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VARIABILITY OF WATER FLOW IN THE EZCURRA INLET*

1. INTRODUCTION

The Ezcurra Inlet constituting a part of Admiralty Bay on King George Island in the South Shetland Islands, was the region of oceanographic measurements during part of the Antarctic summer of 1978. The preliminary results of these investigations in comprehensive form were published by J. Dera [5].

For the last several decades investigations have been carried out in this region by well-known scientific expeditions (e. g., Discovery II — 1927). For the last few years the main object of investigations was the Antarctic Circumpolar Current flowing eastward almost the whole of the year. Comprehensive measurements were carried out under the FDRAKE 75 experiment [2, 12] in Drake Passage. On the basis of experimental data, water flow in the passage amounting to $124 \cdot 10^6\ m^3 \cdot s^{-1}$ and directed eastward was calculated.

Another area of extensive research in recent years was the Weddell Sea, which is the main region of origin of Antarctic bottom waters characterized by high density. The International Weddell Sea Oceanographic Expedition (IWSOE 1968—1977 and IWSOE 1975) was among the expeditions exploring this region [6, 10].

The oceanographic investigations carried out in the Ezcurra Inlet can be related to spatial and time investigations covering larger areas (FDRAKE, IWSOE). The work dealt mainly with tidal phenomena and currents, which, penetrating from the open sea to the inlet, change their characteristics periodically. Data obtained from hydrological measurements *(S, T, D)* facilitated the determination of the properties of water masses in the water bodies affected by such harmonic processes as tidal currents.

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2. OBSERVATIONAL DATA

During the 2nd Polish Antarctic Expedition in January, February and March 1978, a series of hydrological and meteorological measurements were carried out in the Ezcurra Inlet, on King George's Island and the South Shetland Islands.

The location of measuring sites is shown in Fig. 1. Autonomous current measuring stations were installed at points I and II. Measurements were performed with BPW-2 type recording current-meters, with readouts of current speed and direction every 15 min. The depth of the inlet at the measuring sites was about 80 m. At point I, the recording was carried out at depths of 20 and 70 m from 16th January, 1978 to 1st February, 1978, whereas at point II — at depths of 20, 45 and 70 m from 23rd February, 1978 to 9th March, 1978. Recordings at the depth of 45 m were taken for less than three days, due to jamming of the current-meter.

Besides the above water salinity and temperature were measured at standard depths in the region of the anchorage point. Other measurements utilized in this paper include sea levels, wind speed and direction.

Sea levels were measured at point *P* (Fig. 1) in the vicinity of the

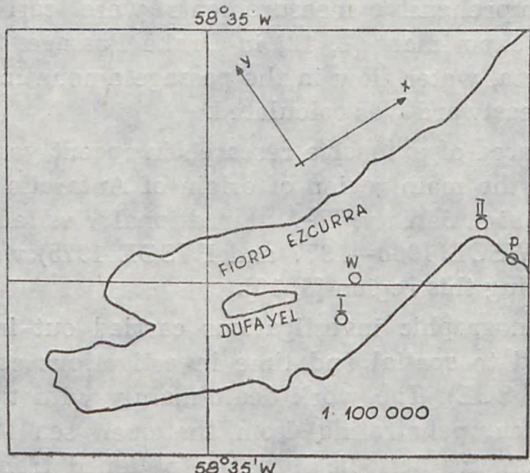


Fig. 1. Location of the measuring points in the Ezcurra Inlet:
I, II — sea current measuring points
P — sea level measuring point
W — wind velocity measuring point

Rys. 1. Lokalizacja punktów pomiarowych we fiordzie Ezcurra:
I, II — punkty pomiarowe prądów morskich
P — punkt pomiarowy poziomu morza
W — punkt pomiarowy prędkości wiatru

Polish „Henryk Arctowski" station at 1-hour intervals. Wind was measured every 3 hrs at point *W* in the ship's anchorage region. All times are related to GMT.

The coordinate system for calculation purposes was chosen in such a manner that the X-axis coincided with the inlet axis and the positive direction of the Y-axis, perpendicular to the shore, was at an angle of 330° to the north.

3. HYDROLOGICAL CONDITIONS

The hydrometeorological conditions in the Ezcurra Inlet can be characterized by the variations of selected parameters shown in Fig. 2. This figure illustrates variations of absolute values of the wind speed *W*, the current speed *U* at point II, at depths of 20 and 70 m, and sea level *P* for the period 23rd February, 1978 — 9th March, 1978. The characteristics presented show no correlation between the wind speed and the cur-

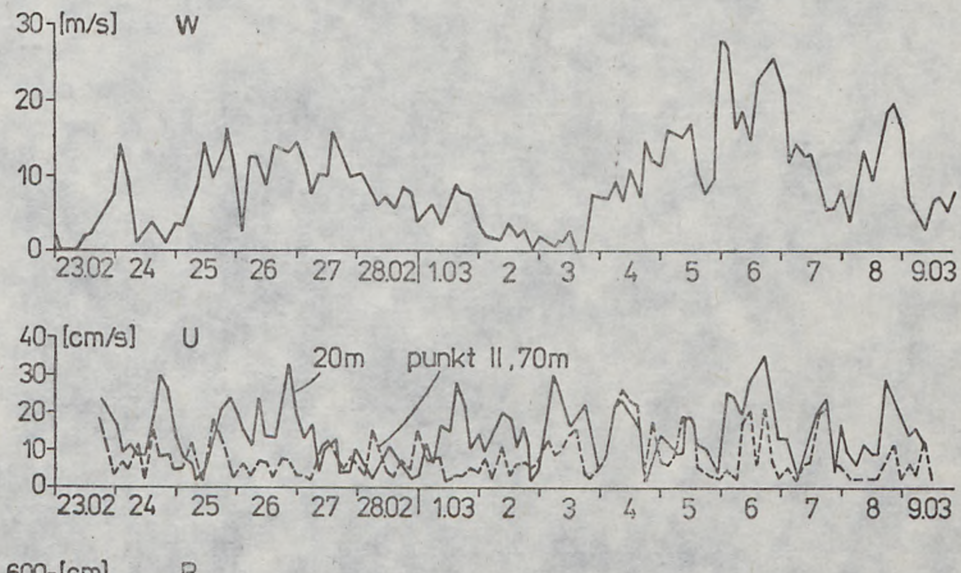


Fig. 2. Variability of wind velocity (*W*), current speed (*U*) and sea level (*P*)
Rys. 2. Zmienność prędkości wiatru (*W*), prędkości prądu (*U*) i poziomu morza (*P*)

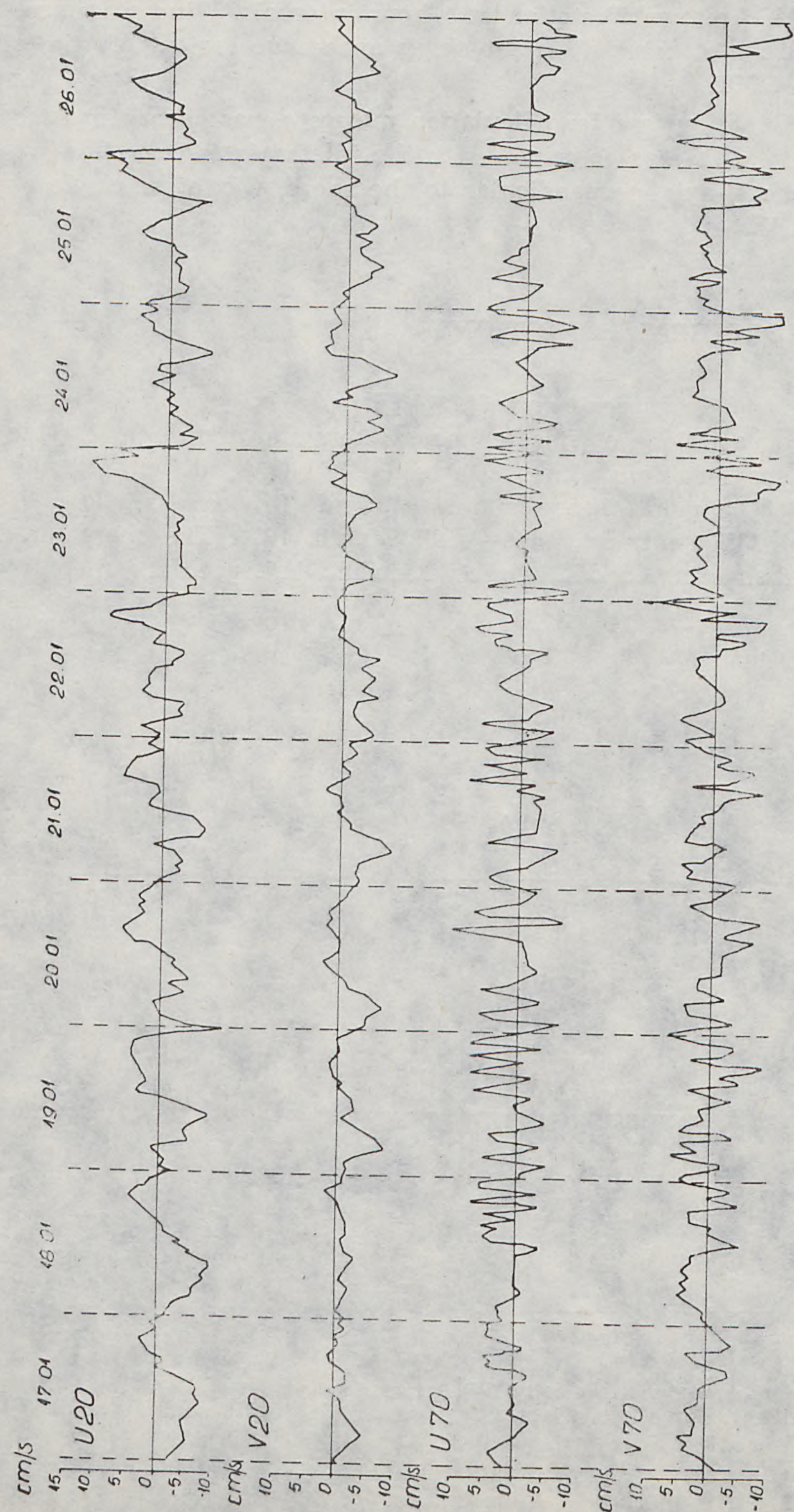


Fig. 3. Current components at point *I* (depths 20 and 70 m)
Rys. 3. Składowe prądów w punkcie *I* (głębokość 20 i 70 m)

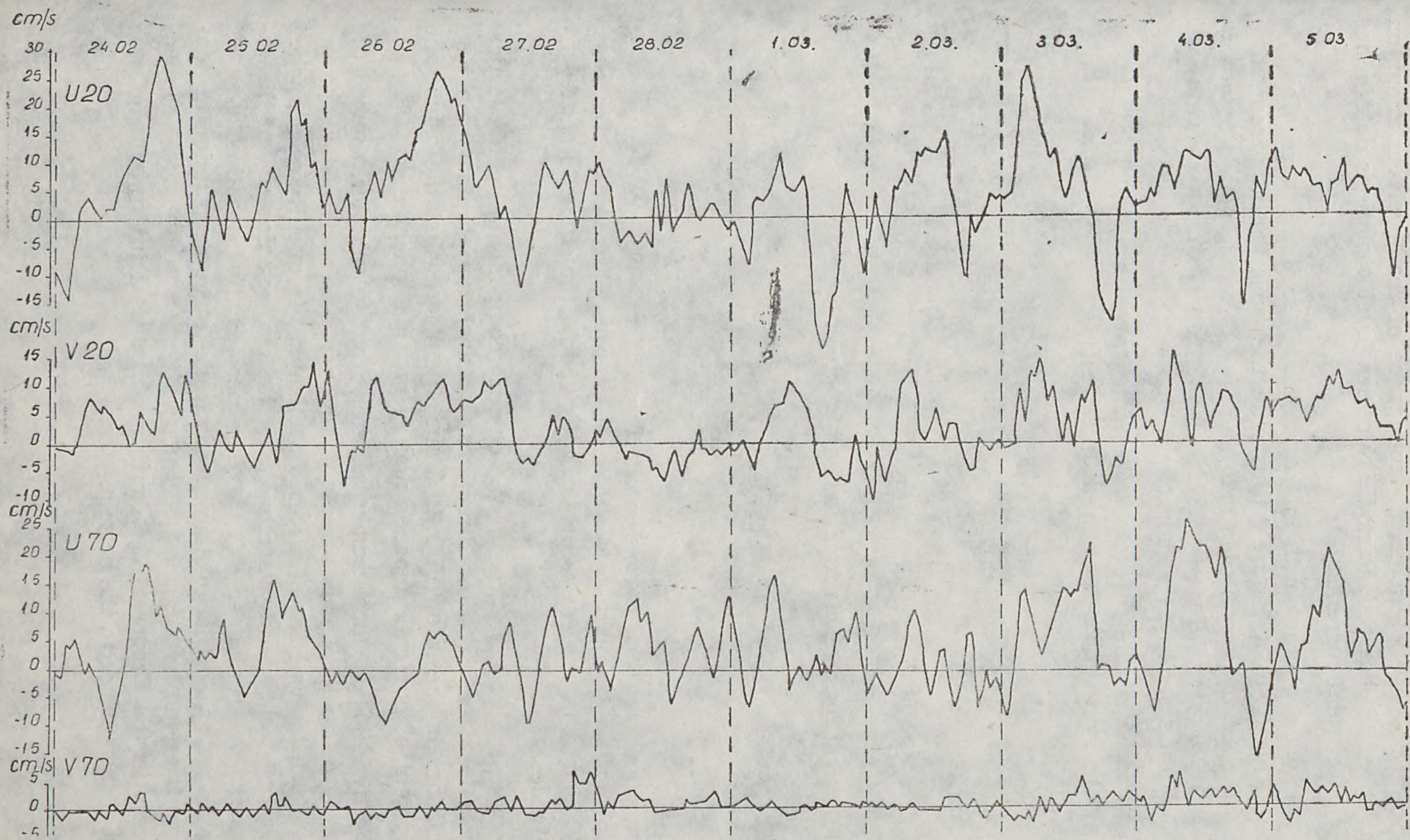


Fig. 4. Current components at point *II* (depths 20 and 70 m)
Rys. 4. Składowe prądów w punkcie *II* (głębokość 20 i 70 m)

rent speed, whilst a pronounced dependence of sea level variations on current speed is observed. Periodicity of sea level variations determines origination of tidal currents.

A complete characteristic of water flows in the Ezcurra Inlet is shown in Figs. 3 and 4. Figure 3 illustrates the variation of current components u and v at point I (depth 20 and 70 m), for the period from 17[th] January, 1978, to 26[th] January, 1978, while Fig. 4 — analogous values at point II for the period 24[th] February, 1978 — 5[th] March, 1978.

Time series of the current components have been smoothed out by applying the symmetrical weighted function [14].

$$P/t/ = \frac{t_0 - |t|}{t_0^2} \qquad \text{for } t_0 \geqslant t$$

$$P/t/ = 0 \qquad \text{for } t_0 < t$$

The numerical form of his function can be given by:

$$P_i = \frac{3 - |i|}{9} \qquad \text{for } i = -2, -1, 0, 1, 2$$

where $\sum P_i = 1$

The components u and v presented (Figs. 3 and 4) were averaged at 1-hour intervals. These plots show a well-marked periodicity of currents in the Ezcurra Inlet. This is particularly visible for currents caused by diurnal tides.

Comparison of variations of the current components in the vertical demonstrates identical flow directions. Even this preliminary analysis of conditions in the inlet (Figs. 2, 3 and 4) suggests that the origin and development of currents depends mainly on tidal phenomena.

The hydrological measurements, carried out in summer, showed the occurrence of homogeneous oceanic water from the surface down to the bottom. Such intermixing of waters (mechanical) frequently occurs when a given reservoir, usually narrow and shallow, remains under the influence of tidal components [1, 4]. The periodically repeating dynamic process in the case of large flow speeds leads to the destruction of density stratification of water masses. Temperature and salinity *(T—S)* measurements in the Ezcurra Inlet confirmed the total intermixing of waters from the surface to the bottom.

4. THE ORIGIN OF TIDAL CURRENTS AND THEIR EVALUATION

The origin of tidal currents results directly from tidal processes. In the case of a narrow reservoir connected with the ocean, the tidal wave forces a current of a bidirectional character, according to the repeatability of a tidal period. Orbits of tidal currents, which are almost ellipses, change from day to day depending on the new or full moon.

According to Defant, the tides can be divided into [4]:

— independent tides,

— co-oscillating tides.

In the former case, the tide-generating forces act directly on the water masses of a basin, whereas in the latter — the reaction is the effect of tidal phenomena in the ocean. In the Ezcurra Inlet, the action of a independent tide is very small. The dimensions of a reservoir affect the value of basic period. For a reservoir connected with the ocean on one--side, the Merian formula is [11]):

$$\tau_n = \frac{4L}{/2n+1/\sqrt{gH}}$$

For a reservoir with a length of $L = 18$ km and depth of $H = 100$ m, the maximum basic period $\tau_n = 4L/\sqrt{gH} = 40$ min. Therefore, the possibility of generation of water resonance does not exist in this basin, as the basic period τ_n is much smaller than the tidal period T.

In Penzhin Bay (Sea of Okhotsk) the basic period of vibrations is equal to $\tau_n = 12.19$ hrs, thus amounting to exactly half the period of a diurnal tide [13]. As a result, the resonance of a partial tide with a diurnal tide often occurs in this bay and the wave amplitude K_1 is one of the highest in the world ocean (ca. 252 cm).

The coastal conditions in the inlet cause deflection and suppression of energy of the tidal wave. Speed and passage time of the wave depend not only on the height and phase of tides, but also on the sea depth [11]. In the case of a long, progressive wave the vertical oscillations can be described by the equation [7]:

$$z = z_0 \cos /\sigma t - kx/$$

where:

z_0 — the amplitude of oscillations, $\sigma = \frac{2\pi}{T}$

T — the wave period, $kx = \frac{2\pi}{\lambda}$ is the phase and λ is the wavelength.

From the equation of motion and continuity one can determine the velocity of tidal current [7]:

$$U = c\,\frac{z_o}{H}\cos(\sigma t - kx)$$

where: $c = \sqrt{gH}$ is the velocity of the tidal wave.

The maximum velocity of tidal current directed along the X-axis is reached when the term cos $(\sigma t - kx)$ is equal to 1. In this case, the velocity is $U = c\, z_o/H$.

Assuming an amplitude of oscillations $z_o = 2$ m and depth of $H = 100$ m for the Ezcurra Inlet, the maximum calculated current velocity is $U = 31$ cm/s. Such a case occurs at high and low water, but the direction of flow changes in the two cases. Under such circumstances the propagation of the wave is bidirectional, the wave moving along the X-axis in one direction during one half-period, and in the opposite direction during the second half-period.

5. TWO-DIMENSIONAL DISTRIBUTIONS OF CURRENT PULSATIONS

According to Reynolds' hypothesis, the variability of currents can be represented by the averages $(\bar{u}, \bar{v})$ and the pulsations (u', v'):

$$u = \bar{u} + u'$$

$$v = \bar{v} + v'$$

$$\text{where: } \bar{u} = \frac{1}{T}\int_0^T u\,dt \quad \text{and} \quad \bar{v} = \frac{1}{T}\int_0^T v\,dt$$

For the purpose of calculation of the average current components the integrals were substituted by the sums with time intervals between the successive readouts $\Delta t = 0.25$ hrs. To confirm the distributions of u' and v' with the normal distribution, the Cornu expression was calculated [8]:

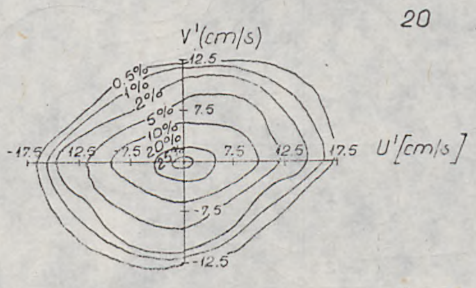
$$C = \left(\frac{\sigma}{\mu}\right)^2 = \left(\frac{\pi}{2}\right) \cong 1.57$$

$$\text{where} \quad \sigma'^2_u = 1/T\int_0^T (u - \bar{u})^2\,dt$$

$$\mu'_u = 1/T\int_0^T |u - \bar{u}|\,dt$$

Quantities σ'^2_v and μ'_v were determined in the same manner.

Calculated values of C give good approximation with an accuracy of 6 to 8%. Only at point I at a depth of 70 m, is the deviation from the theoretical value equal to 20% for the u-component. Quantities u' and v' subsequently calculated, were used to determine two-dimensional distributions of current pulsations at point I (Fig. 5) and II (Fig. 6).



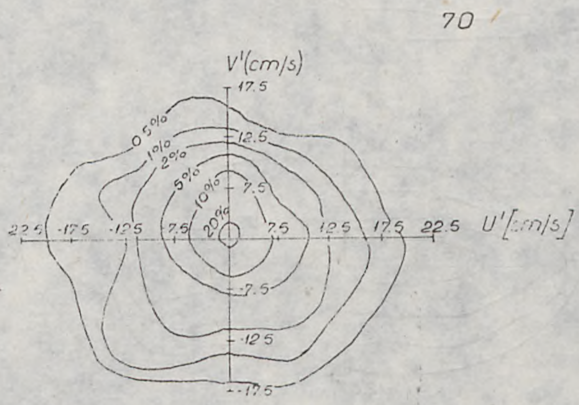


Fig. 5. Two-dimensional distributions of current pulsations at point *I* (depths 20 and 70 m)

Rys. 5. Rozkłady dwuwymiarowe pulsacji prądów w punkcie *I* (głębokość 20 i 70 m)

The distributions, expressed in percentages, enable the isolating of the predominating direction of current pulsations, as well as the structure of these pulsations, in cm/s, for a given depth. In order to plot these relationships, the percentage contribution of the u' — and v' — components of current pulsations in the pulsation velocity ranges $u_i = \pm 2.5$ cm/s and $v_i = \pm 2.5$ cm/s was calculated. The centres of squares are thus located at intervals of 5 cm/s with respect to the origin of the coordinate system ($u'_o = 0, v'_o = 0$). Plotted in this manner, quantities u' and v' indicated non-uniform distribution pulsations with respect to X, Y-axes. The distribution of pulsations runs along the X-axis which is especially pronounced for point II. Isolines of current pulsations form distinct ellipses. In addition, uniform vertical distribution of current pulsations is observed.

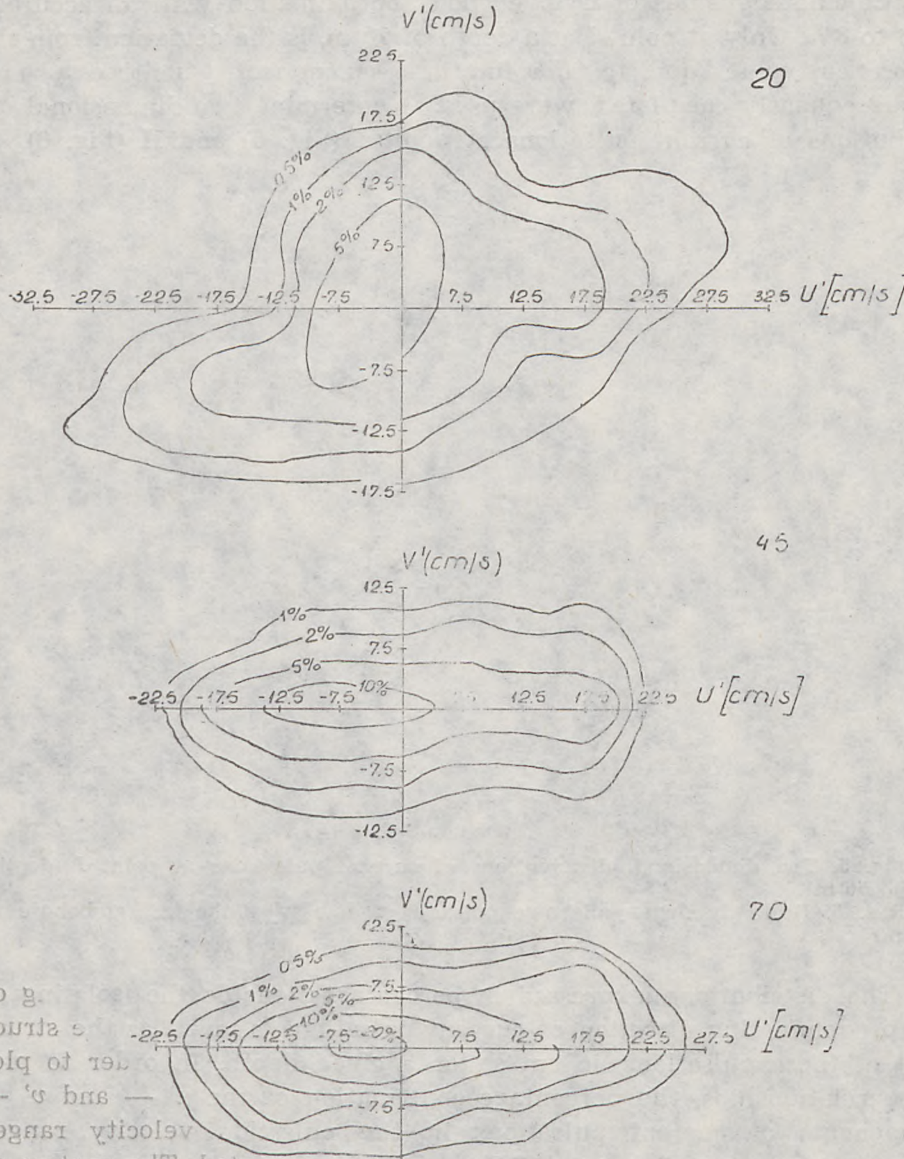


Fig. 6. Two dimensional distributions of current pulsations at point *II* (depths 20, 45 and 70 m)

Rys. 6. Rozkłady dwuwymiarowe pulsacji prądów w punkcie *II* (głębokość 20, 45 i 70 m)

The distribution mentioned above is interesting at point I (depth 70 m) — see Fig. 5. For large values of pulsations, represented by the isolines 0.5 and 1.0%, the distribution runs along the X-axis (along the axis of the inlet). The distribution is reversed in the case of small pulsation values. Such distributions are probably forced by the shape of a shoreline and bottom relief in this region. On moving inside the fiord, the current speed decreases markedly with diminishing depth. In order to confirm this phenomenon, intersection points of the isoline corresponding to 1% with the X-axis at points I and II were compared. At points I and II the values of u' are about $\pm$ 1.5 and $\pm$ 22.5 cm/s, respectively. The differences of current pulsations at a distance of ca. 3 km (between points I and II) are approximately ± 10 cm/s. Additionally, the symmetry of pulsations of the current components u' and v' is observed along both the main X-axis and the Y-axis.

6. VARIABILITY OF WATER FLOW CAUSED BY TIDES

In order to better recognize the variability of tidal currents, the tidal components were isolated from the sea level oscillations. The components are illustrated by the density spectrum of sea level oscillations (Fig. 7). The calculations permitted the isolating of four principal harmonic components — O_1, K_1, M_2, S_2, the characteristics of which are: O_1 — principal lunar diurnal component (T = 25.81 hrs), K_1 — lunisolar diurnal component (T = 23.93 hrs), M_2 — principal lunar semi-diurnal component (T = 12.42 hrs), S_2 — principal solar semidiurnal component (T = = 12.0 hrs).

It should be pointed out that the diurnal tide components (O_1, K_1) dominate in the spectrum. The energy maximum corresponding to a semi-diurnal tide is considerably lower than that of a diurnal tide. The diurnal tide contributes over 9 times more energy to the density spectrum of sea level oscillations than the semidiurnal tide in case a), and 4 times more energy in case b) (Fig. 7). This energy ratio of diurnal and semi-diurnal tides is undoubtedly affected by a half-monthly tide. This tide, however, was outside the analyzed time range.

The spectrum of the sea level oscillations was calculated by means of the maximum entropy method (MEM), derived from Wiener's theory of optimum filtration [9]. The method is usually used to analyze short series of experimental data. The spectral density can be described by the expression:

$$P(f) = \frac{P_m \Delta t}{\left| 1 - \sum_{m=1}^{n} a_{mn} e^{-2\pi i f n \Delta t} \right|^2}$$

where f is the Nyquist frequency: $-1/2\Delta t \leqslant f \leqslant 1/2\Delta t$.

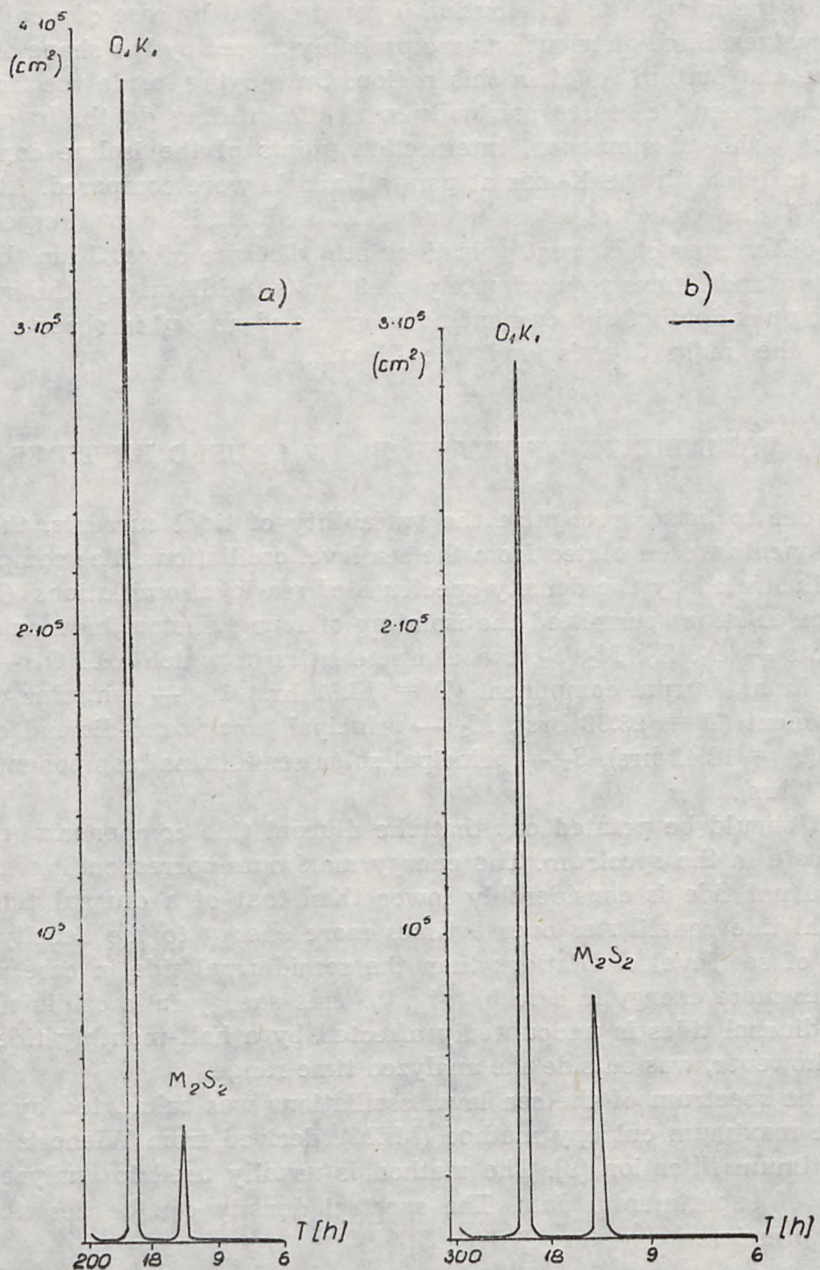


Fig. 7. Spectral density of sea level oscillation: a) during the period of 19th January — 27th January, 1978, b) during the period of 24th February — 5th March, 1978

Rys. 7. Widmowa gęstość zmian poziomu morza: a) 19—27 I 1978 r.; b) 24 II—5 III 1978 r.

Coefficients P_m and a_{mn} can be calculated from the equation:

$$\begin{bmatrix} k_o k_1 & \dots & k_m \\ k_1 & & \cdot \\ \cdot\ \cdot & & \cdot \\ k_m & \dots & k_1 k_o \end{bmatrix} \begin{bmatrix} 1 \\ -a_{m1} \\ \cdot \\ -a_{mn} \end{bmatrix} \begin{bmatrix} P_m \\ O \\ \cdot \\ O \end{bmatrix}$$

where: $k_i = E\,[x_t \cdot x_{t+1}]$.

Tidal phenomena as well as the tidal amplitude and phase associated with them determine the character and intensity of tidal currents.

The amplitudes of periodic oscillations of the current components at points I and II are shown in Figs. 8 and 9. The figures represent so-

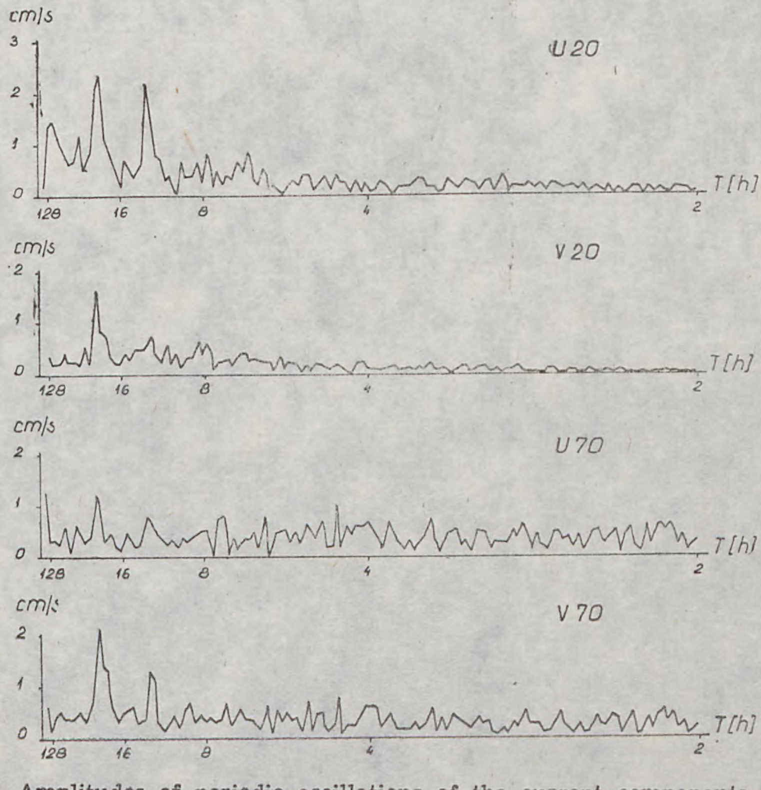


Fig. 8. Amplitudes of periodic oscillations of the current components at point *I* (depths 20 and 70 m)

Rys. 8. Amplitudy okresowych oscylacji składowych prądu w punkcie *I* (głębokość 20 i 70 m)

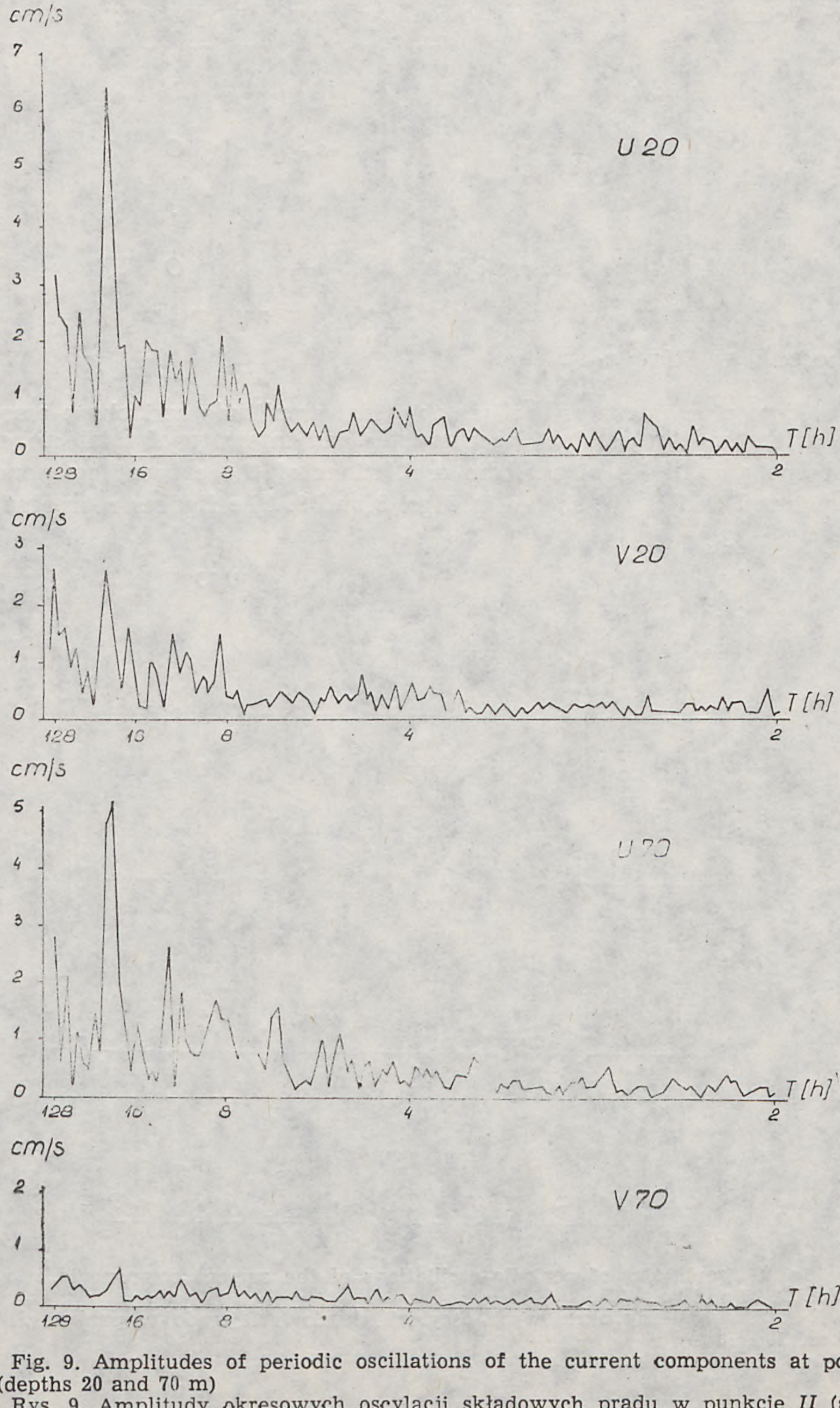


Fig. 9. Amplitudes of periodic oscillations of the current components at point *II* (depths 20 and 70 m)

Rys. 9. Amplitudy okresowych oscylacji składowych prądu w punkcie *II* (głębokość 20 i 70 m)

-called „raw" amplitude spectra calculated by the FFT algorithm [3]. These values differ to a large extent at both points of the Ezcurra Inlet. For point I, situated inside the inlet, the amplitudes of *u*- and *v*-components of current are small. On the other hand, at point II (entry to the fiord), the amplitudes are considerably larger at both depths investigated. Maximal current amplitudes for the diurnal period at point II equal over 6 cm/s for *u* 20 and over 5 cm/s for *u* 70. In the remaining cases, the amplitudes of the tidal currents for 24 and 12 hr periods do not exceed 3 cm/s.

Two oscillation periods of the current components can be identified in addition (ca. 8 and 4 hrs) from the characteristics shown in Figs. 8 and 9.

An interesting fact was observed by comparing the spectrum of the sea level variations (Fig. 7) with the spectra of amplitudes of the current components *u* and *v* (Figs. 8 and 9). The sea level variability is determined primarily by a semi-diurnal tide, whereas the tidal current variability is governed by the diurnal period.

Further work involved spectral analysis of currents in the Ezcurra Inlet using the method of rotational components. The method was used, e.g., for the investigation of current variability in the Baltic [3].

The characteristics of rotational components for points I and II are shown in Figs. 10 and 11. The figures comprise: total spectrum, negative spectrum, rotation coefficient and orientation of the major axis of the current ellipse with respect to the assumed direction (330° from the north). The total spectrum W_t, representing the average kinetic energy, can be written as:

$$W_t = W_- + W_+,$$

where: $W_- = 1/2 < u_- u_-^* >$ is the negative spectrum corresponding to the clockwise motion,

$W_+ = 1/2 < u_+ u_+^* >$ is the positive spectrum (not shown in Figs. 10 and 11) corresponding to the counterclockwise motion,

* — represents the conjugate variable.

The rotation coefficient is defined as:

$$R_0 = \frac{W_- - W_+}{W_t}$$

Spectral analysis was conducted for periods ranging from 42 to 3 hrs. The analysis proved that the maximum of kinetic energy corresponds to the period of diurnal currents (K_1, O_1). This maximum prevailed over the remaining ones in all cases investigated. Other energy maxima

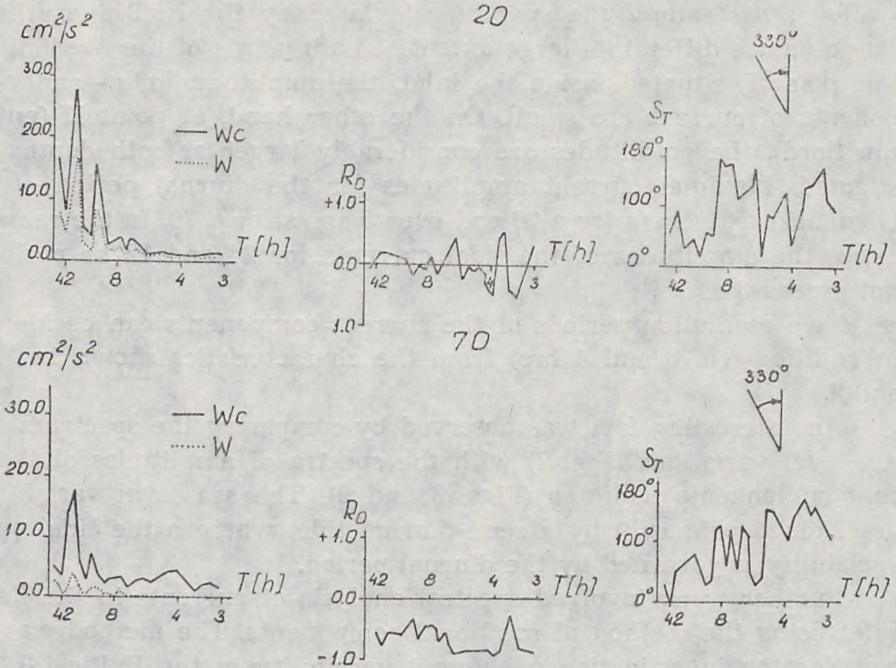


Fig. 10. Rotational spectrum *W*, rotation coefficient R_o and orientation of the major axis of ellipse S_T of currents at point *I*

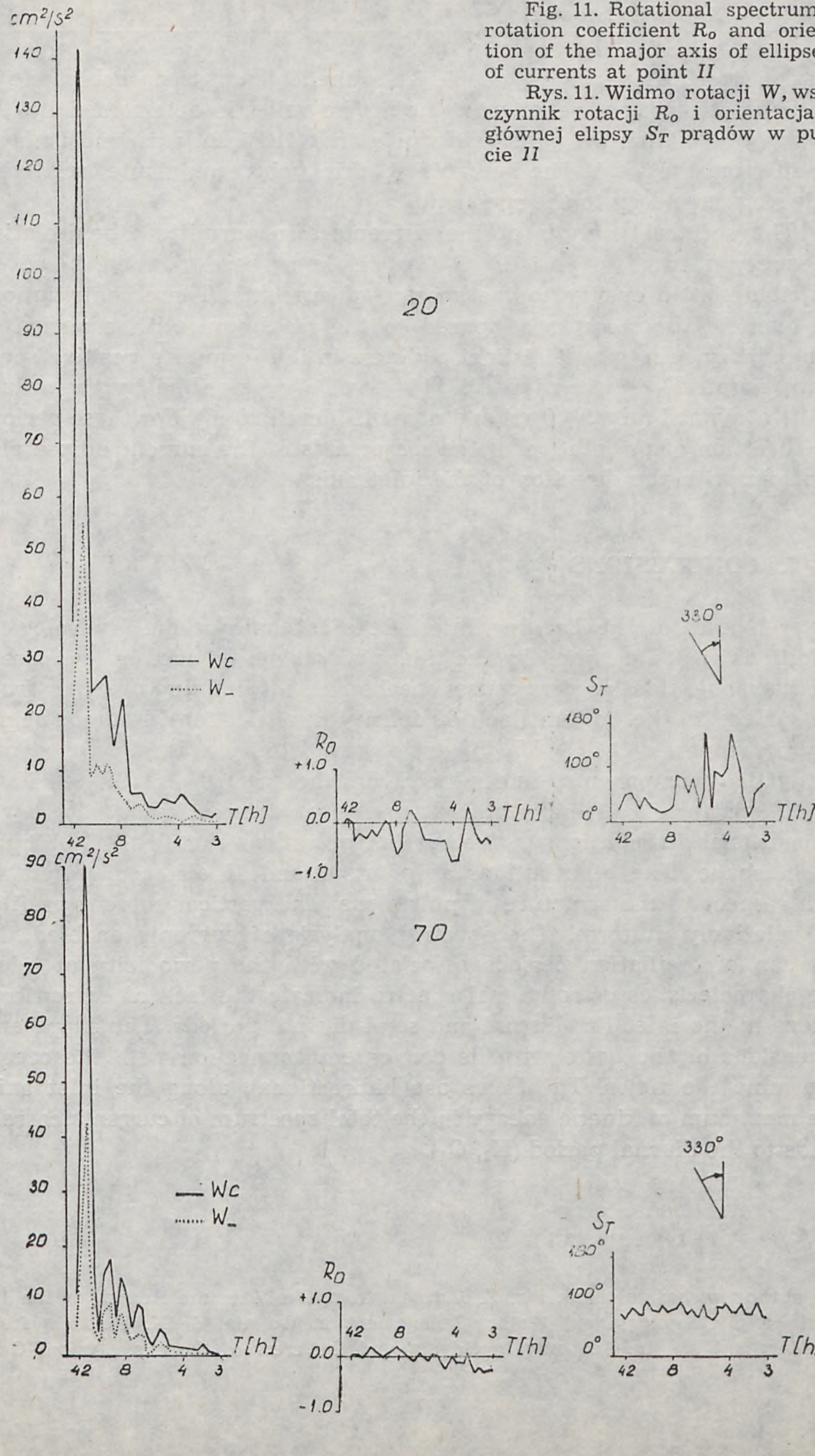
Rys. 10. Widmo rotacji *W*, współczynnik rotacji R_o i orientacja osi głównej elipsy S_T prądów w punkcie *I*

correspond to a period of semidiurnal tidal currents (M_2, S_2) as well as a period equal to ca. 8 and 4 hrs. The predomination of the diurnal tide current is unequivocal at point II in particular. For example, the energy maxima for periods K_1 and O_1 are about 5 times greater than those for periods M_2 and S_2. At point I, where the dynamics of tide-generating processes is considerably smaller, this ratio is only two.

The calculated rotational components indicated that the action of tidal currents in the Ezcurra Inlet is bidirectional along the axis of the basin. The inlet morphometry prevents the occurrence of eddy tidal motion. Assuming that there is no effect of the Coriolis force, no phase shift of tides was observed. The bidirectional water flow is indicated by the rotation coefficient, as well as the orientation of the main axis of the tidal currents ellipse. The value of the rotation coefficient R_0 approaches zero except for point I (depth 70 m), this being the result of a similar contribution of energy into the positive spectrum W_+ and the negative spectrum W_-. The main axis of the ellipse of tidal currents of a period of 24 and 12 hrs is oriented along the axis of the inlet. Counterclockwise rotation was only observed at point I, at a depth of 70 m. In this case the

Fig. 11. Rotational spectrum W, rotation coefficient R_o and orientation of the major axis of ellipse S_T of currents at point *II*

Rys. 11. Widmo rotacji *W*, współczynnik rotacji R_o i orientacja osi głównej elipsy S_T prądów w punkcie *II*



rotation coefficient was R_o=—0.5. This phenomenon is probably due to characteristic bottom relief at point I. The relief is determined by the 100 m isobath from the east (perpendicular to the inlet axis) and Dufayel Island from the west. The currents at this point contribute relatively little kinetic energy to the spectrum.

The spectral analysis of the currents also permitted the isolation of energy maxima of periods of 8 and 4 hrs. These maxima, however, contribute little energy to the spectra of currents. These contributions are over 10 times lower compared to the maximum with a period of 24 hrs. They bring about distinct eddiness in the form of a positive spectrum (counterclockwise motion). This can be exemplified by the values of $W+$ at point I (depth 70 m) and point II (depth 20 m). For these periods the direction of orientation of the major axis of the current ellipse also coincides with the direction of the inlet axis.

7. CONCLUSIONS

Water masses of the Ezcurra Inlet are of oceanic origin. Hydrological conditions are determined by the tidal phenomena induced by the ocean. The harmonic tidal process causes mechanical intermixing of water from the surface to the bottom (lack of density stratification). Four principal tidal components (O_1, K_1, M_2, S_2) are observed in the inlet. The predominating tidal components, determined from the spectrum of the sea level oscillations for chosen periods, are the diurnal components O_1, K_1. Two-dimensional distributions of the current pulsations are distinctly elliptical in shape. The distributions at points I and II differ considerably with respect to the structure of pulsations. The vertical current profiles are relatively uniform. The spectral analysis of currents enabled the isolation of oscillation periods associated with the periodicity of tides. The characteristics of rotational spectra indicate the lack of current rotations in the inlet for diurnal and semi-diurnal periods. The shape and dimensions of the basin with its convenient connection with the ocean, determine the flows. The flows are bidirectional, along the inlet axis. The maximum of kinetic energy in the total spectrum of currents corresponds to the diurnal period (K_1, O_1).

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VARIABILITY OF WATER FLOW IN THE EZCURRA INLET

Summary

The Ezcurra Inlet (King George Island) was the location of oceanographic investigations during the Antarctic summer of 1978. The research constituted a part of the programme of the second Polish Antarctic Expedition at the Arctowski Station.

The main aim of the work involved investigation of the variability of currents as compared with other parameters, such as: sea level, winds, temperature and salinity. Good correlation between the sea level oscillations and the currents was found. The oceanic water occurring in the inlet has a uniform temperature and salinity from the surface down to the bottom. The basin, remaining under the influence of tidal processes induced by the ocean, is characterized by the components O_1, K_1, M_2, S_2. A tidal wave of a given length, period and amplitude of oscillations, penetrating the inlet, causes the formation of a tidal current, closely associated with the periodicity of tides. Variable depth and cross-section of the inlet cause the change of characteristics of these waves.

Two-dimensional distributions of current pulsations are elliptical in shape. The dimensions of the ellipses differ considerably at various points of the inlet. On the other hand, the vertical profiles are characterized by the relatively uniform course of the current pulsations. Oscillation periods corresponding to tidal processes were isolated on the basis of spectral analysis of the currents. The current amplitudes reach their maximum values for a 24-hour period, particularly at the entry to the fiord. Considerably lower amplitudes were found for periods of 12, 8 and 4 hrs. Basing on rotational components, the motion of currents was determined as bidirectional (along the axis of the inlet). This is due to the shape of the fiord, among other factors. Such a character of the motion is confirmed by the rotation coefficient, the value of which is close to zero. A tidal wave moves in one direction during one half-period, and in the opposite direction during the second half-period.

A visible counterclockwise eddiness is observed in the energy maxima of currents with 8- and 4-hour period. These currents contribute very little energy to the current spectrum compared to tidal currents with 24- and 12-hour periods, especially the former.

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ZMIENNOŚĆ PRZEPŁYWU WÓD WE FIORDZIE EZCURRA

Streszczenie

W czasie antarktycznego lata 1978 r. fiord Ezcurra na Wyspie Króla Jerzego był poligonem badań oceanograficznych, stanowiących część programu II Polskiej Wyprawy Antarktycznej.

Głównym celem badań było opracowanie zmienności prądów na tle innych parametrów, jak: poziom morza, wiatr, temperatura i zasolenie wody. Otrzymano ścisły związek między zmianami poziomu morza i prądami. We fiordzie zalega woda oceaniczna, w której wartość temperatury i zasolenia jest wyrównana od powierzchni do dna.

Basen ten, będąc pod wpływem procesów pływowych, indukowanych z oceanu, charakteryzuje się składowymi O_1, K_1, M_2, S_2. Przenikająca do fiordu fala pływowa o określonej długości, okresie i amplitudzie wahań, powoduje powstawanie prądów pływowych, ściśle powiązanych z okresowością pływów. Zmienna głębokość oraz zmienne przekroje poprzeczne powodują zmianę charakterystyk tych fal. Dwuwymiarowe rozkłady pulsacji prądów przyjmują kształt elips. Wymiary ich są bardzo zróżnicowane, w różnych punktach fiordu. Natomiast profile pionowe charakteryzują się stosunkowo wyrównanym przebiegiem pulsacji prądów.

Na podstawie analizy widmowej prądów wydzielono okresy drgań odpowiadające okresom pływów. Amplitudy prądów dla okresu 24 godz. osiągają maksymalne wartości, szczególnie u wejścia do fiordu.

Znacznie mniejsze amplitudy stwierdzono dla okresu 12, 8 i 4 godz. Na podstawie składowych rotacyjnych określono ruch prądów pływowych jako dwukierunkowy (wzdłuż osi fiordu). Ruch ten potwierdza współczynnik rotacji, zbliżony do zera. Fala pływowa rozchodzi się pół okresu pływu w jednym kierunku, natomiast drugie pół okresu pływu w przeciwnym kierunku.

W maksimach energii prądu o okresie 8 i 4 godz. obserwuje się wyraźną wirowość o kierunku przeciwnym do ruchu wskazówek zegara. W porównaniu z prądami pływowymi o okresie 24 i 12 godz. a zwłaszcza 24 godz., wnoszą one bardzo mało energii kinetycznej w widmo prądów.

REFERENCES

1. A r s e n e v a, N., *K voprosu o vlijani prilivo-otlivnych techeni na klimatiches-kiej gidrologicheskie uslovya morya*, Trudy GOIN, 1961, 64.
2. B r y d e n, H., R. Pillsbury, *Variability of deep flow in the Drake Passage from year-long currents measurements*, J. Phys. Oceanogr., vol. 7, 1977, no 6.
3. C a t e w i c z, Z., Z. Kowalik, *Analiza widmowa wielkości wektorowych me-*

todą składowych rotacyjnych na przykładzie prądów w Morzu Bałtyckim, Oceanologia, 1979, 11.
4. Defant, A., *Physical Oceanography,* vol. 2, Pergamon Press 1961.
5 Dera, J., *Oceanographic investigation of the Ezcurra Inlet during the 2nd Antarctic Expedition of the Polish Academy of Sciences,* Oceanologia, 1980, 12.
6. Foldvik, A., T. Kvinge, *Bottom currents in the Weddell Sea,* Univ. of Bergen, Geofys. Inst. Bergen, Report no 21, 1974.
7. Jegorov, N., *Fizicheskaya okeanografya,* Leningrad 1974.
8. Kowalik, Z., S. Taranowska, *Horizontal large-scale turbulence the Baltic Sea,* Cahiers Oceanographiques, XIX, 4, 1967.
9. Lacoss, R., *Data adaptive spectral analysis methods,* Geophysics, vol. 36, 1971 no 4.
10. Middleton, J., T. Foster, *Tidal currents in the Central Weddell Sea,* Deep Sea Research, vol. 24, 1977, no 12.
11. Niekrasow, A., *Prilivnye volny v okrainych moryach,* Leningrad 1975.
12. Nowlin, W., T. Whitworth III, *Structure and transport of the Antarctic Circumpolar Current at Drake Passage from short-term measurements,* J. Phys. Oceanogr. vol. 7, 1977, no 6.
13. Sgibnieva, Ł., *Metod teorieticheskovo rascheta prilivov,* Trudy GOIN 40, 1957.
14. Uusitalo, S., *On smoothing of time series,* Reprint of Geophysica, 13, Helsinki 1975 no 2.

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