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WEST GREENLAND COD CATCHES AND NUTRIENT INPUT TO THE IRMINGER CURRENT

by

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Introduction

For some time I have been developing and applying the hypothesis that fish populations as well as zooplankton volumes in and around the Pacific Sub-Arctic Gyre are strongly affected by the wind-driven circulation of the gyre. The Atlantic Sub-Arctic is an area where the hypothesis can be tested.

Reid (1962) brought together the data on circulation, phosphate-phosphorus content and zooplankton volumes in the upper part of the Pacific Ocean. Horizontal divergence in the upper (Ekman) layer in cyclonic gyres brings regenerated materials into the mixed layer. Zooplankton concentrations increase out from the centre of the gyre and downstream. Parsons and LeBrasseur (1968) confirmed the concentration of zooplankton around the Alaskan Gyre (Fig. 1).

Anderson, Parsons and Stephens (1969) showed that there were higher concentrations of nitrate near the centre of the Alaskan Gyre with decreasing concentrations outward (Fig. 2). Reid (1962) refers to Bohnecke, Hentchel, and Wattenberg's (1930) finding that the surface waters within the cyclonic gyre between Greenland and Iceland were enriched with chemicals, and their proposal that it was caused by horizontal divergence within the gyre with upward movement of the deeper, nutrient-rich water.

The requirement for indices of monthly and annual changes in vertical and horizontal advection has been met by continuing Fofonoff's (1962) calculations of transport from finite surface atmospheric pressure differences. The requirement for nutrient indices on the Pacific coast has been met by using shore station salinity records.

Example From the Pacific Sub-Arctic

First, let us establish the relationship between salinity and nutrients in the Sub-Arctic Pacific. During great-circle crossings of the Pacific at about 50°N during Transpac 69, the correlation coefficients between salinity and nitrate were 0.92, 0.97 at 0 m; 0.94, 0.98 at 50 m; 0.85, 0.74 at 150 m: between salinity and silicate were 0.96, 0.99 at 0 m; 0.95, 0.99 at 50 m; 0.90, 0.53 at 150 m: and between salinity and phosphate were 0.83, 0.76 at 0 m; 0.86, 0.86 at 50 m; 0.81, 0.71 at 150 m.

The correlation coefficients between salinity and phosphate taken vertically in coastal waters and inlets on the west coast of Vancouver Island are high. Data from Tully (1937) show values of 0.92, 0.76, 0.73, 0.95, 0.86, 0.85, 0.78, 0.81, 0.95, 0.90, 0.95 off Nootka and up Tahsis Inlet, and values of 0.85, 0.57, 0.69, 0.76, 0.66, 0.72 in Tlupana and Muchalat Inlets.

Second, let us look at a time series of nitrate values from Station "P" near the centre of the Alaskan Gyre, and vertical transport calculated for a grid point close to the station (Fig. 3). Nitrate values integrated from 175 m to 50 m taken from Anderson, Parsons and Stephens (1969) are less affected by biological activity than surface values. The seasonal changes are well illustrated.

Figure 4 shows the plots of halibut catches in Area 2 (Alaska to Washington) and the annual mean salinity at Langara Island at the northwest tip of the Queen Charlotte Islands, 10 years before the catches. Mean ages in Area 2 were 9.9, 9.4, 9.9 for 1970, 1971, 1972 (Ann. Rpt. IPHC, 1972).

Fifty-six percent of the variance of catch is associated with salinity ($r = 0.75$). Figure 5 shows catch and salinity 10 years before at Station "P". Fifty-one percent of the variance is associated with this salinity record ($r = 0.71$).

Advective Changes in the Atlantic Sub-Arctic

Figure 6 shows Zlobin's (1972) time-series of phosphates in the Faroe-Shetland Channel with monthly vertical transport at 60°N 20°W added. Nutrients are greater at depth and the sudden increase at all levels in March 1967 coincided with a large value (12 m/mo) for divergence upstream (Fig. 7).

The circle indicates 60°N 20°W. This is the location of high values of vertical transport. It is also in the area where horizontal transport can affect the proportion of upper layer water which can be diverted to the south across the underlying northeast flow or diverted across to the underlying Irminger Current which runs to the west. To the extent that heat is a conservative property of the upper layers, temperatures (see Lauzier, 1972) to the west may change with nutrient changes of water masses to the west.

Maxima of winter phosphate in the English Channel reported by Russell et al. (1971) (Wickett, unpubl.) have varied with the vertical and horizontal velocities in the previous year (Fig. 8). Sixty-three percent of the variance of phosphate values is associated with transports. Horizontal transport and vertical transport are closely associated in the same months at 60°N 20°W, so the vector along 145° was taken for the months of September to December while the vertical values were taken for the 12 months preceding September.

It needs to be emphasized that the underlying flows are not considered here. The upper layer is regarded as receiving a changing nutrient supply and this upper layer is slid across the deeper currents or deflected in another direction.

Cod Catches in the West Greenland Area

Cod catches in ICNAF Area 1 (Fig. 9) are found to vary with the English Channel nutrient maxima if a 7-year lag is used (overlay 9 on 8). Since cod take 4 to 5 years to mature, it may not be too far from reality to suggest such a lag from the introduction of nutrients to an area south of Iceland, the growth of phytoplankton and so on up the food web to the survival of young cod and then the harvesting of the adults (Fig. 10).

Population dynamics affect the numbers of fish, but the West Greenland cod may be one population in which a high proportion (63%) of the variance is associated with the environment.

In order to examine further the effect of the blocking of flow to the northeast of 60°N 20°W, Ekman transport was integrated along 60°N from the coast westward to 40°W longitude and examined in a full second degree polynomial with vertical velocities at 60°N 20°W to find its association with cod catch.

The integrated southward transport is associated with vertical velocity for the same period. The MREG1 program (Lindsey, 1971) eliminated all coefficients except the first order integrated southward transport which is highly significant ($F = 12.515$, d.f. 1,11) with 49% of the variance of catch associated with it (Fig. 11). ($Y = 19.68 - 0.3417X$). (Table 1).

Since curl of the wind stress, which leads to geostrophic flow, and wind stress are not necessarily independent variables, it is not surprising to see that Dinsmore and Moynihan's (1972) graphs of volume transport in the Labrador Sea exhibit higher flow in the 1950's with a falling off in the early 1960's with a high value in 1968 (Fig. 12). This indication of changing volume transport does not invalidate the hypothesis that changing concentration of nutrients in the euphotic layer and the shunting of that layer across underlying flows can affect coastal regions all around the Sub-Arctic Gyres.

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Zlobin, V. S. 1972. Elements of forecasting of seasonal changes in the concentrations of phosphates in the Norwegian Sea. Rapp. P.-v. Cons. perm. int. Explor. Mer. 162: 191-194.

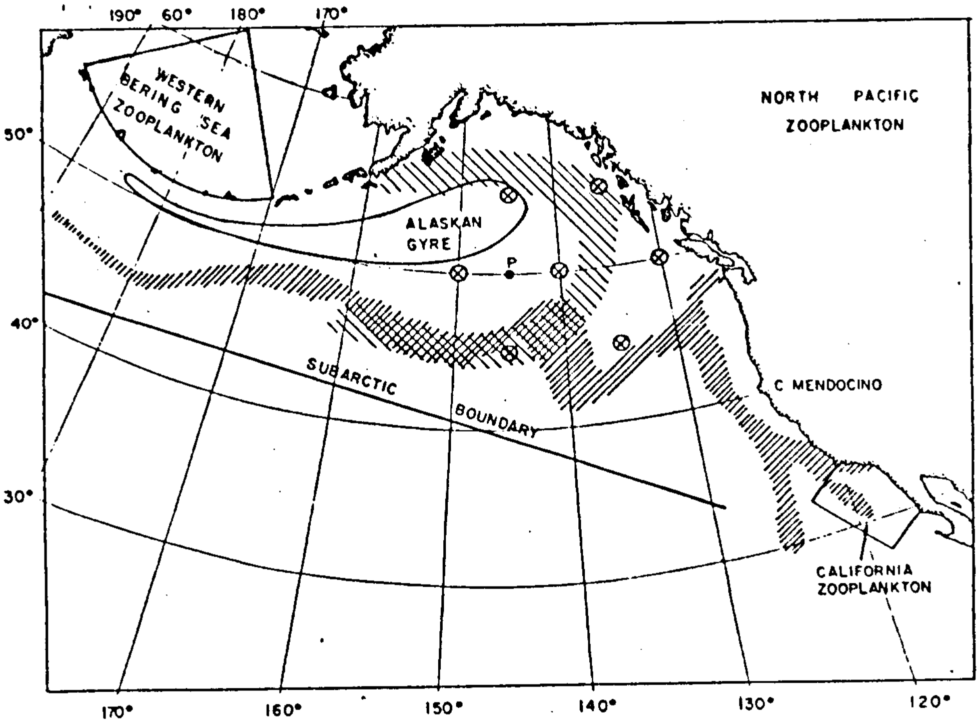


FIG. 1. Map of the Northeast Pacific Ocean showing the seven points used in computing Ekman transport at 50°N,140°W and the concentration of zooplankton according to Reid (1962) (diagonals: down to left) and according to Parsons et al. (1966) (diagonals: down to right).

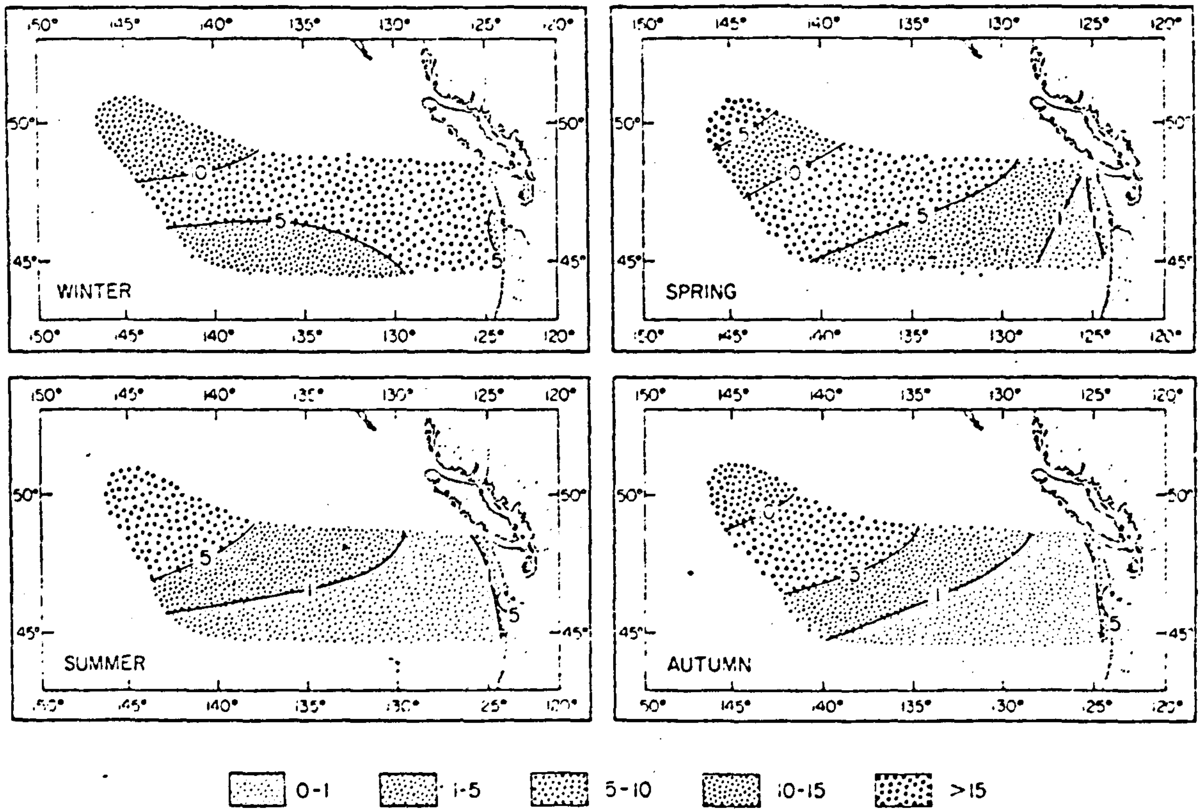
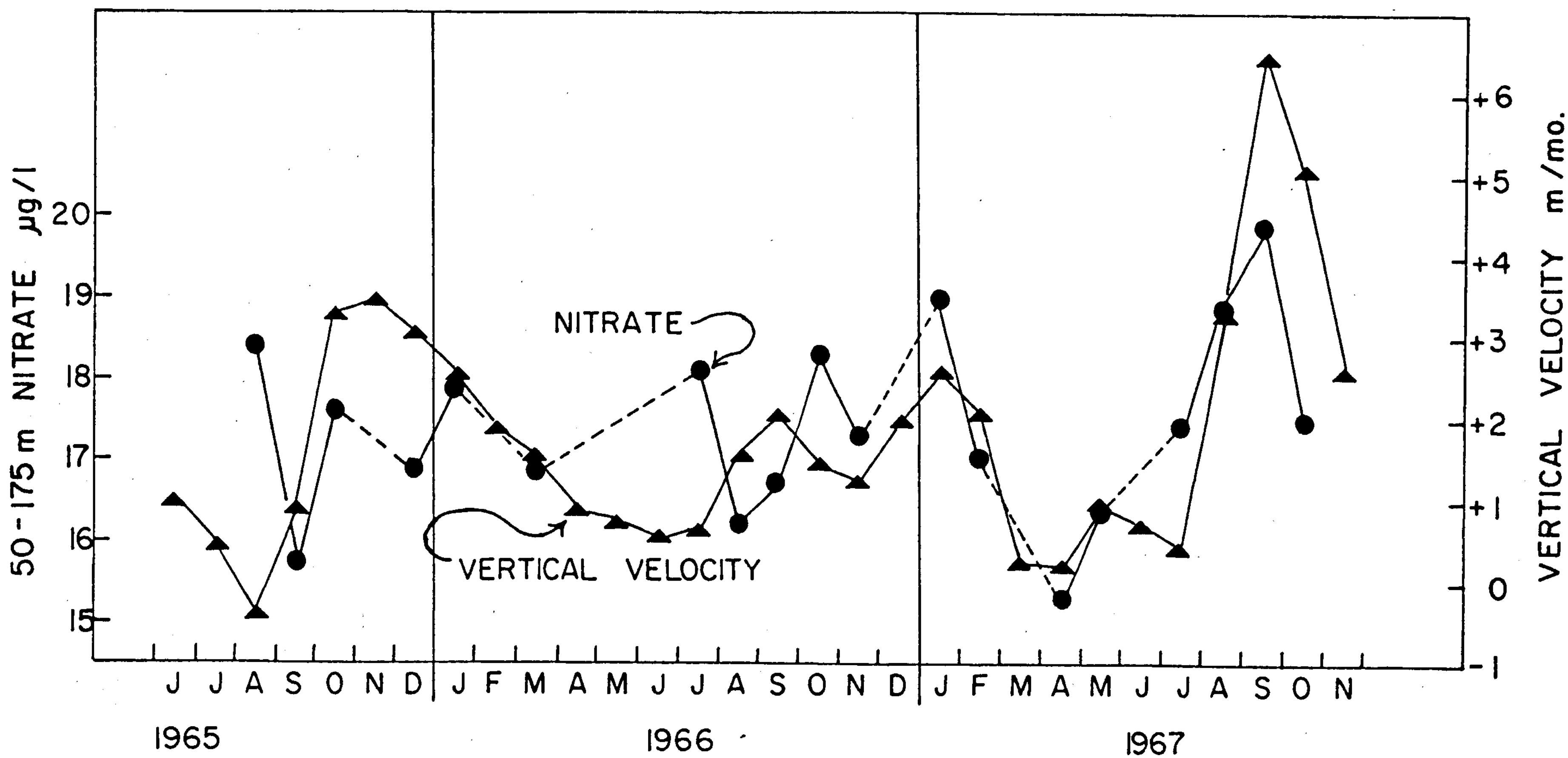


Fig. 2. Seasonal changes in surface nitrate concentration (μg atoms/l.) in the subarctic Northeast Pacific Ocean. Data are averaged according to season.



50 - 175 m NITRATE µg/l
20
19
18
17
16
15
VERTICAL VELOCITY m /mo.
+6
+5
+4
+3
+2
+1
0
-1
NITRATE
VERTICAL VELOCITY
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1965
1966
1967

FIG 3

PACIFIC HALIBUT CATCH AREA 2

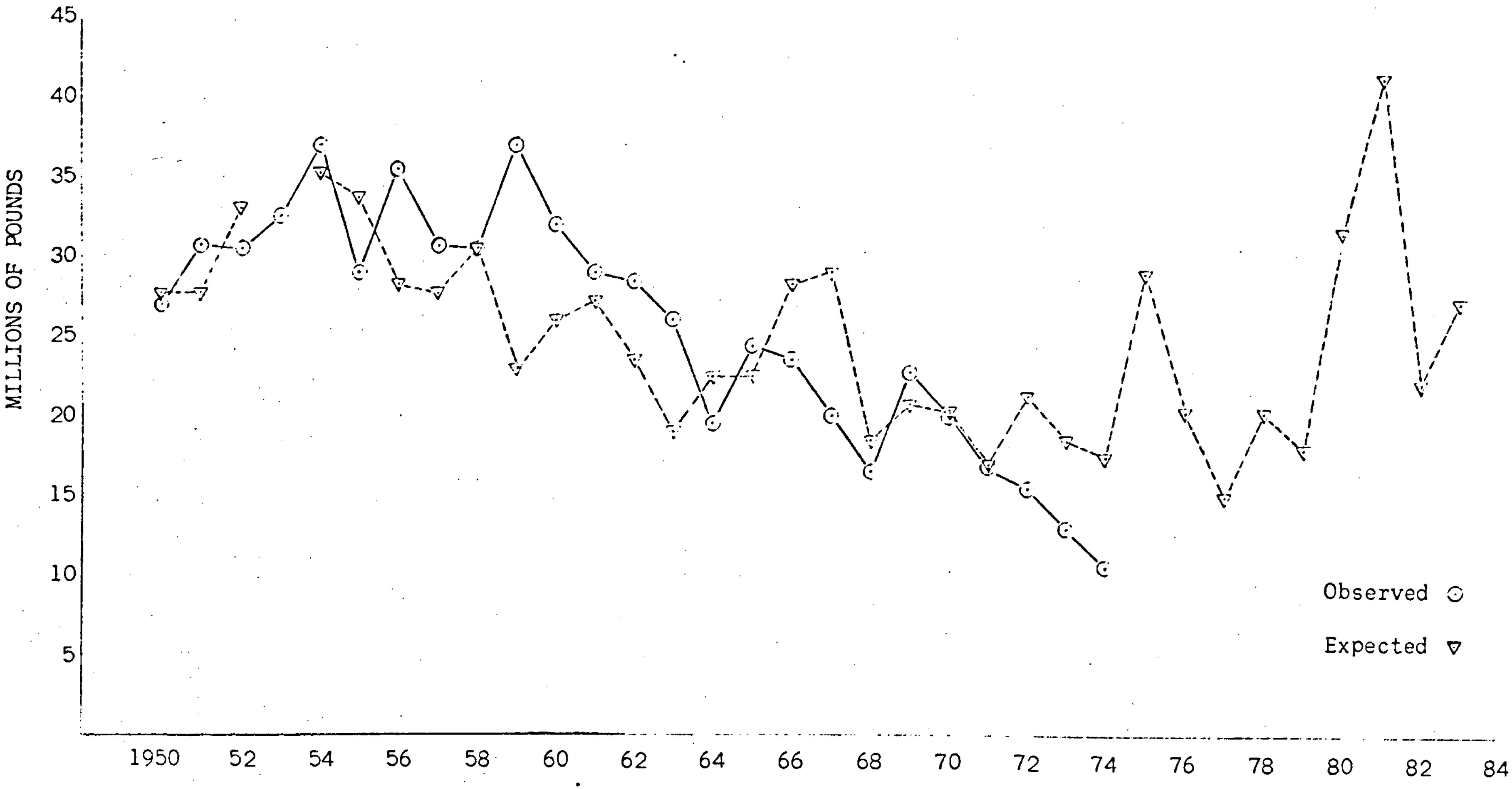


Fig. 4

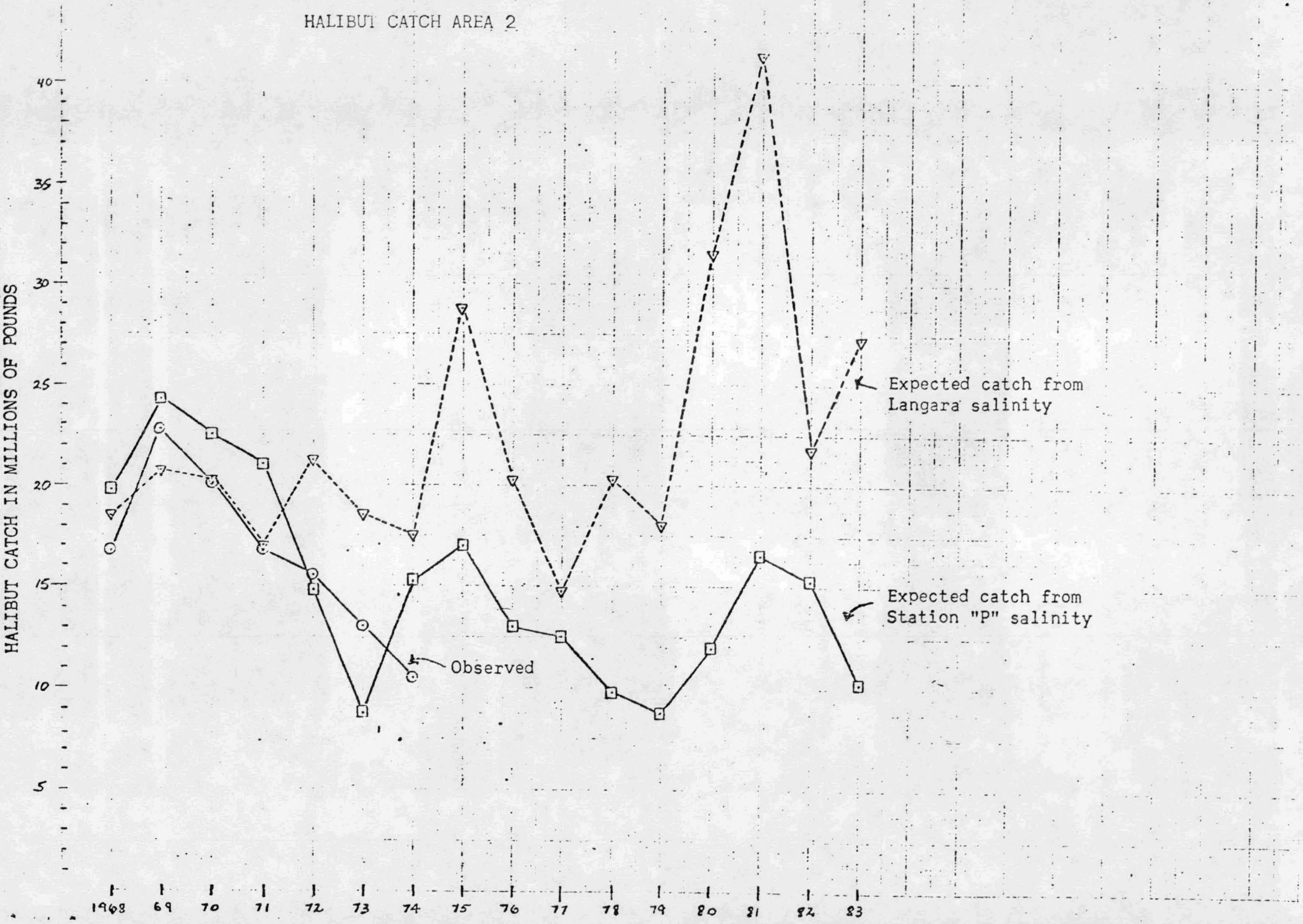

HALIBUT CATCH AREA 2
HALIBUT CATCH IN MILLIONS OF POUNDS
40
35
30
25
20
15
10
5
1968
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
Expected catch from
Langara salinity
Expected catch from
Station "P" salinity
Observed

Fig. 5

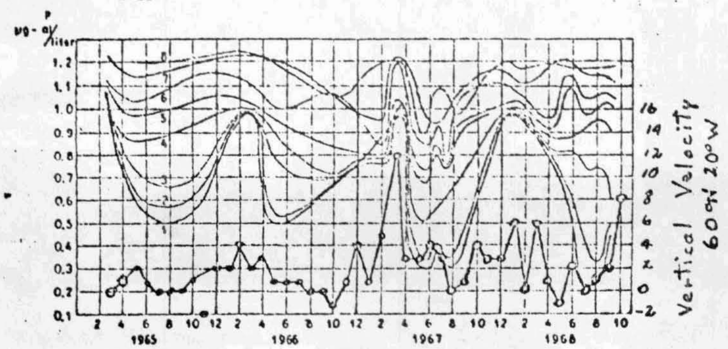


Figure 152. Seasonal changes of concentration of phosphates in the Faroe-Shetland Channel.

Curve 1– 0 m	Curve 4–100 m	Curve 7–500 m
„ 2–20 m	„ 5–200 m	„ 8–800 m
„ 3–50 m	„ 6–300 m	

⊙-Vertical velocity at 60°N 20°W

Fig. 6. (From Zlobin, V.S., 1972).

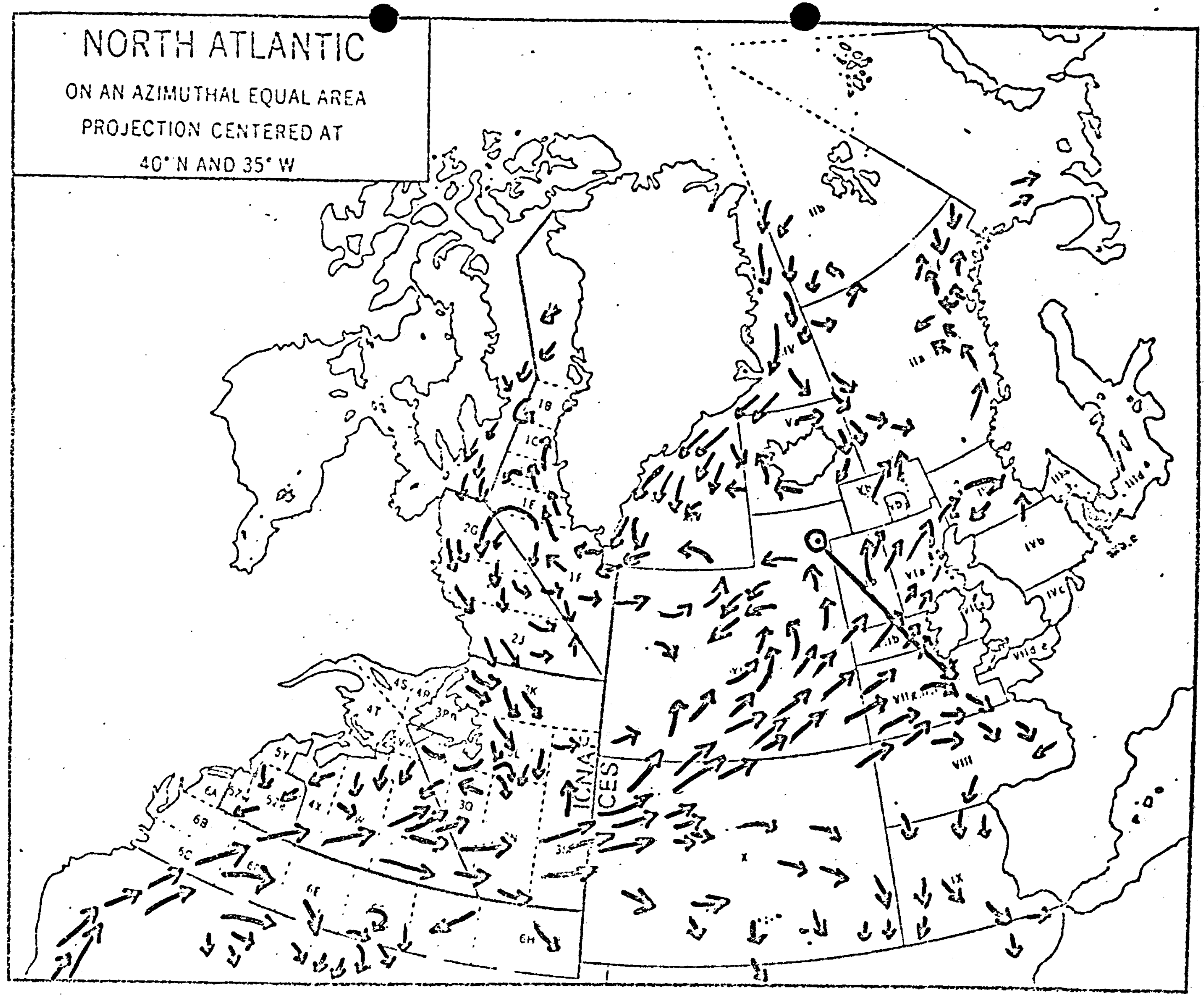

NORTH ATLANTIC
ON AN AZIMUTHAL EQUAL AREA
PROJECTION CENTERED AT
40° N AND 35° W
ICNAF
ICES

Fig. 7

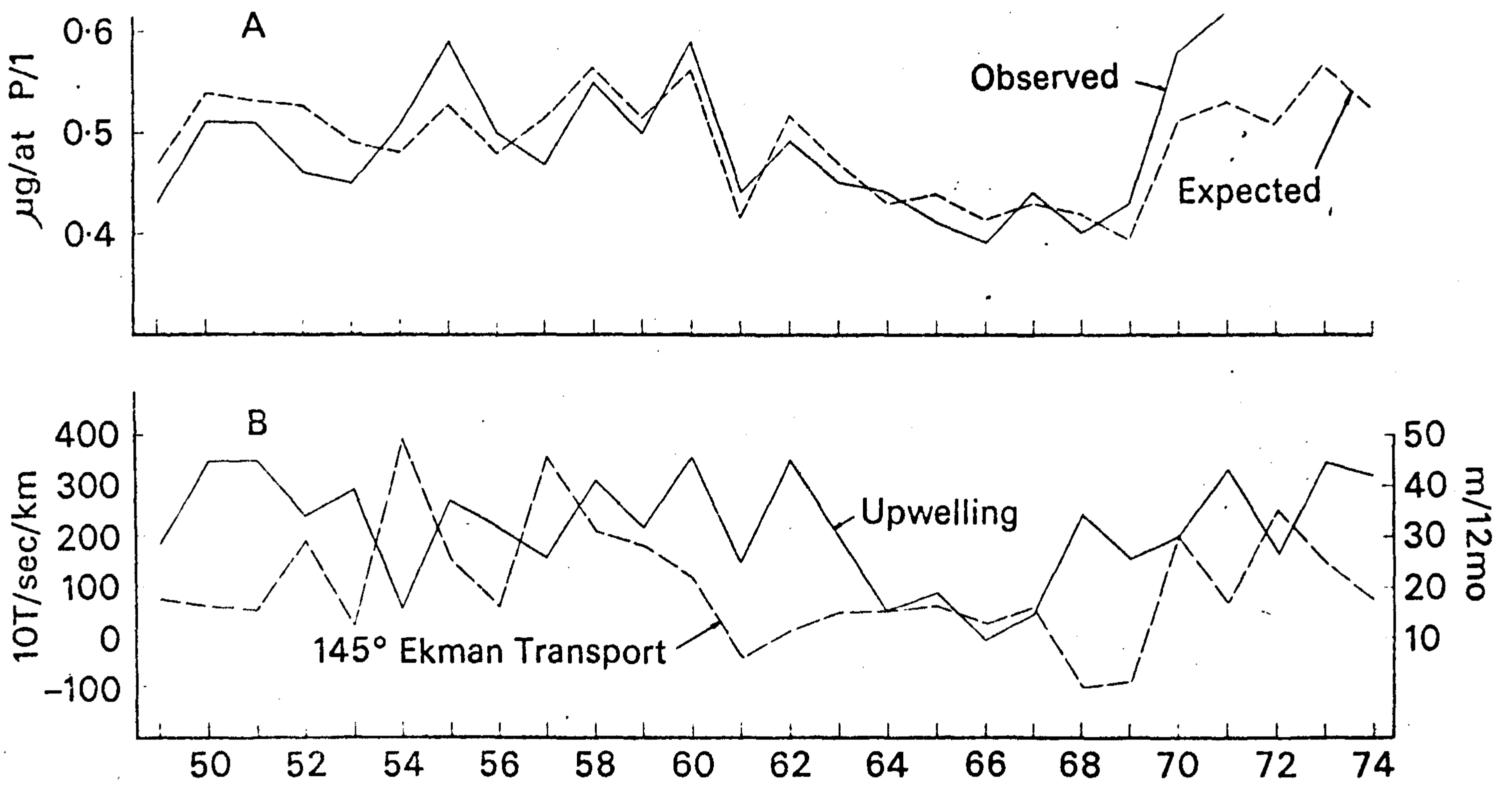
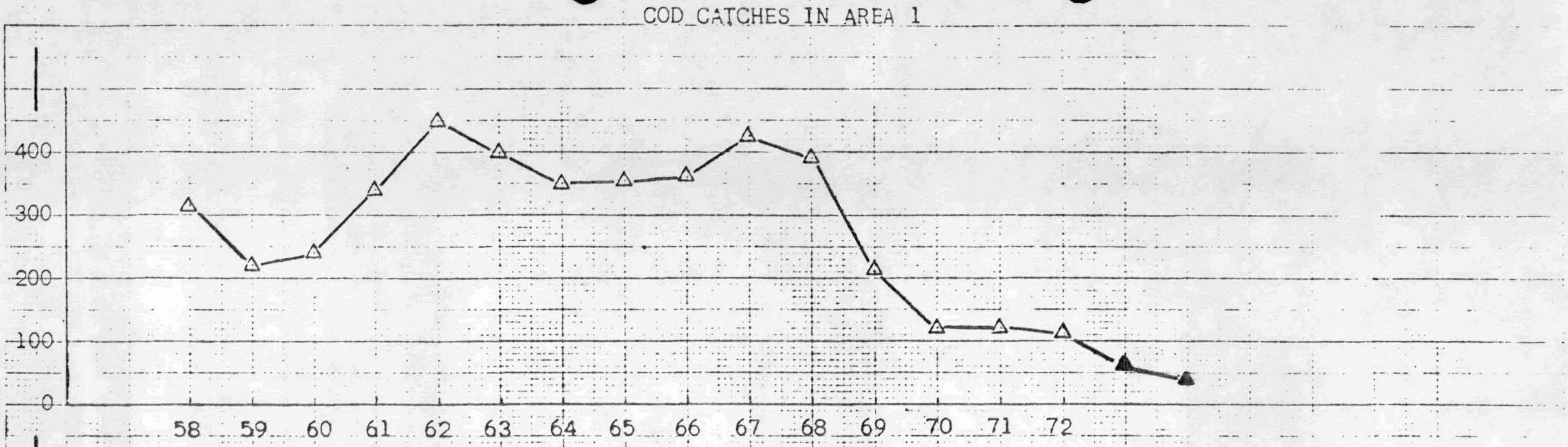
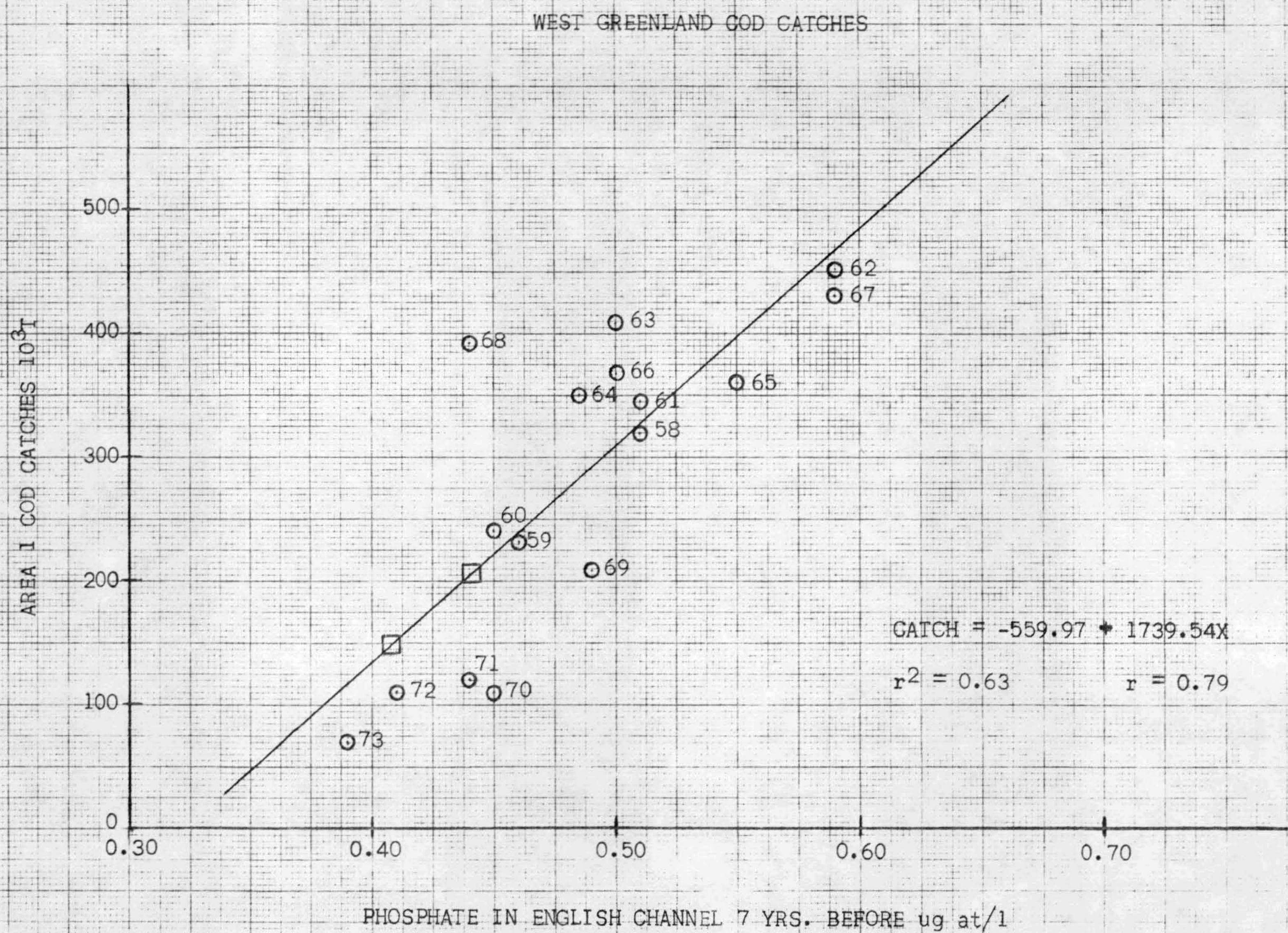


Fig. 8. Channel phosphate.



COD CATCHES IN AREA 1
400
300
200
100
0
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72

FIG 9



WEST GREENLAND COD CATCHES
AREA 1 COD CATCHES 10^3 T
0
100
200
300
400
500
0.30
0.40
0.50
0.60
0.70
PHOSPHATE IN ENGLISH CHANNEL 7 YRS. BEFORE ug at/l
62
67
63
68
66
64
61
65
58
60
59
69
71
72
70
73
CATCH = -559.97 + 1739.54X
r^2 = 0.63
r = 0.79

FIG 10

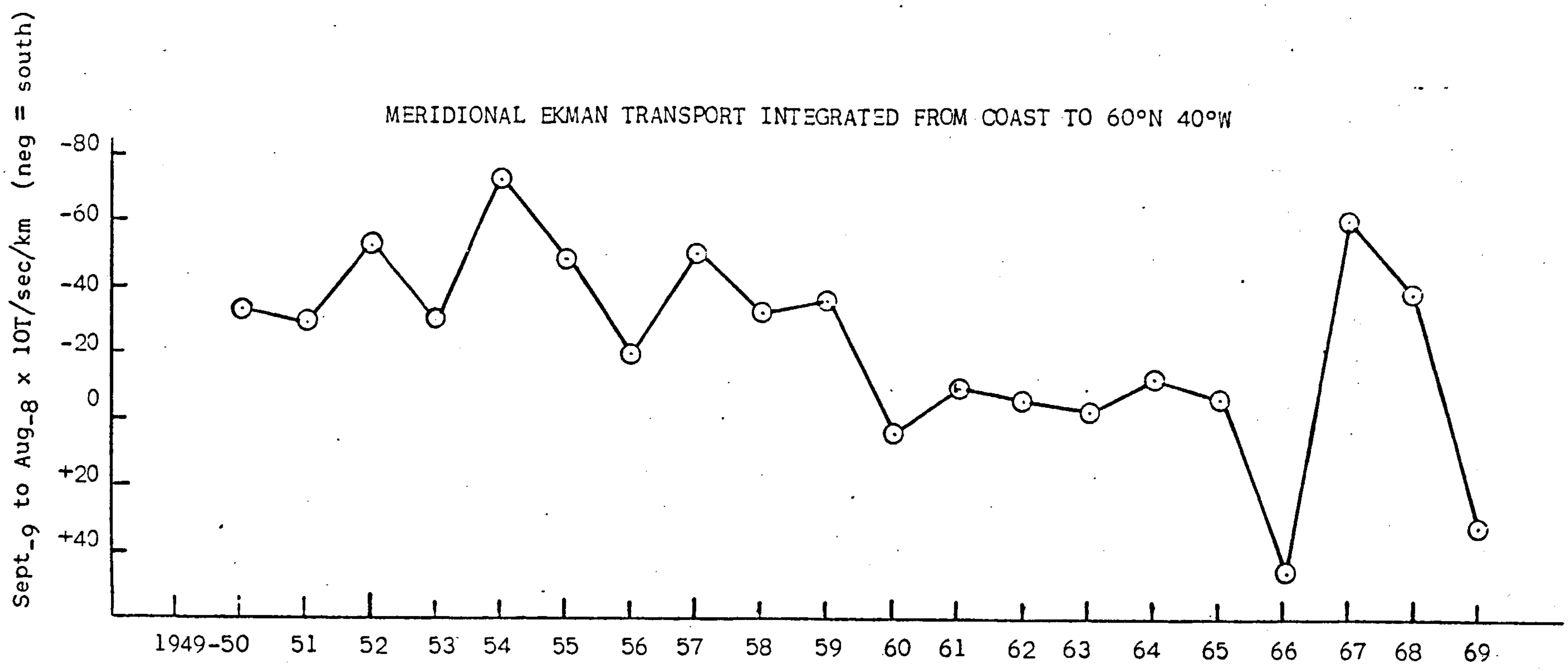

MERIDIONAL EKMAN TRANSPORT INTEGRATED FROM COAST TO 60°N 40°W
Sept-9 to Aug-8 x 10T/sec/km (neg = south)
-80
-60
-40
-20
0
+20
+40
1949-50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69

Fig. 11

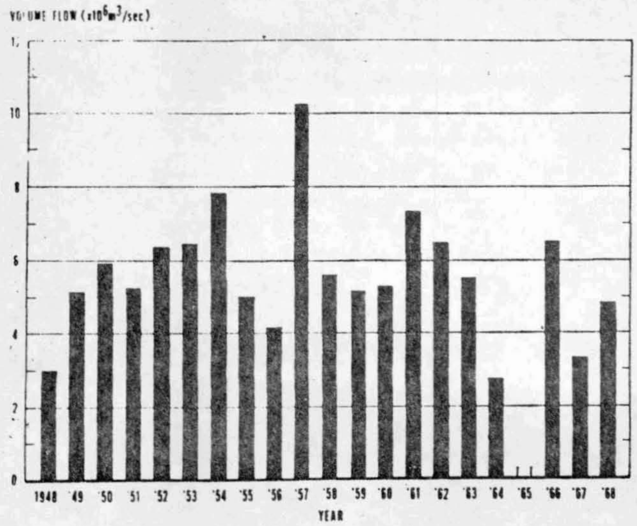


Figure 174. Variation of volume flow of the Labrador Current through the section between South Wolf Island, Labrador and Cape Farewell, Greenland from 1948 to 1968.

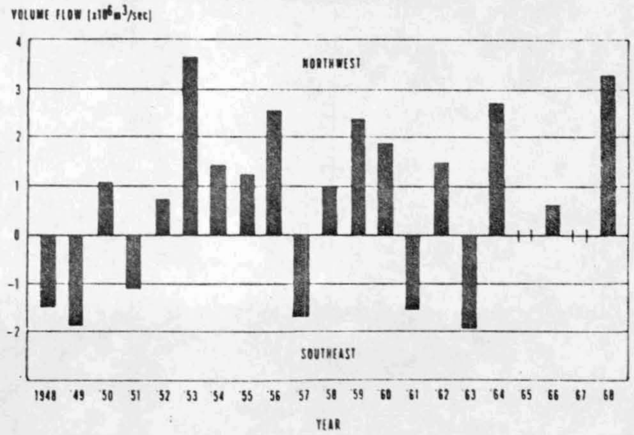


Figure 176. Variation of net volume flow through the section between South Wolf Island, Labrador and Cape Farewell, Greenland from 1948 to 1968.

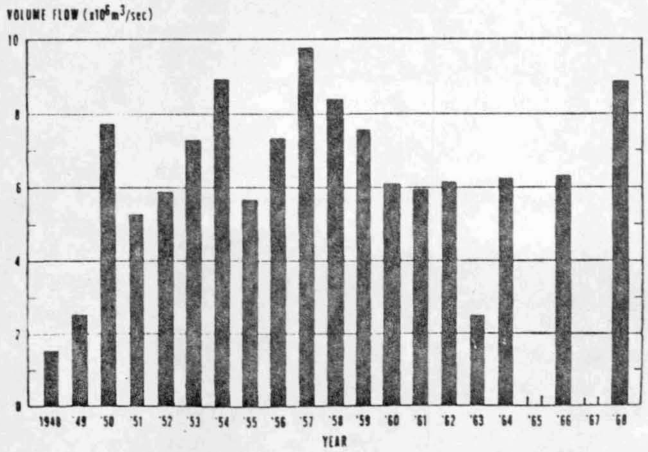


Figure 175. Variation of volume flow of the West Greenland Current through the section between South Wolf Island, Labrador and Cape Farewell, Greenland from 1948 to 1968.

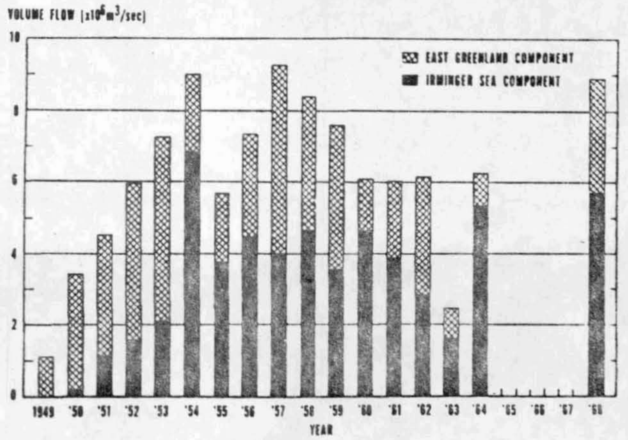


Figure 177. Variation of volume flow of the East Greenland Current and Irminger Current components of the West Greenland Current through the section between South Wolf Island, Labrador and Cape Farewell, Greenland from 1948 to 1968.

Fig. 12 (from Dinsmore, R.P. and M.J. Moynihan (1972).

Table 1. ICNAF Area 1 cod catches.

Year	Upwelling 60°N 20°W Sept.$_{n-9}$, Aug.$_{n-8}$	Int. Mer. Ekman 60°N 40°W Sept.$_{n-9}$, Aug.$_{n-8}$	Cod 10^3 ton
1958	45	-32	32.0
1959	34	-28	23.4
1960	39	-51	24.3
1961	16	-29	34.5
1962	37	-71	45.1
1963	32	-47	40.6
1964	26	-18	35.0
1965	41	-48	36.0
1966	32	-30	36.6
1967	46	-34	43.0
1968	25	+06	39.4
1969	45	-07	21.5
1970	30	-04	11.3
1971	15	0	12.1
1972	19	-10	11.1
1973	10	-04	6.3
1974	15	+49	4.7
1975	35	-61	
1976	26	-39	
1977	30	+32	
1978	43	-55	
1979	27	-22	
1980	45	-51	
1981	42		