

NO A145 594

ONE-YEAR RECORDS OF CURRENT AND BOTTOM PRESSURE IN THE
STRAIT BETWEEN NOR. (U) WASHINGTON UNIV SEATTLE DEPT OF
OCEANOGRAPHY K AAGAARD ET AL. 06 AUG 84 TR-25

1/0

UNCLASSIFIED

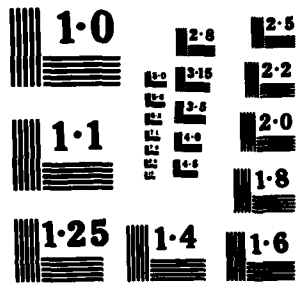
N00014-75-C-0893

F/G 8/3

NI



END
DATE
FORMED
10 84



AD-A145 594

DTIC FILE COPY

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report No. 25	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER (13)
4. TITLE (and Subtitle) One-year records of current and bottom pressure in the strait between Nordaustlandet and Kvitøya, Svalbard, 1980-81.		5. TYPE OF REPORT & PERIOD COVERED Interim 1 Oct. 76 - 31 March 84
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) K. Aagaard, A. Foldvik, T. Gammelsrød and T. Vinje		8. CONTRACT OR GRANT NUMBER(s) N-00014-75-C-0893
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Oceanography, WB-10 University of Washington, Seattle, WA 98195		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 307-326
11. CONTROLLING OFFICE NAME AND ADDRESS Code 425, Arctic Program Office of Naval Research Arlington, VA 22217		12. REPORT DATE 6 August 1984
		13. NUMBER OF PAGES 7
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) LA A		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Barents Sea, Arctic Ocean, Svalbard, tides, currents		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) We have obtained one year of measurements from a subsurface instrumented mooring carrying two current meters and one bottom pressure recorder in the strait between Nordaustlandet and Kvitøya in the northeastern Svalbard archipelago. The observations show a mixed tide with typical amplitudes 0.4db and 10 cm/sec. The semidiurnal tide is characterized by a progressive wave propagating toward the south, together with a cross-channel baroclinic mode. The annual average (non-tidal) current is less than 2 cm/sec toward the north-east, suggesting that the transport into the Arctic Ocean is approximately $0.2 \times 10^6 \text{ m}^3 \text{ s}^{-1}$. (200,000 cum/s.)		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 68 IS OBSOLETE
S/N 0102-LF-014-0001

84 08 17 100

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address <i>University of Washington Seattle, WA 98195</i>	2. NSF Program <i>Div. of Polar Programs</i>	3. NSF Award Number <i>DPP-8100153</i>
	4. Award Period From <i>1 Feb. '84</i> To <i>31 Jul. '84</i>	5. Cumulative Award Amount <i>\$384,193</i>
6. Project Title <i>A Study of the Eurasian Basin of the Arctic Ocean</i>		

PART II—SUMMARY OF COMPLETED PROJECT (FOR PUBLIC USE)

The Eurasian Basin plays a key role in the general circulation of the Arctic. It is the immediate recipient of the warm water coming from the Norwegian Sea, which feeds the thick temperature maximum layer found throughout the Arctic Ocean, representing an enormous storage of sensible heat. The Eurasian Basin is additionally ventilated both from the adjoining shelves and from the Greenland Sea through Fram Strait. The Eurasian Basin also exports southward significant quantities of new deep water, formed within the basin, which subsequently mix with the Greenland Sea deep water and probably contribute to the ventilation of the deep Norwegian Sea.

The Eurasian Basin deep water is relatively warm and saline, and these characteristics appear to result from a mixture of dense, brine-enriched shelf water with intermediate strata in the Arctic Ocean. The deep water exits the Arctic Ocean along the Greenland slope at a depth centered about 1900 m. Conversely, very cold low-salinity deep water from the Greenland Sea enters the Eurasian Basin through the deep channel west of Spitsbergen. This water is excluded from the Canadian Basin by the Lomonosov Ridge, leaving the Eurasian Basin much colder, less saline and lower in silicate than the Canadian Basin. The Eurasian Basin is probably therefore more efficiently ventilated than is the Canadian Basin, which depends on its deep renewal primarily from shelf processes.

Current and temperature measurements show that the Barents Sea contribution of dense shelf water to the Eurasian Basin must come either through the Victoria Island-Franz Joseph Land passage or via the Kara Sea. The inflow from the northwestern Barents Sea through the Northeast Land-White Island passage is of relatively low salinity; its annual volume transport is about $0.2 \times 10^6 \text{ m}^3 \text{ sec}^{-1}$.

The inflow to the Eurasian Basin through eastern Fram Strait (the West Spitsbergen Current) is actually composed of several separate current cores. Our continuing monitoring of this inflow shows a mean current during 1982-83 of 12 cm sec^{-1} at 100 m, 8 cm sec^{-1} at 400 m, and 4 cm sec^{-1} at 1000 m in the core located approximately above the 1 km isobath. These values are very near the annual means from (cont. on 2nd sheet)

PART III—TECHNICAL INFORMATION (FOR PROGRAM MANAGEMENT USES)

1. ITEM (Check appropriate blocks)	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (✓)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations		X			
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results				X	15 Dec 1984
f. Other (specify)					
2. Principal Investigator/Project Director Name (Typed) KNUT AAGAARD	3. Principal Investigator/Project Director Signature <i>Knut Aagaard</i>			4. Date 10 Aug 1984	

Final Project Report

Project Title: A Study of the Eurasian Basin at the Arctic Ocean

Part II (Continued)

1976-79 and 1980-81, so that during these years there has been little interannual variability in the inflow.

Within the Eurasian Basin we find a strong subsurface current along the slope, of order 15 cm sec^{-1} and directed in a counter-clockwise sense around the basin. This deep boundary current could constitute an important part of the thermohaline circulation, possibly analogous to the deep western boundary currents at lower latitudes. The restriction of the current to the boundary as shown by the moored current measurements is not indicated by the temperature distribution, which extends nearly unaltered into the interior. This apparent discrepancy may arise because of lateral mixing.

Part III

- b. One paper has been published: K. Aagaard, A. Foldvik, T. Gammelsrød and T. Vinje, "One-year records of current and bottom pressure in the strait between Nordaustlandet and Kvitøya, Svalbard, 1980-81," Polar Research 1, 107-113, 1983. Two reprints are enclosed. Another paper is ready for submittal: K. Aagaard, J. H. Swift and E. C. Carmack, "Thermohaline circulation in the arctic mediterranean seas," Journal of Geophysical Research. A third paper is in preparation: K. Aagaard, A. Foldvik and S. R. Hillman, "Core structure in the West Spitsbergen Current."
- c. A. Foldvik, dosent, Geophysical Institute, University of Bergen.
D. J. Hanzlick, graduate student
S. R. Hillman, graduate student
- e. Technical description will be furnished as indicated.

SEARCHED
SERIALIZED
INDEXED
FILED
APR 11 1983
FBI - ALBUQUERQUE
A-120



One-year records of current and bottom pressure in the strait between Nordaustlandet and Kvitøya, Svalbard, 1980-81

K. AAGAARD, A. FOLDVIK, T. GAMMELSRØD AND T. VINJE



Aagaard, K., Foldvik, A., Gammelsrød, T. & Vinje, T. 1983: One-year records of current and bottom pressure in the strait between Nordaustlandet and Kvitøya, Svalbard, 1980-81. *Polar Research* 1 n.s., 107-113.

We have obtained one year of measurements from a subsurface instrumented mooring carrying two current meters and one bottom pressure recorder in the strait between Nordaustlandet and Kvitøya in the northeastern Svalbard archipelago. The observations show a mixed tide with typical amplitudes 0.4 db and 10 cm sec^{-1} . The semidiurnal tide is characterized by a progressive wave propagating toward the south, together with a cross-channel baroclinic mode. The annual average (non-tidal) current is less than 2 cm sec^{-1} toward the north-east, suggesting that the transport into the Arctic Ocean is approximately $0.2 \times 10^6 \text{ m}^3 \text{ s}^{-1}$.

K. Aagaard, University of Washington, 4057 Roosevelt Way, N.E. Seattle, Washington 98105, U.S.A.; A. Foldvik and T. Gammelsrød, Geofysisk Institutt, Avd. A, Universitetet i Bergen, 5014 Bergen, Norway; T. Vinje, Norsk Polarinstitutt, Rolfstangveien 12, 1330 Oslo Lufthavn, Norway; December 1982 (revised February 1983).

Introduction

In this paper we present the results from a subsurface mooring between Kvitøya and Nordaustlandet in the northeastern Svalbard archipelago

(Fig. 1). The rig was launched from the Swedish icebreaker YMER on 30 July 1980 and recovered from the Norwegian vessel LANCE on 25 August 1981. It consisted of two Aanderaa RCM-4 current meters at 75 m and 255 m, and one Aanderaa

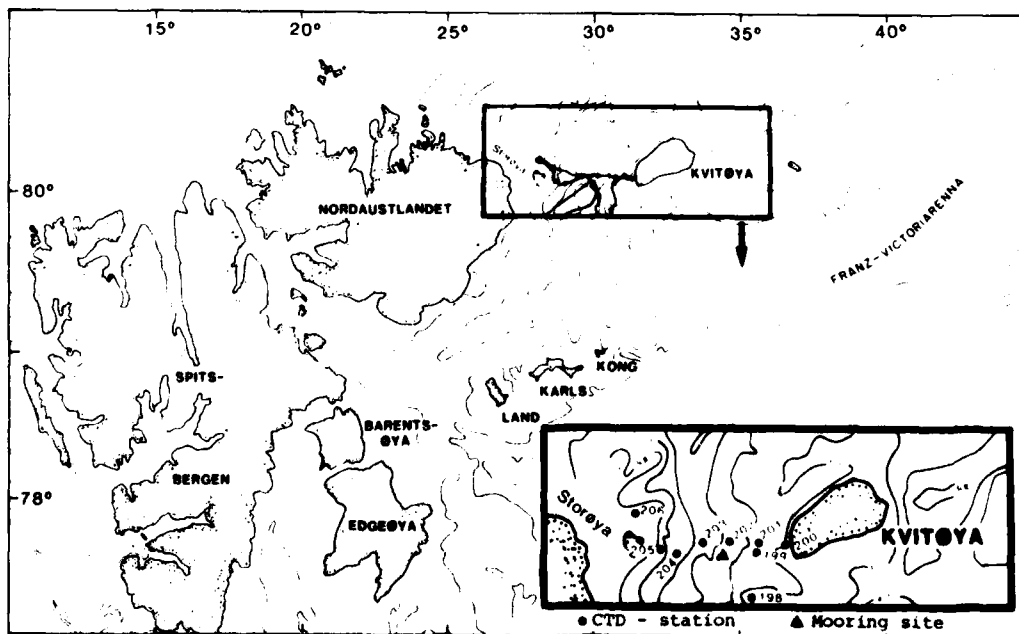


Fig. 1. Map of Svalbard showing positions of mooring and CTD section.

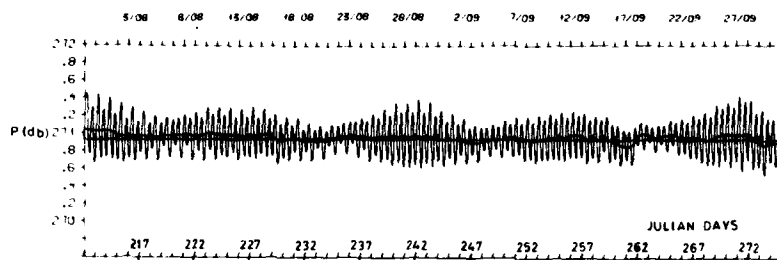


Fig. 2. Hourly bottom pressure from August to September 1980. Time in Julian days. Also shown is the low-passed series, using a filter with a 40 hr cut-off.

TG-2A pressure recorder at the bottom (260 m). The sampling interval was one hour. An apparent deterioration in the speed recording of the lower current meter over the last 20 weeks of deployment caused the only data gap.

Pressure measurements

The bottom pressure record reflects the combined effect of variations in sea level (e.g. that due to tides), varying atmospheric pressure, and baroclinic currents. Fig. 2 shows the pressure recording for the two months immediately following the launching. A typical mixed tide prevailed, with the semidiurnal components dominating. The fortnightly period is due to the interference of the semidiurnal periods M_2 and S_2 . The maximum amplitude is seen to be roughly 0.4 decibar, equivalent to 0.4 m in sea level.

Also presented in Fig. 2 is the residual pressure

after tidal variations have been filtered out using a low-pass filter which suppresses variations with periods shorter than 40 hours. The amplitude of the filtered curve is equivalent to about 10 cm and represents the combined effects of low-frequency currents and atmospheric pressure variations.

The power spectrum of the pressure record (Fig. 3) yields the expected tidal bands. The large subharmonic components which appear near 8 hr, 6 hr, etc., are typical for shallow water tides, and arise from the non-harmonic tidal wave form in shallow water. The amplitude and phase of the major tidal constituents have been computed from the entire one-year record using Foreman's (1977, 1978) method. The results are listed in Table 1.

Current and temperature measurements

Fig. 4 shows a temperature, salinity, and density section across the strait two days after the recovery of the mooring. The lower current meter had been situated near the bottom in the warmest water, while the upper meter was at the position of the cold core at 75 m depth.

Portions of the various temperature and velocity records are shown in Fig. 5, covering the same period as the pressure record in Fig. 2. As with the pressure signal, the tides also dominate the currents. The amplitude and phase of the major tidal constituents have been computed using the full-length records, and the results are listed in Table 1. The V (north)-component of the upper current meter exhibits the largest amplitude, about 10 cm sec^{-1} . Power spectra of the current components (not shown) are similar to the power spectrum for the pressure record (Fig. 3).

The temperature spectra (Fig. 6) show no tidal

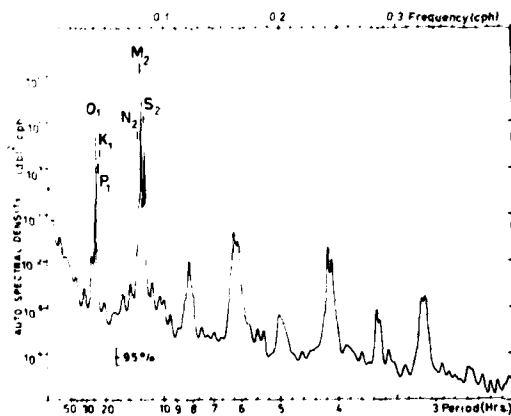


Fig. 3. The power spectrum for the entire one-year bottom pressure record, computed using the maximum entropy method. The frequencies of the major tidal constituents are also shown.

Table 1. Major tidal constituents for the upper current meter (upper numbers), the lower current meter (lower numbers) and the pressure. Positive minor axis denotes counter-clockwise rotation. The angle of inclination denotes the orientation of the major axis and is measured in degrees counter-clockwise from east. Greenwich phase is referred to the northern major semiaxis for the current and to high water for the pressure.

Constituent	Current measurements				Pressure measurements	
	Major axis cm sec ⁻¹	Minor axis cm sec ⁻¹	Angle of inclination degrees	Greenwich phase degrees	Amplitude decibars	Greenwich phase degrees
O ₁	0.45	-0.18	147	34	0.01	320
	0.25	-0.01	158	26		
P ₁	0.47	-0.00	95	68	0.02	295
	0.24	0.04	109	67		
K ₁	1.29	-0.09	104	67	0.07	305
	0.88	0.16	117	68		
N ₂	1.65	-0.45	89	230	0.04	68
	0.70	0.39	104	237		
M ₂	8.63	-2.18	96	265	0.21	97
	3.61	2.37	102	267		
S ₂	3.50	-1.32	105	337	0.06	152
	1.39	0.73	39	268		

influence other than a rather broad semidiurnal peak, probably due to a semidiurnal internal tide (see discussion below). The different spectral levels for the two instruments reflect the weaker temperature stratification in the lower layer (cf. Fig. 4).

We have applied the 40-hr filter to the entire

pressure, current and temperature records; the results are shown in Fig. 7. The filtered currents are weak, about 2 cm sec⁻¹, and exceed 5 cm sec⁻¹ only for short periods of time. The average flow is approximately northeast, i.e. into the Arctic Ocean, as is also apparent from the progressive vector diagrams (Fig. 8).

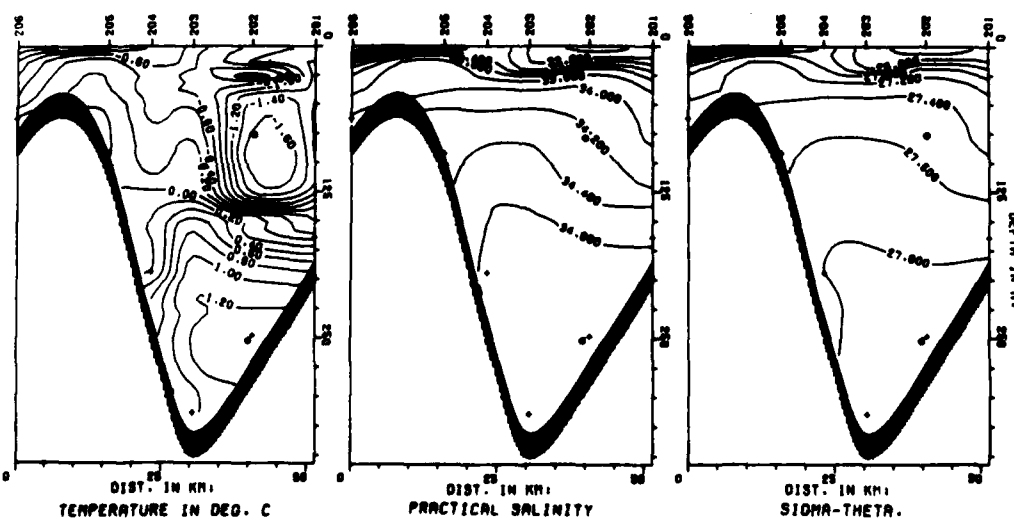


Fig. 4. A temperature, salinity and density section across the strait between Nordaustlandet and Kvitøya. The upper numbers identify the oceanographic stations. The deepest observations are marked with crosses and the positions of the current meters with black dots.

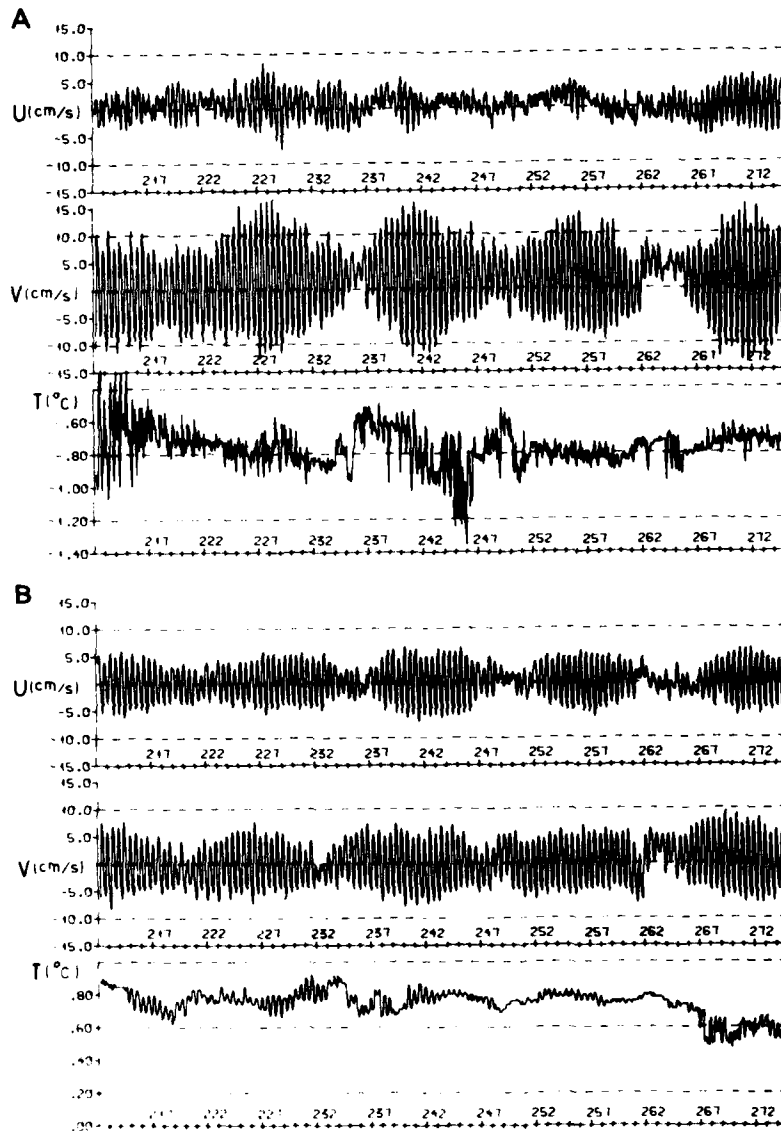


Fig. 5. Hourly current and temperature data from August to September 1980 (cf. Fig. 2). Time in Julian days. Easterly flow is denoted by U, northerly by V and temperature by T. A: Upper instrument, depth 75 m; B: Lower instrument, depth 255 m.

The average velocities in the upper and lower layers are 1.8 cm sec^{-1} and 0.5 cm sec^{-1} , respectively (the latter value was calculated up until 4 April only). From this we estimate that the annual average flow through the strait probably does not exceed about $0.2 \times 10^6 \text{ m}^3 \text{ sec}^{-1}$ (0.2 Sv) toward the northeast. In terms of mass balance for the

Arctic Ocean, this is a small contribution (SCOR Working Group 58, 1979); for example, it is probably less than 5% of the West Spitsbergen Current transport. The temperature records (Fig. 7) show that the structure revealed in Fig. 4, with a cold core above a warm bottom layer, is maintained throughout the year.

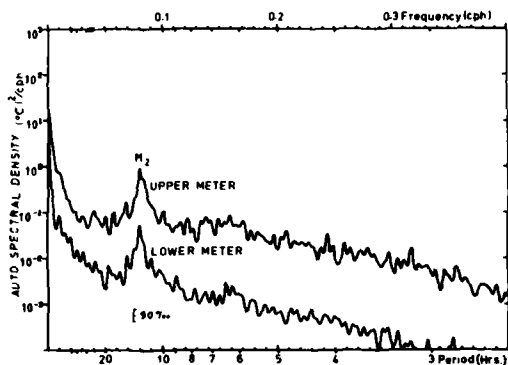


Fig. 6. Power spectra of temperature.

Discussion

Neither the filtered series themselves (Fig. 7) nor their power spectra (not shown) indicate distinct long-term periodicities. There are, however, a few events of strong northerly currents at both instruments (e.g. 28 January and 23 February, cf. Fig. 7) which coincide with anomalously high bottom pressure. On both occasions, relatively intense cyclones passed over the northern Barents Sea, and the strong current events were probably forced by the atmospheric events.

The rotary spectra for the current records are shown in Fig. 9. A comparison of the energy

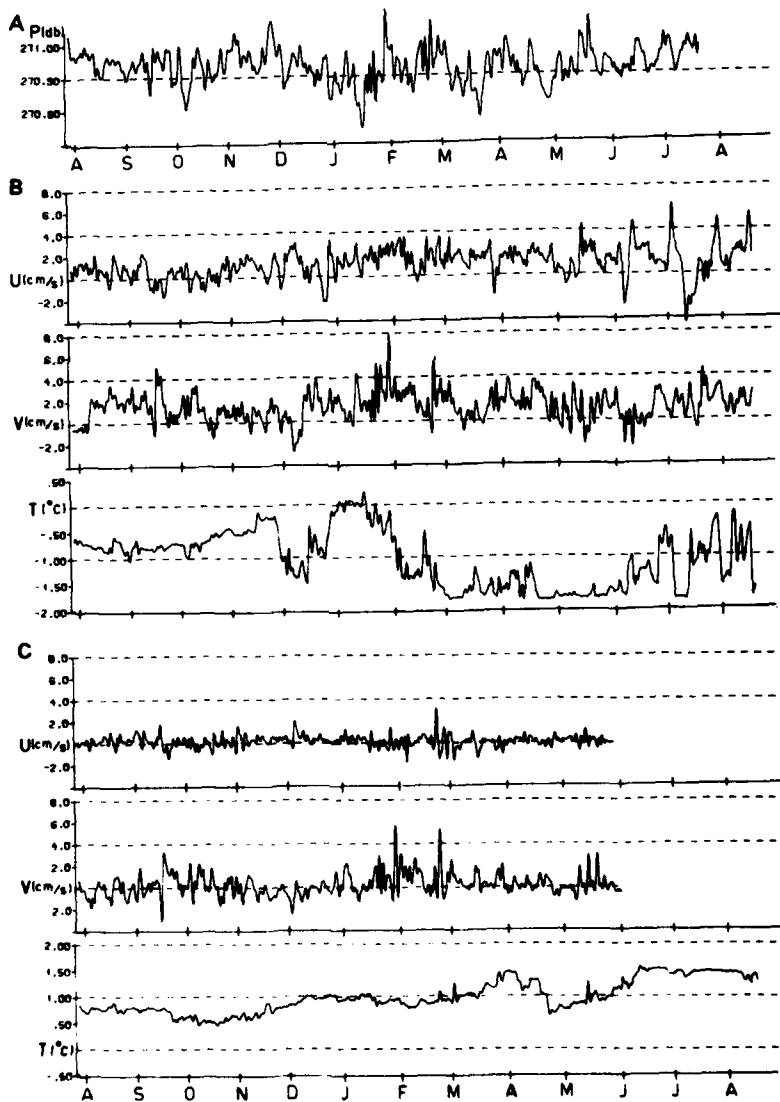


Fig. 7. Low-passed data. A: Bottom pressure; B: Velocity and temperature, upper meter; C: Velocity and temperature, lower meter.

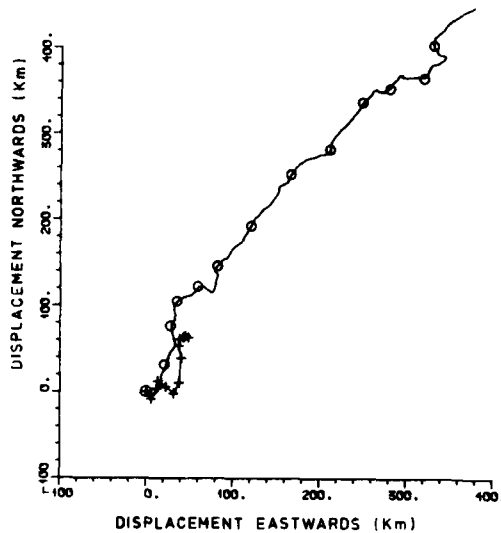


Fig. 8. Progressive vector diagram for the two current meters. Circles (upper meter) and crosses (lower meter) denote position every 30 days.

levels in the tidal bands shows that the counter-clockwise components are equal in the upper and lower layers, whereas the energy in the clockwise component is smaller at the lower instrument, particularly for the semidiurnal tide. The distribution of energy in the tidal bands also shows that the associated tidal currents rotate in opposite directions at the two instruments, clockwise in the upper layer and counter-clockwise in the lower. This is clearly seen in Fig. 10, where the tidal current ellipses are plotted; the current vectors are shown at the time of high tide. The maximum southward flow in both layers is seen to coincide with high tide. Thus the north-south tidal currents have the characteristics of southward-propagating progressive waves. A quarter period after high tide the maximum westward flow in the upper layer coincides with maximum eastward flow in the lower layer. The motion across the axis of the channel thus has the characteristics of a standing internal wave.

Acknowledgements. - The measurements described in this

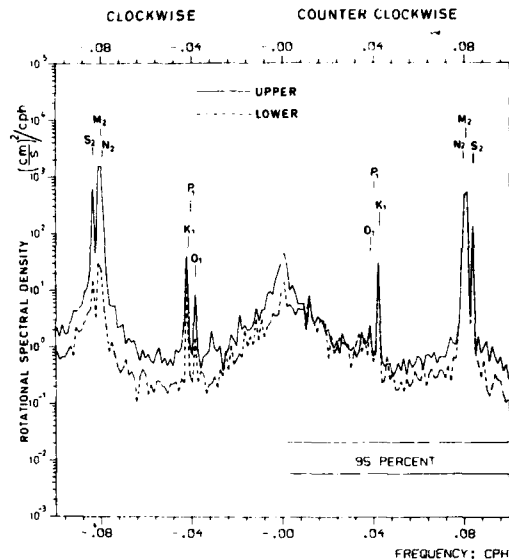


Fig. 9. Rotary current spectra. The frequencies of the major tidal constituents are indicated.

report were the combined efforts of the Norwegian Polar Research Institute, the Geophysical Institute of the University of Bergen, and the University of Washington. We express our appreciation to the officers and crew of the YMER and the LANCE for their enthusiastic cooperation in carrying out the deployment and dredging operations; to Clark Darnall and Richard Tripp at the University of Washington for help with instrumentation and data handling; and to Tor Tørresen and Stein Sandven at the Geophysical Institute, University of Bergen, for programming and helpful discussions. Knut Aagaard was supported financially by the Office of Naval Research through contract No. N00014-75-C-0893 and by the National Science Foundation through grant No. DPP 81-00153.

References

- Foreman, M. G. G. 1977: Manual for Tidal Heights Analysis and Prediction. *Pacific Marine Science Report 77-10* (Corr. 1979). Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.
- Foreman, M. G. G. 1978: Manual for Tidal Currents. Analysis and Prediction. *Pacific Marine Science Report 78-6* (Corr. 1979). Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.
- SCOR Working Group 58, 1979: The Arctic Ocean Heat Budget. *Report No. 52*. Geophysical Institute, University of Bergen, Norway.

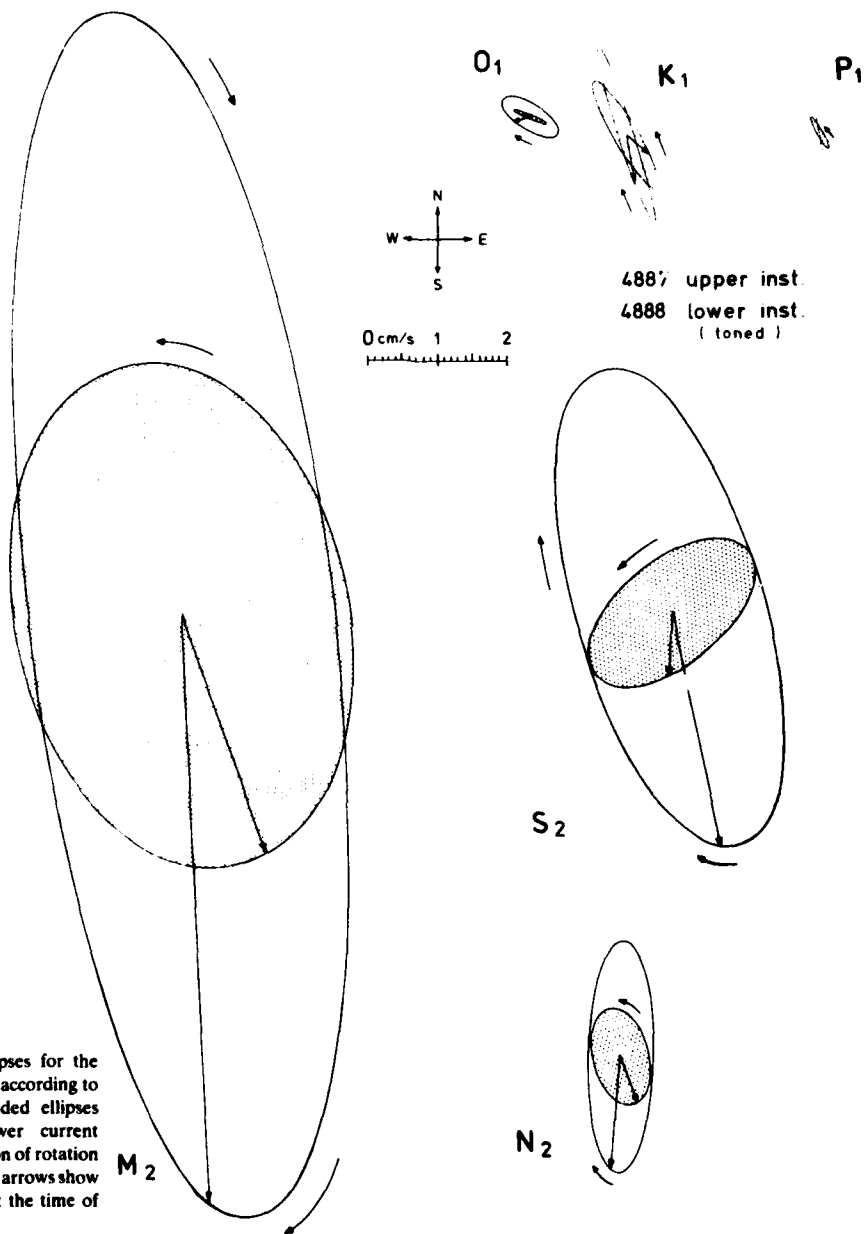


Fig. 10. Tidal ellipses for the major constituents according to Table 1. The shaded ellipses refer to the lower current meter. The direction of rotation is indicated and the arrows show the tidal current at the time of high water.