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Nominal Catch-Per-Unit Effort of Albacore, *Thunnus alalunga* (Bonnaterre), Caught by U.S. Jig Vessels During 1961-70

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ABSTRACT—Catch-per-unit effort data by time-area strata for the albacore, Thunnus alalunga *(Bonnaterre), fishery off the west coast of North America are presented for the years 1961-70. Results indicate that while the fishery may range from central Baja California, Mexico, to British Columbia, Canada, it is usually not continuous over this range, but rather is centered in more restricted regions in a given fishing season. Marked annual latitudinal variations in the fishery were apparent with the fishery mainly located in "southern" waters from central Baja California to San Francisco during 1961-65 and in "northern" waters off the Pacific Northwest during 1966-70. Very little variation among years in the offshore distribution of the fishery was indicated, and for the most part it was restricted to within 200-250 miles of the shore with highest catch rates frequently made within 100 miles of the coast. During "southern" fishery years, catch rates indicative of commercial concentrations of albacore were generally made 2-4 weeks earlier, during mid-June to early July, than during "northern" fishery years. Differences in the pattern of the seasonal distribution of the fishery were also apparent between "southern" and "northern" fishery years.*

A twofold variation was observed in the estimates of annual catch-per-unit effort over the 10-year period; however, relatively high catch rates with little variation were observed during the later years, 1967-70. During all of the years the concentration index was greater than 1.0, indicating that fishers tended to concentrate their effort in areas or periods where or when the average catch-per-unit effort was high.

INTRODUCTION

Catch-per-unit effort data by time-area strata are presented for the albacore, *Thunnus alalunga* (Bonneterre), fishery off the west coast of North America. They were collected by individual States and then merged and standardized. The results are unique in that they make available, for the first time, estimates of standardized catch-per-unit effort for the entire range of the fishery. This has been made possible by the cooperation of scientists from the National Oceanic and Atmospheric Administration; National Marine Fisheries Service; State of California Resources Agency, Department of Fish and Game; and Fish Commission of Oregon[1].

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Many of the statistics for the U.S. albacore fishery have been published separately by the individual States (Clemens, 1955; Ayres and Meehan, 1963; Clemens and Craig, 1965; Meehan and Hreha, 1969; and Hreha, 1974). In this paper, data collected by the States during the years 1961-70 have been combined and uniformly standardized to provide additional information about the entire range of the fishery and to take into account any coast-wide variation in the characteristics of the fishing vessels, of the geographical and seasonal nature of the fishery, or of other factors which may influence estimates of nominal fishing effort.

[1]The Fish Commission of Oregon has since been incorporated into the Oregon Department of Fish and Wildlife.

SOURCE OF INFORMATION

The information about catch localities and nominal fishing effort was obtained from logbooks and from interviewing fishers on the waterfront. A voluntary logbook system has been used by the California Department of Fish and Game since 1954 (Craig, 1963), and information from both logbooks and interviews was available for albacore landed in California. Information for albacore landed in Oregon was available from interviews prior to 1967 and from interviews and voluntary logbooks from 1967-70. The number of such records used for standardizing the catch rates is summarized by year and time period in Table 1. Only statistics from albacore jig boats were dealt with because there were insufficient data from bait boats. Jig boats land approximately 75 percent of the annual U.S. commercial albacore catch (Clemens and Craig, 1965). The total logged jig boat catch was roughly 30 to 40 percent of the total jig boat landings.

METHODS

Great care was taken by the individual States to insure confidentiality of the records of individual fishing vessels. This was done by removing from the records the name of each vessel and any identification numbers which could be traced to it and by assigning a code number which was kept constant each year for a given boat.

The basic data included date, number of fish caught, 1° quadrangle

Table 1.—Combined number of logbooks and interview records available from albacore jig vessels for determining standardized catch rates.

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1-15 June	2	3	4							
16-30	232	409	40	48		3	3		16	
1-15 July	1,126	1,902	1,320	1,328	459	226	100	2	207	274
16-31	885	2,215	1,266	2,075	1,303	688	811	1,260	1,646	891
1-15 August	599	1,581	1,650	1,415	1,184	760	777	1,156	1,723	1,407
16-31	305	1,177	1,027	867	1,001	478	751	1,131	1,171	1,049
1-15 September	282	945	725	647	871	321	487	610	556	960
16-30	304	451	442	652	754	309	278	659	656	625
1-15 October	107	469	310	462	506	246	74	495	304	381
16-31	52	188	194	303	386	96	78	307	381	194
1-15 November	11	17	65	197	191	33	8	41	238	91
16-30			16	47	29	6		8	137	28
1-15 December									66	1
16-31									4	
Year (season) total	3,905	9,357	7,059	8,041	6,684	3,166	3,367	5,669	7,105	5,901

within which vessel operated, boat length, gear type, and often sea surface temperature. Since the data were in several forms—magnetic tape, computer cards, handwritten listings, etc.—and in various formats, they were first put into a common format and on to magnetic tape. Data from individual States were then merged and checked by computer for duplication of records. The latter was done by searching to determine if there was more than one record, for the same day at the same location, of identical catches of albacore by boats of the same length. If so, which was true in only a small number of cases, duplicates were omitted and a final basic data tape was prepared.

A modified version of the computer program FPOW (Berude and Abramson, 1972) was used in the standardization of the nominal fishing effort within each year[2]. The theoretical development and operating characteristics of the FPOW program are described in Fox (1971). The basic model assumed in the program is:

$$C_{ij} = q_i f_{ij} \bar{P}_j \epsilon_{ij}$$

where C_{ij} is the catch of the i^{th} fishing treatment in the j^{th} time-area stratum, q_i is the catchability coefficient of the i^{th} treatment, f_{ij} is the amount of fishing effort expended by the i^{th} treatment in the j^{th} time-area stratum, $\bar{P}_j$ is the average population size in the j^{th} time-area stratum, and ϵ_{ij} is assumed to be a log-normally distributed random variable. It is assumed that: 1) effort is measured such that within each treatment q_i is constant, 2) the units of effort operate independently, and 3) there is no interaction between treatments and time-area strata.

A preliminary analysis indicated differences in fishing power among 1) vessel length, 2) time fished during the season, 3) geographic area of fishing, and 4) years. Although fishing power in reality is probably a continuous function of vessel length, in order to estimate relative fishing power, it is necessary to group the data into strata such that 1) within each class the catchability may be assumed constant, 2) the probability of isolation will be minimized, and 3) sufficient data for analysis will be available in each group.

Following these criteria, the fishing vessels were assigned to length classes, and a separate class was established for each 10-foot increment in length. For each vessel length class, catch and effort data for each year were accumulated by 3° latitude-longitude quadrangle and by 15-day period. Fishing power coefficients were then derived for each vessel length class. Statistically significant differences in fishing power were found among the several length classes and nominal fishing effort for all was standardized in terms of effort of a 45-foot jig boat, which is approximately the median vessel length for the albacore jig fleet.

In addition, apparent geographical and seasonal differences in fishing power were found. Paucity of the data on a coastwide basis precluded rigorous statistical analyses. However, subjective evaluation of the results indicated an apparent need to stratify the fishery in geographic areas, 1) north and 2) south of lat. 38°N (about San Francisco), and to stratify the fishing season into 1) early-season consisting of the months June, July, and August, and 2) late-season consisting of the months September, October, and November. To minimize the geographical and seasonal effects in the calculation of the overall catch-per-unit effort, four sets of fishing power coefficients were calculated, i.e., early-north, early-south, late-north, and late-south, for each vessel size class. The four sets of fishing power coefficients for each vessel size class are given in Table. 2.

In order to examine spatial-temporal variations in the distribution of the albacore fishery and to study fish-ocean relationships, it was desirable to derive estimates of the catch-per-unit effort on a 1° quadrangle basis. Estimates of the mean catch-per-unit effort were computed by a 15-day period and by a 1° quadrangle, applying the appropriate fishing power coefficients as follows:

Where i = region (1 = north, 2 = south)

j = season (1 = early, 2 = late)

k = vessel length class (1 = 30, 2 = 40, . . .)

l = locality, 1° square.

Let f_{ijk} = fishing power coefficient for k^{th} vessel class in ij^{th} stratum

C_{ijkl} = catch of k^{th} vessel class in l in ij^{th} stratum

e_{ijkl} = nominal effort of k^{th} vessel class in locality l in ij^{th} stratum

$$C_{ij \cdot l} = \sum_k C_{ijkl}$$

$$E_{ij \cdot l} = \sum_k e_{ijkl} f_{ijk} .$$

Then the standardized catch-per-unit effort, in terms of a 45-foot jig boat for a 1° quadrangle l will be

$$C_{ij \cdot l} / E_{ij \cdot l}$$

[2]Standardization procedures were carried out under the direction of William Fox with assistance by T. Mulitauaopele and J. Zweifel, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, La Jolla, CA 92038.

and average catch-per-unit effort calculated from total catch and total effort over all strata will be

$$C/E = C..../E.... =$$
$$\Sigma_i \Sigma_j \Sigma_l C_{ij\cdot l} / \Sigma_i \Sigma_j \Sigma_l E_{ij\cdot l},$$

while the average of all catch-per-unit effort for all vessel classes and time-area strata will be

$$C/E = \Sigma_i \Sigma_j \Sigma_l C_{ij\cdot l} / E_{ij\cdot l} / N,$$

where N = number of strata.

The estimates of mean catch-per-unit effort by 15-day period and by 1° quadrangle are given in Figures 1 to 10. We emphasize that the catch rates presented in the figures are based on data only from those vessels for which logbooks or interviews were available; however, we assume they are representative of the entire fleet of jig boats. Further, we wish to point out that 1) the catches were not evenly distributed within the time periods, and 2) the schools of albacore were not uniformly distributed throughout each 1° quadrangle.

RESULTS

Charts of catch-per-unit effort in terms of a 45-foot jig boat by 15-day period and 1° quadrangle are given in Figures 1-10. Some general comments will be made concerning the data given in the figures, including 1) the annual latitudinal variation in the distribution of the fishery, 2) the offshore distribution of the fishery, and 3) the seasonal development of the fishery. A detailed analysis of the charts will not be given. Readers can draw their own conclusions depending on their intended use of the charts. Estimates of the mean standardized catch-per-unit effort and concentration index by years are also presented.

Table 2.—Fishing power coefficients for each vessel size class for early season north of lat. 38°N, late season north of lat.38°N, early season south of lat. 38°N, and late season south of lat. 38°N.

Vessel size class		Early north	Late north	Early south	Late south	Vessel size class		Early north	Late north	Early south	Late south
1961						1966					
	25	—	—	—	—		25	—	—	0.430	—
	35	—	—	0.572	0.622		35	0.773	0.241	0.743	0.650
	45	1.000	1.000	1.000	1.000		45	1.000	1.000	1.000	1.000
	55	0.574	1.891	0.986	0.733		55	0.929	1.095	0.701	1.328
	65	—	—	0.807	0.695		65	1.242	0.717	1.193	0.957
	75	—	—	1.078	—		75	1.098	—	0.091	0.711
	85	—	—	—	—		85	0.612	—	0.927	—
	95	—	—	—	—		95	—	—	—	—
	105	—	—	—	—		105	—	0.116	—	2.287
1962						1967					
	25	—	—	—	—		25	—	—	—	—
	35	0.718	1.520	0.864	0.948		35	0.492	0.930	0.794	0.722
	45	1.000	1.000	1.000	1.000		45	1.000	1.000	1.000	1.000
	55	0.737	0.566	1.191	1.032		55	0.980	1.379	0.981	—
	65	0.713	0.822	0.993	0.971		65	0.906	0.468	1.169	0.915
	75	1.617	0.624	—	—		75	0.863	0.242	—	—
	85	—	—	—	—		85	1.131	0.505	0.893	0.135
	95	—	—	—	—		95	—	—	—	—
	105	0.663	—	—	—		105	—	—	—	—
1963						1968					
	25	—	—	0.219	—		25	—	—	—	—
	35	—	1.074	0.461	0.386		35	0.675	0.594	1.081	0.493
	45	1.000	1.000	1.000	1.000		45	1.000	1.000	1.000	1.000
	55	—	0.829	0.936	0.978		55	0.895	0.663	0.505	0.839
	65	—	0.575	0.767	0.612		65	0.821	1.213	0.289	0.438
	75	—	0.949	0.793	—		75	0.980	1.174	1.810	0.724
	85	—	—	—	—		85	0.597	—	—	—
	95	—	—	—	—		95	1.327	—	—	—
	105	—	0.657	0.370	—		105	0.995	0.593	—	0.454
1964						1969					
	25	—	—	0.449	0.114		25	—	—	—	—
	35	0.332	0.561	0.616	0.425		35	0.941	0.882	0.606	0.893
	45	1.000	1.000	1.000	1.000		45	1.000	1.000	1.000	1.000
	55	0.862	1.210	0.814	1.089		55	1.103	1.197	0.591	0.667
	65	0.599	0.854	0.909	0.606		65	0.988	0.443	1.877	0.822
	75	—	1.428	0.387	—		75	1.260	0.459	—	0.975
	85	—	—	1.630	0.217		85	1.372	—	—	—
	95	—	—	—	—		95	—	—	—	—
	105	—	0.954	0.817	0.612		105	0.819	—	0.567	—
1965						1970					
	25	—	—	0.351	0.090		25	—	—	—	—
	35	0.490	0.857	0.566	0.483		35	0.427	0.903	0.641	0.677
	45	1.000	1.000	1.000	1.000		45	1.000	1.000	1.000	1.000
	55	0.667	1.243	1.032	0.578		55	0.992	2.888	0.761	0.766
	65	0.670	1.394	1.227	0.906		65	1.069	1.003	0.878	1.170
	75	—	—	—	1.001		75	1.014	1.747	0.532	0.820
	85	—	—	—	—		85	0.443	—	—	—
	95	—	—	—	—		95	—	—	—	—
	105	0.731	2.638	0.597	0.798		105	0.162	0.335	0.402	0.781

Annual Latitudinal Variation in the Distribution of the Fishery

Although the jig fishery for albacore ranged from central Baja California, Mexico, to British Columbia, Canada, usually it was not continuous or evenly distributed over this area (Figs. 1-10). Instead, fishing was centered in relatively restricted regions which varied in location both within and between seasons. Marked annual latitudinal variations in the location of the center of the fishery are also clearly evident in the figures. For example, during the period 1961-65 most fishing took place south of San Francisco. In these "southern" waters the geographic range of the fishery was greater and the catch rates usually higher than to the north (Figs. 1-5). By 1966, however, a major part of the fishery had shifted to "northern" waters above San Francisco, where the extent of the fishery and the catch rates were much greater than to the south—these conditions persisted through 1970 (Figs. 6-10).

Annual variations in location of the albacore fishery have been observed over at least the past three decades. They are indicated in Figure 11 (from Laurs, 1971), which gives the percentage of the west coast albacore tuna catch taken north of San Francisco for the years 1938-70. According to Laurs et al. (1974), based on unpublished work by James Renner[3], these variations appear to be related to marine environmental conditions during spring months in the offshore waters through which albacore presumably pass during their migration from the central Pacific into the west coast fishing grounds.

Variation in the location of the fishery has affected the amount of albacore landed in the individual Pacific

[3]Southwest fisheries Center, NMFS, NOAA, La Jolla, CA 92038, pers. commun.

Coast States. For example, during the 1961-65 "southern" fishery years, landings in California ranged from 23.22 to 48.86 million pounds, while landings in Oregon ranged from 3.25 to 12.12 million pounds. However, during the 1966-70 "northern" fishery years, landings in California decreased, ranging from 14.72 to 29.93 million pounds while landings in Oregon increased, ranging from 17.68 to 37.75 million pounds. Albacore landings in Washington also were highest when the fishery was centered to the north (Table 3).

Table 3.—Amount of albacore landed by state (in millions of pounds)[1].

Year	Calif.	Oreg.	Wash.	Total
1961	29.12	3.25	0.46	32.83
1962	36.62	8.95	0.37	45.94
1963	48.86	11.40	0.53	60.79
1964	42.55	4.46	1.05	48.06
1965	23.22	12.12	1.87	37.21
1966	18.19	17.68	1.10	36.97
1967	17.86	29.24	1.24	48.34
1968	15.08	37.75	3.05	55.88
1969	14.72	29.83	3.56	48.11
1970	29.93	21.80	4.39	56.12

[1] Sources of information: Power (1963), Powell and Lyles (1964), Lyles (1965, 1966, 1967, 1968, 1969), U.S. Department of Commerce (1971), and Wheeland (1972, 1973).

The Offshore Distribution of the Fishery

Little variation was apparent in the offshore distribution of the albacore fishery (Figs. 1-10). Most fishing occurred within 200-250 miles of shore, with the highest catch rates frequently made within 100 miles of the coast. However, there was generally a strip of varying width along the coast which was void of albacore catches. The width of this strip was often greatest off northern California and Oregon where it sometimes extended 50 or more miles offshore.

According to several authors (Clemens, 1961; Pearcy and Muller, 1969; Flittner, 1970; Panshin, 1971; Laurs, 1973; and others), albacore may avoid nearshore waters off the coast of North America because water temperatures there are below those considered optimal for albacore (Laevastu and Rosa, 1963). These cool coastal waters result from coastal upwelling (Smith, 1968) and the nearshore areas which were devoid of albacore catches extended the farthest offshore where upwelling has been found to be strongest (Bakun, 1973).

Seasonal Development of the Fishery

General information about the seasonal development of the albacore fishery and its year-to-year variations can be obtained from the charts of catch-per-unit effort. However, since there is a complicated interplay of numerous factors (including availability of albacore, socioeconomic, weather, oceanographic conditions, etc.) that may influence the catch rates, care should be exercised if the charts are used to evaluate such events as the beginning or end of the fishery for specific years, within-season variations, etc.

It can be seen in Figures 1-10 that the albacore jig fishery is seasonal, generally lasting from July through October, although some catches were made as early as the first half of June (Figs. 2 and 3) and as late as mid-December (Fig. 10). During "southern" fishery years, catches indicative of commercial concentrations (catch rates of about 100 fish per day) were often made beginning in mid-June to early July (Figs. 1-5). This is about 2-4 weeks earlier than during the "northern" fishery years when significant catches usually were not made until after mid-July (Figs. 6-10).

There were also differences in the pattern of the seasonal distribution of the fishery between "southern" and "northern" fishery years. During most "southern" years a single fishing center was observed (Figs. 1-5). It expanded, generally moved northward, and then contracted during the fishing season. The fishery usually began between northern Baja California and southern California, expanded northward up the coast during the late summer and early fall months to northern California or Oregon, and then receded southward during the late fall to off central California where the fishing season usually ended. A different pattern was observed during most "northern" fishery years (Figs. 6-10) when two widely separated fishing areas prevailed from the beginning of the season through the late summer months. One of these areas was off the Pacific Northwest and one off southern California, with the former occupying a larger geographic area and having generally higher catch rates than the latter. By early fall, the southern area had shifted northward and the northern area southward, forming a single area off central California where the fishing season usually ended in the late fall.

Annual Standardized Catch-Per-Unit Effort

Estimates of annual standardized catch-per-unit effort were derived to provide information on the trends in albacore fishing success. These estimates were based on data for the period 1 July to 31 October and were derived in two ways: 1) the total catch divided by the total standardized effort,

$$CPUE_1 = \Sigma C / \Sigma f, \qquad (1)$$

and 2) the sum of the *CPUE* for each time-area stratum divided by the number of strata,

$$CPUE_2 = \frac{1}{n} \Sigma C/f \qquad (2)$$

where C denotes catch, f denotes nominal standardized effort, and n denotes the number of time-area strata.

Estimates of the annual standardized catch-per-unit effort based on Equations (1) and (2) above are given in Table 4 and Figure 12.

A two-fold variation in the annual catch-per-effort of albacore was observed during 1961-70. The ratio of averages *CPUE* statistic ranged from 69.24 to 136.99 fish per day, and the average of ratios *CPUE* statistic ranged from 61.24 to 119.03 fish per day. Both estimates of catch-per-unit effort were relatively low in 1961 and 1964-66, and high in 1962-63 and 1967-70 (Fig. 12).

Annual Concentration Index

To obtain a measure of the extent to which the albacore jig fleet has been successful in concentrating nominal effort in areas where or when average catch-per-unit effort has been high, computations were made for each year of the concentration index (Gulland, 1955). This index is the ratio of the ratio of averages *CPUE* statistic, Equation (1), to the average of ratios *CPUE* statistic, Equation (2):

Table 4.—Annual values of standardized fishing effort, logged catch, catch-per-unit effort, and concentration index for the U.S. albacore jigfishery during 1961-70.

Year[1]	Effort[2]	Catch[3]	[4]$CPUE_1$	[5]$CPUE_2$	Concentration index
1961	3,542.2	245,438	69.24	61.24	1.13
1962	9,236.4	1,151,957	124.72	112.55	1.11
1963	5,797.7	772,474	133.24	119.03	1.12
1964	7,102.8	697,331	98.18	76.26	1.29
1965	6,042.5	547,063	90.54	63.25	1.43
1966	3,019.4	276,148	91.46	62.27	1.47
1967	3,249.9	411,046	126.48	90.14	1.40
1968	5,322.7	729,165	136.99	93.97	1.46
1969	6,529.6	754,236	115.51	72.49	1.59
1970	5,308.0	680,083	128.12	88.12	1.45

[1] For period 1 July to 31 October.
[2] Standardized boat-day of logged effort.
[3] Number of logged fish.
[4] Ratio of averages *CPUE* derived using Equation (1).
[5] Average of ratios *CPUE* derived using Equation (2).

$$Ig = [\Sigma C/\Sigma f]\,[1/n\,\Sigma C/f]^{-1}.$$

During each year the concentration index (Ig) was greater than 1.0, ranging from 1.11 to 1.59 (Table 3). The values of Ig fall into two categories 1) one for the years of 1961-63 and 2) another for the years 1965-70. The values in the secondary category are higher than those in the first, and within each category the values are very stable. These results indicate that 1) each year albacore fishers tended to concentrate their effort in areas or period having a high average catch-per-unit effort presumably on relatively high densities of available albacore, and 2) they were relatively more successful in doing so during the years 1965-70 than during 1961-64.

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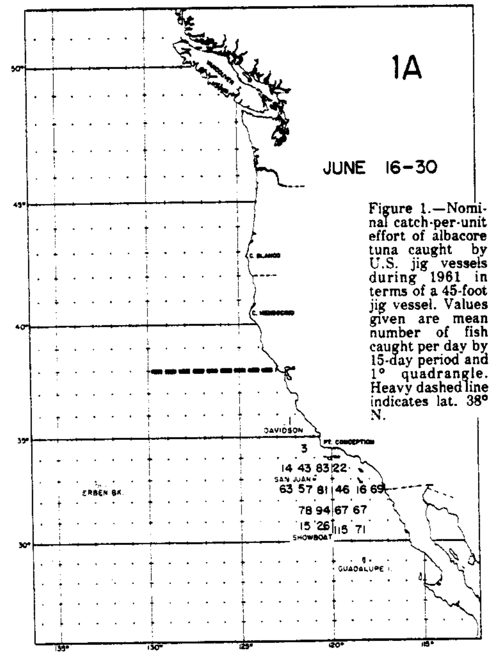
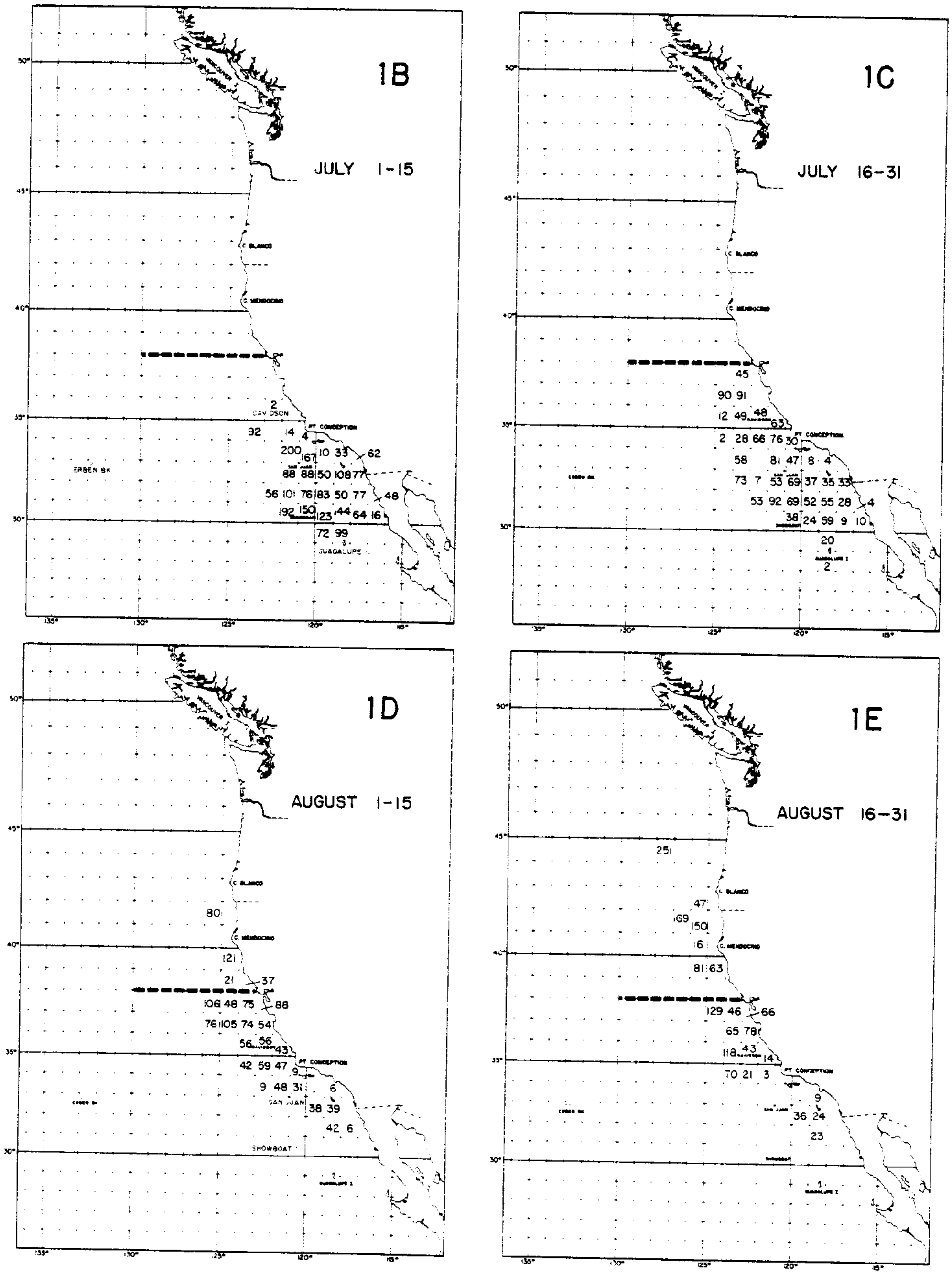
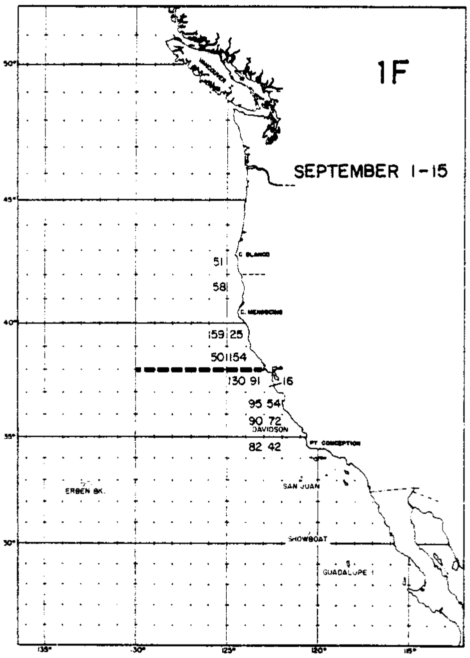


Figure 1.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1961 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.


1B
JULY 1-15
PT CONCEPTION
GUADALUPE
1C
JULY 16-31
1D
AUGUST 1-15
SAN JUAN
SHOWBOAT
1E
AUGUST 16-31



1F
SEPTEMBER 1-15
C. BLANCO
51
58
C. MENDOCINO
159 25
501154
130 91
16
95 54
90 72
DAVIDSON
82 42
PT. CONCEPTION
SAN JUAN
ERBEN BK.
SHOWBOAT
GUADALUPE I
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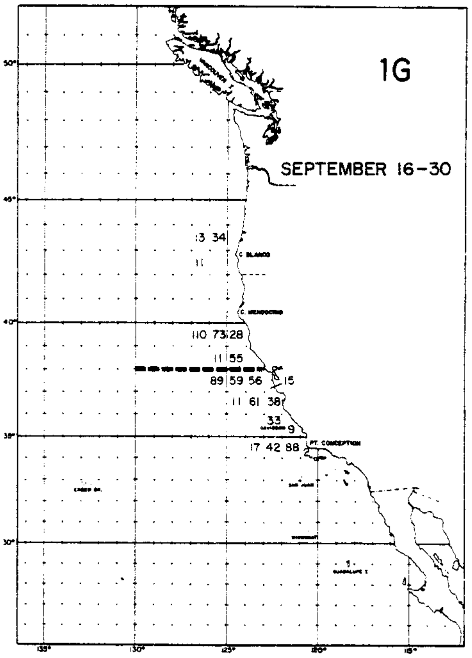
125°
120°
115°



1G
SEPTEMBER 16-30
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110 73 28
11 55
89 59 56
15
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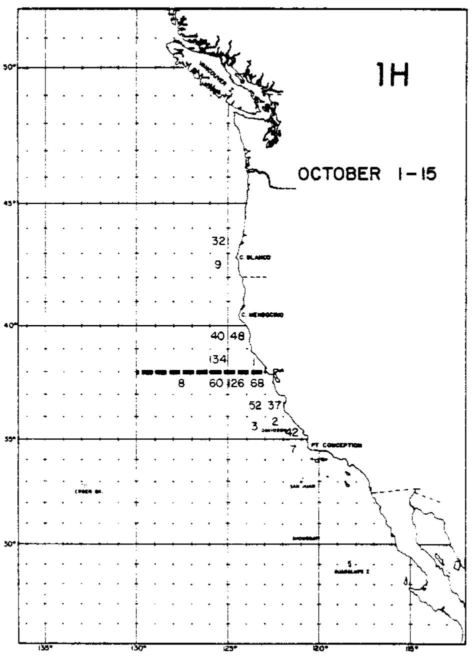

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32
9
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134
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60 126 68
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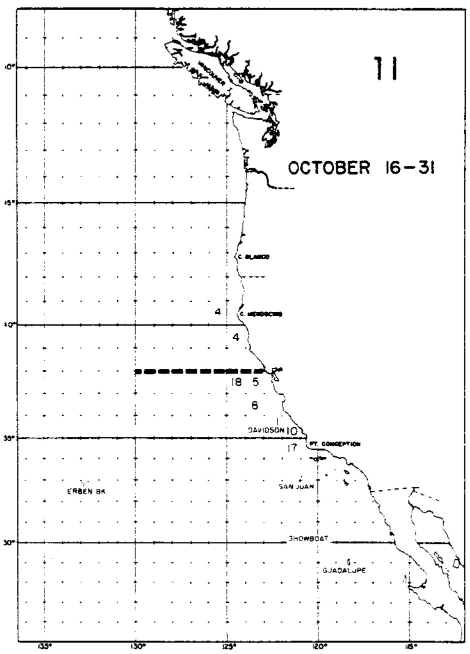

1I
OCTOBER 16-31
C. BLANCO
4
C. MENDOCINO
4
18 5
6
DAVIDSON 10
17
PT. CONCEPTION
ERBEN BK
SAN JUAN
SHOWBOAT
GUADALUPE
50°
45°
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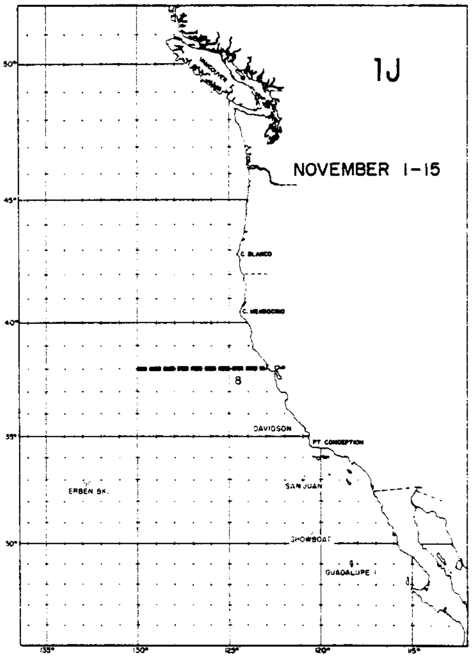
120°
115°



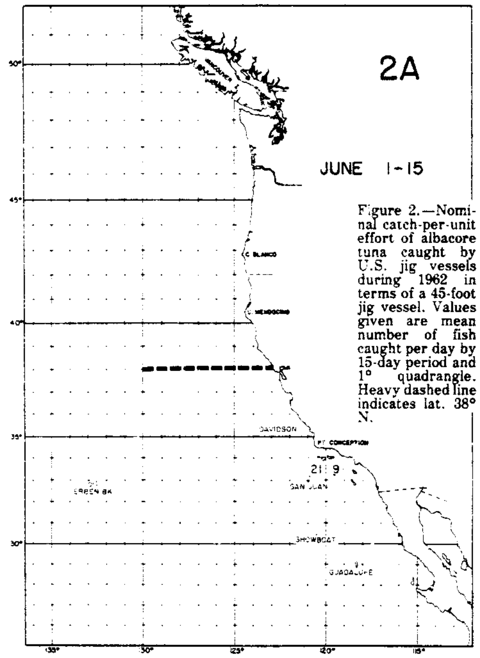
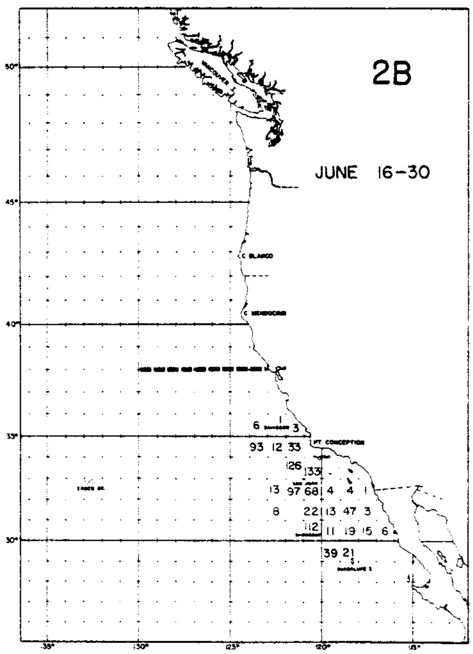
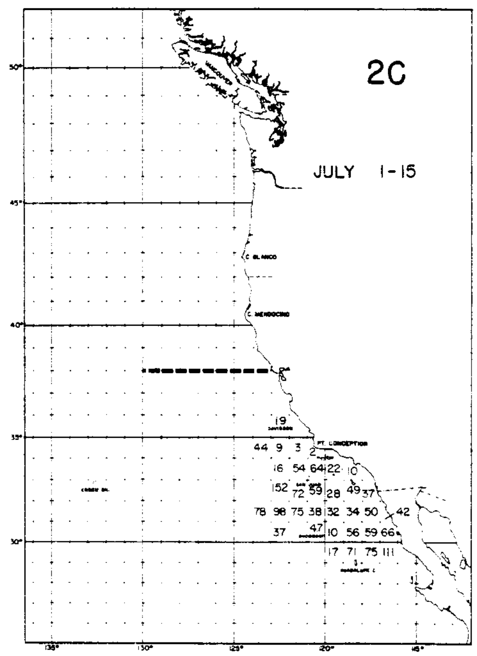
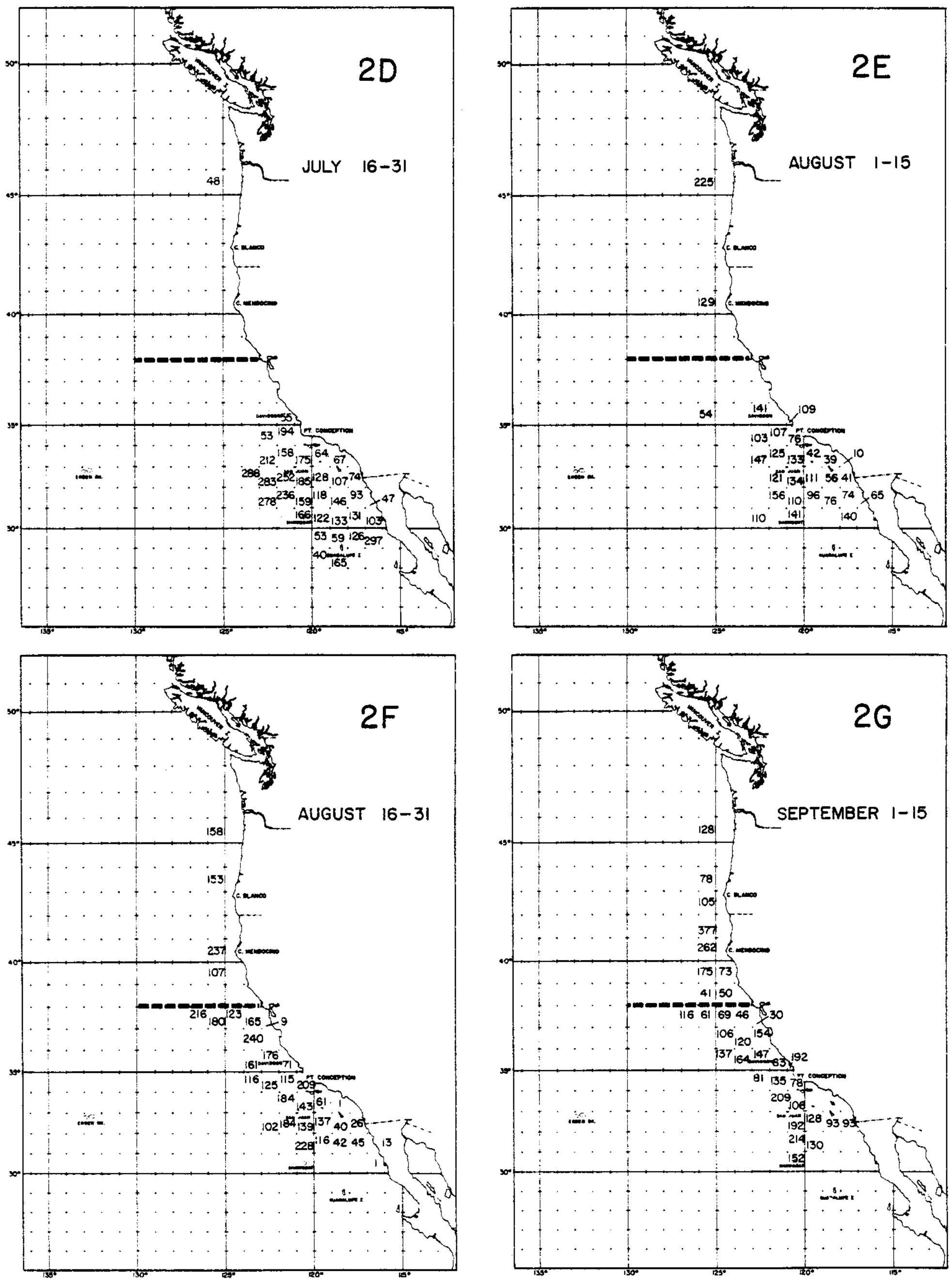


Figure 2.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1962 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.



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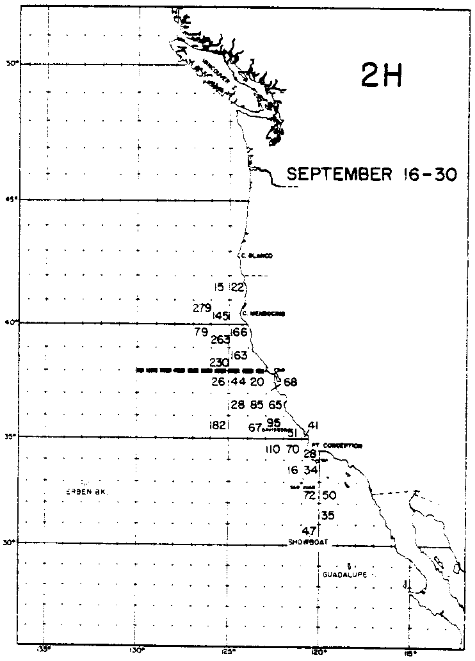
PT. CONCEPTION
2E
AUGUST 1-15
2F
AUGUST 16-31
2G
SEPTEMBER 1-15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C BLANCO
C MENDOCINO
PT CONCEPTION
ERBEN BK.
SHOWBOAT
GUADALUPE
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230 163
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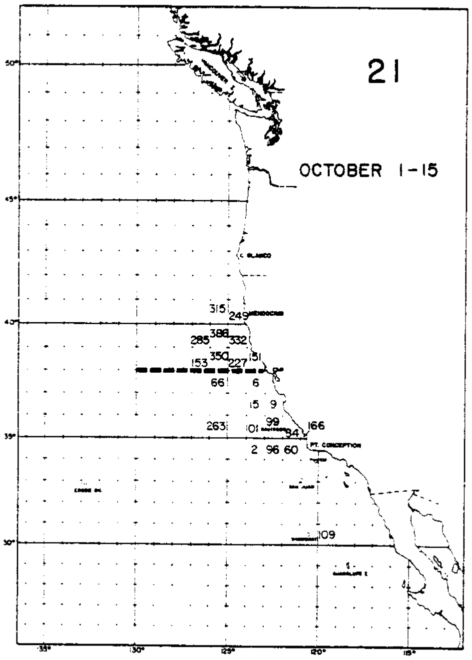
16 34
72 50
135
47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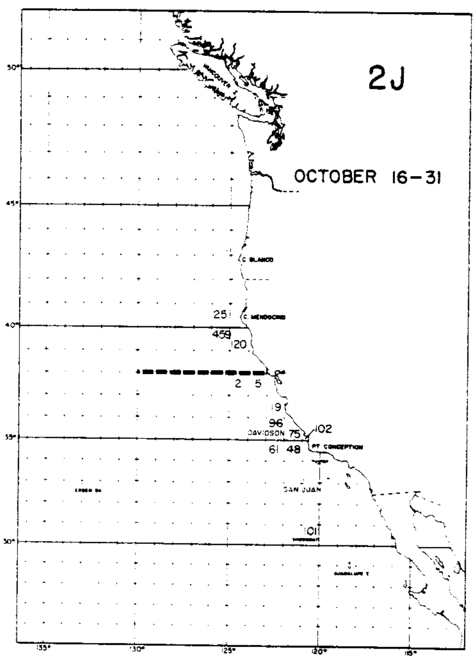
2 96 60
109


2J
OCTOBER 16-31
C BLANCO
C MENDOCINO
PT CONCEPTION
DAVIDSON
SAN JUAN
25
459
120
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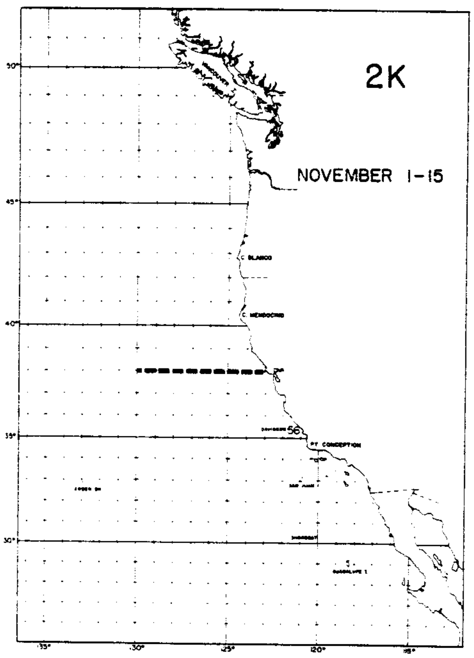
75
61 48
101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NOVEMBER 1-15
C BLANCO
C MENDOCINO
PT CONCEPTION
56

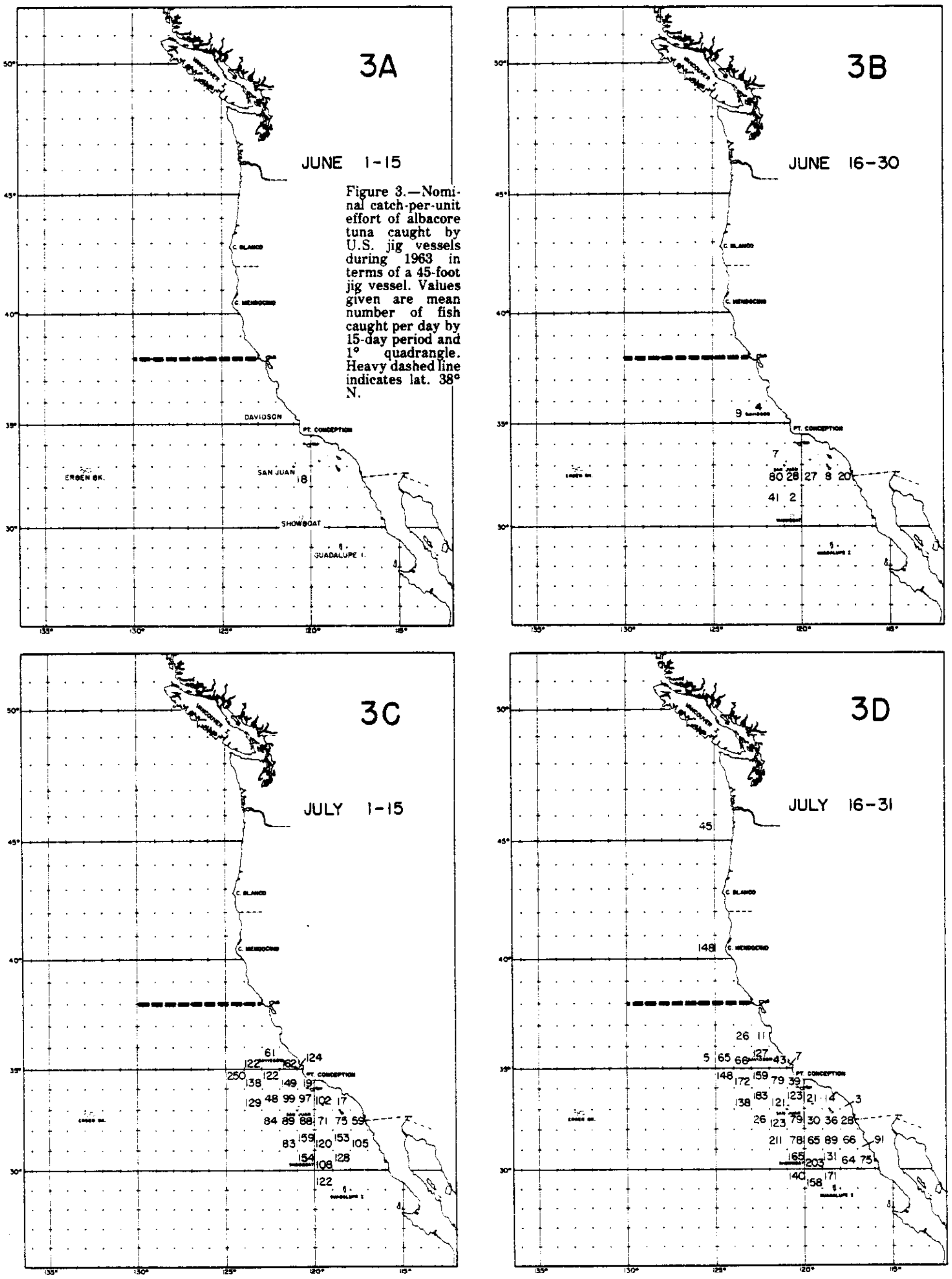
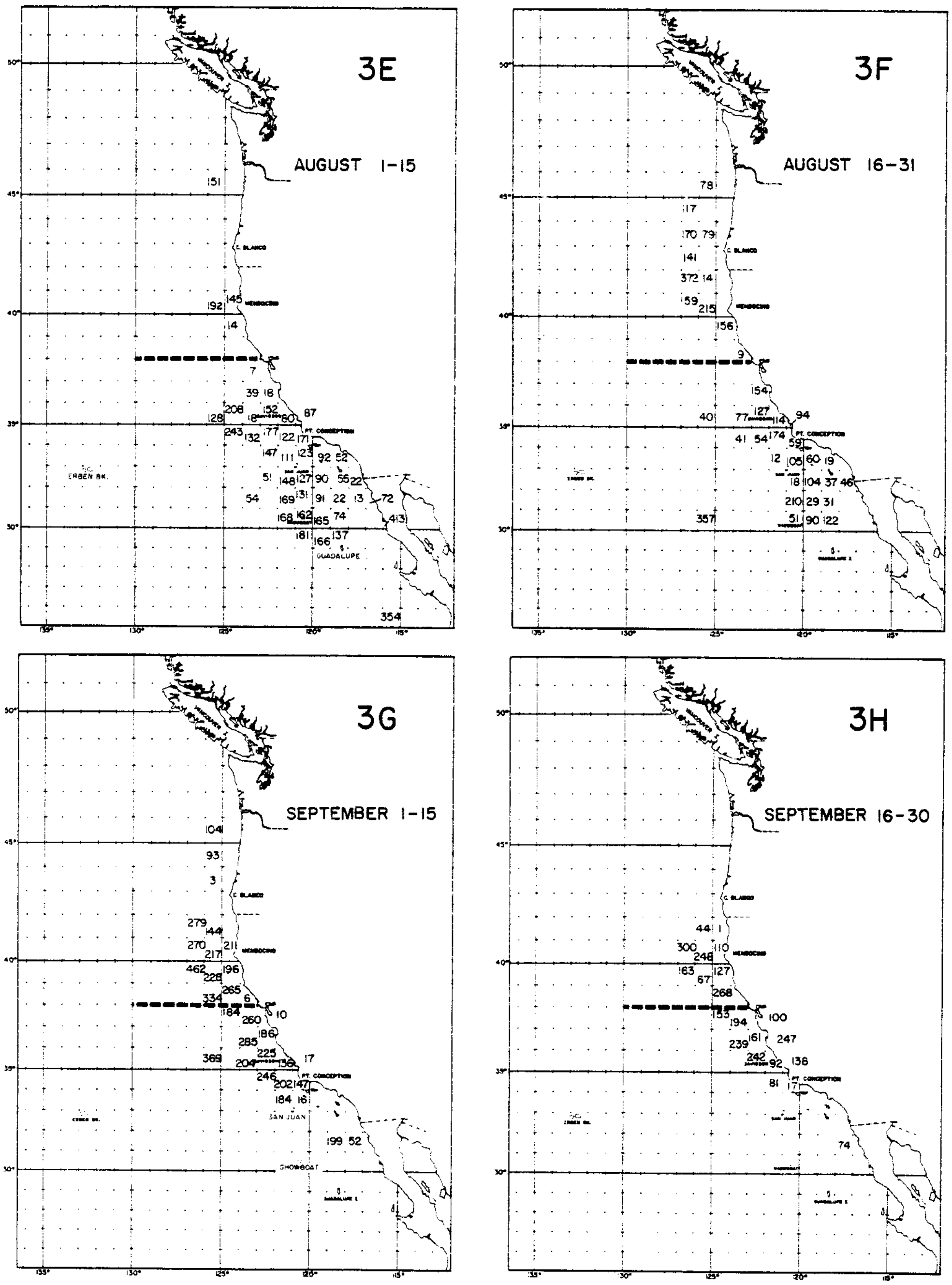
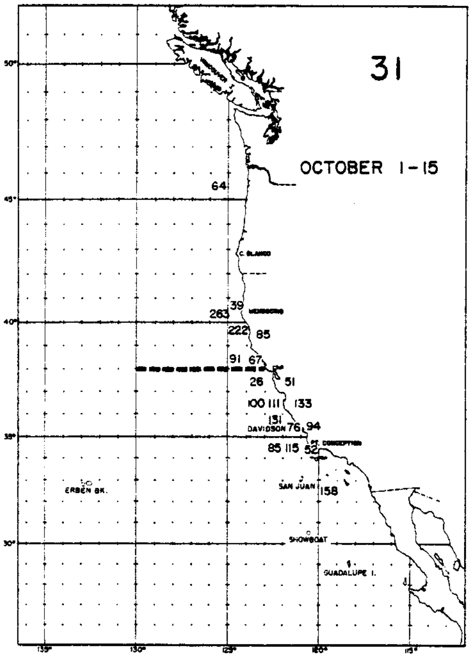


Figure 3.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1963 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.


3E
AUGUST 1-15
3F
AUGUST 16-31
3G
SEPTEMBER 1-15
3H
SEPTEMBER 16-30
PT. CONCEPTION
ERBEN BK.
GUADALUPE
SAN JUAN
SHOWBOAT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94
PT. CONCEPTION
85 115 52
ERBEN BK.
SAN JUAN
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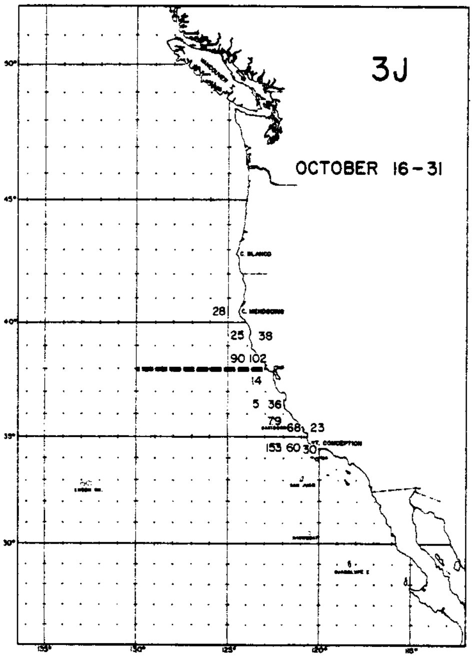
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PT. CONCEPTION
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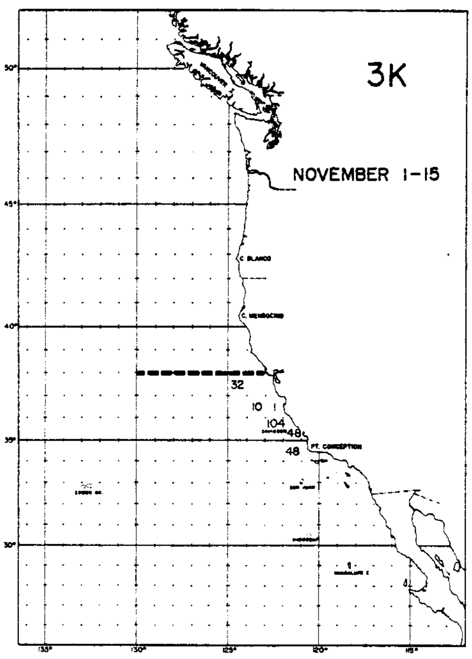
35°
30°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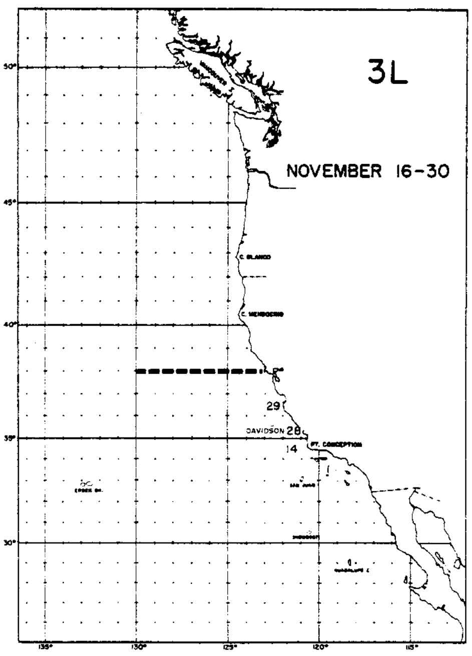
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DAVIDSON 28
PT. CONCEPTION
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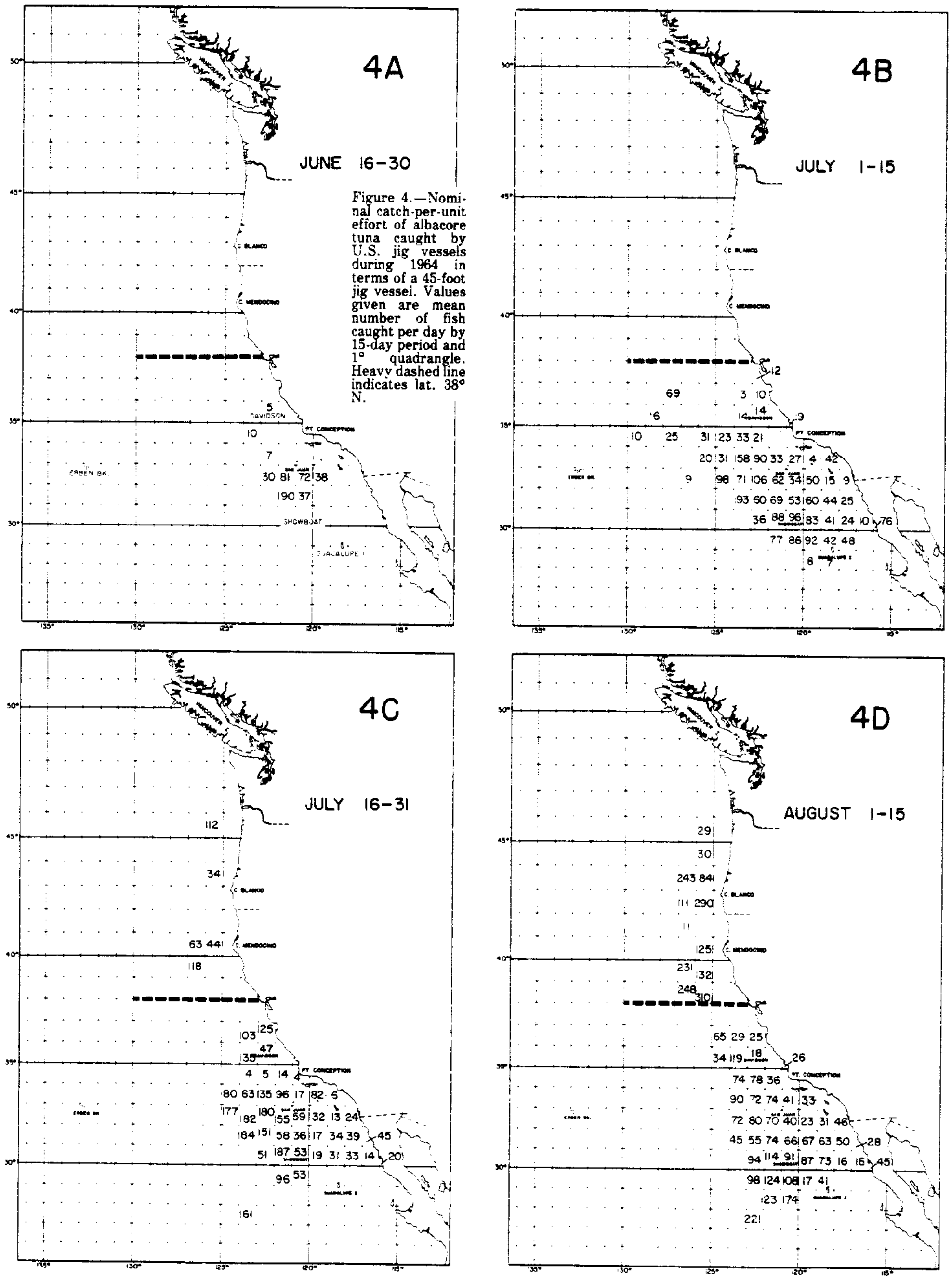
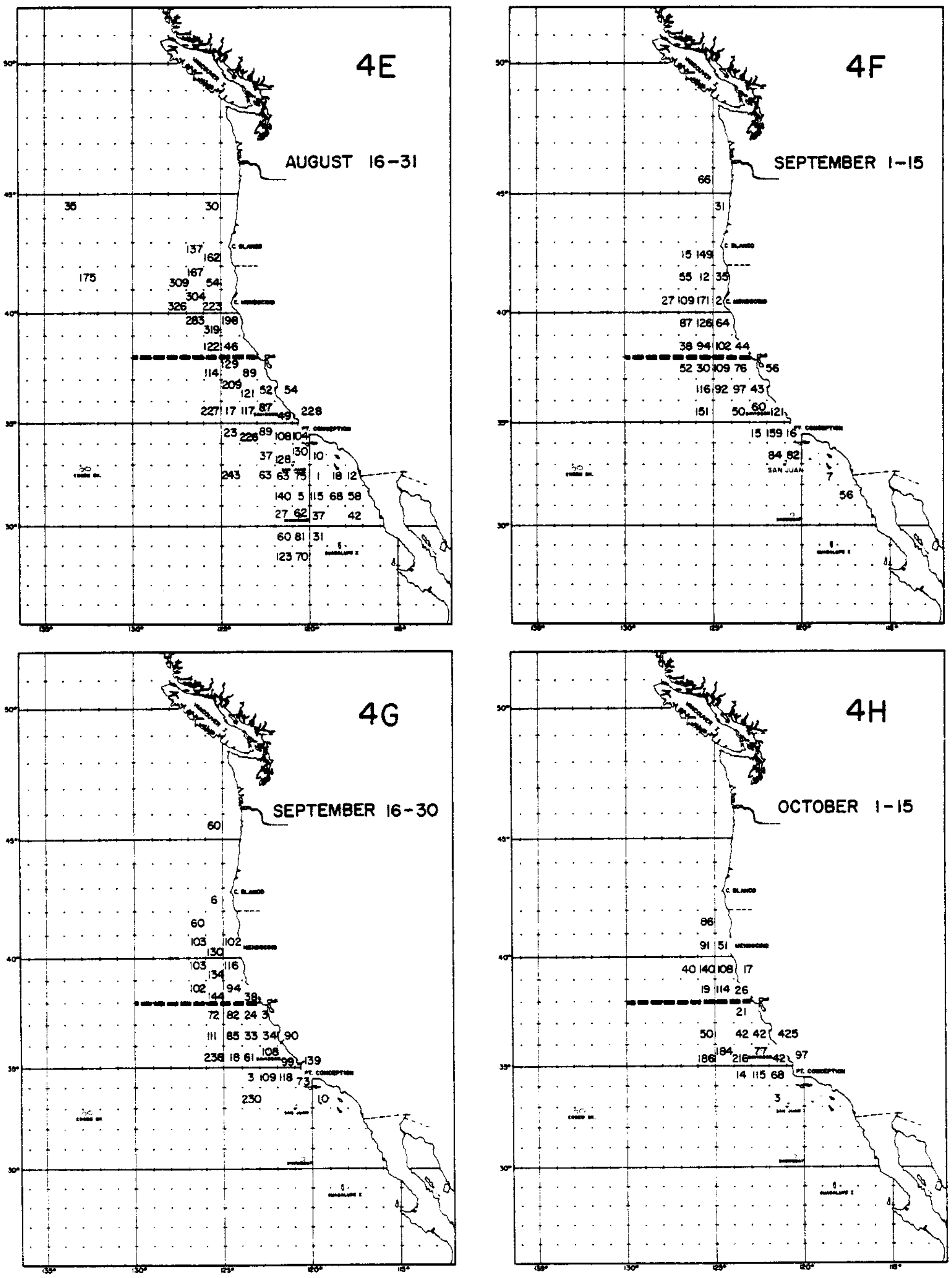


Figure 4.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1964 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.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AUGUST 16-31
4F
SEPTEMBER 1-15
4G
SEPTEMBER 16-30
4H
OCTOBER 1-15

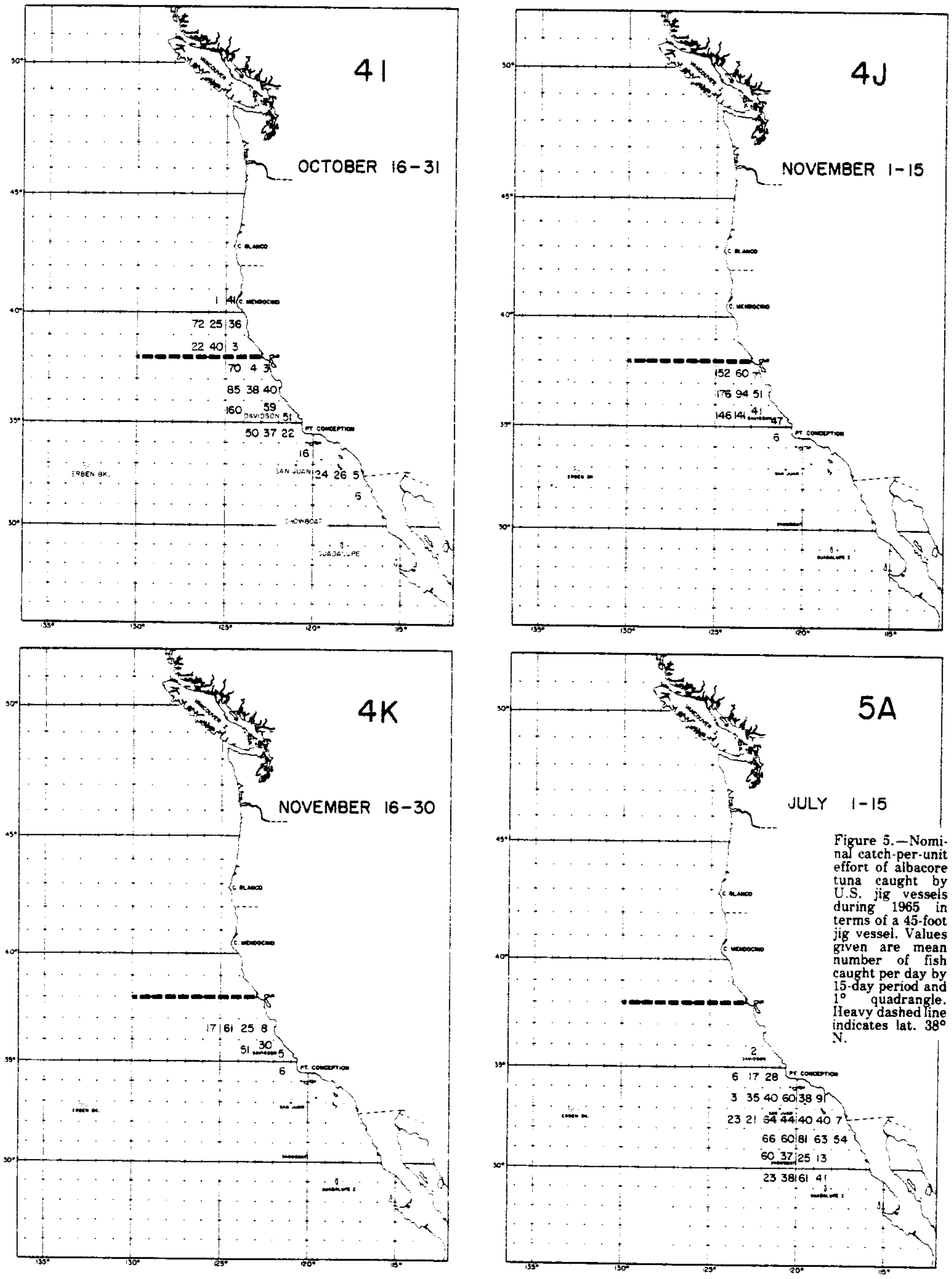
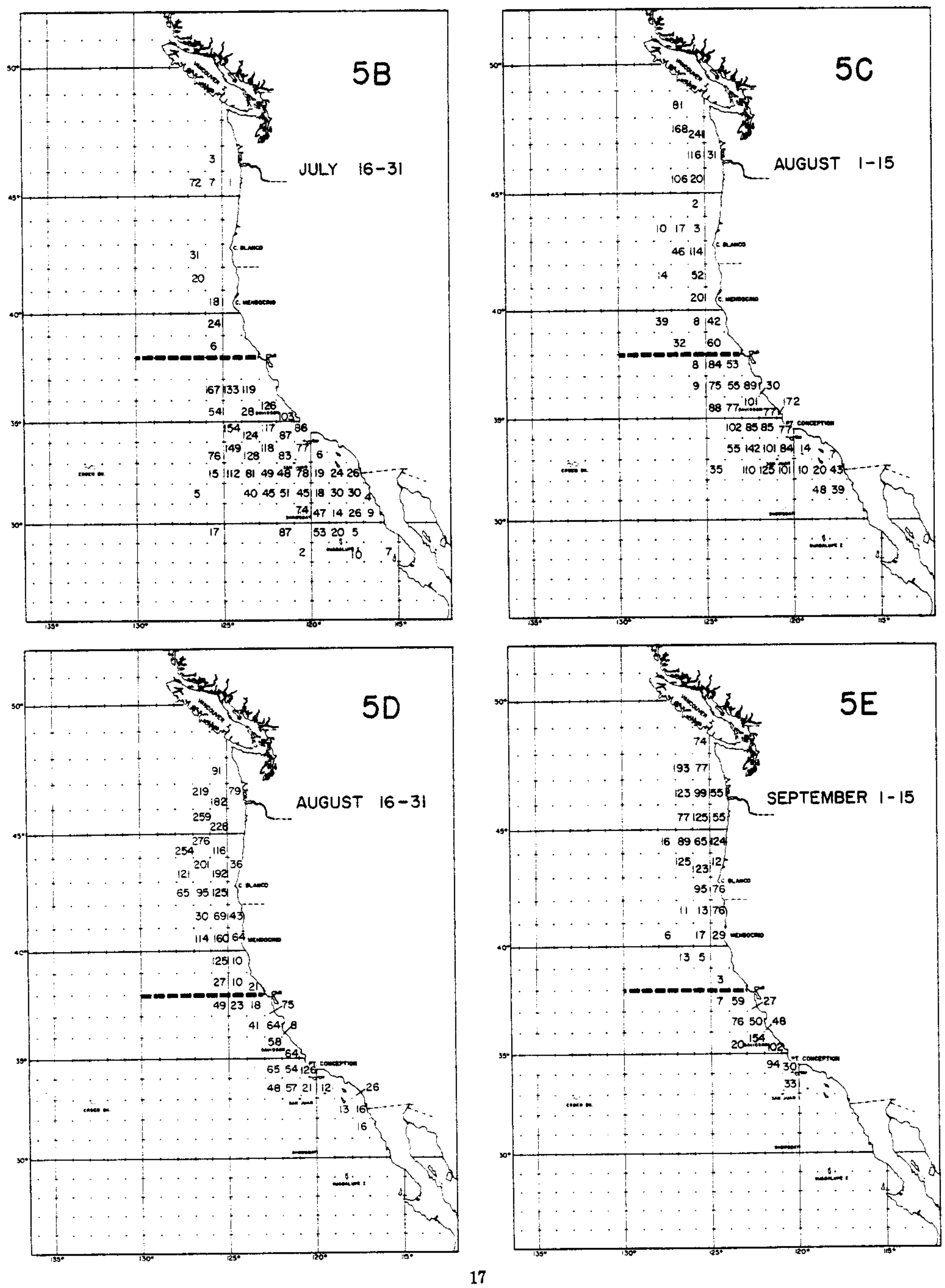


Figure 5.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1965 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.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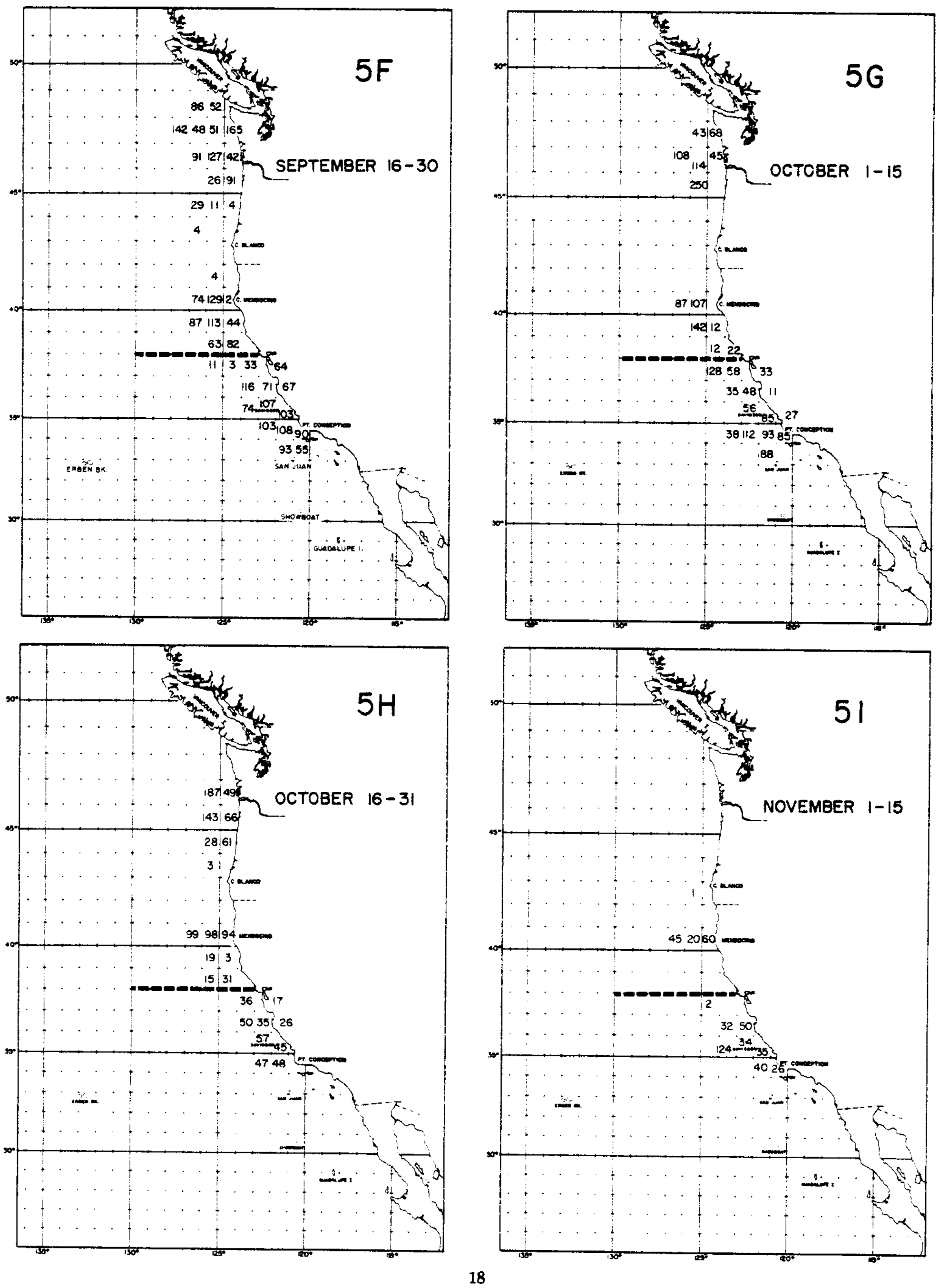
5C
AUGUST 1-15
5D
AUGUST 16-31
5E
SEPTEMBER 1-15


5F
SEPTEMBER 16-30
PT. CONCEPTION
ERBEN BK.
SAN JUAN
SHOWBOAT
GUADALUPE I.
5G
OCTOBER 1-15
5H
OCTOBER 16-31
5I
NOVEMBER 1-15

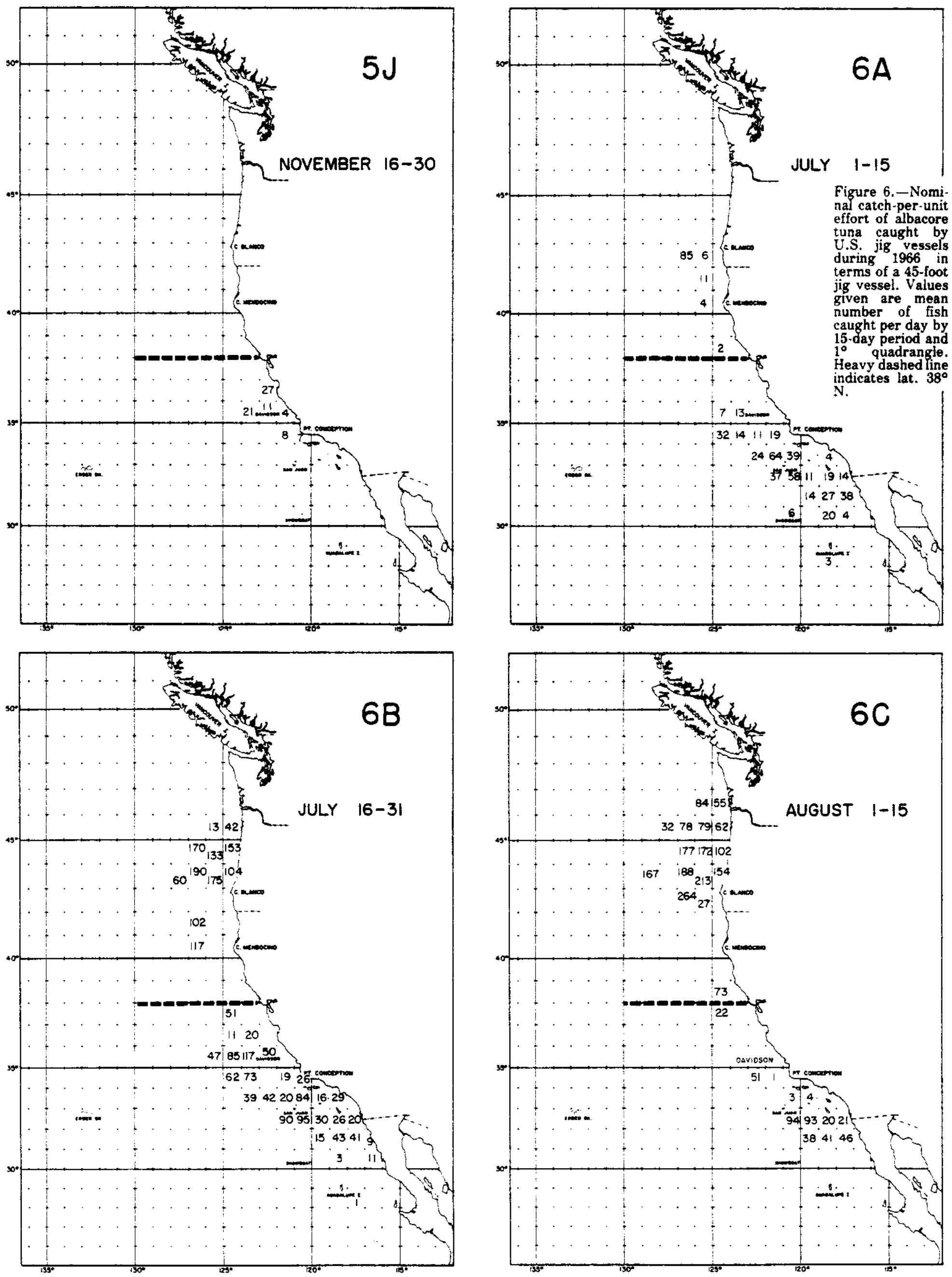
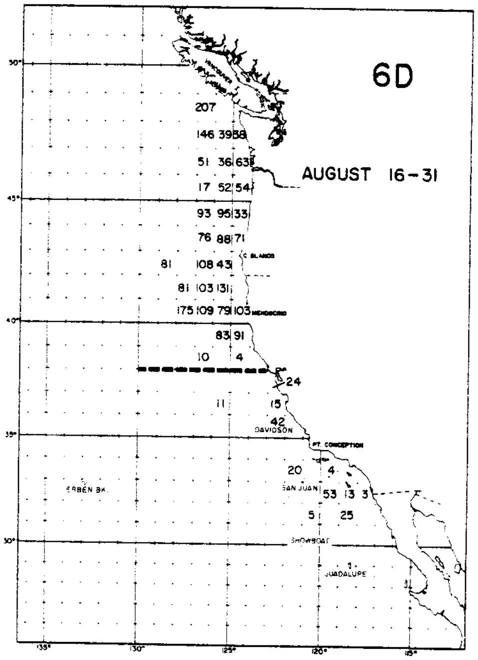


Figure 6.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1966 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.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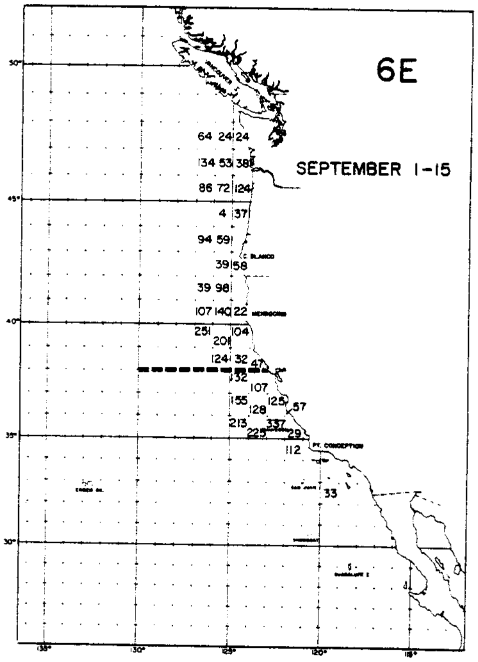
PT. CONCEPTION
ERBEN BK.
SAN JUAN
SHOWBOAT
GUADALUPE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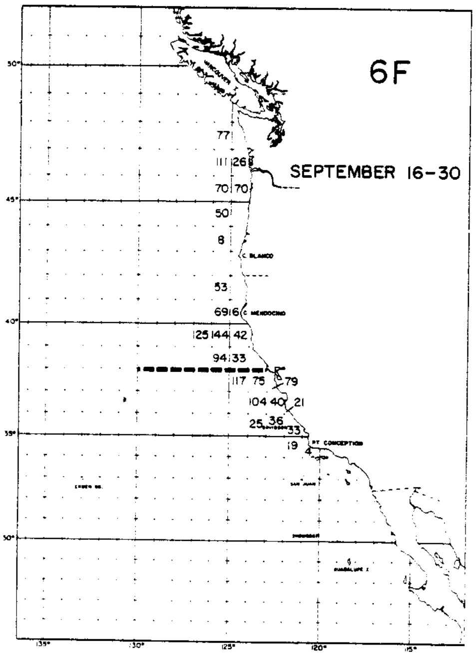
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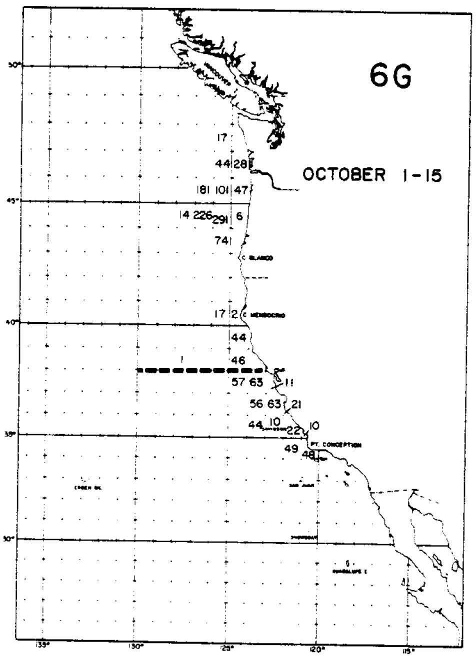

6G
OCTOBER 1-15

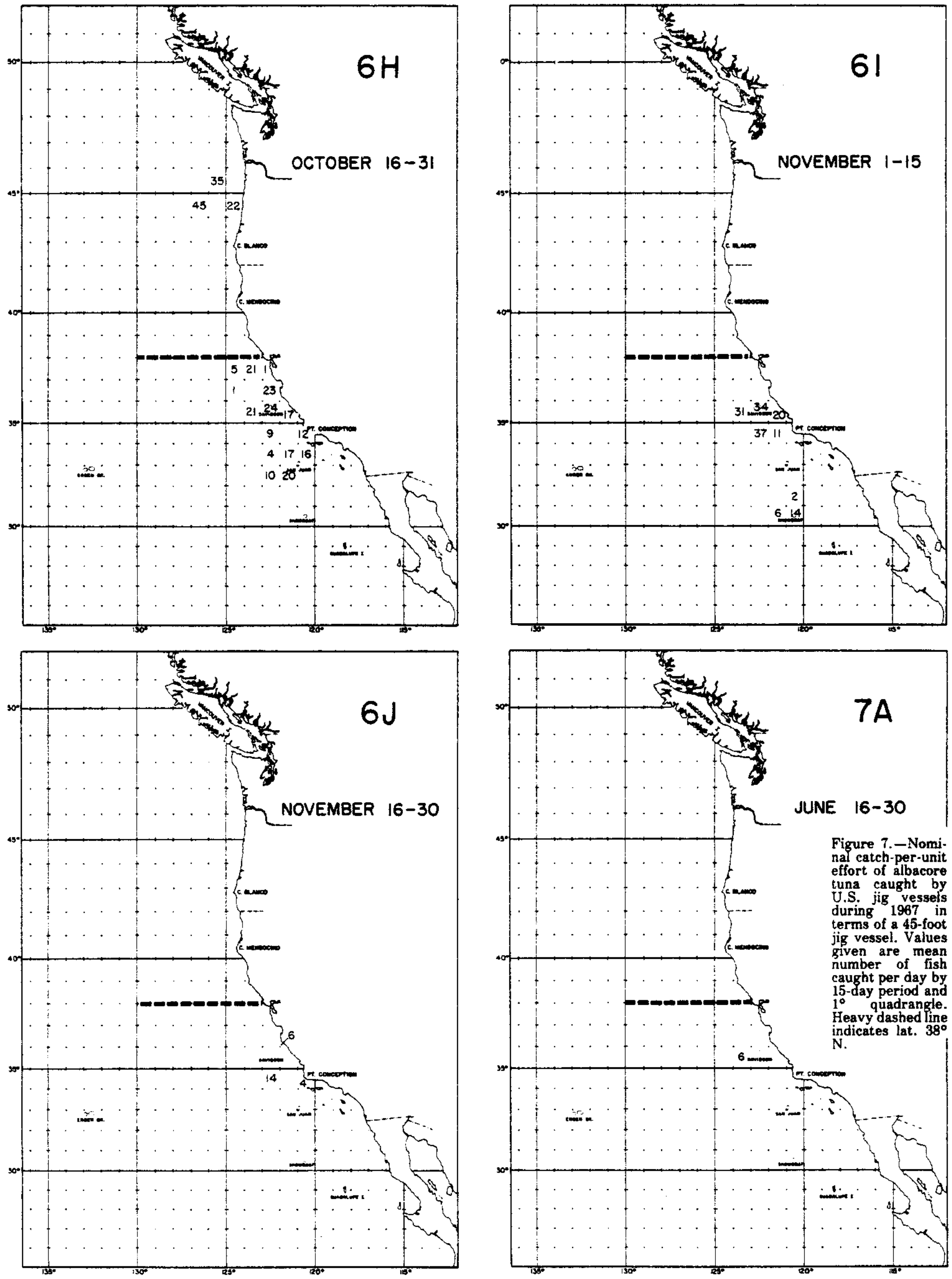
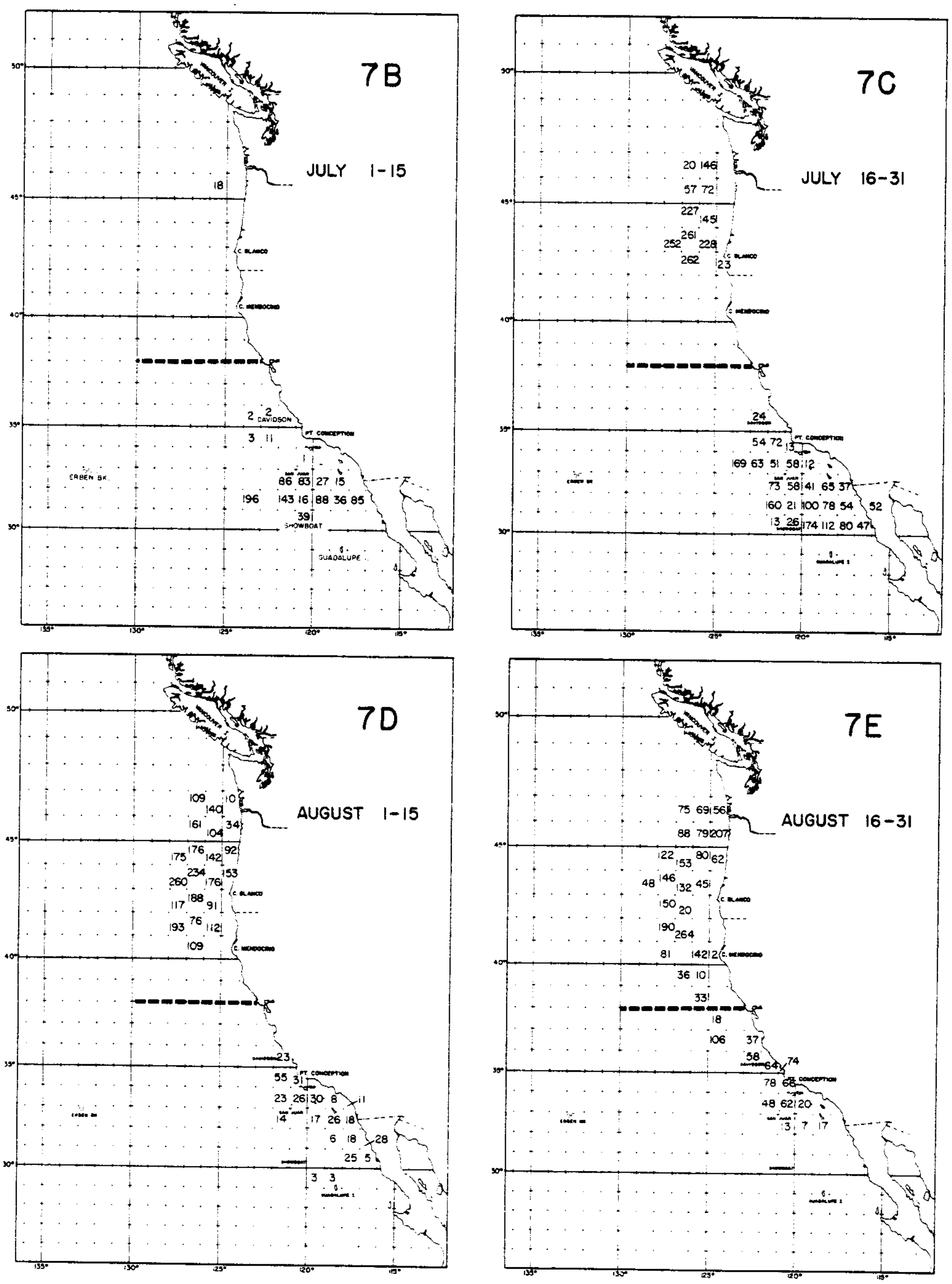


Figure 7.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1967 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.


7B
JULY 1-15
C. BLANCO
C. MENDOCINO
DAVIDSON
PT. CONCEPTION
ERBEN BK.
SHOWBOAT
GUADALUPE
7C
JULY 16-31
7D
AUGUST 1-15
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125°
120°
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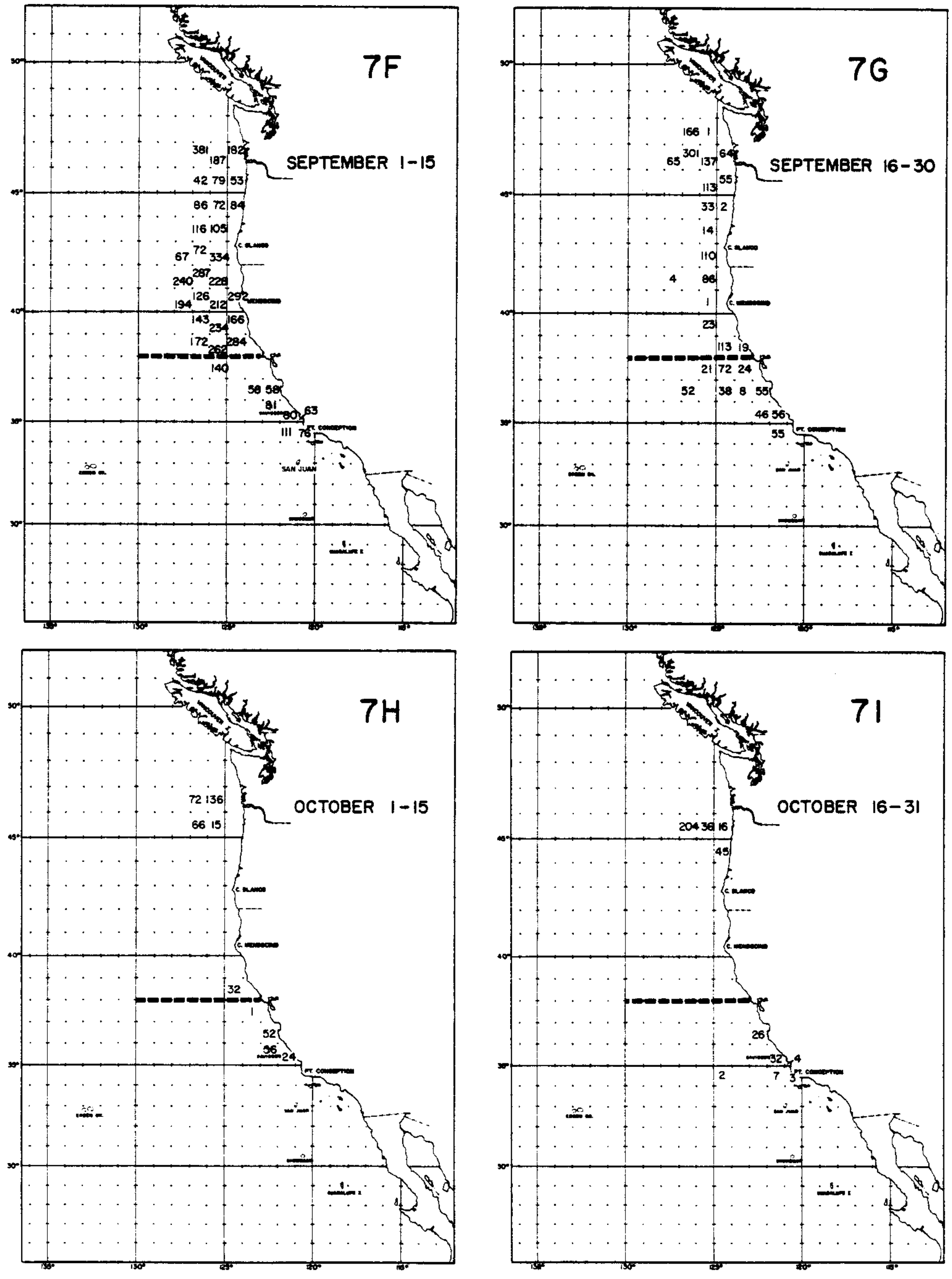
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SEPTEMBER 1-15
7G
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7H
OCTOBER 1-15
7I
OCTOBER 16-31

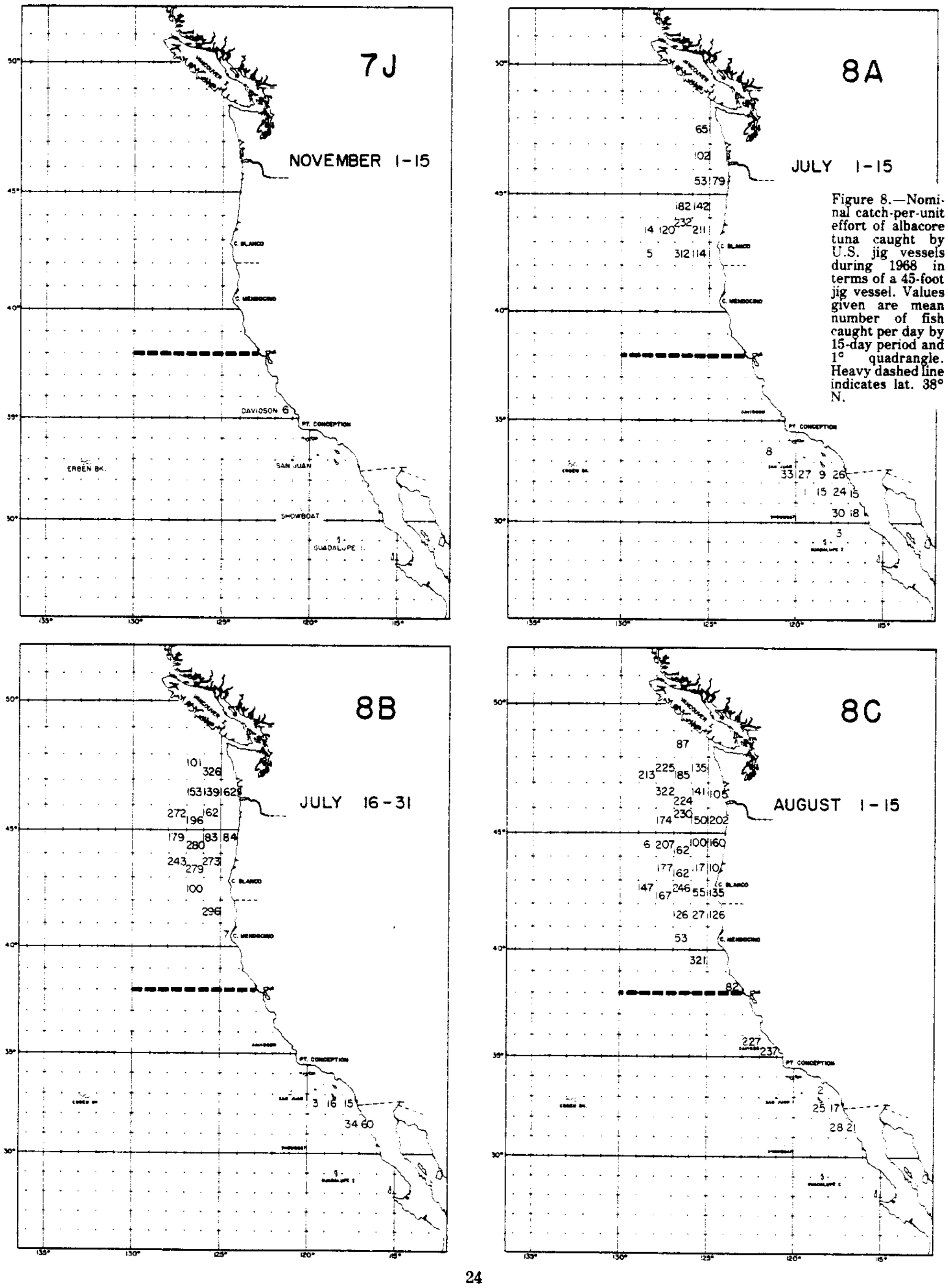
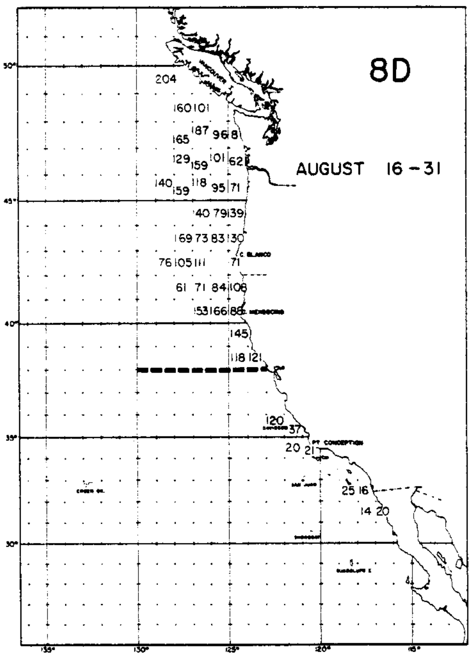


Figure 8.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1968 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.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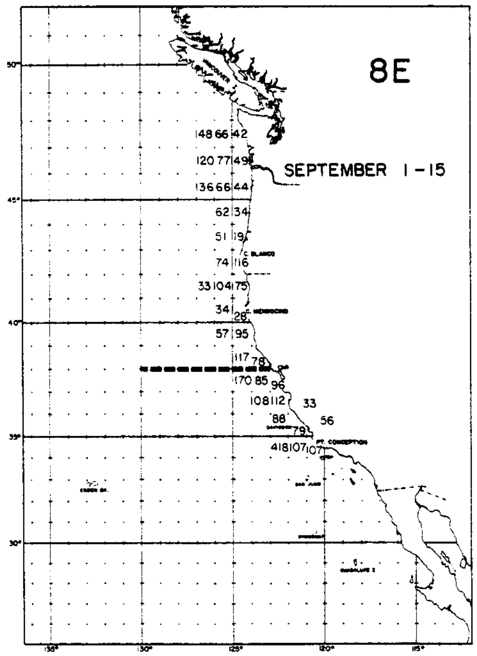
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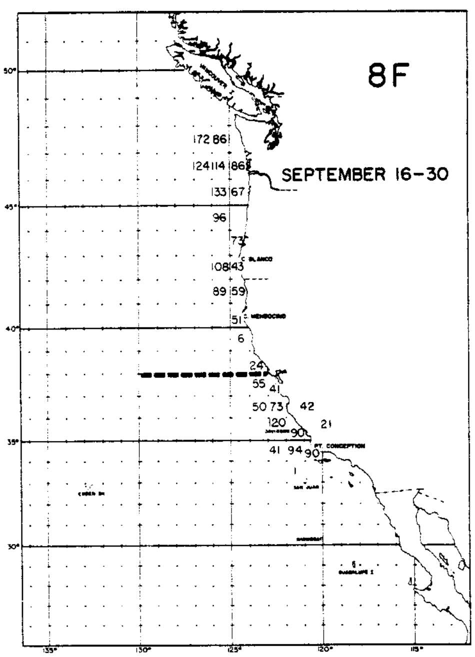
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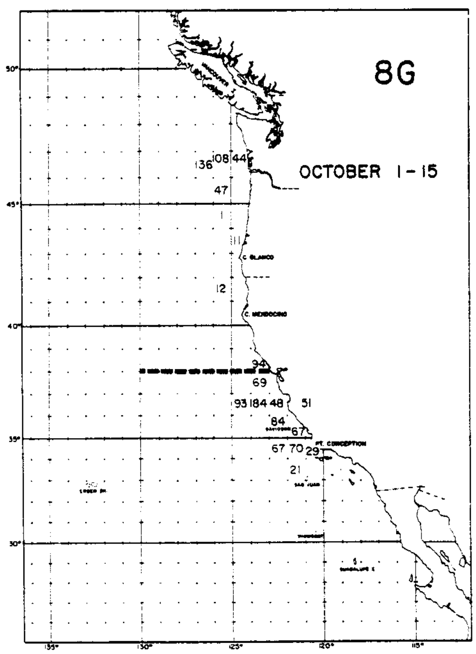
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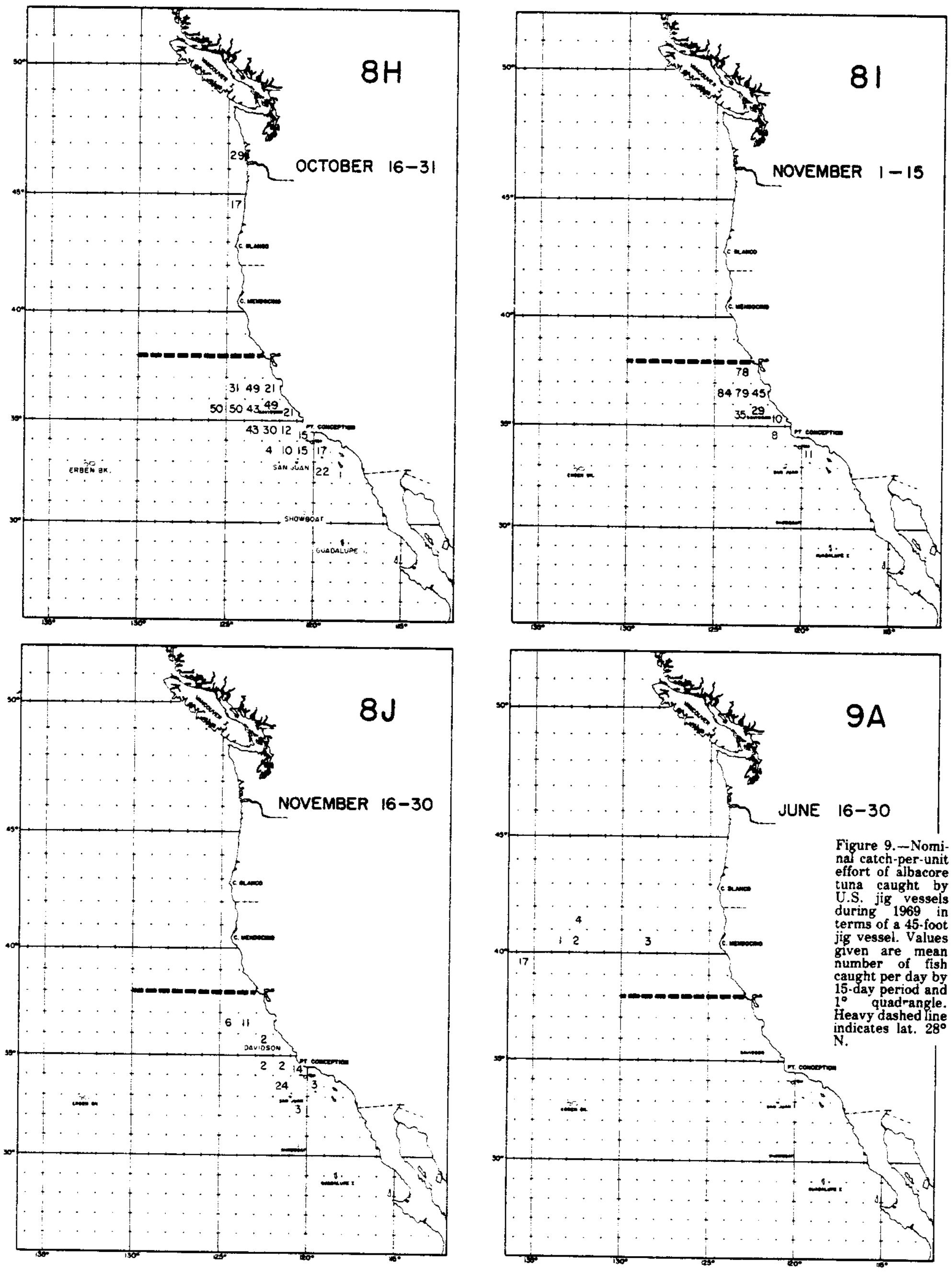
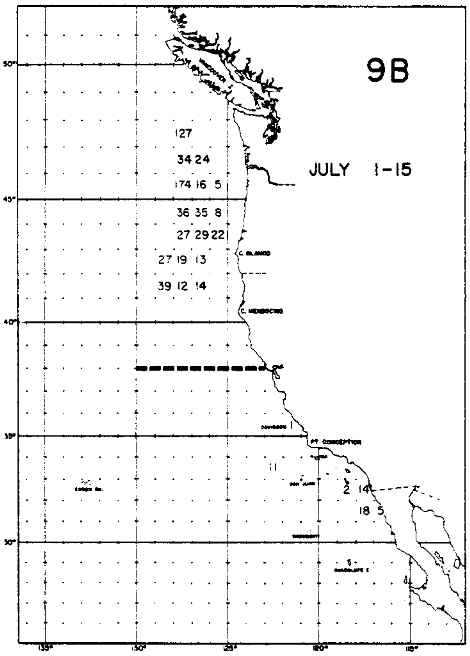


Figure 9.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1969 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 28° N.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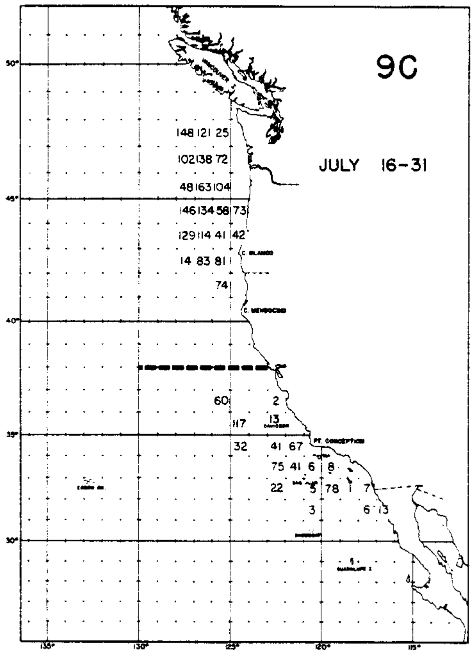
PT. CONCEPTION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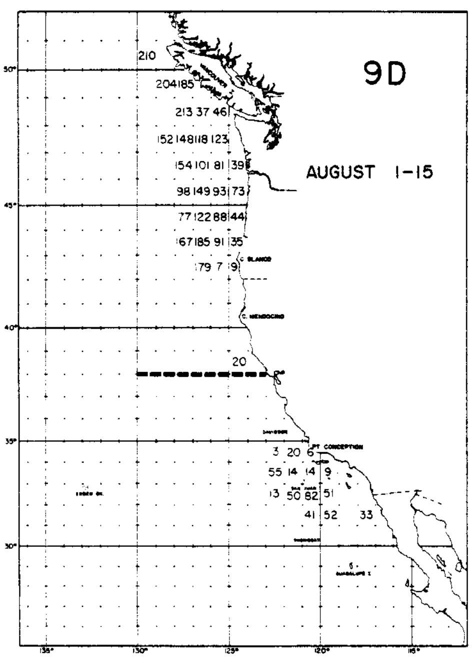
PT. CONCEPTION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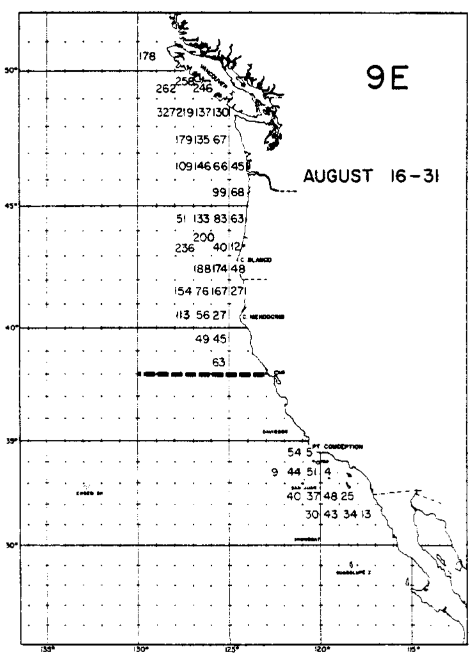
PT. CONCEPTION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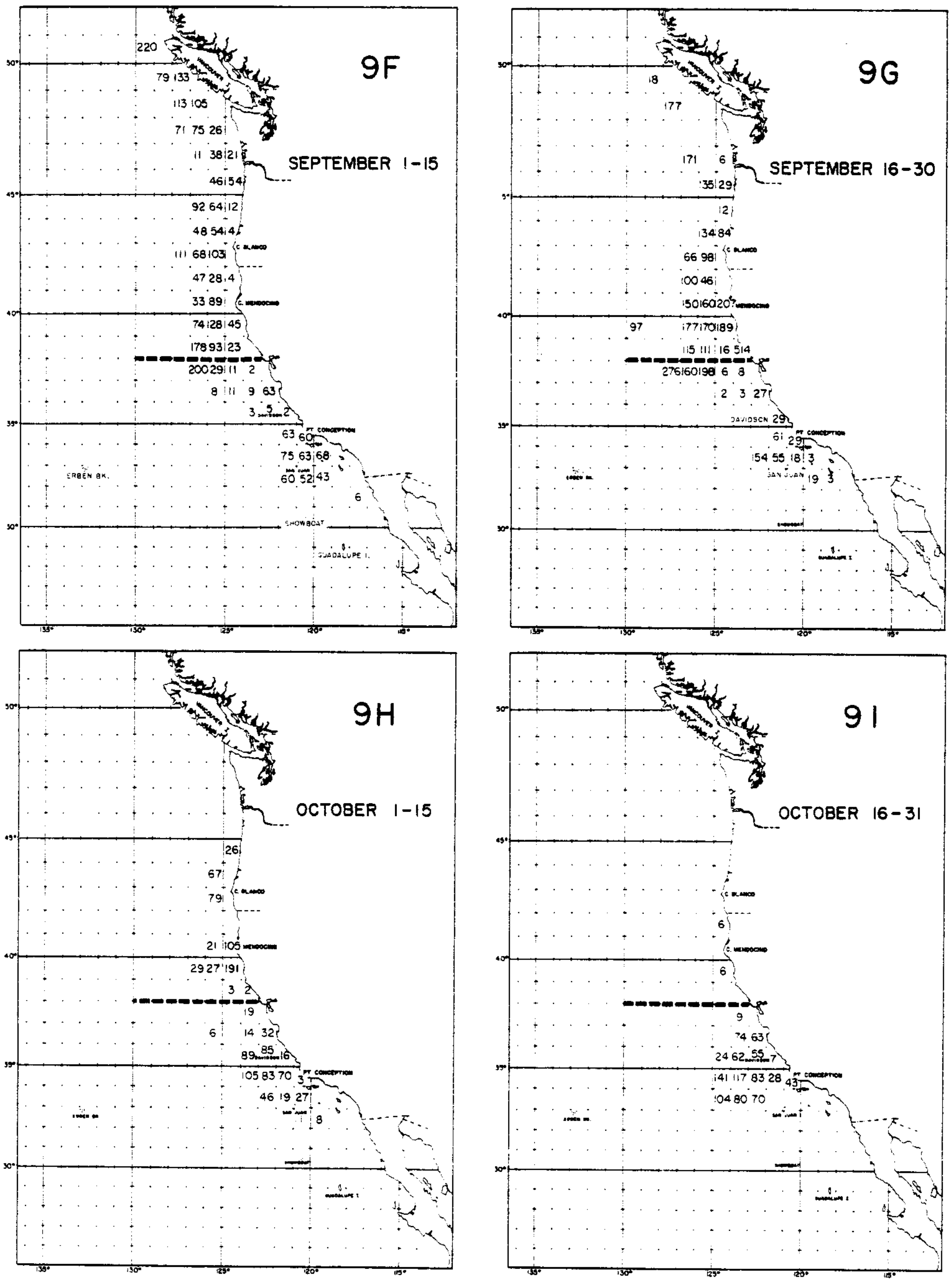
C. MENDOCINO
PT. CONCEPTION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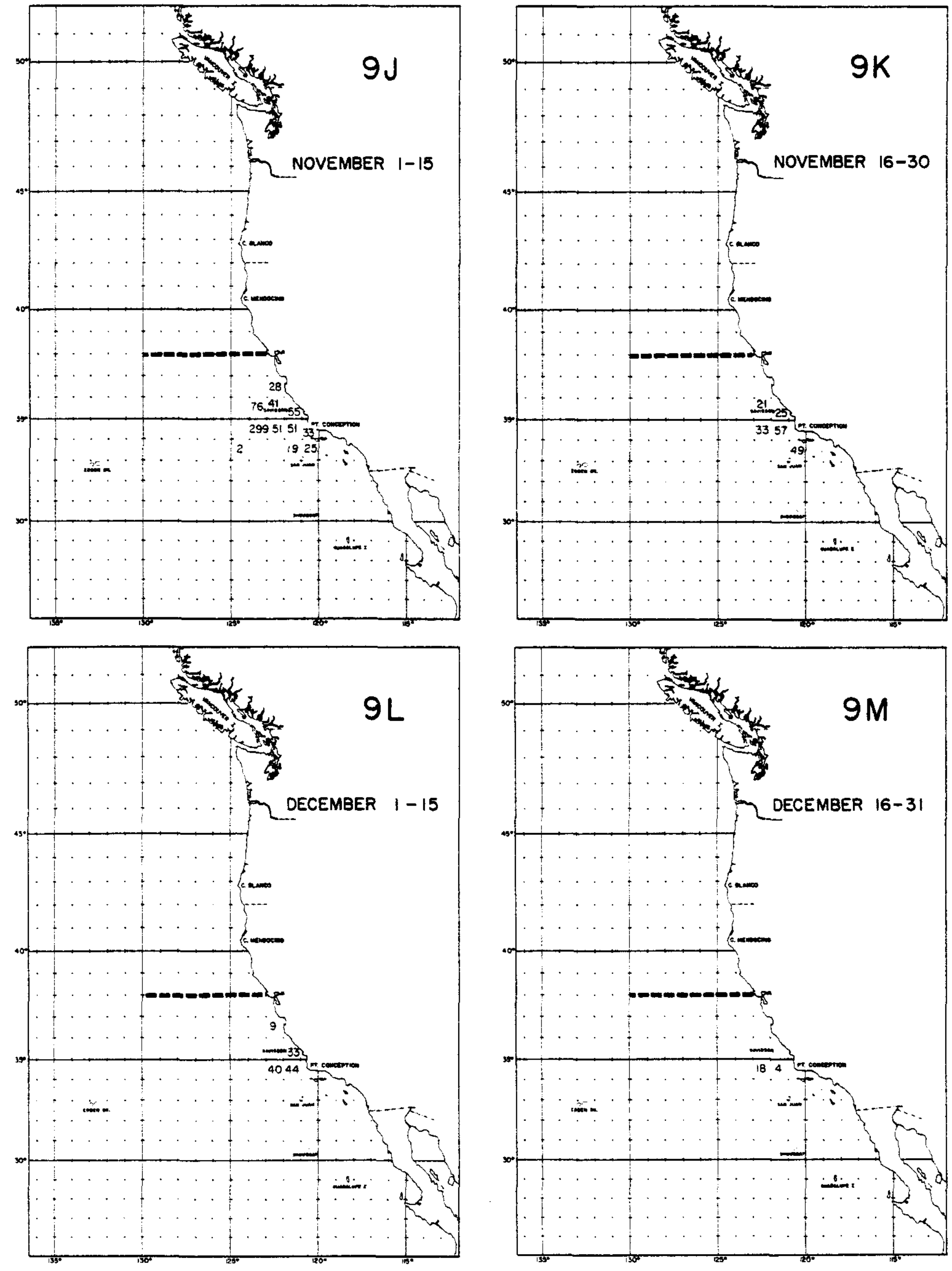
9G
SEPTEMBER 16-30
9H
OCTOBER 1-15
9I
OCTOBER 16-31
PT. CONCEPTION
DAVIDSON
SAN JUAN
SHOWBOAT
GUADALUPE I.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C. BLANCO
C. MENDOCINO
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C. MENDOCINO
PT. CONCEPTION
21 25
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49
9L
DECEMBER 1-15
C. BLANCO
C. MENDOCINO
PT. CONCEPTION
9
33
40 44
9M
DECEMBER 16-31
C. BLANCO
C. MENDOCINO
PT. CONCEPTION
18 4
50°
45°
40°
35°
30°
135°
130°
125°
120°
115°

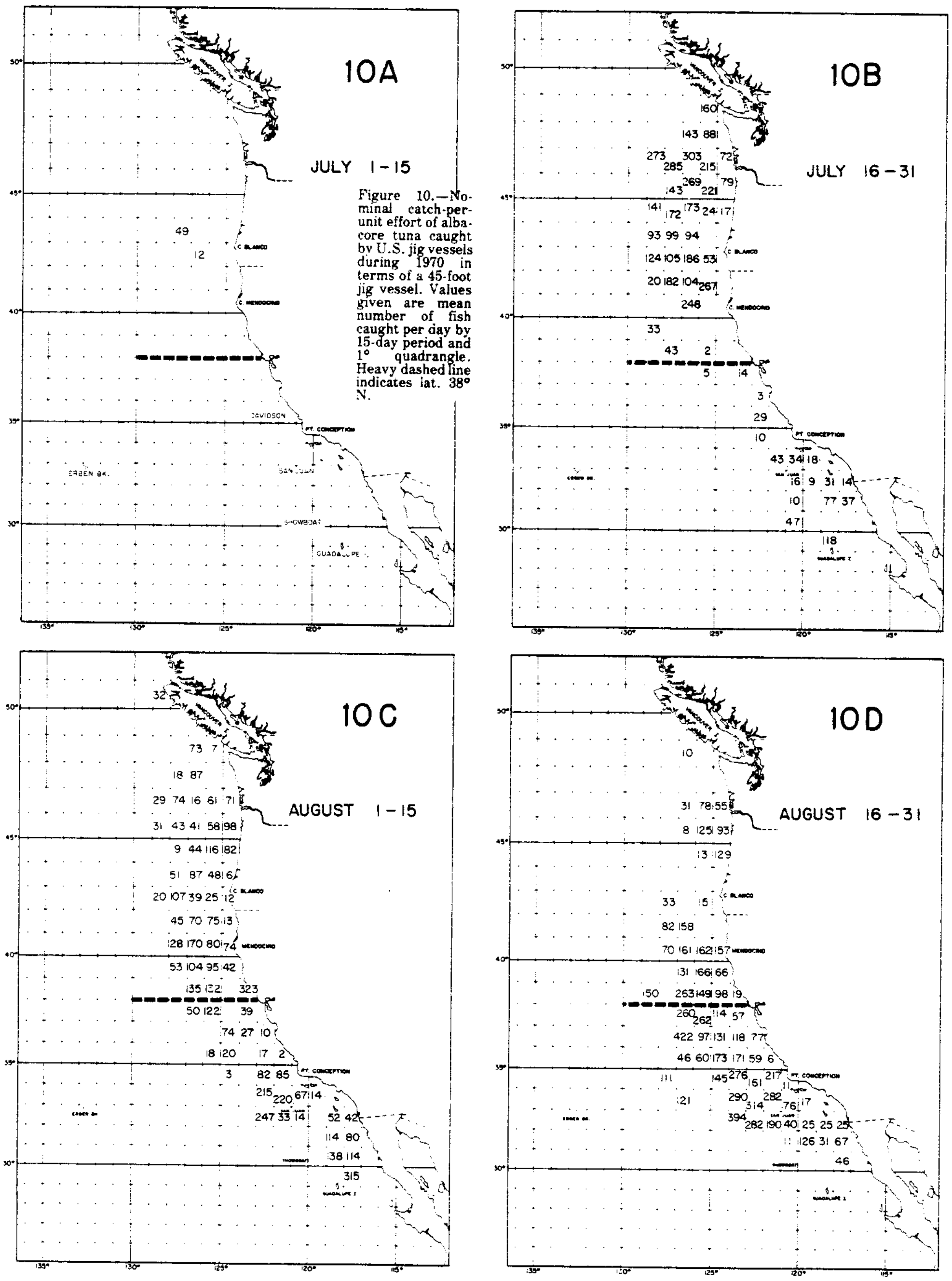
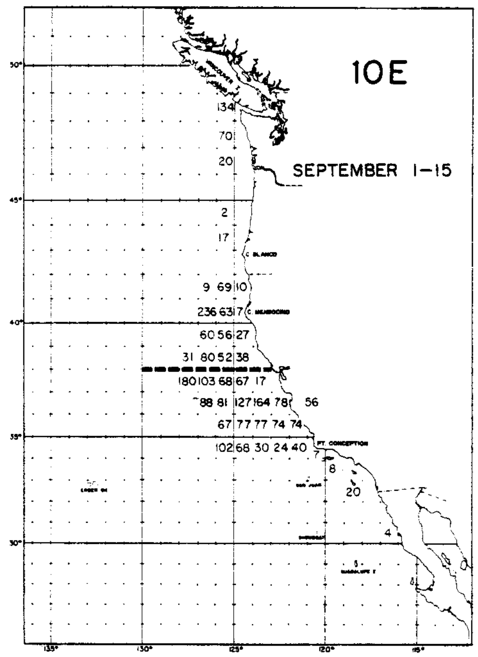
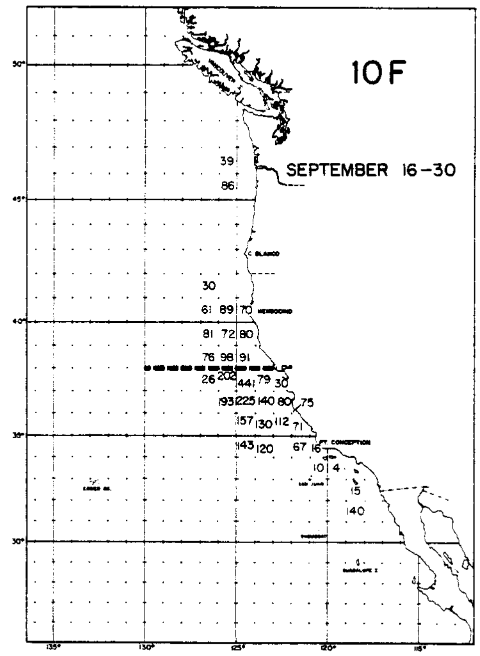
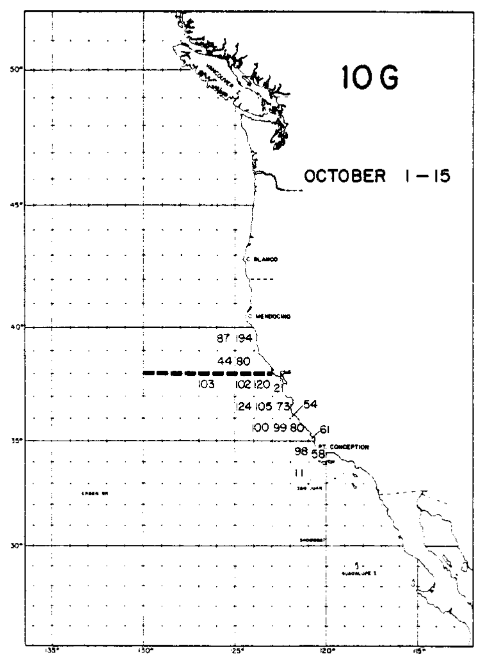
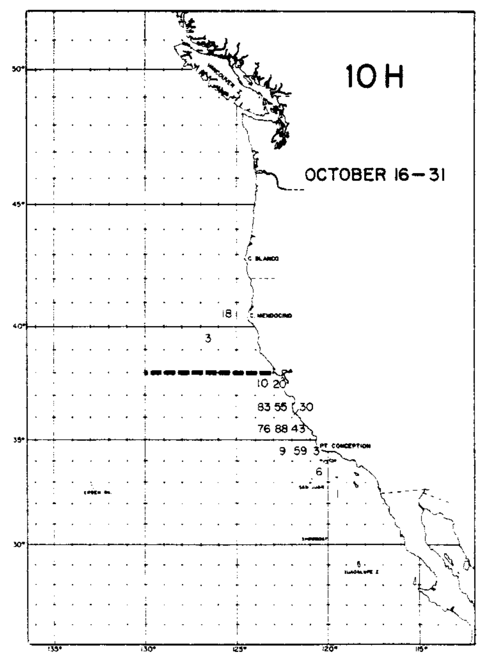


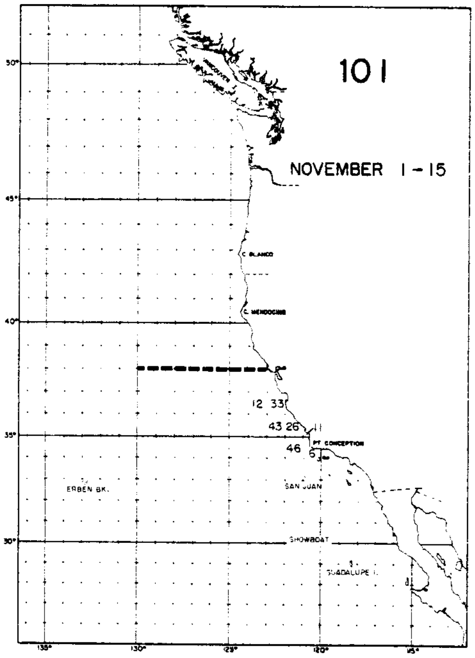
Figure 10.—Nominal catch-per-unit effort of albacore tuna caught by U.S. jig vessels during 1970 in terms of a 45-foot jig vessel. Values given are mean number of fish caught per day by 15-day period and 1° quadrangle. Heavy dashed line indicates lat. 38° N.

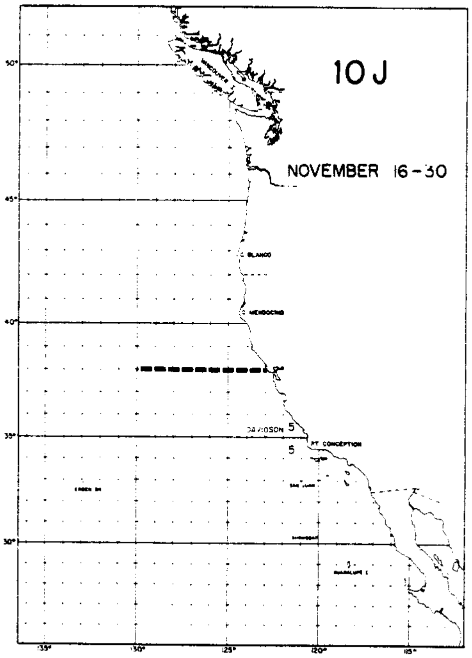

10E
SEPTEMBER 1–15
134
70
20
2
17
C. BLANCO
9 69 10
236 63 17
MENDOCINO
60 56 27
31 80 52 38
180 103 68 67 17
88 81 127 164 78 56
67 77 77 74 74
PT. CONCEPTION
102 68 30 24 40
8
20
4

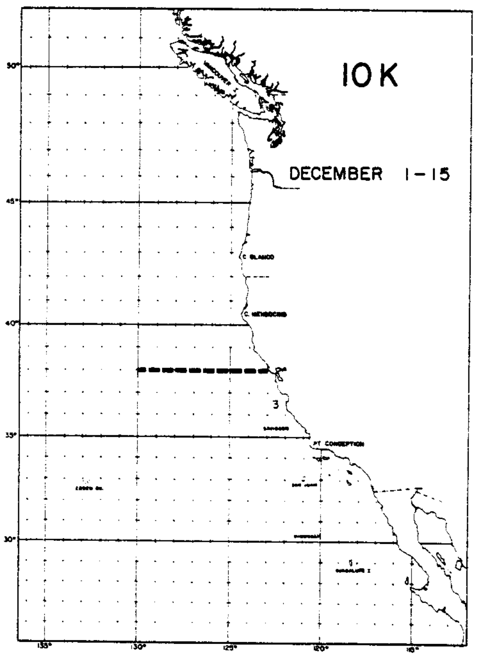

10F
SEPTEMBER 16–30
39
86
C. BLANCO
30
61 89 70
MENDOCINO
81 72 80
76 98 91
26 202 441 79 30
193 225 140 80 75
157 130 112 71
PT. CONCEPTION
143 120 67 16
10 4
15
140


10G
OCTOBER 1–15
C. BLANCO
MENDOCINO
87 194
44 80
103 102 120 2
124 105 73 54
100 99 80 61
PT. CONCEPTION
98 58
11


10H
OCTOBER 16–31
C. BLANCO
18
MENDOCINO
3
10 20
83 55 30
76 88 43
PT. CONCEPTION
9 59 3
6







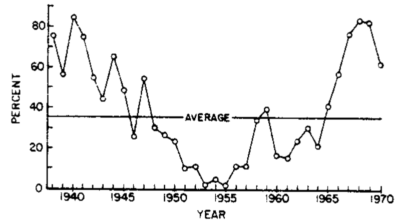
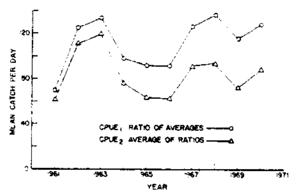


Figure 11.—Percentage of the west coast albacore tuna catch taken north of San Francisco (lat. 38°N) for years 1938-1970.

Figure 12.—Nominal catch-per-unit effort for albacore tuna caught by U.S. jigboats.



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