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Spatial and Temporal Distribution  
of Walleye Pollock  
*(Theragra chalcogramma)*  
Spawning in the Bering Sea  
in 1984

November 1985

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Spatial and temporal distribution of walleye pollock  
(Theragra chalcogramma) spawning in the Bering Sea in 1984.

by

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## INTRODUCTION

Walleye pollock is one of the most important commercial groundfish species in the world and supports an intensive multinational fishery. In the eastern Bering Sea and Aleutian Basin, pollock is the dominant species by weight, and a central component of the marine ecosystem. For these reasons, it is necessary for fisheries managers to achieve an increased understanding of causes underlying the fluctuations in the abundance of this species. Two factors important in the evaluation of the state of pollock stocks are the level of recruitment to the fishery and the extent and characteristics of habitat used by pollock. Examination of the spatial and temporal distribution of spawning will aid in clarifying the linkages between these factors.

The spatial and temporal distribution of spawning of walleye pollock was investigated as part of a study of the reproductive biology and the spawning stock structure of this species in the Bering Sea. Several authors have discussed the timing and distribution of spawning in the Bering Sea (Hirschberger and Smith 1983, Maeda 1972, Okada and Yamaguchi 1985, Serobaba 1968 and 1974, Takahashi and Yamaguchi 1972), but prior work has been fragmented and incomplete.

Pollock are known to congregate in dense shoals to spawn, usually over the continental shelf and slope, at depths of 50 to 250 meters.

Temperatures on the spawning grounds have been reported to range from  $-0.7^{\circ}$  to  $11.0^{\circ}$  C at depths of spawning, and from  $-1.5^{\circ}$  to  $13.0^{\circ}$  C at the surface (Gorbunova 1954). The length of the spawning season varies by area, from two to seven months, and peaks at different times in different

locations. The spawning season in the Bering Sea is greatly protracted in comparison to many parts of its range. For example, spawning in the Shelikof Strait region is largely completed in three to eight weeks time (Dunn and Matarese 1985), whereas spawning has been observed to last as long as seven months in the Bering Sea. Spawning is also spread over a much broader geographic area in the Bering Sea.

The earliest reports of spawning have been from the Aleutian Basin (Figure 1), where spawning has been noted in February and March (Okada 1983). The location of the spawning concentrations appears to then move shoreward over the continental slope and shelf as the season progresses (Nishiyama and Haryu 1981). Spawning may occur later to the northwest of the Pribilof Islands than in the southeastern Bering Sea (Serobaba 1971).

#### METHODS

National Marine Fisheries Service (NMFS) observers aboard foreign commercial fishing vessels in the Bering Sea collected data on the time and location of pollock spawning from December, 1983 to October, 1984. The occurrence of spawning pollock in a haul was logged, along with information on the time, date, gear depth, gear and surface temperature, and whether length or age samples for pollock were taken.

A total of 1538 observations were made (Table 1). It should be noted that fishing effort varied over the season, and therefore to assess the actual intensity of spawning by month, the number of observations per month reported by observers must be weighed against the effort of the fishing fleet.

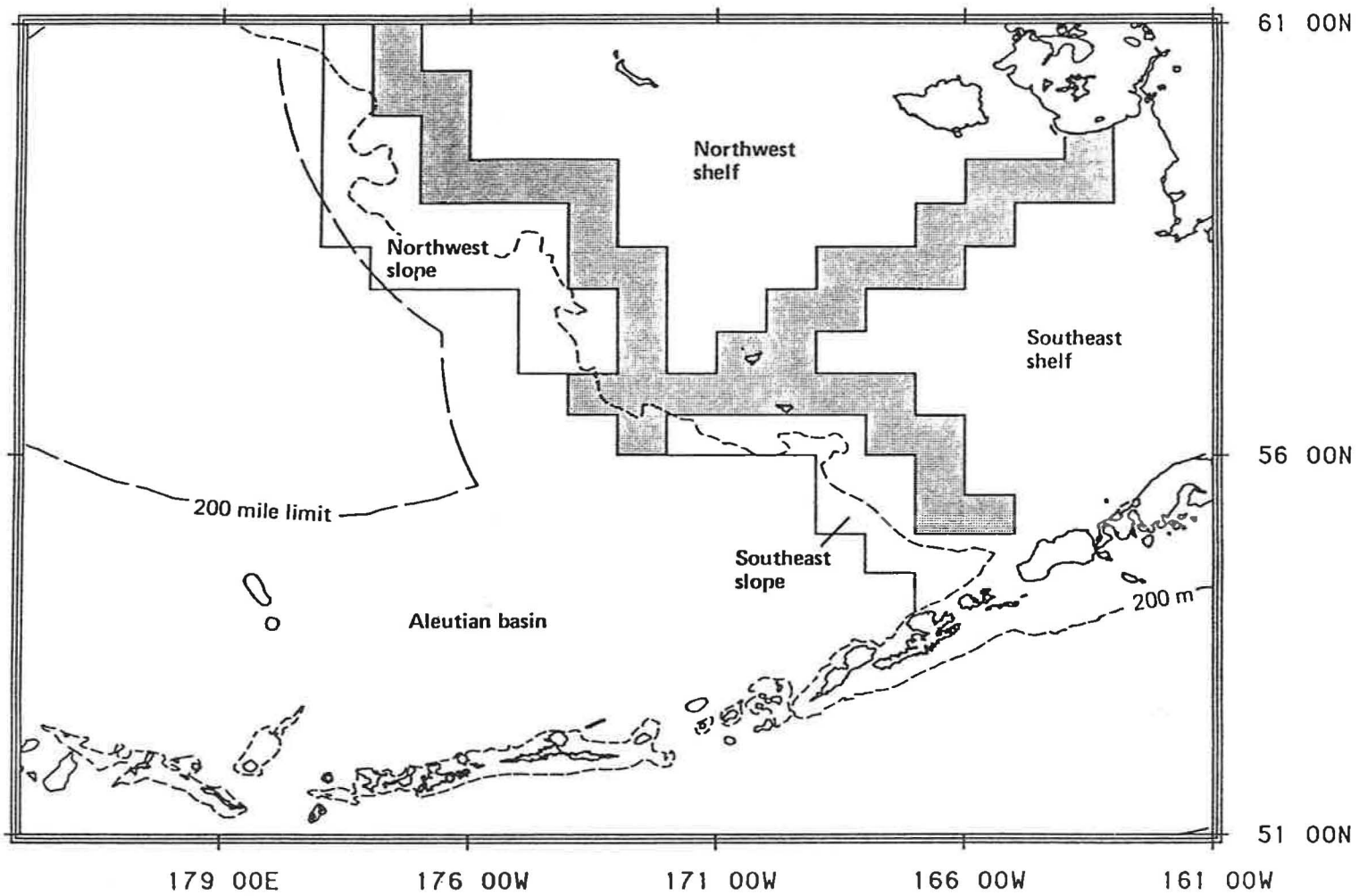


Figure 1.--Sampling regions within the Bering Sea. Shaded areas are buffer zones.

Table 1. Observations of spawning by month.

<u>Month</u>	<u>No. of observations</u>
January	39
February	504
March	534
April	225
May	95
June	50
July	45
August - October	46
<hr/>	
Total	1538

The locations of the hauls in which spawning pollock were observed were plotted by month. Plots were also made of the total distribution of fishing effort by the foreign commercial fleet over the survey period, to compare with locations where spawning was found, and to assess whether the reports from the fishing fleet represented the true distribution of spawning. Gear temperatures, surface temperatures and depths of capture at locations where spawning was encountered, were summarized.



## RESULTS

### Spatial and temporal distribution of spawning in 1984

The earliest pollock spawning was observed in January in the Aleutian Basin, with the densest concentrations located in the region to the north of Bowers Bank (north of the central Aleutian Islands, Figure 2A). In February, the location of spawning concentrations moved to the central and southern part of the Basin (Figure 2B), and in March, to the north-central portion of the Basin (Figure 2C). By April, virtually no spawning was observed in the Basin (Figure 2D).

A few patches of spawning were observed along the continental slope and to the north of Unimak Island in February (Figure 2B). By March, spawning in the Unimak Island area had intensified, and patches were observed over the southeast shelf about 130 km east of the Pribilof Islands (Figure 2C).

In April, spawning was occurring mainly in the area north of Unimak Island (Figure 2D). Spawning was also observed near the Pribilofs and to the east of them. There were a few observations of spawning northwest of the Pribilofs, near the continental slope, in April.

The reports from May indicated spawning was concentrated around the Pribilofs (Figure 2E), but in June, was scattered over the entire shelf from 165° to 178° W (Figure 2F). Significant amounts of spawning were observed to the north and west of the Pribilof

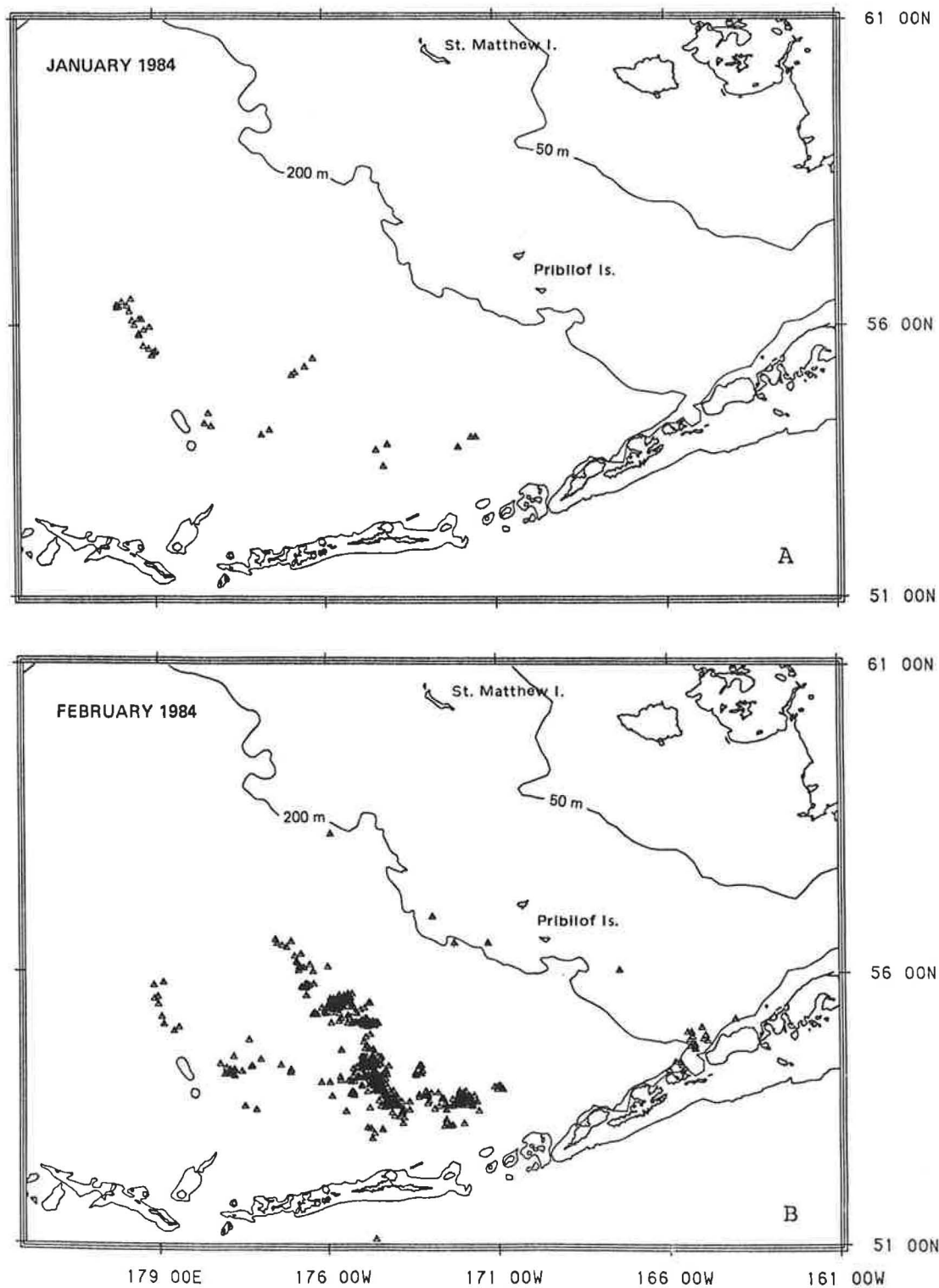


Figure 2.--Observed distribution of spawning pollock in 1984, by month.

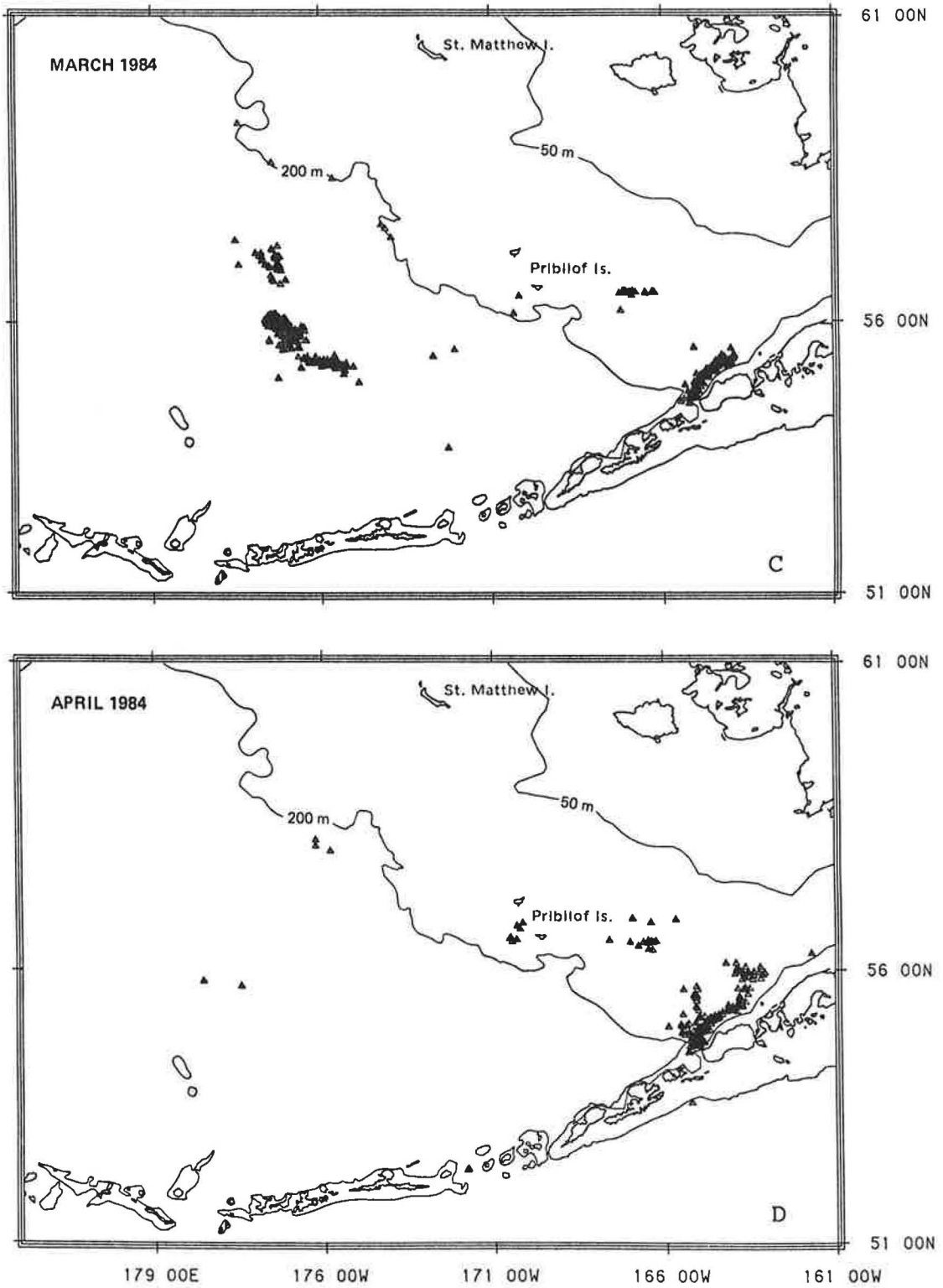


Figure 2(cont.)--Observed distribution of spawning pollock in 1984, by month.

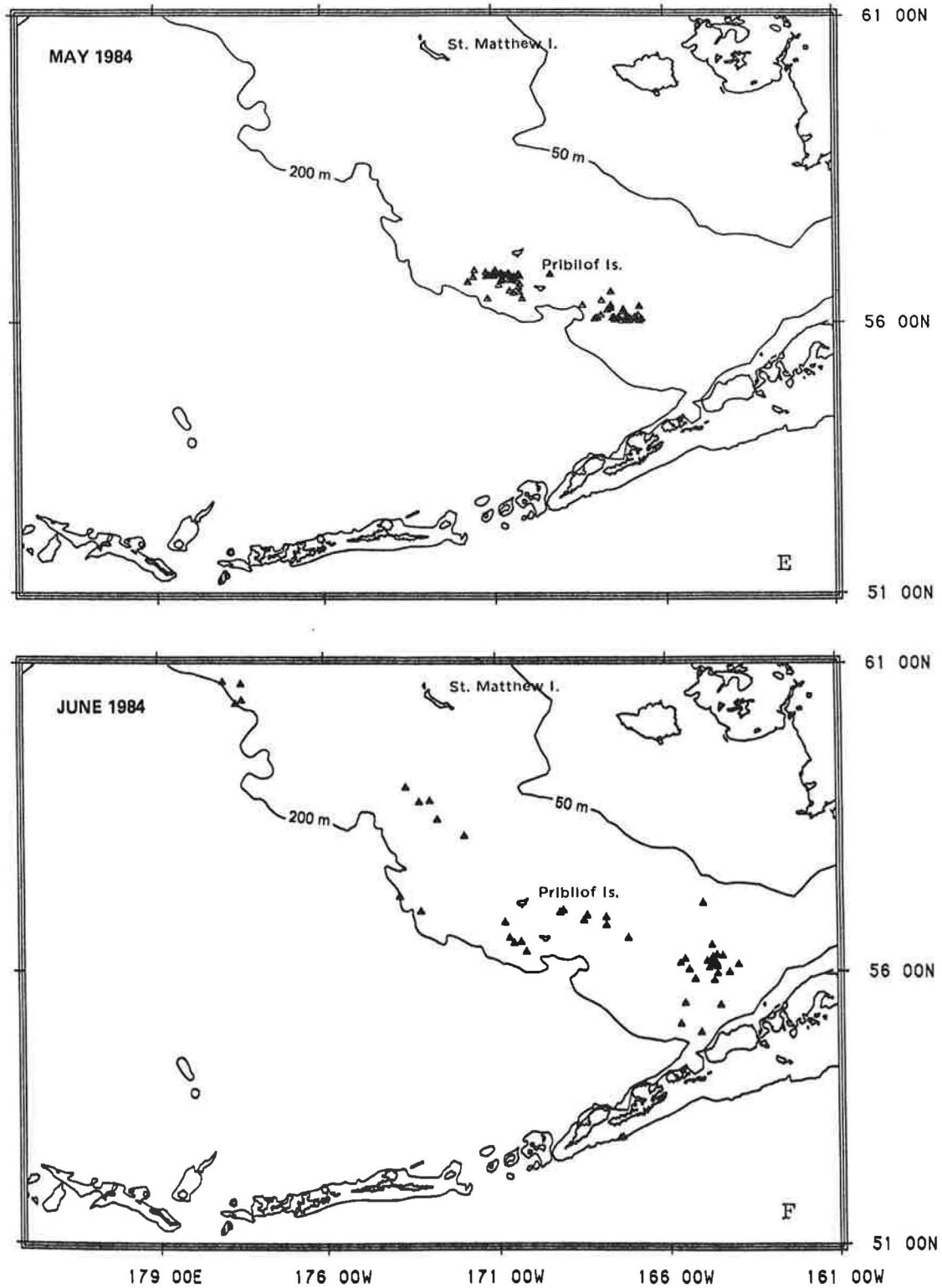


Figure 2(cont.)--Observed distribution of spawning pollock in 1984, by month.

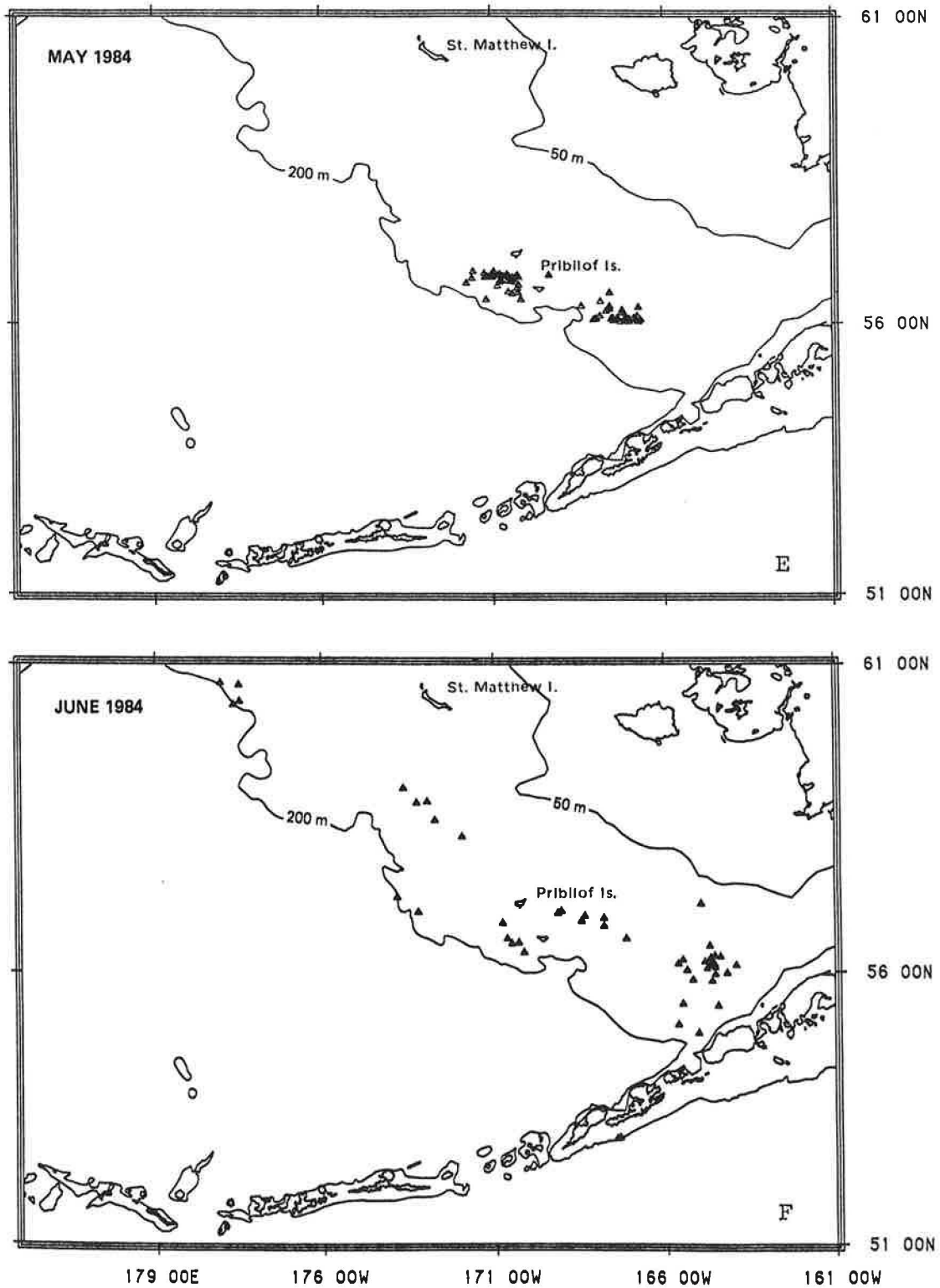


Figure 2(cont.)--Observed distribution of spawning pollock in 1984, by month.

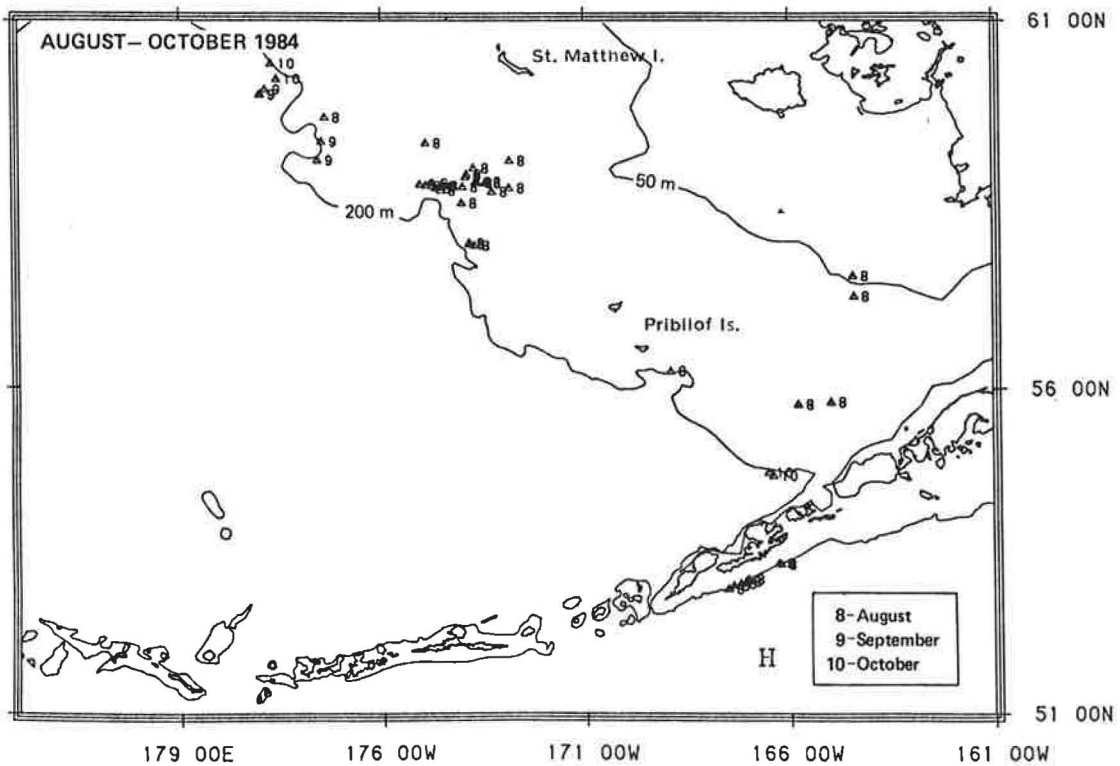
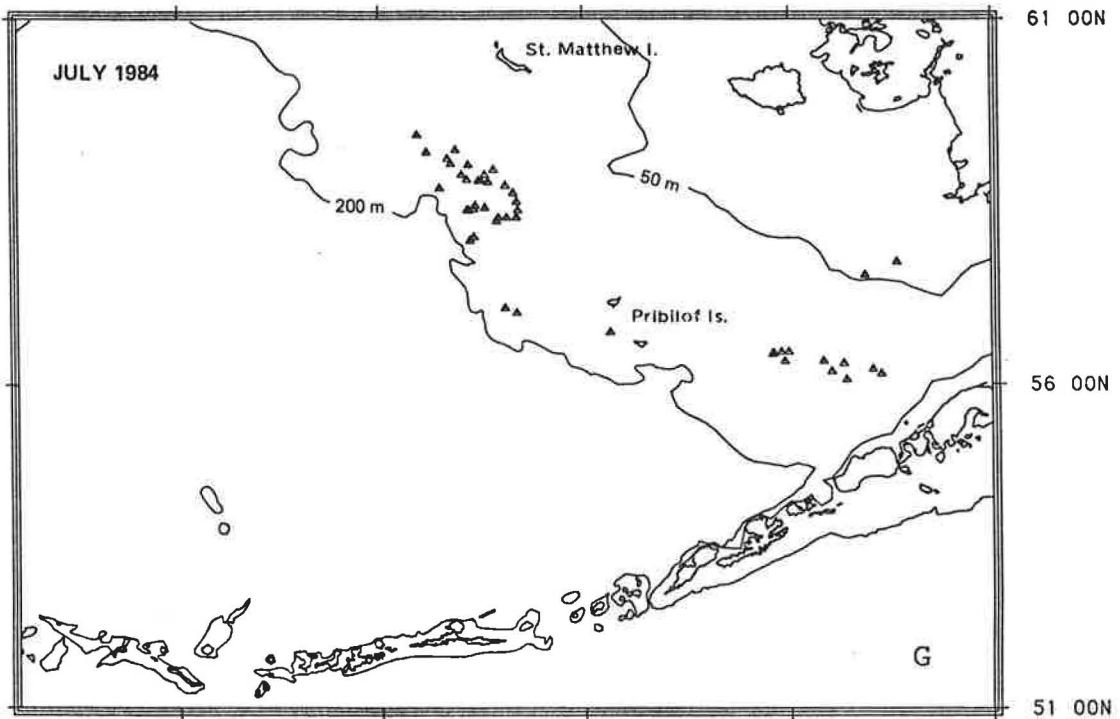


Figure 2(cont.)--Observed distribution of spawning pollock in 1984, by month.

Islands for the first time in June, along the 200-meter contour at about 60° N, and on the middle shelf between the Pribilofs and St. Matthews Island.

In July, spawning observations were patchy both to the southeast and to the northwest of the Pribilofs (Figure 2G). There were several observations from within the 50-meter depth contour on the southeast shelf in July, but most spawning at this time appeared to be in the area between the Pribilofs and St. Matthews Island.

There were only a few observations of spawning from the southeast shelf and slope after July (Figure 2H). Spawning was observed between the Pribilof Islands and St. Matthews Island in August. There were a few observations from the slope area west of St. Matthews Island from August through October. There were several reports of spawning from the area to the south of Unalaska Island in August.

Spawning pollock were caught at depths ranging from 46 to 360 meters, most commonly between 100 and 250 meters (Table 2). Depths of spawning were greater from January to March, when pollock were spawning over deeper water in the Aleutian Basin, than during the period from April to July, when spawning was occurring over the continental shelf and slope. Temperatures at the depth of spawning (gear depth) ranged from -1.8° to 6.0° C ( $\bar{x}$ =2.34 C), and at the surface from -1.5° to 16.1° C ( $\bar{x}$ =4.12 C) (Table 3).

Table 2.--Depths of capture of spawning pollock.

Month	<u>Gear Depth (meters)</u>	
	Range	$\bar{x}$
January	70 to 270	198.1
February	73 to 360	259.2
March	54 to 350	213.1
April	54 to 300	98.5
May	50 to 170	106.7
June	78 to 275	110.7
July	53 to 151	112.8
August to October	46 to 335	159.2
Overall	46 to 360	157.3



Table 3A.--Gear Temperatures at locations of spawning (°C).

Month	Range	$\bar{x}$
January	1.5 to 4.5	3.19
February	0.0 to 5.0	3.15
March	0.0 to 5.0	2.94
April	-1.0 to 4.0	1.70
May	-1.8 to 3.0	0.76
June	0.0 to 4.6	1.72
July	-1.0 to 4.2	2.19
August to October	0.2 to 6.0	3.05
Overall	-1.8 to 6.0	2.34

Table 3B.--Surface Temperatures at locations of spawning (°C).

Month	Range	$\bar{x}$
January	2.0 to 3.6	3.00
February	1.0 to 9.9	3.16
March	-1.0 to 9.0	2.50
April	-1.5 to 12.5	1.93
May	-1.0 to 4.4	2.06
June	-1.0 to 11.0	2.96
July	0.0 to 11.0	7.16
August to October	6.2 to 16.1	10.20
Overall	-1.5 to 16.1	4.12

Total distribution of fishing effort and its relation to  
the distribution of spawning

The overall distribution of the commercial fishing fleet in the Bering Sea (Figure 3A through 3H) was examined by month to assess its relation to the observed distribution of spawning.

Coverage of the Aleutian Basin was comprehensive from January through March (Figures 3A,B,C); vessels in the Basin at this time were targeting on spawning pollock. No spawning was observed here after April (Figure 3D), and vessels continued to work in the Basin through October (Figure 3H), so spawning probably ceased after April in this area.

The continental slope to about 60° N was extensively fished by the commercial fleet from January through October, except that in May (Figure 3E) most of the vessels were concentrated near the Pribilof Islands. The concentration of spawning observations in this area in May (Figure 2E) is therefore probably not representative of the true distribution of spawning at this time.

Coverage of the continental shelf was patchy through May, and fairly complete from June through October (Figure 3F through H). There was no fishing in the area between the Pribilof Islands and St. Matthews Island until June (Figure 3F), at which time spawning was observed. The fleet would probably have discovered concentrations of pollock had they been present in this area before June, as fishing for pollock was occurring in nearby areas throughout this time. Therefore, the spawning observed here

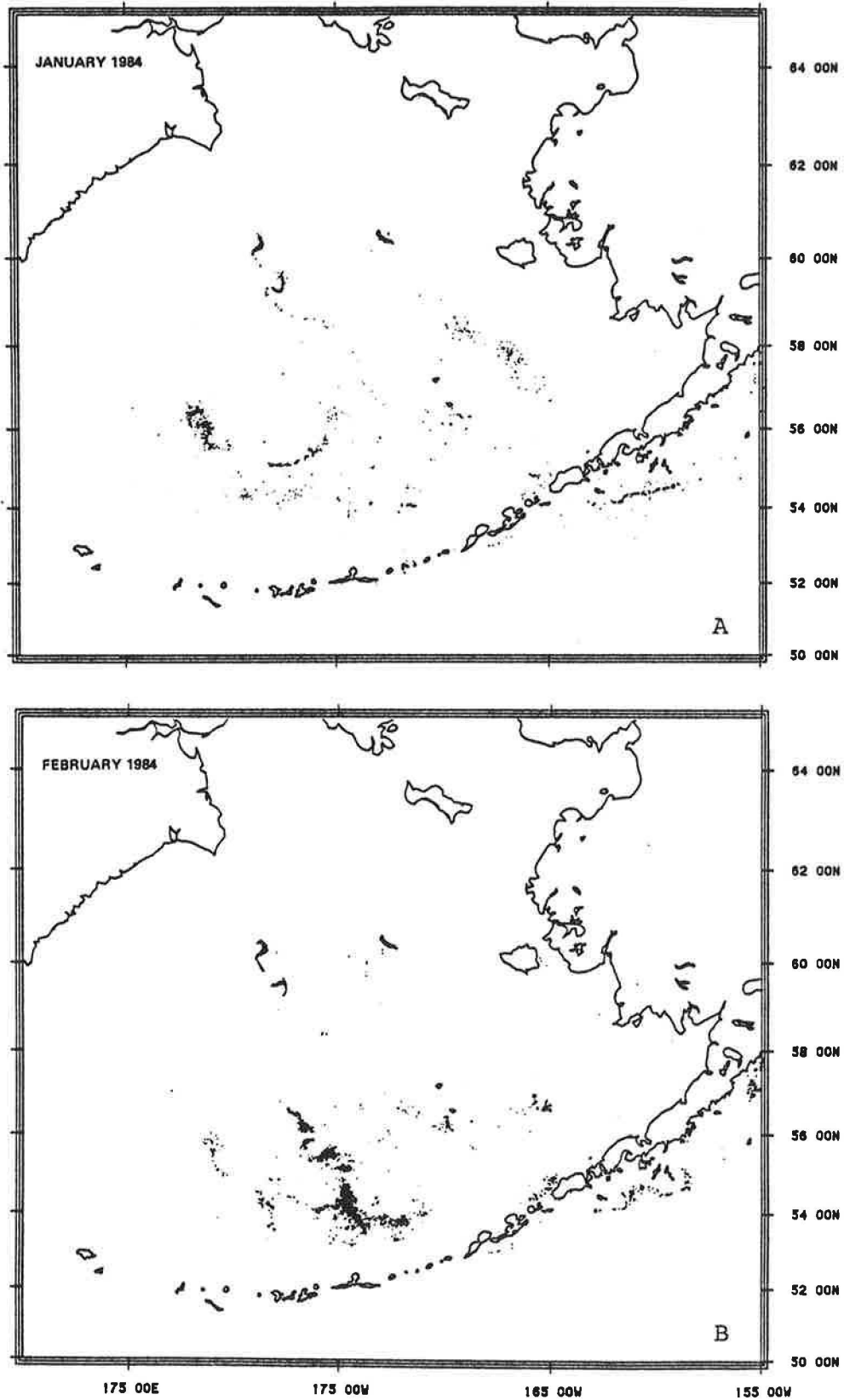


Figure 3.--Total distribution of fishing effort in 1984, by month.

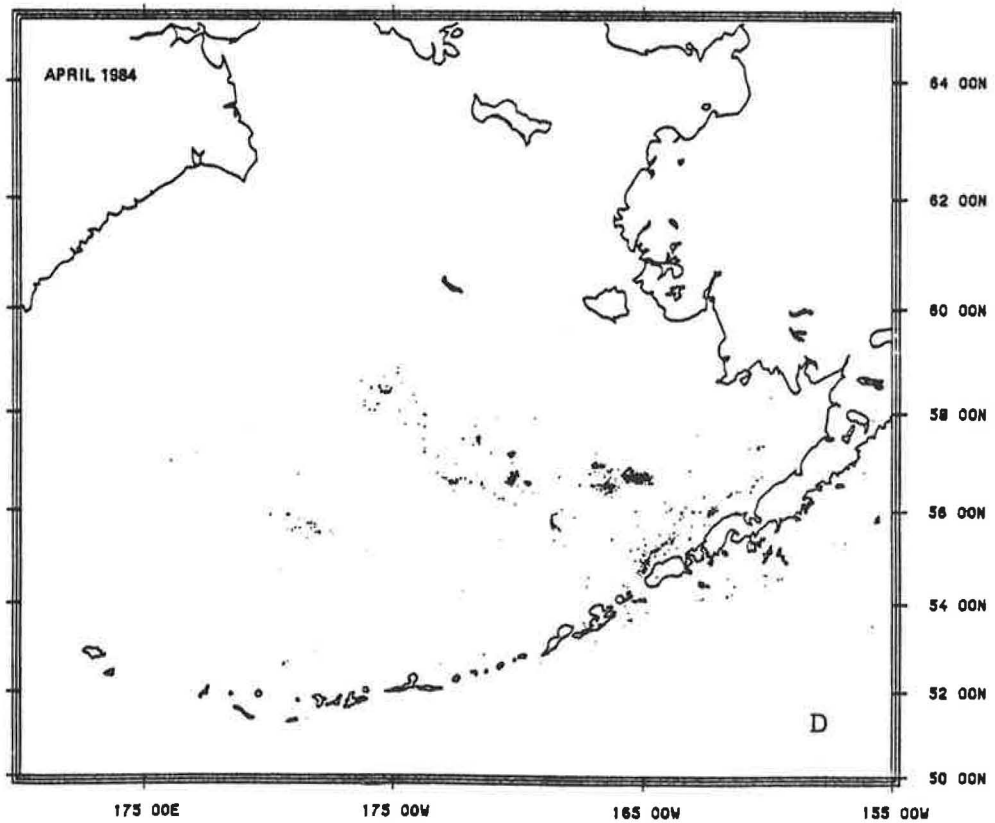
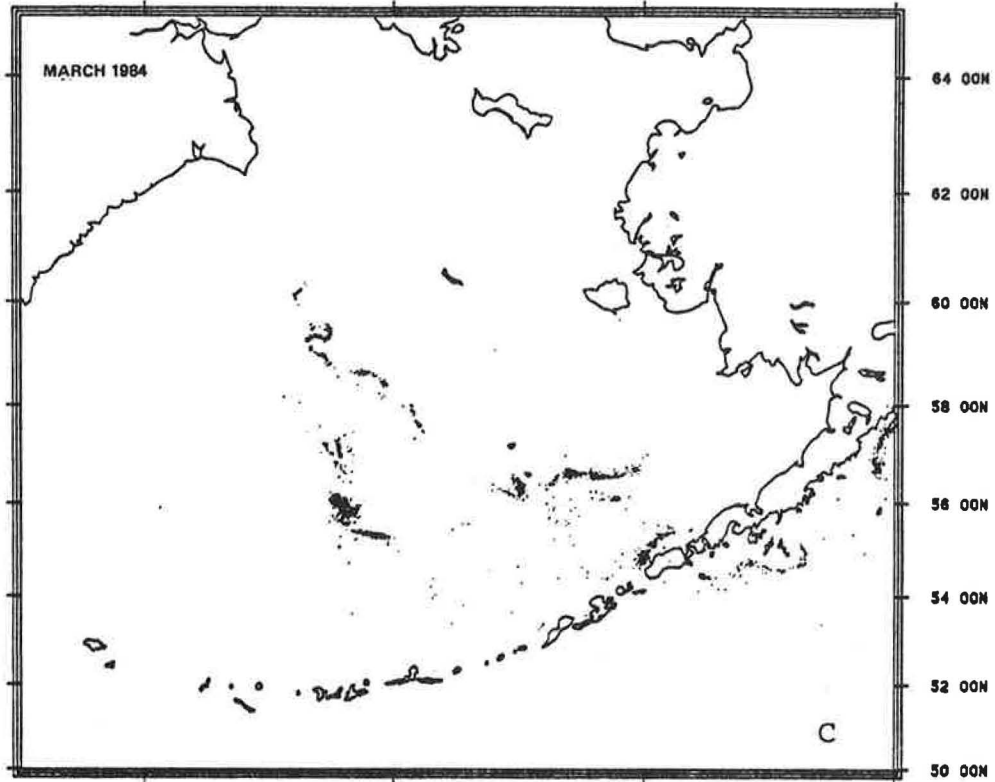


Figure 3(cont.)--Total distribution of fishing effort in 1984, by month.

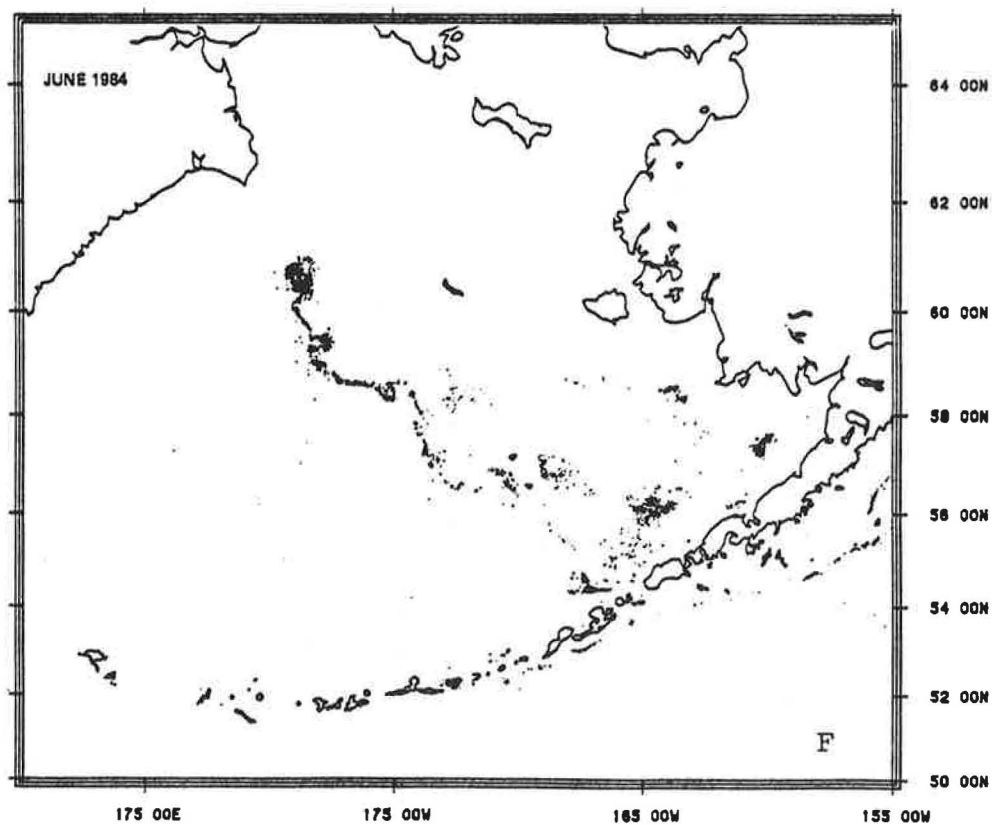
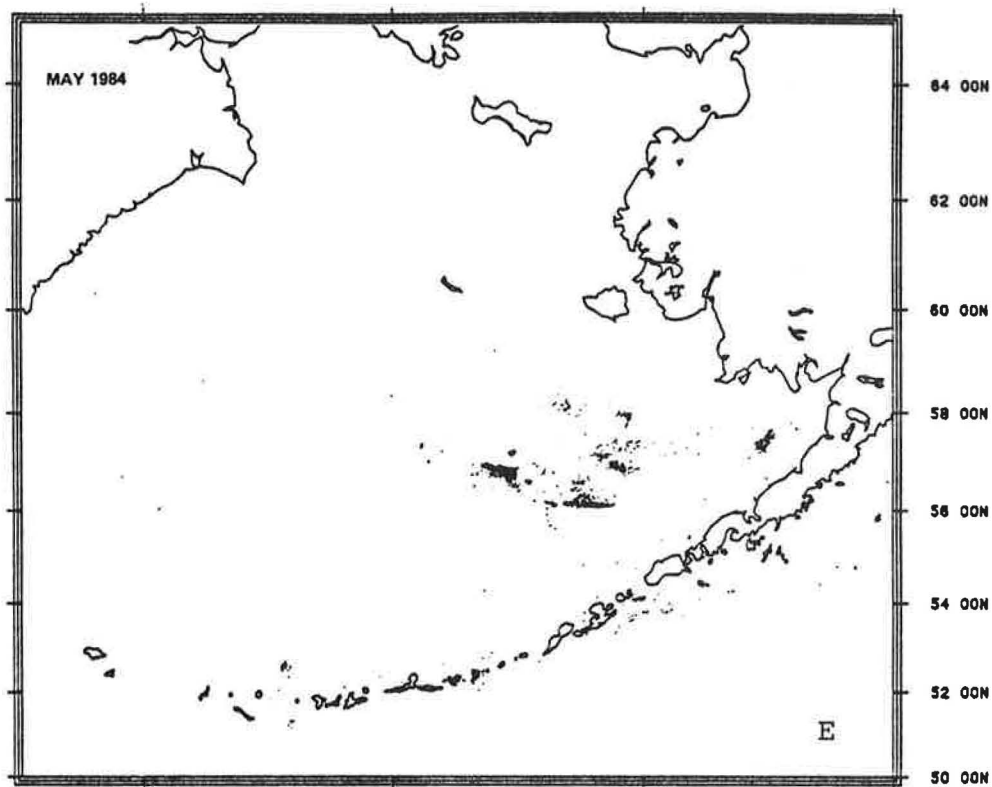
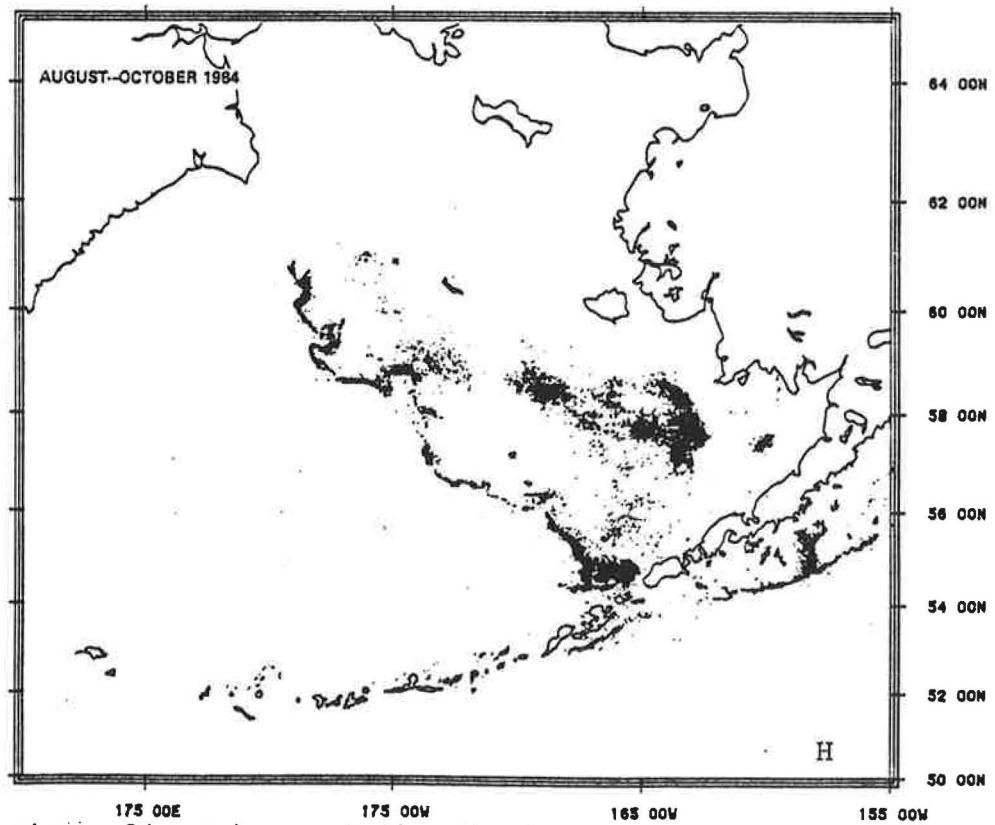
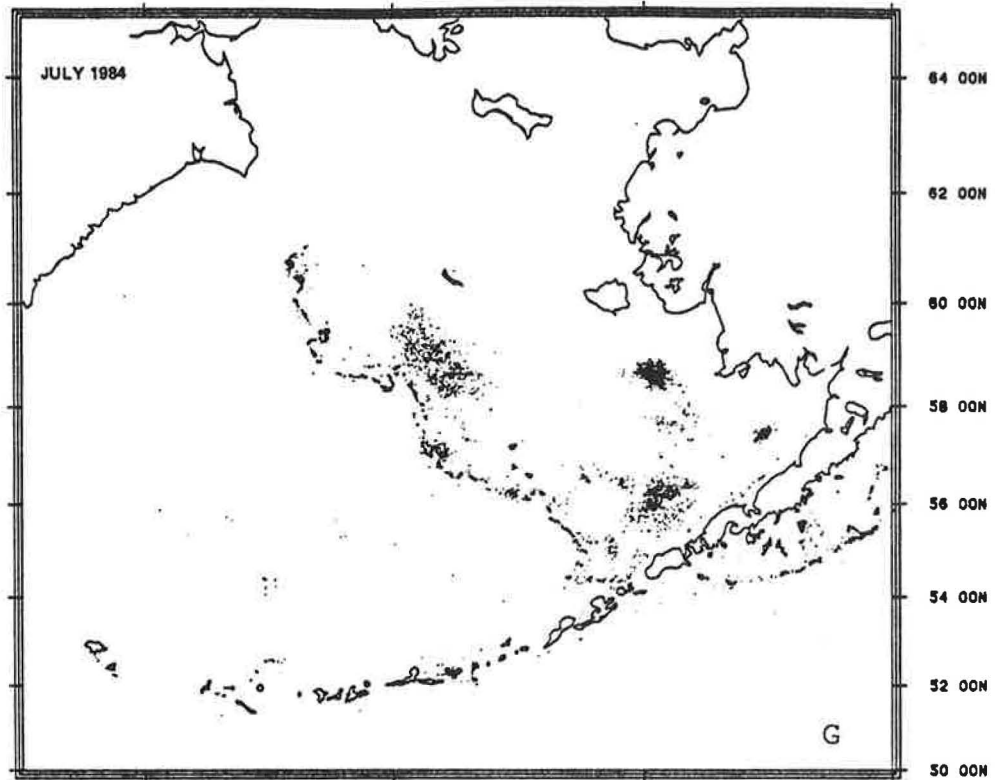


Figure 3(cont.)—Total distribution of fishing effort in 1984, by month.



175 00E      175 00W      165 00W      155 00W

Figure 3(cont.)—Total distribution of fishing effort in 1984, by month.

in June was probably the first to occur in this area. Coverage of the middle and inner shelf areas increased from April through October.

The fishing fleet was widely distributed throughout the spawning season, and probably detected most of the concentrations of spawning pollock (except for in May). The reports from observers probably reflect the true distribution of spawning for 1984.

#### DISCUSSION

In 1984, spawning pollock were seen in the Aleutian Basin from January through March, with the earliest concentrations found in the Bowers Bank region. Spawning moved to the central and southern part of the Basin in February, and to the north-central Basin in March.

From March through June, most of the spawning occurred in the southeastern part of the Bering Sea, over the continental shelf and slope. Concentrations were noted near Unimak Island in March and April, and spawning was scattered over most of the southeast region by June.

Spawning was also occurring to the north of the Pribilof Islands by June, confirming the hypothesis that spawning in this area occurs later than in the southeastern region. A concentration of spawning was observed in the area between the Pribilof Islands and St. Matthews Island from June through August, and scattered observations were made on the northwest slope as late as October.

The overall duration of the spawning season in the Bering Sea appears to be several months longer than was previously thought, extending from January to August, with small amounts of spawning occurring into the autumn months.

The water temperature at spawning depths ranged from  $-1.8^{\circ}$  to  $6.0^{\circ}$  C, a somewhat lower range than had been seen before, although the average temperature at locations of spawning was approximately  $2.0^{\circ}$  C. Spawning pollock may not be limited by the location of the  $2.0 - 3.0^{\circ}$  C isotherm as has been hypothesized (Nishiyama and Haryu 1981). The spawning that occurs at temperatures less than  $0.0 - 1.0^{\circ}$  C may be less successful, however, if recent laboratory estimates of the range within which normal development can occur (Hamai et al. 1971) are valid.

In other parts of its range, pollock are known to utilize well-defined spawning grounds (such as the Shelikof Strait; or bays, inlets and straits on the British Columbia coast) where spawning is completed in three to eight weeks. Pollock spawning in the Bering Sea, however, is prolonged, and the spawning grounds are not well defined. Over the broad time and area in which spawning occurs in the Bering Sea, it is most likely that concentrations of pollock are maturing at different rates due to varying feeding and environmental conditions, and that newly matured adults replace spent adults on the spawning grounds, which change in locations over time due to seasonal changes in environmental conditions (Hinckley 1986).



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