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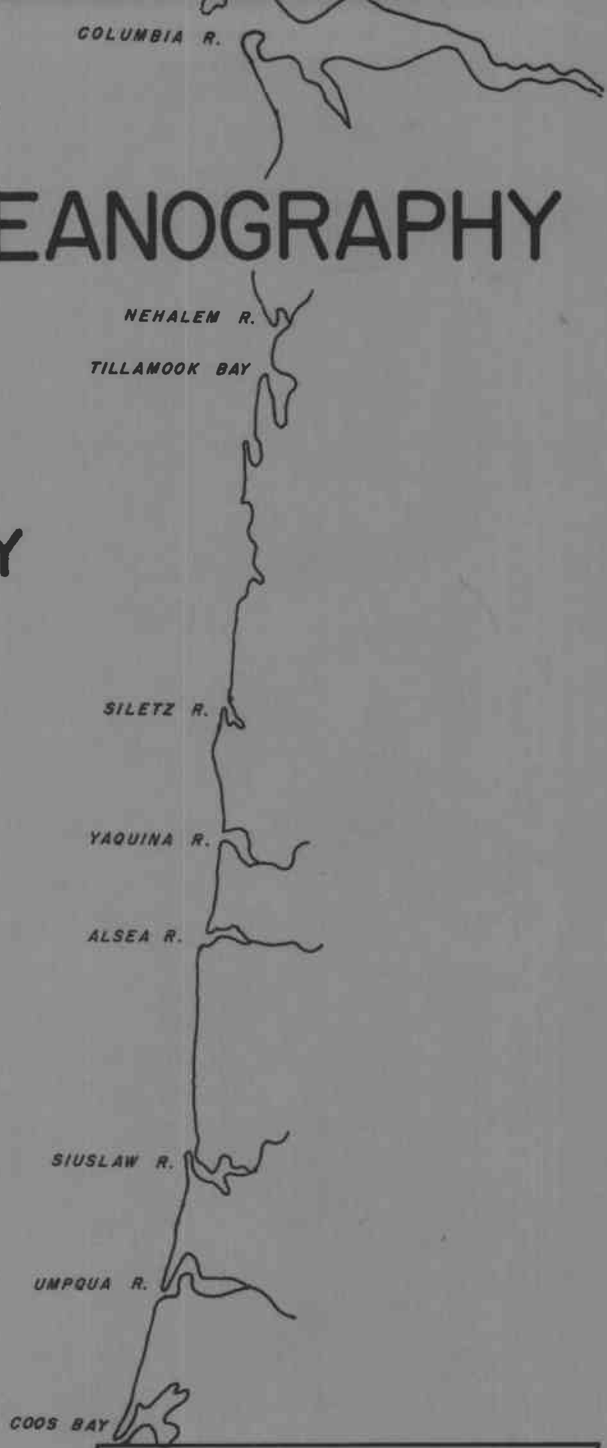

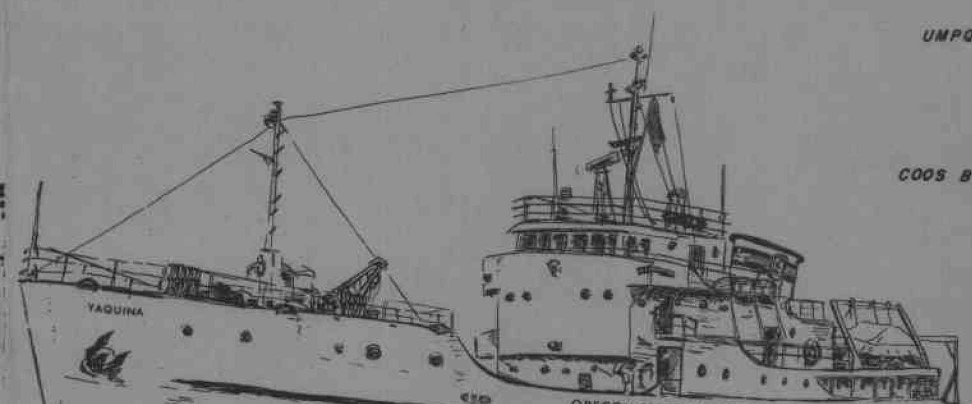

A COMPILATION OF OBSERVATIONS FROM MOORED CURRENT METERS AND THERMOGRAPHS

Volume I: Oregon Continental Shelf
July 1965-February 1966

by

Curtis A. Collins
H. Clayton Creech
June G. Pattullo

National Science Foundation
Grant GP 4472

Data Report 23 **Reference 66-11**
December 1966

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Corvallis, Oregon 97331

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Wayne V. Burt
Chairman

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INTRODUCTION

This is the first data report of a program designed to study physical processes in Oregon shelf waters by means of moored instrument arrays. Various statistics and plots of smoothed data are presented for time series of current velocity and of temperature. Data were collected in July, August, September, and October of 1965 and in January and February of 1966.

Some preliminary results of this program have been described by Burt and Borden (1966).

THE OBSERVATIONAL PROGRAM

Instrument arrays consisting of recording current meters and thermographs were installed at several depths in Oregon shelf waters on four occasions:

1. From 11 July to 2 August, 1965, henceforth referred to as July data;
2. From 28 August to 24 September, 1965, henceforth referred to as September data;
3. From 24 September to 19 October, 1965, henceforth referred to as October data;
4. From 24 January to 19 February, 1966, henceforth referred to as February data.

The location of each installation is indicated in Figure 1.

A schematic of the system used to moor these instruments is given in Figure 2. Details concerning the hardware are as follows:

Subsurface Floats - Two 42-gallon hot water tanks bridled by means of chain or flat bar cages; pressurized with 50 lbs. of air. When submerged, the depth of the top of subsurface float was 15 meters.

Diesel-Filled Floats - Five Geodyne #B-32 mooring buoys filled with diesel oil and used to provide additional bouyancy at depth.

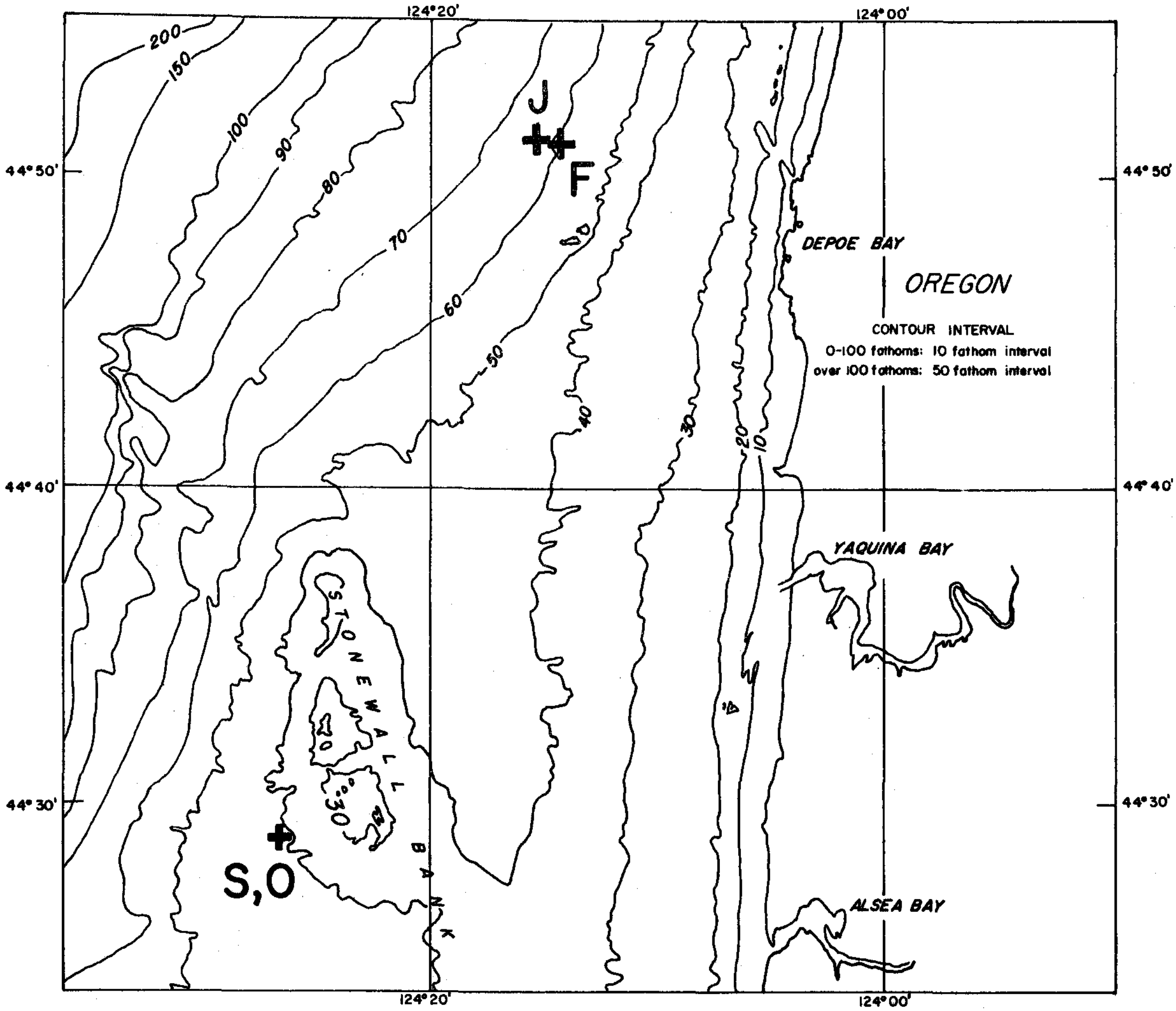

Figure 1. Location of Instrument Arrays (F - February, J - July, O - October, S - September)

Main Anchor - A 55-gallon drum filled with scrap steel and concrete; total weight about 1350 lbs.

Ground Line - 1/4 inch non-rotating galvanized preformed wire rope; 400-700 meters of wire were laid between the main anchor and the secondary anchor. The secondary anchor was attached to the ground line with 1/4 inch pendants and wire rope clips; the wire from the surface float to the main anchor was continuous.

Secondary Anchor - Seven 35-lb shackles and one 25-lb Danforth anchor.

Surface Float - Five air-filled PVC floats (Geodyne #B-322). The surface float was provided with a 2: 1 scope.

Components of the instrument array were fastened together with 7/16 inch galvanized chain safety shackles; 3/16 inch preformed stainless steel wire rope was used in the instrument array. Half-inch swivels were used below the subsurface float and the surface float.

Exceptions to this mooring arrangement made for each individual data period are noted in the text.

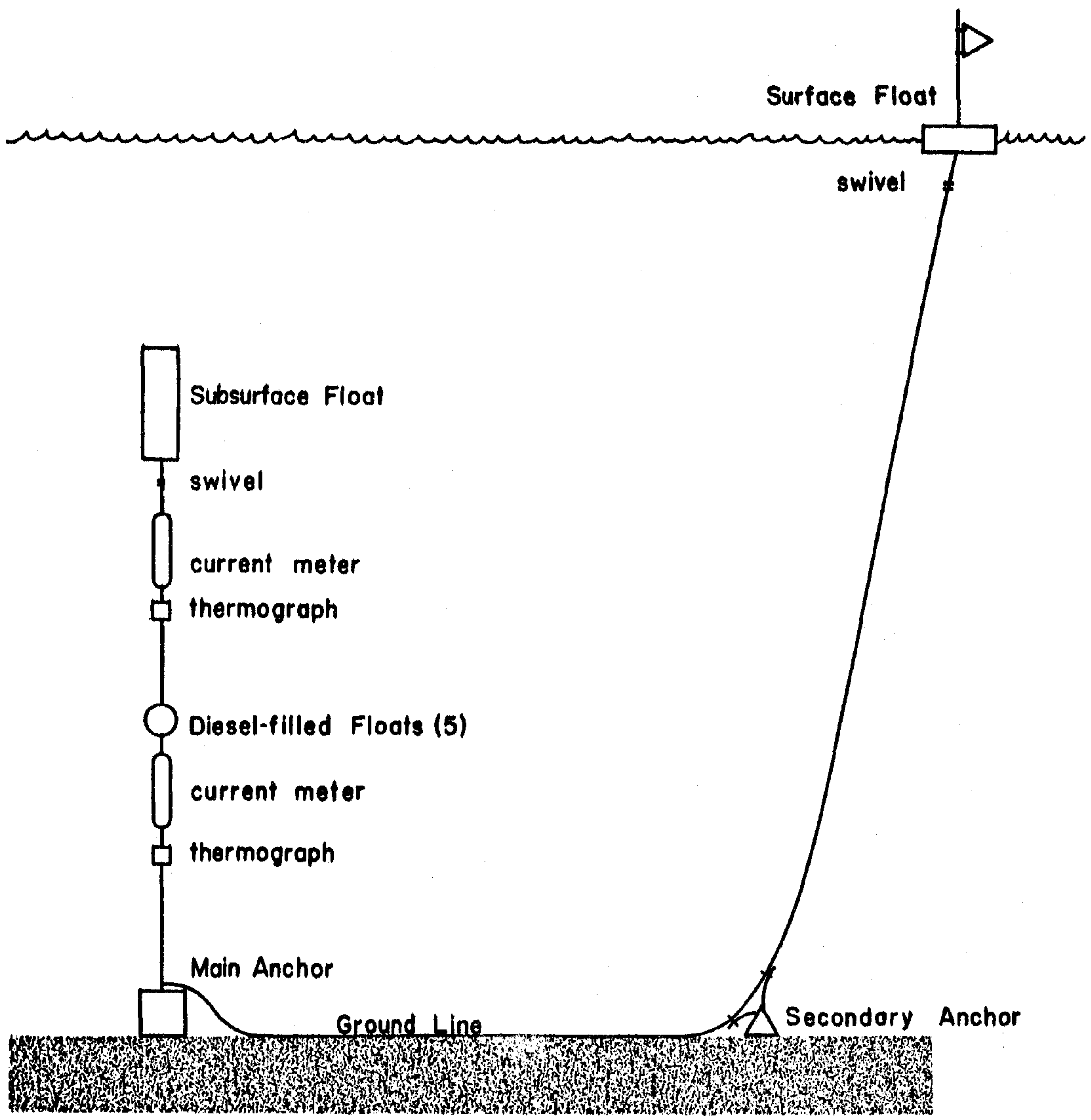

Figure 2. Diagram of the Instrument Array

INSTRUMENTS

Current velocity was measured by Braincon type 316 Histogram Current Meters (Braincon Corporation, 1965, and Sunblad, 1965). Several features of this instrument should be noted. Current observations are made over a ten- or twenty-minute period and recorded on photographic film. Current speed is integrated over this period and recorded as arc length; current direction is recorded in circular format as a quasi-frequency curve. The calibration threshold of the instrument is 2.6 cm/sec (Braincon Corporation, 1965), but it was impossible to detect currents slower than 5.2 cm/sec with a 20 minute cycle. The sensitivity of current speed output is 1.1°/cm/sec for a 20 minute cycle, and the accuracy of speed output is ±7.7cm/sec at 257 cm/sec (Braincon Corporation, 1965). The precision of a given speed measurement is ± 1 cm/sec for a 20 minute cycle (Braincon Corporation, 1965).

Sensitivity of the current direction sensor is 5° at 2.6 cm/sec; sensitivity of current direction output is ± .5° (Braincon Corporation, 1965). The precision of a given direction output is ± 3°. Compasses were checked and found to be free from deviation.

Velocity measurements have not been corrected for mooring motions. Motions of the instrument array were minimized by the use of subsurface floats and do not appear to seriously contaminate velocity data.

Water temperature was measured by Braincon type 146 recording thermographs. These were fitted with -2°C to +25°C thermometers. The thermometer was placed between a phosphorescent source and photographic film; temperature was recorded as a thick dark line where the mercury prevented film exposure. The thermographs were set to advance every five minutes; they achieve 95% of final value in ten minutes (Brainard, 1964). Thermometer readout accuracy is ± .1°C (Brainard, 1964).

Instrument depths are referenced to mean sea level and are accurate to ± 2 meters.

Despite their simple modular construction, these instruments require considerable care and preparation if they are to record worthwhile data.

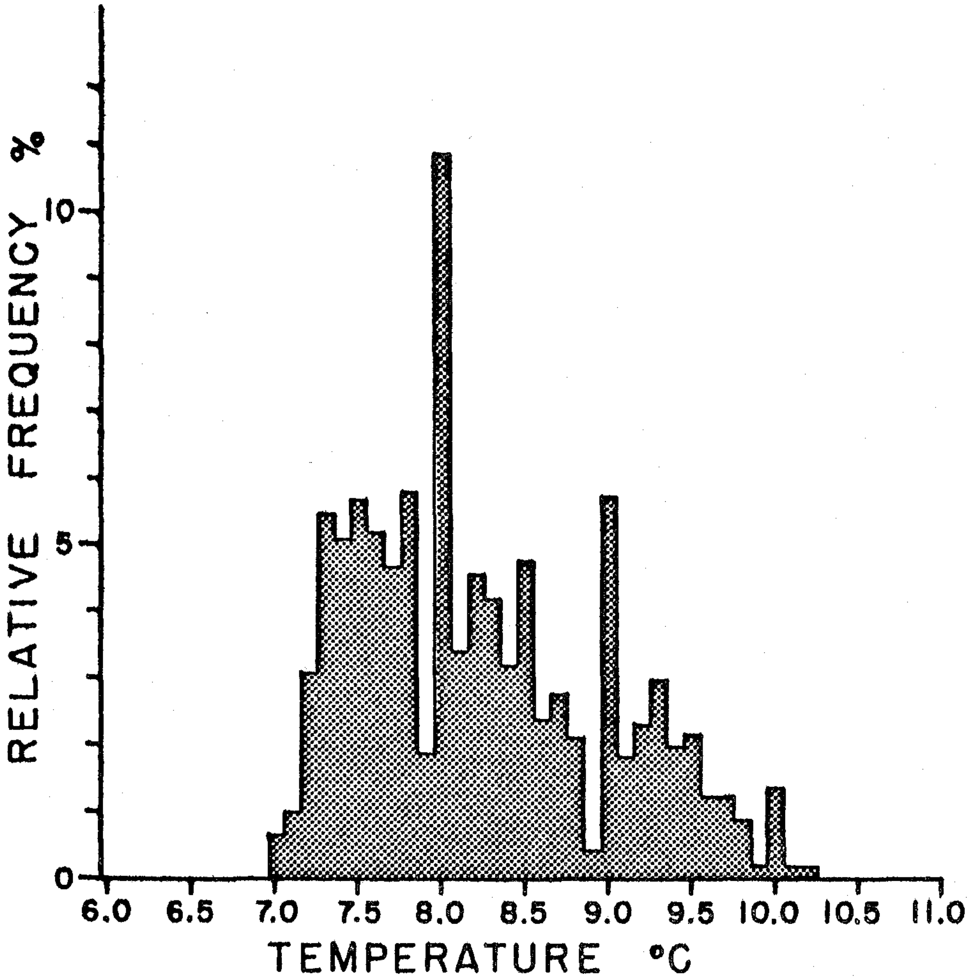

Figure 3. Histogram of Temperature at 20m for July

DATA PROCESSING

Details of film reading are given in Appendix I. The 16 mm film from the current meter was read with a Remington Rand model F72B viewer; an overlay was taped to the screen of this viewer. Velocity data was processed with the program given in Appendix II.

A Dagmar II 35 mm viewer was used to project the image of the 70 mm thermograph film onto a grid graduated in tenths of a degree centigrade. The grid was aligned with the projected image and the temperature read. The image was usually fuzzy, and some difficulty was encountered in choosing a shade of grey to read. It was easiest to read a light grey so temperatures read were the lowest temperatures recorded during the five minute sampling period. However, film readers showed a preference for temperatures x. 0°C and x. 5°C which were scale marks etched on the film and grid; this bias is illustrated in Figure 3. However, readers showed a preference for temperatures at even and half degrees, which corresponded to scale marks etched on the film and grid. This fact led to the bias illustrated in Figure 3.

It took one man-hour to read 75 frames of current velocity data. One day's thermograph film took one man-hour to read.

Data were checked by examining machine plots of the east-west component of velocity(U), the north-south component of velocity (V), direction, speed, tilt, and temperature as a function of time. For those values which did not seem to "fit" the film was reread. The original value was changed only if the value obtained in rereading the film was "significantly" different. One reliable reader checked all data so criteria for "fit" and "significant" would be consistent.

EXPLANATION OF DATA PRESENTATION

In presenting the data, we have followed the format used by Webster and Fofonoff (1965) as closely as feasible. Data are presented for each data period as follows:

1. Progressive vector diagrams (see Webster (1964))
2. Installation details
3. Current velocity time series
   a) Histograms of speed, direction, U and V
   b) Plots of smoothed U and V vs. time
4. Histograms and plots of temperature vs. time for temperature time series.

Speed histograms give relative frequency for successive two degree intervals of arc[1]; U and V histograms are constructed for successive intervals of five cm/sec. Direction histograms have ten degree intervals. Where reading bias distorted temperature histograms, the following averaging scheme has been used: 5.9°, 6.0°, and 6.1° constitute one class, 6.2° and 6.3° the next class, 6.4°, 6.5°, and 6.6° the third class, etc.

Where variables are plotted as a function of time, they were first smoothed with a cosine filter to remove inertial and tidal variations (Sabinin and Shulepov, 1965). The frequency response of this filter is given in Appendix III.

---

[1] Poorly matched quantizing intervals prevented the use of an interval with units of cm/sec (see Webster (1964), p. 24). This is due to the fact that speed is not a linear function of arc.

The following symbols are used:

- S - sample standard deviation
- T - temperature
- U - east-west component of velocity
- V - north-south component of velocity
- $\tilde{U}, \tilde{V}, \tilde{T}$ - smoothed U, V, and T
- $\bar{X}$ - sample mean
- Z - depth

Subscripts indicate the depth (meters) at which the observation was made.

PERSONNEL

Dr. June G. Pattullo is the principal investigator for this project. Mr. C. N. K. Mooers and Mr. David Young developed the mooring details and acquired the instrumentation; they were aided by Mr. Dale Pillsbury, Mr. Hugh Dobson, and Mr. Ed Thayer. Installation and recovery of instruments has been performed under the direction of Mr. Collins, Mr. Mooers, and Mr. Pillsbury. Data processing has been under the direction of Mr. Collins and Mr. Creech. Diane Pillsbury, Ray Jorgensen, Bob George, and Pat Hitson have read film.

Further analyses of data are presently being made by Mr. Collins and Mr. Mooers in consultation with Dr. Robert Smith and Dr. Pattullo.

ACKNOWLEDGEMENTS

This work was initiated under Grant GP 4472 and continued under Grant GA 331 from the National Science Foundation. The National Science Foundation provided ship support for the R/V YAQUINA under grants GP 4247 and GA 295. The work-study program supported by the U. S. Department of Health, Education and Welfare and Oregon State University, provided two full-time assistants during summer 1965 and two part-time assistants from September 1965 through June 1966; three full-time assistants were provided during summer 1966.

Special and invaluable assistance was rendered by Union and Standard Oil Companies of California, and Western Offshore Drilling and Exploration Company, who operated the barge WODECO III, the M/V BIG TIDE, and the M/V MARC VI at coastal locations during the summer of 1965.

Plots used to check data, some histograms and statistics tables, were made at Western Data Processing Center with programs provided by the Health Sciences Computing Facility of UCLA (Dixon, 1965).

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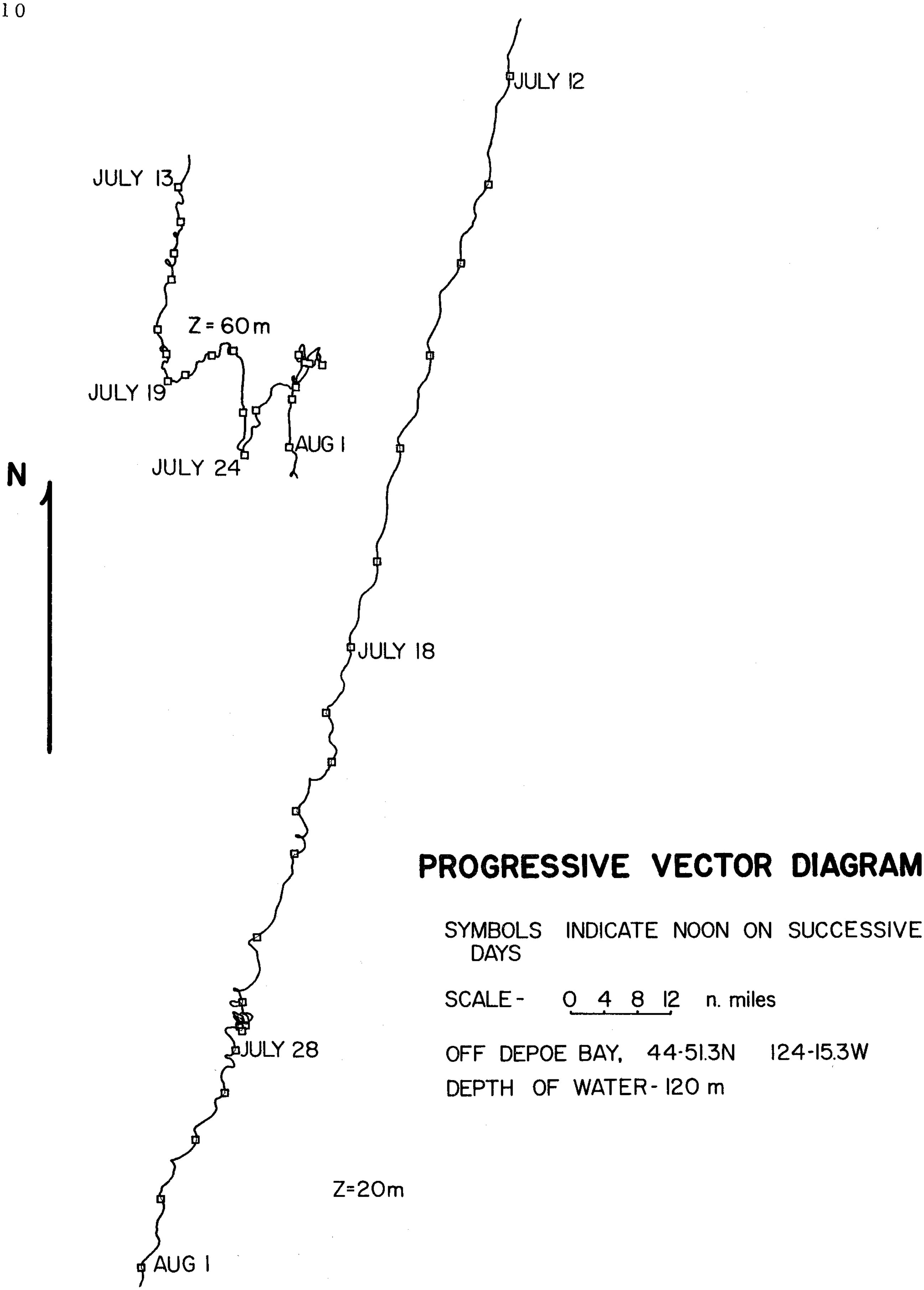
STATISTICS

Date	Depth (m)	Variable	Mean	Standard Deviation	Maximum	Minimum
July	20	Temperature, °C	8.23	0.73	10.5	7.0
		Speed, cm/sec	21.0	7.5	49.8	5.7
		U, cm/sec	- 4.7	10.3	26.2	-30.1
		V, cm/sec	-15.6	11.0	21.4	-49.7
		Tilt, deg. arc	0.3	1.0	5.	0.
	40	Temperature, °C	7.33	0.16	8.5	7.0
	60	Speed, cm/sec	13.3	3.5	29.5	5.7
		U, cm/sec	1.4	6.8	17.7	-18.8
		V, cm/sec	- 4.1	11.2	22.2	-29.5
		Tilt, deg. arc	0.3	0.8	5.	0.
September	20	Temperature, °C	8.94	0.63	11.4	7.6
		Speed, cm/sec	13.8	4.8	43.8	5.2
		U, cm/sec	0.0	9.1	31.0	-31.5
		V, cm/sec	0.8	11.4	28.2	-33.6
		Tilt, deg. arc	0.0	0.6	4.	0.
	40	Temperature, °C	8.00	0.13	9.5	7.7
	60	Speed, cm/sec	15.4	5.2	42.9	5.2
		U, cm/sec	- 0.7	8.5	20.5	-31.4
		V, cm/sec	6.1	12.3	35.8	-41.5
		Tilt, deg. arc	0.0	0.5	7.	0.
October	20	Temperature, °C	10.23	0.98	12.7	8.3
		Speed, cm/sec	19.3	7.4	50.5	5.2
		U, cm/sec	1.2	13.5	49.0	-40.1
		V, cm/sec	3.9	15.0	44.1	-49.0
		Tilt, deg. arc	0.3	1.0	6.	0.
February	25[a]	Temperature, °C	9.80	0.14	10.4	9.4
		Speed, cm/sec	3.2	1.5	22.4	0.9
		U, cm/sec	- 0.2	1.6	9.3	- 9.2
		V, cm/sec	- 0.2	3.1	21.5	-10.9
		Tilt, deg. arc	0.1	0.1	2.	0.
	50	Temperature, °C	9.80	0.16	10.3	9.4
		Speed[b], cm/sec	26.3	14.3	73.1	7.9
		U[b], cm/sec	- 3.4	9.3	28.7	-21.7
		V[b], cm/sec	- 5.6	27.7	72.6	-55.9
		Tilt, deg. arc	0.3	0.7	4.	0.
	75	Speed, cm/sec	27.0	13.2	61.1	7.2
		U, cm/sec	- 4.6	9.8	24.4	-28.1
		V, cm/sec	- 9.8	26.3	61.0	-53.2
		Tilt, deg. arc	0.9	0.0	6.	0.

[a] Speed sensor failed

[b] Statistics computed for first 1559 observations


JULY 12
JULY 13
Z = 60 m
JULY 19
JULY 24
AUG 1
N
JULY 18
JULY 28
Z=20m
AUG 1
PROGRESSIVE VECTOR DIAGRAM
SYMBOLS INDICATE NOON ON SUCCESSIVE DAYS
SCALE - 0 4 8 12 n. miles
OFF DEPOE BAY, 44-51.3N 124-15.3W
DEPTH OF WATER - 120 m

JULY INSTALLATION DETAILS

Position: 44° 51.3'N, 124° 15.3'W (off Depoe Bay)
Depth of Water: 60 fathoms
Set at 1700 PDT, 11 July, 1965, by M/V BIG TIDE
Retrieved at 0900 PDT, 2 August, 1965, by M/V BIG TIDE
Data Interval: 2140 PDT, 12 July-0840 PDT, 2 August

Mooring

Instrument cable consisted of 1/8 inch galvanized preformed wire rope. No swivels were placed in the instrument cable. The main anchor was located 1.0 miles east of the drilling barge, WODECO III.

Instrumentation

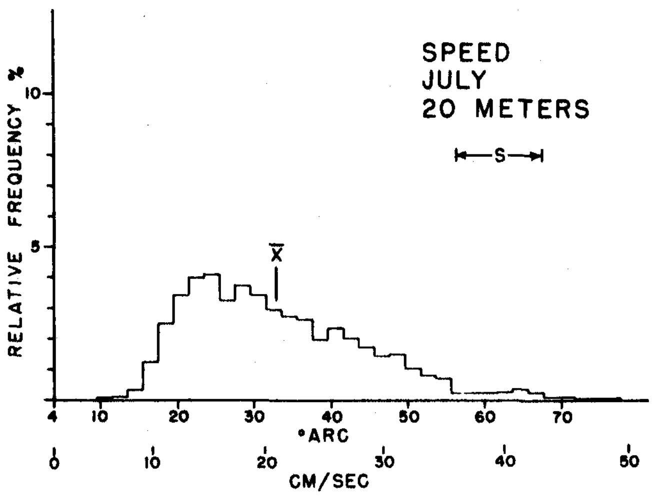
Current meters and thermographs were placed at depths of 20, 40, and 60 meters as follows:

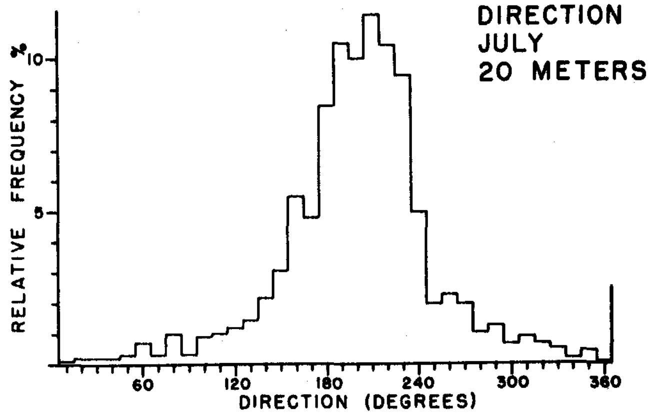
Depth	Histogram Current Meter Serial No.	Thermograph Serial No.
20m	3160049	14600087
40m	3160054	14600088
60m	3160055	14600089

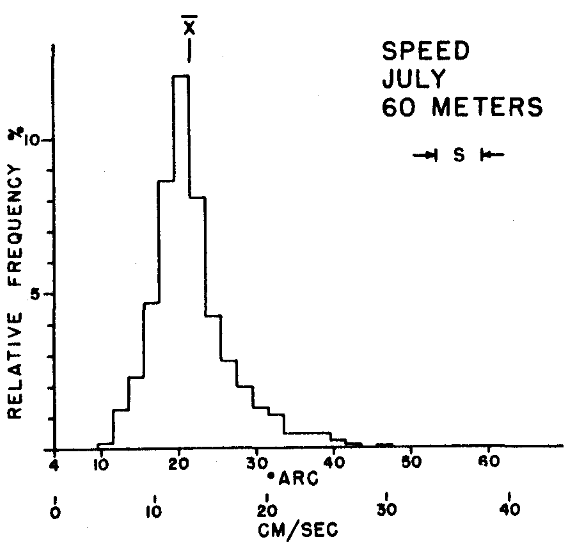
Current meters cycled every 20 minutes; thermographs cycled every five minutes.

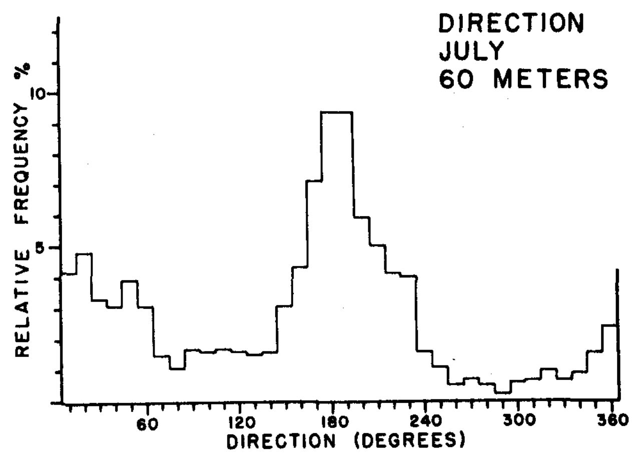
Comments on Results

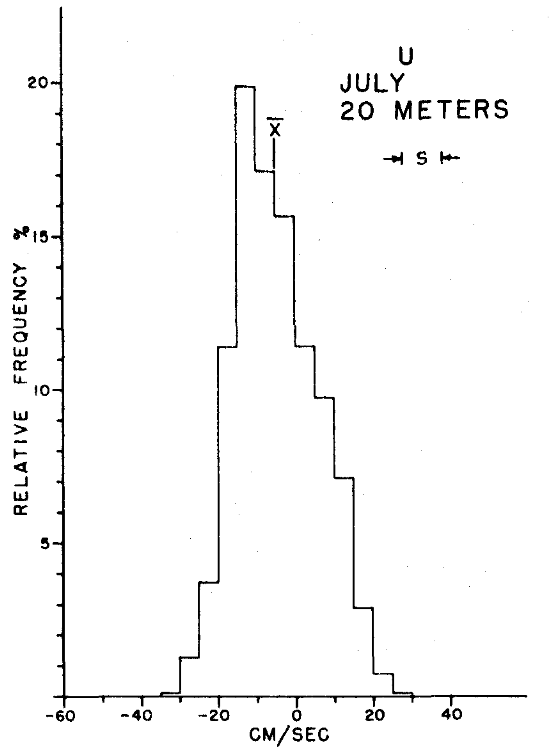
All gear was recovered. The instrument cable was badly hockled, and one strand was frayed. The thermograph at 60m did not operate because the 1.5v clock batteries were not properly secured. The current meter at 40m operated for only two or three days; cause of failure is not known. During photographic processing, some data were lost from records for 20m and 40m when too much leader was removed.

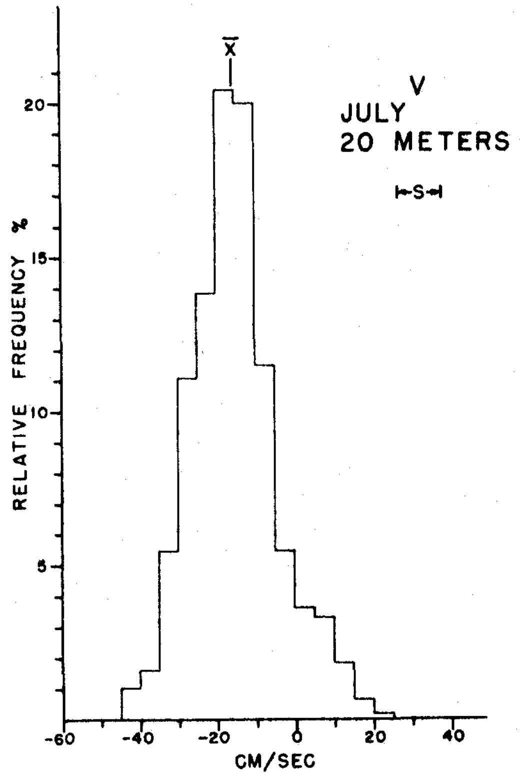

SPEED
JULY
20 METERS
S
X̄
RELATIVE FREQUENCY %
°ARC
CM/SEC

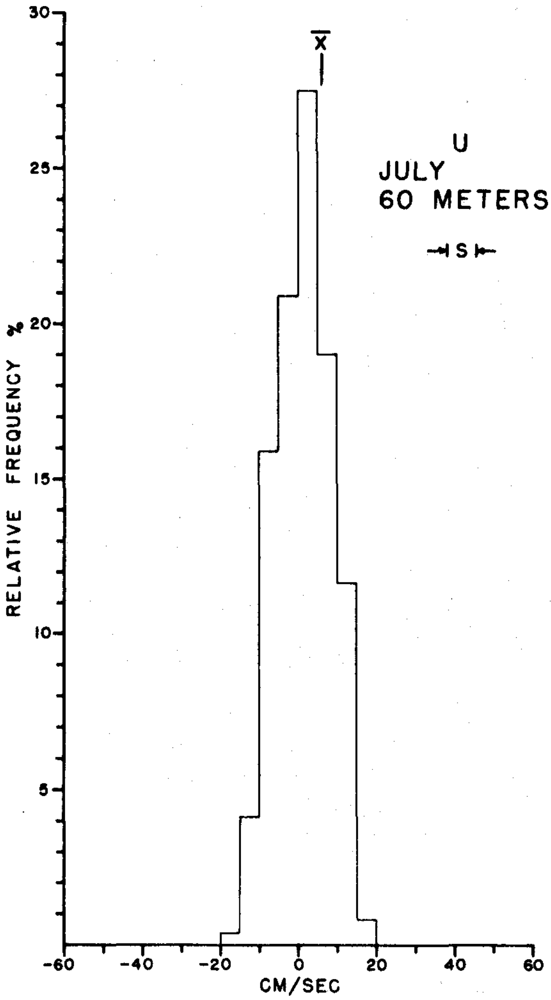

DIRECTION
JULY
20 METERS
RELATIVE FREQUENCY %
DIRECTION (DEGREES)

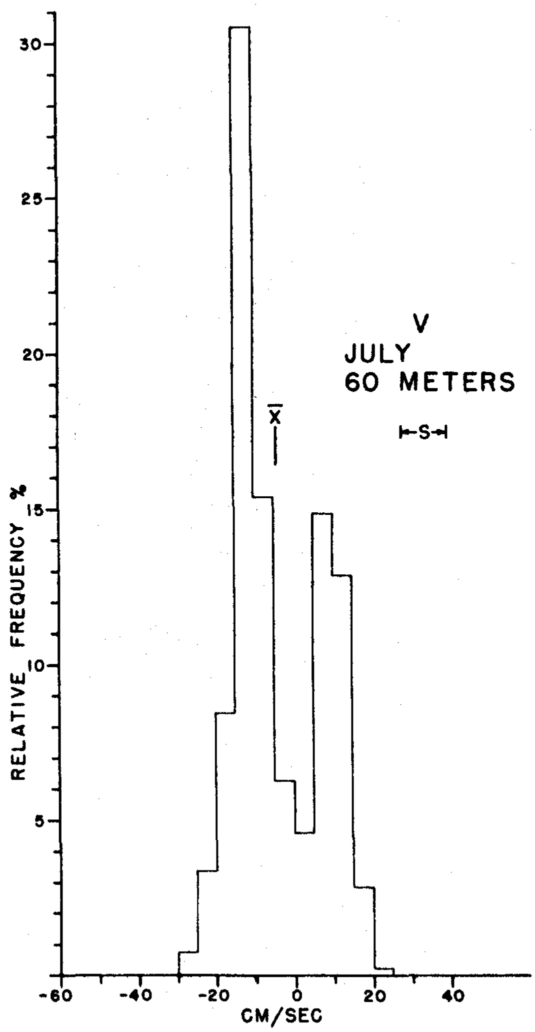

SPEED
JULY
60 METERS
S
X̄
RELATIVE FREQUENCY %
°ARC
CM/SEC

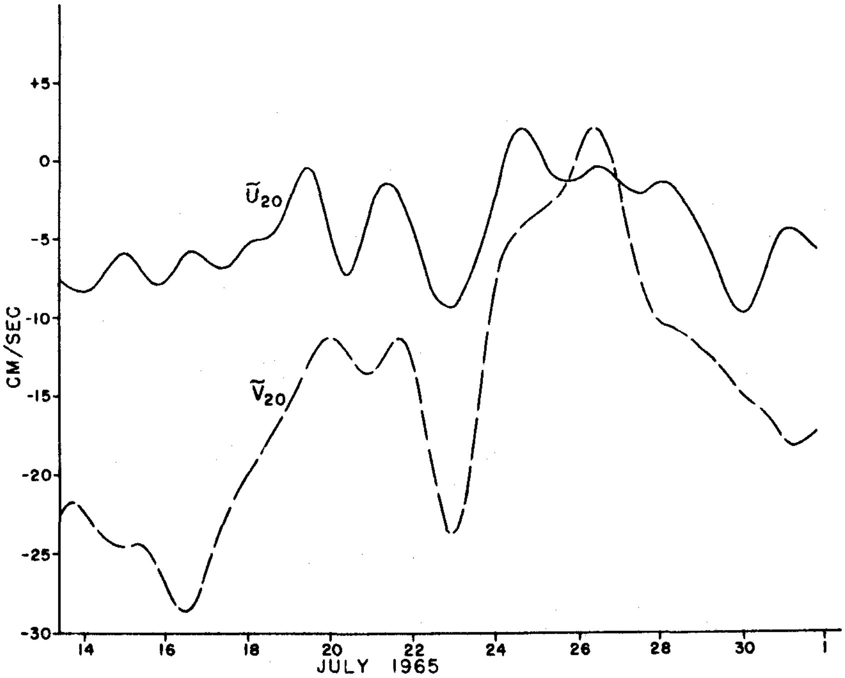

DIRECTION
JULY
60 METERS
RELATIVE FREQUENCY %
DIRECTION (DEGREES)


U
JULY
20 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC

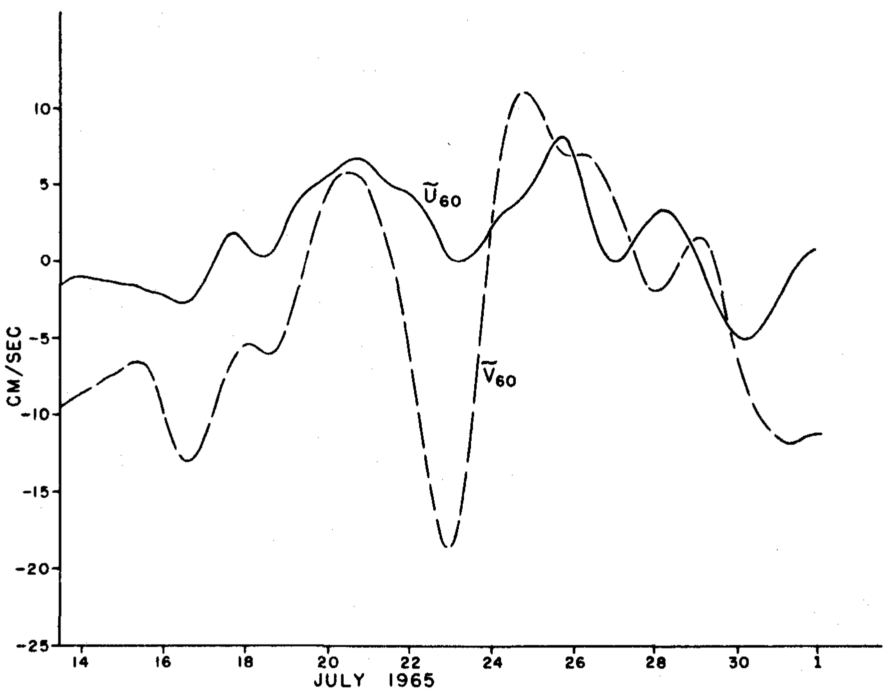

V
JULY
20 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC


U
JULY
60 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC


V
JULY
60 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC



+5
0
-5
-10
-15
-20
-25
-30
CM/SEC
$\tilde{U}_{20}$
$\tilde{V}_{20}$
14
16
18
20
22
24
26
28
30
1
JULY 1965



10
5
0
-5
-10
-15
-20
-25
CM/SEC
$\tilde{U}_{60}$
$\tilde{V}_{60}$
14
16
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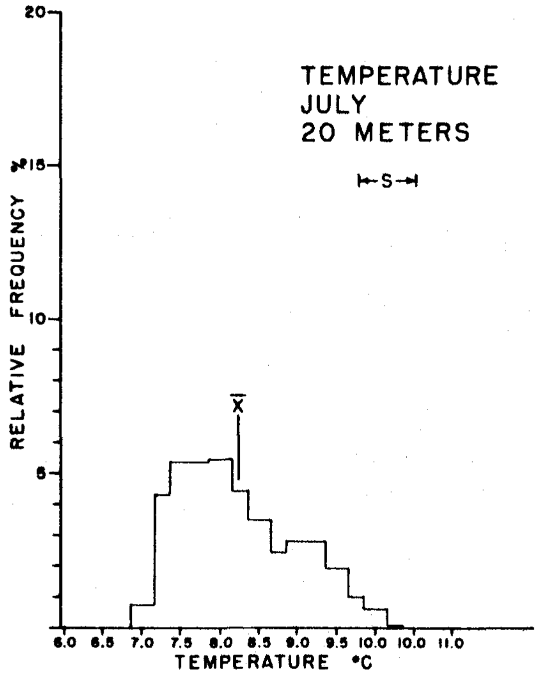
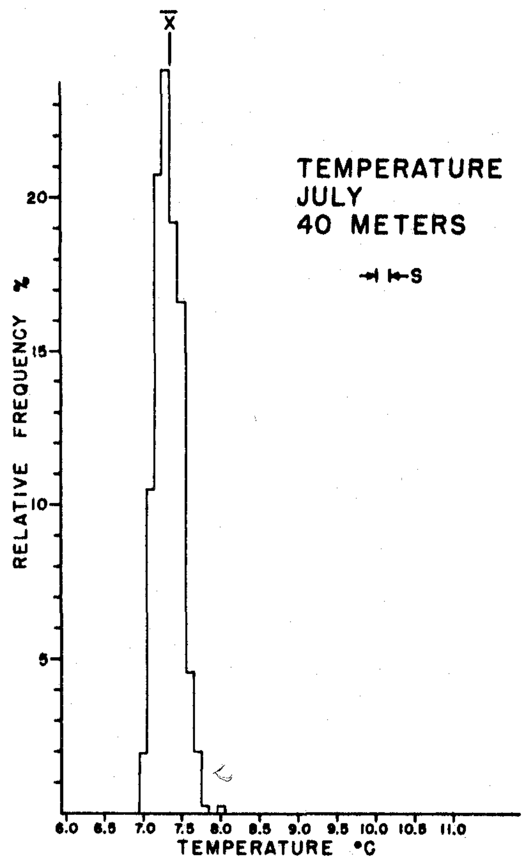
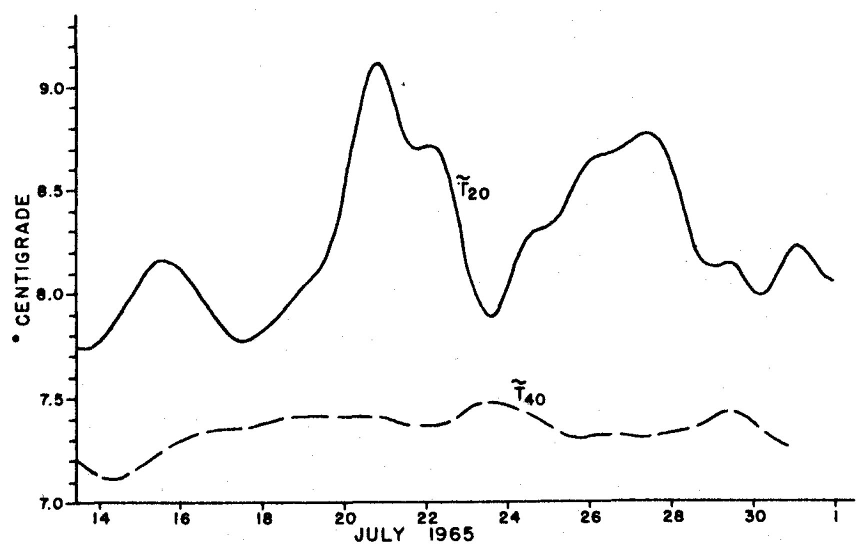
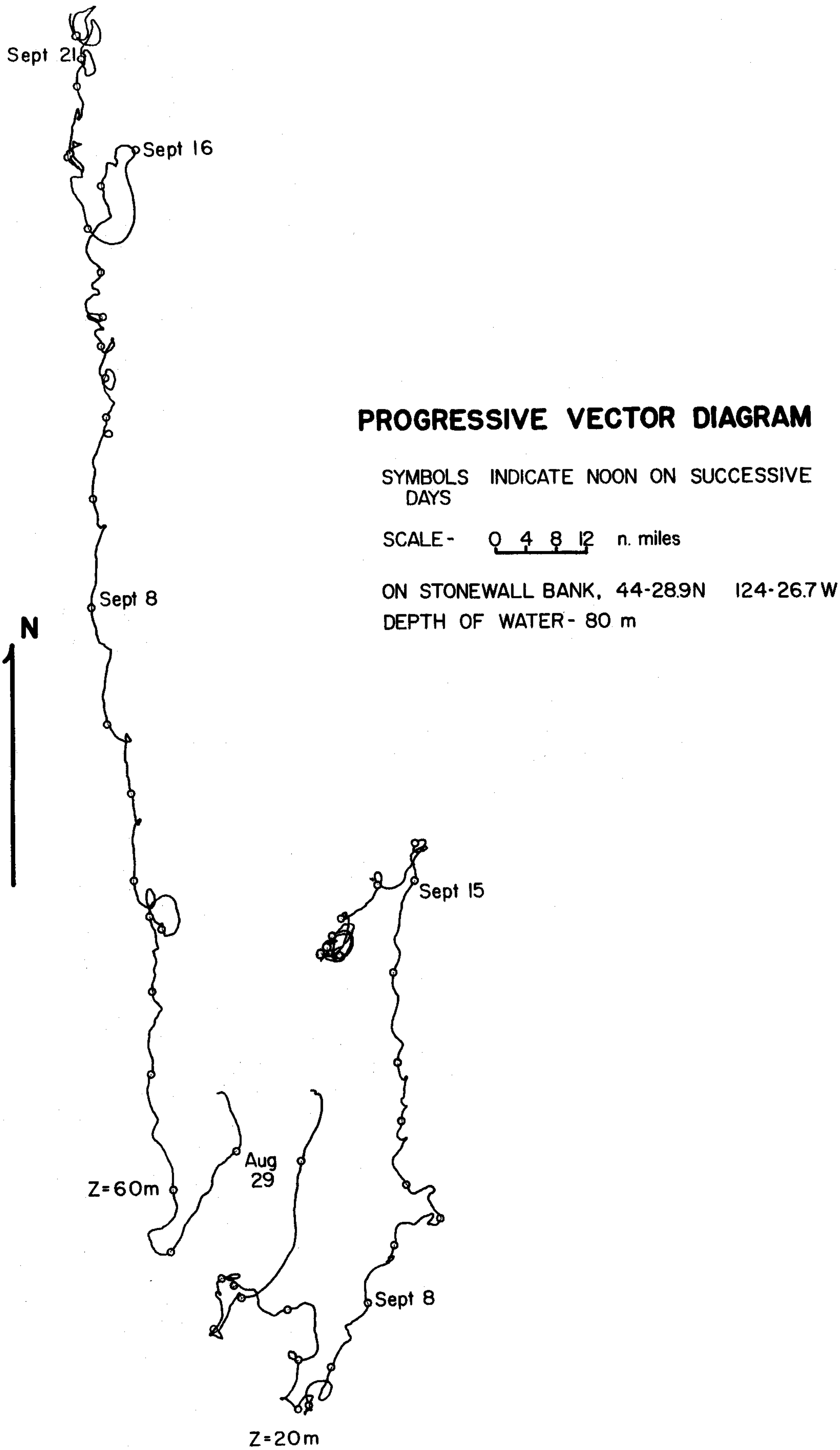
20
22
24
26
28
30
1
JULY 1965


TEMPERATURE
JULY
20 METERS
S
$\bar{X}$
RELATIVE FREQUENCY %
TEMPERATURE °C


TEMPERATURE
JULY
40 METERS
S
$\bar{X}$
RELATIVE FREQUENCY %
TEMPERATURE °C


$\tilde{T}_{20}$
$\tilde{T}_{40}$
° CENTIGRADE
JULY 1965


PROGRESSIVE VECTOR DIAGRAM
SYMBOLS INDICATE NOON ON SUCCESSIVE DAYS
SCALE - 0 4 8 12 n. miles
ON STONEWALL BANK, 44-28.9N 124-26.7W
DEPTH OF WATER - 80 m
N
Sept 21
Sept 16
Sept 8
Z=60m
Aug 29
Sept 15
Sept 8
Z=20m

SEPTEMBER INSTALLATION DETAILS

Position: 44° 28.9'N, 124° 26.7W (on Stonewall Bank)
Depth of Water: 40 fathoms
Set at 2100 PDT, 28 August, 1965, by R/V YAQUINA
Retrieved at 1515 PDT, 24 September, 1965, by R/V YAQUINA
Data Interval: 0010 PDT, 29 August - 1205 PDT, 23 September

Mooring

The main anchor was located 1.6 miles west of the drilling barge, WODECO III.

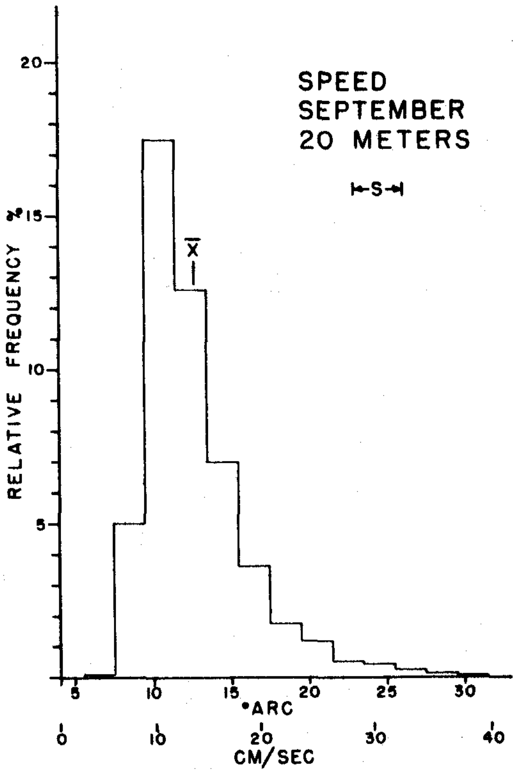
Instrumentation

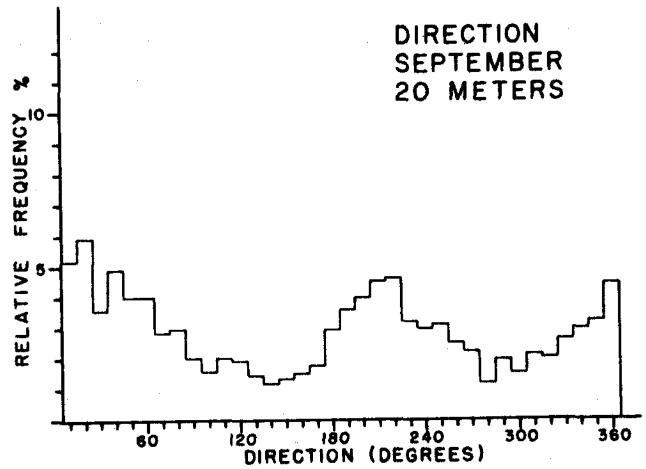
Depth	Histogram Current Meter Serial No.	Thermograph Serial No.
20m	3160049	14600087
40m	3160054	14600088
60m	3160055	

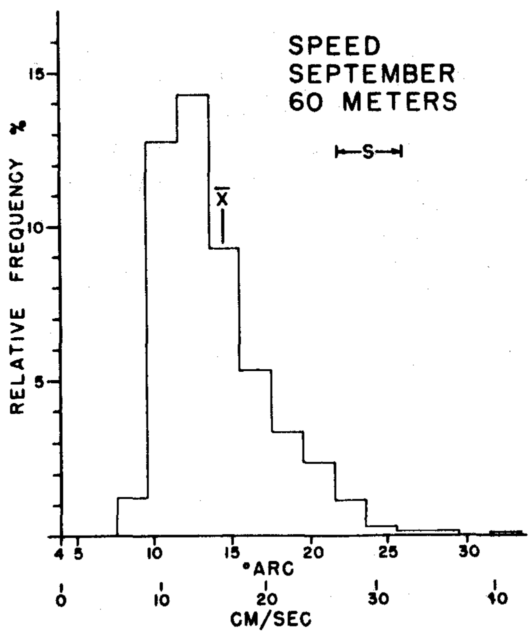
Current meters cycled every 10 minutes; thermographs cycled every five minutes.

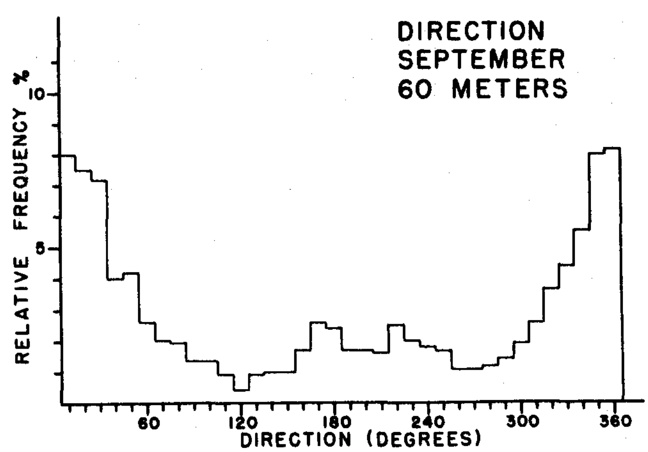
Comments on Results

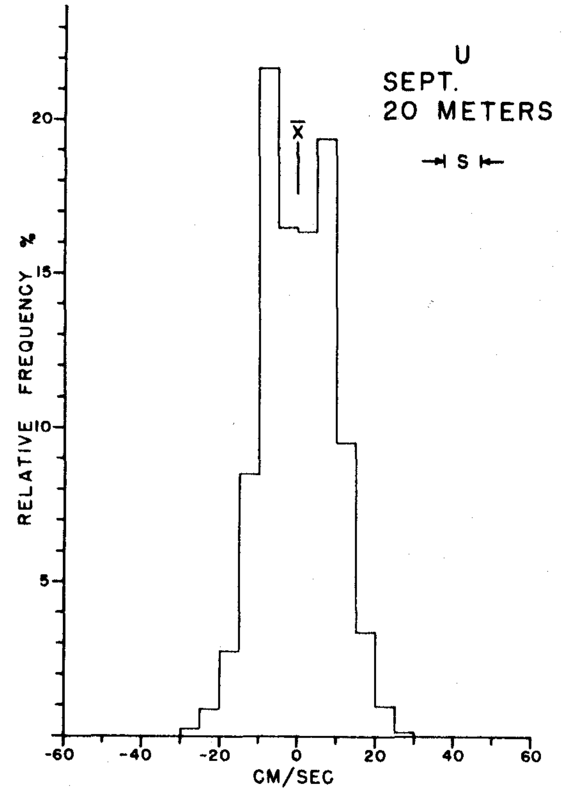
All gear was recovered. The 20m current meter ran out of film at 1420, 23 September, and the 60m current meter ran out of film at 1730, 23 September. The current meter at 40m failed to operate. The thermograph at 20m ran for the entire period. The batteries on the 40m thermograph failed at 1220, 22 September; temperature was extrapolated to the end of the data interval.

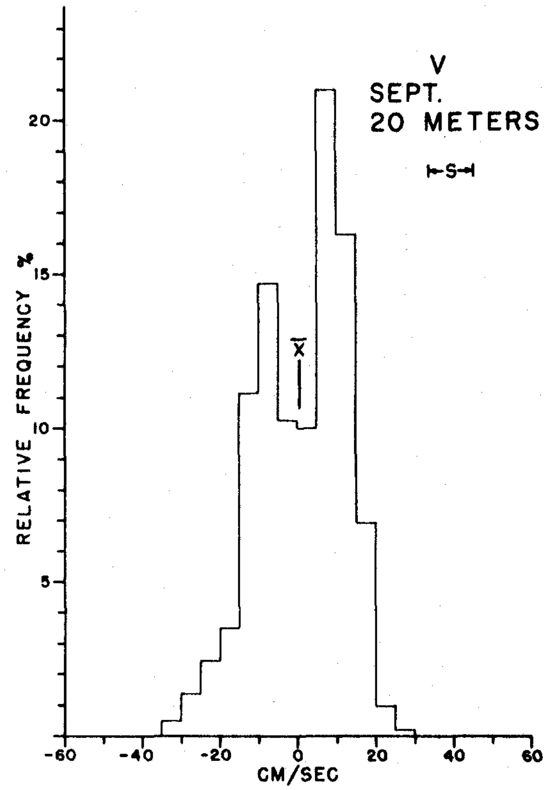

SPEED
SEPTEMBER
20 METERS
S
X̄
RELATIVE FREQUENCY %
20
15
10
5
5 10 15 20 25 30
°ARC
0 10 20 30 40
CM/SEC

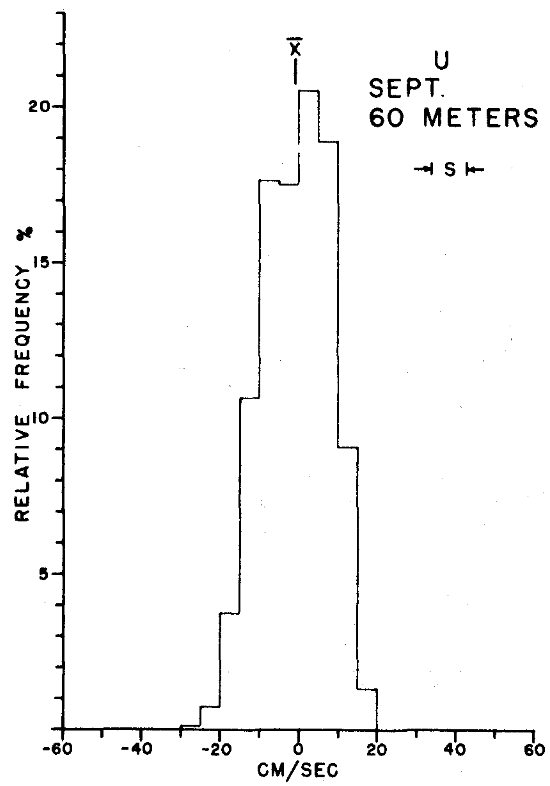

DIRECTION
SEPTEMBER
20 METERS
RELATIVE FREQUENCY %
10
5
60 120 180 240 300 360
DIRECTION (DEGREES)

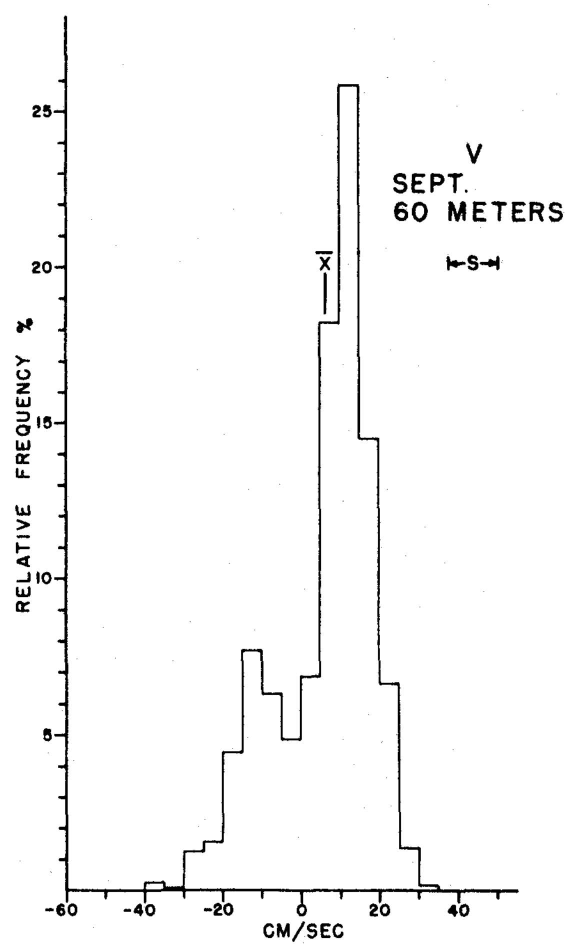

SPEED
SEPTEMBER
60 METERS
S
X̄
RELATIVE FREQUENCY %
15
10
5
4 5 10 15 20 25 30
°ARC
0 10 20 30 40
CM/SEC

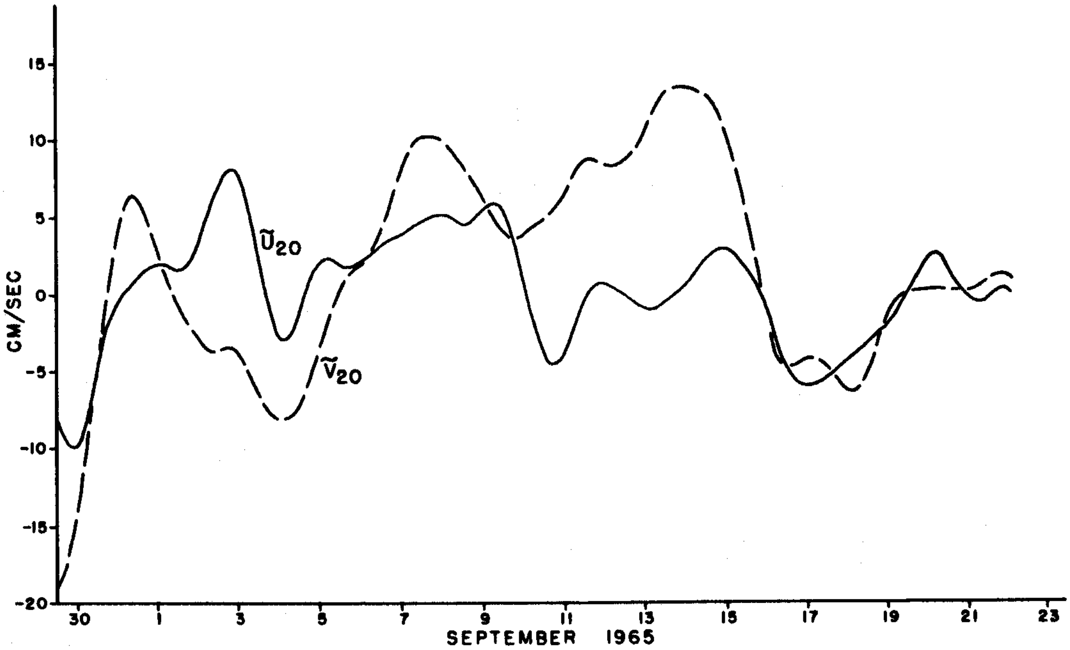

DIRECTION
SEPTEMBER
60 METERS
RELATIVE FREQUENCY %
10
5
60 120 180 240 300 360
DIRECTION (DEGREES)

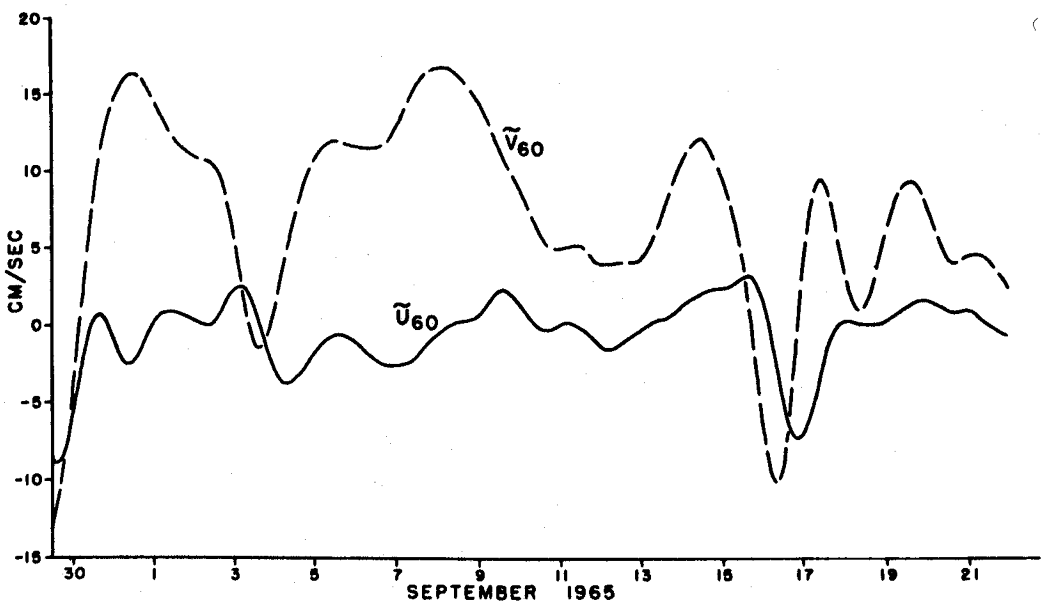

U
SEPT.
20 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
-60
-40
-20
0
20
40
60
5
10
15
20

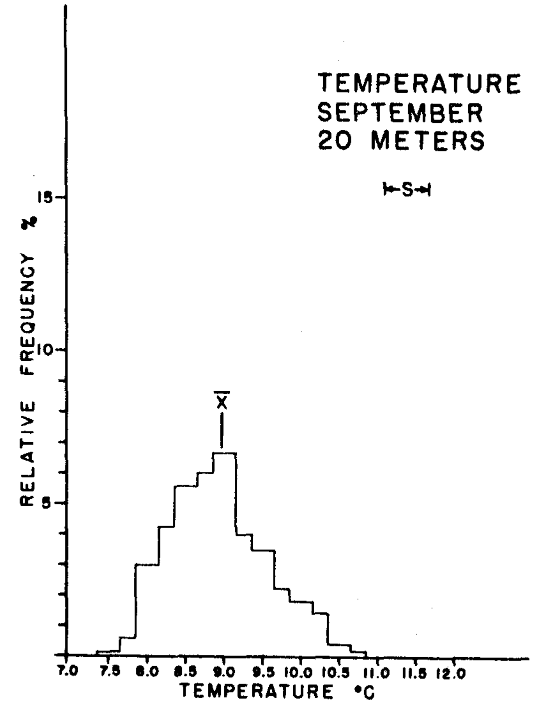

V
SEPT.
20 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
-60
-40
-20
0
20
40
60
5
10
15
20

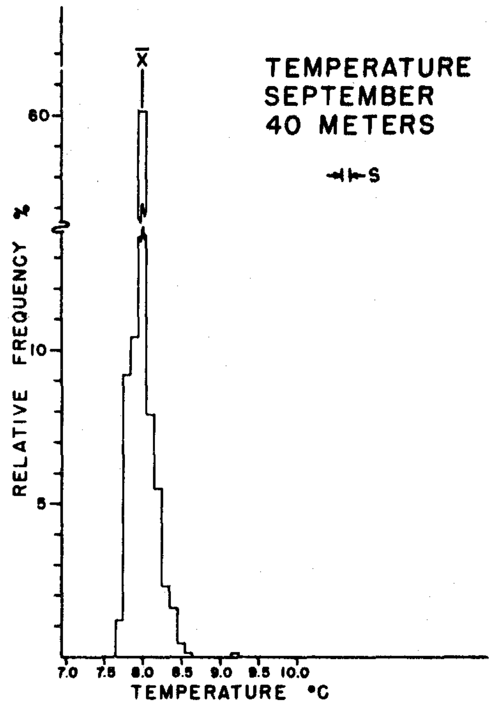

U
SEPT.
60 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
-60
-40
-20
0
20
40
60
5
10
15
20

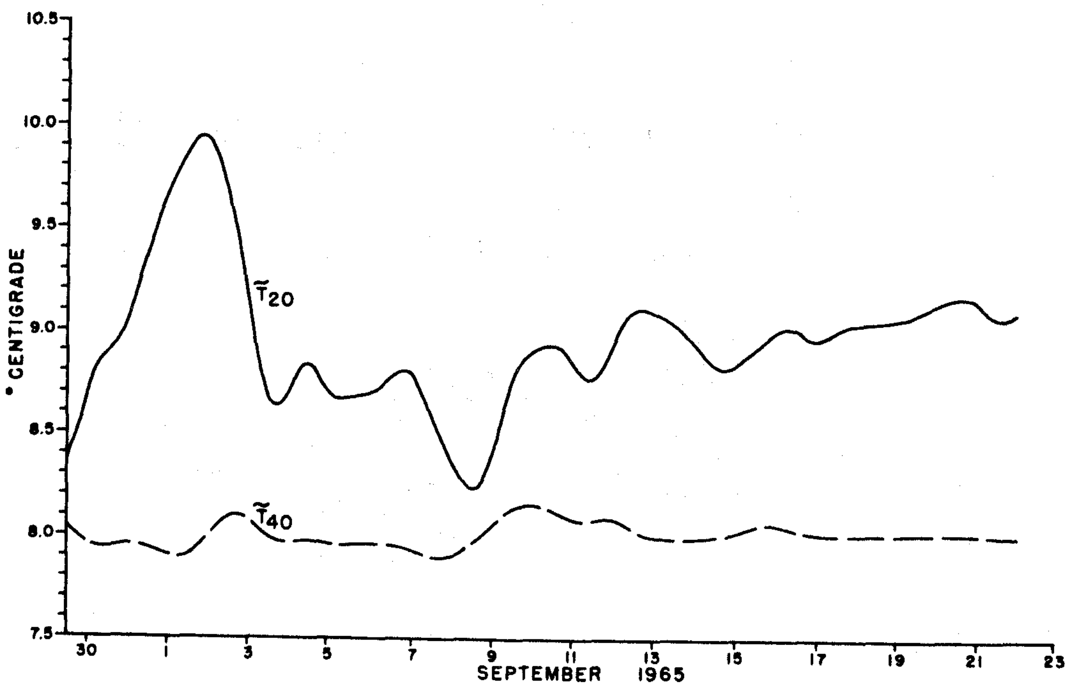

V
SEPT.
60 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
-60
-40
-20
0
20
40
5
10
15
20
25

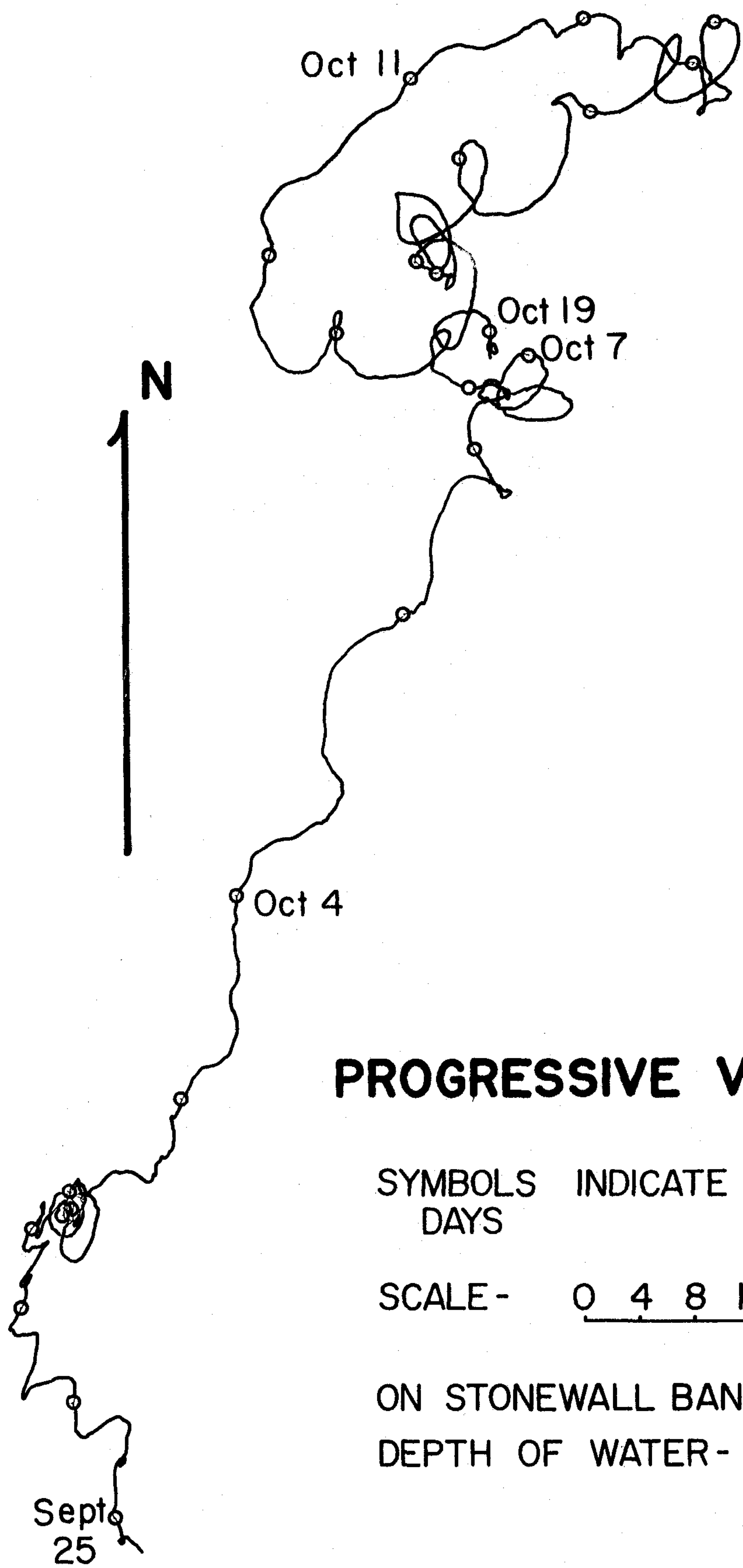

CM/SEC
15
10
5
0
-5
-10
-15
-20
30
1
3
5
7
9
11
13
15
17
19
21
23
SEPTEMBER 1965
$\tilde{U}_{20}$
$\tilde{V}_{20}$


CM/SEC
20
15
10
5
0
-5
-10
-15
30
1
3
5
7
9
11
13
15
17
19
21
SEPTEMBER 1965
$\tilde{V}_{60}$
$\tilde{U}_{60}$


TEMPERATURE
SEPTEMBER
20 METERS
S
X̄
RELATIVE FREQUENCY %
15
10
5
7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0
TEMPERATURE °C


TEMPERATURE
SEPTEMBER
40 METERS
S
X̄
RELATIVE FREQUENCY %
60
10
5
7.0 7.5 8.0 8.5 9.0 9.5 10.0
TEMPERATURE °C


10.5
10.0
9.5
9.0
8.5
8.0
7.5
° CENTIGRADE
T̃20
T̃40
30 1 3 5 7 9 11 13 15 17 19 21 23
SEPTEMBER 1965



PROGRESSIVE VECTOR DIAGRAM

SYMBOLS INDICATE NOON ON SUCCESSIVE DAYS

SCALE- 0 4 8 12 n. miles

ON STONEWALL BANK, 44-28.9N 124-26.7W

DEPTH OF WATER- 80 m

OCTOBER INSTALLATION DETAILS

Position: 44° 51.3'N, 124° 15.3'W (on Stonewall Bank)
Depth of Water: 40 fathoms
Set at 1920 PDT, 24 September, 1965, by R/V YAQUINA
Retrieved at 2010 PDT, 19 October, 1965, by R/V YAQUINA
Data Interval: 2010 PDT, 24 September - 2005 PDT, 19 October

Mooring

A 30-gallon water tank was used in place of one 42-gallon tank in the subsurface float. Since the cage was lighter, flotation remained the same. The main anchor was located 1.6 miles west of the drilling barge WODECO III.

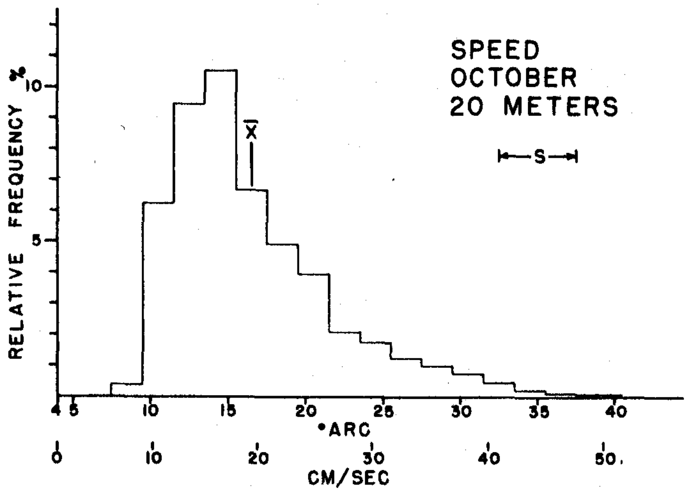
Instrumentation

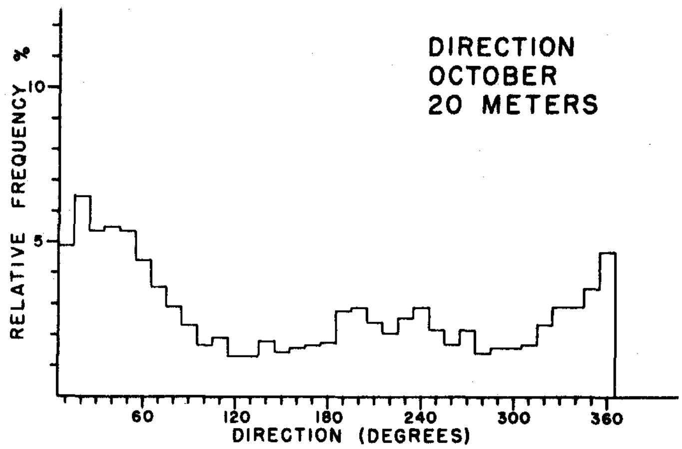
Depth	Histogram Current Meter Serial No.	Thermograph Serial No.
20m	3160049	1460087
40m	3160054	1460089

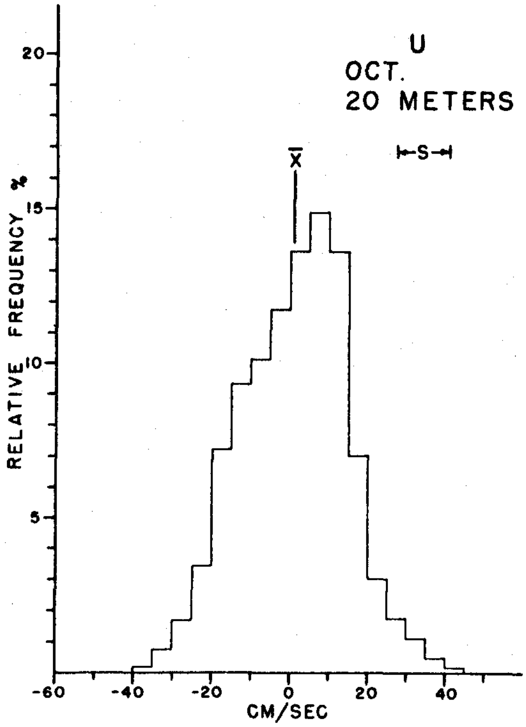
Current meters cycled every 10 minutes, thermographs cycled every five minutes.

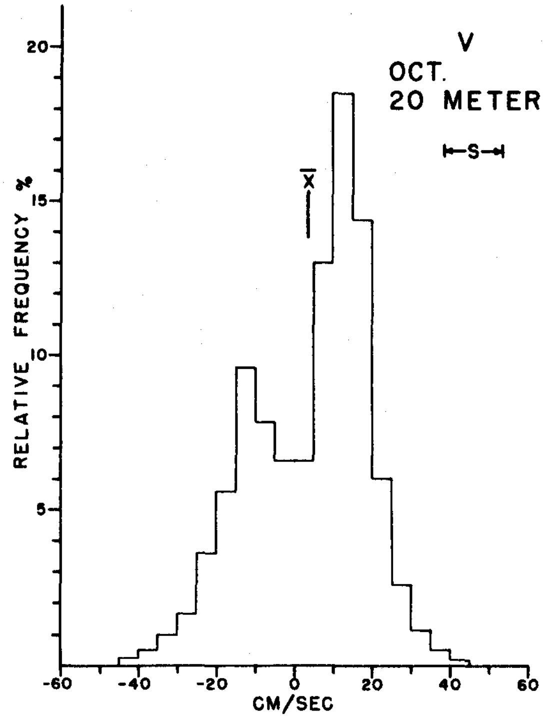
Comments on Results

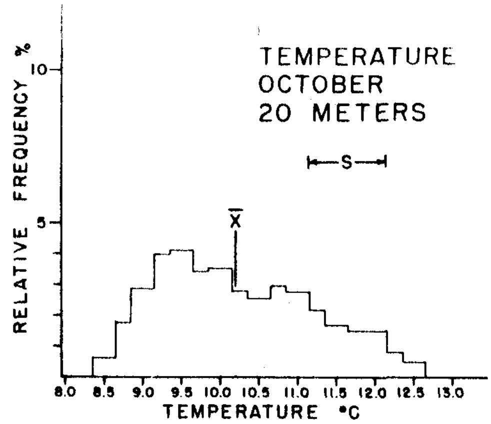
The surface float was lost and it was necessary to grapple to recover the instruments. The surface float was subsequently recovered from the beach just south of Depoe Bay. The current meter and the thermograph at 40m failed to operate. The current meter failure was the result of disengagement of the main drive sprocket and the film take-up spool. The cause of the failure of the thermograph is not known.

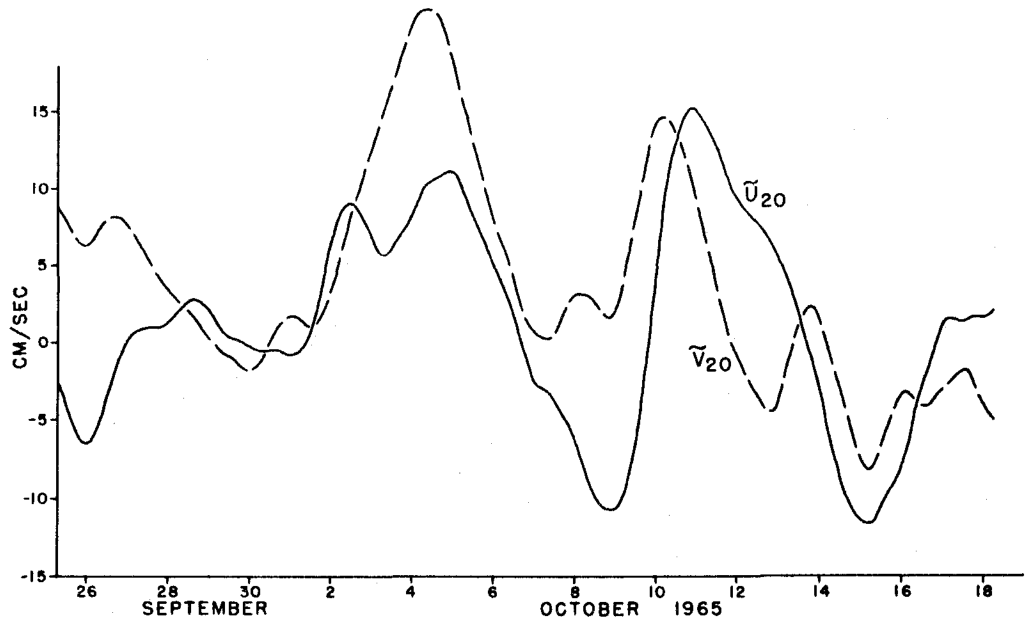

SPEED
OCTOBER
20 METERS
RELATIVE FREQUENCY %
5
10
X̄
S
4.5
10
15
20
25
30
35
40
°ARC
0
10
20
30
40
50.
CM/SEC

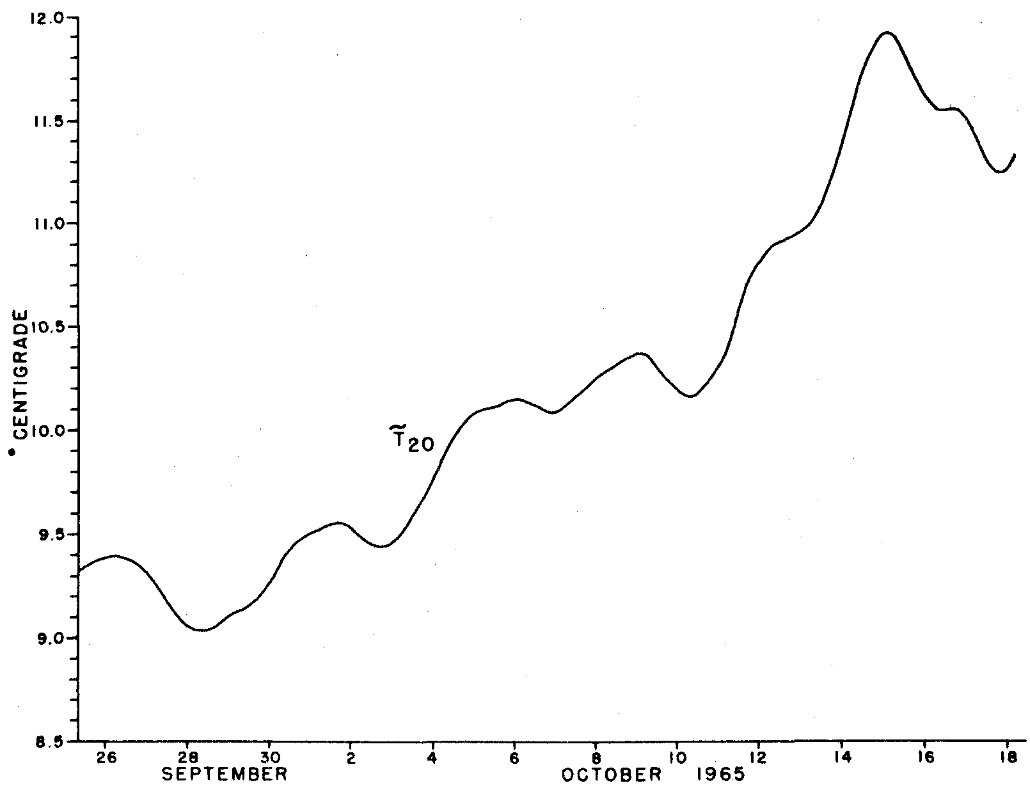

DIRECTION
OCTOBER
20 METERS
RELATIVE FREQUENCY %
5
10
60
120
180
240
300
360
DIRECTION (DEGREES)


U
OCT.
20 METERS
X̄
S
RELATIVE FREQUENCY %
5
10
15
20
-60
-40
-20
0
20
40
CM/SEC


V
OCT.
20 METERS
X̄
S
RELATIVE FREQUENCY %
5
10
15
20
-60
-40
-20
0
20
40
60
CM/SEC


TEMPERATURE
OCTOBER
20 METERS
S
X̄
RELATIVE FREQUENCY %
10
5
8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0 12.5 13.0
TEMPERATURE °C


CM/SEC
15
10
5
0
-5
-10
-15
Ũ20
Ṽ20
26 28 30 2 4 6 8 10 12 14 16 18
SEPTEMBER
OCTOBER 1965


° CENTIGRADE
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
T̃20
26 28 30 2 4 6 8 10 12 14 16 18
SEPTEMBER
OCTOBER 1965

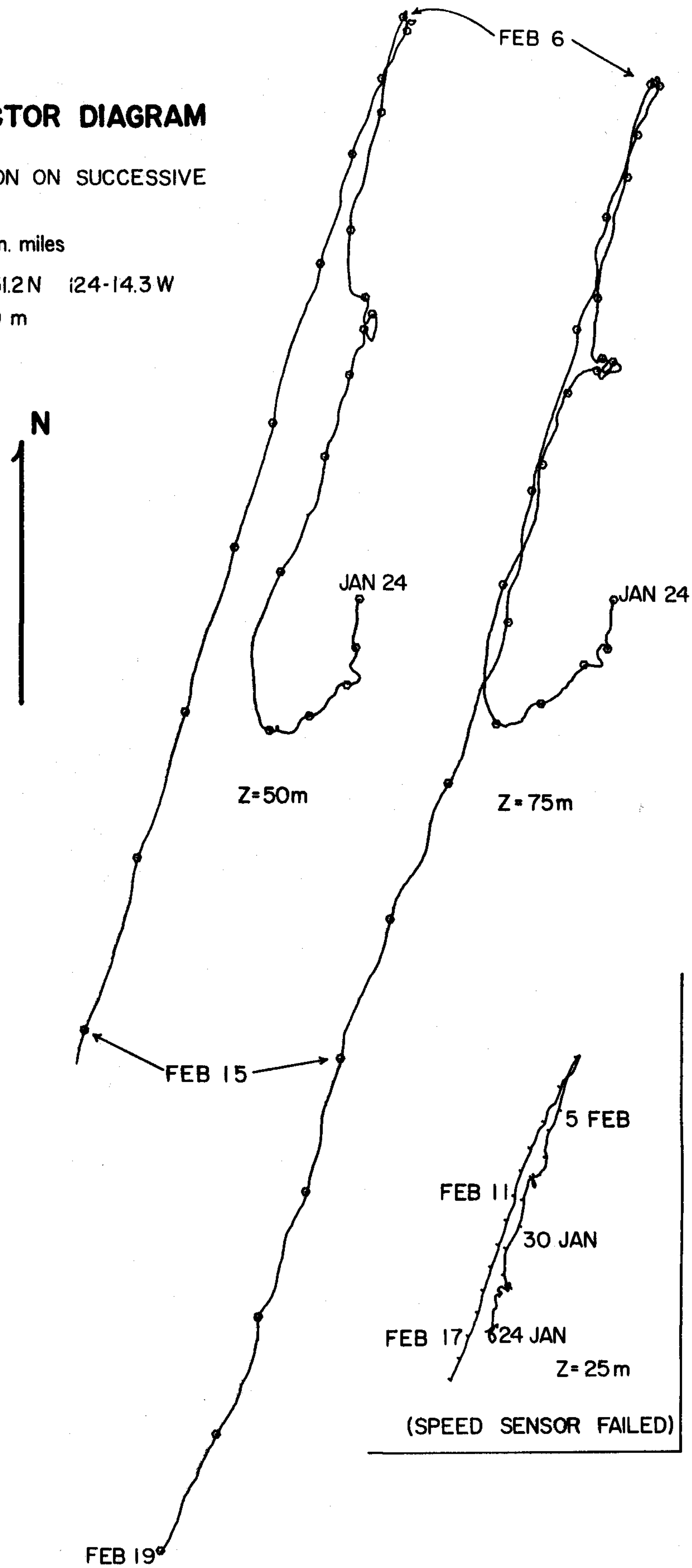
PROGRESSIVE VECTOR DIAGRAM

SYMBOLS INDICATE NOON ON SUCCESSIVE DAYS

SCALE - 0 4 8 12 n. miles

OFF DEPOE BAY, 44-51.2 N 124-14.3 W

DEPTH OF WATER - 120 m



FEBRUARY INSTALLATION DETAILS

Position: 44° 51.2'N, 124° 14.3'W (off Depoe Bay)
Depth of Water: 60 fathoms
Set at 1200 PST, 24 January, 1966, by R/V YAQUINA
Retrieved at 1245, 19 February, 1966, by R/V YAQUINA
Data Interval: 1210 PST 24 January - 1150 PST 19 February

Mooring

Three surface floats were utilized. A single PVC float (Geodyne #B-332) was attached to the subsurface floats with 1/8" galvanized pre-formed wire rope. A secondary surface float consisting of two PVC floats (Geodyne #B-322) was placed midway between the main surface float and the instrument array. The main surface float consisted of a plastic garbage can filled with marine styrofoam. Diesel filled floats were not used. The subsurface float was placed at a depth of 20m. There was no drilling barge in the vicinity.

Instrumentation

Depth	Histogram Current Meter Serial No.	Thermograph Serial No.
25m	3160049	14600087
50m	3160054	14600088
75m	3160055	

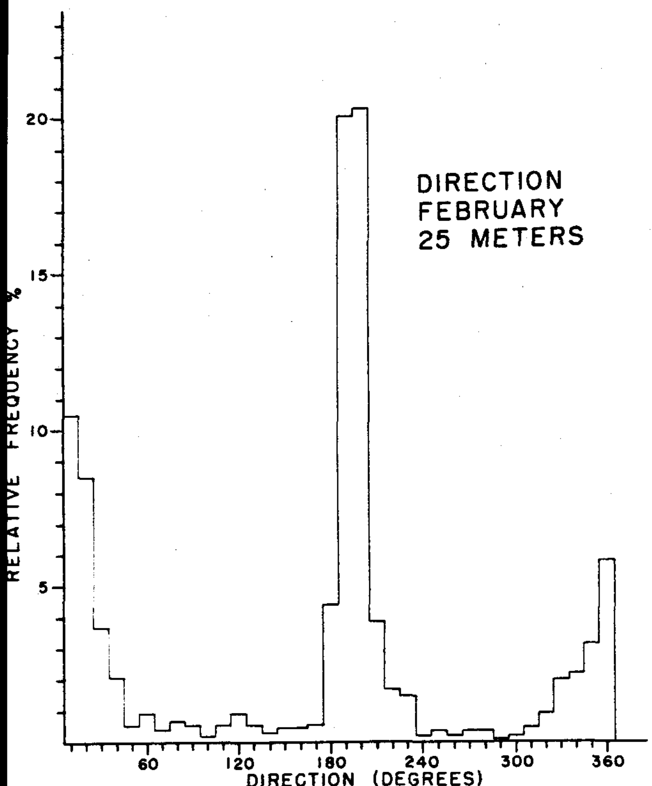
Thermograph #14600089 was placed 28m below the main surface float; the auxillary anchor was 640m north of the main anchor. Current meters cycled every 20 minutes, and thermographs cycled every five minutes.

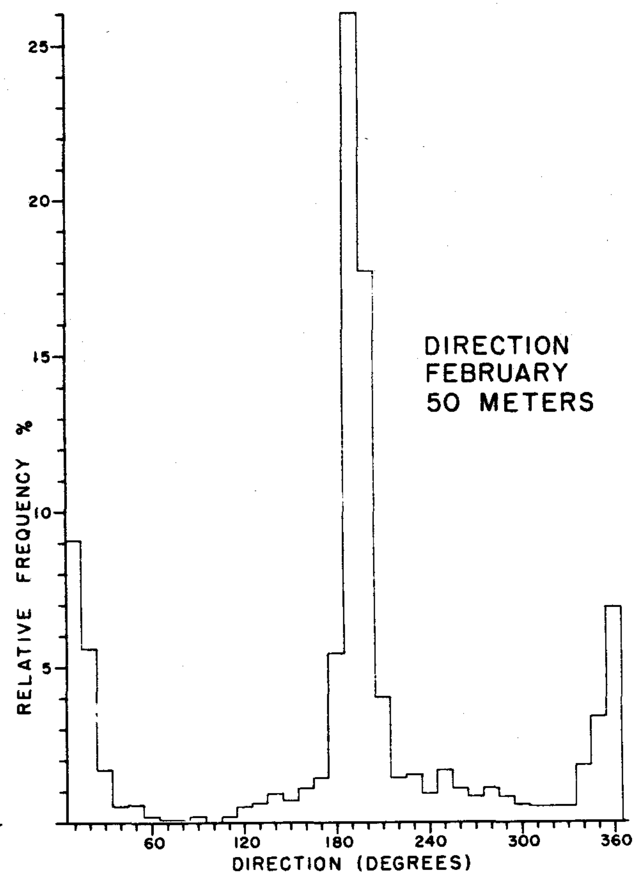
Comments on Results

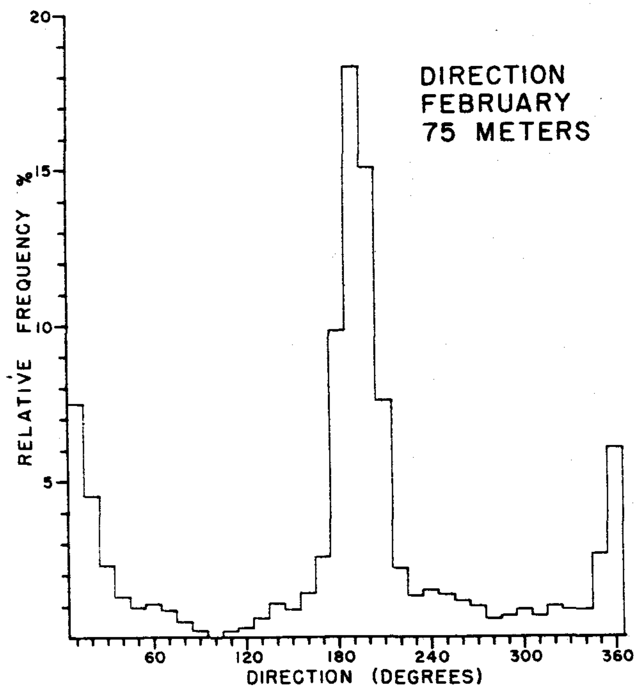
All instruments were recovered. The main surface float sank and recovery was accomplished via the secondary surface float. The surface float over the main instrument string was lost.

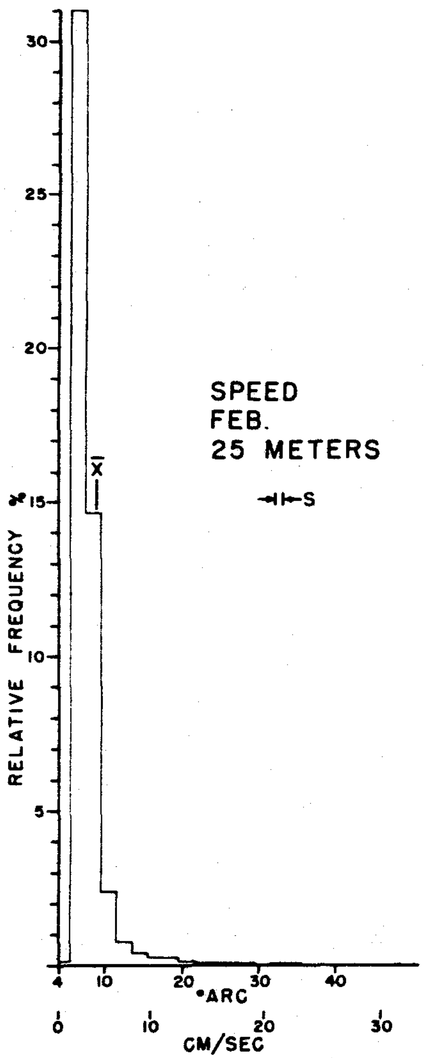
All instruments ran. The batteries in the thermograph beneath the surface float failed at 1810 PST, 16 February. The batteries in the 50m thermograph failed at 1100 PST, 18 February. The rotor on the 25m current meter did not function properly. The rotor on the 50m current meter appeared to jam at 1720 PST, 15 February. On recovery, the direction vane was missing from the 75m current meter.

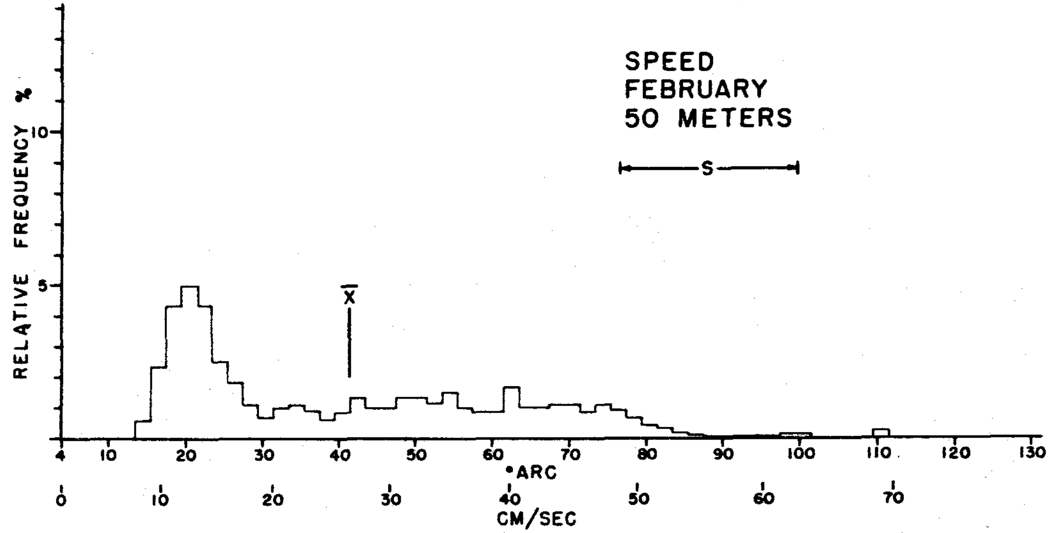
Current meter film was read by Braincon Corporation. The results were poor. Errors appeared in 3.5% of the results (vs. 0.5% in film which was read by students). Instrument tilt was not read properly. Braincon read tilts were multiplied by two before being used in our processing program. In addition, Braincon Corporation used a slightly different convention to read current direction. They read current direction as the center of the direction arc.

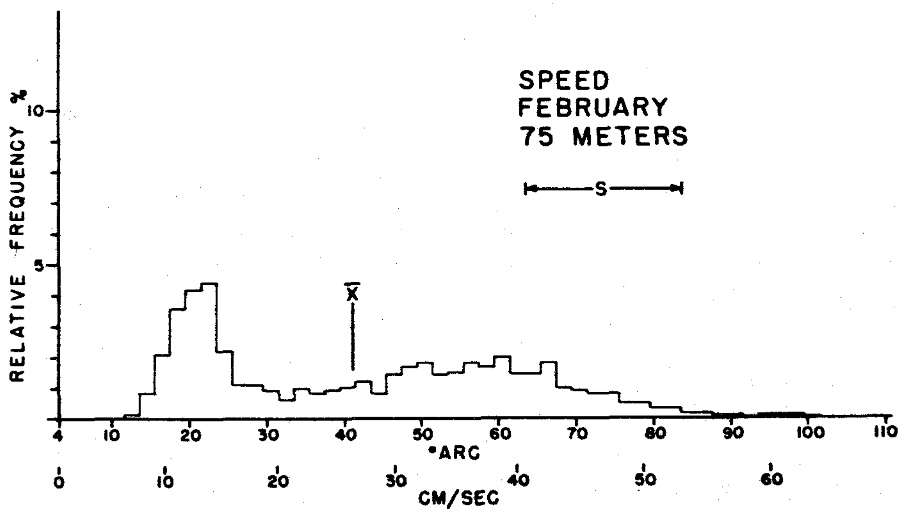

DIRECTION
FEBRUARY
25 METERS
RELATIVE FREQUENCY %
DIRECTION (DEGREES)
5
10
15
20
60
120
180
240
300
360

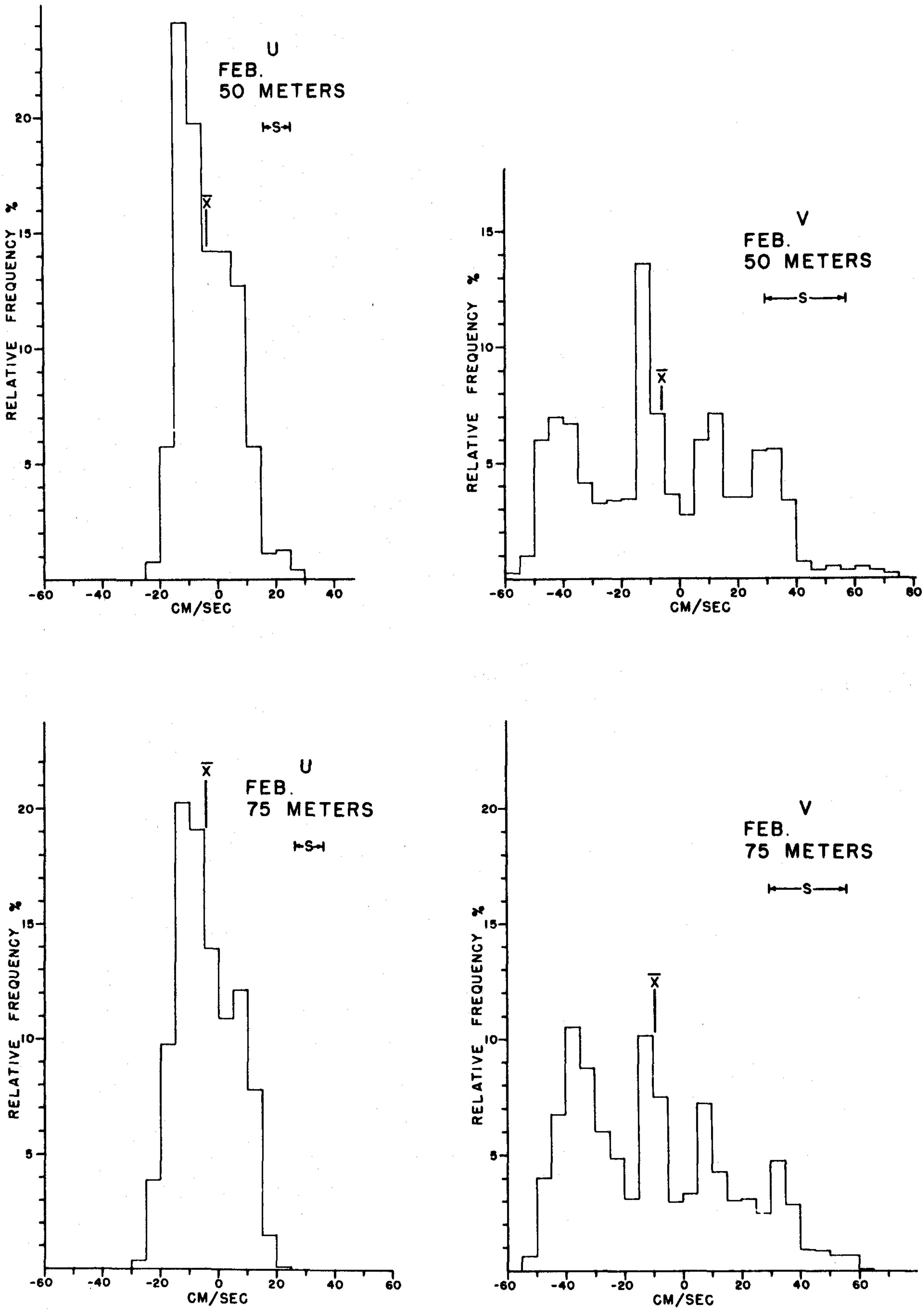

DIRECTION
FEBRUARY
50 METERS
RELATIVE FREQUENCY %
DIRECTION (DEGREES)
5
10
15
20
25
60
120
180
240
300
360

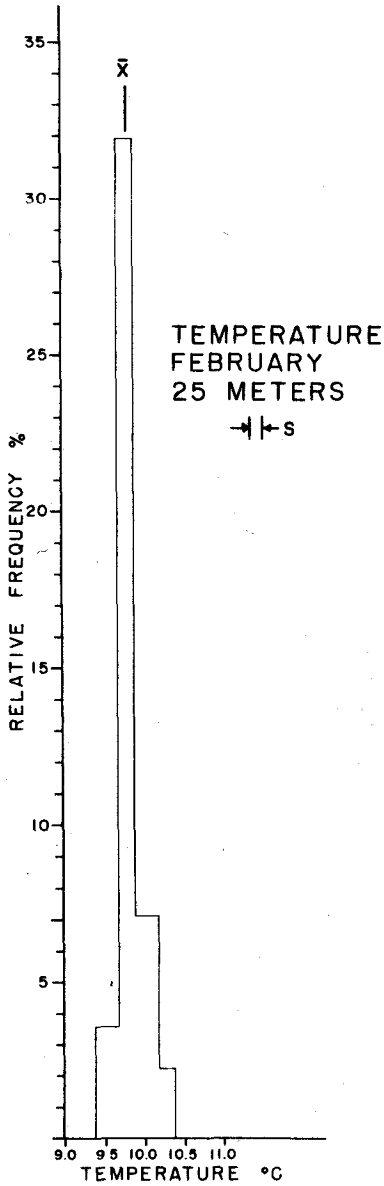

DIRECTION
FEBRUARY
75 METERS
RELATIVE FREQUENCY %
DIRECTION (DEGREES)
5
10
15
20
60
120
180
240
300
360

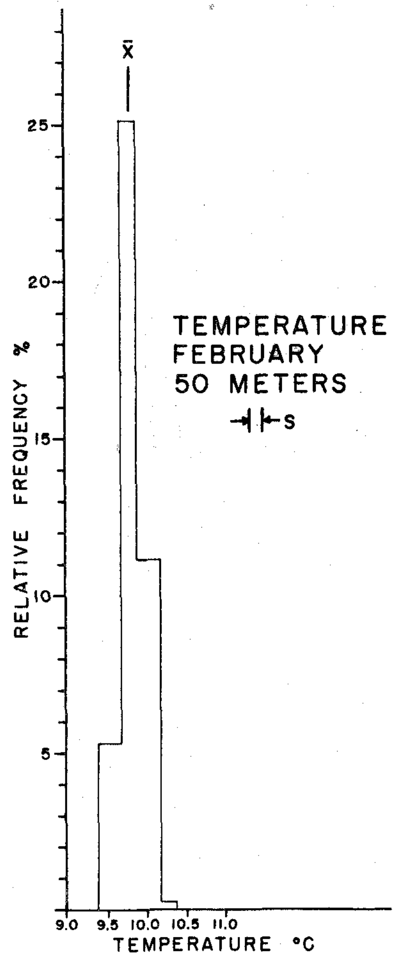

SPEED
FEB.
25 METERS
S
RELATIVE FREQUENCY %
5
10
15
20
25
30
4
10
20
30
40
•ARC
0
10
20
30
CM/SEC

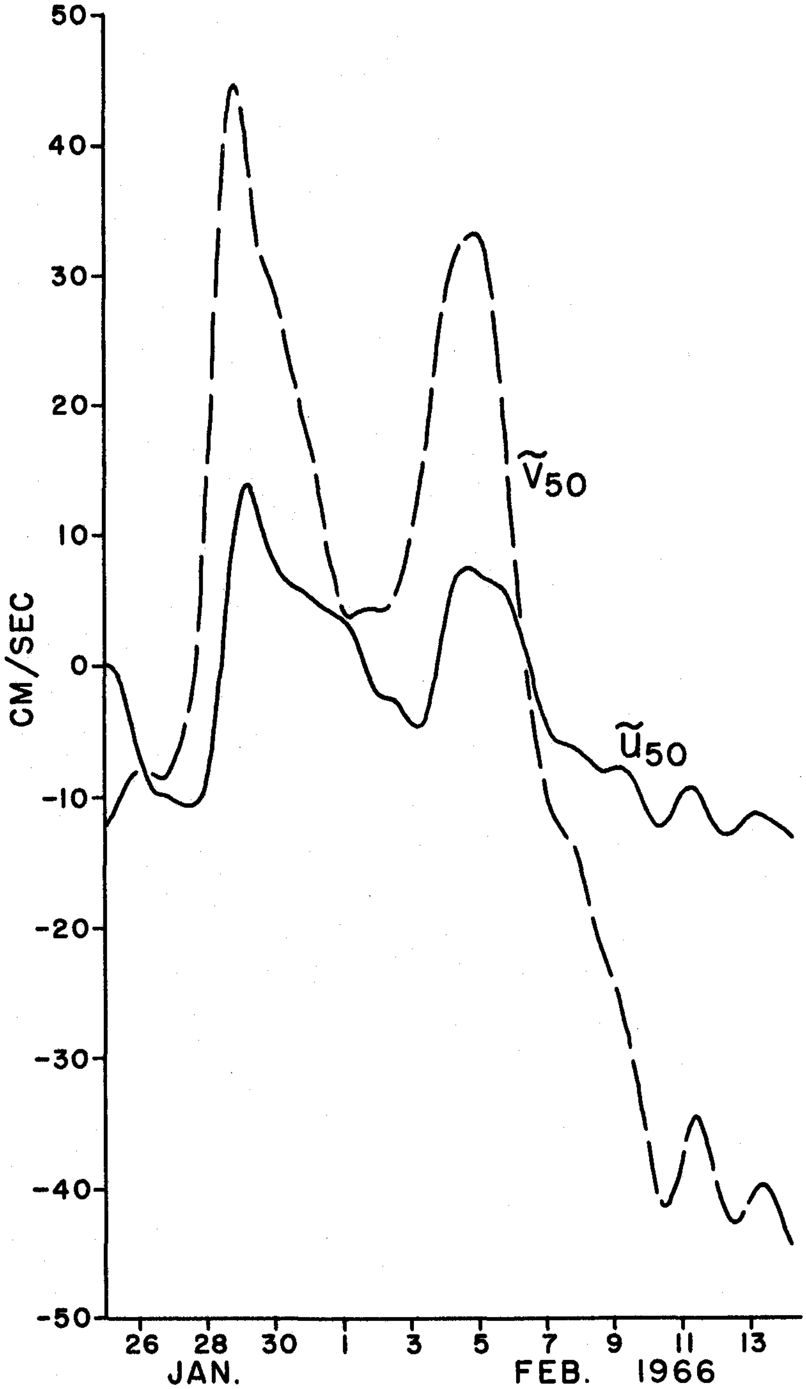

SPEED
FEBRUARY
50 METERS
S
RELATIVE FREQUENCY %
5
10
4
10
20
30
40
50
60
70
80
90
100
110
120
130
•ARC
0
10
20
30
40
50
60
70
CM/SEC


SPEED
FEBRUARY
75 METERS
S
RELATIVE FREQUENCY %
5
10
4
10
20
30
40
50
60
70
80
90
100
110
•ARC
0
10
20
30
40
50
60
CM/SEC

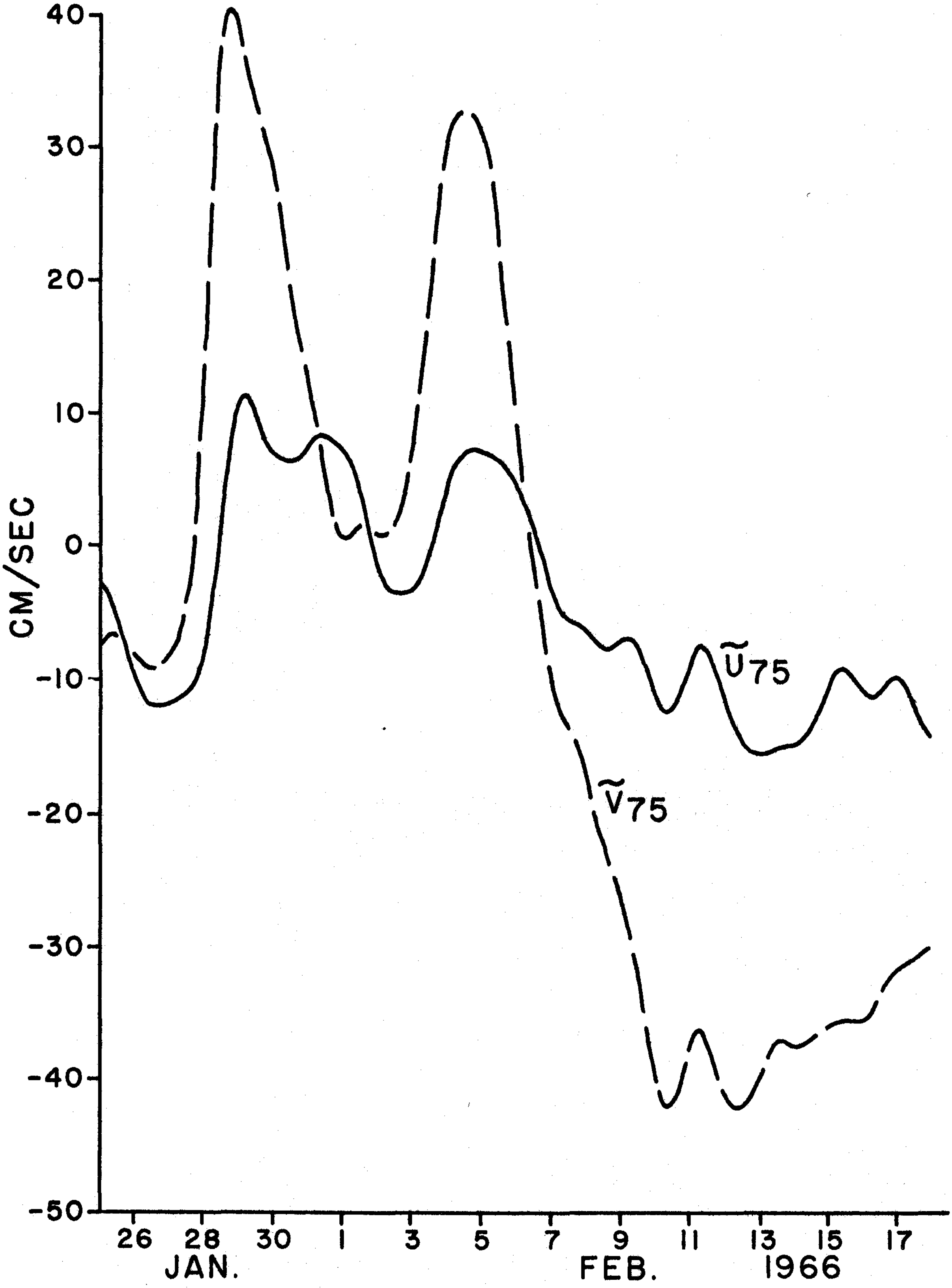

U
FEB.
50 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
V
FEB.
50 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
U
FEB.
75 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC
V
FEB.
75 METERS
S
X̄
RELATIVE FREQUENCY %
CM/SEC


35
30
25
20
15
10
5
X̄
RELATIVE FREQUENCY %
TEMPERATURE
FEBRUARY
25 METERS
s
9.0 9.5 10.0 10.5 11.0
TEMPERATURE °C

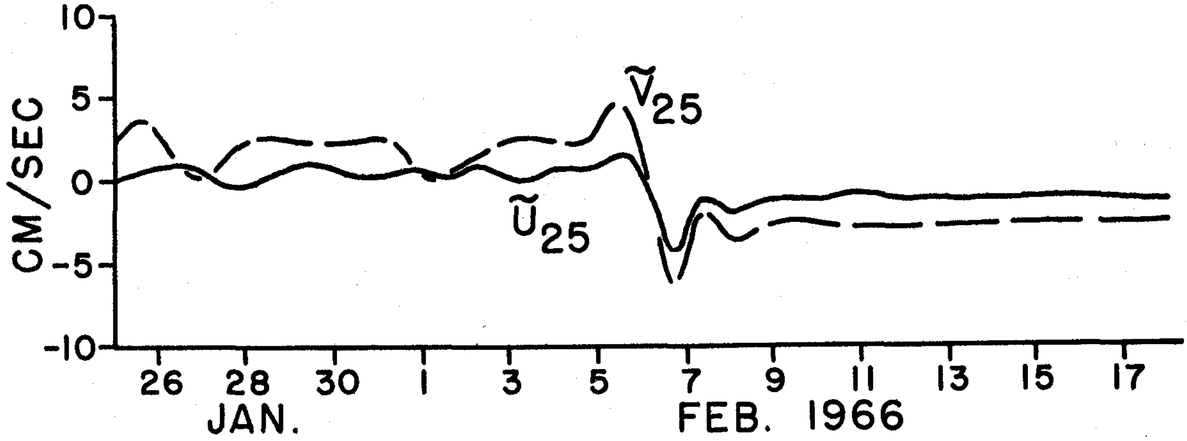

25
20
15
10
5
X̄
RELATIVE FREQUENCY %
TEMPERATURE
FEBRUARY
50 METERS
s
9.0 9.5 10.0 10.5 11.0
TEMPERATURE °C



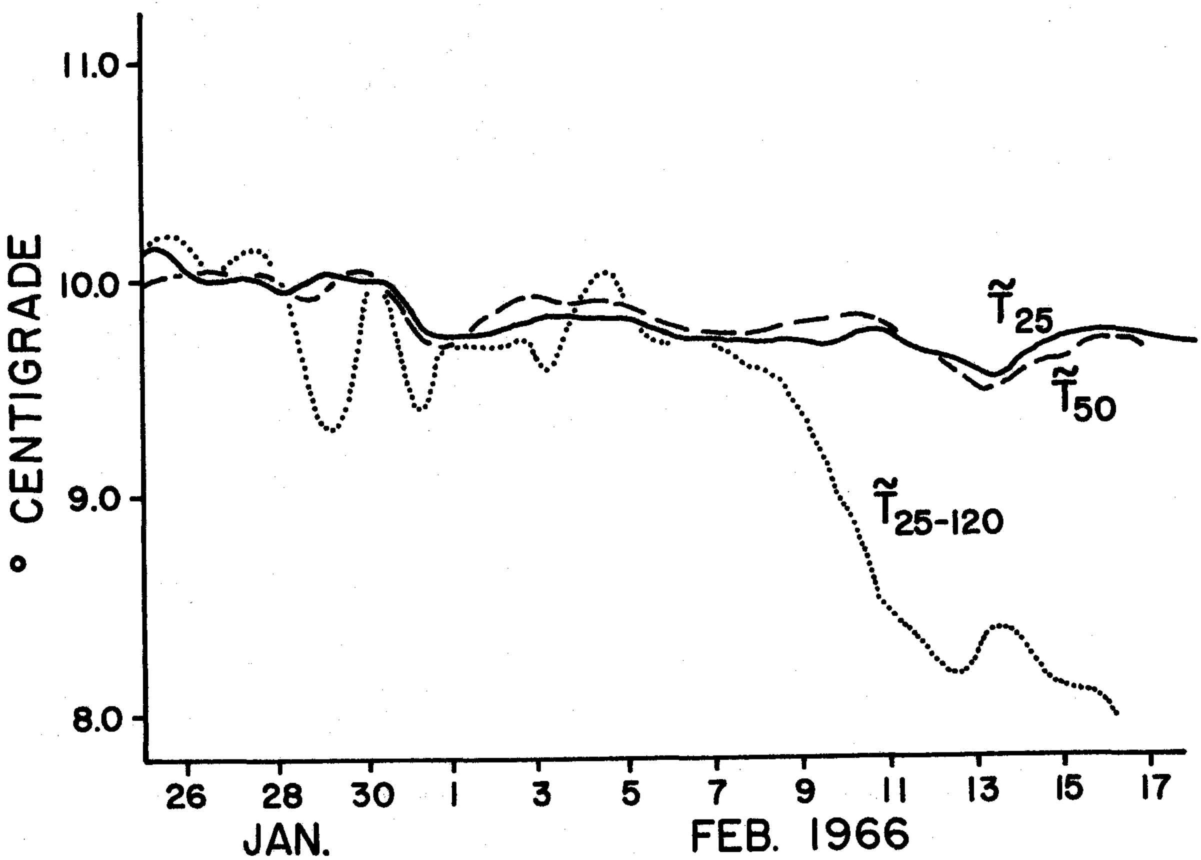
50
40
30
20
10
0
-10
-20
-30
-40
-50
CM/SEC
$\tilde{v}_{50}$
$\tilde{u}_{50}$
26
28
30
1
3
5
7
9
11
13
JAN.
FEB. 1966



40
30
20
10
0
-10
-20
-30
-40
-50
CM/SEC
$\tilde{U}_{75}$
$\tilde{V}_{75}$
26
28
30
1
3
5
7
9
11
13
15
17
JAN.
FEB.
1966



10
5
0
-5
-10
CM/SEC
$\tilde{V}_{25}$
$\tilde{U}_{25}$
26
28
30
1
3
5
7
9
11
13
15
17
JAN.
FEB. 1966



11.0
10.0
9.0
8.0
° CENTIGRADE
$\tilde{T}_{25}$
$\tilde{T}_{50}$
$\tilde{T}_{25-120}$
26
28
30
1
3
5
7
9
11
13
15
17
JAN.
FEB. 1966

APPENDIX I

Film Reading Notes: Current Meters

1. Relative time is placed on each film; 0 hours is assigned by viewing the beginnings of all films and consultation of log entries.

   a) Cranking times on current meters occur simultaneously due to alignment of cams prior to battery insertion.

   b) At noon and midnight, relative day and relative hour are both written on the film, in the following manner:

   3/12 - 3rd day, 12th hours

2. When projected, the following marks may be distinguished:

case number	direction arc
case mark	tilt indicator
speed arc	compass center mark

   Usually the tilt indicator and the compass center mark coincide.

   a) When the film is properly projected, the case number is at the top of the screen and is readable, i. e., right side up and not backwards.

   b) The film is being properly fed through the projector when the speed arc moves clockwise in each successive frame.

   c) Direction should be read counterclockwise from the case mark (which is at the bottom of the screen), 001° - 360°.

3. An overlay is constructed for use in reading the film.

   a) Acetate and acetate ink have proved satisfactory for this purpose.

   b) A template is first constructed by placing tracing paper on the screen, running some of the film through the projector, and tracing paths of the speed and directional arcs, as well as the location of the case number, case mark, and compass center mark.

   c) Circles of constant tilt magnitude are constructed as per Braincon drawing #316047.

4. The following quantities are then read from the film.

   a) Relative time - hour and/day marks are recorded. The relationship between relative time and real time should be constant, and often checks must be made to assure that it is constant. When the real-relative time relationship changes, through an error on the part of the film numberer, this must be noted and recorded.

b) Tilt magnitude - tilt magnitude is read from the compass center mark to the center of the tilt indicator to the nearest degree; it is always recorded as two figures, i. e., 3° of tilt is recorded as 03. It is often quite difficult to estimate; it will help the reader to view a series of tilt angles before attempting to assign a value to the initial tilt angle.

c) Tilt direction - tilt direction is formed by passing an imaginary line through the compass center mark and the center of the tilt indicator and reading the intersection of this line with the direction scale. As this is very difficult to do accurately, tilt direction is read only to the nearest ten degrees, and hence recorded as two figures: 330° would be recorded as 33, 70° would be recorded as 07 (never as 7).

d) Direction - indicated by the DARKEST part of the direction arc; if there are two dark portions which are separated, use the one which is most representative. Direction is always recorded as three figures: 73° would be recorded as 073.

e) Excursion of direction vane - this is indicated by recording two quantities:

1. most counterclockwise position reached by directional vane relative to center of direction arc,

2. most clockwise position reached by directional vane relative to center of direction arc .

Always record these quantities in the same order -- counter-clockwise and then the clockwise excursion value; always use three digits for each of these values (6° is recorded as 006); any excursion of the directional vane should be included within this arc; thus the value read should divide the clear portion of the arc from the grey portion of the arc; if the arc is separated, use your judgment in deciding which way the vane moved.

f) Speed - record the angle subtended by the speed arc in degrees. Two figures should always be used; 8° of speed arc would be recorded as 08.

5. Keep track of your film reading time in the log provided at the beginning of the data book.

Film Reading Notes: Thermographs

1. Film Numbering - Marks are inked on the film as an aid in film reading.

a) Relative Time Marks are used to index the frames on the film and are placed 1 to 3 lines below the shadow. A vertical dash is placed at hour and half-hour frames, and a dot is placed at 15 and 45 minute frames. The hour value was indicated every hour and the day every sixth hour.

b) The thermometer image is labeled with temperature values at three hour intervals.

2. Film Reading

a) Projection and recording.- The film is projected onto a template graduated in 0.1° C intervals. The template has lines at X.0°C colored red and those at X.5°C colored blue. The thermometer image recorded on the film has a mark every X.0°C. The reader must align the template with the projected image marks. Temperatures are recorded on sheets on which time has been listed. Optimum film reading rates were achieved when two persons worked together: a film reader and a recorder. The reader read both temperature and relative time from the film. The recorder recorded both temperature and relative time alongside listed time. The recorder was also responsible for maintaining a constant check on the read time -- listed time relationship so that no readings were omitted.

b) Value of temperature - As the boundary of the mercury image was hazy, it was necessary to make a decision as to which shade of grey to choose. We read a light grey; this corresponded to the lowest temperature recorded during the five minute cycle. Film was read to the nearest 0.1°C.

APPENDIX II DATA PROCESSING PROGRAM

```
C-----PROCESSING CURRENT SPEED AND DIRECTION FOR 20 MINUTE CYCLE
  100 FORMAT(F2.0,F3.0,F3.0,2F4.0,F3.0)
  101 FORMAT(13X,3F6.1,6F5.0,I5)
  102 FORMAT(13X,3F6.1,6F5.0,I5)
  103 FORMAT(61H1                        VEL      U      V  DIR  VAR  LESS GRT  TILT DIR)
  106 FORMAT(1H1)
      WRITE(3,103)
C-----DATA INPUT
      N=0
    1 READ(1,100)TIMAG,TDIRE,DIRE,DIRGR,DIRLS,S
      IF(S.EQ.0.)GO TO 2
      N=N+1
C-----COMPUTING SPEED
      S =5.14*(10.**(.39671*ALOG((S -4.)/6.)-.01173))
C-----CORRECTING SPEED FOR INSTRUMENT TILT
      IF(TIMAG.EQ.0.)GO TO 3
      DIFF=ABS(DIRE-TDIRE)
      IF(DIFF.GT.90.)DIFF=360.-DIFF
      S=COS(DIFF*.01745)*.006*TIMAG*S +S
C-----CONVERTING MAGNETIC DIRECTIONS TO TRUE
    3 DIRE=DIRE+21.
      DIRLS=DIRLS+21.
      DIRGR=DIRGR+21.
      TDIRE=TDIRE+20.
      IF(DIRE .GT.360.)DIRE =DIRE -360.
      IF(DIRGR.GT.360.)DIRGR=DIRGR-360.
      IF(DIRLS.GT.360.)DIRLS=DIRLS-360.
      IF(TDIRE.GT.360.)TDIRE=TDIRE-360.
      IF(TIMAG.EQ.0.)TDIRE=0.
C-----COMPUTING DIRECTION VARIABILITY
      VARB=DIRGR-DIRLS-4.
      IF(VARB.LT.0.)VARB=360.+VARB
C-----RESOLVING CURRENT VELOCITY INTO NORTH-SOUTH AND EAST-WEST COMPONENTS
      R=(450.-DIRE)*.01745
      U=S*COS(R)
      V=S*SIN(R)
C-----OUTPUT
      WRITE(2,101)S,U,V,DIRE,VARB,DIRLS,DIRGR,TIMAG,TDIRE,N
      CALL PAGEND(J)
      IF(J.EQ.2)WRITE(3,103)
      WRITE(3,102)S,U,V,DIRE,VARB,DIRLS,DIRGR,TIMAG,TDIRE,N
      GO TO 1
    2 STOP
      END
```

APPENDIX III

FREQUENCY RESPONSE OF COSINE FILTER

The response, R, for a cosine filter with 2m + 1 weights is given by

$$R(f) = \frac{1}{2m+1} \sum_{K=-m}^{m} \left(1+\cos\left(\frac{2\pi K}{2m+1}\right)\right)\cdot\left(\cos(2\pi fK)\right)$$

where frequency, f, is cycles per data interval. To remove tidal and inertial effects, we set

$$\frac{m}{\text{no. samples/hour}} = 24$$

and the cosine filter had the following response:

Period hours	Frequency cycles/hr	Response	Period hours	Frequency cycles/hr	Response
1.	1.0000	.0000	60.	0.0167	.6494
5.	0.2000	.0003	70.	0.0143	.7310
10.	0.1000	.0018	80.	0.0125	.7880
15.	0.0667	.0063	90.	0.0111	.8292
20.	0.0500	.0265	100.	0.0100	.8596
25.	0.0400	.0153	110.	0.0091	.8827
30.	0.0333	.1212	120.	0.0083	.9006
35.	0.0286	.2422	130.	0.0077	.9147
40.	0.0250	.3542	140.	0.0071	.9261
50.	0.0200	.5299	150.	0.0067	.9353

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