and meridional current variations. Lower salinity (~ 33.2 psu) was observed only at the surface at a few stations. The two June surveys vividly demonstrate the abrupt alternation between the Okhotsk Sea water (lower salinity and higher temperature) and cold, salty WSC water.



F i g. 8. Vertical distributions of temperature (*top*) and salinity (*bottom*) on sections 2 and 3 based on the results of oceanographic survey conducted in the second decade of June 2024

During the first ten days of July, conditions closely resembled those observed in early June (Fig. 9). Salinity values below 33 psu across the entire study area indicate the dominance of the Okhotsk Sea water. However, Fig. 6 shows that the period of weak tides ended just two days prior to sampling. This suggests that the influence of this water mass was only beginning to intensify during the survey. This situation differed markedly from the observations made in early June, when saltier water was confined to the coastal shallows (from the shoreline to 5 m isobath). By early July, the Okhotsk Sea water had spread throughout the study area. Against this backdrop, a distinct freshened coastal band appeared along the shoreline above the 5 m isobath with salinity measurements of 19.4 psu at section 2 and 27.0 psu at section 3. This freshening likely resulted from the heavy rainfall recorded at the Nevelsk WS on July 1–2.

The temperature distributions were nearly uniform. Excluding the surface values, the temperatures ranged narrowly from 7.4–7.8 °C at 1 m to 6.7–6.9 °C near the bottom at deepwater stations. Higher values (up to 10.7 °C) occurred only at the surface.



F i g. 9. Vertical distributions of temperature (*top*) and salinity (*bottom*) on sections 2 and 3 based on the results of oceanographic survey conducted in the first decade of July 2024

In late September, the temperature and salinity distributions were the most complex. Cold and salty WSC water (4.3–6.5 °C, 33.5–33.8 psu) dominated below 13 m. In the shallower layers, salinity was lower and temperature was higher, indicating the influence of water from the Okhotsk Sea (9–10 °C, 32.6–32.8 psu in the upper 5 m). A distinct freshened lens (28.6 psu) was observed at the surface at the 15 m isobath, likely due to heavy rainfall. This survey highlights the complex interaction of waters with markedly different characteristics.

Conclusion

The study revealed that hydrological conditions near the Gorbusha River mouth during the warm season are significantly influenced by the Okhotsk Sea water propagating along the western coast of the Krillon Peninsula due to tidal forcing. Tidal current velocities in the study area can reach 66 cm/s northward and 45 cm/s southward under astronomical conditions. The absence of a time lag between tidal level fluctuations and currents indicates significant tidal energy dissipation on the southwestern Sakhalin shelf, further evidenced by the asymmetry between northward and southward alongshore flows. These findings highlight the atypical tidal dynamics in the study area.

A distinctive feature of this area is the significant temperature and salinity variations driven by the inflow of the Okhotsk Sea water through the La Perouse Strait during tidal cycles. Contrary to conventional understanding, the Okhotsk Sea water is not only less saline but also warmer than WSC water flowing southward along the southwestern coast of Sakhalin Island. The characteristics of the WSC, assessed through long-term average temperature and salinity measurements at a depth of 20 m at the coastal station of the Pereputye–Moneron Island standard oceanographic section, remain nearly constant throughout its duration.

In addition to diurnal variations in oceanographic parameters, with tidal currents exhibiting pronounced daily cycles, a significant accumulation of the Okhotsk Sea water masses occurs on the southwestern Sakhalin shelf. This phenomenon results from incomplete retreat of the Okhotsk Sea water from the shelf zone during ebb tides. The effect persists for 10–11 days within the two-week tidal cycle, becoming particularly pronounced during periods of enhanced tidal currents. Concurrently, the influx of less saline Okhotsk Sea water ceases for approximately 3–4 days during equatorial tidal phases. This mechanism was initially identified through satellite observations of sea surface temperature (SST) and subsequently validated by instrumental measurements.

Diurnal variations in oceanographic parameters are pronounced, with temperature fluctuations exceeding 10 °C and salinity changes reaching 2 psu. Variations over the two-week tidal cycle are also significant (up to 6 °C and 1 psu).

Oceanographic surveys of cross-shore sections indicate that warmer, less saline Okhotsk Sea water initially propagates offshore in the surface layer, subsequently displaces deeper water, and eventually influences coastal shallows.

The near-daily alternation between the Okhotsk Sea and the Sea of Japan waters is the primary defining feature of the hydrological regime in the study area.

REFERENCES

1. Shevchenko, G.V., Chastikov, V.N. and Maryzhikhin, V.E., 2018. Seasonal Variations in Marine Hydrological Characteristics off the Southwestern Coast of Sakhalin Island. *Russian Meteorology and Hydrology*, 43(12), pp. 865-870. https://doi.org/10.3103/S1068373918120087

2. Odamaki, M., 1994. Tides and Tidal Currents along the Okhotsk Coast of Hokkaido. *Journal of Oceanography*, 50(3), pp. 265-279. https://doi.org/10.1007/BF02239517

3. Shevchenko, G.V., Kantakov, G.A. and Chastikov, V.N., 2005. Results of Direct Measurements of the Currents in the La Perouse (Soya) Strait. *Izvestiya TINRO*, 140, pp. 203-227 (in Russian).

4. Shevchenko, G.V. and Maryzhikhin, V.E., 2024. The Effect of the Tide on Water Exchange through the La Perouse Strait. *Journal of Oceanological Research*, 52(3), pp. 95-115. https://doi.org/10.29006/1564-2291.JOR-2024.52(3).6 (in Russian).

5. Mitnik, L.M., Shevchenko, G.V., Sophienko, Yu.A. and Dubina, V.A., 2006. About Tidal Origin of Cold Water Belt in the Stone of Danger Area of the La Perouse Strait. *Issledovanie Zemli iz Kosmosa*, (5), pp. 86-96 (in Russian).

6. Bobkov, A.A. and Fux, V.R., 1997. Tidal Origin of Thermohalinic Anomalies in the La-Perouse Strait. In: Okhotsk Sea & Cold Ocean Research Association, 1997. The *Twelfth International Symposium on Okhotsk Sea and Sea Ice, 2-5 February 1997, Mombetsu, Hokkaido, Japan: Abstracts*. Hokkaido, Japan: Hokkaido University, pp. 242-247.

7. Godin, G., 1972. The *Analysis of Tides*. Liverpool University Press, 292 p.

8. Kantakov, G.A. and Shevchenko, G.V., 2001. Analysis of Nonperiodic Currents in the La Perouse (Soya) Strait due to Changes in Water Level and Wind Impact. In: IMGiG DVO RAN, 2001. *Dynamic Processes on the Sakhalin Shelf and Kuril Islands*. Yuzhno-Sakhalinsk: IMGiG DVO RAN, pp. 62-74 (in Russian).

9. Pishchal'nik, V.M. and Bobkov, A.O., 2000. *Oceanographical Atlas of the Sakhalin Shelf. Volume 2.* Yuzhno-Sakhalinsk: SakhGU, 107 p. (in Russian).

10. Makarov, S.O., 1950. Hydrological Studies Conducted in 1895 and 1896 in the La Perouse Strait and in Other Places. In: *Oceanographic Studies*. Moscow: Geografgiz, pp. 255-275 (in Russian).

11. Leonov, A.K., 1948. Water Masses of the Japan Sea. *Meteorologiya i Gidrologiya*, (6), pp. 61-78 (in Russian).

12. Danchenkov, M.A., Aubrey, D. and Riser, S., 1999. Oceanographic Features of the La Perouse Strait. In: North Pacific Marine Science Organization, 1999. *Proceedings of the Second PICES Workshop on the Okhotsk Sea and Adjacent Areas*. PICES Scientific Reports, no. 12. Sidney, Canada: PICES, pp. 159-171. [online] Available at: https://pices.int/outgoing/Julia/misc/PICES-2011%20USB/Scientific%20Reports/Rep12.pdf [Accessed: 10 July 2025].

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