# Investigation of wave processes on the eastern shelf of Sakhalin Island influenced by tidal currents (Sea of Okhotsk)

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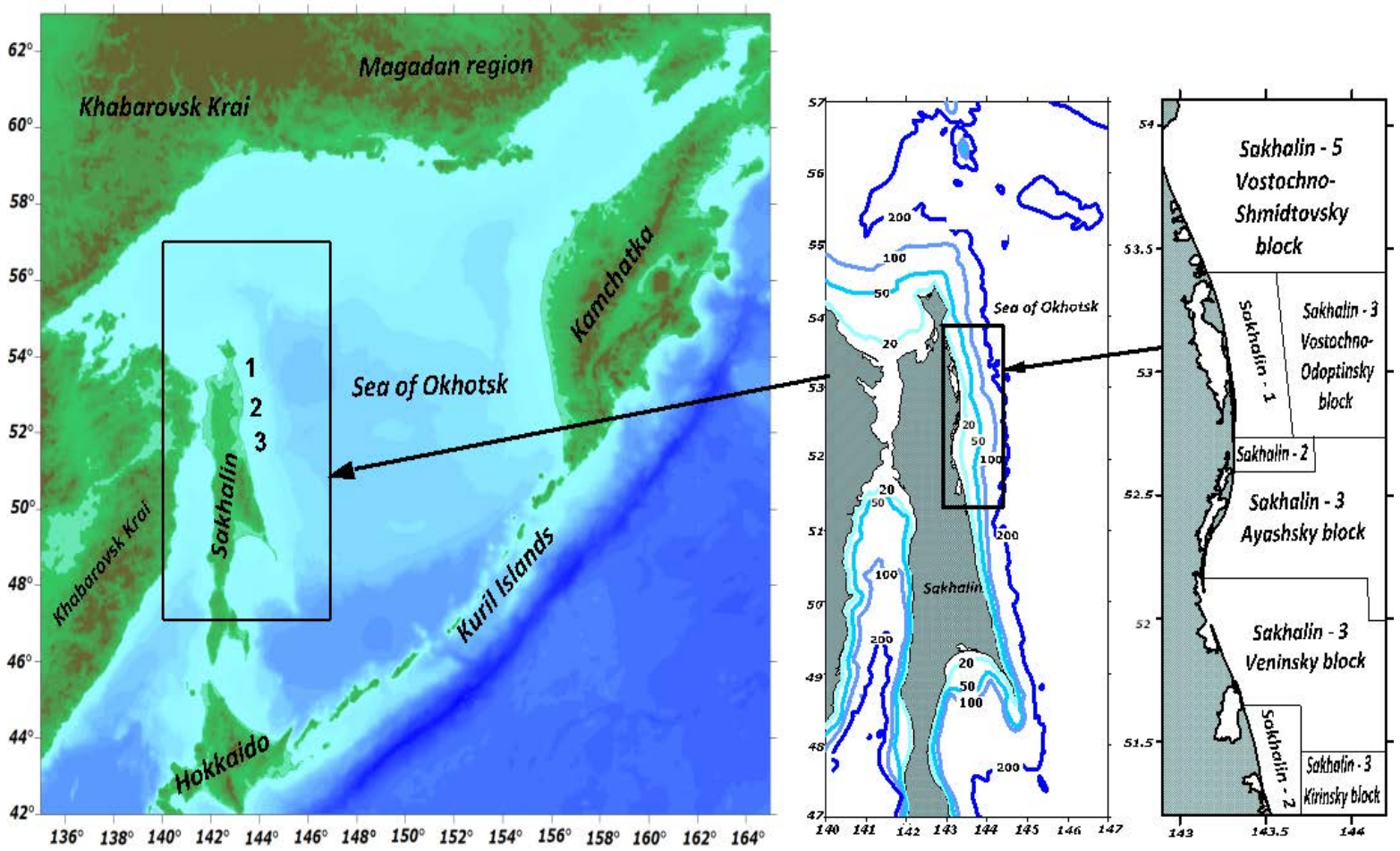



**Introduction: area of research**

The area of research includes three parts:

**1 – the northern part** from Cape Levenshtern to the Odoptu Bay with the shelf width up to 35 km. (up to the 100 m isobate.)

**2 – the central part** from the Odoptu Bay to the Nabilsky Bay with the shelf width up to 80 km.

**3 – the southern part** from the Nabilsky Bay to 51.2°N with the south-south-east oriented coastline and the shelf width up to 24 km.

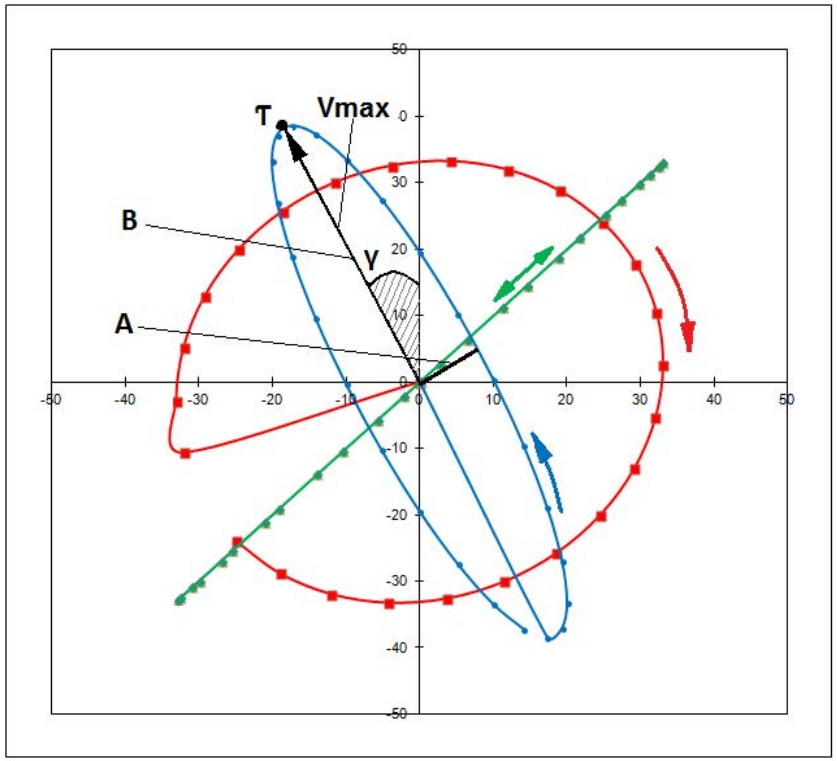
The shelf of East Sakhalin is rich with hydrocarbon resources (oil- and gas-bearing areas are marked on the right panel.)

## Goal and objectives

to conduct experimental charts of tidal currents for certain tidal waves

to understand the process of the wave fluctuations

to identify the waves properties, «wave–bottom topography» and «wave–coastline» interaction.




## The main elements of the tidal ellipses

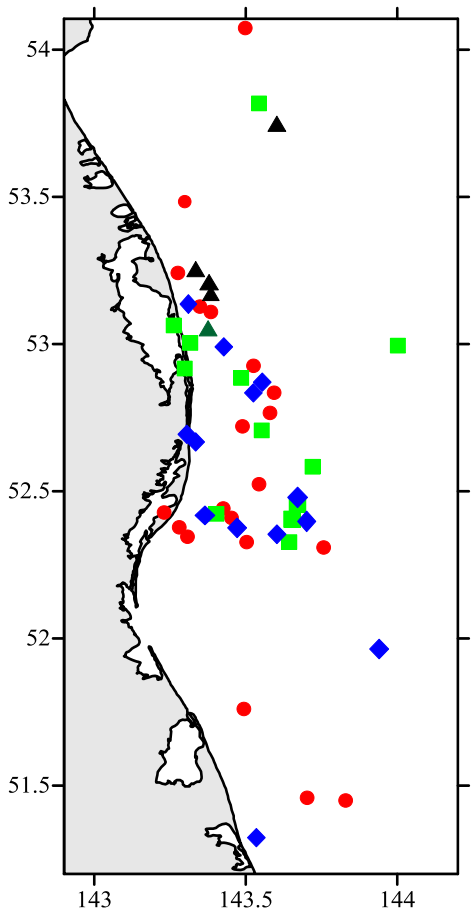
Harmonic constants:
amplitude **Vмax** – magnitude of the semimajor axis of the ellipse

Phase **T** – a moment of time when amplitude reaches **Vmax** (in hours.)

Direction, **γ,** vector of the maximum velocity (in degrees.)

Coefficient of reversibility **β.** Rotatio of **A** to **B.**

Direction of rotation for the tidal current velocity vector: clockwise **«+»,** counter-clockwise **«-»**

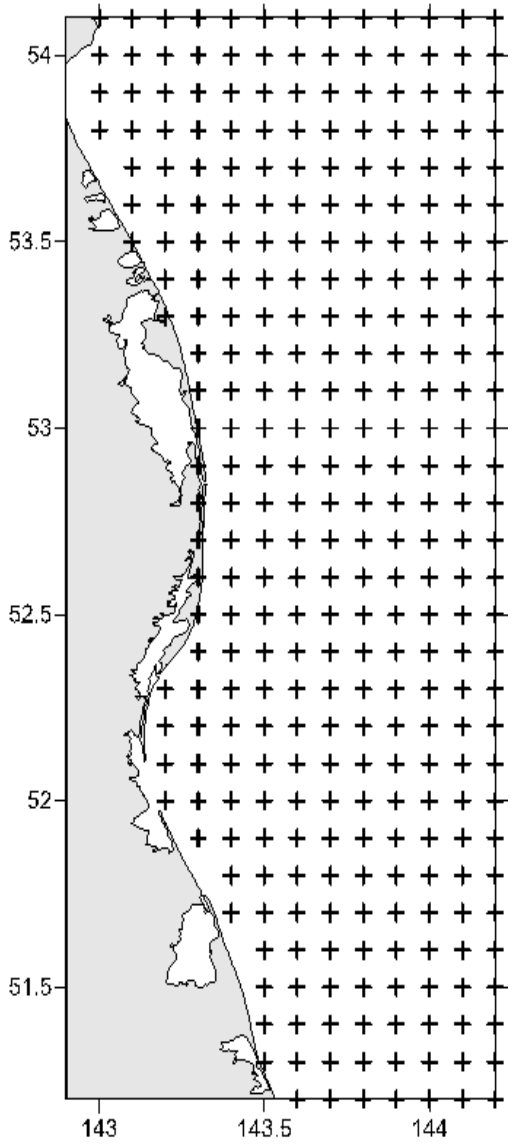



Station exposure:
- ▲ –7-9 days
- ● –10-30 days
- ♦ – 30-60 days
- ■ – over 60 days

- The data are chosen from "Hmd Ocean Station UI" database developed by FERHRI

- Sample: month - August, depth – 10 ± 5 meters.

- Harmonic constants are calculated for 7 waves (K1, O1, Q1, P1, M2, S2, and N2) by "LRFD" software package developed by FERHRI



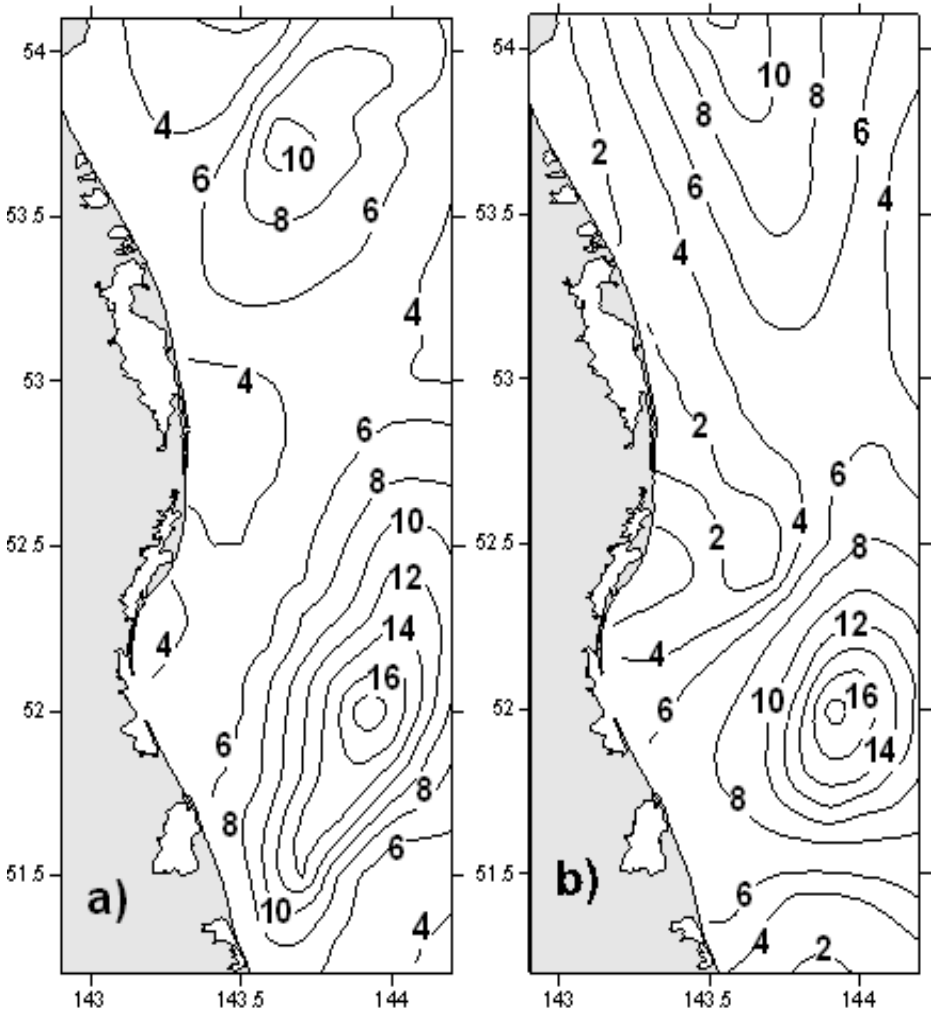

## Approach

To reduce the effects of data spatial heterogeneity, the following processing was done:

a) the data of currents observation were recalculated to the spatial grid of 0.1º

b) the gridded data on currents were presented in the form of harmonic components (X, Y amplitude and phase)

c) harmonic components in each node of the grid were converted back into vector form using Wedemeyer formulas (Altshuler, V.M. 1966. Practical issues of analysis and calculation of tides. Leningrad, Gidrometeoizdat. 309 p.)



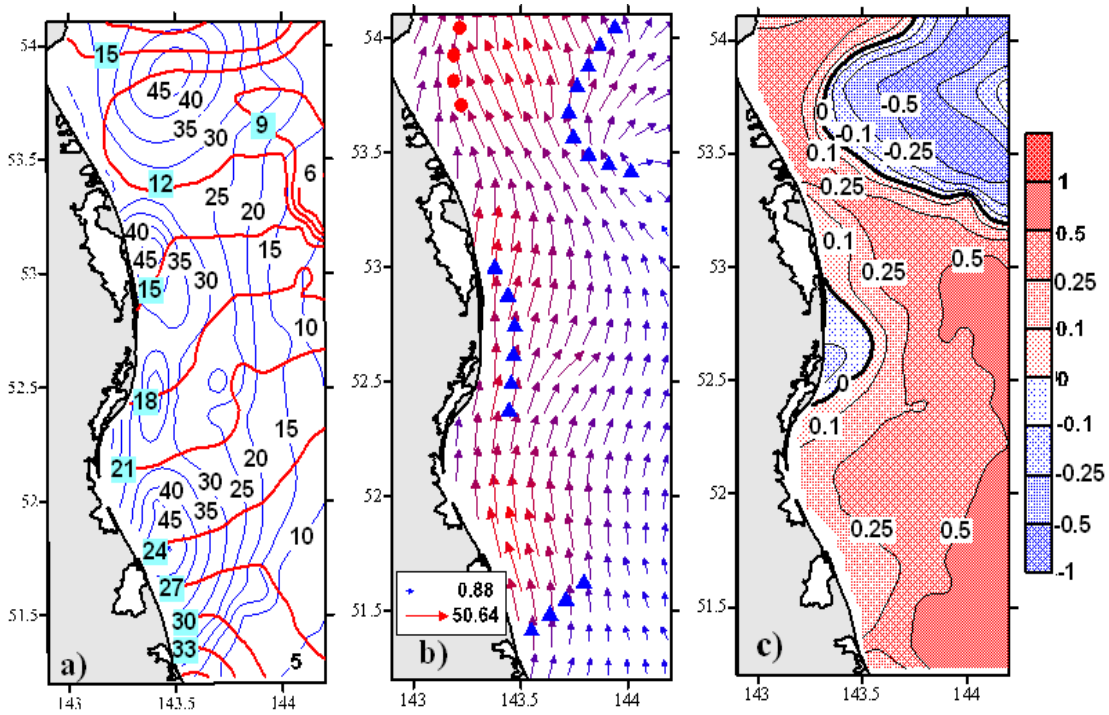

**Tidal current for semidiurnal wave M2.**

The meridional component of the tidal current

a) Amplitude, in cm/s

b) Phase, in hours

The tidal charts show a consistent patterns of spatial distribution for all harmonics, so the tidal parameters can be interpolated to areas without observations.

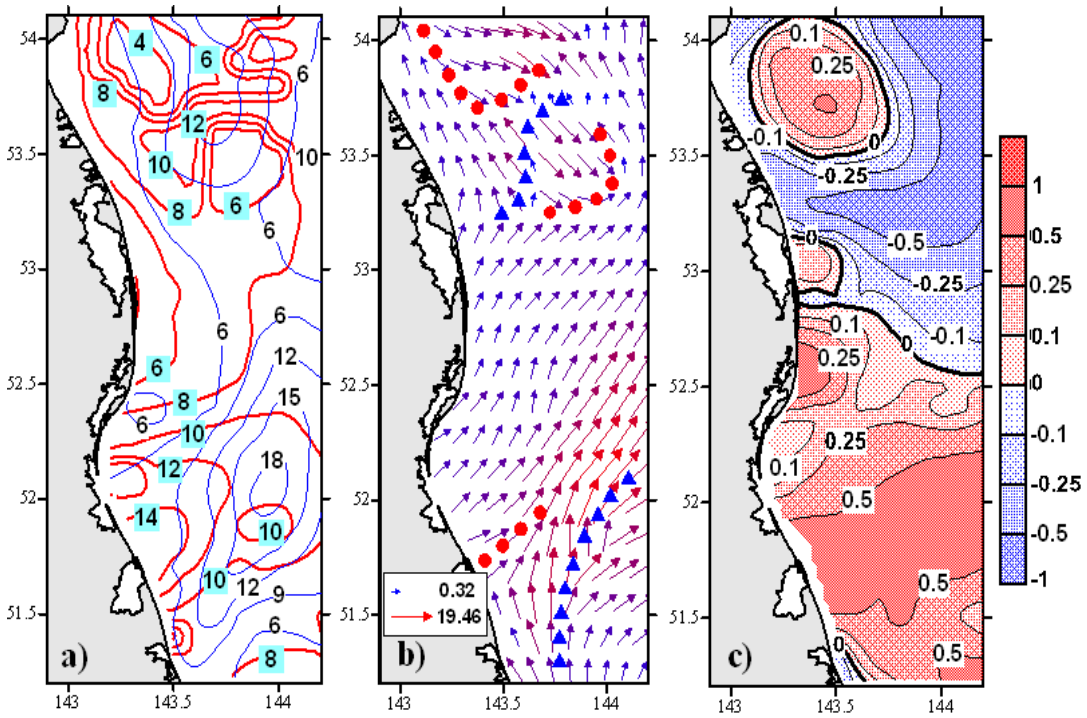



Types of tidal currents:
± 0 - 0.1 - reversible
± 0.1 - 0.25 - semi-reversible
± 0.25 - 0.5 - semi-circular
± 0.5 - 0.1 - circular
"+" - clockwise rotation
"-" - counter-clockwise rotation

## Tidal current charts for diurnal wave K1

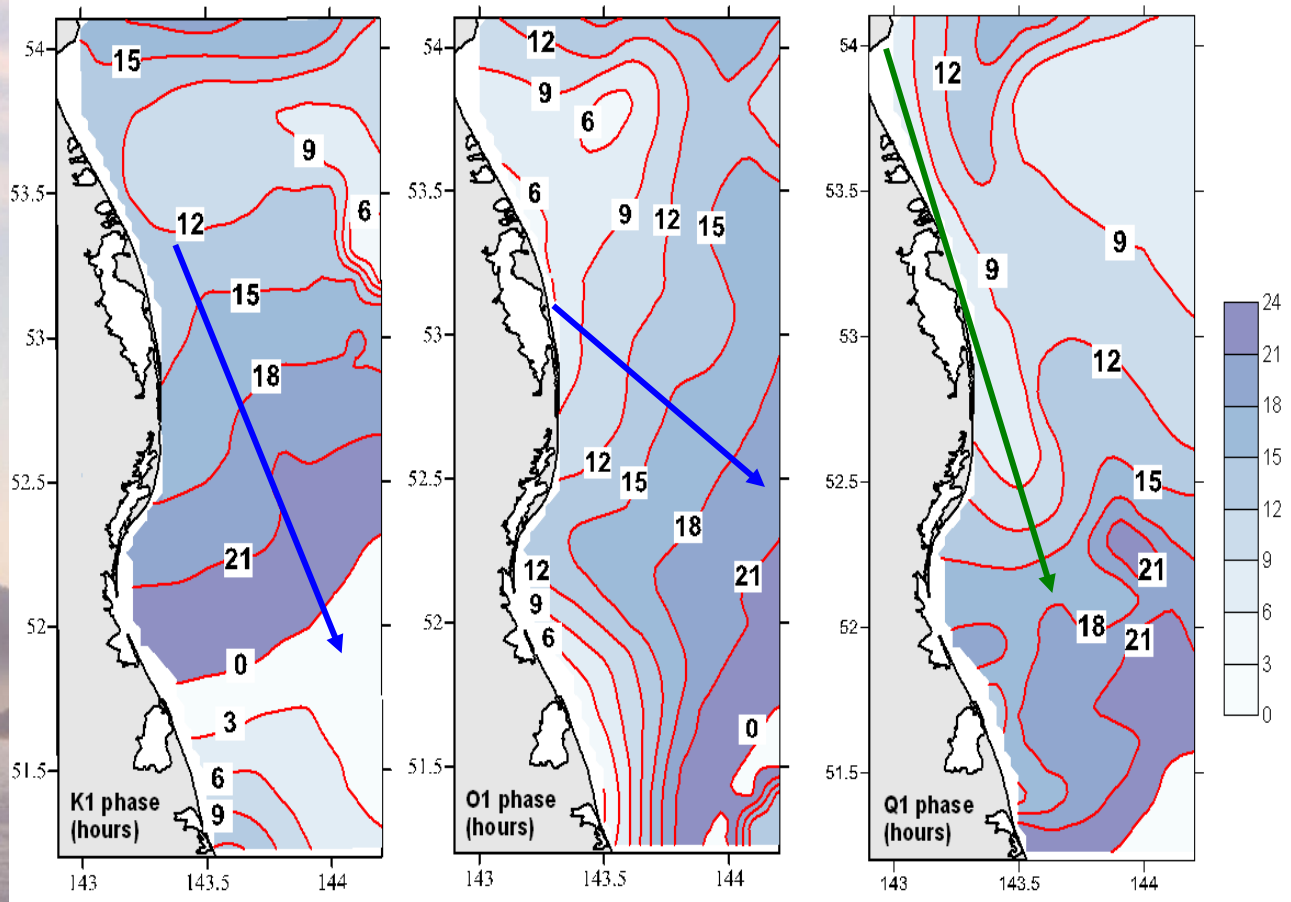
a)distribution of isophases (in hours) and isoamplitudes Vmax (in cm/s.)
b)vector field, ●●● - convergence. ▲▲▲- divergence.
c)distribution of coefficient β.

The tidal current charts present:
a) amplitude (Vmax) and phase (T) distribution combined with each other;
b) directions of Vмax (γ);
c) reversibility coefficient (β) and rotation direction (clockwise "+" counterclockwise "-".)




**Tidal current charts for semidiurnal wave M2.**

a) distribution of isophases (in hours) and isoamplitudes Vmax (in cm/s.)
b) vector field, ●●● - convergence. ▲▲▲- divergence.
c) distribution coefficient β. Types of tidal currents:
± 0 - 0.1 - reversible,
± 0.1 - 0.25 - semi-reversible
± 0.25 - 0.5 - semi-circular
± 0.5 - 0.1 - circular
"+" - rotate clockwise
"-" - rotate counter-clockwise




Co-tidal charts of diurnal tidal waves K1, O1 and Q1 (distribution of isophases in hours.)

Visible phase velocity at the central part:

Wave K1 - ≈ 10-15 km/h
Wave O1 - ≈ 6-8 km/h

Wave front direction.
Reflected wave vector.

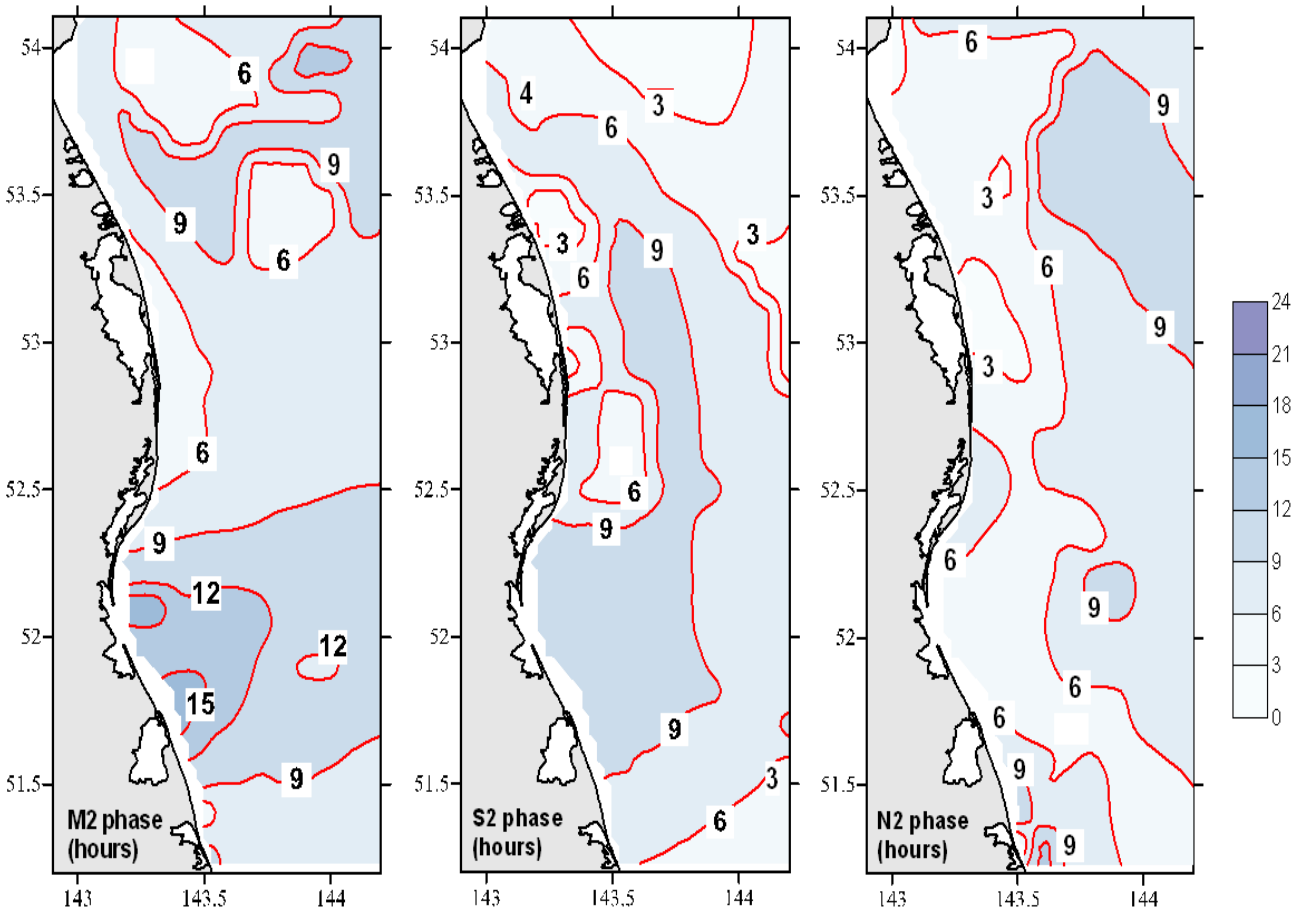
*Isophases are more condensed in the northern(1) and southern(3) parts of the area because of predominance of standing oscillations.*

*The central(2) part of the area is affected mainly by progressive component of a tide and reflected waves in this part propagate in the south-east direction.*

*The phase velocity for wave K1 = 10-15 km/h, for wave O1 = 6-8 km/h.*

*Maximum velocities of tidal currents near the shore are observed in 3-5 hous earlier than in the open sea.*

*The Q1 isophases along the "hollow" formed by the reflected from Cape Levenshtern is oriented to the south-south-east.*




Co-tidal charts of semidiurnal tidal waves M2, S2 and N2. (distribution of isophases in hours.)

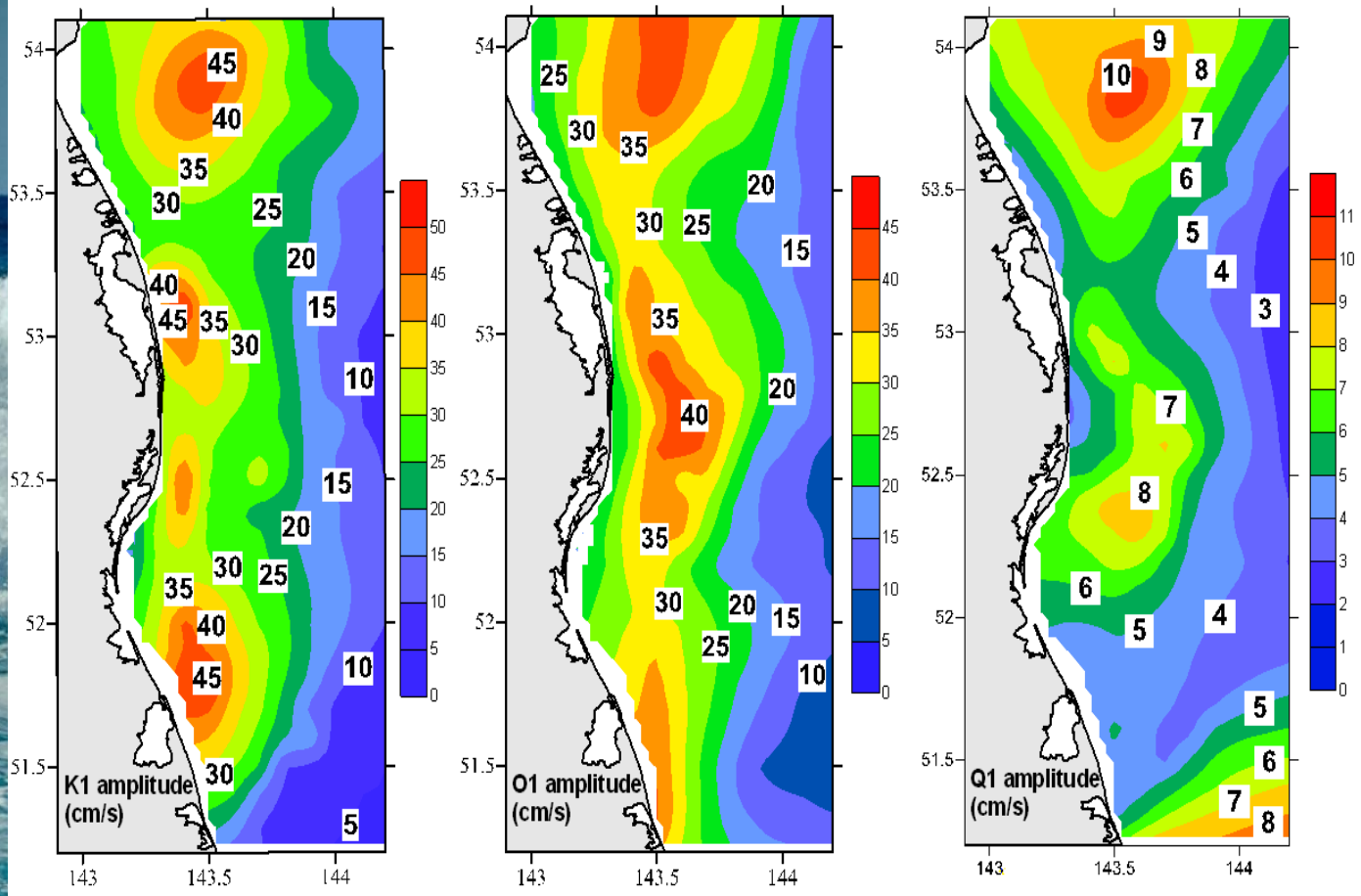
The phase Vmax changing tide period: (≈ ½ on the wave period)

Wave M2 - 6 - 12 hours

Wave S2 - 3 - 9 hours

Wave N2 - 3 - 9 hours

*Inhomogeneous distribution of phases is typical for the semidiurnal waves.*

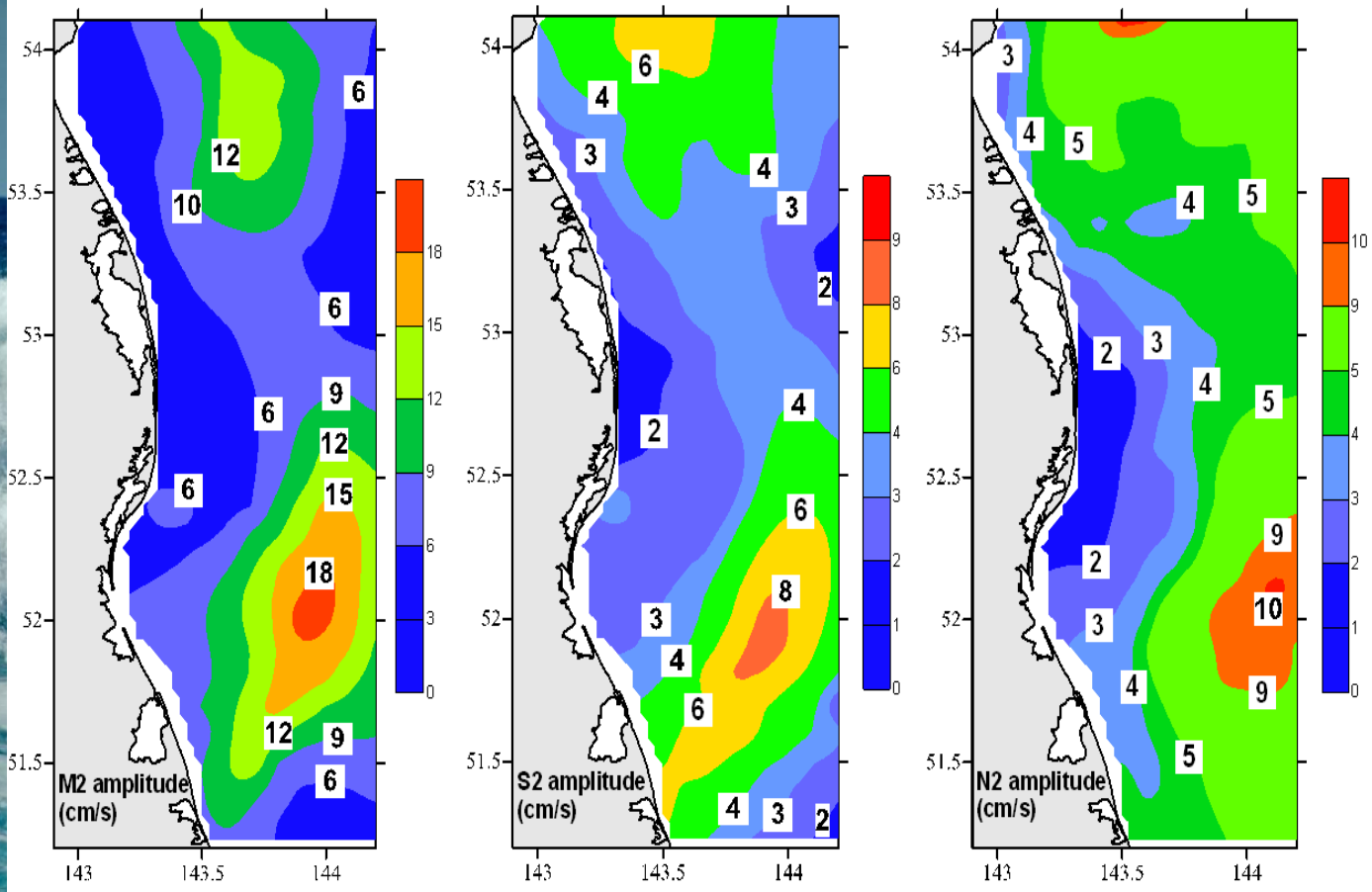



Charts of velocity amplitude distribution for diurnal waves K1, O1, Q1.

For Vmax harmonics:
Wave K1 = 45-50 cm/s
Wave O1 = 40-45cm/s
Wave Q1 = 7-9 cm/s

Distance between the shore and Vmax area (from the Piltun bay – to the Chayvo bay)
Wave K1 - 20-25 km
Wave O1 - 25-30 km
Wave Q1 - 30-35 km

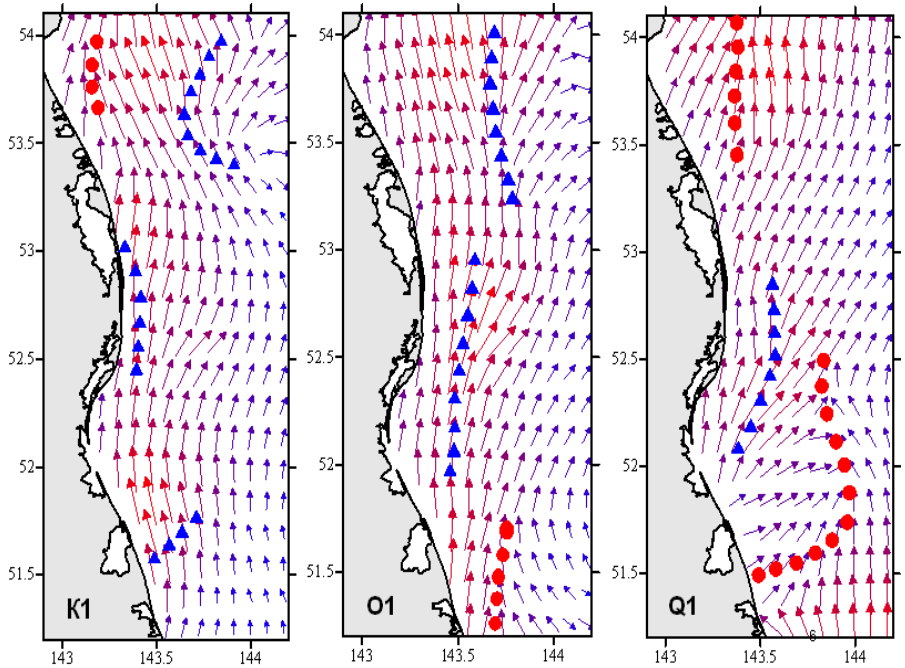
*The areas with maximum amplitude values (Vmax) are located along the shore.*

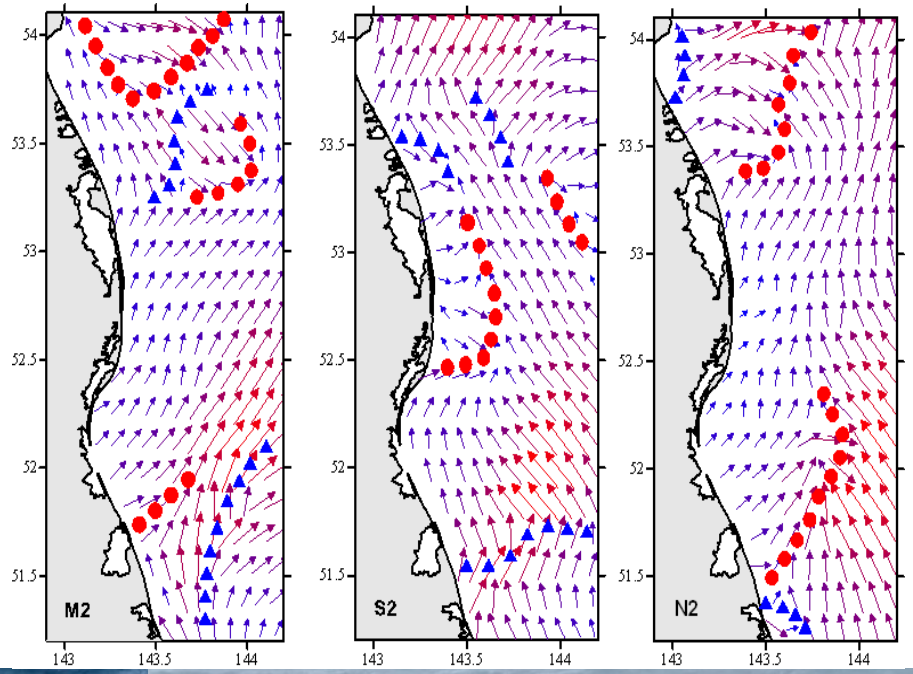



Charts of velocity amplitude distribution for semidiurnal M2, S2 and N2 tides.

The maximum Vmax:
Wave M2 - 19.5 cm/s
Wave S2 - 8.6 cm/s
Wave N2 - 10.5 cm/s

The main peak is located in the south-eastern part of the area in vicinity of the amphidromic point for semidiurnal waves (in this case, we affirm the result of Ogura S., 1933The Tides in the seas adjasent to Japan. Bulletin of Hydrographic Department Japan Navy, Volume 7. Tokyo, 189 p.)




Charts of vector field maximum velocity of the tidal currents of diurnal waves K1, O1, and Q1.

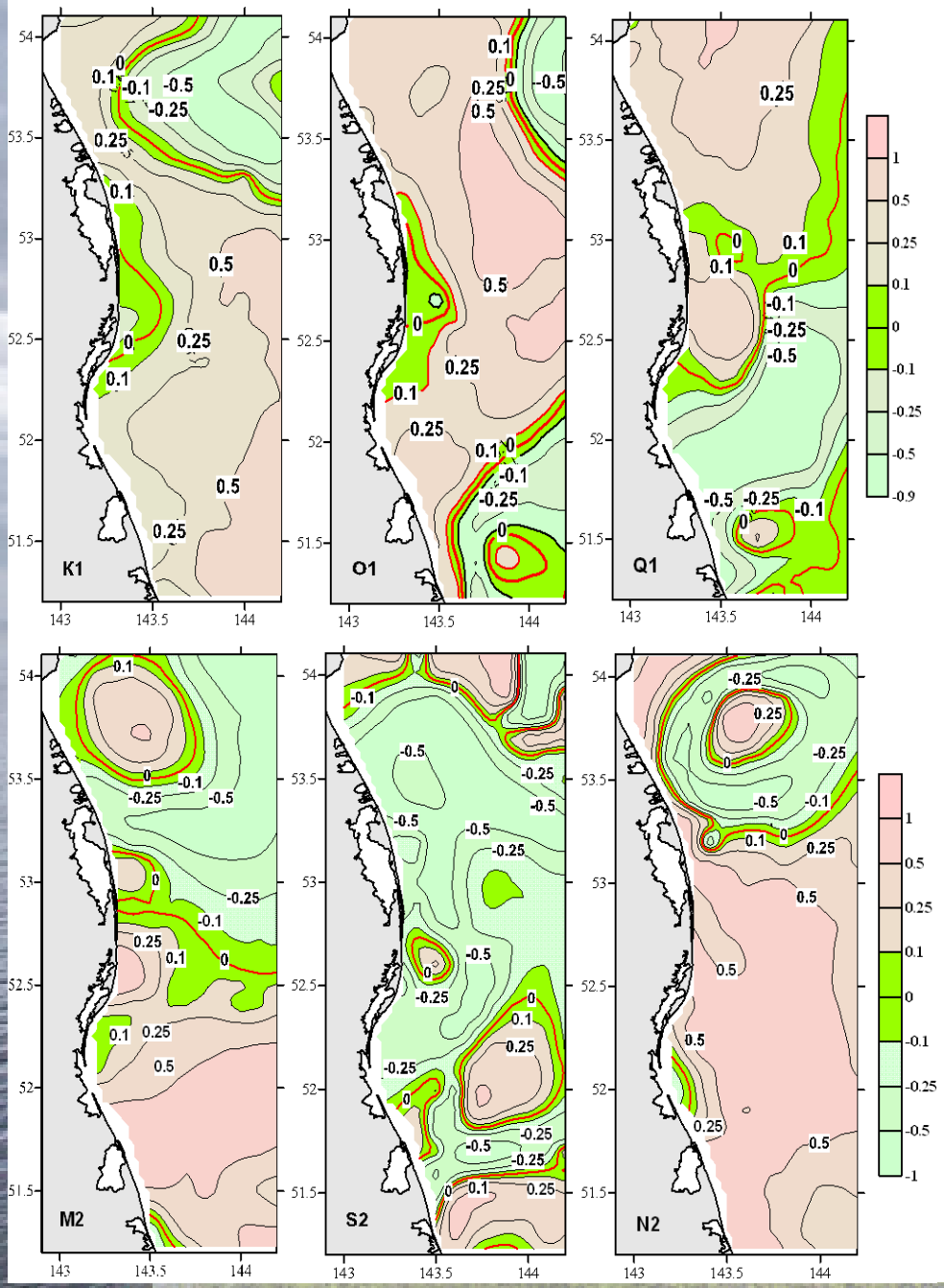
The maximum value Vmax:
Wave K1 - 50.6 cm/s
Wave O1 - 45.0 cm/s
Wave Q1 - 10.6 cm/s

The dynamic education:
●●● - Convergence
▲▲▲- Divergence

Carts of vector field maximum velocity of the tidal currents of semidiurnal waves M2, S2 and N2.

The maximum value Vmax:
Wave M2 - 19.5 cm/s
Wave S2 - 8.6 cm/s
Wave N2 - 10.5 cm/s

*Vector fields of tidal velocity vector (Vmax) for all waves have common patterns of spatial distribution.*
*1) directed mainly to the north and north-east.*
*2) close to the perpendicular to the lines of the isophases.*

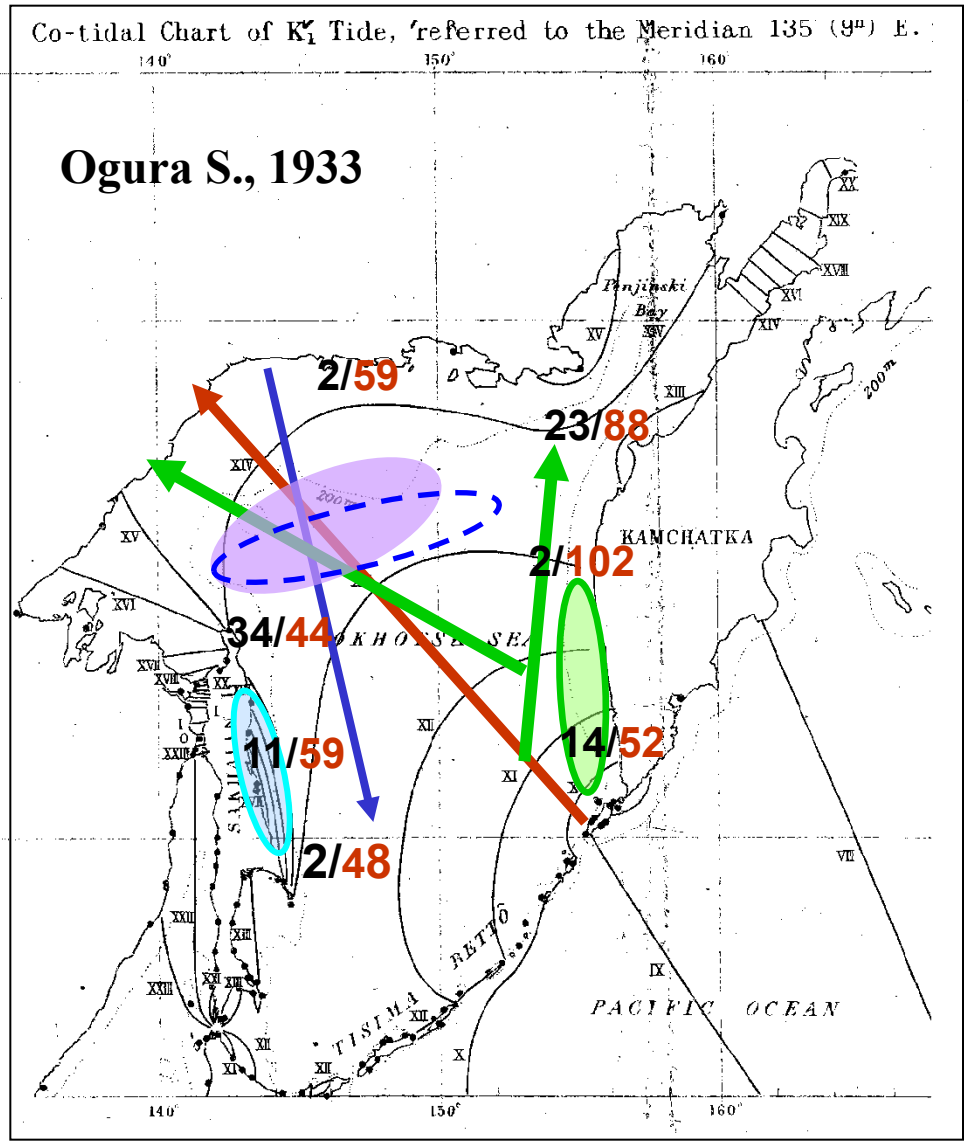



Tidal current reversibility coefficient (β) and direction of the velocity vector rotation for the waves K1, O1, and Q1.

- reverse currents β ≤ 0.1
- circular β > 0.5 clockwise
- circular β > 0.5 counter-clockwise

Tidal current reversibility coefficient (β) and direction of the velocity vectors rotation for the waves M2, S2 and N2.

*Every tidal current circulates. In the center of the each part of the surveyed area, reversibility coefficient β reaches its maximum, and the currents are reversing (β ≤ 0.1.) at the boundaries of the area.*




Ogura S.
Shevchenko G.V.* — Direction of of tidal wave propogation

Reflected wave

Antidones of standind component

Ogura S.
Shevchenko G.V.* — Nodal zone of standing component

High amplitude area

*Structure of tidal waves is shown by numbers:*
*Denominator - translational component of the tidal wave (cm)*
*Numerator - standing component tidal wave (cm)*
*Calculated using the "orbits" method (Supranovich, T.I., 1989.)*

**Vmax formation scheme of the Eastern Sakhalin shelf for K1 tide.**

* Shevchenko, G.V. and Romanov, A.A. 2004. Determine characteristics of tide in the Sea of Okhotsk by satellite altimetry. The study of earth from space. N 1, p. 49-62.

**Conclusions**

During the analysis a question arose - why are there such a significant velocity of the tidal currents for diurnal waves at the analyzed area of the Sakhalin island shelf?

We tried to find the answer to the question considering that the tidal currents and tidal sea level fluctuations are both phenomena of the same process – the tidal process.

High velocity of tidal currents for diurnal waves is observed on Sakhalin shelf because of the waves interference with the nodal oscillation zone.

In this case of incoming tide (the sea level heightening), the tidal streams are directed to the antidone zone, and that is what we got in our analysis.


Thank you for attention!