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REPORT OF JOINT NATIONAL MARINE FISHERIES SERVICE -
AMERICAN FISHERMEN'S RESEARCH FOUNDATION
ALBACORE STUDIES CONDUCTED DURING 1977

R. MICHAEL LAURS AND ROBERT N. NISHIMOTO

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INTRODUCTION

The National Marine Fisheries Service (NMFS) La Jolla Laboratory and the American Fishermen's Research Foundation (AFRF) have conducted cooperative albacore research studies from 1971 through 1977. These cooperative studies have been designed to obtain information to increase our understanding of the North Pacific albacore resource and to improve effective harvesting of the resource by U.S. fishermen. The joint NMFS-AFRF studies have been highly successful and have led to a number of significant findings.

As the result of the joint studies much has been learned about albacore migration patterns in North American coastal waters where the U.S. fishery normally takes place; and between the eastern and western North Pacific. Also, our understanding of the influence of ocean features on albacore has been greatly improved as the result of the joint studies. In addition, we have extended our knowledge concerning albacore biology, including growth and food habits.

The albacore fishing industry has also directly benefited from the joint studies. For example, commercial concentrations of fish have been located by AFRF charter boats during fishing seasons in areas away from where fleets of boats were operating, and when boats have responded they generally have made good catches. The charter boats have also demonstrated the lack of commercial concentrations of albacore in a number of areas during fishing seasons thereby saving search time and fuel costs for the fleet. Also, AFRF charter vessels operating in off-shore waters have shown that there is a potential for fishing there during some years prior to the time that the fishing usually starts along the U.S. west coast.

A great deal of the success of the joint NMFS-AFRF albacore studies has resulted from the outstanding cooperation received from albacore fishermen working with fishery scientists and the fishermen are acknowledged for their contributions.

This informal report is intended to provide albacore fishermen and other members of the albacore fishing industry with a summary of the operations and findings of the cooperative NMFS-AFRF albacore research studies carried on in 1977. Similar reports were prepared on findings of the 1971-1972, 1973, 1974, 1975 and 1976 joint studies.

ALBACORE SCOUTING AND RESEARCH ACTIVITIES, 1977 SEASON

Cooperative NMFS-AFRF albacore scouting and research activities were conducted in nearshore waters during 1977 for the third consecutive albacore fishing season. The purposes of the study were 1) to locate commercial concentrations of fish for the fishing fleet, 2) to conduct tagging operations for the study of the movements of albacore, and 3) to make oceanographic observations for evaluation of the influence of oceanographic conditions on variations in the availability of albacore.

CRUISE OPERATIONS

Three jigboats and one baitboat on charter to AFRF participated in the fish scouting/research operations during the 1977 season. The charter operations commenced on June 14 and terminated on September 25. Jig vessels generally spent a total of 70 days at sea divided into three 20-25 day periods with intervening 5-day port calls for reprovisioning. The baitboat was chartered for a 2-month period from July 11 to September 12.

The fishing vessels and their captains that participated in the 1977 within-season survey were:

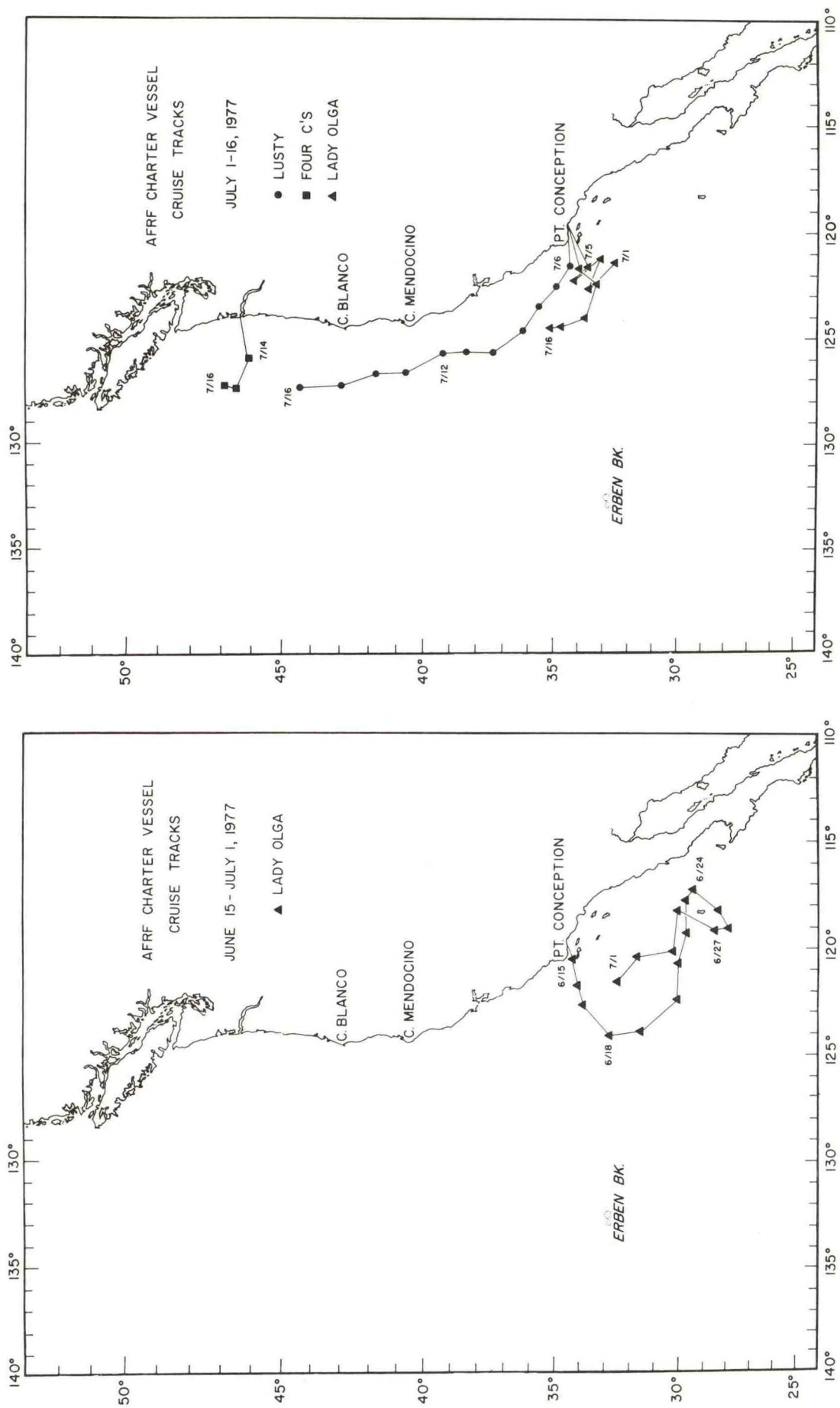
<u>Fishing Vessel</u>	<u>Captain</u>	<u>Date</u>
<u>Lady Olga</u>	Brent Bixler	June 14 - August 29
<u>Linda</u>	Scotty Hazelton	July 11 - September 12
<u>Lusty</u>	Ken Houser	July 5 - September 21
<u>Four C's</u>	Warren Wood	July 13 - September 25

The vessels on charter to AFRF 1) conducted fish scouting, 2) kept detailed fishery logs, 3) made oceanographic observations including surface and subsurface temperature measurements, and surface ocean condition observations, 4) made surface weather observations, and 5) conducted albacore tagging operations aboard the Linda.

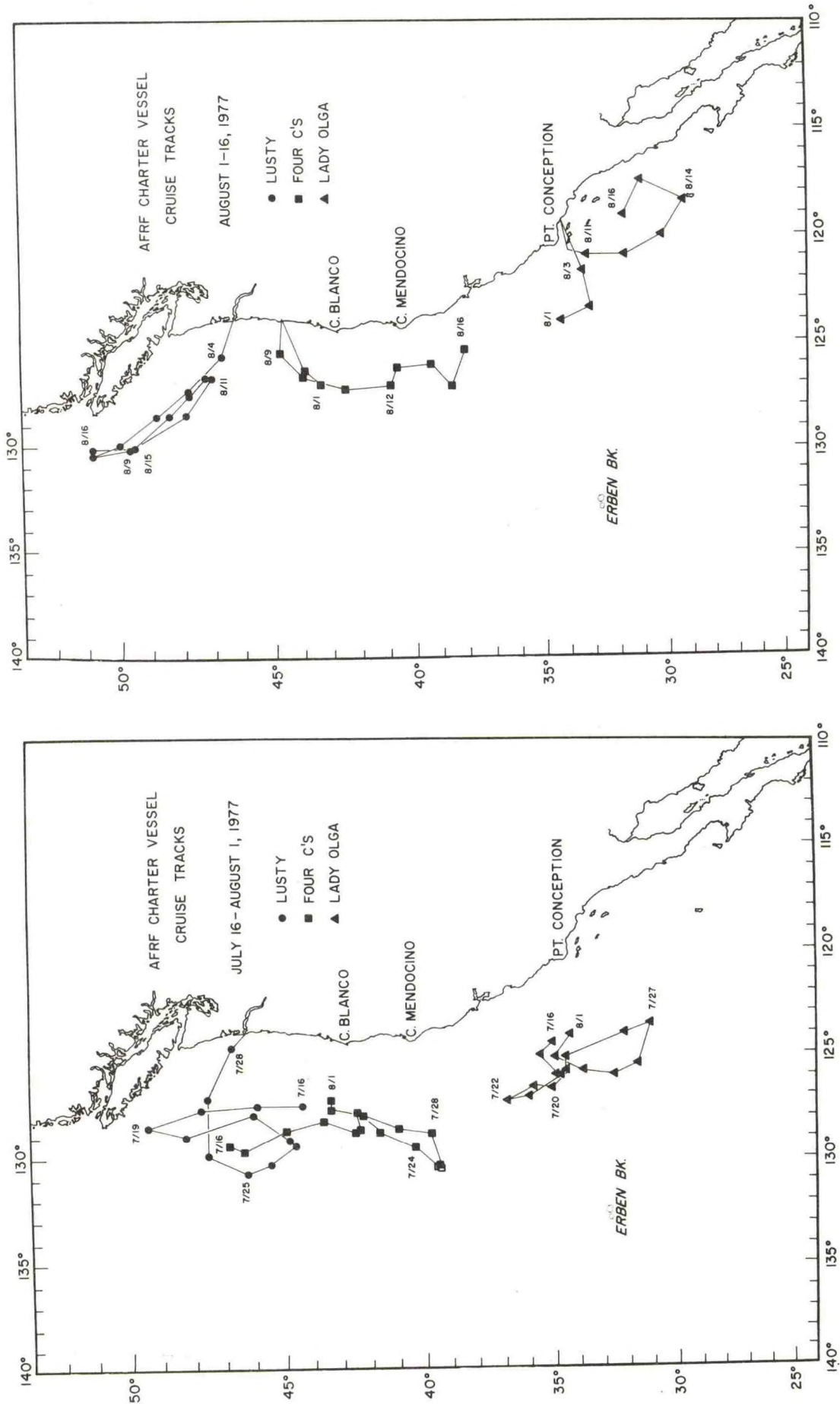
In general, the charter boats operated in areas away from the albacore fleet in waters from Guadalupe Island to the northern tip of Queen Charlotte Islands. Detailed vessel cruise tracks for the charter vessels for various time periods are given in Figures 1a to 1g. The vessels reported their fishing activities to AFRF, NMFS and interested fishing vessels twice daily.

FISHING RESULTS

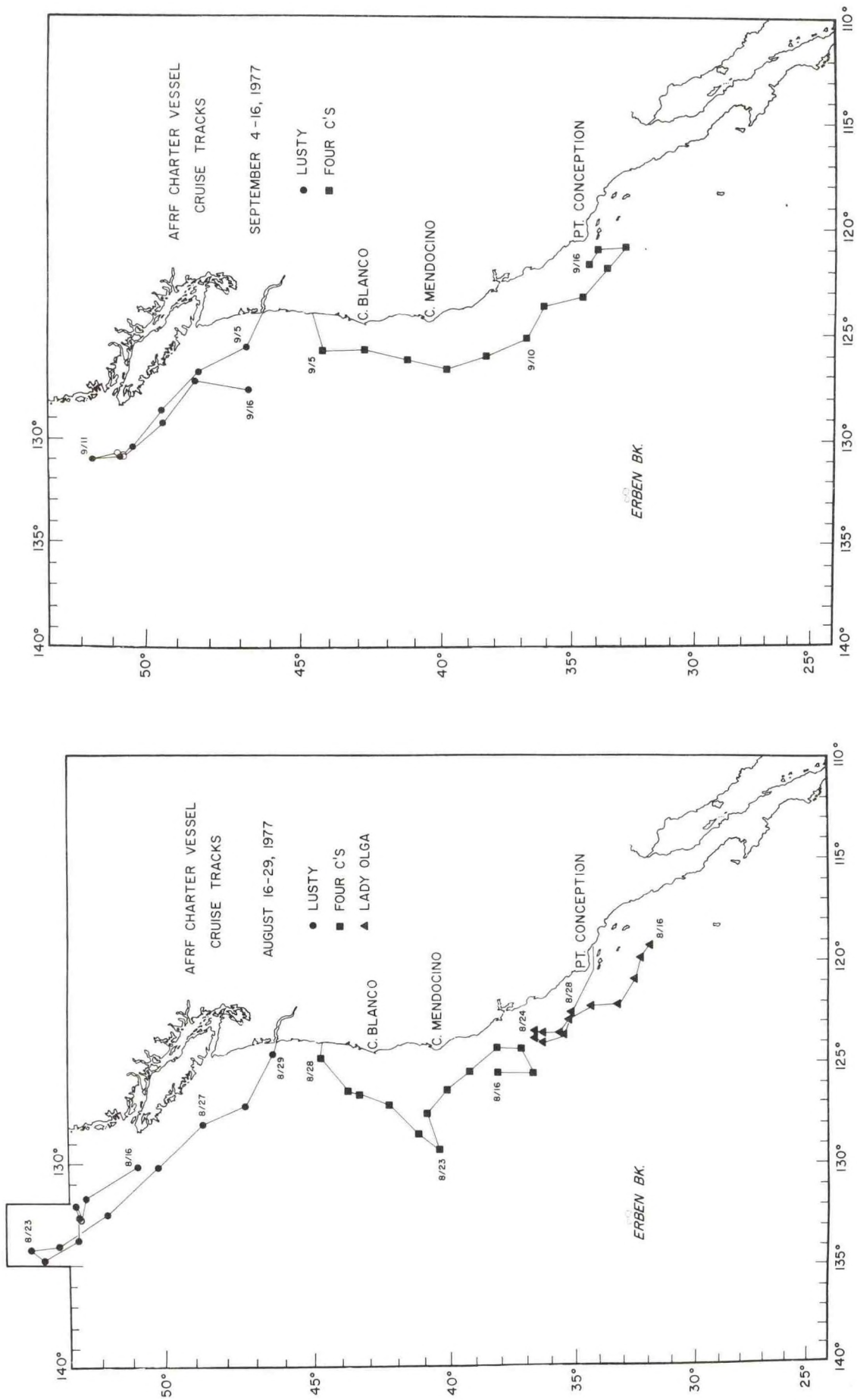
The standardized catches made by the AFRF charter vessels are shown plotted on charts by 15-day time periods in Figures 2a to 2g. In these figures the daily catch for each vessel has been standardized and expressed as the number of fish caught per 150 line-hours, and shown graphically by proportionately increasing size of dots; x's indicate no catch was made. The distribution of sea surface temperature is shown as a contour field on each figure. The contours were derived from temperatures measured by the fishing vessels and augmented by the 15-day sea surface temperature charts published by the NMFS La Jolla Laboratory.



Figures 1a-1b. AFRF charter vessel cruise tracks for stated time periods. Symbols indicate morning positions.



Figures 1c-1d. AFRF charter vessel cruise tracks for stated time periods. Symbols indicate morning positions.



Figures 1e-1f. AFRF charter vessel cruise tracks for stated time periods. Symbols indicate morning positions.

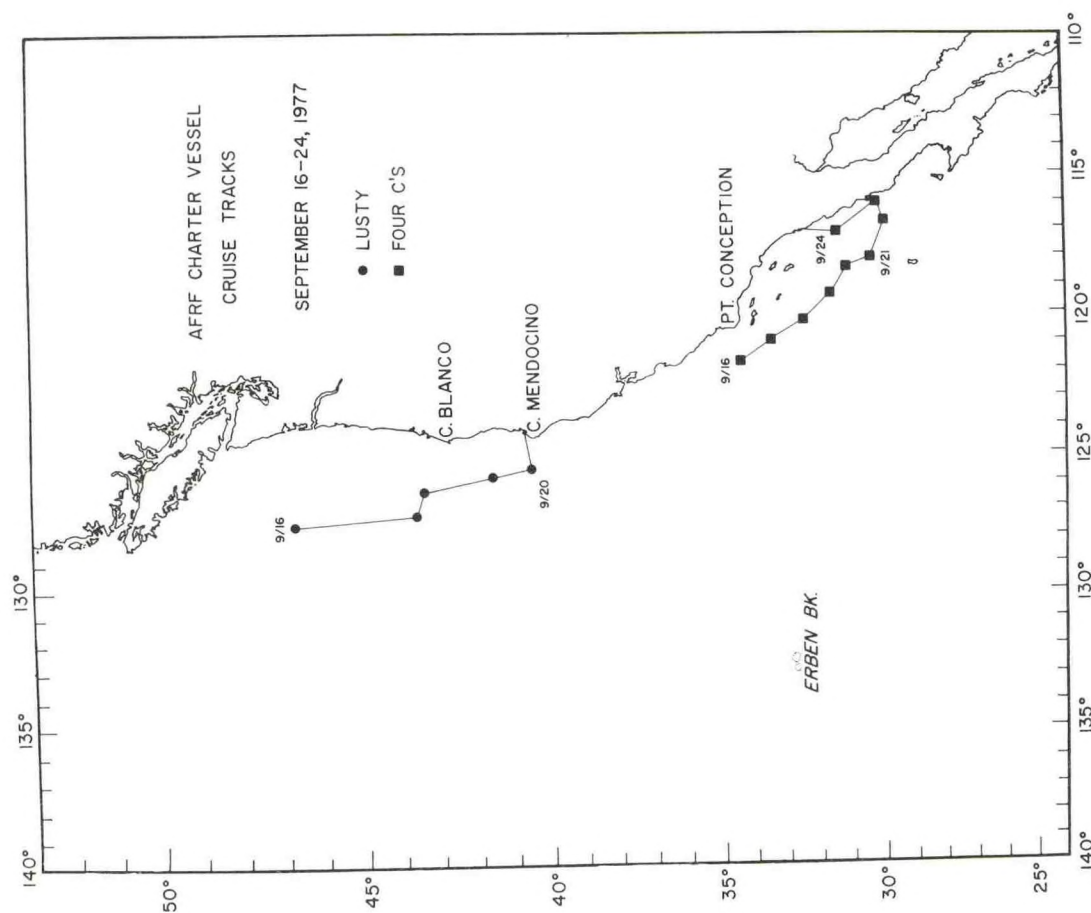
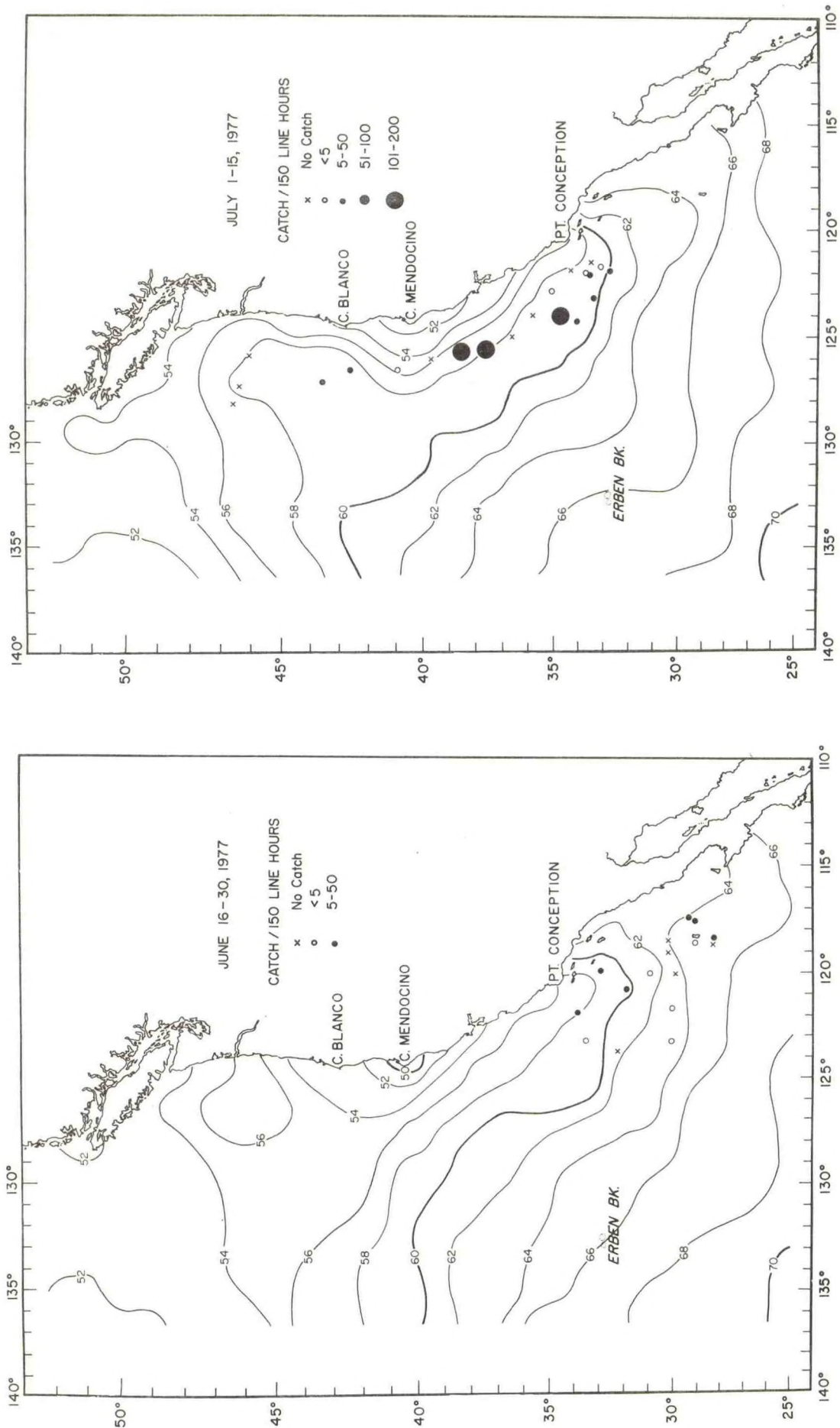
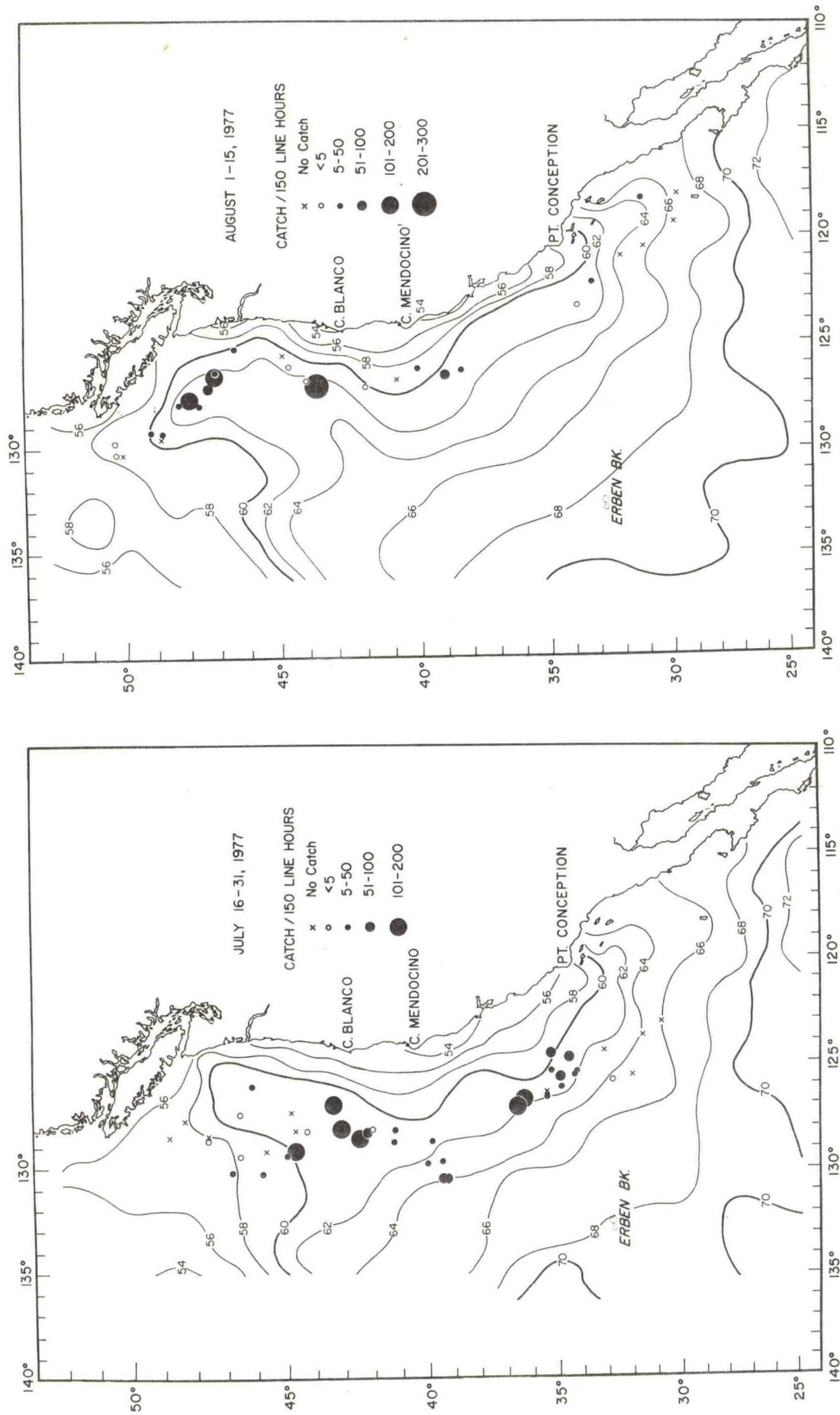


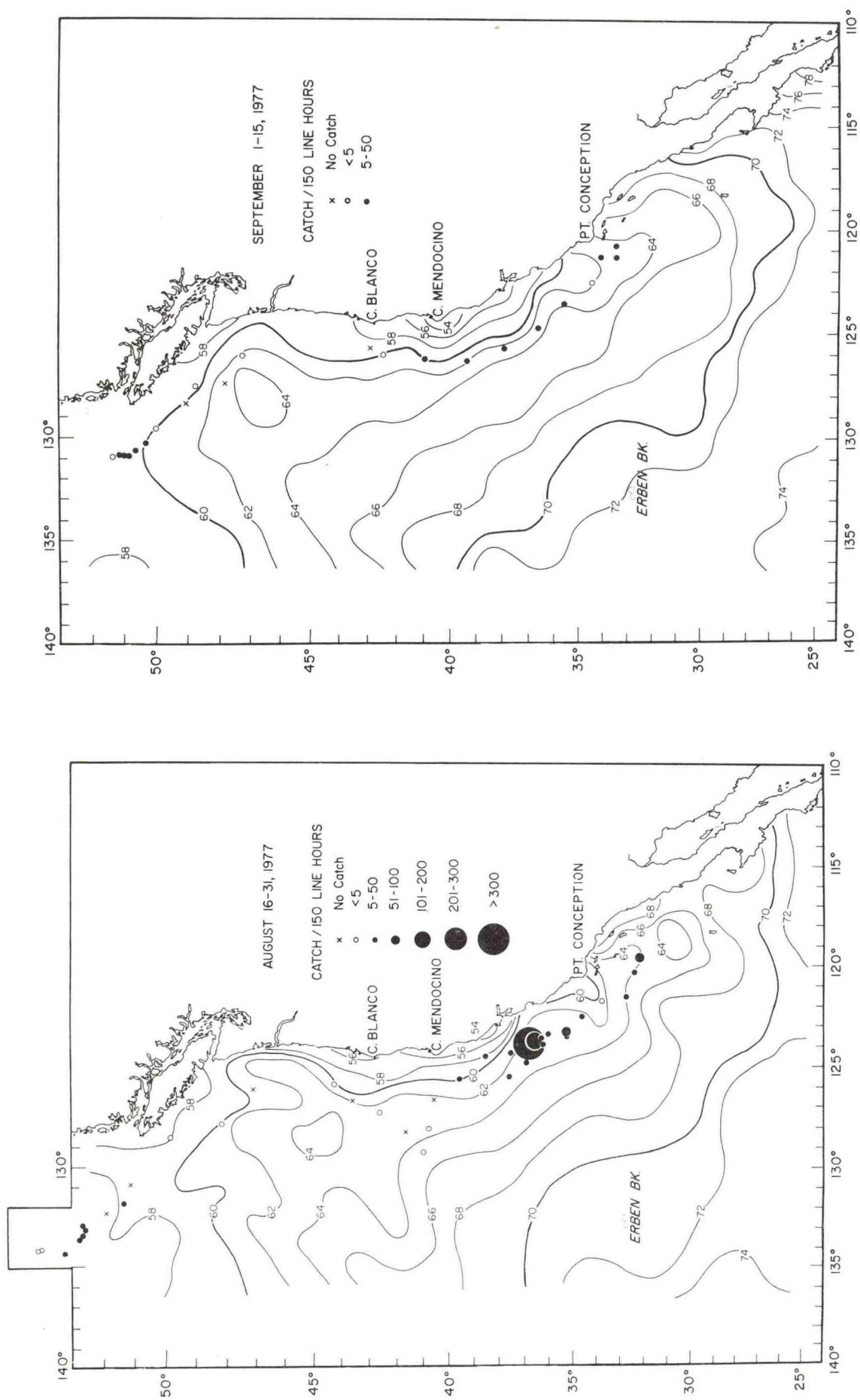
Figure 1g. AFRF charter vessel cruise tracks for stated time periods. Symbols indicate morning positions.



Figures 2a-2b. AFRF charter vessel catch standardized to 150 line-hours with sea surface temperature for stated times.



Figures 2c-2d. AFRF charter vessel catch standardized to 150 line-hours with sea surface temperature for stated times.



Figures 2e-2f. AFRF charter vessel catch standardized to 150 line-hours with sea surface temperature for stated times.

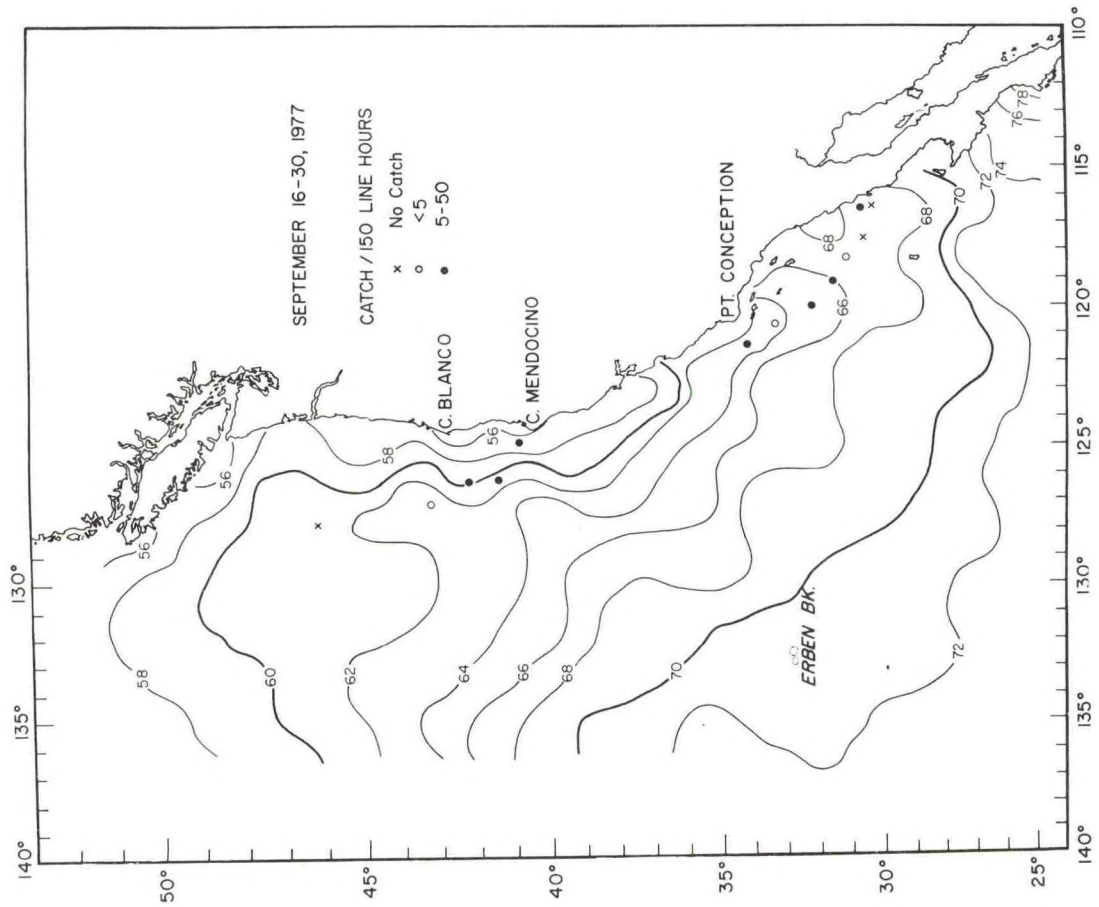


Figure 2g. AFRF charter vessel catch standardized to 150 line-hours with sea surface temperature for stated times.

DISCUSSION

During the 1977 season the charter vessels provided very complete fish scouting coverage of coastal waters from Guadalupe Island to the Queen Charlotte Islands. Reports received from a number of fishermen indicate that interest was high in the albacore fleet in the findings made by the charter vessels, and that findings made by the charter vessels were often used in making tactical fishing decisions.

The charter vessels did not locate any "bonanza" fishing areas this year as had occurred in the charter surveys in past years. However, there were a number of times when boats were called into areas that produced consistent catches for several to many days.

For example, the Four C's made good catches in the vicinity of the Jackson Seamount during the third week of July and a number of boats moved into the area to make substantial catches for several days. The Four C's also located albacore in commercial concentration about 300 miles off Fort Bragg during the fourth week of July. The Four C's successfully scouted albacore again during the first week in August over a large area about 120 miles offshore between Coos Bay and Newport. This find resulted in a large number of boats working out to the area and making good catches for a number of days. The Lady Olga found albacore 90 miles off Monterey which drew a fleet of boats in the fourth week of August, and this area produced good catches of fish for a number of days. The Lady Olga also located fish about 200 miles off Pt. Arguello early in the third week of July that resulted in catches being made by other boats drawn to the area. During the second week in August,

the Lusty located a body of fish 120 miles off Destruction Island and both jigboats and baitboats moved into this area where good catches were made for a number of days.

The charter vessels found no commercial concentrations of albacore in several large areas even after considerable search. At various times, negative reports made by the charter vessels saved boats from moving into unproductive areas, thereby saving search time and effort.

In summary, the 1977 AFRF charters appear to have been worthwhile and beneficial to the U.S. albacore fishing fleet in that 1) they located commercial concentrations of fish during the season away from where the fleet was operating and when boats responded, they generally made good catches, and 2) they demonstrated the lack of commercial concentrations of fish in a number of areas thereby saving search time and fuel costs for the fleet.

JOINT NMFS-AFRF ALBACORE TAGGING STUDY

The purposes of the joint NMFS-AFRF albacore tagging study are to 1) examine the migration patterns of North Pacific albacore and 2) obtain information on growth and mortality for use in population studies.

METHODS

The methods employed during the 1977 tagging operations were similar to those used in past years. About one-half of the fish were caught on jigs and one-half on live bait. Great care was exercised to tag and release only

fish judged to be in prime condition. Fish that showed signs of severe bleeding, were hooked through the roof of the mouth, or showed signs of extreme exhaustion were not tagged. As soon as a prime-condition fish was brought aboard, the fork length was measured, then it was tagged with a single spaghetti-dart type tag and released. For each fish tagged and released, records were kept of the number of the tag, the date and time of tagging, the length of the fish, condition of the fish, and sea surface temperature. About 13% of the fish caught by jigboats were judged in good enough condition to be tagged and released. All tagging aboard jigboats was carried out by fishermen.

A special tagging study was conducted aboard the baitboat Linda while operating south-southwest of San Diego. Fish were tagged with special red tags and injected with a small dose of the antibiotic tetracycline which is incorporated into bones and which will fluoresce when bones are viewed under ultra-violet light. The tetracycline thus "marks" the ear bones (otoliths) of the fish which are used to study fish age and growth. Two NMFS technicians were placed aboard the Linda to conduct the special tagging study operation.

LOCATION OF TAGGING

A summary by 1° square of the number of albacore tagged and released in 1977 is shown in Figure 3. Tagging during 1977 was spread along the entire coast from Guadalupe Island to the southern portion of the Queen Charlotte Islands with most tagging taking place off northern Baja California.

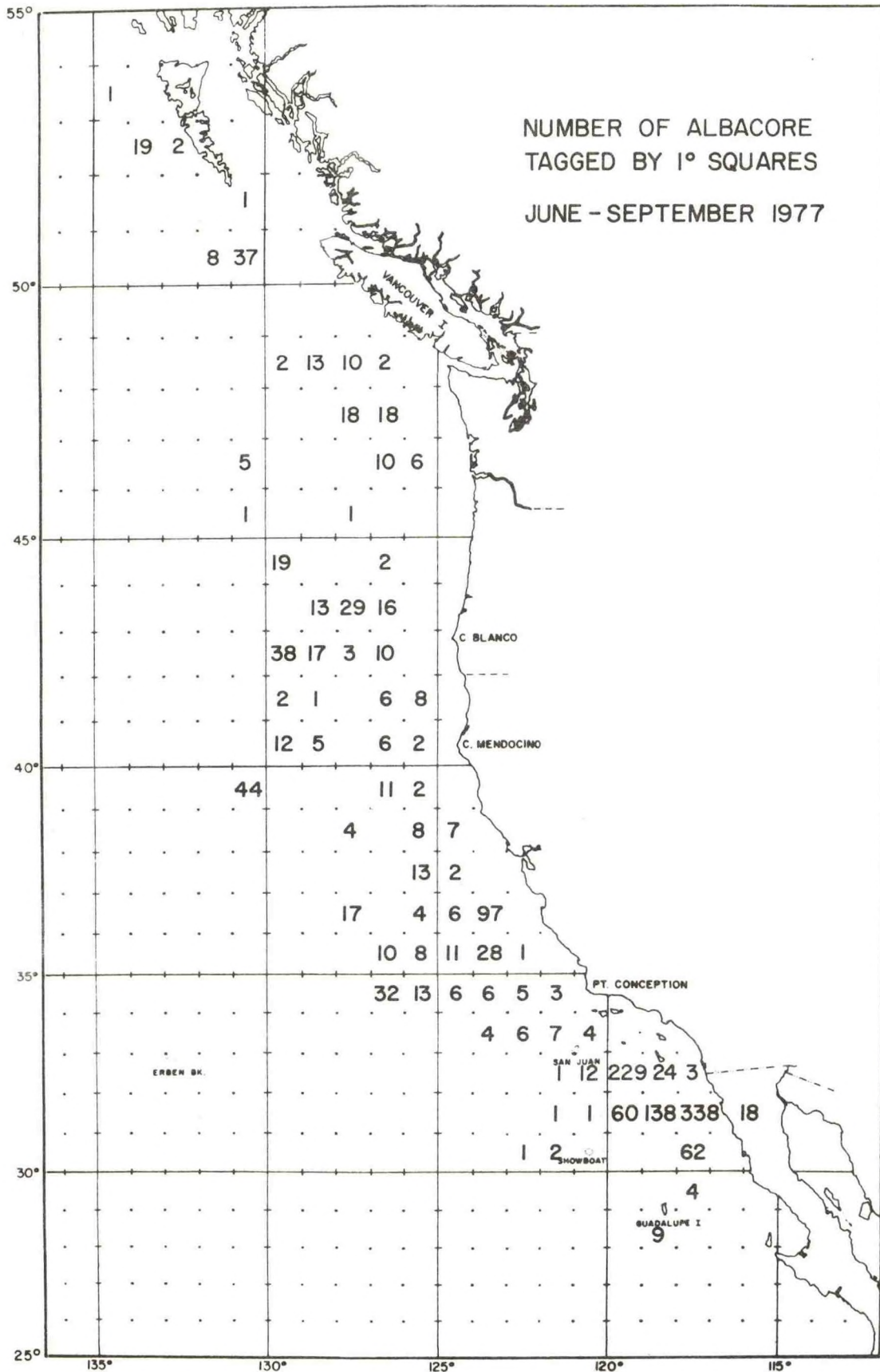


Figure 3. Summary by 1° square of number of albacore tagged and released during joint NMFS-AFRF tagging study, 1977.

A summary by 1° square of the total number of albacore tagged and recovered during the NMFS-AFRF tagging project from October 1971 to October 1977 is shown in Figure 4. The amount of tagging and areal coverage is impressive. However, some void areas are apparent off northern California and the Pacific Northwest.

SIZE OF FISH TAGGED AND RELEASED

Fish tagged and released during 1977 fell into three size groups ranging between 50-55 cm (estimated weight 6-8 pounds), 62-68 cm (estimated weight 11-14 pounds) and 75-78 cm (estimated weight 18-22 pounds). About five times as many fish in the 62-68 cm size group were tagged than in the 50-55 cm or 75-78 cm groups.

Comparisons of Figures 5a and 5b show that the sizes of the fish tagged and released were in the same proportions as the total fish caught. Similar results have been observed in all other years of the NMFS-AFRF tagging project and indicate that there was little bias in size of fish tagged and released.

NUMBER OF FISH TAGGED AND RELEASED

A total of 1,787 albacore was tagged and released during the 1977 charter operations. Nearly 12,000 fish have been tagged and released since the start of the joint NMFS-AFRF albacore tagging study. A summary, by year, of the number of fish tagged and released, recovered, and percent recovery, are given in Table 1.

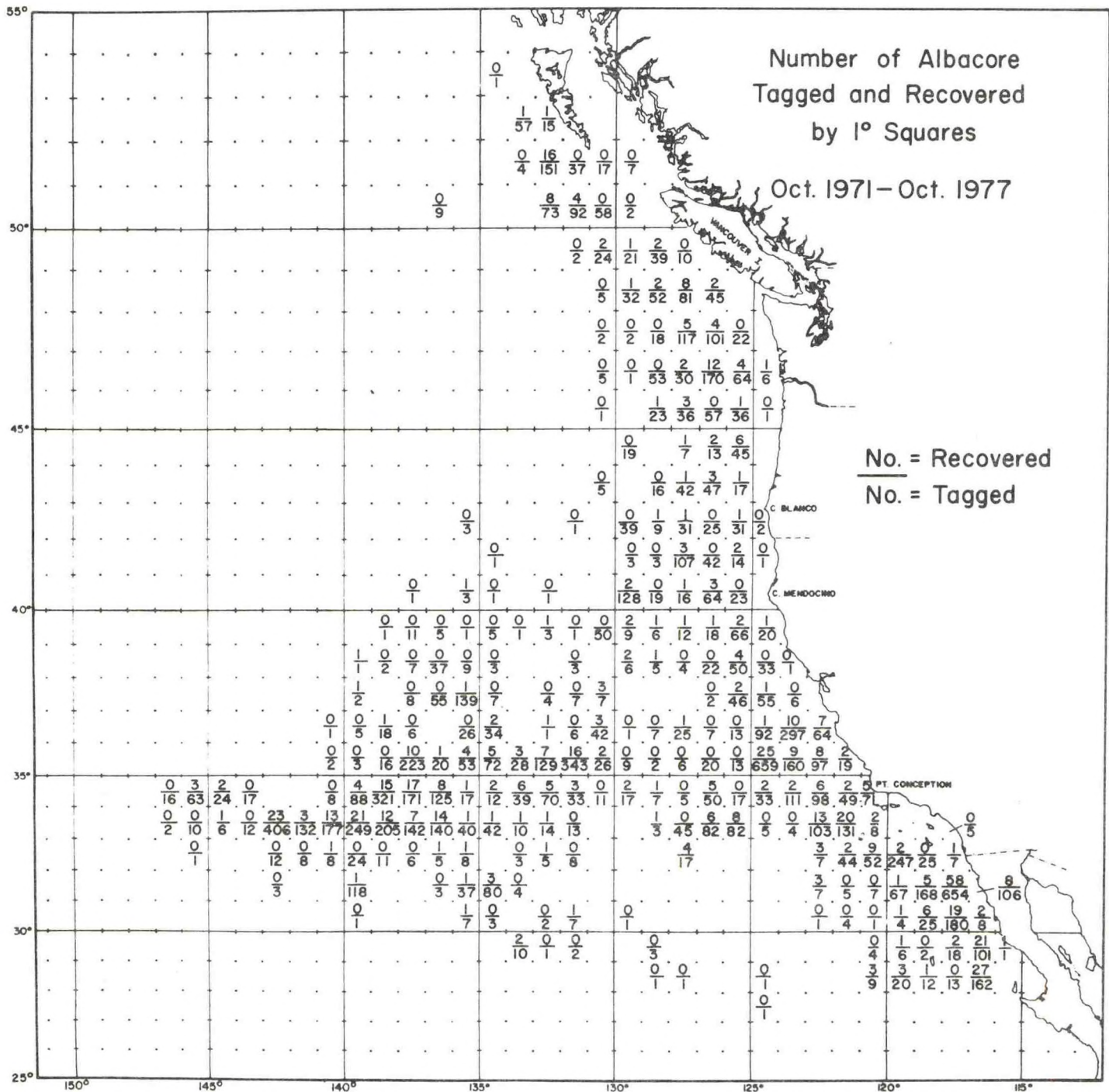


Figure 4. Summary by 1° square of total number of albacore tagged and recovered during NMFS-AFRF tagging project, 1971-1977.

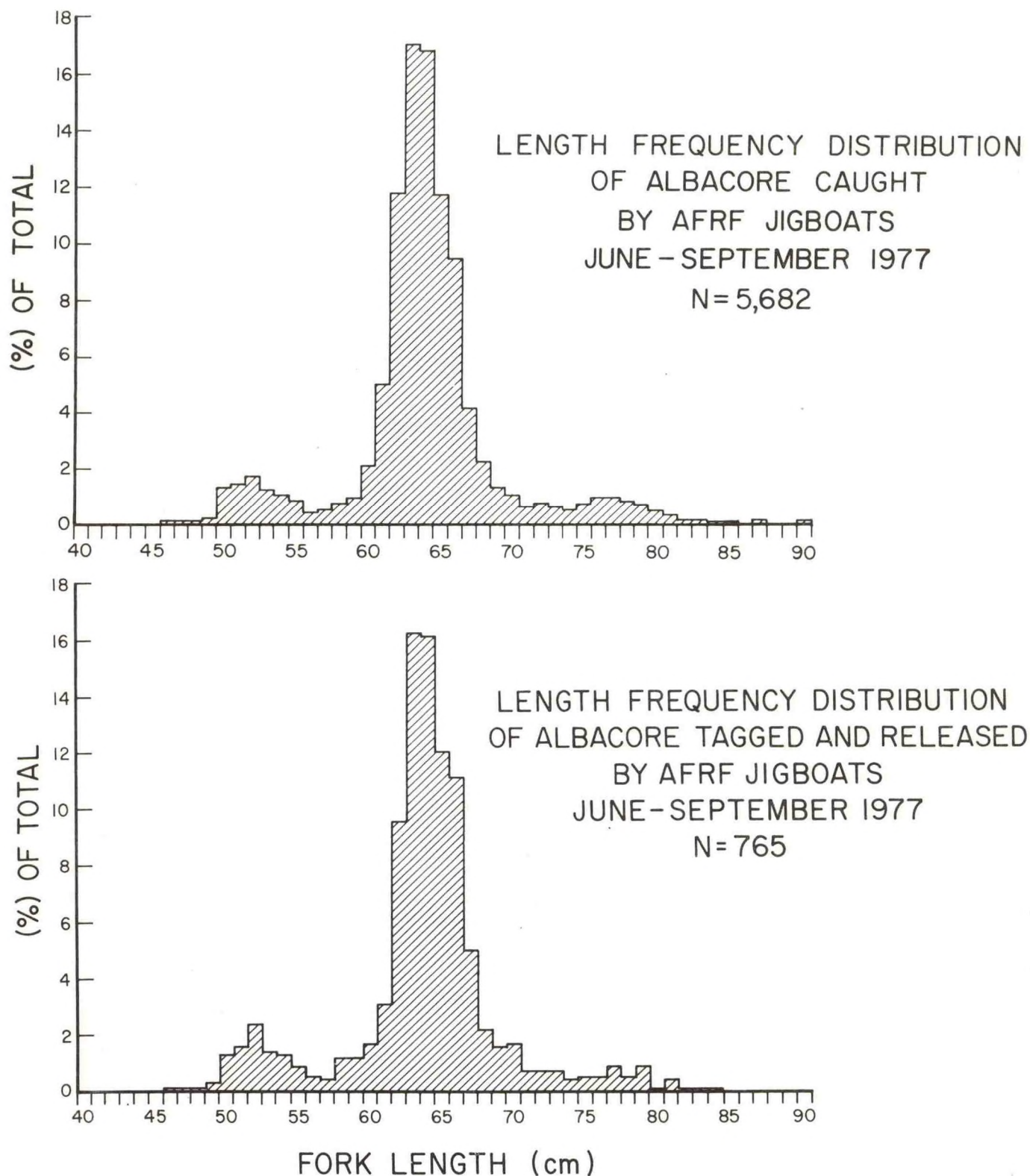


Figure 5. Length frequency distribution of a) total albacore caught by AFRF jigboats inshore, and b) albacore tagged and released inshore during NMFS-AFRF cooperative study, June - September 1977.

Table 1. Summary by year of number of albacore tagged and released, recovered, and percent recovery for joint NMFS-AFRF albacore tagging program.

Year	Number of tagged fish released	Number of tagged fish recovered	Percent recovery
1971	887	33	3.7
1972	2,082	180	8.6
1973	1,807	110	6.1
1974	2,490	171	6.9
1975	1,351	115	8.5
1976	1,526	51	3.3
1977	1,787	36	2.0
Unknown	+	1	-
Total	11,930	697	5.8

NUMBER OF TAG RECOVERIES

During 1977 (up to October 15), 79 tagged albacore were recovered: 40 by U.S. commercial boats, 31 by U.S. sportboats, 6 by Japanese baitboats, 1 by Japanese longliner, and 1 by Japanese gill netter. Of the 79 recoveries, 1 was from a fish tagged in 1973, 6 were from fish tagged in 1974, 11 from fish tagged in 1975, 24 from fish tagged in 1976, 36 from fish tagged in 1977, and 1 unknown. See Table 2 for a summary of the number of tagged fish recoveries made by year and breakdown by the year that recovered fish were tagged and released.

Table 2. Summary of albacore tagged and released and recovered by years¹.

Year released	Year recovered						
	1971	1972	1973	1974	1975	1976	1977
1971	0 ²	15	11	6	0	0	0
1972	-	78	71	21	2	5	0
1973	-	-	13	61	33	1	1
1974	-	-	-	36	75	53	6
1975	-	-	-	-	18	84	11
1976	-	-	-	-	-	28	24
1977	-	-	-	-	-	-	36

¹ There have been eight recoveries made for which the year of recovery or year of tagging is unknown.

² Tagging done in October 1971 near end of season.

As of October 15, 1977, a total of 697 tagged fish has been recovered: 453 by U.S. commercial boats, 93 by U.S. sportboats, 135 by Japanese baitboats, 12 by Japanese and 1 by Korean longliners, 1 by Japanese purse seiner, 1 by Japanese gill netter and 1 by Mexican purse seiner.

The overall recovery rate of fish tagged is 5.8%. See Table 1 for the percent recovery rate for each year.

1977 RECOVERIES OF TAGGED ALBACORE

Recoveries Made by U.S. Boats of Fish Tagged in 1977

There were 36 recoveries made of fish tagged and released during 1977. Figure 6 shows the locations where fish were released in 1977 and the location where recoveries were made with symbols indicating the month of recapture. All the fish recovered were tagged and released in inshore waters off northern

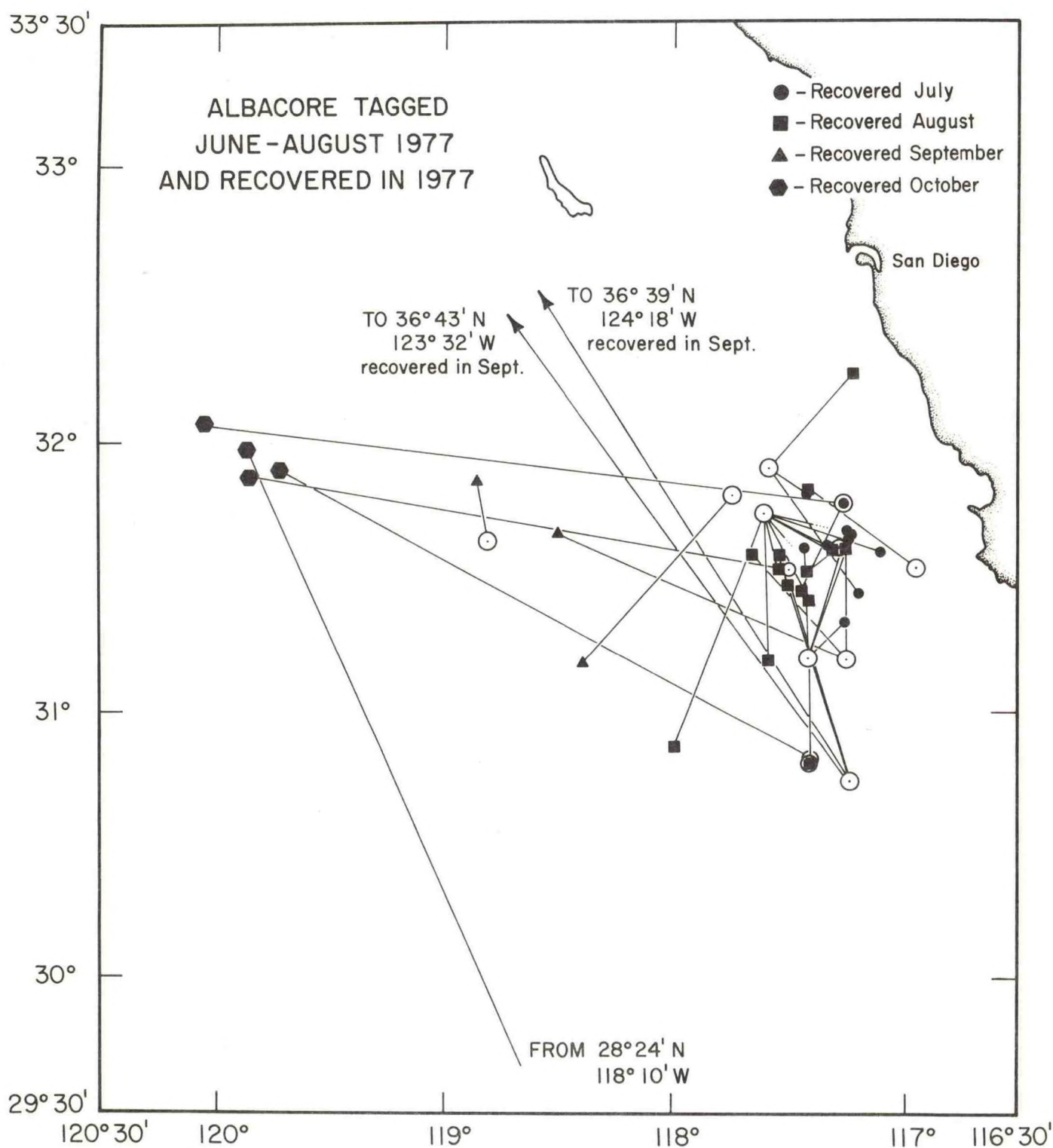


Figure 6. Recoveries of fish tagged and released during 1977 and re-
covered in 1977. Circle indicates location where fish was
tagged and released and symbol indicates month of recapture
as indicated in figure legend.

Baja California mainly in the same latitudinal zone where releases were made. Recoveries made in July and August (shown by circles and squares, respectively, in Figure 6) showed that some fish moved north, some moved south, and some moved inshore from where they had been tagged, but none moved more than a few miles offshore from where they had been tagged. The fish recovered in September and October showed a progressive offshore movement from where they had been tagged, with October recoveries (shown by hexagons in Figure 6) being made farther offshore than September recoveries (shown by triangles in Figure 6). The close pattern of the October recoveries from fish which were tagged relatively far apart suggests that fish schools moving offshore in October were following a rather well-defined migration route.

Recoveries Made by U.S. Boats of Fish Tagged and Released in 1974, 1975 and 1976

The locations of where fish were tagged and released in 1976 and in 1975 and 1974 and recovered in 1977 are shown in Figures 7 and 8, respectively. There were 24 recoveries made in 1977 of fish tagged in 1976 (see Figure 7). All of these recoveries were made south of Cape Mendocino. Two of the fish were tagged in offshore waters between 31° - 34° N, 138° - 139° W in 1976 and recovered in inshore waters southwest of San Diego. Twenty of the fish were tagged in inshore waters between Guadalupe Island and Pt. Arena and recovered in inshore waters, many of them only a short distance from where they had been released the year before. There were 10 recoveries made in 1977 of fish tagged in 1975 (see Figure 8). Eight of these were released between

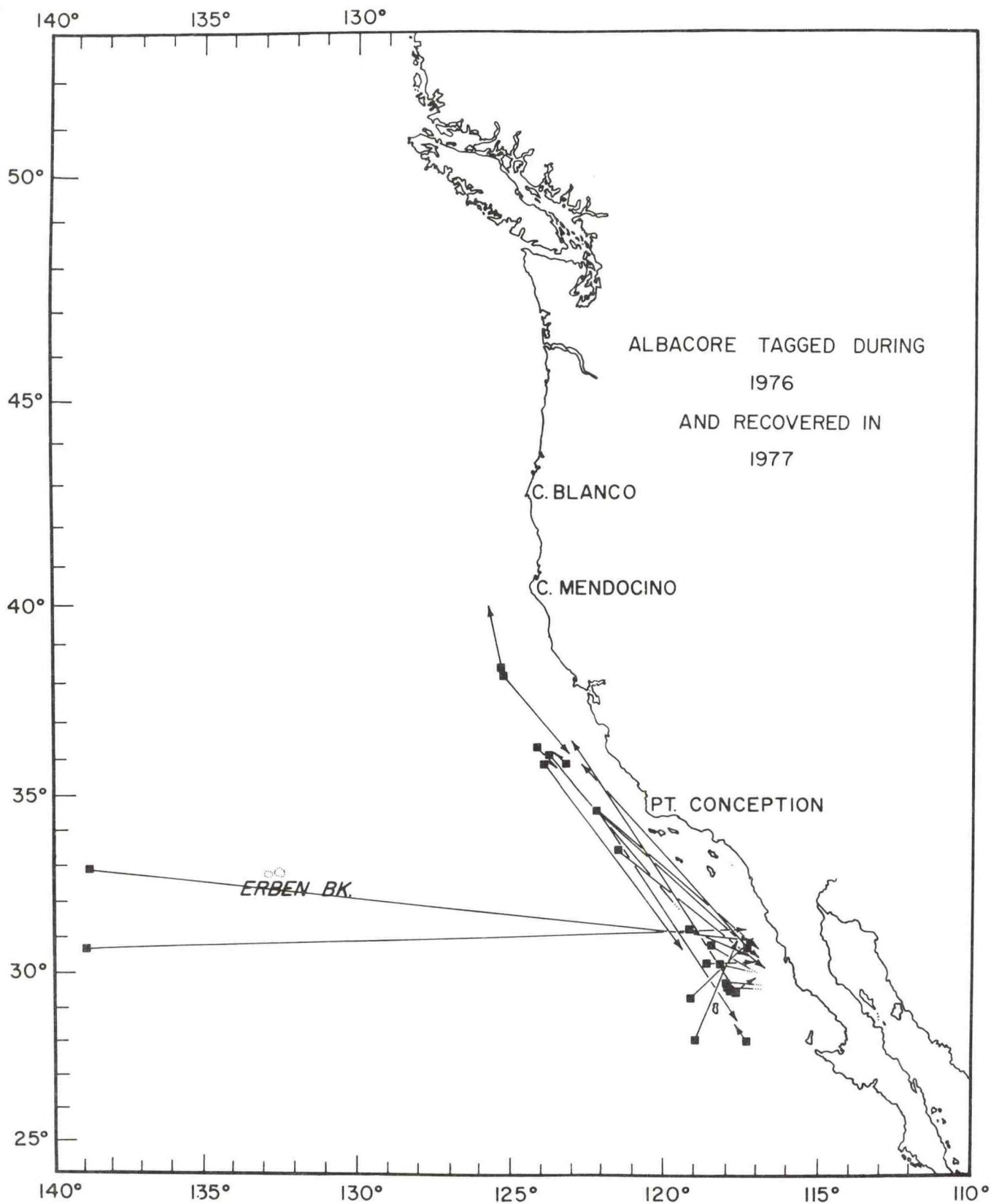


Figure 7. Recoveries of tagged albacore made in 1977 of albacore tagged and released in 1976. Dots indicate location where fish was tagged and released and tip of arrow indicates where fish was recovered.

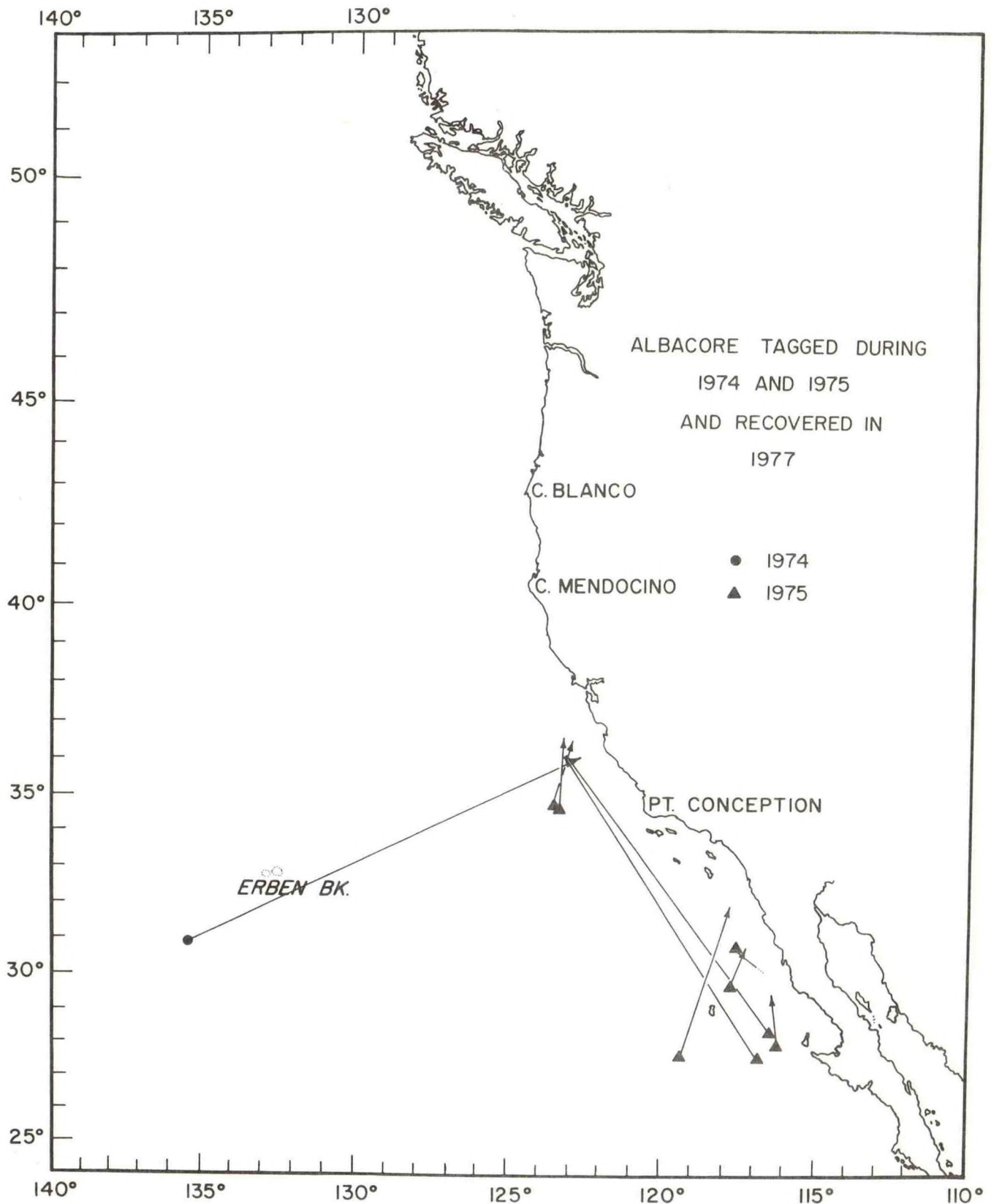


Figure 8. Recoveries of tagged albacore made in 1977 of albacore tagged and released in 1975 and 1974. Dots indicate location where fish was tagged and released and tip of arrow indicates where fish was recovered.

Guadalupe Island and Cape Colnett and recovered two seasons later within a couple hundred miles of where they were released. Two of the fish were released off Avila in 1975 and recovered off Pigeon Point in 1977. There was one recovery made in 1977 off Santa Cruz of a fish tagged and released southwest of Erben Bank in 1974.

The recoveries made in 1977 of fish that had been tagged in 1974, 1975 and 1976 show that fish that were in the southern fishing region during the year of tagging returned to the same region 1 to 3 years later. Similar results have been found in earlier years of the NMFS-AFRF cooperative tagging program. The results provide further evidence that there are geographically separated groups of fish which comprise the North American fishery.

Japanese Recoveries of U.S. Tagged Albacore

There were eight recoveries made in 1977 by Japanese fishermen of fish which were tagged and released during the NMFS-AFRF cooperative tagging program (see Figure 9). Three of the recoveries had been tagged in inshore waters off the Pacific Northwest, 3 in offshore waters off California, 1 in inshore waters off Point Conception, and 1 in the western Pacific by a U.S. jigboat conducting exploratory jigfishing there. All the recoveries made by the Japanese in 1977 were made west (toward Japan) of 165°E . This pattern is similar to the pattern observed in the Japanese recoveries made in 1976 through October, but different from those observed in 1974 and 1975. In 1974 and 1975, the majority of the recoveries made by the Japanese were concentrated near 172°E , 35°N in the vicinity of the Emperor Seamount chain.

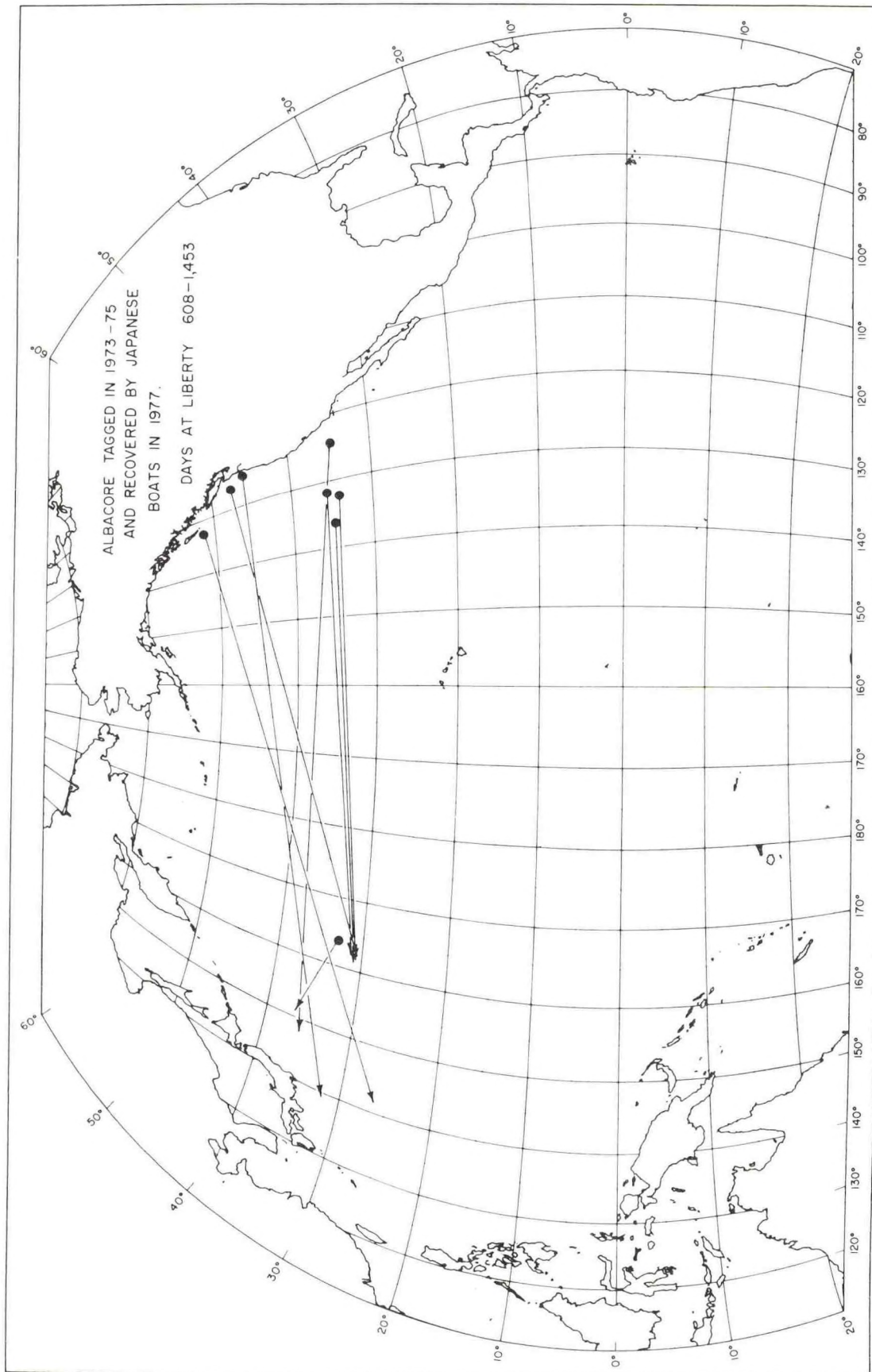


Figure 9. 1977 trans-Pacific recoveries of albacore tagged off the U.S. during 1973 to 1975 and one recovery of an albacore tagged in 1975 in the western Pacific. Dot indicates location where fish was tagged and released and tip of arrow indicates where fish was recovered.

INFORMATION ABOUT ALBACORE MIGRATION LEARNED FROM THE
NMFS-AFRF COOPERATIVE ALBACORE TAGGING PROGRAM

The locations where tagged fish have been released during 1971-1976 were stratified into three areas: 1) tagged in waters offshore 130°W south of 40°N, which will be referred to as offshore; 2) tagged south of 38°N and inshore of 130°W, which will be referred to as southern; and 3) tagged north of 38°N within a couple hundred miles of the coast, which will be referred to as northern. For each of the three release areas, the number and percentage of recoveries made 1) in the southern area, 2) in the northern area, 3) the Japanese live-bait fishery, and 4) the Japanese longline fishery, were determined.

In summary, the results show that:

- 1) Fish tagged in the offshore area are recovered in the southern and northern areas off the U.S. and in the Japanese albacore fisheries.
- 2) Most of the fish tagged in the southern area are recovered in the southern area with none recovered in the northern area the same season as release and only a small number in later seasons.
- 3) Only a small number of fish tagged in the southern area are recovered in the Japanese albacore fisheries.
- 4) Most of the fish tagged in the northern area are recovered in the Japanese fisheries.
- 5) About 1/3 of the fish tagged in the northern area are recovered in the northern area.
- 6) Only a small number of fish tagged in the northern area are recovered in the southern area.

Based on the tagging results, conditional speculations at this time are:

- 1) More than one group of fish make up the U.S. albacore fishery with fish which comprise the fishery north of about 38°N off the Pacific Northwest being separate from those which make up the fishery south of 38°N off California.
- 2) During a given season, the amount of exchange of fish between the northern and southern groups is small.
- 3) The northern group of fish make trans-Pacific migrations between the eastern and western North Pacific resulting in an exchange of fish between the northern area of the U.S. fishery and the Japanese live-bait, and at least part of the longline, fisheries.
- 4) The southern group of fish appear to have a different migration scheme from the northern group of fish.
- 5) Only a small proportion of the southern group of fish appear to migrate between the eastern and western Pacific.
- 6) While it is not known where the majority of the southern group of fish migrate, it is presumed that they migrate between the eastern and central North Pacific.
- 7) The amount of exchange of fish between the southern area of the U.S. fishery and the Japanese live-bait fishery does not appear to be large.

Considerable further analysis will be required to confirm these speculations.

FOOD HABITS OF ALBACORE CAUGHT IN OFFSHORE WATERS DURING 1977

The stomach contents of 47 albacore caught on jigs by the R/V David Starr Jordan between 30-36°N, 130-140°W during June 1977 were examined to further investigate the feeding habits of albacore tuna in the offshore region. The food habits of albacore caught from this area during June 1973, 1974 and 1976 have been studied previously.

About 60% of the stomachs examined were removed from the fish on board ship and preserved in formalin, and the remainder were frozen intact in the fish. At the shore laboratory, the stomachs were slit open and the contents emptied for examination. Organisms removed from the stomachs were sorted into categories, counted and displacement volumes measured.

Food was found in 37 of the 47 stomachs examined. The amount of food ranged from 0-17.9 ml, with an average of 2.9 ml per stomach and a median of 1.4 ml. Ten of the stomachs examined were empty. Table 3 shows the frequency distribution of the number of albacore stomachs and the amount of food found in them.

Table 3. Frequency distribution of the number of albacore stomachs and the amount of food found in them.

Volume of food (ml)	Number	Percent
Empty	10	21.3
< 1.0	10	21.3
1.0-2.4	12	25.5
2.5-4.9	6	12.8
5.0-9.9	5	10.6
>10	4	8.5
Total	47	100.0

Nearly 58% of the stomachs examined contained fish other than saury (mostly juvenile jack mackerel), 47% amphipod crustaceans, 28% squid, 11% crustaceans other than amphipods or krill, and 11% miscellaneous remains. The percentage distribution of the various food categories found in the stomachs is shown in Figure 10.

On a biomass or displacement volume basis, amphipods comprised about 42% of the total volume of food found in the stomachs of the fish examined. Fish other than saury formed about 32%, squid about 15% and miscellaneous remains 10% of the volume of the food in the stomachs. The percentage composition by volume of the various food organisms found in the stomachs is shown in Figure 11.

Numerically, fish other than saury comprised about 48% of the food organisms counted and were the most numerous food organism in the stomachs. Amphipods accounted for 41% and squid about 7% of the organisms found in the stomachs. Crustaceans other than amphipods or krill formed about 4% and miscellaneous remains about 1%. The percentage composition by number of the various food categories found in the stomachs is shown in Figure 12.

Differences are apparent in the amounts of food found in albacore stomachs and in diet when comparing stomach analysis data for the different years that stomach contents have been examined from fish caught in the offshore area. A summary by year of the number of stomachs examined, number and percent of stomachs that were empty, amount of food found in the stomachs, and the predominant food organism(s) is given in Table 4. The percentage of stomachs that were empty was lower, and the range and average amount of food found in

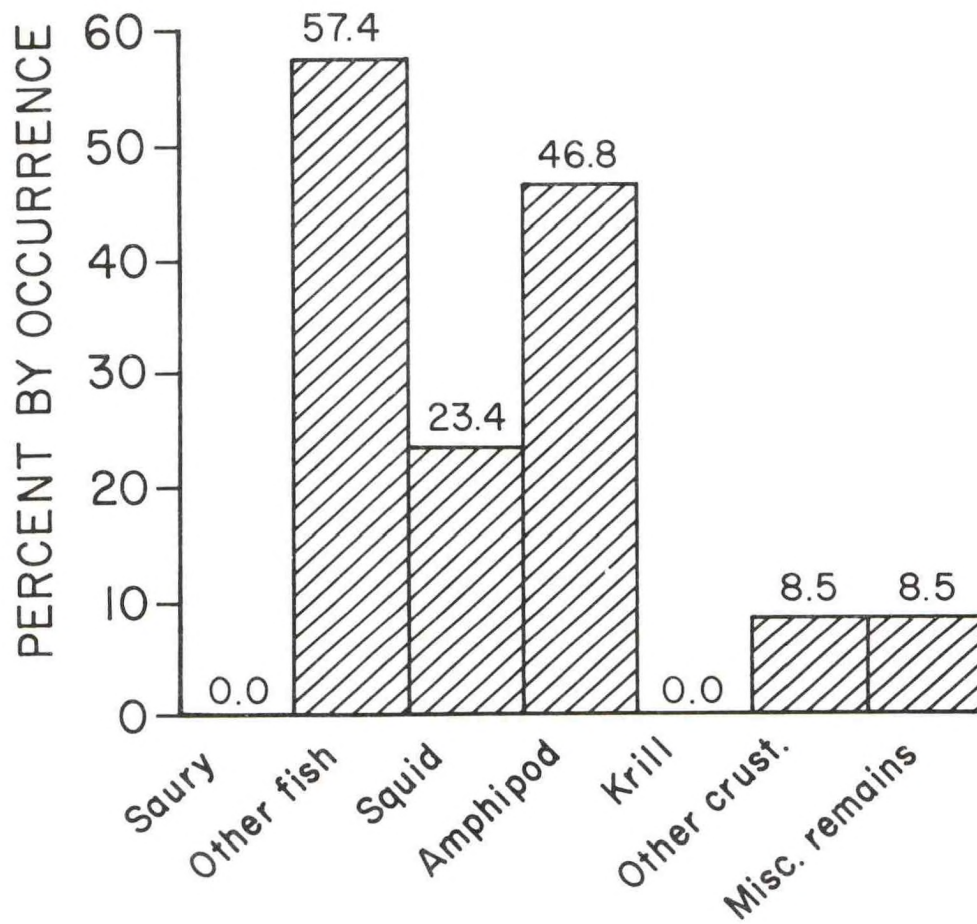


Figure 10. Composition by percent distribution of the stomach contents of albacore caught offshore in June 1977.

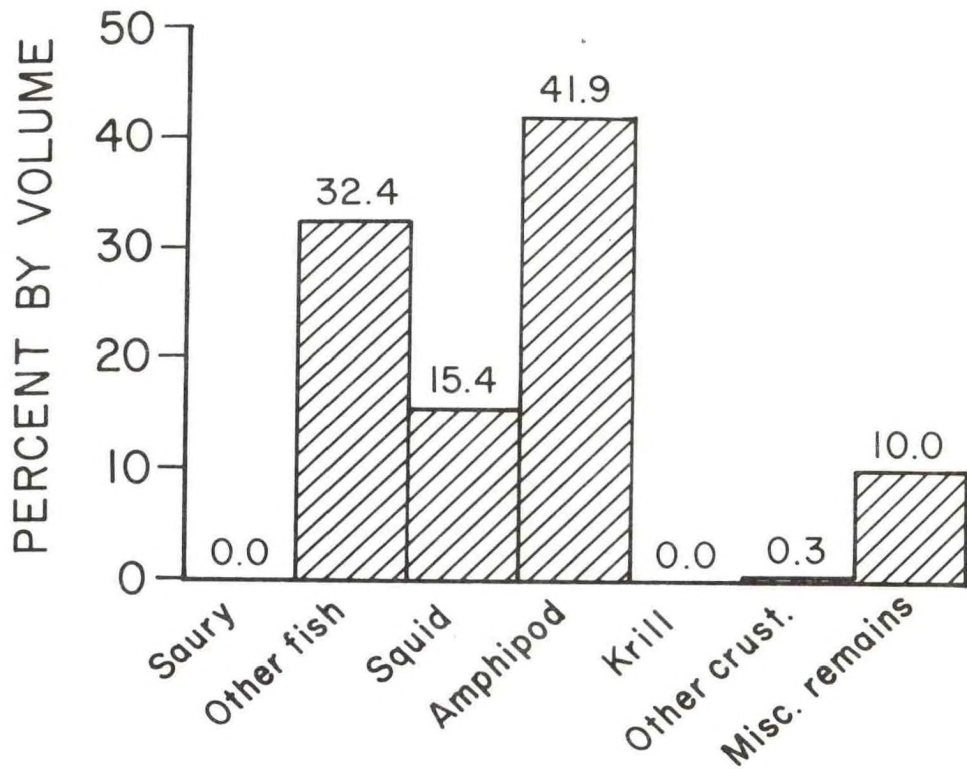


Figure 11. Composition by biomass of the stomach contents of albacore caught offshore in June 1977.

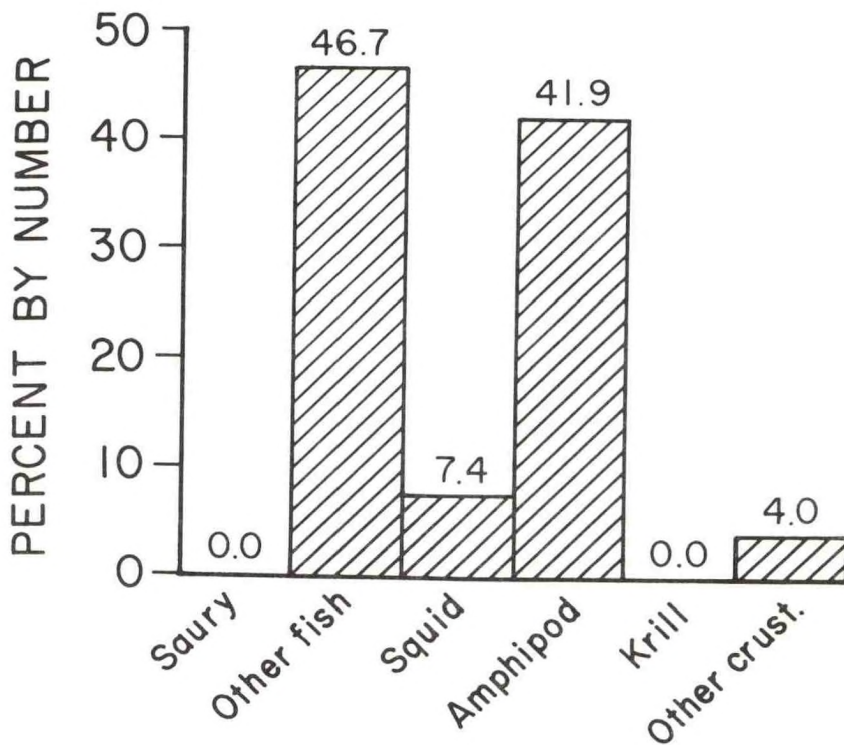


Figure 12. Composition by number of the stomach contents of albacore caught offshore in June 1977.

Table 4. Summary by year of the number of albacore stomachs examined, number and percent empty, amount of food found in the stomachs, and predominant food organism(s) found in the stomachs.

Year	Number of stomachs	Number (percent) empty	Amount of food in stomachs (ml)		Predominant food
			Range	Average	
1973	33	0 (0%)	0.2-104	16.3	Fish (saury)
1974	75	9 (12%)	0 -165	13.3	Squid
1976	56	7 (13%)	0 - 48	6.5	Crustaceans (amphi-pods) and Fish (saury & juveniles)
1977	47	10 (21%)	0 - 18	2.9	Crustaceans (amphi-pods) and Fish (juvenile mackerel)

the stomachs were higher during 1973 and 1974 than in 1975 and 1976. Fishes (mostly saury) were the predominant food organism in 1973 and squid were predominant in 1974. In 1976 and 1977, crustaceans (mostly amphipods) and juvenile fishes were the predominant forage organisms.

There is an interesting relationship between the success of fishing in the offshore area during June and the amount of food found in the stomachs from fish caught there. There was good fishing in the offshore waters by AFRF charter vessels and non-charter vessels during June 1973 and 1974 when the amounts of food found in albacore stomachs were large relative to the amounts found in 1976 and 1977 when fishing in offshore waters was poor.

It is generally believed that tuna are opportunistic carnivores and that they feed on the food organisms most readily available. There is also evidence that the rate of feeding in fishes is directly proportional to the availability of food. Based on analyses of albacore food habits, it appears that variations in the availability of food organisms may play a role in determining fishing success in the offshore area during the time when albacore are presumably migrating through that area to inshore waters. In those years when saury and squids are readily available for albacore to feed on in the offshore area, fishing success in that area is high relative to those years when albacore apparently must depend on crustaceans and juvenile fishes as food organisms.