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by Donald F. Keene
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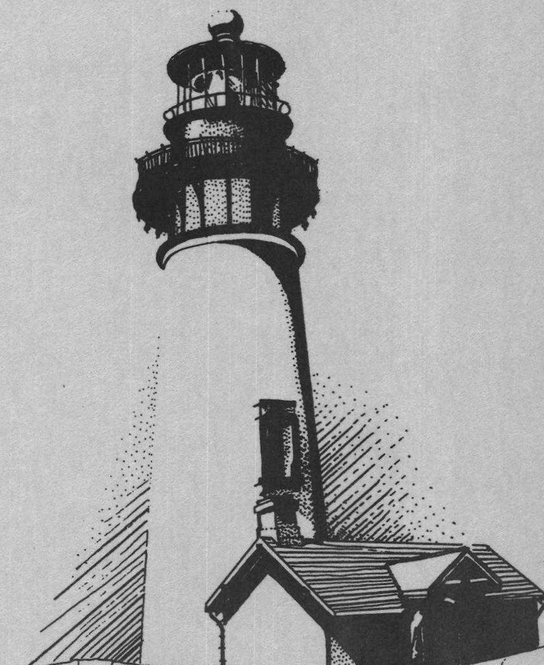

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COMPARISON OF THE MOST SUCCESSFUL AND LEAST SUCCESSFUL WEST COAST ALBACORE TROLL FISHERMEN

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ABSTRACT

Catch data for albacore troll boats were collected from fishermen's logbooks and from dockside interviews during the 1968, 1969, and 1970 seasons. Fishing powers of these boats were calculated and used to determine the 10 most successful and 10 least successful fishermen (highliners and lowliners, respectively) who fished off Oregon and Washington. Characteristics of these two groups of fishermen were then compared. In general, highliners had longer boats and fished nearer the fleet center and along the offshore margin of the fleet. Lowliners tended to have smaller boats and fished along the trailing (south) inshore margin of the fleet. Both groups responded to changes in apparent albacore abundance by aggregating on days of high apparent abundance, although this response was less pronounced in 1969 and 1970. Highliners caught significantly smaller (but more) fish than the lowliners.

The west coast albacore troll-boat fleet consists of many types and sizes of vessels (Clemens 1955). Troll boats range in length from about 10.7 m (35 feet) to over 22.9 m (75 feet) with a displacement of about 15 tons. Part of this fleet begins fishing for albacore off the coast of Baja California in early summer. During the peak of the season (July, August, September) boats may be found from Mexico to the Gulf of Alaska. However, the most productive area usually lies between central Baja California and the Columbia River (Clemens 1961). Many boats, particularly those from Oregon and Washington, fish for other species (salmon, crab, shrimp) during part of the year (Roberts 1972) and occasionally during the albacore season when albacore fishing is slow.

Fishermen in the albacore fleet exhibit a large range of fishing success. Fishing success has been related to strictly physical parameters of the vessel, such as boat length (Fox[3]). Abramson (1963) suggested that fishing success is related to the skill and experience of the captain and crew, as well as the physical parameters of the boat. Little is known, however, about how fishing success is related to the activities of individual albacore fisherman and the activities of the surrounding fleet. (The fleet is considered to be an assemblage of fishing boats within an area of arbitrarily chosen size.) The objective of this paper is to describe and compare the characteristics and movements of the most successful with those of the least successful albacore fishermen during the 1968, 1969, and 1970 seasons.

METHODS

Sources and Treatment of Data

Information on number of fish caught per day by troll boats, location of the catch, boat length, and number of lines (1970 only) was collected from three sources for the 1968, 1969, and 1970 albacore seasons: 1) logbooks distributed by Oregon State University (1969 and 1970), 2) logbooks distributed by California Department of Fish and Game to fishermen who volunteered to submit daily information, and 3) interviews obtained by personnel of the Oregon Fish Commission at dockside during unloading of the albacore. Careful screening avoided duplication of logbook records since vessels often submitted records to more than one source. Only catch locations between lat. 42° and 49°N were used.

The number of reporting boats varied considerably between years. In 1968, 205 boats reported their daily catches and locations. In 1969 and 1970, 70 and 113 boats, respectively, reported. The total number of boats fishing during the 3 yr is unknown but is estimated to have been between 750 (Panshin 1971) and 1,000.

Data from the logbooks and interview sheets

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were punched on computer cards. Each card contained three pieces of information: the boat number, an area-data code (signifying the 1° latitude by 1° longitude rectangle and the calendar day), and the boat's catch of the day. There were approximately 3,300 observations in 1968, 1,500 in 1969, and 1,000 in 1970.

A particular boat was chosen to represent the standard unit of effort. Criteria for the standard boat choice included the following: it fished 1) during all three seasons; 2) in area-date strata concurrently with a majority of the fleet; 3) most of each season; and 4) consistently to provide a standard, nonvarying reference for the other boats.

Estimates of fishing power[4] of all boats in the fleet were initially determined relative to the standard boat. This was accomplished using a computer program called FPOW (Berude and Abramson 1972). FPOW utilizes Robson's (1966) linear two-factor analysis model for estimating the relative fishing power of fishing vessels. The estimates of fishing power derived from the model are logrithms. FPOW provides an approximate correction for this bias using a Taylor series expansion of the estimate about its true value. The method and assumptions used in FPOW are described in Robson (1966) and Abramson and Tomlinson (1972:1022-1023). The program's storage capacity was limited to 2,000 catch observations from a combined total of not more than 200 distinct boats and area-date strata. Data for each year were broken up into time segments short enough to satisfy this limitation. Ten segments were required in 1968, five in 1969, and three in 1970. Each segment was run independently and provided estimates of each boat's relative fishing power during the time segment.

Considerable within-season variation occurred in the average fishing power of the fleet (Table 1), suggesting that the standard boat fished inconsistently relative to the fleet. An examination of the logbooks showed that the standard boat occasionally experienced periods of very low catches (10 to 15 fish per day) while the majority of the fleet in the immediate area was catching 100 to 200 fish per boat. This was particularly obvious during segment 1 of the 1969 season.

As a result of the standard boat's inconsistent fishing, values of standardized catch per boat day were also inconsistent between data segments. For example, an average boat had fishing powers of 3.70 and 1.01 on 25 July and 26 July 1969, respectively (Table 1). If the average boat caught 100 fish on 25 July and 100 on 26 July 1969, values of standardized catch per boat day (100 fish/average fishing power) would be 27 and 99, respectively, for these 2 days. Therefore a serial examination of apparent abundance could not be performed without normalizing fishing power estimates of each boat in each data segment.

Fishing power estimates were normalized by subtracting the appropriate segment's average fishing power from each boat's fishing power and adding unity. (By definition the standard unit of effort is 1.0.) Each boat's fishing power estimate was now relative to the average fishing power of all boats fishing during the data segment. This procedure required the assumption that the fleet fished consistently relative to the standard boat throughout each season.

Daily standardized catch per boat within each area-date stratum was determined by summing the fish catches and dividing by the summation of fishing power in that area-data stratum. The standardized catch per boat day is an index of

TABLE 1.—Data segments for the 1968, 1969, and 1970 albacore seasons.

Segment	Dates	No. of obs.	No. of boats	No. of area-dates	Average fishing power
1968:					
1	6-16 July	242	60	47	0.69
2	17-21 July	320	85	34	1.14
3	21-31 July	410	74	76	0.99
4	1-4 Aug.	357	109	45	0.91
5	5-7 Aug.	290	108	33	0.70
6	8-11 Aug.	310	100	39	0.88
7	12-18 Aug.	420	88	78	0.82
8	19-24 Aug.	373	82	69	1.03
9	25-30 Aug.	235	72	46	0.53
10	31 Aug.-10 Sept.	385	70	113	0.99
1969:					
1	15-25 July	305	51	59	3.70
2	26 July-3 Aug.	374	66	60	1.01
3	4-11 Aug.	326	65	59	1.15
4	12-18 Aug.	212	56	63	1.47
5	19 Aug.-11 Sept.	296	40	111	1.16
1970:					
1	15-22 July	160	52	64	0.35
2	23-28 July	470	99	54	0.91
3	29 July-2 Sept.	262	65	86	0.67

[4]Fishing power is defined (Beverton and Holt 1957:172) as the ratio of the catch per unit of fishing time of a particular vessel to that of another vessel designated as the standard. It is assumed that both boats must have fished on the same density of fish during the same time interval and within the same fishing area when the ratio is determined. Fishing success, on the other hand, is related to fishing power but is more descriptive. It includes parameters difficult to quantify. For example, fishing success may include crew motivation, attitude, and access to useful information. Together with fishing power, these parameters are determinants of fishing success.

apparent abundance, the latter being a function of the accessibility of the albacore to the boats, the vulnerability of the fish to the lures (Marr 1951), and the true abundance of albacore.

The 10 most successful and 10 least successful fishermen (highliners and lowliners, respectively) of each season were selected according to their boats' average fishing power estimates throughout the entire season. Highliners and lowliners selected had fished for at least 15 days in 1968 and 1969 and 8 days in 1970. Thus fishermen who fished exceptionally well or poorly for only a few days in a season were not considered.

Area-Date Stratum of Apparent Abundance

Small-scale time and space information of catches and boat positions allowed a departure from the traditional time-area stratum of 1 mo and 1° latitude-longitude rectangle (Ayers and Meehan 1963; Clemens and Craig 1965). A mobile stratum was conceived to allow comparisons of apparent abundance and effort regardless of where the fleet moved, and without the problems of fixed geographic boundaries.

The new stratum was a circular area, the center being the daily medial location of the fleet. This medial point was determined such that the fleet was equally divided in the north-south and east-west planes. Criteria for the radius of the circular area were that it should be 1) as small as possible to include a homogeneous distribution of fish, but 2) large enough to accommodate a sufficient number of boats fishing on a given day so that catch and effort could be reliably estimated, and 3) large enough to give reasonable assurance that boats within the area remained in the area the entire day. Because of the lack of knowledge of small-scale albacore distributions, there was little basis for satisfying the first criterion.

Consecutively larger concentric circles were drawn around the medial point while noting the ratio of boats within each circle to the number of boats in the entire fleet. (Danils (1952) has presented theoretical considerations of sample point distributions within such circles.) During much of each season, over half the boats could be found within 25 miles of the fleet's center. Exceptions occurred in each season when the fleet was highly dispersed or split into two distinct groups. Two distinct groups of boats occurred on 2, 3, and 4 August 1968 and also 1, 2, and 8 August 1969. During these days the northernmost center was chosen to represent the fleet center because it always contained more boats.

The third criterion suggested a radius of at least 31 miles to insure that vessels remained within the area the entire day. This radius was determined on the basis of distances traveled daily by albacore boats. (This is reported later in this study.) A circle with a radius of 31 miles was therefore used as the area size. Figure 1 shows the percentage of boats that provided catch data within 31 miles of the fleet center each day during the 1968, 1969, and 1970 seasons. Only the time periods within the vertical lines in Figure 1 will be considered for this study. On days outside these periods few boats reported their catch, or the fleet was small and highly dispersed. The average daily percentage of those boats reporting within 31 miles of the fleet center was 46%, 57%, and 65% for the 1968, 1969, and 1970 seasons, respectively. The differences between the 1968 average and the 1969 and 1970 averages were highly significant (t-test, $P<0.01$), indicating that the 1968 fleet was more dispersed in general than the 1969 and 1970 fleets. (This was not a result of a greater number of boats reporting in 1968 because the number of boats reporting per day was often greater in 1969 and 1970 than in 1968.) There was a tendency in both 1968 and 1969

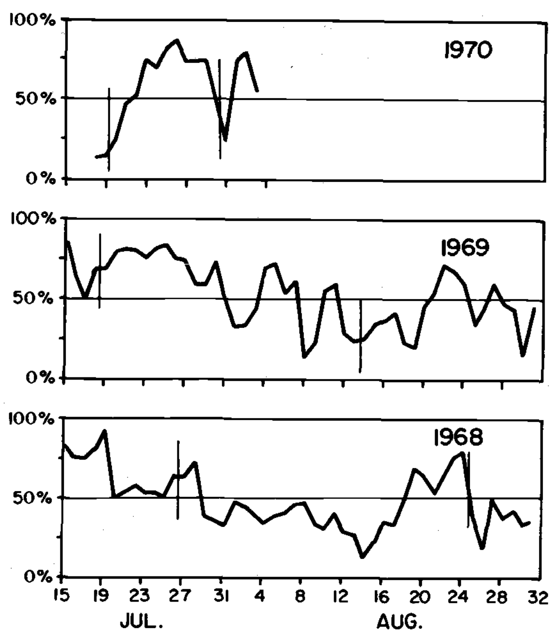

FIGURE 1.—Daily percentage of boats within 31 miles of the albacore fleet center; 1968, 1969, and 1970. Vertical lines on plots indicate the time periods considered in detail in this study.

for the fleet to become more dispersed as the season progressed.

Aggregation of the Boats

The index of aggregation used in this study was the mean separation distance of boats within a specified area. The index was determined by summing separation distances between all boats in the area and dividing this sum by the number of separation distances. This calculation required converting LORAN coordinates (given as the 2100 h PDT boat positions) to latitude-longitude coordinates. Accuracy of the iterative technique used to compute the coordinates has been estimated at 10 m (Thomas 1965:7-9, 38-52), although the absolute position accuracy varied considerably due to the precision of the LORAN operator and the distance from the LORAN transmitters. Boat positions reported at 2100 h within 200 miles of the coast are estimated to be within 3 miles of the absolute positions.

Hunter (1966) stated that mean separation distance is preferred for measuring relative changes in spacing, but for comparison of samples containing different numbers of individuals, mean distance to nearest neighbor (Clark and Evans 1954) should be used. We did not use mean distance to nearest neighbor because most fishermen fish together with one or more companion boats. Mean distance to nearest neighbor would thus represent the average distance separating the same groups of boats and would give little if any information on actual compactness of the fleet within a specified area.

RESULTS AND DISCUSSION

Fishing Power Versus Boat Length and Number of Lines

Sixty-six area-date strata (1° latitude by 1° longitude rectangles and 1-day periods) were selected to examine the relationship between the fishing power of a boat and its length and number of lines trolled. All strata had at least 20 boats reporting within them. (The new mobile stratum was not used here because the intent was to partition the fishery area into a number of equal quadrats, the size and location of the quadrat being of no consequence. Daily boat positions had been assigned to 1° longitude rectangles by FPOW, so this stratum was used for convenience.)

Fishing power estimates were then regressed on boat length and number of lines. (Data on number of lines were available only for the 1970 season.) In none of the strata, in any season, was a significant regression (F-test, $P < 0.05$) found. This indicated that no significant relationship existed between a vessel's fishing power and its length or reported number of lines trolled within a given 1° by 1° rectangle during any given day.

Because of the scatter of data for small-scale time and area strata, the above conclusion did not rule out the possibility of a significant relationship between fishing power and boat length or number of lines. Therefore, a larger stratum was chosen which included all data for each year. Fishing power estimates were again regressed on boat length (1968, 1969, 1970) and number of lines (1970). The results are shown in Table 2.

Boat length was significantly related ($P < 0.05$) to fishing power of albacore boats in a time-area stratum of one season and the entire fishery, particularly in 1968. The significance of boat

TABLE 2.—Regression equations and analysis of variance data for boat length (in meters) and number of lines (1970) versus boat fishing power.

1968	Fishing power = 0.238 + 0.046 (boat length) FP (12.2-m boat) = 0.798 FP (18.3-m boat) = 1.078			
Source	df	Sum of squares	Mean square	F value
Total	810	185.459	0.229	
Regression	1	13.835	13.835	
Residual	809	171.624	0.212	65.23**
1969	Fishing power = 0.263 + 0.049 (boat length) FP (12.2-m boat) = 0.863 FP (18.3-m boat) = 1.163			
Source	df	Sum of squares	Mean square	F value
Total	271	165.265	0.610	
Regression	1	3.214	3.214	
Residual	270	162.051	0.600	5.35*
1970	Fishing power = 0.636 + 0.022 (boat length) FP (12.2-m boat) = 0.916 FP (18.3-m boat) = 1.056			
Source	df	Sum of squares	Mean square	F value
Total	200	24.777	0.129	
Regression	1	0.698	0.698	
Residual	199	24.079	0.121	5.76*
	Fishing power = 0.816 + 0.018 (number of lines) FP (8 lines) = 0.960 FP (12 lines) = 1.032			
Source	df	Sum of squares	Mean square	F value
Total	200	24.777	0.139	
Regression	1	0.110	0.110	
Residual	199	24.667	0.124	0.89 ns

** significant at the 0.01 level.
* significant at the 0.05 level.
ns nonsignificant.

length as it related to fishing power was considerably less in 1969 and 1970 than in 1968, although the 1968 and 1969 regression equations were nearly identical.

Fox (see footnote 3) reported that fishing power of albacore troll boats was related to boat length in a curvilinear manner for the 1961-70 period, with boats of the length class 12.2 to 14.9 m exhibiting the highest estimates of fishing power. There was no clear indication of a curvilinear relationship in 1968, 1969, or 1970, although several very long boats (>22.9 m) generally did not have as large fishing powers as the linear relationship predicted, thus supporting Fox's conclusions. The sample of boats used by Fox was considerably larger (10 yr) and therefore had many more observations of longer boats than used in this study.

Large boats, moreover, make up a minor portion of the albacore fleet. The average length (and standard deviation) of the sample of boats in 1968, 1969, and 1970 was 14.9 m (2.7), 14.9 m (2.1), and 15.2 m (2.7), respectively. Some fishermen feel that larger boats are more successful because of their increased seaworthiness and endurance, resulting in fewer trips to port and permitting more time on the fishing grounds. Fishermen also feel that larger boats fish the lures better in rough weather. Whereas smaller boats tend to jerk the lures as the waves hit the boats, larger boats push smoothly through the waves with less jerking of the lures.

The reported number of lines trolled in 1970 was not significantly related to fishing power. The number of lines reported varied from 6 to 14, with 10 being the mean and mode. The standard deviation was 1.0. The number of trolling lines reported on log sheets bears little resemblance to the number of lines used during varying periods of fishing activity, according to fishermen. When fishing activity increases, only two or possibly three lines are pulled by each man. During periods of intense activity, each man may only handle one line, although periods of intense activity are usually of very limited duration. When the catch rate increases, the longest lines are pulled on board first and only the short lines are fished. One fisherman stated that the number of lines used was determined primarily by the ability of the crew in avoiding tangling of lines. However, over 90% of the 1968 logbooks (in which crew size was recorded) indicated a crew size of two. It would appear that the possible increase in catch as a result of a larger crew size during the infrequent periods of intense fishing activity are offset by the increase in financial cost of a larger crew size. This is even more apparent considering that a daily catch of 180 fish (i.e., about 5 fish per hour per man for a two-man crew) is considered a very good catch by an albacore fisherman.

Comparison of Highliners and Lowliners

Some comparisons of highliner and lowliner boats are given in Table 3. Both groups fished approximately the same number of days and in the same period each season. The difference in boat length was highly significant in all years, particularly in 1968 when highliner boats averaged 4.9 m longer than lowliner boats. In 1969 and 1970 only 1.5 m separated the average length of highliner and lowliner boats. Seven of the 1968 highliner boats were over 15.5 m, whereas none of the 1969 and only one of the 1970 highliner boats were over 15.5 m. Essentially the same proportions of 15.5 m and longer boats made up the fleet samples in each season. Lowliner boat lengths were consistently short, between 14.0 and 15.2 m.

Lowliners often fished along the trailing margin of the fleet during all years as the fleet moved to the north. Highliners were more centrally located in the fleet and along the offshore or leading margin, as shown in Table 3. In 1968 lowliners were removed from the main body of the fleet, generally located far to the south and inshore of the fleet, whereas highliners tended to be slightly to the south but offshore of the main fleet center. In 1969 and 1970 both groups were located closer to the fleet center, although the lowliners were still three to four times farther away from the fleet center than were highliners. Lowliners fished consistently south of the center in all 3 yr.

A detailed description of the location of highliners and lowliners is presented in Figures 2-4.

TABLE 3.—Comparison of highliners with lowliners, west coast albacore trollers.

Item	1968	1969	1970
Average boat length (m):			
Highliners	19.2	15.5	16.2
Lowliners	14.3**	14.0**	14.6**
Average distance to fleet center (miles):			
Highliners	30 SW	5 W	8 N
Lowliners	104 SSE	22 SW	25 S
Average daily travel (miles):			
Highliners	21	26	27
Lowliners	31**	29 ns	28 ns
Average relative fishing power:			
Highliners	1.61	1.57	1.24
Lowliners	0.65	0.46	0.85

** significant at the 0.01 level, *t*-test.
ns nonsignificant.

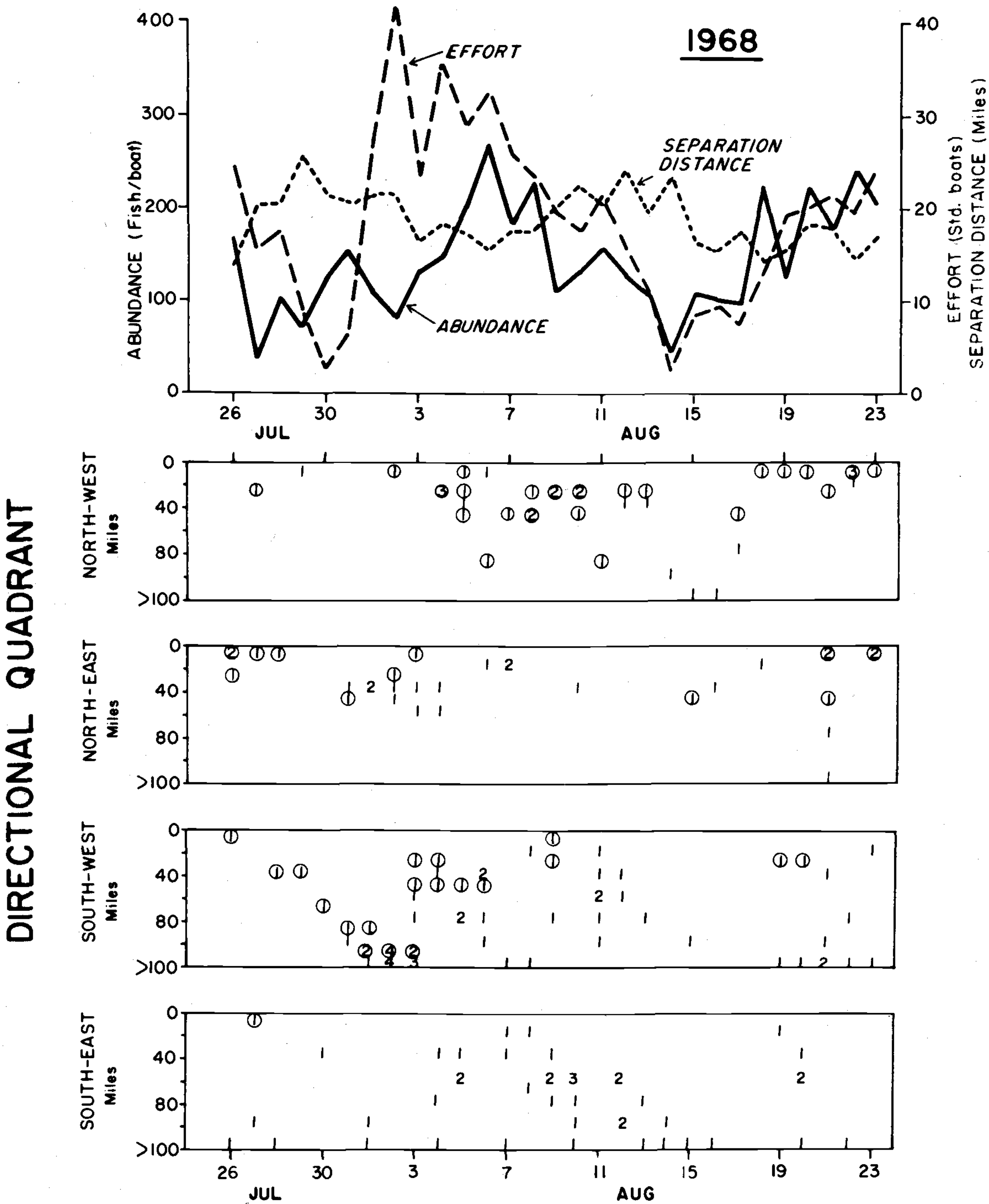

FIGURE 2.—Locations of 1968 highliners and lowliners relative to the center (medial) of the fleet. The top graph indicates the corresponding levels of apparent abundance of albacore, fishing effort, and boat separation distance within 31 miles of the fleet center. The lower four plots show the distance of highliners (circled numbers) and lowliners (noncircled numbers) from the medial fleet center.

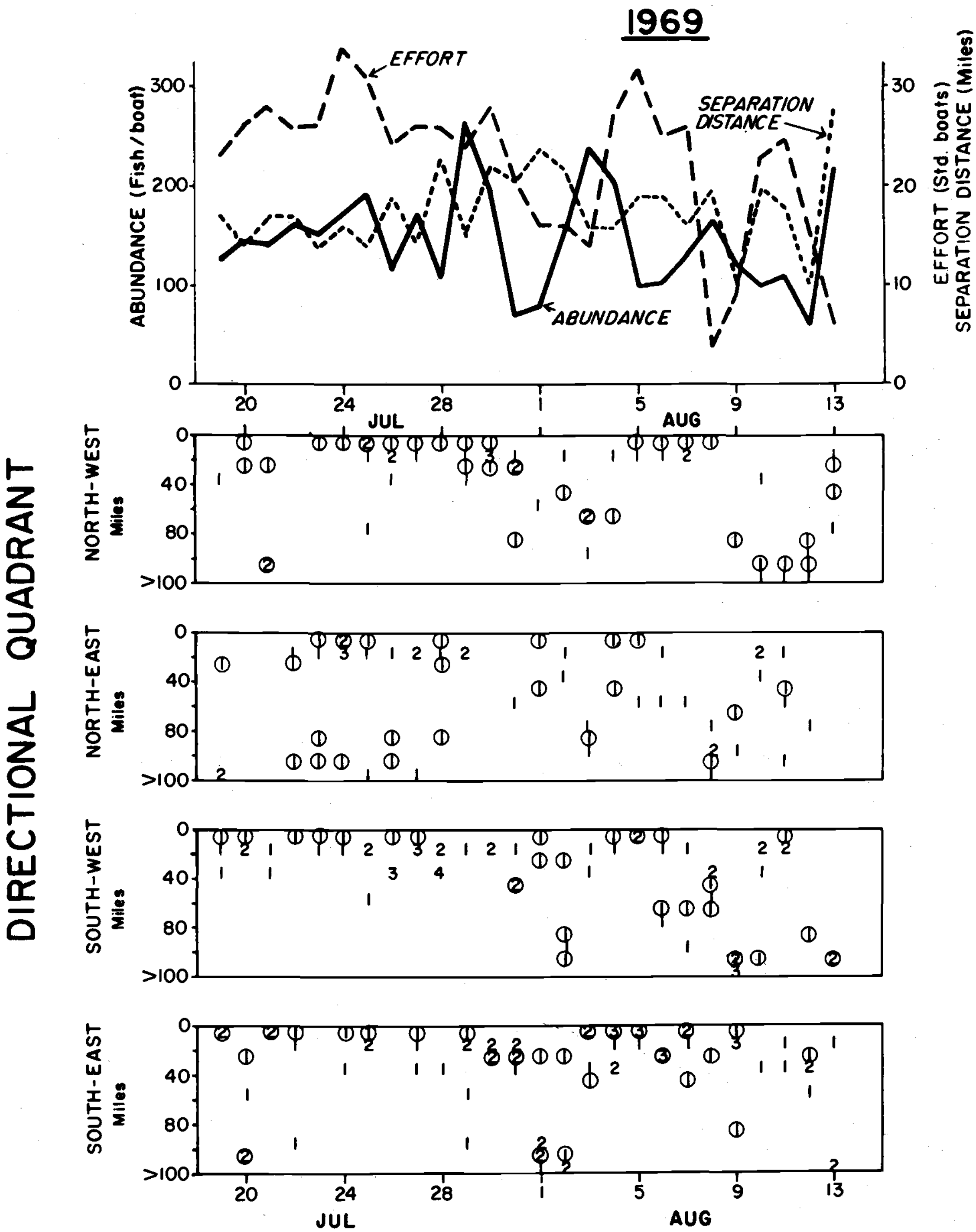

FIGURE 3.—Locations of 1969 highliners and lowliners relative to the center (medial) of the albacore fleet. See Figure 2 for explanation of plots.

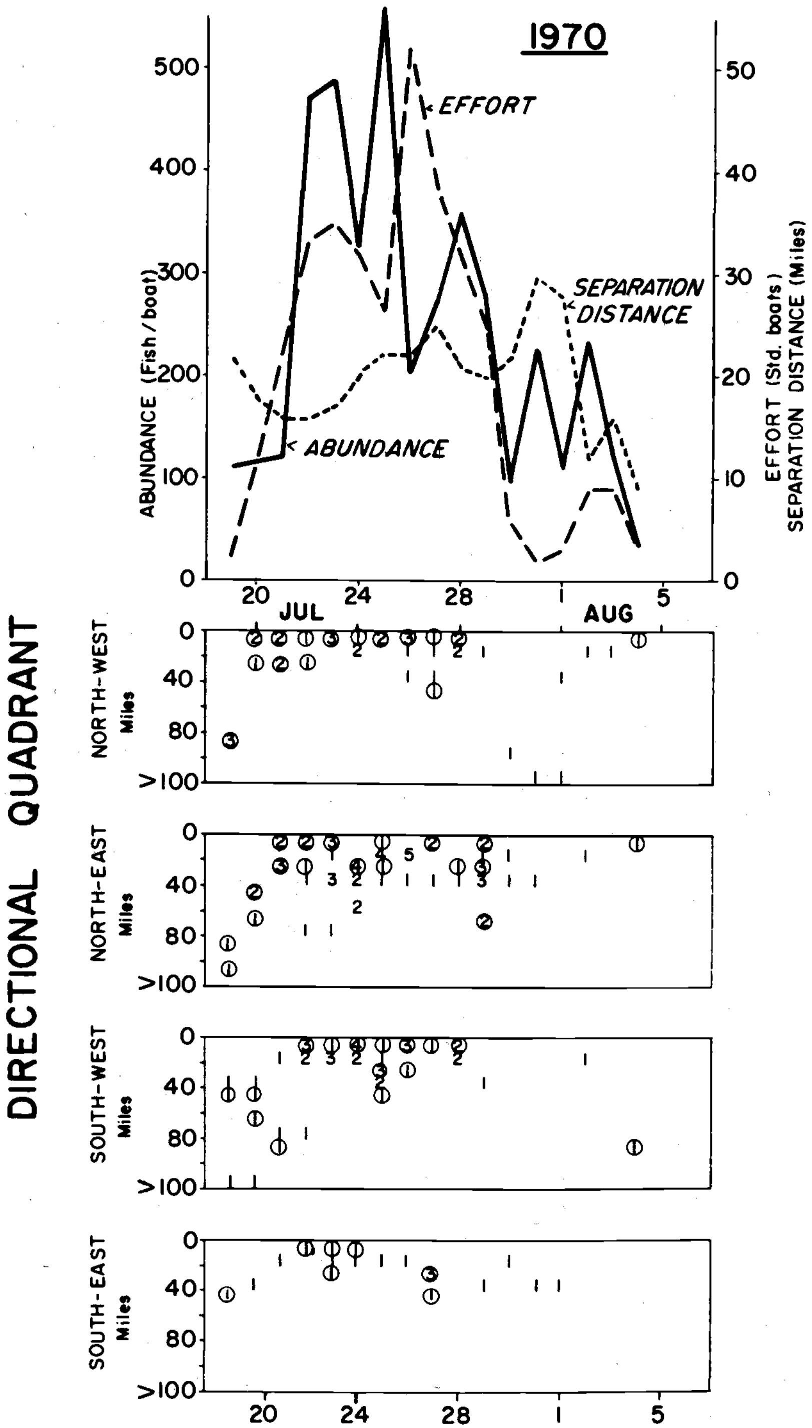

FIGURE 4.—Locations of 1970 highliners and lowliners relative to the center (medial) of the albacore fleet. See Figure 2 for explanation of plots.

The plots show where these two groups fished with respect to the fleet center during periods of variable levels of albacore abundance, fishing effort, and boat separation distance (shown at the top of the figures).

A very obvious separation of highliners and lowliners occurred in 1968 (Figure 2). Highliners fished almost exclusively to the northwest and southwest of the fleet center. When abundance was low and effort high (26 July-3 August), highliners moved far from the fleet center, as seen in the southwest quadrant. During 5 and 6 August, when high catches coincided with high levels of effort, highliners were found close to the fleet center, but not as close as during periods of low effort. Lowliners fished mainly to the south and away from the fleet center during all levels of abundance. When abundance was high (5-8 August), lowliners in the southeast quadrant moved closer to the fleet center. Later as catches declined, the lowliners moved away from the center (southeast quadrant, 9-15 August).

There was no obvious separation of highliners and lowliners in 1969 (Figure 3) comparable to 1968. Highliners fished in all quadrants, as did lowliners. Some highliners fished away from the fleet center during periods of low abundance (31 July-2 August; 5-12 August), particularly in the northwest and southwest quadrants when effort was high (10-12 August). Lowliners again fished more in the southern quadrants than did highliners but not exclusively so and not as far from the fleet center as in 1968. In fact, most lowliners were located near the fleet center until all catches began decreasing after 5 August. Then, some lowliners moved away from the fleet (southwest, northeast; 10-11 August) but the majority remained near the fleet center.

The short 1970 season provided little information on the responses of highliners and lowliners (Figure 4). As the season began (19-21 July) highliners were fishing at some distance from the fleet center. During the period of very high catches (22-29 July) both highliners and lowliners fished within 40 miles of the fleet center. No boat reported a location farther than 80 miles from the center during this time. There was no indication that either group dispersed in response to the high levels of effort and aggregation of boats which occurred. On 22 July, when separation distance was lowest and on 26 July when effort was highest, most highliners were fishing within 20 miles of the fleet center.

Most highliners did not fish Oregon waters after 30 July, the day catches dropped precipitously. The lowliners that stayed were northwest of the fleet center. Catches never returned to their original high levels, and on 4 August the season was essentially over for the troll boats.

Some albacore fishermen believe that large numbers of small fish are located in the offshore fishing area and that highliners are able to exploit these fish to a greater degree because of their greater endurance and seaworthiness. To test this hypothesis, the average weight of each fish per trip reported by highliners during July and August was compared with the average fish weight per trip for lowliners. The results, given in Table 4, show that highliners caught significantly smaller fish than lowliners. This supports the fishermen's belief that smaller fish are found along the offshore margins of the fishery where highliners often fish, while larger fish are found along the inshore margins of the fishery where lowliners expend more effort.

The difference between average daily net travel of highliners and lowliners, based on 2100 h PDT positions, changed significantly within the 3 yr. Highliners in 1968 moved 10 miles less per day than did lowliners (Table 3). In 1969 and 1970 there was no statistical difference between the average distance traveled by the two groups. Travel distances in Table 3 can be compared with the daily travel of the fleet center (Figure 5). The fleet center moved an average of 14 miles per day in 1968, 29 miles per day in 1969, and 29 miles per day in 1970. Highliners moved in a much closer relationship with the fleet in 1968 than did lowliners. Lowliners in 1968 traveled twice as far as the general fleet, yet lagged behind the fleet's northerly movement. This was much less apparent in 1969 and 1970.

A comparison of average relative fishing powers showed that highliners of 1968 and 1969 were about three times more successful than lowliners in catching fish (Table 3). Lowliner fishing power decreased in 1969, even though lowliner and highliner boat lengths and daily distances traveled were similar. In 1970 lowliner and highliner characteristics were quite simlar to those of 1969, except for calculated fishing power. In 1970 fishing power of lowliners increased while that of highliners decreased. This was probably due to the

TABLE 4.—Average weight (kilograms) of individual albacore per trip taken by highliners and lowliners during July and August 1968, 1969, and 1970.

Year	Highliners	Lowliners
1968	5.7	6.2*
1969	6.0	6.4**
1970	6.1	6.8*

* significant at the 0.05 level.
** significant at the 0.01 level.

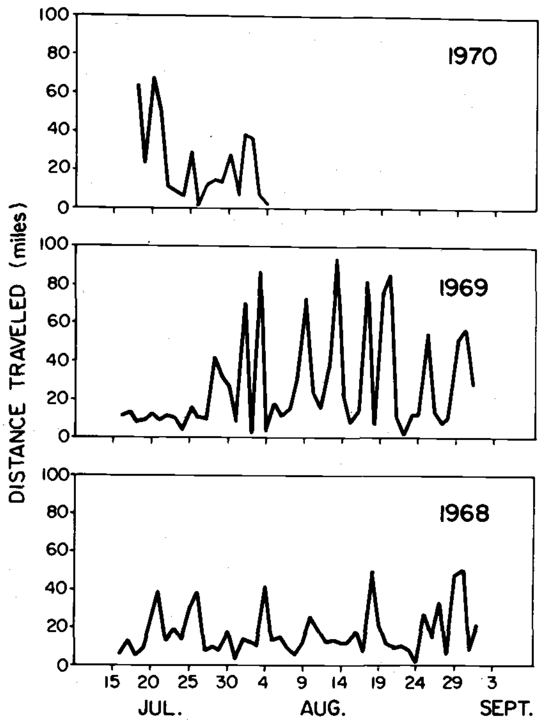

FIGURE 5.—Net daily movement of albacore fleet centers—1968, 1969, and 1970.

extremely short season on highly vulnerable fish, a situation which did not provide highliners the opportunity to utilize their capabilities and fully develop their tactics and strategies.

This study has shown that the most successful and least successful fishermen can be characterized by their activities as well as by the physical parameters of their vessels. Success is not assured by many years of experience, or by a large vessel, although these characteristics are often associated with the most successful fishermen. We agree with Abramson's (1963) suggestion that the fishing power of individual albacore boats is related to intrinsic factors of the captain and crew, in addition to the boat's physical parameters.

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