CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 48 JULY, 1962 NUMBER 3

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CHANGE OF EDITORSHIP

With this issue, John E. Fitch of the Marine Resources Branch assumes the duties of Editor-in-Chief of *California Fish and Game.*

Mr. Fitch's assumption of the editorship follows the department's policy of rotating the editorship of its quarterly technical journal between staff members representing Marine Resources, Inland Fisheries and Game Management.

For eight years Mr. Fitch, whose position is Marine Biologist IV, has served as Editor for Marine Resources with the publication. Through this service he has gained a knowledge of the policies and procedures of the journal.

Mr. Fitch will be ably assisted in his duties by four associate editors. David P. Borgeson will be the representative for Inland Fisheries, Albert E. Naylor for Game Management, John L. Baxter for Marine Resources, and Donald H. Fry, Jr., for salmon and steelhead.

To Mr. Carol M. Ferrel, Editor-in-Chief the past four years, we wish to express our appreciation for a job well done.—*Walter T. Shannon, Director, California Department of Fish and Game.*

CATCH RECORDS FROM THE STRIPED BASS SPORTFISHERY IN CALIFORNIA [1]

HAROLD K. CHADWICK
Inland Fisheries Branch
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INTRODUCTION

Catch records, so important in evaluating the status of a fish population, are difficult to obtain for most large sportfisheries. However, California is fortunate in having catch records from two sources that have been collected since the late 1930's on its important striped bass *(Roccus saxatilis)* fishery.

The more accurate of these records are party boat reports—party boats being boats on which anglers pay to be taken out fishing. Since 1936, a State law has required the skippers of these boats to keep records of the catches made during each trip and to submit them monthly to the California Department of Fish and Game. Calhoun (1949) analyzed these catch records for the period 1938 through 1948. The 1949-1959 catch records are analyzed in this report.

The second source of catch records are postal card surveys. These consist of questionnaires sent out to a random sample of angling license buyers, asking them to estimate and report their fish catches for the previous year. Postal card surveys have been made for 16 of the years between 1936 and 1959, and the results have been published elsewhere (Calhoun, 1950, 1951, 1953; Skinner, 1955; Ryan, 1959; Tharratt, ms.).

These catch records are the only available means for determining trends in population size and age structure over the whole period. This information is essential to managing and regulating the fishery.

GENERAL DISCUSSION OF PARTY BOAT OPERATIONS

The only areas in California where party boats are engaged primarily in striped bass fishing are the Sacramento-San Joaquin Delta and the San Francisco Bay (Figure 1). Since striped bass are migratory, fishing in each locality is seasonal. A few party boats follow the bass from area to area, but most boats remain in one locality and operate only during the seasons when bass are present.

There have been appreciable annual fluctuations but no general trend in the amount of reported party boat fishing since 1938. This is indicated by the fact that the mean number of angler days reported per year for eight nonwar years between 1938 and 1948 was 15,913 (Cal-

[1] Submitted for publication December, 1961. This work was performed as part of Dingell-Johnson Project California F-9-R, "A Study of Sturgeon and Striped Bass," supported by Federal Aid to Fish Restoration funds.

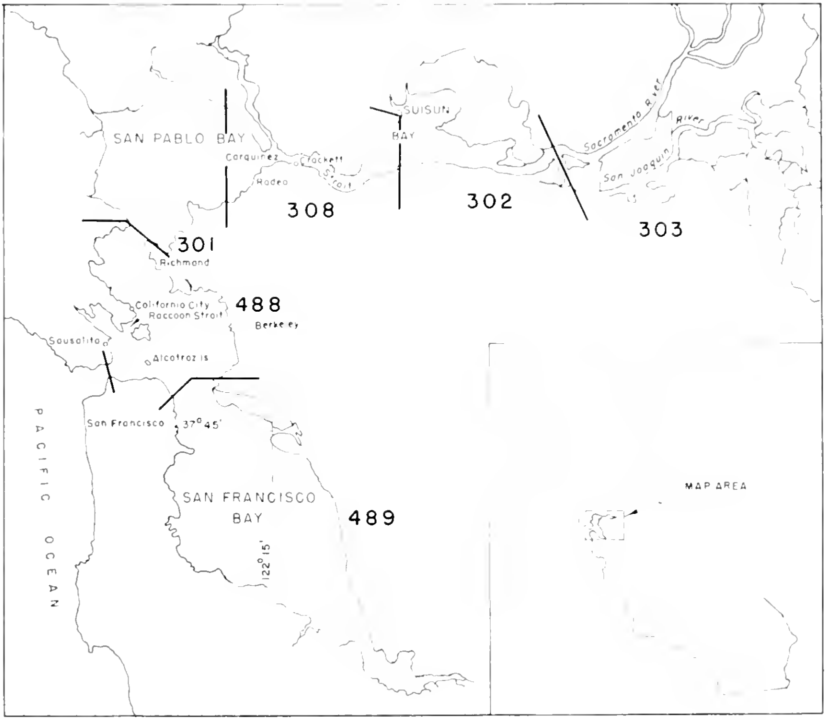

FIGURE 1. Map of California striped bass party boat fishing area. The numbers indicate the fishing blocks referred to in the text.

houn, 1949), while the corresponding figure for 1949 through 1959 was 15,625 (Table 1). Since the number of successful striped bass anglers has more than doubled since 1938 (Table 2), total angling effort has presumably increased greatly, so that the party boat fishery now constitutes a smaller portion of the fishery.

Most party boats fish for eight hours or until "limits" are caught. These are termed "full-day boats." A few boats make two shorter trips a day and some participate in a summer evening troll fishery. Records from the latter two categories are excluded from most of the tabulations in this report.

Report forms are furnished to party boat operators by the Department of Fish and Game. Most of the information requested has remained the same through the years, but there have been a number of changes in the forms. Two of the forms used in earlier years are pictured by Calhoun (1949), and Baxter and Young (1953). Figure 2 shows the form used from 1955 through 1959. It is self-explanatory except for the block number, which denotes the area of fishing. Six blocks comprise the main fishing area (Figure 1).

TABLE 1

Party-Boat Fishing Effort From 1949 Through 1959

Year	Number of operators reporting	Angler days reported on full-day boats
1949	161	16,797
1950	147	12,320
1951	125	13,224
1952	133	14,286
1953	156	16,761
1954	139	14,513
1955	102	12,513
1956	123	11,637
1957	125	20,004
1958	129	18,853
1959	111	20,971
Mean	132	15,625

TABLE 2

Summary of Striped Bass Catch Estimates *

Year	Total catch in thousands of fish	Number of successful anglers in thousands	Mean catch per successful angler	Mean catch per angler day
1936	2,110	84.4	25	--
1937	2,040	81.9	25	--
1938	1,940	92.8	21	--
1939	1,880	89.3	21	--
1941	1,940	106.0	18	--
1942	1,680	88.2	19	--
1943	1,680	75	22	--
1944	1,420	--	--	--
1946	1,380	113	12	--
1948	1,650	161	10	--
1949	1,750	165	11	----
1951	1,490	144	10	----
1953	1,590	166	10	1.0
1954	1,440	158	9	0.9
1956	1,000	127	8	0.6
1957	1,890	230	8	0.7
1959	2,260	224	10	0.8

* From Ryan, 1959, except 1959 data which are from Tharratt, M.S.

EVALUATION OF PARTY BOAT RECORDS

Calhoun pointed out certain unique advantages of the party boat records. These were: accurate reports could be obtained with reasonable effort; party boat catches measured striped bass abundance well, because operators scouted widely and thus covered the fishing grounds; and, finally, there was a high degree of continuity in the fishery.

These observations still hold true, although these records have definite limitations. One of the most serious is their failure to cover all segments of the fishery. Currently, party boats are a substantial portion of the fishery only in northern San Francisco Bay, San Pablo Bay and Carquinez Strait. A party boat fishery in the San Joaquin portion of the Delta has declined during the last few years, and it is now probably too small to reflect changes in abundance of striped bass. Elsewhere there is little or no party boat fishing.

These reports are further deficient in yielding little reliable information on the size of fish caught, which is essential to interpreting catch statistics.

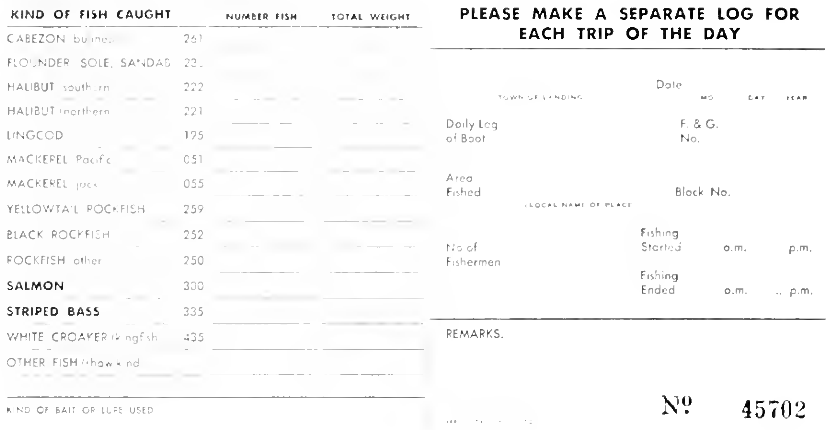

FIGURE 2. Daily log form used for party boat reports from 1955 through 1959.

The accuracy and completeness of the party boat reports have never been thoroughly evaluated, but some observations were made at the ports in Blocks 301 and 308 during August, September and October of 1950 (Johnson, 1951). Reports were received for 82 percent of the 277 party boat trips observed. In the reports received, the number of anglers was underestimated by 16.7 percent, and the number of bass was underestimated by 3.5 percent. The reported catch per angler day was 1.01 bass, while the observed catch per angler day was 0.87 bass. This is an overestimate of 16 percent.

Somewhat more extensive observations on the accuracy of the party boat reports were made during the summer and fall of 1960, when creel

TABLE 3

Completeness of Reporting of Party-Boat Trips During Summer and Fall of 1960

Port	Number of trips		Percent reported
	Observed	Reported	
Sausalito	49	20	41
San Francisco	73	34	47
Berkeley	242	171	71
Other San Francisco Bay ports	12	5	42
Richmond	46	39	85
Rodeo	128	73	57
Crockett	64	53	83

TABLE 4

Comparison of Party-Boat Reports With Observations of the Corresponding Trips During Summer and Fall of 1960

Port	Observations						Reported				
	Number of trips	Total anglers	Total hours	Total bass	Catch/ angler hour	Catch/ angler day	Total anglers	Total hours	Total bass	Catch/ angler hour	Catch/ angler day
Berkeley	167	1,051	4,421	2,072	*0.46	1.97	1,057	4,534	2,127	*0.46	2.01
Sausalito	8	53	250	73	0.29	1.38	66	385	52	0.14	0.79
San Francisco	28	181	589	263	0.45	1.15	193	827	301	0.36	1.56
Richmond	18	139	760	205	0.27	1.47	128	687	231	0.34	1.83
Crockett	12	91	341	80	0.23	.88	90	197	112	0.23	1.24
Rodeo	45	460	2,010	433	0.21	.94	456	2,108	463	0.22	1.02
Total	278	1,975	8,401	3,126	*0.37	1.58	1,990	9,038	3,289	*0.36	1.65

* Does not include two boats which failed to report hours of fishing.

censuses of both private and party boats were made in San Francisco and San Pablo Bays. Since all types of boats were checked routinely without discussing the party boat reports with the skippers, and since biologists had not been in close contact with the fishery to encourage adherance to the reporting regulations since 1952, it is unlikely that the creel check influenced the party boat reports.

Comparison of the observations made with the reports received indicates that there is wide variation in the completeness of reporting at the various ports (Table 3). Applying the estimates of the completeness of reporting for the various boats and ports to the 1959 reports from Blocks 488, 301, and 308, it was estimated that approximately 55 percent of the trips in Block 488 and 80 percent of the trips in Blocks 301 and 308 were reported. This estimate for Blocks 301 and 308 amazingly is close to Johnson's estimate considering the fact that biologists have made virtually no effort to contact boat skippers to stimulate interest since 1952.

The total catch per unit of effort figures determined from the creel checking data and from the reports received for the same boat trips are similar (Table 4), even though there was considerable variation in the accuracy of individual boat operators' reports. In general, the number of anglers was reported accurately, but the fishing hours and catch were both overestimated. Hence, the reported catch per hour was slightly more accurate than the reported catch per day. Since the main components of the fishery were sampled, it appears reasonable to conclude that reports received are accurate enough to provide a reliable index of fishing success.

The accuracy of the reported weights was not verified, and in any event, their usefulness is limited, since only the total weight of a day's catch is reported. Despite this, they probably reflect important trends with reasonable accuracy.

Measurements of Catch Per Unit of Effort

Catch per angler day was used previously as a measure of party boat fishing success (Calhoun, 1949). Now, several factors make it desirable to change to catch per angler hour.

The most important factor is changes in angling regulations. These had remained essentially unchanged from 1944 to 1955, when the five-fish bag limit was reduced to four. In 1956 it was further reduced to three fish, and the 12-inch minimum length limit was increased to 16 inches.

No measure of fishing success can be comparable before and after a size-limit change. However, catch per hour is more nearly comparable before and after bag limit changes than catch per angler day, as it is less dependent on the length of an angler day and the total number of fish caught. It is not completely comparable though, because on days of good fishing the number of angler hours expended is limited by the bag limit.

The effect of the bag limit on the catch per unit of effort is an important practical consideration in this fishery. This is indicated by the curvilinear relationship between catch per hour and catch per day under the three-fish bag limit (Figure 3). Below a catch per day of about 1.5 bass, both measures accurately reflect changes in fishing

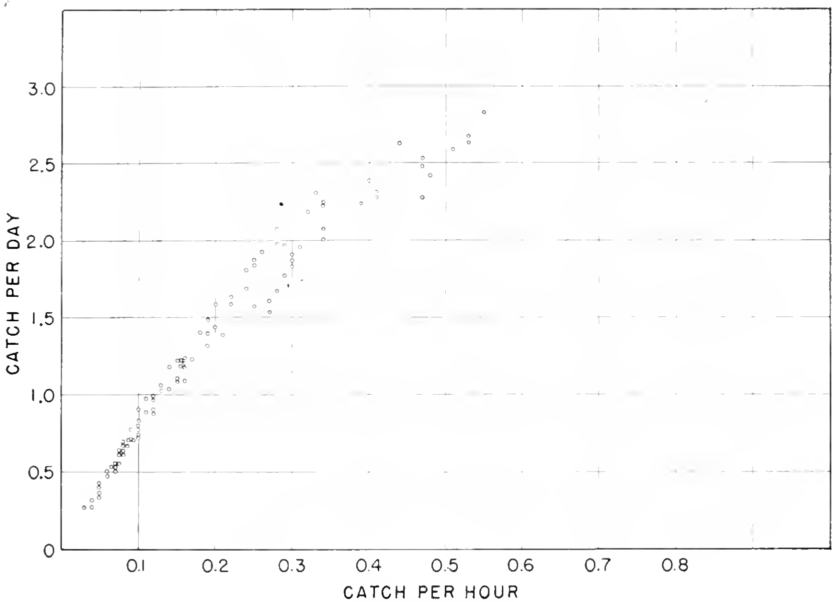

FIGURE 3. Comparison of mean monthly catch per day with catch per hour in a block on full-day party boats from 1956 through 1959. Only months when 1,000 or more hours of effort were expended in a block are included.

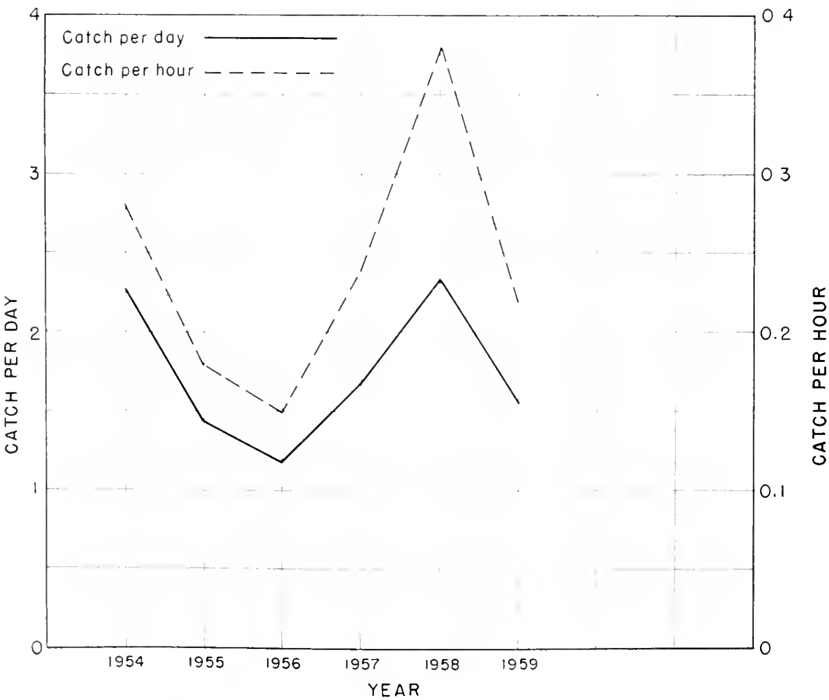

FIGURE 4. Comparison of mean annual catch per day with catch per hour on full-day party boats in Block 301.

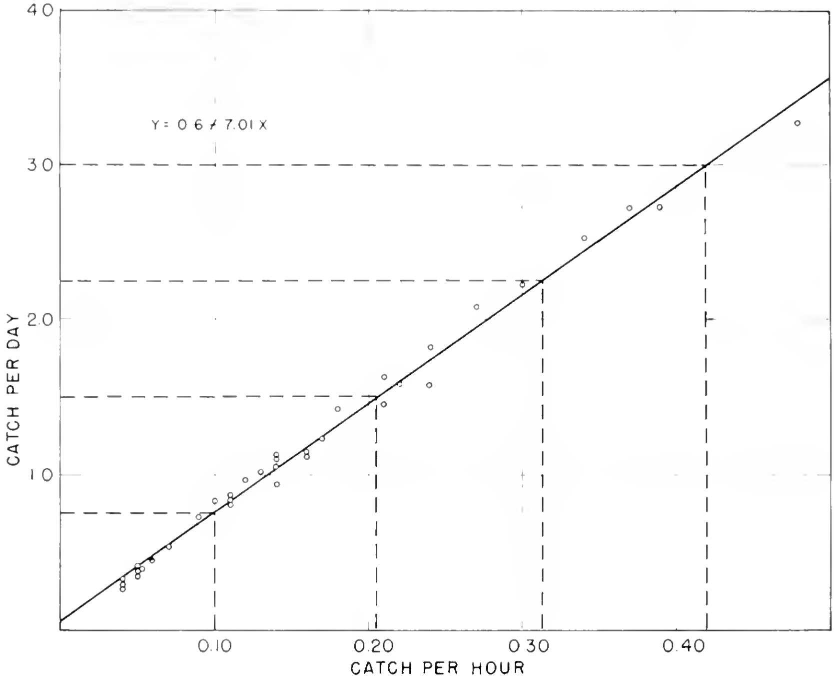

FIGURE 5. Relationship of monthly catch per day and catch per hour during 1954 and 1955 for blocks and months with 30 or more full-day party boat trips. Dotted lines indicate equivalent intervals on the two scales, which are used in subsequent charts as measures of fishing success.

success, but above 1.5 the catch per day becomes progressively more distorted. This distortion is sufficient to cause marked differences in the yearly means during good fishing periods. For example, the catch per day indicates that fishing was 95 percent better in Block 301 in 1958 than it was in 1956, while the catch per hour indicates that it was 153 percent better (Figure 4).

Differences in the average number of hours in a fishing trip in various blocks or seasons would also bias catch per day but not catch per hour. However, this is not a serious consideration at the present time, because the average length of an angler's day on full-day boats only varies between seven and eight hours in various blocks and seasons.

Catch per hour figures are available only after 1953. To make the 1956–59 data as nearly comparable to earlier data as possible, the catch per day intervals previously used as standards of success (Calhoun, 1949) were equated to catch per hour intervals. This was done by fitting a line to the relationship between the mean monthly catches per day and the mean monthly catches per hour during 1954 and 1955 (Figure 5). The comparable intervals, indicated by the dotted lines, were then used in the graphs of fishing success for each block. Both catch per day and catch per hour are included on the graphs for 1954 and 1955, so that the similarity of the two during this period can be seen.

BLOCK RECORDS

Block 308—The Carquinez Strait Region

Calhoun (1949) presented detailed maps and physical descriptions of all blocks, and readers are referred to these. An important consideration in the interpretation of the boat reports is the inclusion in block 308 of a portion of San Pablo Bay ecologically identical with most of Block 301 (Figure 2). In recent years, party boat fishing has centered around the dividing line between the blocks creating considerable difficulties in the identification of fishing areas for reported trips. The two blocks are still being maintained separately to facilitate comparison with earlier years and to better define the location of the fishery which is only partially masked by the overlap.

The only significant changes in this area since 1948 resulted from the increased size limit. This reduced the spring fishery and practically eliminated the fishery on the sand bar in western Suisun Bay, since both were primarily dependent on fish under 16 inches.

TABLE 5

Summary of Full-Day Party-Boat Reports From Carquinez Strait, (see Table 7) Block 308

Year	Angler days		Striped bass				
	Number	Percent of annual total	Number	Percent of annual total	Catch/ angler day	Catch/ angler hour	Mean weight
1938-48 mean	5,357	39	13,298	47	2.48	----	4.6
1949	5,216	31	8,497	32	1.63	----	4.8
1950	5,614	46	11,289	58	2.01	----	4.3
1951	6,456	49	13,052	53	2.02	----	2.9
1952	4,709	33	7,060	35	1.50	----	2.9
1953	5,989	36	12,011	49	2.01	----	3.6
1954	6,473	45	13,125	58	2.03	0.25	3.9
1955	6,082	49	11,199	61	1.84	0.25	3.5
1956	3,875	33	4,299	36	1.11	0.15	3.8
1957	5,092	25	8,091	27	1.59	0.22	4.8
1958	2,730	14	4,170	11	1.53	0.22	4.6
1959	2,092	10	2,588	7	1.24	0.17	4.4
1949-59 mean	4,939	32	8,671	35	----	----	4.0

Reported party boat fishing effort has remained relatively constant (Table 5) except for 1956, when it declined due to poor fishing, and 1958 and 1959, when much of the effort usually expended in this block moved into Block 301.

Average catches per unit of effort and the mean weights are shown by months in Figures 6 and 7. Comparison with corresponding figures for the preceding 11 years (Calhoun, 1949) indicates that the same seasonal trend has continued, with most of the fishing taking place between June and November, and the best fishing being in the fall. However, the annual mean catch per angler day for each of the last 11 years has been below the weighted annual catch per angler day for the previous 11 years, and the highest category of fishing success has occurred in only 5 months during the last 11 years, while it occurred in 15 months during the previous 11 years. These facts indicate a general decline in fishing success during the last 11 years.

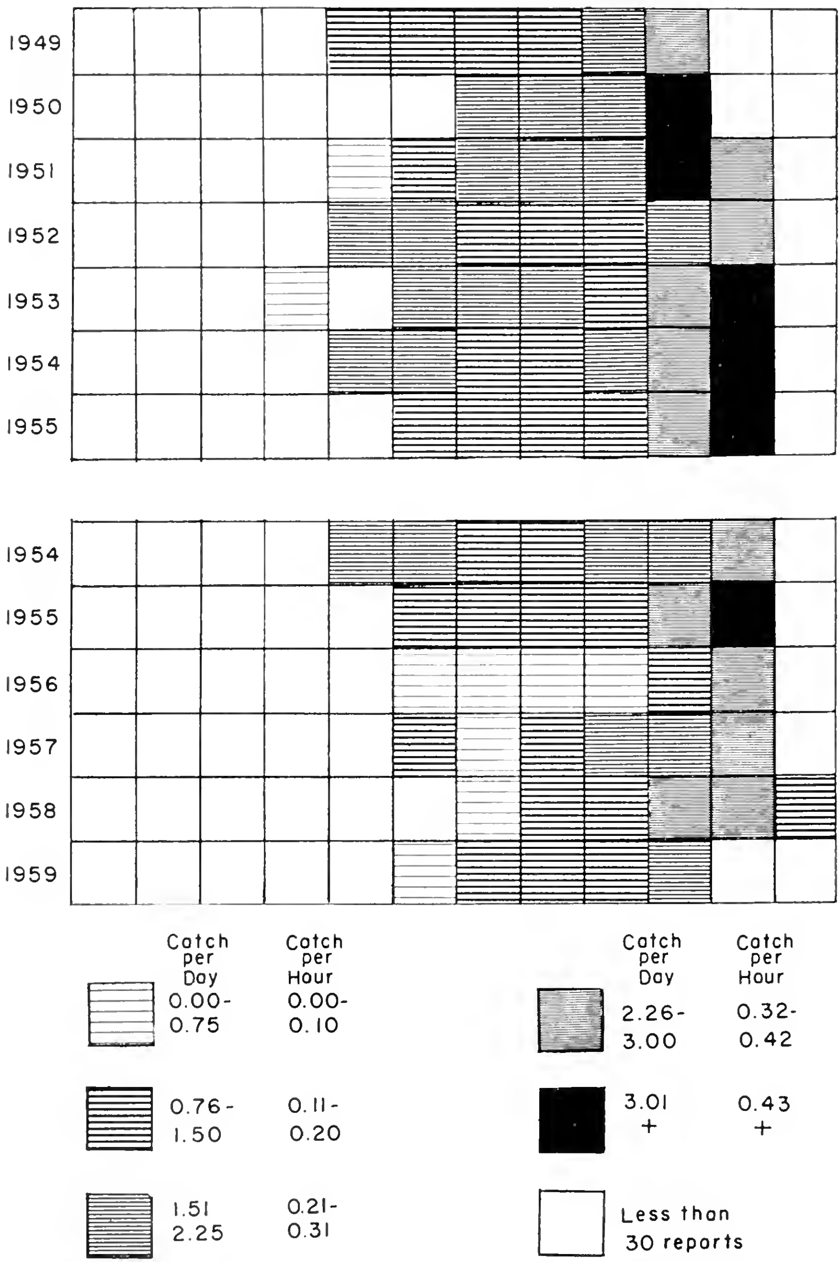

FIGURE 6. Monthly catches per unit of effort for striped bass by anglers fishing from full-day party boats in Block 308 during the period 1949 through 1959. The figures in the top portion of the graph represent catches per day, while the figures in the lower portion of the graph represent catches per hour.

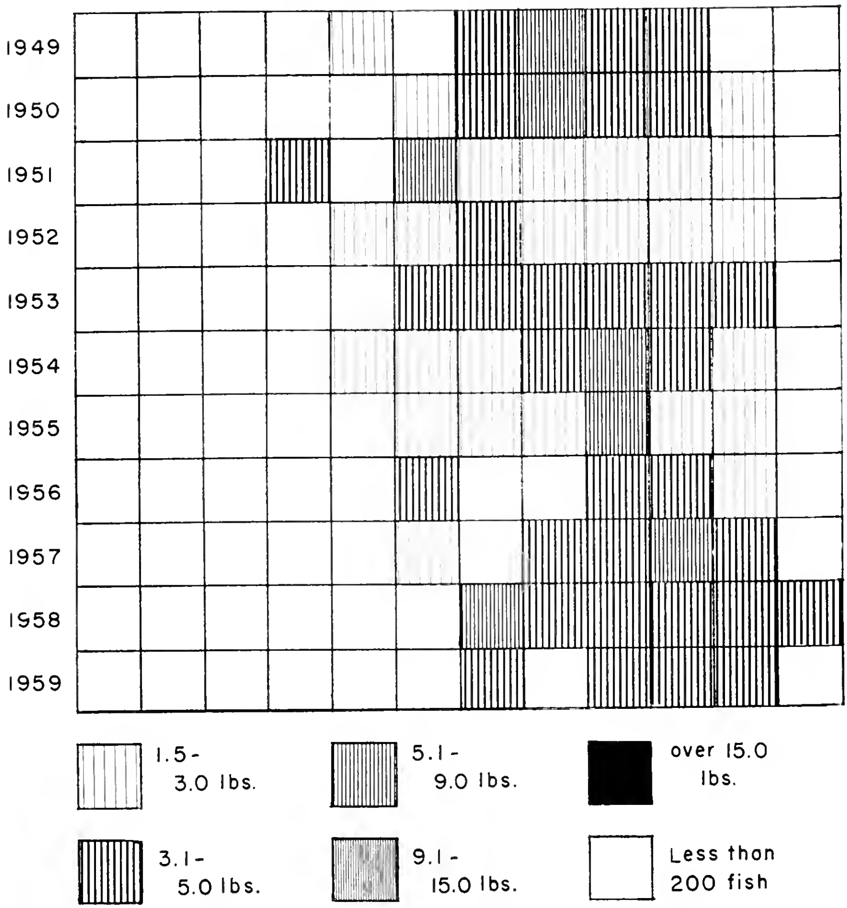

FIGURE 7. Monthly average weights of striped bass caught on full-day party boats in Block 308 during the period 1949 through 1959.

The reported fish size has also declined slightly since 1948, with the mean weight for the earlier period being 4.6 pounds compared with 4.0 pounds since 1949. The elimination of the smallest fish from the catch by the 1956 size limit change increases the significance of this.

Block 301—San Pablo Bay

The importance of this area has fluctuated considerably since 1948. The number of angler days reported annually between 1950 and 1955 ranged from about one-third to one-half of the 1938-1948 average (Table 6). It then increased, and in 1958 and 1959 more angler days were recorded there than in any other of the last 22 years.

The fishing season (Figures 8 and 9) also changed considerably during this period. From 1938 through 1948, it was primarily a spring and fall fishery (Calhoun, 1949), but from 1953 through 1958, significant amounts of fishing occurred only in the fall.

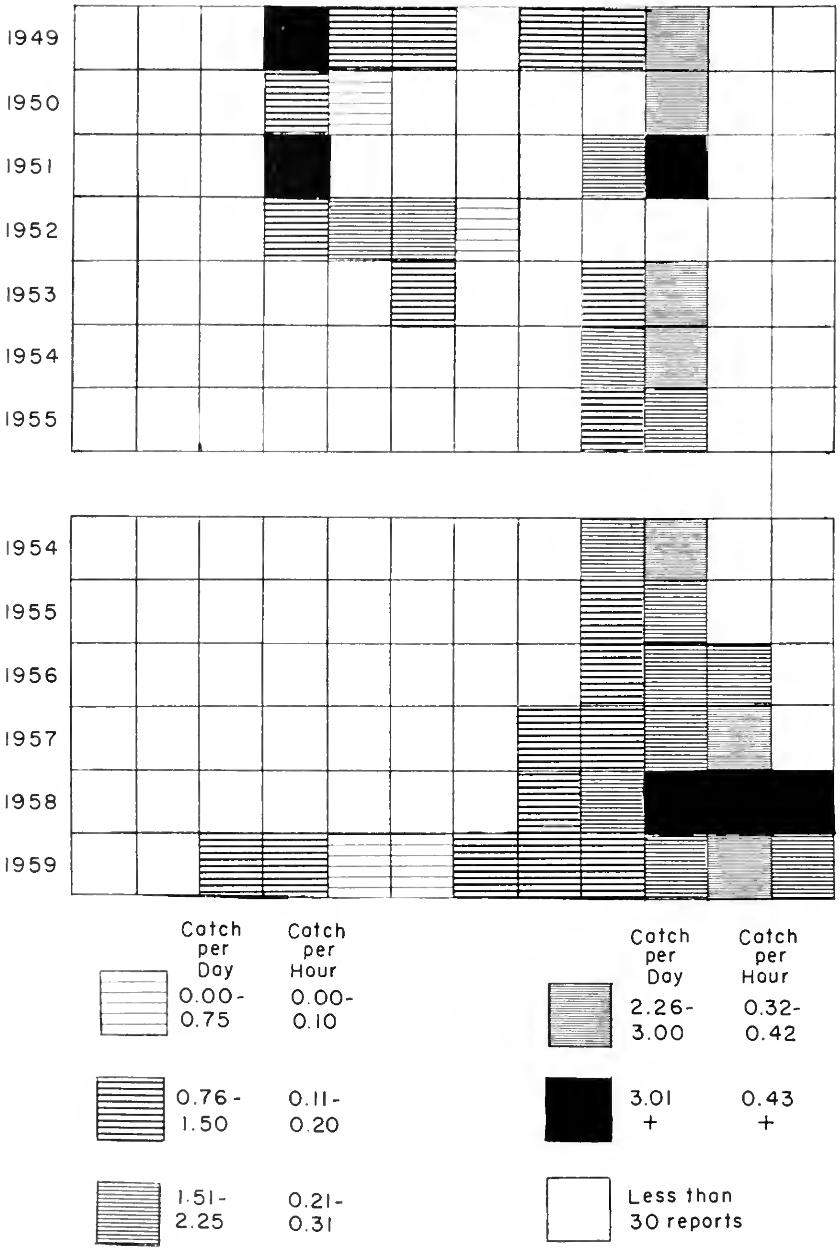

FIGURE 8. Monthly catches per unit of effort for striped bass by anglers fishing from full-day party boats in Block 301 during the period 1949 through 1959. The figures in the top portion of the graph represent catches per day, while the figures in the lower portion of the graph represent catches per hour.

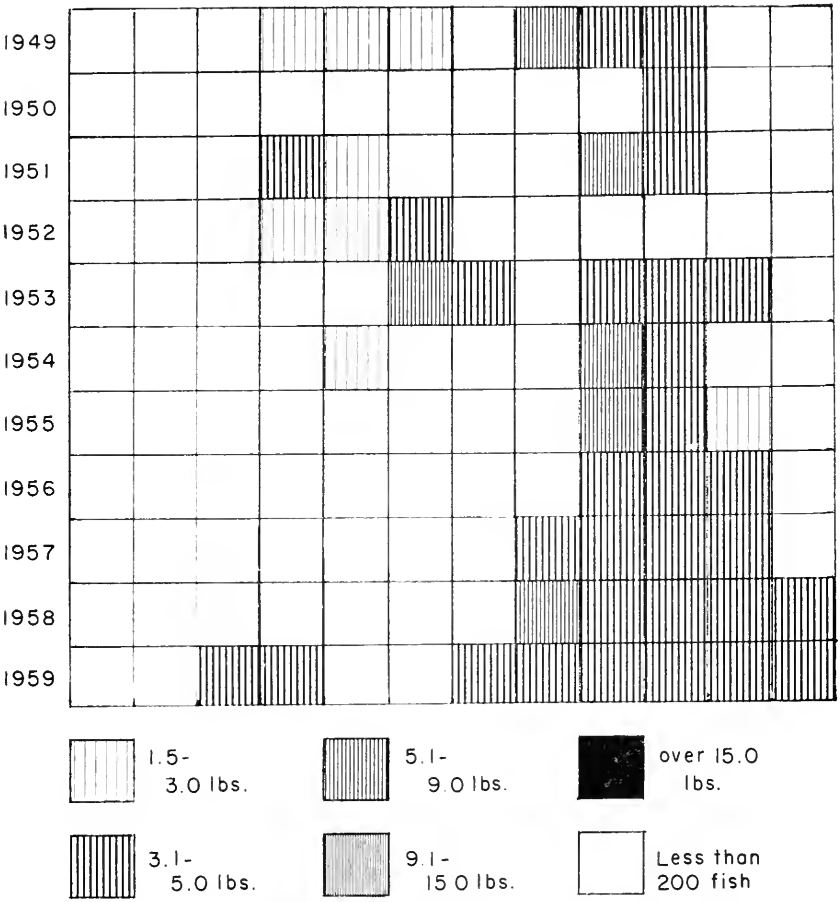

FIGURE 9. Monthly average weights of striped bass caught on full-day party boats in Block 301 during the period 1949 through 1959.

The mean annual catch per angler day has remained about the same, although it has fluctuated considerably more than it did during the 1938-48 period. However, fall fishing has generally been poorer during the past 11 years, with the exception of 1958. The best fall fishing in the 22-year period occurred that year, with peak success in November, when the average catch per angler day was 2.8 bass despite the three-fish limit.

The weight of the fish reported has changed appreciably. From 1938 through 1948, the mean annual reported weight ranged from 4.4 to 8.3 pounds, with the highest average occurring during the fall months (Calhoun, 1949). In contrast, the corresponding figures for the 1949-1959 period ranged from 3.1 to 4.9 pounds, even though fishing was restricted mostly to the fall months, and despite the size limit increase in 1956.

TABLE 6

Summary of Full-Day Party-Boat Reports From San Pablo Bay, Block 301

Year	Angler days		Striped bass				
	Number	Percent of annual total	Number	Percent of annual total	Catch/angler day	Catch/angler hour	Mean weight
1938-48 mean	3,803	28	7,156	25	1.88	----	6.2
1949	3,859	23	8,198	32	2.20	----	3.5
1950	1,522	12	2,862	15	1.88	----	4.9
1951	1,173	9	3,465	14	2.95	----	3.6
1952	1,708	12	2,136	11	1.25	----	3.1
1953	1,300	8	2,596	11	1.99	----	3.8
1954	1,861	13	4,198	18	2.26	0.28	3.9
1955	1,894	15	2,719	15	1.44	0.18	4.4
1956	2,723	23	3,247	27	1.19	0.15	4.1
1957	3,636	18	6,100	20	1.68	0.24	4.1
1958	8,766	46	20,135	55	2.33	0.38	4.0
1959	8,277	39	12,911	35	1.56	0.22	3.9
1949-59 mean	3,338	21	6,288	25	--	----	3.9

TABLE 7

Summary of Full-Day Party-Boat Reports From The Delta, Block 303

Year	Angler days		Striped bass				
	Number	Percent of annual total	Number	Percent of annual total	Catch/angler day	Catch/angler hour	Mean weight
1938-48 mean	1,522	11	2,096	7	1.38	----	6.1
1949	6,479	39	8,802	33	1.36	----	6.2
1950	4,683	38	5,181	27	1.11	----	6.0
1951	4,921	37	7,520	30	1.53	----	4.4
1952	6,809	48	9,790	49	1.44	----	4.1
1953	6,515	39	6,089	25	0.93	----	5.2
1954	4,378	30	3,073	14	0.70	0.07	6.2
1955	3,677	29	3,768	21	1.02	0.12	4.8
1956	3,630	31	2,339	20	0.61	0.08	5.6
1957	3,616	18	2,222	7	0.61	0.08	5.7
1958	2,469	13	2,133	6	0.86	0.11	4.7
1959	1,585	8	1,345	4	0.85	0.11	4.8
1949-59 mean	4,433	28	4,751	19	----	----	5.2

Block 303—The Delta

Virtually no party boat fishing occurred in the Delta before 1945 (Calhoun, 1949). Reported fishing operations then increased to a peak of almost 7,000 angler days in 1952, after which they declined steadily, falling below the 1945 level in 1959 (Table 7). Calhoun (1949) points out that the increasing fishing effort there in the late 1940s represented an expansion of the fishery, independent of changes in fishing success in the Delta.

Several factors have contributed to the decline since 1952. One was the growing number of private trailer boats suitable mostly for the smaller waters of the Delta. Another was a decline in fishing success,

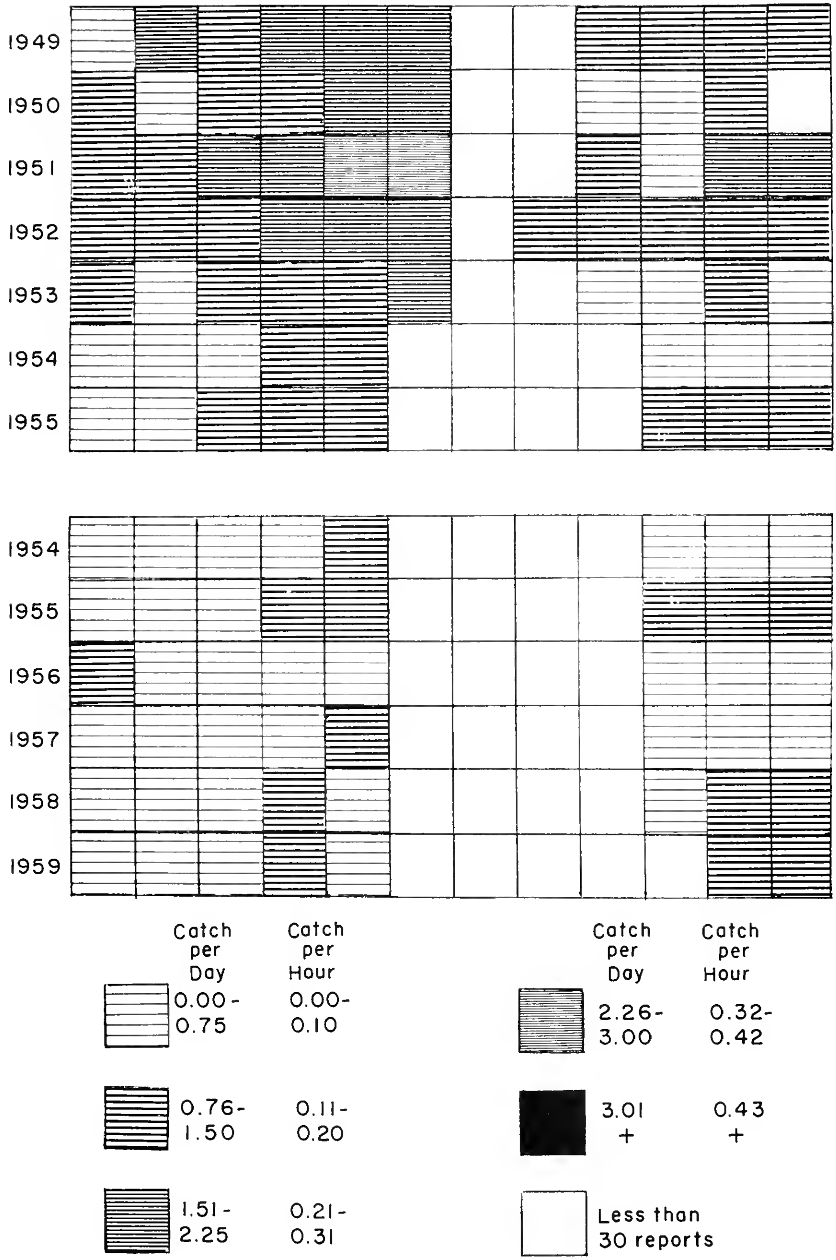

FIGURE 10. Monthly catches per unit of effort for striped bass by anglers fishing from full-day party boats in Block 303 during the period 1949 through 1959. The figures in the top portion of the graph represent catches per day, while the figures in the lower portion of the graph represent catches per hour.

which is indicated by the decline in mean annual catch per angler day from a range of 1.11 to 1.55 for the 1945-1952 period to 0.61 to 1.02 for the 1953-1959 period (Calhoun, 1949 and Table 7). A final contributing factor was the improved late fall and spring fishing in the Bay area, which resulted in some of the boats staying there rather than moving to the Delta.

While Block 303 includes the entire Delta, the party boat fishery has been restricted to the main San Joaquin River and immediately adjacent channels and flooded islands. Therefore, the party boat reports represent only a portion of the area.

The fishing season occurs from October through May and has remained relatively unchanged (Figures 10 and 11).

The reported mean weight of the bass caught has declined compared with the 1938-1948 period (Table 7). While there have been fluctuations during this period, the decrease reflects the same general trend found in the other fishing areas.

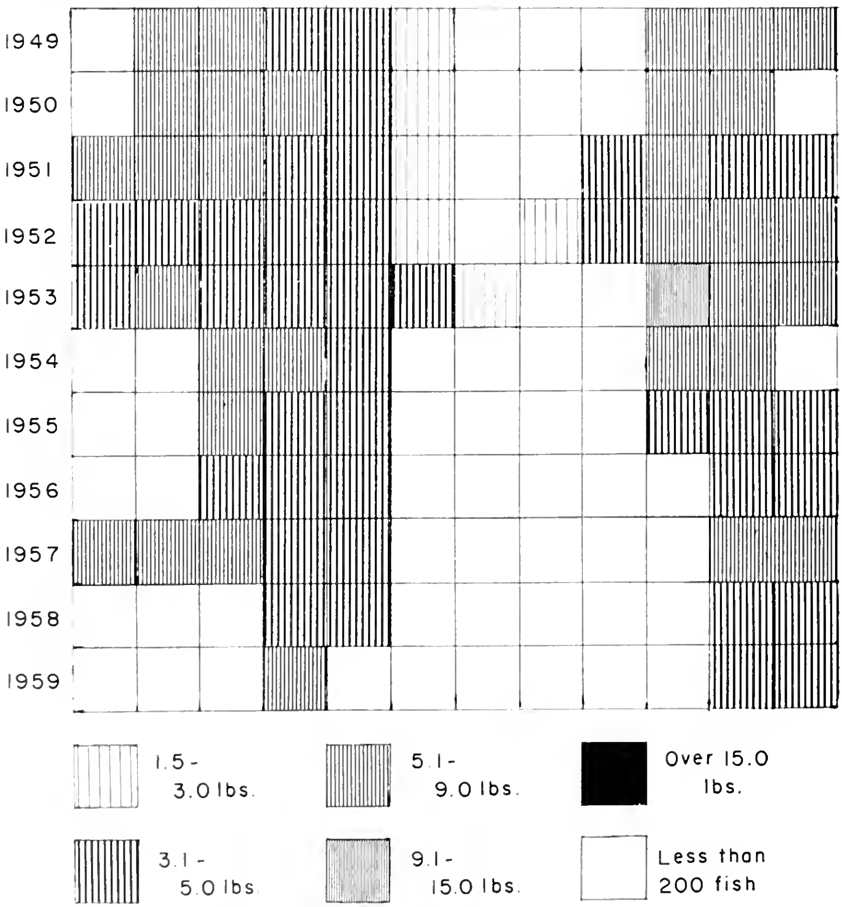

FIGURE 11. Monthly average weights of striped bass caught on full-day party boats in Block 303 during the period 1949 through 1959.

Block 488—Upper San Francisco Bay

This is the only other block in which significant amounts of party boat fishing have occurred during the 11-year period, and it is also the block where the greatest changes have occurred.

Between 1938 and 1943, considerable fishing occurred in this block, with good catches during the spring and summer. Trolling was the primary means of fishing, although bait was also used.

From 1944 through 1951, the number of angler days reported annually was less than 1,000 each year, and fishing was poor. Calhoun (1949) discusses a number of possible explanations for this decline.

TABLE 8

Summary of Full-Day Party-Boat Reports From Upper San Francisco Bay, Block 488

Year	Angler days		Striped bass				
	Number	Percent of annual total	Number	Percent of annual total	Catch/angler day	Catch/angler hour	Mean weight
1938-48 mean	1,195	9	2,048	7	1.71	----	6.5
1949	83	+	3	+	----	----	----
1950	14	+	0	0	----	----	----
1951	348	3	468	2	----	----	----
1952	1,029	7	892	4	0.87	----	11.7
1953	2,563	15	3,097	13	1.21	----	8.5
1954	1,382	10	1,593	7	1.15	0.17	7.0
1955	599	5	244	1	----	----	----
1956	1,255	11	1,873	16	1.49	0.25	11.3
1957	7,352	37	13,513	45	1.84	0.31	8.2
1958	4,760	25	10,022	27	2.11	0.36	5.1
1959	8,759	42	19,918	54	2.27	0.43	5.5
1949-59 mean	2,559	16	4,693	19	----	----	----

Fishing effort increased between 1952 and 1955, but catches remained relatively low (Table 8 and Figure 12). Fishing started to improve in 1956, and from 1957 through 1959 there was a tremendous increase in both pressure and success. These changes resulted primarily from new fishing methods. Previous trolling had been restricted to shallow water, but in the mid-1950s fishermen started trolling in deep water with a three-pound sinker and a sinker release. This type of fishing first occurred on a large scale during the summer of 1957, when a collapse of the ocean salmon fishery caused many salmon boats to fish for striped bass. Party boat anglers caught many bass off Alcatraz Island in 1957 using this technique, and subsequently it was used successfully in Raccoon Strait and off California City. Most of the bass caught in this block during the summer and fall of 1957, 1958 and 1959 were taken by this method.

The winter fishery in 1958 and 1959 is attributable to yet another new development. At that time, Pacific herring (*Clupea pallasi*) are spawning in the Bay, and fishermen started catching bass feeding on them. Some were taken by deep trolling, but many were also taken by surface trolling, often in shallow water.

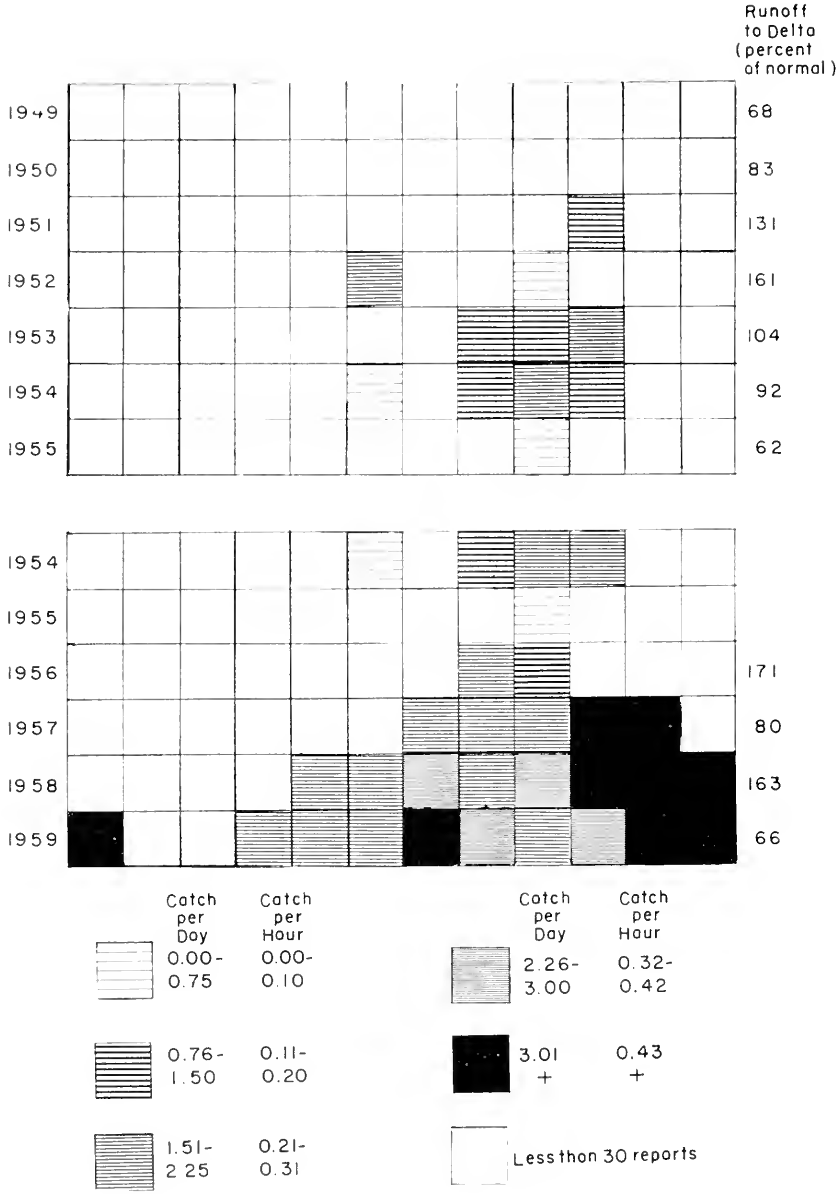

FIGURE 12. Monthly catches per unit of effort for striped bass by anglers fishing from full-day party boats in Block 488 during the period 1949 through 1959. The figures in the top portion of the graph represent catches per day, while the figures in the lower portion of the graph represent catches per hour.

Since fishing techniques in this area have changed so radically, the party boat catch cannot be used to measure changes in abundance of striped bass.

Calhoun (1949) noted an apparent positive correlation between fishing quality in this block and water runoff from the Sacramento-San Joaquin River system. Although the figures are difficult to interpret because of the changes in fishing techniques and the low angling pressure during the early part of the period, this relationship is not evident during the last 11 years (Figure 12).

Block 302—Suisun Bay

Little party boat fishing has been reported in this block since 1948, with the maximum number of boat trips in any month being 20, and the annual mean number of angler days and striped bass reported during the 11-year period being 105 and 190, respectively. Since other observations indicate that fishing is frequently quite good there, the lack of party boat fishing does not indicate an absence of bass.

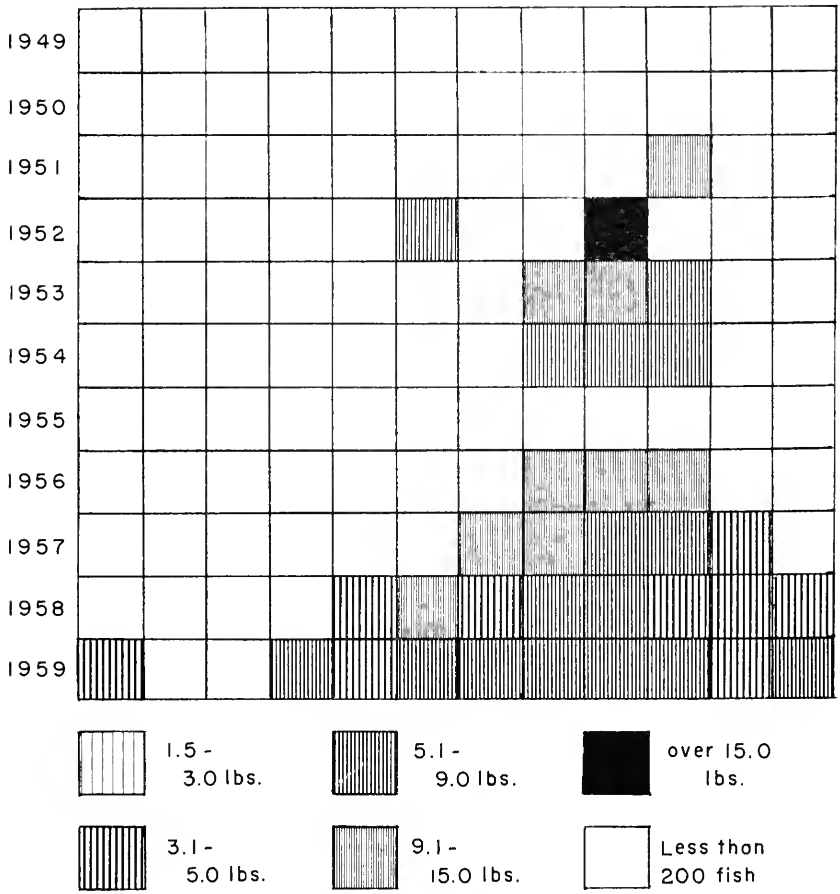

FIGURE 13. Monthly average weights of striped bass caught on full-day party boats in Block 488 during the period 1949 through 1959.

Block 489—Lower San Francisco Bay

Very little fishing has occurred in this block during the last 11 years, with the annual mean number of angler days and striped bass reported during the 11-year period being 252 and 146, respectively. The only months when more than 30 boat days were reported were June, July, and August of 1949, and July of 1950 and 1951. The respective catches per angler day for these months were 0.23, 0.55, 0.93, 0.21, and 0.20. The very low catches per day for these months and for the few trips in subsequent years suggest that fishing was poor in this block during the 1949-1959 period.

POSTAL CARD SURVEYS

The striped bass catch estimates derived from the postal card surveys are summarized in Table 2. Several serious limitations restrict their usefulness in measuring abundance. One limitation is the bias resulting from the inclusion of only successful licensed anglers, which prevents the development of a good catch per unit of effort measurement. The best measure, catch per angler day for successful anglers, is available only for the last five surveys. This is subject to the same limitations discussed in the section on party boat catch per unit of effort.

The only measure of catch per unit of effort available for all the surveys is annual catch per successful angler, and this is subject to the same deficiencies as catch per day, plus the errors due to variations in the average number of days fished annually by each angler. There is no way of estimating the average number of days fished per year for the earlier surveys, but in the five surveys since 1953 it has ranged from 9 in 1954 to 12 in 1959.

A potentially more serious limitation is that the accuracy of the surveys has never been thoroughly evaluated. It has been shown that nonresponse does not bias the estimates (Calhoun, 1950), but the accuracy of the estimates made by individual anglers has never been investigated for striped bass.

In other evaluations of postal card surveys appreciable exaggerations in catch estimates have been shown. For example, studies of the California ocean salmon fishery have indicated that the total catch estimates from the postal card surveys was about three times the actual catch in 1956 (Wendler, 1960), and data collected subsequently suggest that there may be substantial errors in the trends indicated by the postal card surveys (Marine Resources Branch, California Department of Fish and Game, unpublished data). In Idaho, creel censuses of salmon and steelhead fisheries have indicated a 100 percent exaggeration in postal card surveys (Bjornn, 1961).

In summary, only poor measures of catch per unit of effort are available from the postal card surveys, and the reported catches are likely to be biased. Therefore, they should be used only to indicate trends and caution should be used in accepting them for this purpose.

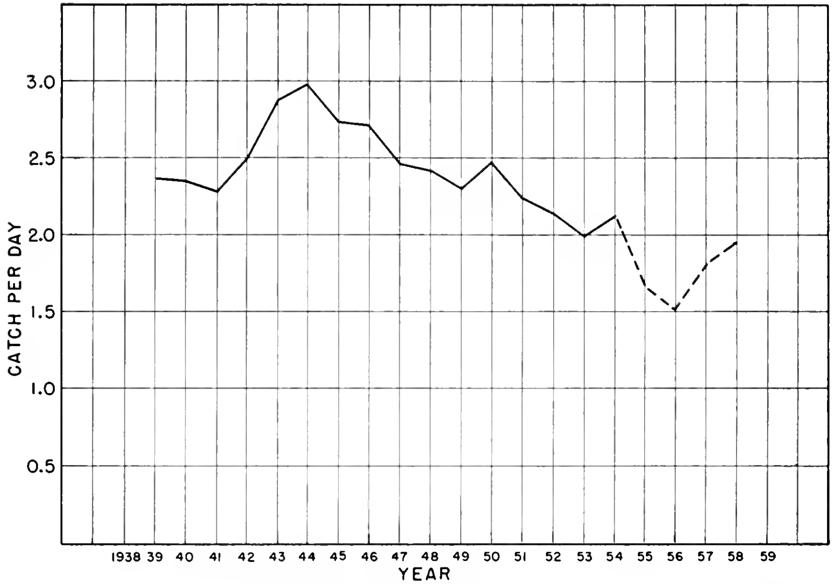

FIGURE 14. Three-year moving average of mean catches per day on full-day party boats fishing in Blocks 301 and 308 during September and October. Catches per day for years 1955-1959 were interpolated from Figure 5 using mean catches per hour.

DISCUSSION

Significant conclusions about the status of the striped bass population can be drawn from party boat reports and the postal card surveys in spite of their deficiencies. However, care must be taken in deriving indices of population status from them.

In discussing party boat reports, it was indicated that reports of fishing success in Blocks 301, 303 and 308 are most suitable for indicating trends in population size. The accuracy with which population trends are reflected by fishing success would be influenced in all of these blocks by annual variations in migrations. If any variations in migrations were random, population trends would still be indicated reliably. However, progressive changes in migratory patterns could bias indications of population trends.

Tag returns indicate that there have been some substantial changes in bass migration between 1953 and 1958 (Chadwick, unpublished data). One of these changes is that the bass have shown a definite tendency to move farther downstream during the summer in recent years. This would result in poorer summer fishing in Blocks 301 and 308, and Figure 6 does indicate that summer fishing in Block 308 has deteriorated. This would bias any index of population size based on summer fishing success there.

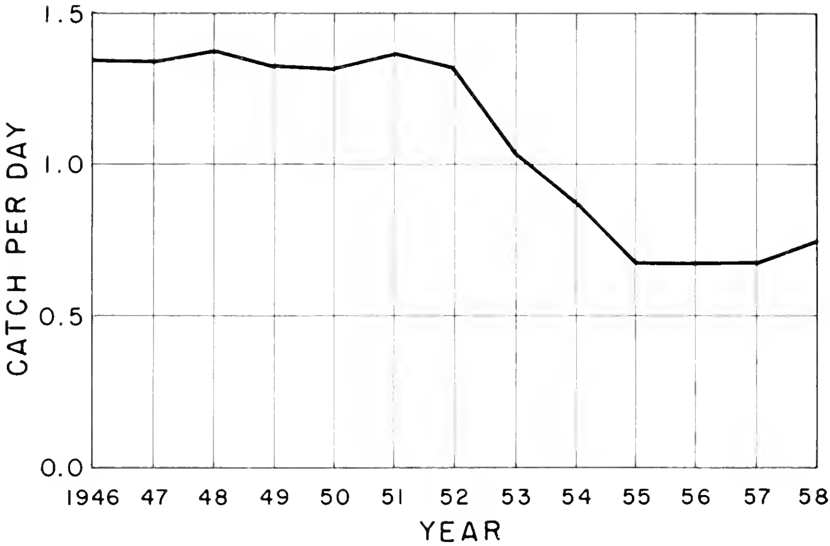

FIGURE 15. Three-year moving average of mean catches per day on full-day party boats fishing in Block 303. Catches per day for years 1955-1959 were interpolated from Figure 5 using mean catches per hour.

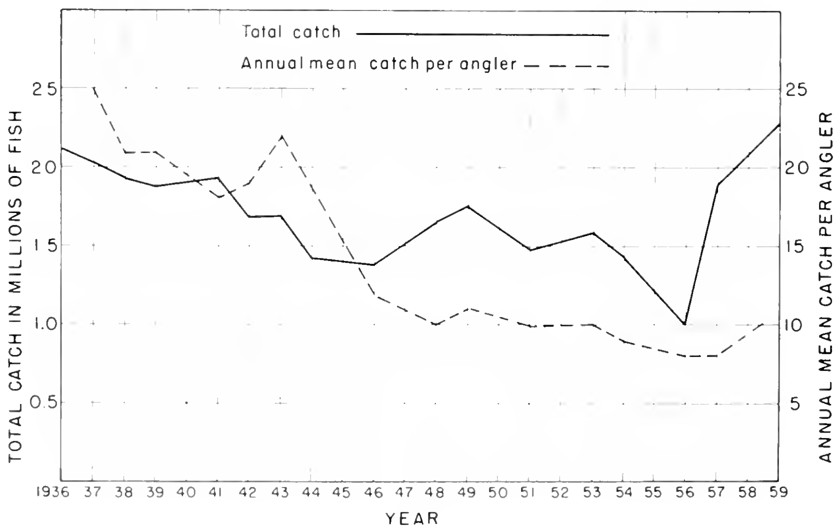

FIGURE 16. Striped bass catch estimates from postcard surveys.

Therefore, the best measures of trends in population size appear to be the fall catches in Blocks 301 and 308, which were used by Calhoun, (1949), and the catches made in Block 303. The former measures the abundance of the bass that return to the Delta during the fall; the latter reflects the size of population overwintering in the Delta, as well as the abundance of bass which overwinter in the San Francisco Bay area and migrate to the Delta to spawn in the spring.

The three-year moving averages of the September-October catches per unit of effort for striped bass in Blocks 301 and 308 are graphed in Figure 14 and the three-year moving averages of the catches per unit of effort for striped bass in Block 303 are graphed in Figure 15. Only averages for the years since 1945 were used from Block 303, since fishing effort there was negligible before that time.

Both graphs indicate a low point in fishing success in the mid-1950's. The catches in Blocks 301 and 308 show a rather gradual decline from 1944 through 1956, while the figures from Block 303 indicate a stable catch from 1946 through 1952, with a sharp decline from then until 1956. Some increase in fishing success after 1956 is shown in both graphs, but the increase is more marked in Blocks 301 and 308. If the size limit had not been increased in 1956, the recovery in fishing success would undoubtedly have been greater, as 12- to 16-inch fish previously formed important components of the catch in both areas.

The mean annual catch per angler and the total catch indicated by the postal card surveys show trends (Figure 16) quite similar to those shown by the party boat reports.

While both measures of fishing success have serious defects, the similar trends shown in Figures 14, 15 and 16 are convincing evidence that the striped bass population declined gradually in size through the

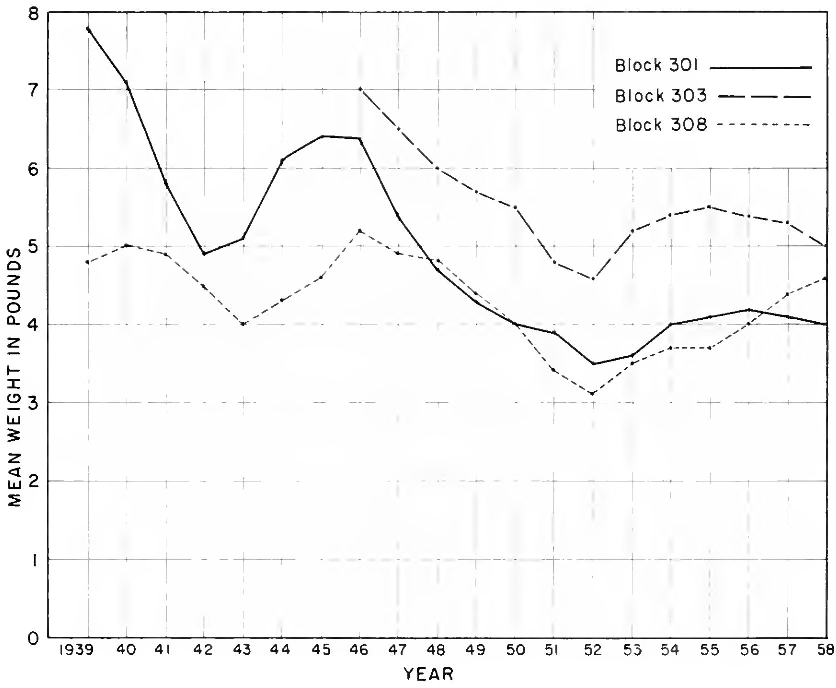

FIGURE 17. Three-year moving averages of mean annual weights of striped bass caught on full-day party boats fishing in Blocks 301, 303, and 308.

late 1940's and early 1950's to a low point in the mid-1950's. Since 1956, there apears to have been a substantial increase in population size, but it is too early to tell whether this reverses the long-term trend or is merely a short-term fluctuation. Since this increase became evident just one year after the change in regulations, it could not have resulted from the regulation change.

Another safe conclusion is that the size of the bass caught since 1948 has generally been less than the size caught earlier. This has been noted in all three blocks with consistent records (301, 303, and 308). The trends in mean annual weight are very similar in all three blocks (Figure 17), with all featuring low points about 1942 and 1952, and an overall downward trend. The most probable explanation for this trend is that increased fishing pressure on a decreasing bass population has increased the harvest rate which would reduce the average age of the fish caught.

ACKNOWLEDGMENTS

Britton C. McCabe tabulated the party boat reports for the years 1949 through 1952. The 1953 reports were edited by Richard Pycha, and the 1957-1959 reports were edited by John B. Robinson, who also tabulated much of the data for the years 1953 through 1958. The basic tabulating of the 1953-1959 reports was done using standard machine procedures by the Biostatistical Section, Marine Resources Operations, California Department of Fish and Game.

SUMMARY

Catch records from a party boat fishery and postal card surveys are examined to determine the status of California's striped bass population during the period 1949-1959. This paper supplements an earlier paper covering the party boat fishery for the period 1938-1948, and several papers reporting postal card survey results.

Total reported party boat fishing has remained quite constant over the 22-year period, although there have been major changes in various segments of the fishery. The chief changes since 1948 have been a decline in the importance of the Delta fishery, between 1952 and 1959, and a great increase in the northern San Francisco Bay fishery associated with changes in fishing methods in 1957.

A gradual decrease in fishing success during the late 1940's and early 1950's is indicated by both catch records. During this same period, the number of anglers increased, and these facts are interpreted as indicating that the population itself declined during this period.

The trend in fishing success reversed after 1956 indicating an increase in population size.

The average size of the fish caught also decreased during the 1949-1959 period, probably indicating an increase in the harvest rate.

REFERENCES

Baxter, John L., and Parke H. Young
1953. An evaluation of the marine sportfishing record system in California. Calif. Fish and Game, vol. 39, no. 3, pp. 343-353.

Bjornm, Ted C.
1961. Statewide fishing harvest survey, 1960. Idaho Dept. of Fish and Game, Annual Progress Report for Investigations Project F-18-R-7, 19 pp.

Calhoun, A. J.
1949. California striped bass catch records from the party boat fishery: 1938-1948. Calif. Fish and Game, vol. 35, no. 4, pp. 211-253.
1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish and Game, vol. 36, no. 3, pp. 177-234.
1951. California statewide angling catch estimates for 1949. Calif. Fish and Game, vol. 37, no. 1, pp. 69-75.
1953. Statewide California angling estimates for 1951. Calif. Fish and Game, vol. 39, no. 1, pp. 103-113.

Johnson, William C.
1951. The reliability of the striped bass party boat catch records. Report to Bur. Fish Cons., Calif. Div. Fish and Game, 51-1, Jan. 9, 1951. 14 pp. (Typewritten.)

Ryan, James H.
1959. California inland angling estimates for 1954, 1956, and 1957. Calif. Fish and Game, vol. 45, no. 2, pp. 93-109.

Skinner, John E.
1955. California statewide angling estimates for 1953. Calif. Fish and Game, vol. 41, no. 1, pp. 19-32.

Tharratt, Robert
California inland angling estimates for 1959. (M. S. in preparation.)

Wendler, Henry O.
1960. The importance of the ocean sport fishery to the ocean catch of salmon in the states of Washington, Oregon and California. Calif. Fish and Game, vol. 46, no. 3, pp. 291-300.

THE 1960 PRESEASON ALBACORE SURVEY IN THE NORTHEASTERN PACIFIC OCEAN[1]

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INTRODUCTION

The California Department of Fish and Game has conducted several exploratory fishing and oceanographic cruises to study albacore *(Thunnus germo)* and their environment prior to the regular fishing season (Craig and Graham, 1961; Graham and Craig, 1961). These surveys have been conducted during the spring, to learn more about the movements of these economically valuable tuna prior to and during the beginning of the annual fishing season. Although a great deal has been learned about their movements through a tag-and-recovery program (Clemens, 1961; Otsu, 1960) and by studying catch records (Clemens, 1955), their migration route into the American fishing grounds needs additional investigation.

The location of early-season albacore concentrations is vitally important to commercial fishermen, for they must be prepared to catch a large portion of the season's total within three months after the fish appear in local waters. Because albacore are a popular sport fish and the season is short, recreational fishermen become frenzied by the appearance of the early migrants. Thus, locating and charting the progress of inbound schools enables scientists to study albacore and their environment, and by relaying the information to sport and commercial fishermen great savings of tedious and expensive scouting time are realized.

A program of oceanographic observations for the 1960 survey was planned and carried out, in co-operation with the U.S. Bureau of Commercial Fisheries, Biological Laboratory, San Diego, to determine relationships between the physical environment and albacore movements during their entry into the West Coast fishing grounds. A series of these ecological data should enable us to make more refined predictions of albacore movements when coupled with advance knowledge of environmental conditions. Toward this end, the present report embodies a compilation and a limited analysis of the physical and biological information collected during the 1960 survey.

[1] Submitted for publication August 1961.

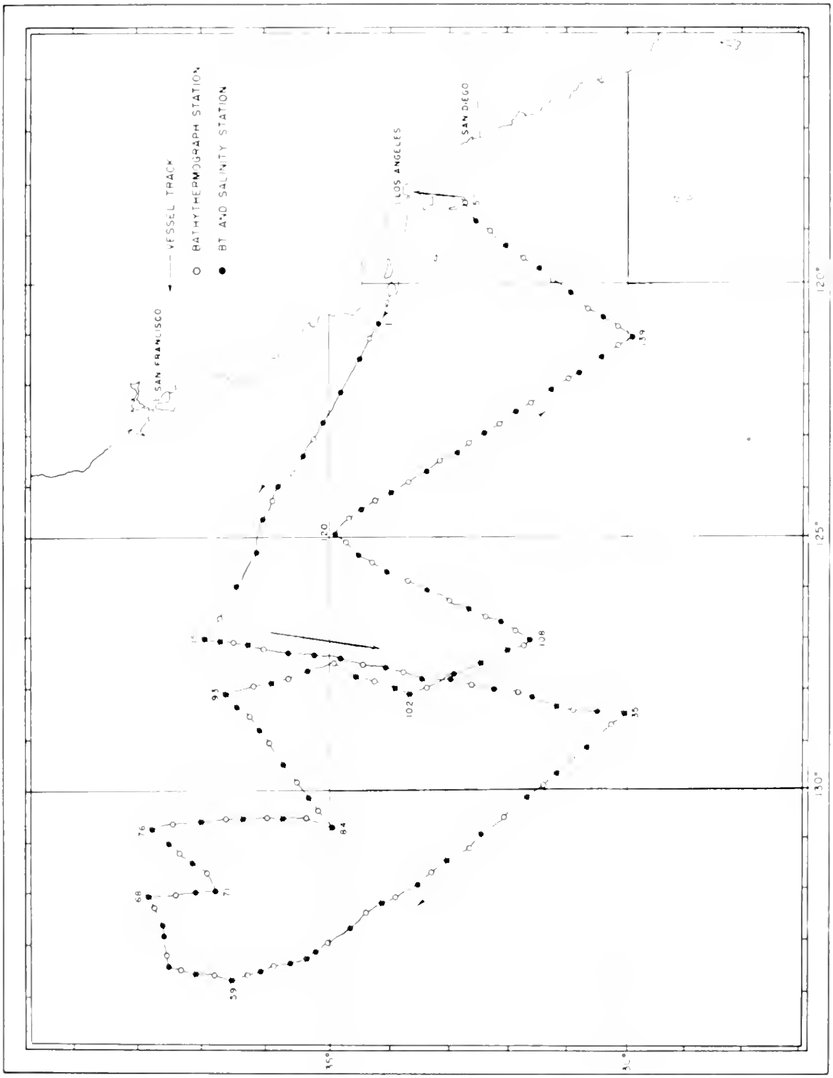

FIGURE 1. Vessel track and position of oceanographic stations occupied by the *N. B. Scofield* during an albacore survey, May 23 to June 18, 1960. Arabic numerals indicate BT station numbers.

CRUISE PLAN

For the second consecutive year the Department of Fish and Game vessel *N. B. Scofield* (Cruise 60S3) was used in an effort to intercept the incoming albacore schools by fishing along three predetermined lines between Cape Mendocino, California, and Punta Baja, Baja California. Should albacore be caught on one of these fishing lines, the cruise pattern was to be modified in an attempt to outline their latitudinal range while following them coastward (Figure 1).

The vessel proceeded from San Pedro toward the initial trolling line the evening of May 23 and returned to port 26 days later on June 18, 1960.

Fishing Method

Surface trolling gear was used to locate albacore schools. Artificial lures consisting of feathered japheads, and various plastic or bone jigs were attached to 6 or 7 lines of various lengths and trolled during daylight hours. Barbless hooks were used so that fish in good condition could be unhooked quickly for tagging. Trolling speed varied from 6 to 10 knots and averaged 6 to 7.

Plans to carry a small supply of live anchovies *(Engraulis mordax)* for bait fishing, in the event large concentrations of albacore were located, were changed when the tidal effects of a severe Chilean earthquake roiled Los Angeles Harbor and ruined baiting for a few days.

Oceanographic Observations

The survey plans placed primary emphasis on trolling for albacore, and secondarily, on gathering the most pertinent oceanographic data with the least interference to the primary purpose. Sea temperature and salinity were selected as the most useful physical observations under these restricted conditions.

A comprehensive record of sea temperature was obtained by means of the bathythermograph (BT) as well as bucket and recording thermometers. Bathythermograph lowerings to 450 feet were made at intervals approximately 20 miles apart. At each BT station an accurate reading of surface temperature was obtained with a bucket thermometer. The recording thermometer operated continuously during the survey.

Water samples for salinity determination were collected from Nansen bottle casts to 33 foot (10 meters) depths at intervals approximating 40 miles or at alternate BT stations. All oceanographic stations were occupied while the vessel moved slow ahead (1 to 3 knots) since stopping to drift meant securing all the fishing gear and losing precious scouting time. Movement of the vessel at these speeds resulted in obtaining the samples from a different depth than they would have been obtained if the cable had dropped perpendicular to the sea surface. This was compensated somewhat by considering the wire angle and varying the amount of cable metered off the winch. Most of the water samples thus collected were from depths closely approximating 10 meters. In some instances, however, the necessary compensation could not be made and the resulting samples were taken in depths estimated between 20 and 56 feet (6 and 17 meters).

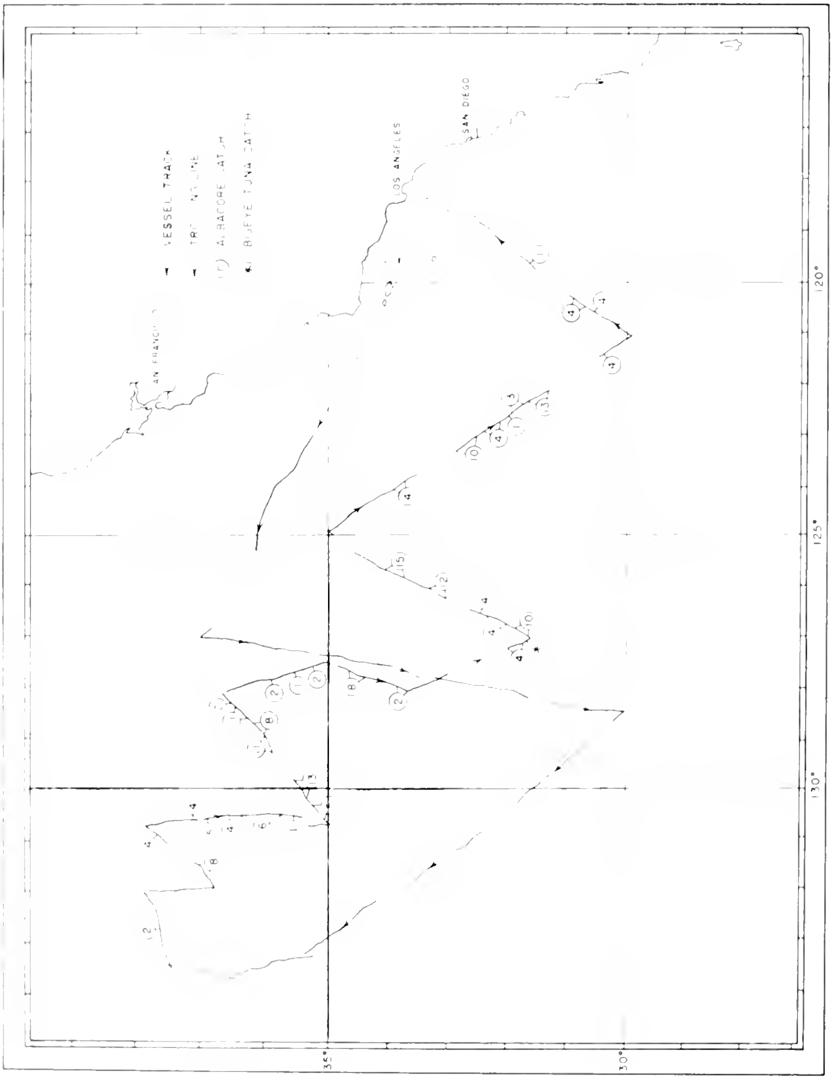

FIGURE 2. Trolling lines of the *N. B. Scofield* showing location of catches. Numerals within circles show numbers caught including "strikes" that were not landed.

Miscellaneous Observations

Several incidental observations were made to further the study of environmental conditions. Night light stations were attended while the vessel drifted on sea anchor. A 1,500-watt lamp was supended over the water at dusk and observations or collections were made throughout the evening. Weather and sea conditions were noted in connection with the BT log. Significant physical and biological occurrences or changes were also noted.

CRUISE RESULTS

Fishing Data

Trolling took place during daylight hours from approximately 120 miles west-northwest of Point Arguello to the south side of San Clemente Island. Slightly over 3,000 miles were traveled during the 26 days; nearly 2,300 miles were fished with trolling lines (Figure 2).

The first albacore were caught on the twelfth day of the cruise about 500 miles west of San Francisco (lat. 37° 43′ N., long. 132° 45′ W.). From that point, catches ranged from 1 to 26 fish each day throughout the remainder of the survey (Table 1).

For the sake of uniformity, no intense fishing effort was expended in any one area. By maintaining a straight course, fishing effort was evenly distributed allowing estimates of relative abundance between various areas. Catches of the *N. B. Scofield* indicated albacore were in greatest concentration in three localities: the northwestern area south of lat. 37° N. in close proximity to long. 130° W.; in the central portion south of lat. 34° N. and west of long. 125° W.; and southeast of the central portion west of long. 120° W.

The only other species caught on the trolling lines was bigeye tuna (*Parathunnus sibi*). Early in the morning of June 12, near Fieberling Guyot (lat. 32° 23′ N., long. 127° 49′ W.), all six lines hooked-up at the same instant. Five of the six fish broke off carrying the tackle with them. The sixth was landed and proved to be a bigeye tuna weighing approximately 50 pounds.

To further substantiate their coastward migration route, albacore were tagged at numerous offshore localities. Recoveries of preseason tagged fish early in the regular fishing season would aid materially in establishing a pattern of movement to the coast. Of 153 fish landed, 74 were considered in suitable condition and were tagged and released. None, however, was subsequently recovered.

Fork-length measurements on 135 of the 153 fish arranged as a size frequency distribution, show 90 percent of the fish averaged 12 pounds each. This is the size group usually dominating the Pacific coast fishery (Clemens, 1961). The remaining 10 percent consisted of fish in three size groups, averaging 7, 18, and 25 pounds each; these contribute to the commercial fishery in lesser quantities (Table 2).

Oceanographic Observations

In addition to sea-surface temperature measurements, 450-foot bathythermograph casts were made at 150 stations during the cruise (Figure 1). Water samples for salinity determination were collected at 85 positions. Generally the samples were obtained at alternate BT stations though occasional exceptions were necessary to complete the data (Figure 1).

TABLE 1

Albacore Catch Localities for the N. B. SCOFIELD Scouting Cruise (60S3) May 23 to June 18, 1960

Date	Position		Number tagged	Number saved	Number lost	Total catch	Surface Temperature (Degrees F.)
	N. lat.	W. long.					
6/1/60	37°13′	132°15′	--	2	--	2	61.1
6/5/60	37°02′	131°39′	--	2	--	2	62.1
	37°01′	131°37′	--	2	--	2	61.9
	37°06′	131°33′	1	2	1	4	61.7
6/6/60	37°16′	130°52′	1	2	1	4	59.5
	37°10′	130°38′	1	1	--	2	61.9
	37°07′	130°38′	2	--	--	2	61.9
6/7/60	36°57′	130°37′	1	2	2	5	62.1
	36°36′	130°35′	2	--	2	4	62.1
	36°24′	130°36′	--	--	1	1	60.6
	36°12′	130°36′	1	1	--	2	62.6
	36°07′	130°36′	--	--	1	1	62.4
	36°03′	130°36′	--	--	1	1	62.2
	36°01′	130°36′	1	1	--	2	62.4
	35°56′	130°36′	--	2	3	5	62.1
	35°49′	130°36′	2	2	--	4	62.8
	35°33′	130°36′	--	1	--	1	62.2
6/8/60	35°05′	130°35′	1	--	--	1	62.4
	35°07′	130°31′	1	--	1	2	62.4
	35°12′	130°23′	1	--	1	2	62.6
	35°22′	130°06′	--	2	--	2	62.4
	35°27′	129°57′	1	1	--	2	62.6
	35°30′	129°52′	6	2	1	9	62.1
6/9/60	35°52′	129°17′	2	2	--	4	61.0
	35°53′	129°15′	2	--	--	2	61.0
	35°56′	129°11′	--	1	--	1	61.0
	35°57′	129°08′	1	2	--	3	61.2
	36°03′	129°00′	--	1	--	1	61.0
	36°03′	128°57′	1	1	1	3	61.0
	36°07′	128°52′	1	--	--	1	61.0
	36°14′	128°42′	1	2	1	4	61.2
	36°19′	128°34′	--	4	--	4	60.8
	36°23′	128°30′	3	--	2	5	60.6
	36°25′	128°28′	1	--	1	2	60.6
	36°32′	128°19′	--	1	1	2	59.9
6/10/60	35°53′	127°53′	--	1	1	2	60.4
	35°29′	127°45′	--	1	--	1	60.8
	35°11′	127°39′	1		--	1	60.8
6/11/60	34°37′	127°43′	1	2	--	3	60.6
	34°31′	127°46′	--	1	--	1	61.3
	34°26′	127°47′	2	--	1	3	61.3
	34°25′	127°49′	--	--	1	1	61.5
	33°52′	128°02′	1	--	--	1	62.3
	33°43′	128°05′	1	--	--	1	62.6
6/12/60*	32°01′	127°15′	--	--	1	1	64.1
	32°00′	127°14′	--	1	1	2	64.2
	31°53′	127°11′	--	1	--	1	64.0
	31°38′	127°01′	2	--	2	4	63.5
	31°40′	127°00′	1	--	1	2	63.5

* One bigeye tuna caught at lat. 31°43′N., long. 127°06′W., surface temperature 64.2°F.

TABLE 1—Continued

Albacore Catch Localities for the N. B. SCOFIELD Scouting Cruise (60S3)
May 23 to June 18, 1960

Date	Position		Number tagged	Number saved	Number lost	Total catch	Surface Tempera-ture (Degrees F.)
	N. lat.	W. long.					
6/12/60*------	31°46′	126°56′	1	--	--	1	63.5
	31°48′	126°55′	--	2	1	3	63.5
	32°08′	126°45′	--	1	--	1	63.5
	32°12′	126°41′	1	--	--	1	63.3
	32°17′	126°39′	1	--	--	1	63.3
	32°19′	126°38′	--	--	1	1	63.3
	32°27′	126°33′	2	--	2	4	63.7
6/13/60------	33°02′	126°14′	--	1	--	1	62.8
	33°04′	126°13′	1	--	1	2	62.8
	33°16′	126°06′	1	--	--	1	62.8
	33°18′	126°05′	4	2	2	8	62.8
	33°47′	125°50′	1	1	1	3	61.0
	33°52′	125°47′	2	--	--	2	61.0
	33°57′	125°44′	2	2	3	7	61.0
	33°58′	125°43′	--	--	1	1	61.0
	34°02′	125°41′	1	1	--	2	61.2
6/14/60------	33°54′	124°06′	--	2	1	3	60.1
	33°47′	124°00′	1	--	--	1	60.3
6/15/60------	32°51′	123°20′	--	1	--	1	60.4
	32°49′	123°18′	--	3	1	4	60.6
	32°46′	123°16′	--	2	--	2	60.6
	32°38′	123°09′	3	--	--	3	61.0
	32°21′	122°56′	--	1	1	2	61.3
	32°17′	122°53′	1	--	--	1	61.5
	32°14′	122°15′	--	--	1	1	61.5
	31°59′	122°39′	--	1	--	1	61.7
	31°55′	122°35′	1	1	--	2	61.7
	31°45′	122°29′	--	1	--	1	61.7
	31°37′	122°22′	--	--	1	1	61.5
	31°34′	122°20′	1	2	2	5	61.5
	31°30′	122°17′	--	1	--	1	61.5
	31°27′	122°15′	--	1	--	1	61.5
	31°25′	122°12′	2	1	--	3	61.7
	31°20′	122°10′	1	1	--	2	61.7
6/16/60------	30°21′	121°24′	--	3	1	4	61.5
	30°28′	120°36′	1	1	2	4	62.8
	30°40′	120°27′	1	--	--	1	62.6
	30°44′	120°24′	--	--	1	1	62.4
	30°48′	120°20′	2	--	--	2	62.6
6/17/60------	31°34′	119°42′	--	1	--	1	60.4
TOTALS---	------	-------	74	79	52	205	----

* One bigeye tuna caught at lat. 31°43′N., long. 127°06′W., surface temperature 64.2°F.

TABLE 2

Length Frequency Distribution of 135 Albacore Caught During the Albacore Survey, May 23 to June 18, 1960

Length (cm)	Frequency	Percent	Length (cm)	Frequency	Percent
51	2	1.5	66	9	6.7
56	1	0.7	67	4	3.0
60	1	0.7	75	1	0.7
61	5	3.7	76	2	1.5
62	16	11.9	77	5	3.7
63	29	21.5	78	1	0.7
64	38	28.1	81	1	0.7
65	19	14.1	82	1	0.7

Surface water temperature ranged from 51.3 degrees F. around the northern Channel Islands to 65.3 degrees F. 400 to 500 miles west of Point Arguello. Salinities varied from 32.90 parts per thousand at stations within 200 miles west of Monterey, to 33.95 parts per thousand in the extreme southwestern area. Albacore catches were restricted to temperatures between 59.5 and 64.2 degrees F. and salinities between 32.95 and 33.53 parts per thousand. Superimposing the catches upon isograms of sea temperature and salinity illustrates their relationship to the distribution of these physical properties (Figures 3 and 4).

Vertical temperature profiles were prepared from selected BT slides to relate areas of good fishing with subsurface temperature changes or with the thermocline depth. Cursory examination failed to show any obvious relationship hence further analysis was discontinued. Temperatures were tabulated at standard depths for each BT cast (Table 3).

Miscellaneous Details

Nine night-light stations were occupied while the vessel drifted on a sea anchor. Small Pacific sauries (*Cololabis saira*) showed up in varying numbers at all but one station which was located in the northwestern area at lat. 35° 23′ N., long. 130° 36′ W. Other organisms observed at fewer stations were jack mackerel (*Trachurus symmetricus*), lantern fish (Family Myctophidae), shark, squid and tunicates (Table 4).

Stomachs of most of the 79 fish unfit for tagging, were examined qualitatively in the field to determine the nature and extent of feeding. Most were empty or contained only a small amount of nearly digested material. Among the more common recognizable organisms were Pacific saury, jack mackerel and cephalopods. Several stomachs contained unfamiliar organisms in reasonably good condition. These were frozen and returned to the laboratory for identification (Table 5).

Two parasitic helminths occurred commonly in the albacore stomachs; one was a nematode and the other a trematode. These have not been positively identified, but their striking resemblance to illustrations of the nematode *Contracaecum legendrei* and the trematode *Hirudinella fusca* from albacore caught in the eastern Atlantic Ocean (Dollfus, 1940) suggests a generic relationship between these parasites in the two oceans.

Daytime observations were typical of those encountered in the same area on previous cruises. One small whale and two sea lions were the only mammals observed. Albatross were present in small numbers most of the time. Storm petrels, though less prevalent, were frequently observed. Behavior of the birds appeared no different in areas where fish were caught and at no time did feeding birds indicate the presence of fish. Two vast areas of *Velella lata* were noted: one, near San Miguel Island, extended for approximately 60 miles, the other for about 30 miles near the location of the first albacore catch. Numerous glass net-floats were seen, particularly in the north-central portion of the survey area. Most of these were heavily encrusted with stalked barnacles indicating a long period of drifting in the sea.

While running the last survey line, the sea itself proved interesting to observe. Characteristic "tide rips," typical of an area where water masses converge (Sverdrup, *et al.*, 1942), were visible in all directions. The recording thermometer sometimes fluctuated plus and minus one degree C. in less than five minutes. The water remained clear, but the color in some of the "fingers" was greenish and contained floating kelp, while in others oceanic blue color prevailed without kelp.

DISCUSSION

Japanese workers have suggested that albacore may be identified with a distinct current system (Nakamura, 1954; Suda, 1956). With this in mind the *N. B. Scofield* cruise data were examined for evidence of such an alliance in the California Current system during the spring albacore migration.

It is possible to estimate water mass transitions taking place during the cruise by analyzing the temperature-salinity structure (Miller, 1950), (Figure 5). In the area of Point Conception, temperatures were much cooler than any subsequently encountered, yet salinities were in the upper part of the range (Stations 1, 3 and 4). Such a temperature-salinity distribution is undoubtedly the result of upwelling along the adjacent coastline. Northwest of Point Conception and farther offshore, the stations shown between 5 and 18 (Figure 5) were characterized by a marked decline in salinity values, but only a slight increase in temperature. This combination is indicative of water transported by the California Current and presumably represents passage of the *N. B. Scofield* through the eastern boundary of this system. The grouping of values between 33.00 and 33.40 parts per thousand salinity and 60 to 63 degrees F. temperature constitutes data collected in the expanse of the California Current itself. Values in excess of these probably represent the transition from the California Current to the warmer more saline water of the central northeastern Pacific Ocean.

Investigators have often used the horizontal temperature-salinity profile to relate a biological entity to different water masses (Bary, 1959). With the albacore this approach provides an interesting distribution. Most of the albacore were taken in a restricted range of temperatures and salinities (Figure 5). Of the catch, 87 percent was landed in water of 60.5 to 63.0 degrees F. and in salinities from 33.05 to 33.30 parts per thousand. Averages for June (1949 through 1959)

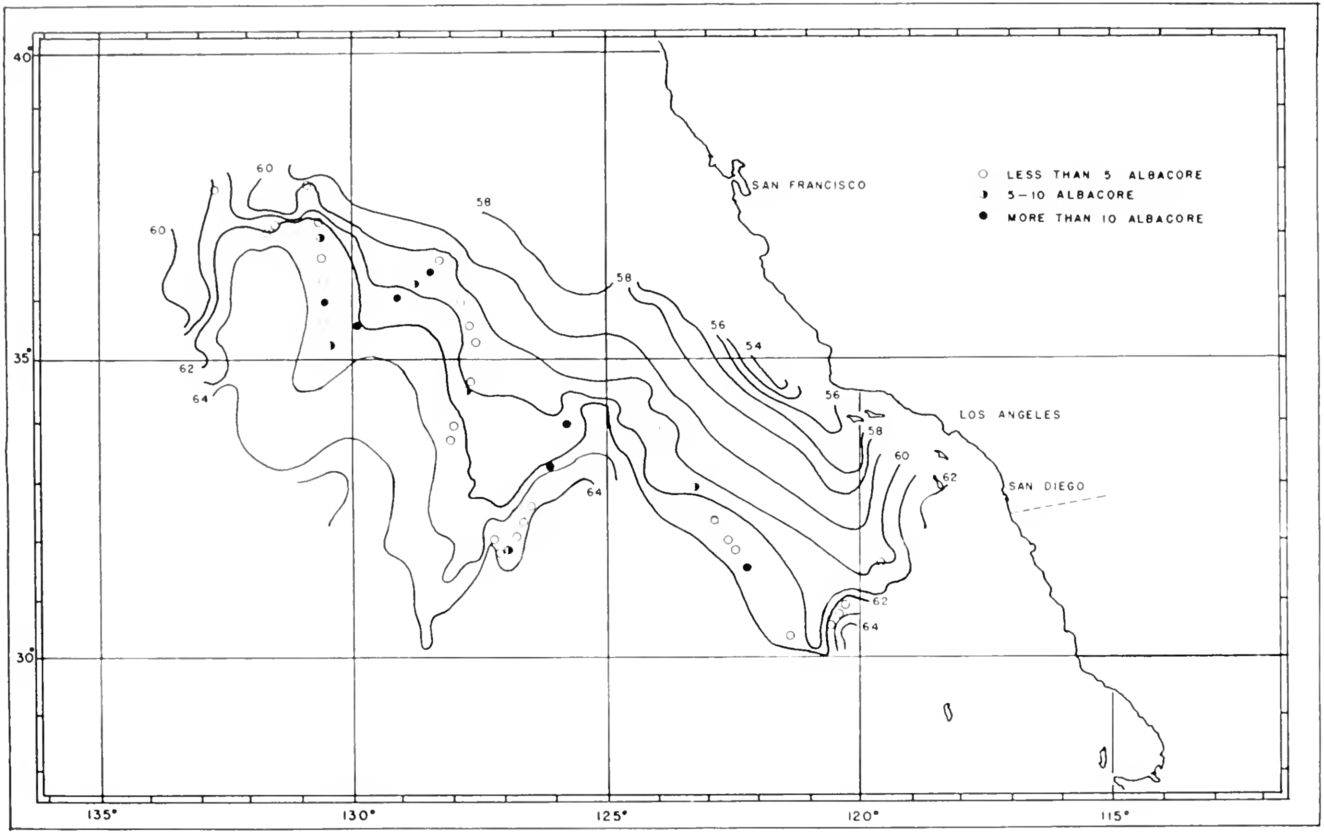

FIGURE 3. Sea-surface temperature contours by one degree F. intervals showing relationship of albacore catches made during the 1960 survey.

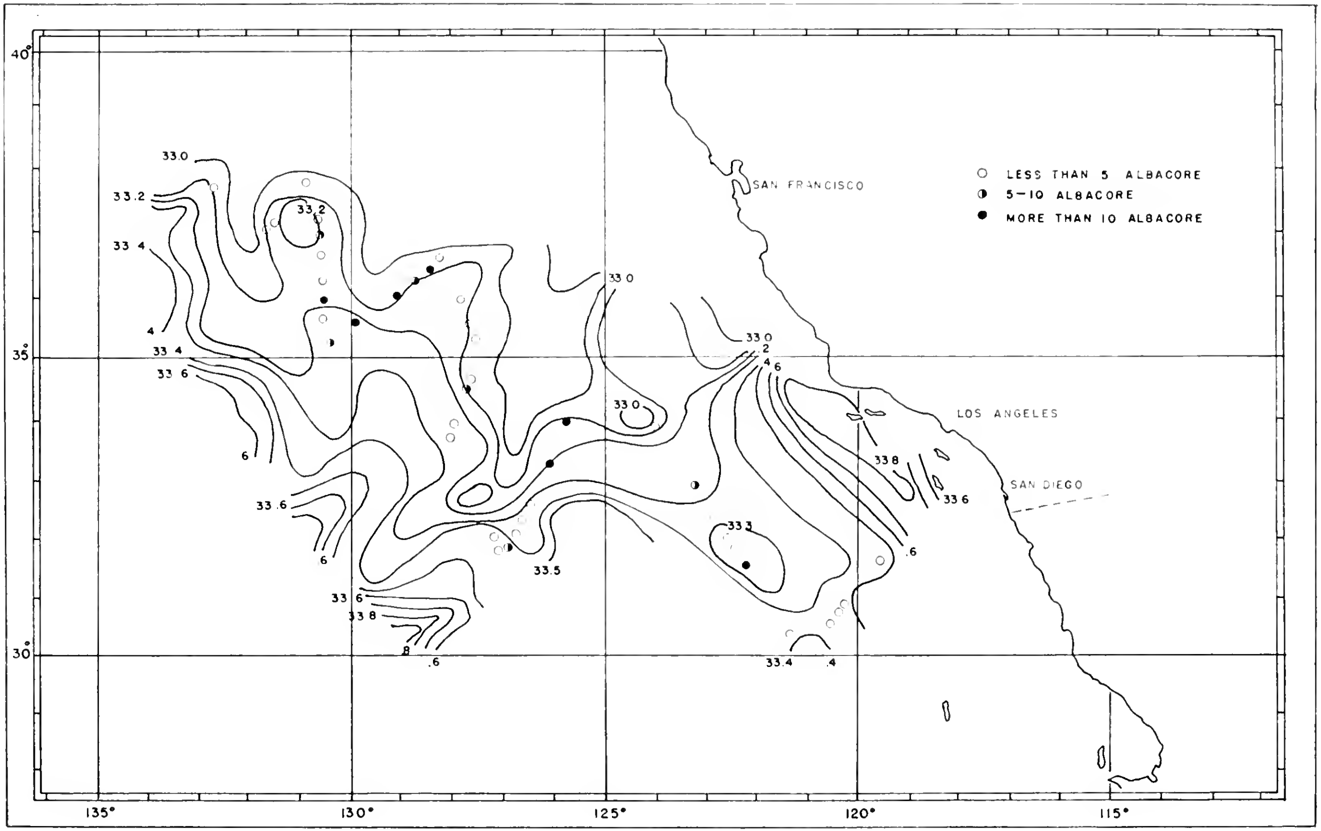

FIGURE 4. Ten-meter salinity contours by 0.10 parts per thousand (0/00) intervals showing relationship of albacore catches made during the 1960 survey.

TABLE 3

Summary of Observations at Bathythermograph Stations Occupied During the Albacore Survey, May 23 to June 18, 1960

			Location					TEMPERATURE (°F.)																	
								Air		Water															
											Bathythermograph (depth in feet)														
Serial No.	Date	Time GMT	N. lat.	W. long.	Depth (fm)	Salinity ‰ (10M)	Barometer (mb)*	Wet	Dry	Bucket (surface)	0	30	50	100	150	200	250	300	330	400	490	500	600	655	700
1a	V-24	2318	34-10	120-47	430	33.87	1016	58.0	59.0	55.8	55.2	52.9	52.5	51.3	50.4	48.9	48.0	47.5	47.1						
1b	V-24	2325	34-10	120-47	430	-------	1016	58.0	59.0	55.8	55.8	52.7	52.5	51.1	49.3	48.6	48.0	47.5	47.3	47.1	47.1	46.9	46.9		
2	V-25	0131	34-19	121-07	860	-------	1017	57.0	58.0	55.4	54.9	51.8	51.6	50.9	49.6	48.6	48.0	47.5	47.1						
3	V-25	0353	34-29	121-30	1000	33.79	1017	55.5	57.0	54.1	54.1	51.6	51.3	51.1	50.9	50.5	49.8	48.4	47.5						
4	V-25	0803	34-47	122-10	2100	33.47	1018	55.0	56.0	54.0	53.6	52.5	52.5	51.6	51.4	50.4	50.2	49.5	48.9						
5	V-25	1148	35-05	122-45	-------	33.15	1018	55.0	57.0	55.8	55.9	55.9	55.6	55.2	54.5	53.4	52.9	52.0							
6	V-25	1400	35-17	123-06	2100	-------	1019	58.0	60.0	56.8	56.7	56.1	55.4	55.2	55.2	54.3	54.0	53.8	52.3	49.8					
7	V-25	1601	35-26	123-26	1700	33.04	1020	60.0	64.0	57.7	57.2	56.5	56.1	55.2	55.0	53.6	52.3	51.4	50.5	48.2					
8	V-25	1802	35-35	123-46	2100	-------	1020	60.0	63.5	57.2	56.5	54.9	54.1	52.3	51.8	51.1	50.9	50.2							
9	V-25	2001	35-49	124-01	2150	33.12	1021	61.0	64.0	58.5	57.9	57.0	56.8	56.1	54.9	53.6	52.0	50.5							
10	V-25	2201	35-56	124-19	2125	-------	1022	60.0	63.0	57.0	56.7	55.6	55.6	54.3	52.5	52.0	50.5	49.6							
11	V-26	0028	36-05	124-43	2250	33.16	1024	61.0	63.5	58.6	58.3	57.9	57.9	57.6	57.4	55.0	52.7	50.7							
12	V-26	0414	36-12	125-20	2420	32.91	1022	59.0	60.5	57.7	57.7	57.7	57.4	57.0	56.8	56.7	54.3	53.6	53.2						
13	V-26	0803	36-29	125-58	2420	32.90	1022	58.5	59.0	57.7	57.9	57.9	57.2	56.1	55.9	55.2	54.3	54.1	54.3						
14	V-26	1153	36-48	126-37	2275	-------	1020	58.0	59.0	57.7	58.8	58.8	58.8	58.3	57.9	56.3	55.9	55.2	54.7						
15	V-26	1430	37-00	127-00	-------	32.99	1020	59.0	60.0	57.9	57.9	57.9	57.9	57.6	57.4	56.5	54.5	54.0	53.1						
16	V-26	1602	36-47	127-03	2450	33.09	1022	60.0	62.0	58.5	58.6	58.6	58.6	58.3	58.3	56.8	55.8	54.5	54.3						
17	V-26	1758	36-33	127-06	2450	-------	1022	61.0	62.5	58.6	59.0	59.0	58.8	58.6	58.1	56.5	54.5	54.1	54.1						
18	V-26	1956	36-19	127-09	2525	32.99	1022	62.0	64.0	58.5	59.7	59.5	59.4	59.2	56.1	55.8	55.4	53.8	53.1						
19	V-26	2200	36-04	127-12	2500	-------	1025	61.5	63.0	59.7	59.7	59.4	59.2	58.1	57.9	56.8	55.4								
20	V-27	0050	35-41	127-17	2500	33.01	1025	60.0	61.0	59.7	59.7	59.0	58.8	58.5	58.5	57.0	56.3	55.6							
21	V-27	0350	35-16	127-21	2480	33.04	1026	59.0	60.0	60.1	60.1	59.9	59.5	58.6	58.5	58.3	55.8	51.7							
22	V-27	1602	34-51	127-28	2575	33.02	1027	56.0	59.0	60.1	60.4	59.9	59.9	59.4	57.9	56.7	55.8								

23	V-27	1900	34-27	127-33	2580	--------	1027	55.0	59.0	61.0	61.2	61.2	61.0	60.1	59.2	56.8	55.9	55.2							
24	V-27	2201	34-06	127-37	------	33.14	1027	58.0	62.0	61.3	61.5	61.5	61.3	60.4	60.1	57.9	55.8	54.9							
25	V-28	0053	33-46	127-42	2500	--------	1025	57.0	62.0	61.5	61.9	61.9	61.9	61.0	60.8	57.6	55.6	54.1	53.4						
26	V-28	0325	33-29	127-49	2350	33.26	1024	56.5	60.0	61.7	61.9	61.9	61.9	60.8	60.6	56.5	54.7	52.0	52.7	50.4					
27	V-28	1631	33-01	127-51	2430	33.23	1022	56.0	59.0	61.7	61.9	61.9	61.9	61.5	61.0	60.1	59.7	59.7	59.5	59.7					
28	V-28	1923	32-38	127-56	2300	--------	1022	57.0	59.0	61.9	62.1	62.1	62.1	61.9	61.3	59.9	59.9	59.9							
29	V-28	2230	32-14	128-02	2225	33.40	1022	58.0	61.0	62.8	62.8	62.8	62.6	62.4	61.9	61.7	59.9	60.8							
30	V-28	2332	31-50	128-07	2280	--------	1021	57.5	62.0	63.1	63.1	63.1	63.1	63.1	63.0	62.8	60.8	59.2							
31a	V-29	0317	31-37	128-12	2210	33.51	1021	57.0	60.0	62.8	63.3	63.3	63.3	63.3	62.8	61.9	60.8	59.7	58.1	54.5					
31b	V-29	0322	31-37	128-12	2210	--------	1021	57.0	60.0	62.8	63.0	63.0	63.0	62.2	61.7	60.6	59.0	57.0	55.6	51.8	48.6	48.4	47.3	46.9	46.6
32	V-29	1601	31-11	128-21	2280	33.50	1022	59.0	63.0	63.1	63.3	63.5	63.5	63.3	62.8	62.8	61.5	60.8							
33	V-29	1839	30-53	128-26	2350	--------	1023	61.0	64.0	63.5	63.7	63.7	63.7	64.4	64.2	62.2	62.6	61.5	60.8						
34	V-29	2132	30-31	128-29	2400	33.95	1023	61.5	65.0	64.6	65.1	65.1	65.1	65.1	64.8	64.8	63.7	63.1	63.7						
35	V-30	0132	30-00	128-30	2300	33.55	1022	61.0	63.0	64.2	64.0	64.0	64.0	65.1	64.9	64.9	64.4	63.9	64.4						
36	V-30	0503	30-15	128-44	2500	--------	1023	62.5	65.0	64.8	64.9	64.9	64.9	64.9	64.4	63.1	62.6	62.8	63.0						
37	V-30	1402	30-40	129-11	2400	33.91	1023	61.5	63.0	64.6	64.9	64.9	64.9	64.9	63.9	64.0	63.9	65.5	65.5						
38	V-30	1701	30-56	129-26	2400	--------	1022	62.0	65.0	64.4	64.2	64.2	64.2	63.7	63.1	63.9	63.7	63.1	63.0						
39	V-30	2001	31-11	129-41	2400	33.68	1022	61.5	66.5	64.8	64.9	64.8	64.8	64.2	64.0	62.2	61.0	61.0	61.7						
40	V-30	2302	31-27	129-55	2425	--------	1025	61.5	65.5	64.2	64.8	64.8	64.4	64.2	63.9	62.2	61.2	60.8	60.6						
41	V-31	0201	31-44	130-09	2400	33.39	1024	61.5	65.0	64.4	64.8	64.6	64.0	62.8	62.4	61.0	61.1	60.4	60.1						
42	V-31	0739	32-07	130-33	2380	--------	1025	61.5	64.0	64.8	64.8	64.8	64.8	63.5	63.0	61.5	60.3	60.3	60.4						
43	V-31	1431	32-31	130-56	2400	33.70	1026	61.5	64.0	65.7	65.8	65.8	65.8	64.6	61.2	60.8	60.8	60.8	61.3						
44	V-31	1732	32-46	131-09	2200	--------	1027	62.0	64.0	65.5	65.5	65.5	64.6	63.9	63.5	61.7	61.3	62.4	60.4						
45	V-31	2101	33-04	131-24	2350	33.41	1027	63.0	67.0	64.0	64.0	64.0	63.9	63.5	62.1	59.9	59.7	61.0	59.2						
46	VI-1	0002	33-19	131-39	2510	--------	1027	62.0	64.5	63.7	63.7	63.7	63.1	62.6	60.8	60.8	60.8	60.8	61.9						
47	VI-1	0302	33-34	131-54	2625	33.66	1026	61.0	61.5	63.7	63.9	63.9	63.9	62.8	61.1	61.0	60.8	60.6	60.6						
48	VI-1	0908	33-55	132-08	2775	--------	1025	62.0	65.0	63.7	63.9	63.9	63.9	62.4	62.2	61.7	61.1	61.0	61.0						
49	VI-1	1353	34-09	132-15	2700	33.58	1025	60.5	61.5	63.3	63.3	63.3	63.3	62.4	62.1	61.0	61.0	61.1	61.3	60.8					
50	VI-1	1701	34-26	132-28	2830	--------	1026	63.0	65.0	64.6	64.2	64.2	64.2	62.8	62.8	63.3	62.4	62.6	62.2						
51	VI-1	2009	34-43	132-44	2200	33.64	1026	62.0	65.0	62.4	63.3	63.1	63.0	61.9	61.3	60.6	60.3	60.6	60.1						
52	VI-1	2304	35-01	133-01	2650	--------	1025	62.0	64.0	60.8	61.7	61.7	61.3	59.7	59.7	60.1	59.9	60.1	59.4						
53	VI-2	0152	35-14	133-13	2700	33.33	1024	62.0	64.0	62.6	63.0	63.0	62.2	59.7	59.7	61.7	58.6	56.5	55.6						
54a	VI-2	0407	35-21	133-20	2660	33.19	1024	61.0	62.0	61.7	61.5	61.5	61.5	59.7	58.8	57.0	57.2	59.2	58.6	57.0					
54b	VI-2	0412	35-21	133-20	2660	33.19	1024	61.0	62.0	61.7	61.0	60.8	59.9	59.2	56.3	55.6	57.9	57.2	57.7	55.4	51.6	50.7	47.7	46.8	46.4
55	VI-2	1804	35-36	133-26	2450	33.30	1022	60.5	62.0	59.4	59.0	59.2	59.0	57.9	57.0	57.2	56.7	56.8	56.7	55.9					
56	VI-2	2055	35-53	133-30	2680	--------	1022	63.0	64.5	60.1	59.9	59.7	59.7	57.6	57.0	56.5	55.4	54.7	54.7	55.2					
57	VI-3	0003	36-06	133-35	2780	33.40	1021	62.0	63.5	60.3	60.1	60.1	60.1	58.5	57.7	57.4	56.8	56.1	55.9	55.4					
58	VI-3	0301	36-20	133-40	2750	--------	1021	61.0	63.0	60.4	60.3	60.3	60.3	59.9	57.9	57.2	56.8	56.8	57.2						
59	VI-3	1701	36-35	133-47	2725	33.39	1020	59.0	61.0	59.5	59.7	59.7	59.7	58.5	58.1	57.7	57.6	56.5	56.5						
60	VI-3	2000	36-52	133-43	2600	--------	1021	60.0	62.0	59.7	59.7	59.7	59.7	57.6	56.5	56.1	54.7	53.8	54.3	52.9					
61	VI-3	2305	37-08	133-38	2770	33.30	1020	64.0	64.0	60.4	60.8	60.8	60.6	59.2	56.8	55.9	54.9	54.5	53.6						
62	VI-4	0146	37-23	133-34	2675	--------	1020	59.0	61.0	60.3	60.4	60.4	60.4	58.8	58.1	55.8	54.7	54.0	54.3						
63a	VI-4	0345	37-33	133-31	2650	33.31	1020	58.5	59.5	60.6	60.8	60.4	60.1	58.5	57.6	56.7	55.9	54.9	54.7	53.6					

TABLE 3—Continued

Summary of Observations at Bathythermograph Stations Occupied during the Albacore Survey, May 23 to June 18, 1960

Serial No.	Date	Time GMT	Location N. lat.	Location W. long.	Depth (fm)	Salinity ‰ (10M)	Barometer (mb)*	TEMPERATURE (°F.) Air Wet	Air Dry	Water Bucket (surface)	Bathythermograph (depth in feet) 0	30	50	100	150	200	250	300	330	400	490	500	600	655	700
63b	VI-4	0353	37-33	133-31	2650	33.31	1020	58.5	59.5	60.6	60.4	59.0	57.9	57.6	56.1	54.9	51.3	53.8	52.9	52.0	49.8	49.6	46.2	47.8	47.5
64	VI-4	1705	37-34	133-16	2650	------	1018	59.5	61.5	60.1	60.4	60.6	60.6	60.1	59.2	58.1	57.6	54.7	54.3						
65	VI-4	2002	37-40	132-55	2700	33.12	1018	60.0	62.5	60.8	61.2	61.0	60.8	59.0	58.5	58.1	57.7	55.9	55.6						
66	VI-4	2153	37-43	132-43	2720	33.08	1017	60.5	62.5	61.2	61.2	61.2	61.0	59.0	58.6	57.9	56.3	56.5	56.1	53.4					
67	VI-5	0101	37-50	132-21	2725	------	1017	61.0	63.0	60.4	60.4	60.4	60.4	60.1	58.8	58.3	57.7	57.0	57.0	52.9					
68a	VI-5	0104	37-55	132-06	2550	33.13	1016	59.5	61.0	60.6	60.8	60.8	60.8	60.1	58.1	57.6	57.2	56.8	56.3	55.9					
68b	VI-5	0108	37-55	132-06	2550	33.13	1016	59.5	61.0	60.6	60.6	60.1	59.9	58.1	57.2	56.7	56.5	55.6	55.4	54.7	50.9	50.4	48.6	47.7	47.5
69	VI-5	1705	37-29	132-05	2725	------	1011	61.0	63.0	59.9	60.3	60.3	60.3	59.5	57.9	56.7	54.9	55.6	55.2						
70	VI-5	2002	37-08	132-02	2450	33.17	1017	61.0	64.0	61.9	62.2	62.2	62.2	62.1	59.7	58.1	56.5	56.5	53.6						
71	VI-5	2302	36-48	131-59	2680	33.01	1014	63.5	67.0	63.0	63.0	61.7	61.7	60.1	59.4	58.1	56.3	53.2	51.8						
72	VI-6	0232	37-02	131-40	2575	------	1013	61.0	64.0	61.9	62.2	61.9	61.7	61.2	59.2	57.7	55.6	54.1	52.7	50.0					
73	VI-6	0642	37-13	131-26	2500	33.24	1014	59.9	62.0	62.2	62.1	62.1	62.1	62.1	60.1	57.2	56.8	56.3	54.7	52.0					
74	VI-6	1304	37-25	131-15	2480	------	1015	58.0	61.0	60.1	60.1	60.1	60.1	59.9	57.9	57.0	55.6	55.2	55.0	54.7					
75	VI-6	1657	37-37	131-03	2560	33.21	1017	59.0	62.0	60.4	60.3	60.3	60.3	59.7	57.9	57.2	56.1	56.1	55.1	54.3					
76	VI-6	2133	37-52	130-45	------	33.01	1019	58.5	61.0	59.0	58.8	58.8	58.8	58.5	57.4	56.8	55.8	55.2	54.9	54.0					
77	VI-7	0032	37-31	130-12	2100	------	1019	57.0	59.0	59.4	59.7	59.7	59.7	57.0	56.5	55.2	54.3	51.0	53.1						
78a	VI-7	0412	37-05	130-38	------	33.19	1020	57.0	59.0	61.9	62.1	62.2	62.2	62.1	59.9	58.3	57.2	57.6	56.5	52.5					
78b	VI-7	0116	37-05	130-38	------	33.19	1020	57.0	59.0	61.9	61.9	61.9	61.9	59.9	58.1	56.5	57.4	55.6	53.4	50.5	50.0	49.6	48.0	47.1	
79	VI-7	1702	36-41	130-36	2650	------	1022	55.0	59.0	62.2	62.1	62.4	62.1	62.1	58.1	57.7	57.4	57.2	56.1						
80	VI-7	1933	36-21	130-36	2700	33.17	1023	57.0	62.0	62.6	63.0	63.0	63.0	61.2	58.6	58.1	58.1	57.7	58.3						
81	VI-7	2231	36-03	130-36	2575	------	1023	58.0	62.5	62.6	62.6	62.6	62.6	61.7	58.6	57.4	57.2	56.7	56.7						
82	VI-8	0102	35-46	130-36	2690	33.25	1022	57.0	61.0	63.0	62.4	62.4	62.1	60.8	58.1	57.2	56.8	54.7	56.3						
83a	VI-8	0108	35-23	130-36	2650	------	1022	56.0	59.0	62.6	62.6	62.6	62.6	60.3	58.5	57.9	57.0	56.7	56.1	55.6					
83b	VI-8	0112	35-23	130-36	2650	------	1022	56.0	59.0	62.6	62.4	62.4	62.4	58.8	57.9	57.0	56.7	55.6	55.2	53.6	49.3	49.1	48.2	47.1	46.9
84	VI-8	1731	34-58	130-46	2650	33.21	1021	57.0	61.0	62.6	62.6	62.6	62.6	62.2	61.7	59.7	58.6	57.9	57.7	57.0					

85	VI-8	2115	35-10	130-26	2575	--------	1023	58.0	63.0	62.6	62.8	62.8	62.8	61.0	58.6	57.6	57.0	55.2	55.0						
86	VI-9	0032	35-20	130-09	2560	33.25	1022	57.0	61.0	62.4	62.4	62.4	62.4	61.5	61.7	60.6	60.1	57.7	56.7	56.3					
87	VI-9	0416	35-31	129-50	2560	--------	1022	56.0	58.0	61.9	62.1	62.1	62.1	60.8	59.7	59.2	58.5	58.6	57.9	56.8					
88	VI-9	1003	35-44	129-30	2580	33.09	1021	55.5	59.5	61.3	61.5	61.5	61.5	61.3	59.9	58.5	57.2	57.2	56.1						
89	VI-9	1547	35-58	129-06	2540	--------	1021	57.1	58.9	61.2	61.5	61.5	61.5	61.5	59.7	57.9	56.8	56.1	55.8	51.1					
90	VI-9	1901	36-08	128-51	2550	33.12	1021	59.0	62.0	60.8	61.0	61.0	61.0	61.0	58.8	57.6	56.3	55.4	55.2	52.7					
91	VI-9	2201	36-18	128-35	2500	--------	1021	59.0	61.0	60.8	61.0	61.0	61.0	61.0	60.8	59.7	58.3	57.9	58.3						
92	VI-10	0103	36-29	128-22	2540	33.08	1020	58.5	61.0	60.8	60.8	60.8	60.8	60.6	59.9	58.3	58.1	56.7	56.3	56.8					
93	VI-10	0408	36-40	128-08	2520	33.10	1020	56.5	59.0	60.1	60.1	60.1	60.1	60.1	59.9	57.9	56.8	56.5	56.5	53.6					
94	VI-10	1623	36-14	127-59	2450	--------	1023	57.0	61.0	59.5	59.5	59.5	59.5	59.5	59.5	58.3	56.3	56.1	55.8						
95	VI-10	1902	35-55	127-54	2100	33.12	1023	57.0	61.0	60.8	60.8	60.8	60.8	60.8	60.6	59.0	56.8	55.8	55.2						
96	VI-10	2138	35-37	127-47	2500	--------	1023	58.0	61.0	60.8	60.6	60.6	60.6	60.6	58.8	58.1	56.1	55.4	55.4						
97	VI-11	0002	35-20	127-41	2550	33.08	1023	58.0	61.0	60.8	60.4	60.4	60.4	60.4	58.3	57.4	56.1	55.2	54.9						
98a	VI-11	0315	34-57	127-32	2500	--------	1023	57.0	59.0	60.4	60.3	60.3	60.3	60.3	59.0	57.0	56.0	55.6	55.4	53.8					
98b	VI-11	0322	34-57	127-32	2500	--------	1023	57.0	59.0	60.4	60.4	60.4	60.4	59.4	58.3	56.1	55.8	55.0	54.1	52.5	49.6	49.5	47.8	47.3	47.1
99	VI-11	1554	34-34	127-45	2550	33.09	1023	57.8	60.0	60.8	60.6	60.6	60.6	60.6	59.0	56.3	51.5	51.7	54.7						
100	VI-11	1833	34-15	127-52	2520	--------	1023	59.0	63.0	61.7	61.3	61.3	61.3	61.3	60.6	57.6	55.8	54.9	53.8						
101	VI-11	2111	33-56	128-01	2430	33.24	1023	60.5	63.5	62.2	62.1	62.4	62.4	62.4	61.7	56.7	51.5	54.1	53.6						
102	VI-11	2332	33-40	128-07	2475	33.23	1023	60.5	64.0	62.6	62.2	62.2	62.2	62.1	61.0	56.8	54.7	53.4	52.5						
103	VI-12	0154	33-23	127-58	2350	--------	1023	62.0	65.0	62.4	61.9	61.9	61.9	61.9	60.6	59.5	57.2	55.2	54.5						
104	VI-12	0504	32-57	127-44	2400	33.08	1023	60.5	62.5	62.2	61.9	61.9	61.9	61.9	59.4	58.1	56.5	56.1	56.5						
105	VI-12	0903	32-30	127-30	2100	33.22	1023	59.0	63.0	62.8	62.4	62.4	62.4	62.4	61.2	60.1	59.0	57.9	58.8						
106	VI-12	1304	32-03	127-16	2325	33.49	1023	59.0	62.0	61.0	63.7	63.7	63.7	63.7	63.3	61.2	59.9	59.9	59.9						
107	VI-12	1532	31-45	127-07	2300	--------	1023	60.5	64.0	64.4	63.7	63.7	63.7	63.7	63.7	61.3	59.7	59.2	58.3						
108	VI-12	1706	31-37	127-02	--------	33.13	1023	60.2	64.2	63.7	63.5	63.5	63.5	63.5	63.7	63.3	61.5	61.2	61.2	59.4					
109	VI-12	2001	31-54	126-52	2200	--------	1023	61.5	65.0	63.7	63.5	63.5	63.5	63.5	63.5	63.5	62.4	60.1	59.7						
110	VI-12	2259	32-10	126-43	2000	32.37	1023	61.0	64.0	63.7	63.5	63.5	63.5	63.5	62.8	62.1	61.3	60.8	60.1	58.1					
111	VI-13	0150	32-24	126-35	2380	--------	1023	60.0	64.0	64.0	62.4	62.4	62.4	62.4	61.9	60.1	59.7	58.8	58.1						
112	VI-13	0504	32-40	126-26	2330	33.50	1024	58.0	62.0	63.7	63.9	63.9	63.9	63.9	63.9	60.4	58.6	57.7	57.0						
113	VI-13	1302	33-01	126-14	2300	--------	1023	59.0	60.5	63.1	63.1	63.1	63.1	63.1	61.7	60.3	60.1	59.7							
114	VI-13	1614	33-23	126-03	2380	33.19	1023	60.5	62.5	61.9	61.9	62.1	62.1	62.1	62.6	61.2	60.4	60.4	59.0						
115	VI-13	1901	33-43	125-52	2370	--------	1021	62.0	64.0	61.3	61.3	61.3	61.3	61.3	61.2	59.0	58.6	57.2	57.9	55.6					
116	VI-13	2204	34-02	125-41	2500	33.10	1022	60.0	63.5	61.3	61.5	61.2	61.0	61.0	61.0	59.0	58.1	56.1	51.9						
117	VI-14	0106	34-18	125-30	2480	--------	1021	60.4	62.9	62.2	62.6	62.6	62.6	62.4	61.3	60.3	59.7	59.4	58.8	57.2					
118	VI-14	0403	34-34	125-20	2420	33.05	1021	58.5	61.0	60.4	60.6	60.6	60.6	60.6	60.4	58.3	57.7	57.4	55.4						
119	VI-14	0904	34-44	125-07	2450	--------	1019	58.0	61.0	59.9	60.4	60.6	60.6	60.4	60.3	56.1	51.7	54.0	53.6	51.3					
120	VI-14	1305	34-53	124-58	2400	33.12	1018	58.0	60.0	59.4	59.5	59.5	59.5	59.2	58.5	56.5	51.0	51.6	50.4						
121	VI-14	1633	34-42	124-43	2330	--------	1020	59.5	61.5	59.9	59.7	59.7	59.7	59.5	59.0	57.0	54.0	52.9	51.8						
122	VI-14	1904	34-27	124-30	2350	33.10	1020	61.5	67.0	60.6	60.6	60.4	60.3	60.3	60.1	58.5	57.6	57.2	56.5						
123	VI-14	2133	34-14	124-20	2350	--------	------	61.0	63.5	60.1	59.9	59.9	59.9	59.7	58.5	56.3	55.2	54.7	54.0						
124	VI-15	0001	33-58	124-09	2325	32.95	------	62.0	64.0	60.1	60.1	60.1	60.1	60.1	57.9	57.0	55.6	55.8	51.7						
125	VI-15	0237	33-41	123-56	2425	--------	1018	61.0	63.0	60.3	60.3	60.3	60.3	59.4	58.8	58.3	56.7	55.2	54.0						
126	VI-15	0504	33-25	123-45	2325	33.26	1019	59.0	60.0	59.7	59.7	59.7	59.7	59.7	59.4	57.0	55.9	55.2	51.9						
127	VI-15	0833	33-10	123-33	2175	--------	1019	59.0	61.0	60.1	60.1	60.1	60.1	58.8	57.2	56.1	55.4	54.1	53.6						
128	VI-15	1205	32-54	123-23	2300	33.26	1018	60.0	61.5	60.6	60.4	60.4	60.4	60.1	58.6	57.0	55.4	51.7	53.8						

TABLE 3—Continued

Summary of Observations at Bathythermograph Stations Occupied During the Albacore Survey, May 23 to June 18, 1960

Serial No.	Date	Time GMT	Location N. lat.	Location W. long.	Depth (fm)	Salinity ‰ (10M)	Barometer (mb)*	Temperature (°F.) Air Wet	Air Dry	Water Bucket (surface)	Bathythermograph (depth in feet) 0	30	50	100	150	200	250	300	330	400	490	500	600	655	700
129	VI-15	1431	32-11	123-12	2210	--------	1019	61.5	62.0	61.0	60.6	60.6	60.6	60.6	59.4	57.4	55.8	54.3	52.7						
130	VI-15	1703	32-26	123-00	2200	33.33	1019	61.0	62.0	61.5	61.2	61.2	61.2	61.0	59.2	58.5	56.1	53.8	52.5						
131	VI-15	1927	32-12	122-48	2325	--------	1019	62.0	63.0	61.5	61.5	61.5	61.5	61.5	60.3	58.6	56.5	57.2	55.8						
132	VI-15	2204	31-55	122-36	2240	33.25	1018	64.0	67.0	61.9	61.7	61.7	61.7	61.2	59.7	58.3	58.3	57.9	57.7						
133	VI-16	0034	31-39	122-23	1930	--------	1017	63.0	66.0	61.9	61.5	61.5	61.5	61.3	60.3	58.8	57.0	56.3	51.7						
134	VI-16	0402	31-16	122-06	2070	33.28	------	61.0	62.0	61.5	61.5	61.5	61.5	61.5	60.1	58.8	58.1	58.1	56.7						
135	VI-16	0632	31-00	121-54	2175	--------	1018	60.5	60.8	61.3	61.2	61.2	61.2	60.1	59.5	59.2	58.1	58.1	57.6						
136	VI-16	0801	30-50	121-48	2200	33.35	1018	60.0	61.0	62.2	62.1	62.1	62.1	61.2	59.9	59.0	57.7	57.4	56.5						
137	VI-16	1204	30-24	121-27	2150	33.40	1016	60.5	61.0	61.5	61.5	61.5	61.5	61.3	59.9	59.2	58.5	58.1	57.2						
138	VI-16	1431	30-09	121-16	2080	--------	1019	60.5	61.5	61.5	61.5	61.5	61.5	61.2	60.3	59.5	58.8	58.6	58.3						
139	VI-16	1633	29-55	121-05	1900	33.25	1019	61.5	62.5	62.1	62.1	61.9	61.9	61.7	61.3	59.9	59.2	58.5	58.5						
140	VI-16	1833	30-08	120-53	2120	--------	1019	62.0	64.0	61.0	61.0	59.7	59.7	59.2	58.1	57.0	56.3	56.1	55.4	51.7					
141	VI-16	2101	30-21	120-10	2000	33.44	1018	62.0	65.0	63.7	63.7	61.0	61.0	58.1	57.0	56.5	56.3	55.0	51.5						
142	VI-17	0002	30-39	120-27	2080	--------	1017	61.5	64.5	63.9	63.3	61.9	61.2	58.5	57.4	56.5	55.0	52.5	51.8						
143	VI-17	0337	30-57	120-13	2020	33.53	1017	59.5	61.0	62.2	62.1	60.8	60.4	60.1	57.0	56.1	52.9	52.3	51.3						
144	VI-17	0802	31-15	119-59	2050	--------	1018	58.5	59.5	60.3	60.8	59.9	59.7	57.7	57.2	55.9	55.2	54.5	54.0						
145	VI-17	1205	31-31	119-32	2050	33.43	1016	59.0	59.5	60.8	60.8	60.6	60.3	57.7	57.0	55.6	54.7	54.1	51.8						
146	VI-17	1503	31-47	119-32	1750	--------	1018	58.0	59.0	59.7	60.1	60.1	60.1	56.3	51.3	52.7	51.8	50.5	50.0						
147	VI-17	1804	32-04	119-18	830	33.71	1018	59.0	60.0	61.0	61.3	61.2	61.0	53.6	52.9	52.0	49.5	48.7	48.6						
148	VI-17	2114	32-21	119-01	410	--------	1016	61.5	63.2	61.3	62.4	61.3	59.9	58.3	55.2	52.0	49.8	49.1	48.9						
149	VI-18	0003	32-35	118-46	115	33.63	1017	60.0	61.5	62.8	63.3	62.2	61.9	57.0	55.0	52.9	50.9	49.8	49.5						
150	VI-18	0250	32-46	118-25	48	--------	1016	61.0	62.0	62.2	62.8	62.8	62.8	62.1	55.8	52.7									

* Located 25 feet above sea level.

compiled from California Cooperative Oceanic Fisheries Investigations (CCOFI) data, gathered within the California Current in the area of this cruise, show that temperatures have consistently run from 60 to 61 degrees F. and salinities from 33.20 to 33.30 parts per thousand. This suggests, at least through the period of the scouting cruise, that the albacore favored conditions associated with the California Current. Since the current is generally oriented from northwest to southeast parallel to the California coast south of San Francisco, the spring albacore migration may have been similarly oriented in 1960.

The lack of fishing response along the westernmost leg of the cruise (upper righthand limits of the temperature-salinity range in Figure 5) further indicates that the fish tended to migrate well within the confines of this water mass. This explanation is not, however, entirely consistent with the intimation by Yamanaka (1956), that albacore concentrations are linked with current boundaries. Trolling failed to yield a single fish in the transitional water at the western limit of the cruise area. Perhaps the boundary, as such, has become so mixed that the natural advantages of this type of region elsewhere are nonexistent off the coast of California.

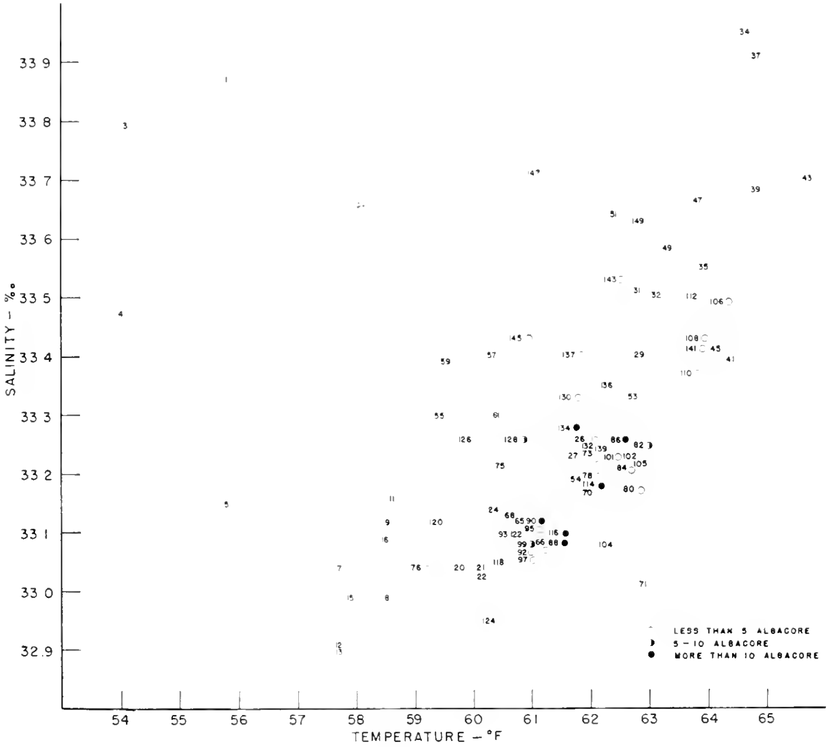

FIGURE 5. A temperature-salinity (T-S) diagram of the surface waters covered by the 1960 *N. B. Scofield* albacore survey. Arabic numbers indicate station numbers and are plotted to show the relationship between the two variables. Small circles indicate the relative position of albacore catches.

TABLE 4

Night-Light Observations Made During the Albacore Survey, May 23 to June 18, 1960

Date	Position		Summary of observations
	N. lat.	W. long.	
May 27	33° 29′	127° 48′	Approximately: 12 *Cololabis saira* (5-8 cm); 12 *Myctophum californiense* (2-8 cm); 6 *Trachurus symmetricus* (40 cm)
28	31° 37′	128° 12′	A few *Cololabis saira* intermittently under the light
June 1	35° 21′	133° 20′	Only 1 or 2 *Cololabis saira* persisted under the light; 1 small myctophid and a large squid observed but not collected
3	37° 33′	133° 31′	A small ball of *Cololabis saira* persisted; colonial tunicates were abundant; 1 large squid observed
4	37° 55′	132° 06′	About 25 *Cololabis saira* persisted; several *Trachurus symmetricus*, colonial tunicates and 1 shark observed; 1 *Myctophum affine* (35 mm) and 2 *Tarletonbeania crenularis* (23-24 mm) were collected
6	37° 05′	130° 38′	Only 1 small *Cololabis saira* observed
7	35° 23′	130° 36′	A single large *Trachurus symmetricus* observed
9	36° 40′	128° 08′	About 6 *Cololabis saira* persisted
10	34° 57′	127° 32′	Only 1 or 2 *Cololabis saira* observed

TABLE 5

Unusual Organisms Collected From Albacore Stomachs During the Albacore Survey, May 23 to June 18, 1960

Date	Location		Species
	N. lat.	W. long.	
June 7	35° 33′	130° 36′	*Lophotus* sp. (1) *Anotopterus pharao* (1)
8	35° 30′	129° 52′	*Anotopterus pharao* (1)
12	31° 48′	126° 55′	*Notolepis* (2) *Tetragonurus* sp. (1) *Vinciguerria nimbaria* (1)
15	31° 55′	122° 35′	*Icichthys lockingtoni* (1)

SUMMARY

1. The 1960 preseason survey of the northeast Pacific albacore fishing grounds was conducted from May 23 to June 18, 1960, by the Department of Fish and Game vessel *N. B. Scofield* (Cruise 60S3).

2. The oceanographic program was planned and co-ordinated jointly by the California Department of Fish and Game and the U.S. Bureau of Commercial Fisheries, Biological Laboratory, San Diego.

3. The area surveyed was bounded roughly by lat. 30° to 38° N., and long. 134° W. and the Channel Islands off California.

4. Surface trolling was used to locate albacore schools.

5. Except for one bigeye tuna the catch was entirely albacore. Of 153 landed 74 were tagged and released. At least an additional 50 albacore and five bigeye tuna were hooked but not landed.

6. Sea temperatures were measured from the surface to as deep as 700 feet and water samples for salinity determination were collected from approximately 33 feet (10 meters). Surface temperatures within the areas of catch ranged from 59.5 to 64.2 degrees F. and salinities from 32.95 to 33.53 parts per thousand.

7. The relationship between sea temperature and salinity indicated catches were restricted to the water mass of the California Current system.

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REFERENCES

Bary, B. M.

1959. Species of zooplankton as a means of identifying different surface waters and demonstrating their movements and mixing. Pac. Sci., vol. 13, no. 1, pp. 14-54.

Clemens, Harold B.

1955. Catch localities for the Pacific albacore *(Thunnus germo)* landed in California, 1951 through 1953. Calif. Dept. Fish and Game, Fish Bull. 100, 28 pp.

1961. Migration, age and growth of the Pacific albacore *(Thunnus germo)*. Calif. Dept. Fish and Game, Fish Bull. 115, 128 pp.

Craig, William L., and Joseph J. Graham

1961. Report on a co-operative, preseason survey of the fishing grounds for albacore *(Thunnus germo)* in the eastern north Pacific, 1959. Calif. Fish and Game, vol. 47, no. 1, pp. 73-85.

Dollfus, Robert Ph.

1940. Helminthes du Germon. *In* La Faune Pélagique de L'Atlantique au large du Golfe de Gascogne, recueillie dans des estomacs de germons. Pt. 3, Invértebrés (cephalopodes exclus). Parasites du germon, by René Legendre, pp. 276-288. L'Institut Océan., Ann., n.s., vol. 20, no. 4, pp. 127-310.

Graham, Joseph J., and William L. Craig
1961. Oceanographic observations made during a cooperative survey of albacore (*Thunnus germo*) off the North American west coast in 1959. U.S. Fish and Wildl. Serv., Spec. Sci. Rept.: Fish., no. 386, 31 pp.

Miller, Arthur R.
1950. A study of mixing processes over the edge of the continental shelf. Jour. Mar. Res., vol. 9, no. 2, pp. 145-160.

Nakamura, H.
1954. Present status of tuna research in Japan. III. Outline of surveys on land. From average year's fishing conditions of tuna long-line fishery, 1958 ed., Fish. Agency, Japan, pp. 14-15. (English summary.)

Otsu, Tamio
1960. Albacore migration and growth in the North Pacific Ocean as estimated from tag recoveries. Pac. Sci., vol. 14, no. 3, pp. 257-266.

Suda, A.
1956. Present status of tuna research in Japan. III. Outline of surveys on land. From average year's fishing conditions of tuna long-line fishery, 1958 ed., Fish. Agency, Japan, 17 pp. (English summary.)

Sverdrup, H. U., Martin W. Johnson and Richard H. Fleming
1954. The Oceans. New York, Prentice-Hall, Inc., p. 716.

Yamanaka, S. H.
1956. Present status of tuna research in Japan. III. Outline of surveys on land. From average year's fishing conditions of tuna long-line fishery, 1958 ed., Fish. Agency, Japan, 16 pp. (English summary.)

THE ELECTROPHORETIC CHARACTERISTICS OF ALBACORE, BLUEFIN TUNA, AND KELP BASS EYE LENS PROTEINS[1]

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INTRODUCTION

This is the first known report of electrophoretic studies on the fish eye lens proteins. The lenses of higher animals have been studied and reported upon, but the literature is not extensive. Wood, Massi, and Solomon (1954), working with the soluble rabbit lens proteins, showed that at least five different components could be distinguished by electrophoresis; further studies suggested they were all globulins. Halbert, *et al.* (1957) also found five soluble antigens in rabbit lenses. The immunologic studies of Rao, *et al.* (1955) suggested beef lenses contained at least six different soluble antigens. Wood and Burgess (1961) carried out continuous flow electrophoresis on the soluble lens proteins of cows, hogs, sheep, dogs, cats, and chickens. For each species the lens proteins separated into at least five components and gave characteristic soluble protein concentration curves. No intraspecific differences between curves were described in any of the papers.

In the present study, I investigated the electrophoretic characteristics of the soluble lens proteins from three marine fishes and evaluated electrophoresis of fish lenses for identifying separate, noninterbreeding populations of the same species.

MATERIALS AND METHODS

The lenses of Pacific albacore *(Thunnus germo)*, California bluefin tuna *(T. saliens)*, and kelp bass *(Paralabrax clathratus)* were removed from one eye of each fish and freed of aqueous and vitreous humor, pieces of retina, etc.; then placed in dry bottles and stored at 5-6° C. until ready for extraction.

An extract of soluble lens proteins was prepared by mechanically mincing the hard core of the lens in 0.9 percent saline solution and storing at 5-6° C. for at least 24 hours. Electrophoresis of the protein extract was carried out as described for serum proteins in Spinco's *Technical Bulletin* (1961). The separation was performed in a Spinco Model R Electrophoresis Apparatus in Veronal buffer, having a pH of 8.6 and an ionic strength of 0.75. The current used was 2.5 ma per cell and was allowed to flow for 24 hours.

[1] Submitted for publication March 1962.

When separation was completed, the paper strips containing the protein concentrations were dried in an oven at 120 to 130° C. and then stained by immersion in methanol (six minutes), bromphenol blue dye (30 minutes), and finally in three consecutive rinses of 5 percent glacial acetic acid (six minutes each). The strips were then dried in an oven at 120 to 130° C. and placed for 15 minutes in an atmosphere of ammonium hydroxide vapor.

The concentrations of the components on the paper strip were evaluated by scanning in the Spinco Model RB Analytrol.

EXPERIMENTAL RESULTS

Electrophoresis of the soluble proteins from the lenses of 4 albacore, 4 bluefin tuna, and 16 kelp bass demonstrated a constant number of components characterizing each species. There were, however, slight variations in the patterns of the protein concentration curves between individuals for all three species, especially albacore where the variations could be grouped to form two curves (Figure 1).

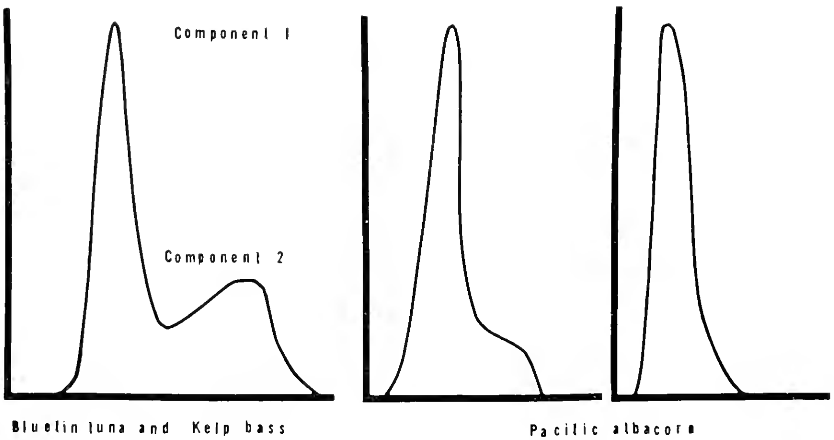

FIGURE 1. Generalized protein concentration curves from electrophoresis of soluble lens proteins of three fish species.

DISCUSSION

Electrophoresis indicated one or two components were in the fish lenses tested. Bluefin tuna and kelp bass each demonstrated two components with several slight pattern variations and albacore had one component with two pattern variations. Although the kelp bass and bluefin tuna electrophoretic curves were too similar to allow distinguishing between the two species, individual differences within either species could still be identified by their characteristic curves.

The pattern variations noted within the three species were considered minor and probably due to small differences in quantity of eye lens extract applied to the paper strips or other unknown factors rather than to real genetic differences between the individuals of a species. Significant intraspecific variation (*e.g.* the presence of extra components) could reasonably be attributed to genetic differences, and may yet be discovered when larger samples of lenses are electrophoresed. In that event, it should be possible to identify separate, noninterbreeding populations of fish by the differential frequencies of the rare lens components.

SUMMARY AND CONCLUSIONS

1. Electrophoresis of California bluefin tuna and kelp bass soluble lens proteins separated them into two components having characteristic curves which appeared to be identical for both species. A single component was demonstrated from albacore lenses.

2. No intraspecific pattern variations were considered important enough to reflect genetic differences between individuals of the same species, but they may be discovered when larger samples are tested. Such a discovery would provide a practical method of identifying separate, noninterbreeding populations of fish.

REFERENCES

Audubert, R., and S. de Mende
1960. The principles of electrophoresis. New York, Macmillan Co.

Halbert, S. P., D. Locatcher-Khorazo, L. Swick, R. Witmer, B. Seegal, and P. Fitzgerald
1957. Homologous immunological, studies of ocular lens. I. *In vitro* observations. Jour. Exper. Med., vol. 105, pp. 439-452.

Rao, S. S., M. E. Kulkamie, S. N. Cooper, and M. R. Radhakrishnan
1955. Analysis of proteins of bovine lens, vitreous, and aqueous by electrophoresis and by Oudins gel diffusion technique. Brit. Jour. Ophthalmology, vol. 39, pp. 163-169.

Spinco Division of Beckman Instruments Inc.
1961. A method for serum proteins using bromphenol blue dye in alcoholic solution. Tech. Bull. no. 6095 A, pp. 6-7.

Wood, D. C., and L. Burgess
1961. An electrophoretic study of soluble lens proteins from different species. Amer. Jour. Ophthalmology, vol. 51, pp. 305-313.

Wood, D. C., L. Massi, and E. L. Solomon
1954. The isolation, crystallization, and properties of proteins from rabbit eye lens. Jour. Biol. Chem., vol. 234, no. 2, pp. 329-334.

BITTERBRUSH STOCKING AND MINIMUM SPACING WITH CRESTED WHEATGRASS[1]

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INTRODUCTION

Research has developed successful methods for artificial seeding of bitterbrush *(Purshia tridentata)*. Now the question arises as to how many plants per acre constitutes proper stocking with bitterbrush. Up to a point, the more plants, the more herbage produced. But there is a limit. Soil moisture is scarce on most of the semidesert deer winter ranges where browse seeding has application. This scarcity limits the amount of plant life that land can sustain. Where seeded bitterbrush is so dense that the plants compete critically with each other for the available moisture, herbage production will go down, and some plants may die. Other species growing with bitterbrush also enter into this struggle for available moisture.

Bitterbrush plants from a 1953 seeding in Modoc County began dying in 1959, apparently from lack of moisture due to competition among themselves. Because this seeding was experimental, had a known history, and was never grazed, it provided a good chance to learn how many plants the site could support. An adjoining stand of crested wheatgrass, planted at the same time as the bitterbrush, provided a chance to study the maximum distance from which perennial grass competition affects bitterbrush growth and survival.

THE STUDY

The study plot (Figure 1), 25 x 320 feet, supported 588 seven-year-old bitterbrush plants in 1959. In terms of average stocking density this is 3,231 plants per acre. Distribution of the plants was uneven. A dense stand of crested wheatgrass, planted at the same time as the bitterbrush, bordered one side. Weed-free areas adjoined the other sides. Cheatgrass *(Bromus tectorum)* and other annual grasses and weeds composed the understudy on the experimental plot. Many bitterbrush plants growing within 2 or 3 feet of the crested wheatgrass were dead or in poor condition. Grazing had never been permitted and pathologists were unable to find any causative disease.

The study plot was located in a transition type of vegetation, between ponderosa pine and the sagebrush-juniper complex. Big sagebrush *(Artemisia tridentata)*, juniper *(Juniperus occidentalis)*, rabbitbrush *(Chrysothamnus* spp.), and bitterbrush made up the bulk of the

[1] Contribution from co-operative investigation between the Experiment Station and the California Department of Fish and Game. Work was done under Federal Aid in Wildlife Restoration Act, Pittman-Robertson Research Project W51R, entitled "Big Game Investigations." Submitted for publication October 1961.

FIGURE 1. General view of the experimental plot.

brush cover. The understory was composed of perennial grasses and annual and perennial forbs. A few scattered ponderosa pine *(Pinus ponderosa)* were present. Annual precipitation averaged between 12 and 14 inches, much of it as snow. The soil, a sandy loam of basalt origin, was classified in the Underwood soil series (Gardner, 1956). This was a good bitterbrush site and it probably could support as many browse plants as any deer winter range likely to be seeded. Maximum stocking for drier, more difficult sites is likely to be lower. A drought in 1959 may have caused mortality to show up earlier than it would have otherwise.

EXPERIMENTAL METHODS

Each of the 588 bitterbrush plants was located on a large-scale map of the plot. At the time of mapping we measured the total height and two diameters of each plant and classified its condition as follows:

Class	*Dead branches*
A	None
B	Scattered minor basal branches
C	0-20 percent
D	20-40 precent
E	40-60 percent
F	60-80 percent
G	80-99 percent
X	100 percent

From the map, 100 plants were randomly selected. Each plant was considered as a plot center and the following measurements made to characterize plant competition:

a. Number of plants in a 3-foot circle.
b. Number of plants in a 5-foot circle.
c. Number of plants in a 10-foot circle.

d. Crown cover in a 3-foot circle.
e. Crown cover in a 5-foot circle.
f. Crown cover in a 10-foot circle.
g. Average distance to the nearest 2, 4, 6, 8, and 10 plants.
h. Distance to crested wheatgrass.
i. Distance to plowed ground.

These data were subjected to regression analyses to determine which variables were significant.[2]

COMPETITION

Plant condition, or percent of dead branches, gave the most sensitive response to competition. The measure of competition between bitterbrush plants most closely related to plant condition and size proved to be the average distance to the nearest 10 plants. But even this "best" measure of competition explains only 25 to 33 percent of the variation in plant condition and size. It is apparent that many other influencing factors were not included in the study.

Other factors that are important, include soil variation, insect damage, and variation in the amount of understory vegetation. We know that understory vegetation did vary because one-fourth of the plot had been weeded the first four years to determine the effect of annual vegetation on young seedlings. This known difference of minor importance was not analyzed in this study. Also, because bitterbrush distribution was not regular, our measures of competition only partially reflect competition values. Many other factors could have been at work.

Nevertheless, the effects of competition are material and significant.

Competition, as reflected by plant condition and size, became negligible in this study when the average distance to the nearest 10 plants

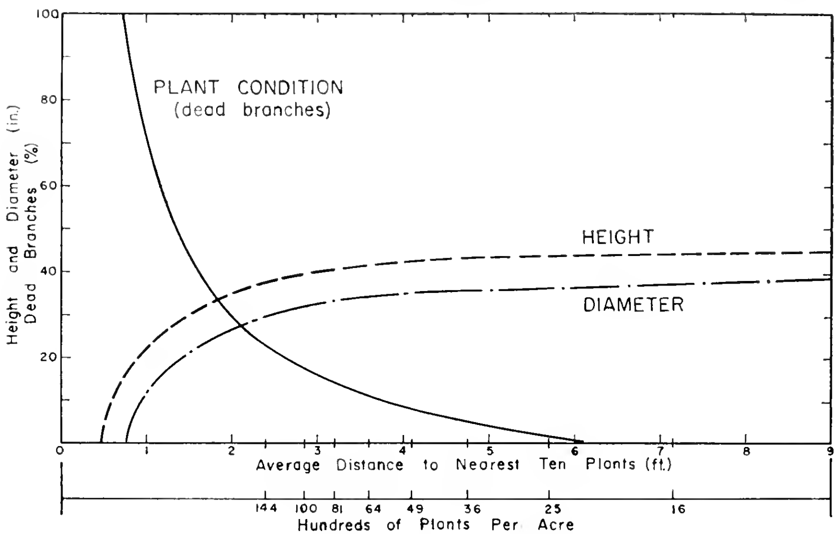

FIGURE 2. The effect of competition between bitterbrush plants (as measured by the average distance of the nearest 10 plants) on the condition and size of bitterbrush plants.

[2] The analytical methods and regression equations may be obtained from the director, Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley 1, California, as "Analysis Supplement—Bitterbrush Stocking."

was more than six feet (Figure 2). This spacing corresponds to about 2,200 plants per acre, assuming a regular distribution in which plants are located at the corners of regular squares.

Competitive effects increased sharply when the average distance to the nearest 10 plants was less than three feet. This spacing means stocking at 10,000 plants per acre. Almost the same story was told by all three dependent variables: condition, height, and diameter.

Competition effects on plant condition and growth on the area probably will become more apparent as time goes by. In 1959, stocking averaged 3,231 plants per acre. As many as 8,000 plants per acre have resulted from some seedings on similar sites (Hubbard, *et al.*, 1959). Competition is likely to become evident much earlier in the life of plants with such high stocking.

BITTERBRUSH AND CRESTED WHEATGRASS SPACING

Many land managers contend that both brush and grass are needed on a particular range. At certain times of the year grass is valuable deer feed (Leach, 1956), and it is the mainstay of cattle. The question is, what spacing between the brush and grass is best?

We know that bitterbrush plants stand only a slim chance of survival if the seed is mixed and planted with grass seed. The grass competes directly with the young bitterbrush plants (Hubbard, 1956). The course to take is planting bitterbrush far enough away from the crested wheatgrass to avoid competition between the two species. How far away? This study showed that plants within two feet of crested wheatgrass had more dead branches than more distant ones (Figure 3). Height and diameter were not appreciably affected unless the plants were within about a foot of the grass.

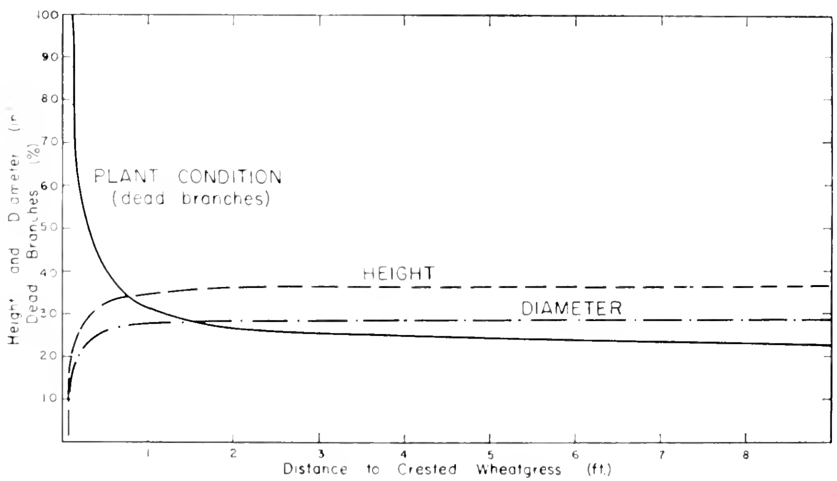

FIGURE 3. The effect of proximity to crested wheatgrass on the condition and size of bitterbrush plants.

This means that we should plant bitterbrush and crested wheatgrass at least two feet apart. This rules out planting grass and bitterbrush from alternate drill rows. Probably the best approach, where both grass and bitterbrush are desired, is to plant a drill width of bitterbrush, skip two or three feet and plant a drill width of grass. This also has the advantages of creating more "edge" and making the brush stand less susceptible to wildfire.

The other independent variables measured in this study were the distances to a plowed edge and to a weeded edge. This measurement has little practical meaning since it is not economically feasible to cultivate seeded bitterbrush. But the weeded edge did influence the growth of the bitterbrush in this stand so we assessed its importance. Plants within two to three feet of the weeded strip had fewer dead branches and were both taller and wider (Figure 4) than others. The reason, of course, was that roots of these plants reached the plowed ground where there was an abundance of ground water and no competitive plants. Let us re-emphasize that bitterbrush grew well with a minimum of mortality in competition with annual weeds where the average distance to the nearest 10 plants was more than six feet.

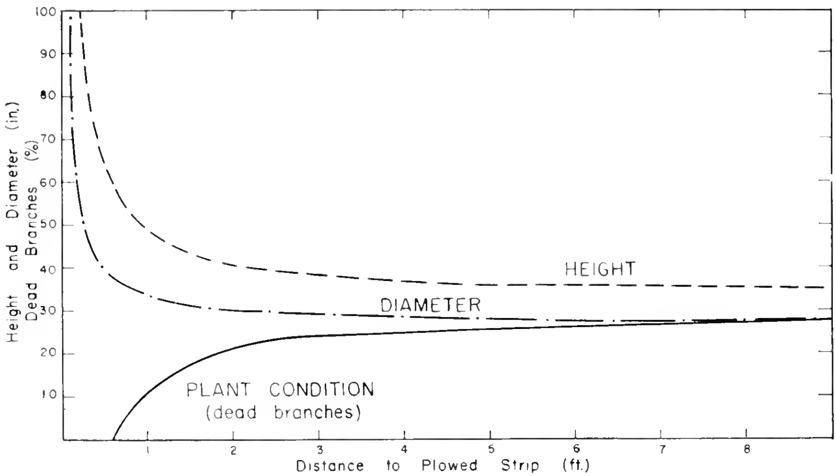

FIGURE 4. The effect of proximity to plowed ground kept weed free during the life of the bitterbrush stand.

PRACTICAL IMPLICATIONS

On a good site, maximum bitterbrush stocking should be less than 2,200 plants per acre. Above this level, plants compete critically for soil moisture and space. But competition may not take effect while the plants are small and need little moisture; in the study plot, bitterbrush plants approached mature size before losses from lack of moisture occurred. The time needed for competition to develop is the main reason that plant condition proved to be a more sensitive measure of competition effects than plant size.

Competition between seeded bitterbrush plants probably will not destroy a stand. The stronger plants achieve dominance and the weaker die until, eventually, the stocking is in balance with the site. But all this takes time—important time. The longer it takes, the more chance undesirable plants have to invade and enter the fight for critical moisture. Also, it means a longer time before plants become large enough to produce useful amounts of herbage. Every year of delay means a grazing loss. Furthermore, even the potentially dominant plants may be so reduced in vigor that they are easily damaged by grazing, insects, or disease.

Between overstocking and understocking with bitterbrush, slight understocking is preferable. Then the plants will be vigorous, will mature rapidly, and will produce herbage earlier. The crux of the problem is to set the minimum below which a seeding is a failure—the point where the value of herbage produced is not enough to offset the cost of establishment. This isn't an easy point to determine because (1) bitterbrush seedings are mainly for game use, and dollar values are not available for this type of grazing; (2) it is difficult to determine herbage production.

Natural bitterbrush stocking is considerably below the 2,200 plants per acre we recommend. In a study of natural bitterbrush stands in northern California, E. C. Nord (personal communication) found 778 plants per acre on the average and a maximum stocking of 1,420 plants. Even this maximum may be too few for artificially seeded areas.

REFERENCES

Gardner, Robert A.
1956. Reconnaissance soil investigation game-browse restoration experimental areas and soil-bitterbrush relationships. Soil-Vegetation Survey Project. U. S. Forest Serv. Calif. Forest and Range Expt. Sta., Berkeley, Calif., 22 pp. (Typed report).

Hubbard, Richard L.
1956. The effects of plant competition on the growth and survival of bitterbrush seedlings. Jour. Range Mgt., vol. 10, pp. 135-137.

Hubbard, R. L., Nord, E. C., and Brown, L. L.
1959. Bitterbrush reseeding—a tool for the game range manager. U. S. Forest Serv., Pacific Southwest Forest and Range Expt. Sta. Misc. Paper 39, 14 pp., illus.

Leach, Howard R.
1956. Food habits of the Great Basin deer herds of California. Calif. Fish and Game, vol. 42, no. 4; pp. 243-308.

NOTE

AN UNUSUAL CATCH OF A LARGE NUMBER OF PACIFIC ROUND HERRING OFF LONG BEACH, CALIFORNIA

On November 9, 1961 the purse seiner *Frankie Boy* from San Pedro caught approximately two tons of Pacific round herring (*Etrumeus accuminatus* Gilbert) in a mixed school comprising eight tons of Pacific jack mackerel and Pacific mackerel. The catch was made on the Horseshoe Kelp off Long Beach, California at approximately Lat. 33° 39′ N. Long. 118° 10′ W. I can find only four previous records for round herring from California waters and these were, for the most part, single fish.

A figure of a Pacific round herring appears in Roedel (1953) who gives their range as Monterey Bay to Panama and states "recorded but once from north of the Los Angeles area."

Phillips (1951) reported on a 253 mm long round herring taken 65 miles south of Monterey Bay on December 16, 1950.

Frederick H. Berry of the U. S. Fish and Wildlife Service, Scripps Institution of Oceanography states, by personal communication, that there are three round herring from California in the collection at Scripps Institution of Oceanography, La Jolla. Two were taken off San Diego in mid-June 1947, and measured 258 and 260 mm standard length, the third was taken outside Santa Catalina Island, on August 2, 1953, by purse seine in a load of "mackerel." It measured 267 mm s.l.

A fourth round herring from California was taken in Los Angeles harbor in September 1958 (Radovich, 1961).

Sexes, total lengths (in millimeters) and weights (in grams) of six fish taken at random from the two-ton load delivered by the *Frankie Boy* are:

Sex	Length	Weight
F.	290	223
F.	290	209
M.	271	176
F.	268	170
M.	266	159
M.	247	129

Mr. Walter Winter, Coast Fisheries Division of the Quaker Oats Company of Wilmington called me about this unusual catch.

REFERENCES

Phillips, J. B.
1951. Round herring off Central California. Calif. Fish and Game, vol. 37, no. 4, p. 512.

Radovich, John
1961. Relationship of some marine organisms of the northeast Pacific to water temperatures, particularly during 1957 through 1959. Calif. Dept. Fish and Game, Fish Bull. 112, 62 pp.

Roedel, Phil M.
1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. 91, 184 pp.

—John G. Carlisle, Jr., Marine Resources Operations, California Department of Fish and Game, November, 1961.

A RANGE EXTENSION FOR THE MEXICAN SCAD TO MONTEREY BAY, CALIFORNIA

On July 17, 1961, Chris Arcoleo, of Chris' Fishing Trips, noticed two fish that he thought were the *opélu* with which he had been familiar in the Marshall and Hawaiian Islands. Since, to his knowledge, the species had not previously been known from California, he secured one of them and presented it to the Hopkins Marine Station. It proved not to be the Hawaiian *Decapterus pinnulatus* (Eydoux and Souleyet) but the closely related Mexican scad, *D. hypodus* Gill, previously reported only as far north as Santa Catalina Island and Los Angeles Harbor (Radovich, 1961). While it was not possible to determine the exact location of capture, the specimen was taken July 15, 1961 in the immediate Monterey area in a perch gillnet, indicating an inshore position in comparatively shallow water.

In May 1937, Mr. J. M. Rainey, collector for the Steinhart Aquarium, California Academy of Sciences, captured a small fish in Monterey Bay and kept it in the aquarium until February 1938 when it died. Although it was somewhat abnormal in appearance, Clark and Halstead, 1938, reported it as *D. scombrinus* (Valenciennes) failing, however, to include any meristic data. Its identity remains uncertain (Roedel and Fitch, 1952), but judging from previously known range limits it was probably an aberrant *D. hypodus*. In 1958, 1959 and 1960 fair numbers of Mexican scad were taken north of their previously known range limit of San Clemente Island as reported by Roedel and Fitch; however the Monterey Bay specimens were approximately 300 miles north of the Los Angeles area, and this is the first time this species has definitely been reported north of Point Conception, a well known faunal limit.

The Monterey individual that was saved fits quite nicely within the meristic limits given for the species by Roedel and Fitch and I have no doubt that it is conspecific with their material so morphometric data will not be given here. Its color pattern before preservation was as follows: the body was dark greenish-blue dorsally, gradually lightening to a line about midway down the sides, and then blending into the silvery-white that covered the entire ventral surface except for the isthmus, which was dark gray; there was a small black shoulder spot on the posterior margin of each operculum slightly above the pectoral base; beginning at this spot a greenish-yellow stripe ran posteriorly to the caudal and the upper lobe of this fin was tinged with the same color. The pectoral fin was bluish with the axillary side of its base black. Spines and rays of the dorsals were greenish-blue with opaque connecting membranes. The ventrals and the anal fin were of the same silvery-white as the rest of the lower part of the body.

It has been placed in the Stanford University collection as specimen number 58626.

REFERENCES

Clark, H. Walton and Bruce Halstead
1938. *Decapterus scombrinus* (Valenciennes) in Monterey Bay. Copeia, no. 4, p. 205.

Croker, Richard S.
1937. Occurrence of mackeral-scad in Southern California. Calif. Fish and Game, vol. 23, no. 4, pp. 331-333.

Gill, Theodore
1862. Catalogue of the fishes of Lower California, in the Smithsonian Institution, collected by Mr. J. Xantus. Part III. Proc. Acad. Nat. Sci. Phila., vol. 14, pp. 249-262.

Norman, J. R.
1935. The carangid fishes of the genus *Decapterus* Bleeker. Ann. Mag. Nat. Hist., 10 ser., vol. 16, no. 92, pp. 252-264.

Radovich, John
1961. Relationships of some marine organisms of the northwest Pacific to water temperatures particularly during 1957 through 1959. Calif. Dept. Fish and Game, Fish Bull. no. 112, 62 p.

Roedel, Phil M. and John E. Fitch
1952. The status of the carangid fishes *Trachurus* and *Decapterus* on the Pacific coast of Canada and the United States. Copeia, no. 1, pp. 4-6.

—*Herbert W. Frey, Hopkins Marine Station of Stanford University, Pacific Grove, California, December, 1961.*

REVIEW

Animal Behaviour

By J. L. Cloudsley-Thompson, The Macmillan Company, New York, 1961; xiii + 162 pp., illus. black and white photographs and 16 color plates, $4.50.

This book is a potpourri of isolated fragments drawn from the immense technical literature on animal behavior to illustrate various phases of the subject. The style is pleasant and readable, with photographs and many pen-and-ink drawings adding interest. General readers and beginning biology students should find it profitable.—*Alex Calhoun, California Department of Fish and Game.*

The Natural History of the Lewis and Clark Expedition

Edited by Raymond Darwin Burroughs; Michigan State University Press, East Lansing, 1961, 340 pp. $7.50.

This unusual book begins with a 50-page introduction summarizing the course of the Lewis and Clark expedition. A series of scholarly chapters follows. Each chapter covers a group of animals; and each consists of dated excerpts from Thwaites' *Original Journals of the Lewis and Clark Expedition,* arranged chronologically by species, and interspersed with Burroughs' comments and interpretations. For example, the chapters on mammals start with "Bears and Raccoons" and conclude with "Mountain Goats and Bighorn Sheep." There is a similar series on birds, and one each on "Fishes," "Reptiles and Amphibia" and "Quantity and Distribution of Game Killed." Inclusion of 190 "Indian Dogs" in a list of game killed by the expedition illustrates the diversity of the menu on this memorable trip.

This book will be a convenient source of material for mammalogists and ornithologists seeking detailed and complete records of the natural history of the expedition.—*Alex Calhoun, California Department of Fish and Game.*

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