UDK:551.46.07(269)

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FIRST RESULTS OF OCEANOGRAPHIC WORKS ON UKRAINIAN LONGLINE VESSELS IN ANTARCTICA (CCAMLR ZONE) IN 2017/2018 SEASON

ABSTRACT. **Aim** of works is implementation of duties, taken by Ukraine on XXXVI Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Session and study of habitation of main fishing objects in Antarctica waters. **Methods** of works were the use of DST CTD recorder produced by STAR OGGICompany (Iceland) and the analysis of the obtained data. **Results** of works include 36 longline and 11 other stations (on a line, on streamer, on Juday plankton net) executed in Amundsen, Ross and Weddell Seas during the period from December 2017 to April 2018. Vertical changeability of temperature, temporal changeability of benthic temperature were analyzed; spatial changeability of temperatures in separate Seas was found out; 4 basic water masses were distinguished, influence of bottom temperature to the catches of Antarctic toothfish was analyzed. **Conclusion** was made about the increase in catches while lowering the bottom temperature in Weddell Sea.

Keywords: Antarctic, temperature, changeability, water masses, Antarctic toothfish.

INTRODUCTION

With the aim of study of ecological connections between fishery objects and environment and according to duty, taken by Ukraine on XXXVI Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Session, observers on the Ukrainian ships additionally to the main duties have made some oceanographic works. There are many works about oceanographic conditions in some seas of Antarctica (Arnold, 1977, Arnold et al, 2001, Deband Adrian, 2006, George, 1981, Jacobs et al, 2012, Walker et al, 2013). The major fundamental work that united the efforts of scientists of many countries became The Biogeographic Atlas of the Southern Ocean (De Broyer, et al., 2014). Our works had more specific orientation – to study influence of changeability of oceanographic elements to forming and dynamics of concentrations of fishery objects / firstly Antarctic toothfish (*Dissostichus mawsoni* Norman). Information was presented at XXXVII CCAMLR Session at 2018 (Paramonov, 2018).

Cite: Paramonov V. V. First results of oceanographic works on Ukrainian longline vessels in Antarctica (CCAMLR zone) in 2017/2018 season. *Ukrainian Antarctic Journal*, 2019. № 1(18), 75–83.

MATERIALS AND METHODS

Oceanographic works on Ukrainian vessels were carried out with the help of DST CTD (hereinafter CTD). DST CTD is a compact microprocessor-controlled temperature, depth and conductivity (salinity) recorder with electronic placed in a waterproof housing. It is a complex of programmable sensors, allowing making measurements of temperature, water, pressure (depths), conductivity and calculating salinity and speed of sound up to a depth of 2500 m approximately. Producer is STAR OGGI Company (Iceland) (https://www.star- od di.com/products/data-loggers/salinity-logger-probe-CTD).

The sensor was fastened to rope of the anchor in the distance a few meters from it and, accordingly, from the bottom.

The instruments had the following accuracy: temperature measurement ±0.1 °C, depth measurement ± 14.4 m, electrical conductivity measurement ± 1.36 μS / cm. At a water temperature of —1.2°, the accuracy of calculated salinity was ± 1.35 ‰. Depth determination could be adjusted with the depth sounder of the longline setting. Salinity data due to insufficient measurement accuracy were only used to determine water masses.

In addition, the sensors had a fairly large inertia. To obtain 95% accuracy, the values had to be kept at a predetermined horizon for about three minutes, which was not possible during the longline setting. Usually objective data started from depths of 100—200 m, when the temperature differences between the horizons were not so large. It was better to use the data obtained during longline hauling, but this was not always possible.

For the season of 2017—2018 the next volume of works (Table 1) was executed.

RESULTS AND DISCUSSION

Vertical changeability of temperature

The surface temperature in the Ross and the Amundsen Seas in the moment of beginning of works (December) was — 1,1—1,5°. In an eventual period of works (January) the surface temperature was — 0,2—0,9°.

The surface temperature in the Weddell Sea in March-April changed from 0° to —0,3°.

A vertical thermal structure is characterized by a drop in temperature from the surface to the depths of 100—300 m, where the temperature of water was — 1,2—1,7°, after which it begun to increase.

The bottom temperature in the places of toothfish fishing was in the Amundsen Sea: at a depth of 600 m from —1,1° to 0°, at a depth of 800 m +0,4°, at a depth of 900 m +0,58°, at a depth of 950 m +0,99 +1,02°, at a depth of 1150 m — +0,91 + 0,95°, at a depth of 1200 m +0,65+0,68°, at a depth of 1306—1372 m +0,61+0,79°, at a depth of 1496—1512 m +0,42+0,52°.

In the Ross Sea the temperature was at depths of 650—675 m + 0, 18—0, 43°, at depths of 1600—1700 m +1, 06 + 1,17°.

In the Weddell Sea at a depth of 1000 m the temperature was +0,17 + 0,34°, at 1400 m +0,13 + 0,17°, at 1500 m — 0,11 + 0,30°, at 1600 m fluctuated around zero.

The examples of vertical change of temperature in different Seas are presented in Fig. 2.

Absence of subsurface minimum of temperature in the Ross Sea, probably, is explained by the insufficient detailing of survey (a graph was built only for 8 points).

Changeability of bottom temperature in the areas of survey and fishery

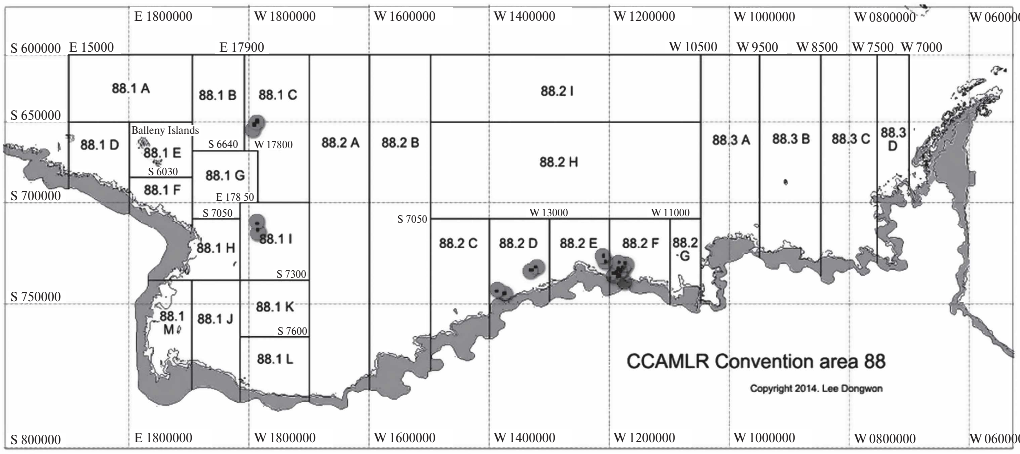
The obtained data are generalized in Tables 2—4. In the Amundsen Sea (Table 2) at depths of about

Table 1. **Amount of CTD stations executed by the Ukrainian vessels in separate areas of Antarctica in the season of 2017—2018**

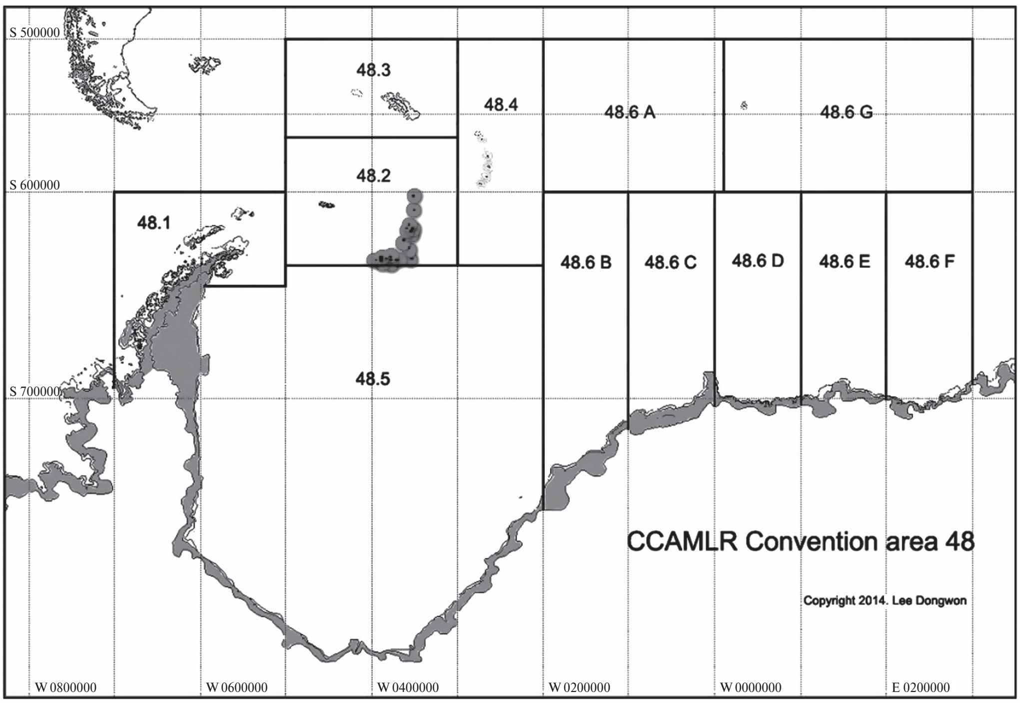
Ship	Amundsen Sea (88.2)		Ross Sea (88.1)	Weddell Sea (48.2)	Total	
	Longline	Other*	Longline	Longline	Longline	Other*
SIMEIZ	4			16	20	
KOREIZ	10	11			10	11
CALIPSO	2		4		6	
Total	16	11	4	16	36	11

* The "other" included the halyard, streamer, and Juday plankton net.

Distribution of longline CTD stations is indicated in Fig. 1



a



b

Fig. 1. Distribution of longline CTD stations in the Amundsen and the Ross Seas (*a*) and the Weddell Sea (*b*)

600 m the presence of both ascending and descending trends and presence of harmonic oscillations are registered in the change of bottom temperature. At depths of 800—1368 m the temperature practically did not change at times or changed very weak. More often there was a tendency to the rise of bottom temperature. In case of presence of harmonic oscillations, they had a daily period.

In the Ross Sea (Table 3) on the whole there were the same regularities. The most interesting changes were marked at a longline № 37 (Fig. 3), where both gradually attenuation oscillation a daily period and increasing trend, were simultaneously marked.

In the Weddell Sea (Table 4) oscillation a daily period observed only one time at a minimum depth (of about 1000 m), and tendencies to the increase and drop in the temperature were observed almost equal frequently.

It is interesting that there were oscillations of a daily period in all three seas. Most often they were

Table 2. **Bottom temperature in the Amundsen Sea**

№ of longline	Depth, m		Temperature, deg.		Tendency, period
	limits	middle	limits	middle	
KOREIZ					
12	1119—1191	1172	+0,61+0,69	+0,65	
18	581—603	596	–1,08—0,12	-0,76	Weak increase, after lowering
22	887—991	897	+0,56+0,61	+0,58	
33	618—661	635	+0,09+0,29	+0,16	Weak increase
39	1006—1013	1010	+0,60+0,64	+0,64	
44	1211—1216	1214	+0,64+0,68	+0,67	
49	792—802	801	+0,28+0,48	+0,36	Weak oscillation a daily period
51	610—662	656	+0,17+0,33	+0,22	Weak increase
53	—	—	—	—	Measuring only near the surface
56	—	—	—	—	Measuring only at a surface
CALIPSO					
50	904—905	905	+0,99+1,02	+1,02	
56	1149—1169	1155	+0,87+0,95	+0,92	Tendency to the increase
SIMEIZ					
33	1363—1388	1368	+0,67+0,79	+0,73	Oscillation a daily period
40	1306—1310	1308	+0,67+0,75	+0,73	Oscillation a daily period
61	1314—1323	1320	+0,63+0,71	+0,67	Increase
62	1499—1512	1501	+0,42+0,54	+0,45	

Table 3. **Bottom temperature in the Ross Sea (CALIPSO)**

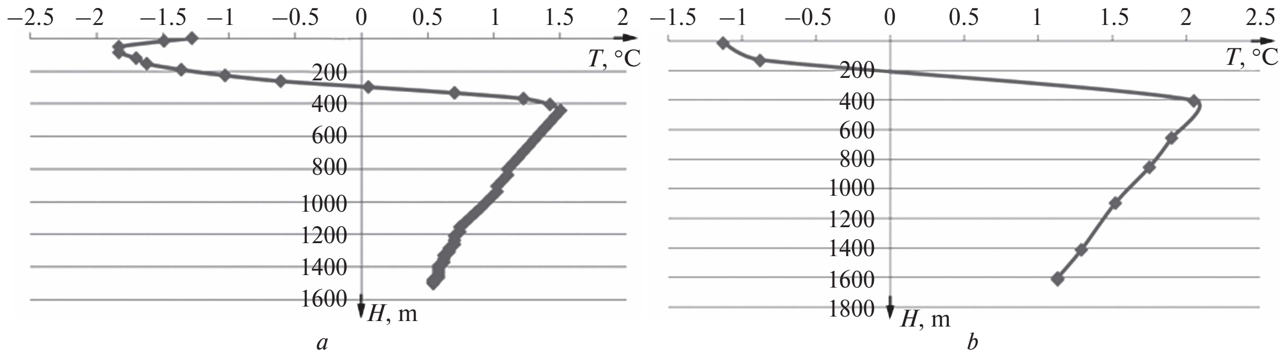
№ of longline	Depth, m		Temperature, deg.		Tendency, period
	limits	middle	limits	middle	
1	1604—1611	1609	+1,13+1,17	+1,14	
6	1708—1698	1702	+1,06+1,14	+1,10	Oscillation a daily period
33	641—649	647	–0,43-0,27	–0,35	Oscillation a daily period
37	663—688	681	–0,35+0,18	–0,14	Oscillation a daily period; increasing trend

registered in the Ross Sea, the least – in the Weddell Sea. It is possible, they have a tide origin.

Spatial changes of temperature

In the Amundsen Sea water in eastern parts is colder, than in western. So, at a depth of 1000 m the temperature of water in a SSRU 88.2F was more cold (+0,57+0,64°), than in SSRUs 88.2.C and 88.2.D (+0,91+1,03°). In the Ross Sera water in the north (650 m +1,90°) in a SSRU 88.1C is notably warmer, than in the south (650 m — 1,14°) in a SSRU 88.1I.

But the best of all spatial changeability can be estimated from data of the survey executed in the Weddell Sea. At a depth of 1000 m the increase of



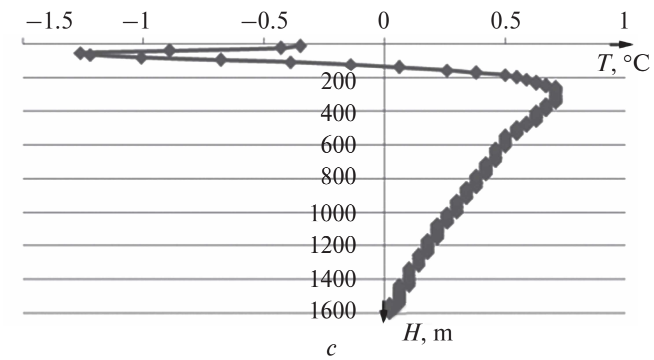


Fig. 2. Typical vertical distribution of temperature in the Amundsen Sea (*a*), the Ross Sea (*b*) and the Weddell Sea (*c*)

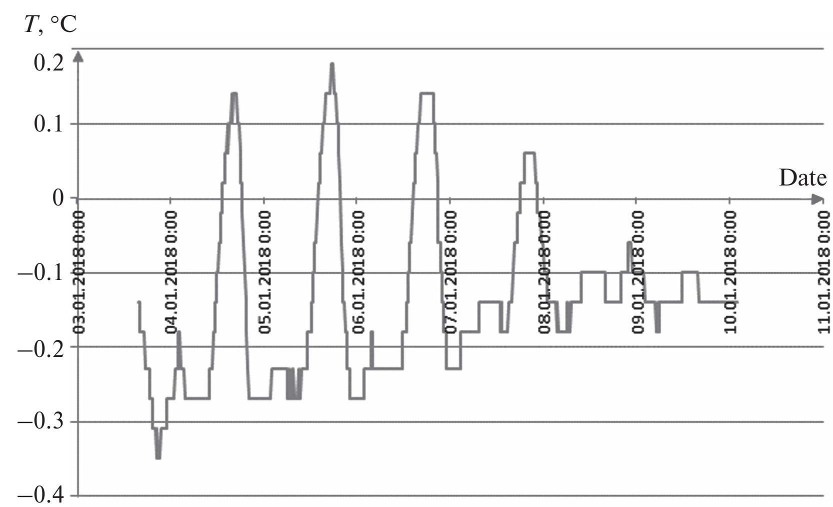


Fig. 3. Change of temperature in a bottom layer. Longline № 37 (CALIPSO)

Table 4. **Bottom temperature in the Weddell Sea (SIMEIZ)**

№ longline	Depth, m		Temperature, deg.		Tendency, period
	limits	middle	limits	middle	
1	1000—1015	1008	+0,17+0,34	+0,28	Oscillation a daily period
2	1545—1550	1548	–0,10+0,22	+0,03	Tendency to the increase
3	1604—1610	1607	+0,02+0,10	+0,02	Tendency to the increase
4	1510—1515	1512	–0,01+0,01	–0,08	Tendency to the decrease
7	1545—1560	1552	0+0,09	+0,09	
8	1427—1430	1428	+0,20+0,34	+0,29	
9	1158—1161	1160	+0,35	+0,35	
10	1683—1687	1685	–0,03–0,15	–0,07	Tendency to the decrease
13	1601—1605	1603	–0,02	–0,02	
17	1473—1478	1476	+0,14+0,26	+0,16	Weak increase at the end
20	1497—1502	1500	+0,22+0,30	+0,22	
21	1585—1590	1588	+0,02+0,22	+0,10	Tendency to the increase
23	1339—1407	1402	–0,03+0,30	+0.19	Weak tendency to the decrease
25	1595—1605	1600	–0,01+0,02	–0,01	
42	1402—1409	1406	+0,13+0,17	+0,16	
46	1651—1654	1652	+0,10+0,18	+0,14	

Table 5. **Water masses of the Amundsen, Ross and Weddell Seas**

Water mass	Amundsen Sea	Ross Sea	Weddell Sea
Antarctic Surface Water (AASW)	Lower boundary 50—100m Temperature –0,6—1,2°	Lower boundary 50—100m Temperature –0,6—1,2°	Lower boundary 50 m Temperature 0—0,4°
Winter water (WW), or Antarctic Intermediate Cold Layer (AICL)	Lower boundary 200—600m Temperature –1,2—1,8°	Lower boundary 200—300m Temperature –1,2—1,8°	Lower boundary 50—200m Temperature –0,9—1,4°
Circumpolar deep water (CDW)	Lower boundary 1500m Temperature +0,7 + 1,0°	Lower boundary 400—500m Temperature +0,3 + 1,1°	Lower boundary 1000m Temperature +0,5 + 0,7°
Deep water of the Ross Sea (RSDW)	No	Lower boundary 600—700m Temperature –0,2—0,4°	No
Deep water of the Weddell Sea (WSDW)	No	No	Lower boundary 1600 m Temperature near 0°

temperature is observed from the southwest (+0,21°) to the northeast (+0,46°). The same conformity is observed at a depth of 1500 m (–0,07° in the southwest and +0,22° in the northeast). In the southwest the most considerable temperature gradients are marked in a bottom layer (up to 0,05—0,07° on a mile). In the northeast the increase of temperature is observed above depth high.

The water masses

Three water masses are in the Amundsen Sea: Antarctic surface water (AASW), Winter water (WW), or Antarctic Intermediate Cold Layer (AICL) and Circumpolar deep water (CDW).

AASW extends from a surface to the depth of 50—100 m. It is the near-surface layer of water warmed up in a spring-summer period with a temperature — 0,6–1,2°. WW (AICL) is lower, with a temperature in a core near to the freezing-point of salt water in this region — 1,8°. It extends to the depth of 200 m in the north and to 600 m in the south. Warm CDW being penetrating to the south waters of the Antarctic Circumpolar Current (ACC) is deeper located. Temperature in the core within the limits of measuring is +0,7. Water mass extends to the maximal depth of measuring of 1500 m and, maybe, deeper. A characteristic feature of this Sea is the absence of its own deep water mass, at least within the surveyed parts, which is confirmed by literature (Deb et al, 2006; Jacobs et al, 2012; Walker et al, 2013).

In the Ross Sea the limited amount of data was received, however, in the north part of the sea the structure of waters and the water masses on the whole are analogical to the Amundsen Sea. In the south part of the sea, on a continent slope near-by a shelf the waters structure is a bit different – the core of CDW is located in the depths about 350 m and temperature in the core is +0,3+1,1°, thus, the farther south, the weaker it is traced. Cold water mass (temperature near the bottom –0.2—0.4°) extends deeper towards the bottom (600—700 m), this is the deep water mass of the Ross Sea (RSDW), which is formed on the Ross Sea shelf and transforms after contact with the CDW. It is more localized than a similar water in the Weddell Sea (George, 1981).

Measuring in the Weddell Sea was carried out in March-April, at least 3 months later, then in previous seas, and this made some adjustments. AASW here extended up to 50 m depth and had a temperature on a surface 0—0,4°. WW (AICL) occupied a layer of 50—200 m and had a temperature in the core — 0,9—1,4°. Warm CDW (in the core +0,5+0,7°) extended from 200 up to 1000 m. According to a number of scientists (Arnold, 1977, Arnold et al, 2001, Eberhard et al, 1995, Fogviket al, 1985) this is slightly transformed water mass of ACC. Subjacent the Weddell Sea deep water (WSDW) is located. Temperature in the core within the limits of measuring is — 0,1 + 0,2. Water mass extends to the maximal depths of measuring 1600 m and, obviously, deeper.

Determination of water masses and their borders was made from limited and incomplete data. The data are summarized in Table 5.

Antarctic toothfish and bottom temperature

The Antarctic toothfish *Dissostichus mawsoni* in the Weddell Sea was observed at almost all stations, only at one station there was no catch at all. Increased catches (over 50 fish per longline) were in the northeast of the survey and in some places in the south.

An attempt was made to relate catches and bottom temperatures. Since the standard longlines (2500 hooks) were displayed and thus the catches were comparable, the absolute value of the catches was taken. In this case, the correlation coefficient of the catch with the temperature at a depth of 1000 m was –0.44, with the bottom temperature at the place of fishing –0.55, and with a temperature at a depth of 1500 m –0.62. The values of the correlation coefficients are quite large and indicate an increase in catches with decreasing temperature at the bottom. However, testing the null hypothesis by the Student's criterion in all three cases does not indicate that the correlation coefficient is significant, which is related to short series of observations (10—14 cases).

Thus, despite the shortcomings that occurred during the preparation and execution of works, interesting data were obtained characterizing the living conditions of the objects of longline fishery. Work in this direction has been continued in the 2018/19 season and data are currently being processed. Continuation of the work is planned in subsequent years.

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ПЕРШІ ПІДСУМКИ ОКЕАНОГРАФІЧНИХ РОБІТ
НА УКРАЇНСЬКИХ ЯРУСОЛОВНИХ СУДАХ В АНТАРКТИЦІ
(ЗОНА ДІЇ ККАМЛР) У СЕЗОН 2017/2018 РОКІВ

РЕФЕРАТ. З **метою** виконання обов'язків, взятих Україною на XXXVI сесії Комісії зі збереження морських живих ресурсів Антарктики (ККАМЛР) та вивчення умов проживання основних об'єктів промислу у водах Антарктики на українських риболовних судах, які вели промисел іклача, українські спостерігачі, окрім своїх основних завдань, здійснювали також деякі океанологічні роботи. **Методами** робіт було використання самопису DST CTD ісландської фірми STAR OGGI та аналіз отриманих даних. **Результати** робіт включають в себе 36 приярусних та 11 інших станцій (на фалі, на стрімері, на сітці Джеді), які були виконані в морях Амундсена, Роса та Ведделла у період з грудня 2017 по квітень 2018 року трьома українськими судами («Сімеїз», «Кореїз» та «Каліпсо»). На основі отриманих матеріалів була проаналізована вертикальна мінливість температури, яка звичайно знижувалась від поверхні до глибин 70—250 м, потім зростала до глибин 300—400 м і далі знижувалась. У часовій мінливості придонної температури найбільші коливання спостерігалися на глибині біля 600 м, нижче вони здебільшого були незначні. Виявлена просторова мінливість температури в окремих морях. Крім очікуваного зниження температури з півночі на південь у морі Амундсена вода в східних частинах була холодніша, ніж у західних, тоді як у морі Веддела простежується підвищення температури з південного заходу на північний схід. У межах вимірювань (1000—1500 м глибини) були виділені чотири основні водні маси у морях Роса та Веддела: Антарктична поверхнева водна маса (АПВМ); Антарктичний холодний проміжний шар (АХПШ) або Зимова водна маса (ЗВМ); Циркумполярна глибинна водна маса (ЦГВМ) та Глибинна водна маса морів Роса і Веддела (відповідно ГВМР та ГВМВ) та три — у морі Амундсена, де не було власної глибинної водної маси. Проаналізовано вплив придонної температури на улови антарктичного іклача. Зроблені **висновки** про зростання уловів з пониженням придонної температури у морі Веддела. Роботи мають бути продовжені в наступні роки.

Ключові слова: Антарктика, температура, мінливість, водні маси, антарктичний іклач.