Oceanographic survey in the Bering Sea by the crab research vessel in 1982

Fisheries Agency of Japan
1982年のベーリング海のカニ調査船による海洋調査

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ベーリング海の日本ズワイガニ漁業の漁場を中心とする陸棚上及びその周辺海域における海洋調査は、1978年からひきつづき行われている。

1982年の調査は5月17日から6月17日の間に行われた。各調査点ではXBTによって水温の資料を得た。更に59°30' N, 170°30'Wの点と57°30' N, 176°Wの点を結ぶ線上では、11の点で各層観測により水温と塩分の資料を得た。底層についての調査は、59°N, 169°50'W（5月20日～6月15日）と59°20' N, 171°50'W（5月26日～6月14日）の2点でAanderaa Current Meterによって行われた。

調査によって得られた資料の分析は現在進行中であるが、底層水温についての予備的な分析結果は次の通りである。

底層水温の年変動

1979年～1982年の5月～6月の底層水温分布をFig. 1～4に、1978年～1980年の7月～8月の底層水温分布をFig. 5～7に示したが、陸棚外については、各年とも水深200 mの水温を底層水温として用いた。

これらの図が示すように、調査水域の北部にみられる2℃以下の冷水の広がりは年によりまた季節によって異なるが、大体セント・マシュー島付近で南東または南に、177°～176°W付近で南に張り出していている。このうち、セント・マシュー島の南東に張り出す冷水の勢力は、177°～176°W付近のそれと比べて強く、年変動も大きいとみられる（川崎ほか，1978，川崎，1980，1981）。

5月～6月におけるセント・マシュー島の冷水の勢力は（Fig. 1～4参照）、1980年と1982年が強く、1981年がそれに次ぎ、1979年が最も弱い。一方、177°～176°W付近のそれは、1979年が最も強く、1980年と1981年がそれに次ぎ、1982年が最も弱い。これら冷水の勢力の変動に比べ、8℃等温線

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線の位置の年変動は小さく、底層水温分布の変動は、174°W以東の58°N以北、特に水深100m以浅の水域で大きい。それと対照的に、174°W以西58°N以北の200m等深線に沿う陸棚緣辺部の年変動は小さいようにみえる。しかし、60°N以北の水域の調査は、1979年と1981年は5月、1980年は6月に行われている。また1982年の調査は、セント・マーシュ島の東側ではほぼ60°N以北の水域が、また西側では61°N以北の水域が6月に行われている。後述するために、5月〜6月の調査期間中における底層水温の上昇は無視できない場合がある。それ故、1980、1982年と1979、1981年との低層水温の差は見掛けより大きいかもしれない。

7月〜8月におけるセント・マーシュ島付近の冷水の勢力は（Fig.5〜7参照）、1980年が最も強く、1978年、1979年の順に弱い。3℃等温線の位置の年変動は、174°W以東の水域では5月〜6月と異なり冷水の勢力の年変動と対応して大きいが、それに比べて174°W以西の水域では5月〜6月と同様に年変動が小さい。従って、174°W以東水域の底層水温分布の年変動は、5月〜6月と異なり全体にわたって大きい。

調査水域を北東〜南西に横切る各層観測線AとB（Fig.8）の各観測点における底水温についてもその年変動を検討した。

1979年〜1982年の5月と1978年〜1980年の7月〜8月におけるA線上的各観測点の底水温をFig.9に、1979年〜1981年の5月〜6月と1979年〜1980年の7月におけるB線上の各観測点の底水温をFig.10に示した。陸棚外については、水深200mにおける水温を底水温として用いた。

A線における5月の底水温は、1980年が最も低く、1982年、1981年、1979年の順に高い。その年変動は、陸棚縁辺部から浅海部に向かう程大きくなり、それと対照的に、陸棚縁辺部の水深150m付近から沖合域の各点における底水温の年変動は極めて小さい。7月〜8月における底水温は、1980年が最も低く、1978年、1979年の順に高いが、その年変動は5月〜6月に比べて全体的に小さい。そのなかでも、173°W以東（水深約110m以浅）の各点における底水温の年変動はやや大きいが、175°Wより沖合域にかけての各点のそれは極めて小さい（Fig.9参照）。

B線における5月〜6月の底水温は、1980年が最も低く、1981年、1979年の順に高いが、その年変動はA線上のそれに比べて小さい。そのなかでも、171°W以東（水深約70m以浅）の浅海部の各点の底水温の年変動はやや大きいが、171°Wより沖合域にかけての各点のそれは極めて小さい。7月〜8月における底水温は、1980年が1979年に比べて低い。その年変動は、5月〜6月に比べてやや大きいが、175°W（水深約180m）より浅海部に向かう程大きくなる（Fig.10参照）。

これらは、前述の底層水温分布と同じ傾向を示している。

底層水温の季節変動

1979年及び1980年の5月〜6月の底層水温分布と7月〜8月のそれにと比較し、175°W以西の水域より175°W以東の水域の方が、底層水温分布の季節変動が著しいことはすでに述べた。すなわち、1979年においては175°W以東の水域全域にわたって、約2ヶ月の間に各等温線が緯度にして約1度北上し、
1980年においては特に171°W線付近で各等温線が緯度にして約2度北上した（川崎，1981）。このことは各層毎測線上の底水温についても同様である。A線においては、1979年では174°W以東の各点において2ヶ月間に約1℃の昇温が認められた。一方1980年の昇温は1979年より大きく、特に171°Wの点では3℃以上の昇温を示した（Fig.9参照）。B線においては、1979年では178°Wより東方に向かうに従って昇温が大きくなり、1980年でも171°Wとその東の2点で昇温が大きく、170°80°Wの点では両年とも2℃以上の昇温を示した（Fig.10参照）。


底層水温とベーリング海の海水

1982年において、調査船若竹丸は5月20日に60°N，170°W付近で流氷（pack-ice）に遭遇した。次いで5月25日には59°30′N，171°W付近で、5月27日には60°30′N，175°～174°Wで、5月29日には61°N，177°～176°Wで遭遇した。近年においては初めての経験である。


1978年～1982年の1月～5月におけるベーリング海の水城に関する情報は、日本漁業情報サービスセンターが5日毎に発行する北太平洋における表面水温分布図（Fig.11）から得られる。これらの図に示されている水城から、密接な流氷（close-pack-ice）の水城の南限を求め、176°W，174°W，172°W，170°Wの各等度線上の位置をFig.12に示した。これによると、1980年は他の年に比べて氷城が南下し、かつ持続しており、1979年は他の年に比べて氷城が最も北寄りの位置にある。氷城の南下は1980年に次いで1981年が著しい。Niebauer（1981）は、氷の南限の季節変動は170°W線上で最も著しいと述べており、1978年～1982年においてもその傾向が認められる。そのなかでも1982年は、他の等度線においても季節変動が大きい。また1982年の176°～172°W線上の氷城の南下傾向は、1979年を除く他の年に比較して特に著しいとは考えられないが、170°W線における南下の傾向とその持続は他の年に比べて著しく、前記の若竹丸の報告もこれを裏付けている。
以上のことを考えると、各年の水温の南下状態は前述の底層水温の年変動に影響を与えていると考えられる。

底層水温の短期間における変化と東部ベーリング海陸棚上の流れ

1978年～1982年にはAanderaa Current Meter による測流が実施されている。1978年には、16測流点で10分ごとに25時間以上の連続観測が行われた。1979年以降は、1ないし8の測流点で10分または20分ごとに、10日以上の連続観測が行われた。これらの測流と同時に得られた底層水温の資料と、XBTによる底層水温の資料をTable 1に示した。これによると、1979年7月における8測流点は前述の各層観測Aの線上にあるが（Fig. 8参照）、約10日の観測期間中における底層水温の変化はわずかである。1980年の測流点は、5月の1点と7月の2点とも観測線Bの線上にあるが、これらの点の大きさを10日～14日の観測期間中の変化は極めて小さい。これらのことは調査水域の南部にいて、冬季の観測期間中には底層水温の変化が極めて少ないことを示すものと考えられる。しかし1981年5月の測流点においては、18日の観測期間中に底層水温が約1.5℃、底水温が約1.1℃昇温したことを示した。1982年5月の測流結果は未だ分析されていないが、59°N、168°50'Wの点では26日間に底水温が約1.8℃上昇している。一方59°20'N、174°50'Wの点では、20日間に底水温はほとんど変化していない。前記の2測流点における短時間の昇温は、前述の季節変動において171°W線上の等温線の北上傾向を示すものであり、一方の測流点における底水温は、セント・マシュー島の南に張り出した冷水の強度とその持続の状態を示すものかもしれない（Fig. 2, 4及び7参照）。

1979年以降の測流資料は現在分析中であるが、流れについての予備的な分析結果である25時間移動平均の流れのベクトルを1時間毎に連続的に図示した（Fig. 18）。これと1978年の測流結果（木谷ほか、1979）との大きな相違は、1979年7月の58°12'N、174°09'Wの点の底層における流れ（Fig. 18の最上列のグラフ）と1981年5月の流れ（Fig. 18の最下列のグラフ）を示す。下から2列目のグラフは表層、下から2列目のグラフは底層について示される。前者では18 cm/sec以上の北向きの流れが認められるが、この流速は1978年の表層及び底層における最大流速を越えるものである。この流れがまだ続く可能性があるようにみえるのに対し、1981年は短時間に強い流れが出現している。すなわち観測初期に、流速が急激に増大し底層では80 cm/sec、表層では40 cm/secを越える。この強い北向きの流れは約2日間続くが、また急激に減少して流速は5 cm/sec以下となり、流速も安定となる。一方1978年において上記の測流点に近い点（セント・マシュー島の南、Fig. 8参照）では、表層で北向きの1.5 cm/sec、底層で西向きの2.0 cm/secの流れが観測されている。前述の1979年の8測流点における底層水温の上昇はいずれも極めて小さいが、1981年のそれは約1.5℃である（Table 1参照）。その昇温の傾向は明らかで、観測第1日目に0.14～0.17℃の底層水温で3日目には0.28～0.85℃、5日目には1.27～1.80℃に急激に上昇し、以後徐々に昇温して18日後に1.62～1.65℃に達している。このことは、短期間かつ強度の南からの流れが底層水温急激に上昇させたことを明らかに示すものである。

170°W以西のスワイガニ漁場とその周辺海域における底層水温の変動と季節変動については前に述べた。このうち全般的な底層水温の変動はベーリング海の海氷の変動の影響が大きいと考えられる。
方174°W以西の陸棚縁辺部の底層水温と172°W以東の陸棚浅海部の底層水温の変動は、ともに南からの強い流れに影響されると考えられる。

References


Fig. 1 Temperature distribution at the bottom layer, May 19 - June 15, 1979.

Fig. 2 Temperature distribution at the bottom layer, May 16 - June 16, 1980.

Fig. 3 Temperature distribution at the bottom layer, May 16 - June 13, 1981.

Fig. 4 Temperature distribution at the bottom layer, May 17 - June 17, 1982.
Fig. 5 Temperature distribution at the bottom layer, July 24 - Aug. 23, 1978.

Fig. 6 Temperature distribution at the bottom layer, July 18 - Aug. 8, 1979.

Fig. 7 Temperature distribution at the bottom layer, July 18 - Aug. 16, 1980.

Fig. 8 Current measurement stations and serial observation lines.  
Fig. 9 Bottom water temperature on the serial observation line A indicated in Fig. 8, 1978-1982.

- XBT, * BT, ▲ Serial observation

Fig. 10 Bottom water temperature on the serial observation line B indicated in Fig. 8, 1979-1981. • XBT
Fig. 11 An example of surface temperature distribution in the North Pacific Ocean issued by Japan Fisheries Information Service Center (every fifth day). upper: 1978 lower: 1979-1982
Fig. 12 Southern ice limit in the eastern Bering Sea along 176°W, 174°W, 172°W and 170°W, January-May 1978-1982 (from JFISC, see Fig. 11). ....... open pack-ice
Fig. 13 Time series of 25 hours running mean current of the eastern Bering Sea shelf, 1979-1981 (see Table 1 and Fig. 8).
Table 1  Bottom layer temperature changes within a month at the current measurement stations indicated in Fig. 8, 1979 - 1982.

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<td>0.12</td>
<td>-0.21</td>
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*  Aanderaa current meter, about 10m above the bottom.
**  XBT, on the bottom.
***  Serial observation, 9m above the bottom.
OCEANOGRAPHIC SURVEY IN THE BERING SEA
BY THE CRAB RESEARCH VESSEL IN 1982

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Introduction

Oceanographic research has been conducted on the continental shelf and adjacent waters of the Bering Sea with emphasis on the fishing grounds for tanner crabs.

The survey period in 1982 was from May 17 to July 17. Data on water temperature were collected at each station using an XBT. In addition, at 11 stations on a line connecting the point 59°30'N, 170°30'W to the point 57°30'N, 176°00'W, serial observations of temperature and salinity data were collected. Observations on bottom layer currents were made with an Aanderaa Current Meter at two stations: 59°00'N, 169°50'W (May 20 to June 15) and 59°20'N, 171°50'W (May 26 to June 14).

Compilation and analyses of the survey data are in progress and preliminary data on temperature distribution at the bottom layer only are reported here.

Annual fluctuations in water temperature at the bottom layer

In this analysis bottom layer temperature on the outer shelf was defined as temperature at 200 m depth. Temperature distributions at the bottom layer for May to June in 1979-82, and for July to August in 1978-80 are shown in Figs. 1 to 4 and 5 to 7, respectively.

The data show that the degree of expansion of cold water below 2°C in the bottom layer which appeared in the northern part of the survey area varied by year and by month. However, cold water generally extended towards the southeast or south at around St. Matthew Island and south at 176° to 177°W. The extension of the cold water mass to southwest of St. Matthew Island was relatively greater than that at 176° to 177°W in strength and also in annual fluctuations (Kawasaki et al. 1978, Kawasaki 1980 and 1981).
The extension of cold water at St. Matthew Island from May to June was strongest in 1980 and 1982, followed by 1981, and was weakest in 1979. In contrast, the extension of cold water at 176° to 177°W was strongest in 1979, followed by 1980 and 1981, and was weakest in 1982. Compared with these fluctuations, the fluctuations in location of the 3°C isotherm were smaller. Annual fluctuations in bottom layer water temperature were greater in waters east of 174°W and north of 58°N, particularly in depths shallower than 100 m. In contrast, annual fluctuations in bottom water temperature appear to be small on the outer shelf along the 200 m contour. The surveys in waters north of 60°N were conducted in May in 1979 and 1981 and in June in 1980. The survey in 1982 was conducted in waters north of 60°N on the east side of St. Matthew Island and in waters north of 61°N on the west side of the island in June. As described later, increases in bottom layer water temperature during the research period in May and June cannot always be ignored. Therefore, the difference in bottom layer water temperature between that in 1980 and 1982 and that in 1979 and 1981 might actually be greater than appeared.

The southward extension of cold water around St. Matthew Island during July and August was strongest in 1980 followed in order by 1978 and 1979 (Figs. 5 to 7). Annual fluctuations in the location of the 3°C isotherm during July and August were great which was different from that during May and June in water east of 174°W and corresponded to the annual fluctuations in the extension of the cold water. In contrast, in waters west of 174°W, annual fluctuations were small during July and August as in May and June. Therefore, annual fluctuation of bottom layer water temperature in waters east of 174°W were different from in May and June, and were great in July and August throughout the whole research area.

Annual fluctuations in bottom water temperature were also examined based on temperatures observed at each station on lines A and B which crossed the survey area in a northeast and southwest direction (Fig. 8). Bottom temperatures for stations on line A in May from 1979
to 1982 and in July and August from 1978 to 1980 are shown in Fig. 9 and for stations on line B in May and June from 1979 to 1981 and in July from 1979 to 1980 in Fig. 10. Temperature in the bottom layer of outer shelf was defined as temperature at 200 m depth.

The bottom temperatures on line A in May were lowest in 1980, followed in order by 1982, 1981, and 1979. The annual fluctuations were greater from the outer shelf towards shallower areas. In contrast, at each station in areas off the outer shelf at depths around 150 m, the range of annual fluctuations was extremely small. The bottom temperature in June and August was lowest in 1980, followed by 1978 and 1979, but the range of fluctuation was generally smaller than in May and June. The annual fluctuations in bottom temperature at stations in waters east of 173°W (shallower than 110 m in depth) were rather large but in areas west of 173°W were extremely small (Fig. 9).

Bottom temperatures on line B in May and June were lowest in 1980 followed in order by 1981 and 1979 and range of fluctuations was smaller than on line A. In particular, each station east of 171°W (shallower than 70 m in depth) showed fairly large fluctuations but in the offshore area west of 171°W fluctuations were fairly small. The bottom water temperature in July and in August was lower in 1980 than in 1979. The annual fluctuation was slightly greater than that in May and June, and was the greater from 173°W towards shallower areas (Fig. 10). These facts showed similar tendency to the distributions of bottom layer water temperature.

Seasonal change of bottom layer water temperature

Comparison has already been made of bottom water temperature between May to June and July to August in 1979 and 1980. Seasonal changes in waters east of 175°W are more pronounced than in waters west of 175°W. That is, in 1979 in waters east of 175°W in general, every isotherm moved one degree of latitude northwards in about two months and in 1980 particularly around 171°W longitude each isotherm moved
two degrees of latitude northwards (Kawasaki 1981). Similar phenomena were observed in the observations on A and B lines. At each station in waters east of 174°W on line A in 1979, a temperature increment of 1°C was observed in two months. Temperature increments in 1980 were greater than in 1979, particularly at station 171°W where an increment of more than 3°C was observed (Fig. 9). On line B in 1979, greater temperature increments were observed in stations east of 173°W, and in 1980 at the 171°W station and at two stations east of 171°W temperature increments were large. At the station at 170°30'W water temperature increments of more than 2°C were observed in both 1979 and 1980 (Fig. 10).

Thus, the bottom layer water temperature in the whole research area in May and June was generally low in years when the extension of cold water was strong in the area southeast of St. Matthew Island. In observations from 1979 to 1982, bottom water temperature was lowest in 1980, followed in order by 1982, 1981, and 1979. The annual fluctuations were greater in waters east of 174°W, particularly in depths of 100 m and shallower, and smaller on the outer shelf along the 200 m contour in waters west of 174°W. The bottom layer water temperature during July and August was lowest in 1980 followed in order by 1978 and 1979. Judging from the increasing trend in temperature from May and June to July and August (seasonal change) and the strength of extension of cold water at St. Matthew Island, it appears that the bottom water temperature in July and August in 1982 was the second lowest after that in 1980, and that in 1981 was as low as or higher than in 1978 and was lower than in 1979. The annual fluctuations in July and August were smaller in the outer areas shelf and greater in shallow areas.

Bottom water temperature and sea ice in the Bering Sea

The research vessel Wakatake maru encountered pack ice on May 20 in the area adjacent to 60°N, 170°W, on May 25 at 59°30'N, 171°W, on May 27 at 60°30'N, 175° to 174°W, and on May 29 at 61°N, 177° to

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176°W. These are the first experiences of encountering ice in recent years during the crab survey.

Niebauer (1981) reported on changes of sea ice distribution in the eastern Bering Sea. According to this author, during 1973 to 1976, an abnormally expanded distribution of sea ice caused by abnormally low temperatures and wind from the north was characteristic. In contrast, during 1976 to 1979 large temperature increases and wind from the south caused reduction in the area of distribution of sea ice. A great change was thus observed in sea ice distribution during 1973 to 1979.

Information on ice areas during January to May from 1978 to 1982 were obtained from "Surface temperature distribution in the North Pacific Ocean" issued by Japan Fisheries Information Service Center (Fig. 11). Using this data, the locations of southern extremes of the close-pack-ice on longitudes of 176°W, 174°W, 172°W, and 170°W are shown in Fig. 12. This figure shows that in 1980 the ice limit moved southward and lasted for a long period compared to the other years. The location of the ice limit was northernmost in 1979. The southward movement of ice limit in 1980 was most pronounced and followed by 1981. Niebauer (1981) described the seasonal change in southern limit of ice areas as most pronounced on 170°W longitude, and our data from 1978 to 1982 shows a similar tendency. The seasonal change was large in 1982 not only on 170°W longitude but also on other longitudes. Although the southward movement of ice limit observed on longitudes from 176°W to 172°W in 1982 was not considered to be pronounced compared to the other years (excluding 1979), the southward movement and its long duration in 1982 was fairly pronounced on 170°W longitude compared to other years and the report of the Wakatake maru supported this phenomenon.

The southward movement of the ice limit is considered to influence the annual fluctuations in bottom layer water temperature as described above.
Change of bottom layer water temperature in a short term and currents on the continental shelf in the eastern Bering Sea

Current measurements in the eastern Bering Sea have been made since 1978 using an Aanderaa Current Meter. Serial observations at 10 minute intervals were made at 16 stations in 1978 for a period of more than 25 hours. From 1979 observations have been conducted at one to three stations with 10 or 20 minute intervals for more than 10 days serially. These data on current directions are shown in Table 1 with bottom layer water temperature obtained at the same time and with bottom temperature taken by an XBT.

The change in bottom layer water temperature was small during the observation period of 10 days at three stations in July 1979 which were on the serial observation line A (Fig. 8). One station in May and two stations in July 1980 were on the observation line B and showed extremely small changes in water temperature during the observation period of 10 to 14 days. From these facts, it is considered that changes in water temperature in the bottom layer were extremely small in the research periods in summer. However, at the station in May 1981, water temperatures in the bottom layer increased 1.5°C and on bottom increased 1.1°C during the research period of 18 days. All of the data collected in May 1982 have not yet been analyzed but at the station at 59°N, 169°50'W, an increase of 1.3°C in water temperature on the bottom during 26 days was observed. On the other hand, at the station at 59°20'N, 171°51'W, little change in water temperature on the bottom was observed during 20 days. The temperature increases in a short period at the stations described above might correspond to the northward movement of isotherms on the 171°W longitude, and the small changes in temperatures on bottom at another station might suggest conditions of strong southward extension of cold water and its duration at St. Matthew Island (Figs. 2, 4, and 7).
Although data on current speed and direction from 1979 are now being analyzed, the results of preliminary analysis on current, and current vectors obtained with 25 hours running mean, are shown in Fig. 13. The significant differences between the results and the results on current measurements in 1978 (Kitani et al. 1979) are found in the bottom layer current at the station 58°12'N, 174°09'W in July 1979 (upper portion of the graph for 1979 in Fig. 13) and on the currents in May 1981 (in the graph for 1981 in Fig. 13, the upper portion is for the bottom layer, the bottom portion is for the surface layer). In the graph for bottom layer in 1979, currents of a north direction with speed of more than 18 cm/sec are found. This current speed is faster than the fastest current observed in surface and bottom layers in 1978. In this graph this fast current speed seems to have lasted, but in 1981 strong currents were observed over a short period. At the beginning of observations in 1981 current speed increased rapidly, reaching more than 30 cm/sec in the bottom layer and more than 40 cm/sec in the surface layer. This strong north direction current lasted for two days and then decreased in speed to less than 5 cm/sec and its direction became unstable. On the other hand in 1978, at the station close to the station described above (south of St. Matthew Island, Fig. 8), currents of a north direction with speed of 1.5 cm/sec in the surface layer and currents of a west direction with speed of 2.0 cm/sec were observed.

As described earlier, increases of bottom layer water temperature at three stations in 1979 were extremely small but those in 1981 were about 1.5°C (Table 1). This increase was observed clearly: water temperatures in bottom layers on the first day of observation were 0.14°C to 0.17°C and increased rapidly on the third day to 0.28° to 0.85°C. On the fifth day of observation, temperatures reached 1.27° to 1.30°C and then increased gradually and after 13 days reached 1.62° to 1.65°C. These data suggested that a strong current over a short term from the south rapidly increased water temperature in the bottom layer.
The annual fluctuations and seasonal changes of bottom layer water temperature on the fishing grounds for tanner crab west of 170°W and adjacent areas were described in the earlier part of this paper. Of those changes, general fluctuations in water temperature are considered to be largely influenced by the movement of sea ice in the Bering Sea. On the other hand, the bottom layer water temperatures on the outer shelf west of 174°W and in the shallow areas on the continental shelf east of 172°W are both considered to be influenced by strong current from the south.

REFERENCES, TABLE 1 AND FIGS. 1 TO 13 ARE IN ENGLISH IN THE JAPANESE DOCUMENT
TRANSLATION

OCEANOGRAPHIC SURVEY IN THE BERING SEA
BY THE CRAB RESEARCH VESSEL IN 1982

Seiwa Kawasaki and Hitoshi Fujita
Fisheries Agency of Japan
1982 August

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Oceanographic survey in the Bering Sea by the crab research vessel in 1982. (Document submitted to the International North Pacific Fisheries Commission.)
9 p. Fisheries Agency of Japan, Tokyo, Japan 100
Introduction

Oceanographic research has been conducted on the continental shelf and adjacent waters of the Bering Sea with emphasis on the fishing grounds for tanner crabs.

The survey period in 1982 was from May 17 to July 17. Data on water temperature were collected at each station using an XBT. In addition, at 11 stations on a line connecting the point 59°30'N, 170°30'W to the point 57°30'N, 176°00'W, serial observations of temperature and salinity data were collected. Observations on bottom layer currents were made with an Aanderaa Current Meter at two stations: 59°00'N, 169°50'W (May 20 to June 15) and 59°20'N, 171°50'W (May 26 to June 14).

Compilation and analyses of the survey data are in progress and preliminary data on temperature distribution at the bottom layer only are reported here.

Annual fluctuations in water temperature at the bottom layer

In this analysis bottom layer temperature on the outer shelf was defined as temperature at 200 m depth. Temperature distributions at the bottom layer for May to June in 1979-82, and for July to August in 1978-80 are shown in Figs. 1 to 4 and 5 to 7, respectively.

The data show that the degree of expansion of cold water below 2°C in the bottom layer which appeared in the northern part of the survey area varied by year and by month. However, cold water generally extended towards the southeast or south at around St. Matthew Island and south at 176° to 177°W. The extension of the cold water mass to southwest of St. Matthew Island was relatively greater than that at 176° to 177°W in strength and also in annual fluctuations (Kawasaki et al. 1978, Kawasaki 1980 and 1981).
The extension of cold water at St. Matthew Island from May to June was strongest in 1980 and 1982, followed by 1981, and was weakest in 1979. In contrast, the extension of cold water at 176° to 177°W was strongest in 1979, followed by 1980 and 1981, and was weakest in 1982. Compared with these fluctuations, the fluctuations in location of the 3°C isotherm were smaller. Annual fluctuations in bottom layer water temperature were greater in waters east of 174°W and north of 58°N, particularly in depths shallower than 100 m. In contrast, annual fluctuations in bottom water temperature appear to be small on the outer shelf along the 200 m contour. The surveys in waters north of 60°N were conducted in May in 1979 and 1981 and in June in 1980. The survey in 1982 was conducted in waters north of 60°N on the east side of St. Matthew Island and in waters north of 61°N on the west side of the island in June. As described later, increases in bottom layer water temperature during the research period in May and June cannot always be ignored. Therefore, the difference in bottom layer water temperature between that in 1980 and 1982 and that in 1979 and 1981 might actually be greater than appeared.

The southward extension of cold water around St. Matthew Island during July and August was strongest in 1980 followed in order by 1978 and 1979 (Figs. 5 to 7). Annual fluctuations in the location of the 3°C isotherm during July and August were great which was different from that during May and June in water east of 174°W and corresponded to the annual fluctuations in the extension of the cold water. In contrast, in waters west of 174°W, annual fluctuations were small during July and August as in May and June. Therefore, annual fluctuation of bottom layer water temperature in waters east of 174°W were different from in May and June, and were great in July and August throughout the whole research area.

Annual fluctuations in bottom water temperature were also examined based on temperatures observed at each station on lines A and B which crossed the survey area in a northeast and southwest direction (Fig. 8). Bottom temperatures for stations on line A in May from 1979
to 1982 and in July and August from 1978 to 1980 are shown in Fig. 9 and for stations on line B in May and June from 1979 to 1981 and in July from 1979 to 1980 in Fig. 10. Temperature in the bottom layer of outer shelf was defined as temperature at 200 m depth.

The bottom temperatures on line A in May were lowest in 1980, followed in order by 1982, 1981, and 1979. The annual fluctuations were greater from the outer shelf towards shallower areas. In contrast, at each station in areas off the outer shelf at depths around 150 m, the range of annual fluctuations was extremely small. The bottom temperature in June and August was lowest in 1980, followed by 1978 and 1979, but the range of fluctuation was generally smaller than in May and June. The annual fluctuations in bottom temperature at stations in waters east of 173°W (shallower than 110 m in depth) were rather large but in areas west of 173°W were extremely small (Fig. 9).

Bottom temperatures on line B in May and June were lowest in 1980 followed in order by 1981 and 1979 and range of fluctuations was smaller than on line A. In particular, each station east of 171°W (shallower than 70 m in depth) showed fairly large fluctuations but in the offshore area west of 171°W fluctuations were fairly small. The bottom water temperature in July and in August was lower in 1980 than in 1979. The annual fluctuation was slightly greater than that in May and June, and was the greater from 173°W towards shallower areas (Fig. 10). These facts showed similar tendency to the distributions of bottom layer water temperature.

Seasonal change of bottom layer water temperature

Comparison has already been made of bottom water temperature between May to June and July to August in 1979 and 1980. Seasonal changes in waters east of 175°W are more pronounced than in waters west of 175°W. That is, in 1979 in waters east of 175°W in general, every isotherm moved one degree of latitude northwards in about two months and in 1980 particularly around 171°W longitude each isotherm moved
two degrees of latitude northwards (Kawasaki 1981). Similar phenomena were observed in the observations on A and B lines. At each station in waters east of 174°W on line A in 1979, a temperature increment of 1°C was observed in two months. Temperature increments in 1980 were greater than in 1979, particularly at station 171°W where an increment of more than 3°C was observed (Fig. 9). On line B in 1979, greater temperature increments were observed in stations east of 173°W, and in 1980 at the 171°W station and at two stations east of 171°W temperature increments were large. At the station at 170°30'W water temperature increments of more than 2°C were observed in both 1979 and 1980 (Fig. 10).

Thus, the bottom layer water temperature in the whole research area in May and June was generally low in years when the extension of cold water was strong in the area southeast of St. Matthew Island. In observations from 1979 to 1982, bottom water temperature was lowest in 1980, followed in order by 1982, 1981, and 1979. The annual fluctuations were greater in waters east of 174°W, particularly in depths of 100 m and shallower, and smaller on the outer shelf along the 200 m contour in waters west of 174°W. The bottom layer water temperature during July and August was lowest in 1980 followed in order by 1978 and 1979. Judging from the increasing trend in temperature from May and June to July and August (seasonal change) and the strength of extension of cold water at St. Matthew Island, it appears that the bottom water temperature in July and August in 1982 was the second lowest after that in 1980, and that in 1981 was as low as or higher than in 1978 and was lower than in 1979. The annual fluctuations in July and August were smaller in the outer areas shelf and greater in shallow areas.

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