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ATLANTIC WATER ON THE CHUKCHI SHELF

BY

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## ATLANTIC WATER ON THE CHUKCHI SHELF

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**Abstract.** An anomalously warm saline layer at the bottom of the shallow Chukchi Sea in 1975 is believed due to a surge which brought water from the Atlantic Layer of the Arctic Ocean up onto the shelf. Two earlier occurrences of this kind of water in the Chukchi Sea have been identified in historical data.

During the period 2 to 11 August 1975, near the margin of the Chukchi Sea, we observed an unusual warm layer on the bottom which, to our knowledge, has been recorded only twice before by the MAUD in 1922 and by the MIKHAIL LOMONOSOV in 1958. Figure 1 shows where the warm water was found (solid circles) and Figure 2 shows the temperature, salinity and density profiles at Station 40, a point at which the water is vivid and the warmth of the bottom is moderate. At this point the temperature, salinity and sigma-t at the bottom were 1.04°C, 33.15 ‰ and 26.66. In the layer above they were -1.62°C, 32.79 ‰ and 26.40, respectively. This latter is typical of but somewhat less saline than the water we have found on the bottom near the ice in the past (Paquette and Bourke, 1976).

The inference is that the warm water intruded beneath the bottom water which otherwise has been resident in the Chukchi Sea. The warm water reached its peak of temperature and salinity at 1.04°C and 33.62 ‰ at the station marked A\* in Figure 1. The corresponding density was 26.96, a value which sometimes is found near and beyond the ice margin but rarely only when accompanied by very low temperatures, colder than -1.6°C. The salinities and temperatures were highest in general in the westerly of the two patches shown; the low-temperature and salinity positively identified in the warm layer was at -1.28°C and 33.06 ‰ in the westerly patch. As the temperature rises, the anomalous water begins to assume properties not greatly dissimilar from the normal bottom water, in which case it could be recognized if it lay under colder water. Therefore, the water may have occurred in other stations.

conceivable sources for the warm water are as follows:

1. The warm water had its origin in Bering Sea perhaps one or two months earlier and was advected northward by the usual northerly transport of water.

2. The warm water is a relic of dense water formed in the Chukchi Sea two winters previously after an overturn; water dense enough to re-form it has not formed during Winter 1974-75 either in the Chukchi Sea or in the Bering Sea,

whichever one considers to be the normal source of bottom water in the Chukchi Sea.

- The water was formed by mixing cold saline bottom water with a warmer water to the south.
- Warm, high-salinity water has surged up onto the Chukchi Shelf from the Arctic Basin and some mixing with water on the shelf has occurred.

In discussing these options, use will be made of the T-S diagram, Figure 3. The anomalous warm water, designated by circles, is called Type A. Attention will be concentrated on the warmest and most saline of these observations, the one previously designated as A\*. This water provides the most stringent test of the various hypotheses because it is high temperature coupled with high salinity which is rare in the Chukchi Sea. This group also characterizes bottom water from the six MAUD stations, identified by crosses, which showed bottom water warmer than the overlying water. These stations were located in the north central Chukchi Sea near 72° N between about 171° and 175° W. The triangles denote the bottom water properties from a time series conducted by the MIKHAIL LOMONOSOV near Herald Island at 71-30° N, 176-01° W.

The waters designated B in Figure 3 categorize the most saline and warmer waters which have been found in Bering Strait in the archives of the National Oceanographic Data Center. Area C in the same figure contains perhaps three different kinds of water, all of which are represented in the stations south of the dashed line in Figure 1. This line is the northern limit of stations in which salinities > 31 ‰ associated with temperatures > 1°C occupy a minimum of 5 m thickness, generally more than 10% of the water column. The most southerly line of stations near Pt. Hope contains in its lower layer, water approximating 1°C and > 32 ‰, water which Coachman *et al.* (1976) would call Bering Sea Water. The upper layer in this same line is as warm as 7°C with salinities approximating 31 ‰. This Coachman *et al.* would call Alaskan Coastal Water. The line of stations north of Cape Lisburne has the latter water in its lower layer but it has a more dilute warm water in its upper layer which we believe is formed from Alaskan Coastal Water by the addition of fresh water due to ice melt (Paquette and Bourke, 1976). This water reached temperatures greater than 7°C and salinities less than 29 ‰. This is within the range of properties for the Chukchi Surface Water of Coachman *et al.* We have put it in the Area labeled D, which is off the diagram. The stations just south of the dashed line have the melt water of Type D in the upper layer, considerable thicknesses of Type C Water in the thermocline and a beginning of the appearance

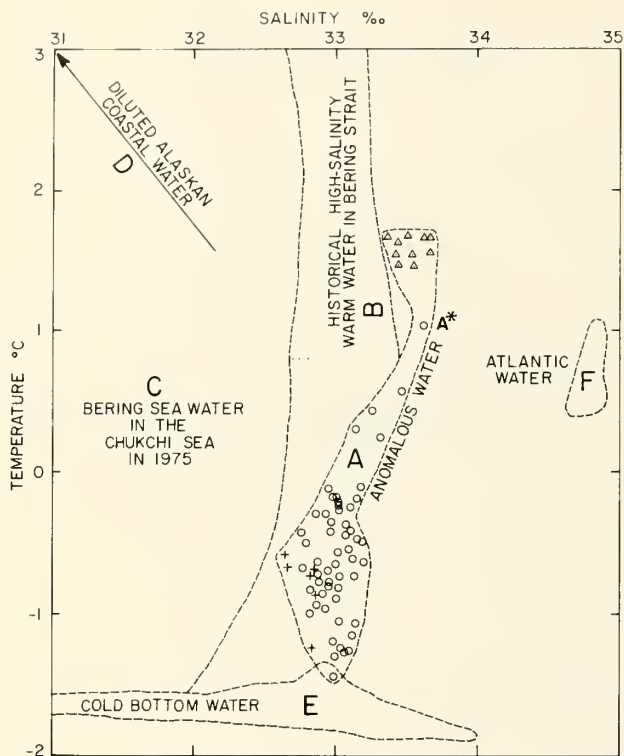


Figure 3. Temperature-salinity diagram showing various water types found in the Chukchi Sea in summer. Open circles are the anomalous warm water, crosses are the MAUD data, and the triangles are from the MIKHAIL LOMONOSOV data.

GLACIER using the University of Washington-A Physics Laboratory (APL) CTD, ably operated Mr. Peter Becker of that laboratory. The data were partially reduced by APL. Others assisting were Dr. M. Allan Beal, LT John A. Roeder, USN, and LCDR William J. Zuberbuhler, USN. LCDR W. Workman kindly searched the historical weather files of Fleet Numerical Weather Center to provide the Pt. Barrow-Nome pressure differences.

#### References

- Coachman, L. K., K. Aagaard, and R. B. Tripp. Bering Strait: The Regional Physical Oceanography, University of Washington Press, Seattle, WA, 1976.
- Mountain, D. B., Bering Sea Water on the North Alaskan Shelf, p. 153, Ph.D. Thesis, University of Washington, Seattle, WA, 1974.
- Paquette, R. G., and R. H. Bourke, Observations on the coastal current of Arctic Alaska, *Marine Res.*, 32(2): 195-207, 1974.
- Paquette, R. G., and R. H. Bourke, Oceanographic investigations of the marginal sea ice zone of the Chukchi Sea-MIZPAC 1974, Tech. Rep. NPS-58PA76051, p. 119, Naval Postgraduate School, Monterey, CA, 1976.

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