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Management of The White Seabass (Cynoscion Nobilis) In California Waters

by
JAMES C. THOMAS
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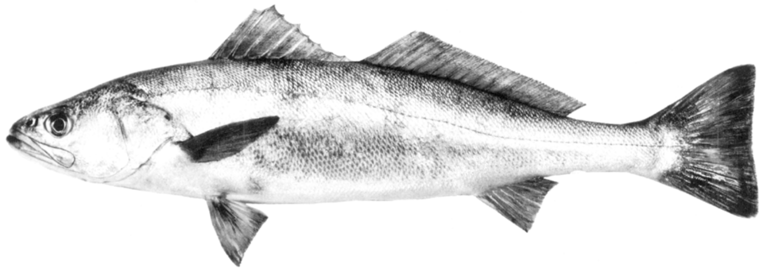

FRONTISPIECE: White seabass, *Cynoscion nobilis* (Ayres).

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ABSTRACT

Analyses of the white seabass commercial fishery and the regulations governing it revealed that management techniques in use since 1931 have probably affected the yield. Values from catch-per-unit-of-effort, weight-length, age-growth, and population parameters were utilized in an equation to determine the best possible equilibrium yield under existing environmental, biological, and socio-economic conditions. Results indicate that under present fishery practices (namely, fishing on only a portion of the resource) the yield in weight per recruit could be increased if actual harvesting were to begin at age 5 (28 inches TL). Current regulations have sufficient latitude to permit the fishery, on its own volition, to harvest younger fish, namely 5- to 8-year-olds rather than 8- to 11-year-olds.

ACKNOWLEDGMENTS

This study has been the result of a group effort by many people in Marine Resources Operations, California Department of Fish and Game. Leo Pinkas, project leader, gave counsel and support throughout the study. He also made many helpful suggestions for the preparation of the manuscript. Other project personnel aided in collecting the data. Norman J. Abramson and Harold W. Cogswell, Biometrical Analysis Section, gave me statistical advice. Edward C. Greenhood and David J. Mackett, Biostatistical Section, aided by discussing and supervising the compilation of special reports on white seabass catch and age. In addition, Edward C. Greenhood critically evaluated the manuscript, as did John E. Fitch and John L. Baxter. We ran several computer programs at the Western Data Processing Center, University of California at Los Angeles. James A. Rollins and Gareth W. Coffin, U. S. Bureau of Commercial Fisheries, Boothbay Harbor, Maine, drafted and photographed the figures. I sincerely thank everyone who assisted me and hope that this paper justifies their endeavors.

James C. Thomas
April, 1968

1. INTRODUCTION[1]

California sport and commercial fishermen esteem white seabass for its prestige and monetary value. A general history of declining and erratic catches, particularly by the California sportfishery in the 1950's, indicated that this resource was not stabilized despite regulations designed to achieve a consistent and relatively high yield (Table 1). A Federal Aid to Fish Restoration project was undertaken by the California Department of Fish and Game in 1958 (California Dingell-Johnson F16R Barracuda-White Seabass Management Study) to elucidate life history factors that could have a bearing on management decisions.

The species was first described by W. O. Ayres in 1860. Since then, taxonomic studies and life history observations have been reported by Jordan and Evermann (1898), Starks (1919), Skogsberg (1925, 1939), Clark (1930), Walford (1931, 1937), Croker (1932), Barnhart (1936), Clemens and Wilby (1946), Roedel (1948), Limbaugh (1955), and Fitch (1958). The sport and commercial fisheries in California were described by Skogsberg (1925, 1939), Whitehead (1930a), Croker (1937), Fitch (1949), and Pinkas (1960). Only Whitehead (1930b) used a mathematical approach in analyzing the white seabass population by deriving catch-per-unit-of-effort values for the commercial fishery.

1.1. Life History Summary

The white seabass of the eastern North Pacific Ocean ranges over the continental shelf from Juneau, Alaska, to Magdalena Bay, Baja California, and also occurs in the northern portion of the Gulf of California. There they may or may not represent an isolated population. Their principal area of abundance shifts with environmental conditions within the area bounded by Point Conception, California, and Ballenas Bay, Baja California. During years when sea temperatures are above average, white seabass are found in fair abundance as far north as San Francisco. The southern California sport and commercial fishing fleets catch white seabass within the principal areas of abundance.

The white seabass is the largest member of the family Sciaenidae in California. It may reach a weight of 83 pounds and a length of 4 feet, but individuals exceeding 60 pounds are rarely seen.

Precise spawning areas, fecundity, and embryonic development have not been delineated or determined for the species, but existing data indicate that spawning normally occurs from April through August in southern California waters. During these periods, mature fish appear to congregate near shore, over rocky habitat, and frequently near kelp beds. Some of the typical areas are Long Point, Palos Verdes Peninsula; Dana Point; and off the west end of Santa Catalina Island.

[1] This work was performed as part of Dingell-Johnson Project California F-16-R, "Barracuda-White Seabass Management Study," supported by Federal Aid to Fish Restoration Funds. The author is now with the Maine Department of Sea and Shore Fisheries, Boothbay Harbor, Maine.

TABLE 1

Sport and Commercial White Seabass Landings [1]

	Commercial						Sport[3] California Numbers	California Sport and Commercial Numbers	Grand Totals Sport and Commercial Numbers
	California Pounds	Mexico Pounds	Total Pounds	California Numbers[2]	Mexico Numbers[2]	Total Numbers[2]			
1936	564,956	242,823	807,779	22,598	9,713	32,311	11,046	33,644	43,357
1937	263,195	336,224	599,419	10,528	13,449	23,977	11,244	21,772	35,221
1938	269,987	356,660	626,647	10,800	14,266	25,666	14,093	24,893	39,159
1939	806,604	187,792	994,396	32,264	7,512	39,776	30,218	62,482	69,994
1940	809,231	104,080	913,311	32,369	4,163	36,532	15,979	48,348	52,511
1941	832,454	75,842	908,296	33,298	3,034	36,332	---	33,298	36,332
1942	356,526	197,200	553,726	14,261	7,888	22,149	---	14,261	22,149
1943	379,178	121,005	500,183	15,167	4,840	20,007	---	15,167	20,007
1944	254,050	139,918	393,968	10,162	5,597	15,759	---	10,162	15,759
1945	380,093	147,262	527,355	15,204	5,890	21,094	---	15,204	21,094
1946	471,649	144,272	615,921	18,866	5,771	24,637	---	18,866	24,637
1947	692,314	390,709	1,083,023	27,693	15,628	43,321	20,724	48,417	64,045
1948	789,691	324,599	1,114,290	31,588	12,984	44,572	24,078	55,666	68,650
1949	945,502	466,736	1,412,238	37,820	18,669	56,489	65,545	103,365	122,034
1950	1,123,429	409,301	1,532,730	44,937	16,372	61,309	54,718	99,655	116,027
1951	955,145	591,410	1,546,555	38,206	23,656	61,862	44,367	82,573	106,229
1952	692,232	456,474	1,148,706	27,689	18,259	45,948	41,043	68,732	86,991
1953	471,206	437,868	909,074	18,848	17,515	36,363	27,603	46,451	63,966
1954	434,354	772,198	1,206,552	17,374	30,888	48,262	41,588	58,962	89,850
1955	544,953	370,173	915,128	21,798	14,807	36,605	30,103	51,901	66,708
1956	413,956	676,754	1,090,710	16,558	27,070	43,628	19,755	36,313	63,383
1957	1,261,755	245,140	1,507,095	50,470	9,806	60,276	19,030	69,500	79,306
1958	2,750,652	99,111	2,849,763	110,026	3,964	113,990	34,039	144,065	148,029
1959	3,385,791	37,562	3,423,353	135,432	1,502	136,934	10,593	146,025	147,527
1960	1,086,895	149,303	1,236,198	43,476	5,972	49,448	15,697	59,173	65,145
1961	458,491	238,509	697,000	18,340	9,544	27,884	14,082	32,422	41,966
1962	208,867	365,541	574,408	8,355	14,622	22,977	14,564	22,919	37,541
1963	372,479	518,741	891,220	14,899	20,750	35,649	19,800	34,699	55,449
1964	550,817	841,061	1,391,878	22,033	33,642	55,675	14,901	36,934	70,576

[1] The commercial catch figures do not represent actual poundages of fish caught because a considerable, variable, and undesignated portion of the catch is landed eviscerated, heads-on.
[2] Computed value, conversion factor 25 pounds per fish.
[3] No records available during World War II.

TABLE 1
Sport and Commercial White Seabass Landings

Clark (1930), in a preliminary study, determined that males start maturing at 20 inches (508 mm) TL while females begin maturing at 24 inches (610 mm) TL. In her opinion, females begin maturing a year later than the males.

Cursory examination of white seabass stomach contents revealed that squid (Loligo opalescens) , sardines (Sardinops caeruleus) , and anchovies (Engraulis mordax) are most commonly eaten. Pelagic red crabs (Pleuroncodes planipes) are also favored when available.

Juvenile white seabass have been captured in Newport Bay and Long Beach-Los Angeles harbors. Intermediate sized fish probably inhabit kelp beds or sandy areas along the open coast. Large fish are generally captured near rocky headlands or offshore islands, especially where there are kelp beds.

1.2. Sport Fishery 1936 Through 1964

Sportfishermen take white seabass chiefly in the area between Santa Barbara and the U. S.-Mexico border and around the offshore islands, particularly Santa Catalina and San Clemente. The sport catch is made with live bait or artificial lures on hook and line from a boat that is drifting or at anchor. Occasionally a night fishery develops when squid come close to shore to spawn. The technique involves using an intense light to attract the squid which in turn lure the seabass. Conventional rod and reel, as well as spinning gear, are currently the most popular forms of tackle. Divers using various types of commercial or homemade spear guns direct their efforts toward trophy sized animals.

Partyboat records date back to 1936 with a gap for the war years (1941–1946). Prior to World War II, the partyboat catch averaged about 18,000 fish per year with a high of 30,000 in 1939. Between 1947 and 1964 annual landings averaged 38,457 fish growing rapidly from 21,000 in 1947 to over 65,000 in 1949, then declining to an all-time low of 10,500 in 1959.

1.3. Commercial Fishery, 1951 Through 1964

During the period 1951 through 1964 most commercial fishing for white seabass in California occurred in coastal waters from Morro Bay to the Mexican border, but was centered in the San Pedro area including the offshore islands, particularly Santa Catalina and San Clemente. Although commercial operations occurred the year around, most of the catch was landed from April through September.

A survey of the commercial fishermen who had made the most consistent catches revealed that they used 30- to 40-foot boats and gill nets, usually of the set type, with 6.0- to 7.5-inch mesh sizes (stretched mesh, knot to knot), although the legal minimum mesh size was 3.5 inches.[1] Fishermen combined two or three individual nets to form a "gang." They used four to eight gangs per fishing trip, with each gang from 40 to 110 fathoms long and 4 to 4.5 fathoms deep. Generally, boats with a mechanical drum carried the longer pieces of gear (Figure 1) . The advent of the drum and nylon gill nets in the late

[1] The reasons for the voluntary increase in mesh size were difficult to determine. Some fish buyers indicated it was due to a consumer desire for larger fish, others said that larger fish were easier to prepare for the fresh fish markets. Several fishermen claimed that a better price resulted from the larger fish.

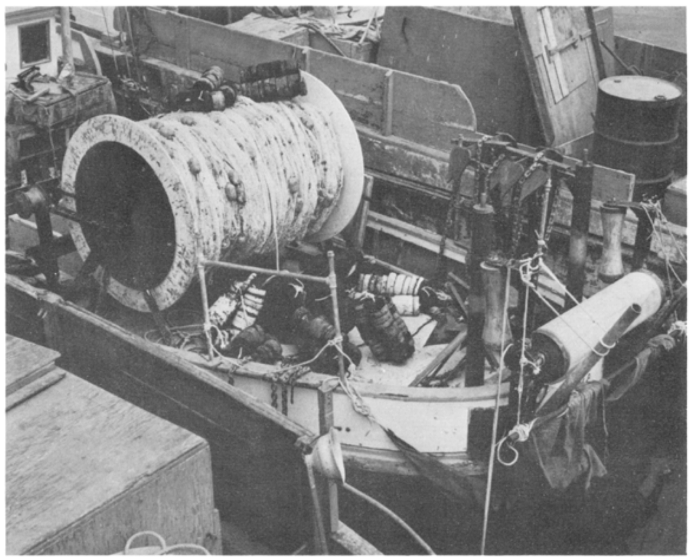

FIGURE 1 Gill-net boat with a mechanical drum. Commercialmen attach cork floats and anchors as they set the net. The rollers on the stern keep the net moving freely. *Photograph by Jack W. Schott.*

FIGURE 1 Gill-net boat with a mechanical drum. Commercialmen attach cork floats and anchors as they set the net. The rollers on the stern keep the net moving freely. Photograph by Jack W. Schott.

1940's enabled fishermen to set greater quantities of gear than at the time of the analysis of Whitehead (1930b).

1.4. Commercial Regulations and the Annual Catch

To determine if management practices affected the fishery, I juxtaposed the details of the regulations on a graph of the total catch from 1916 through 1961 (Figure 2) . This synoptic picture revealed some trends which could have resulted from these laws. White seabass regulations started in 1931 with the enactment of two laws: (i) the closing of all net fishing from May 1 to June 30, and (ii) a 28-inch minimum size limit. These and the closed-season regulations of 1933 and 1935 possibly led to the decreased total catches in the 1930's. It is also conceivable that this group of regulations led to the comparatively large catches from 1957 through 1960. Interestingly, most of these regulations are intended to stabilize the size of the white seabass population. I believe it is now important to determine if it is feasible to manage this

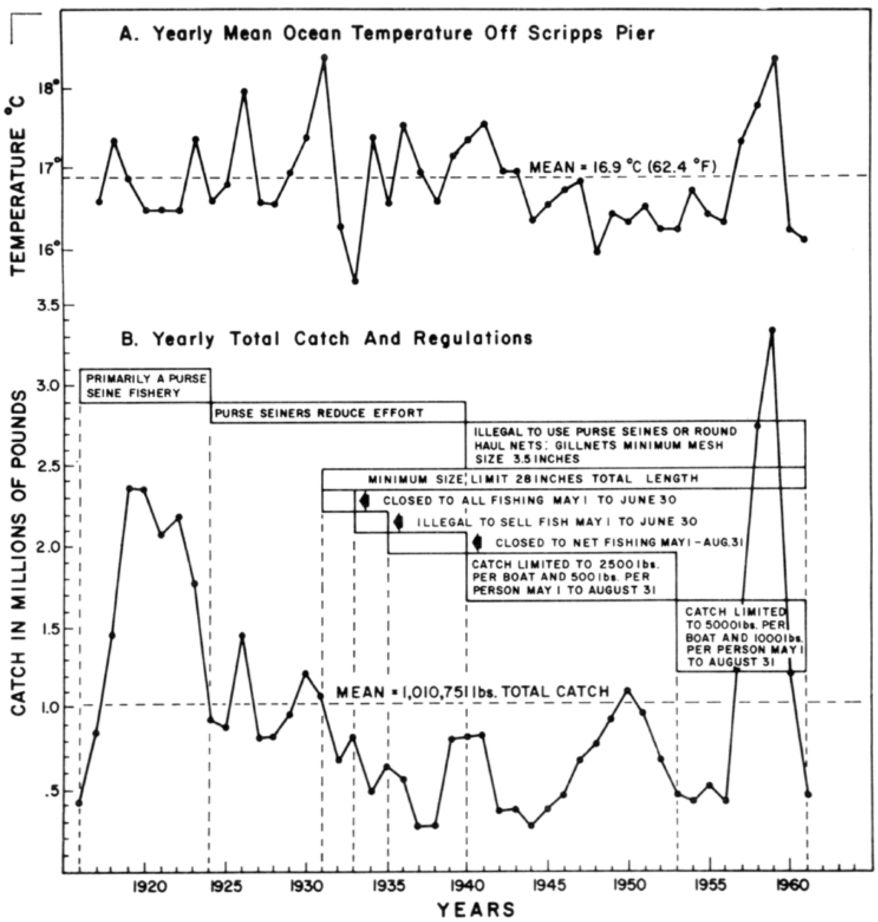

FIGURE 2 White seabass commercial landings from California waters with regulations and mean yearly ocean temperatures, 1916 through 1961.

FIGURE 2 White seabass commercial landings from California waters with regulations and mean yearly ocean temperatures, 1916 through 1961 fishery so that fishermen may harvest the best possible poundage from the white seabass population.

Also included in the white seabass catch-regulations graph (Figure 3) were the yearly mean ocean temperatures off Scripps Pier (Scripps Institution of Oceanography, 1958). These values and the total catch of white seabass showed some correlation. A good relationship occurred from 1956 through 1961 which certainly lends credence to the discussions on this subject by Skogsberg (1939) and Radovich (1961).

1.5. Goals of Investigation

The aims and goals of this investigation were: (i) to measure the relative abundance of the white seabass resource, (ii) to determine the rate of growth (age-weight-length relationships), (iii) to determine the age and size composition of the resource, (iv) to estimate survival and mortality rates, and (v) to evaluate current management practices as they apply to both the sport and commercial fisheries.

White seabass sportfishing practices and results could be described as a cyclic, widely fluctuating, sporadic, and fortuitous fishery. This situation is not amenable to a limited (time, money, and manpower) biological investigation. Despite the willing and whole-hearted cooperation of the sportfishing fraternity, we were forced to look elsewhere for a relatively large and consistent source of specimens and fishery data—namely the commercial fishery.

Project personnel obtained the necessary data to achieve the above objectives from four principal sources: (i) fish sampled at the commercial markets, (ii) catches aboard fishing vessels, (iii) specimens caught by project fishing efforts, and (iv) catch statistics collected by the California Department of Fish and Game.

Values from catch-per-unit-of-effort, weight-length, age-growth, and population parameters were used in a yield equation to determine an optimum harvestable size so that fishermen could crop the best possible weight from the existing white seabass population.

2. CATCH-PER-UNIT-OF-EFFORT

I used catch-per-unit-of-effort data to determine the relative abundance of white seabass in California waters. Many authors have established the value of such an analysis, provided a somewhat stable fishery exists. Clark (1939), Rounsefell and Everhardt (1953), and Beverton (1963) wrote good general sections on this subject. While analyzing catch and effort data, I also evaluated the effect of a regulation that limits the trip poundage from May 1 to August 31.

2.1. Source of Data

The staff of the California Department of Fish and Game (1952) described the commercial fish receipt ("pink ticket") system used to gather catch and effort data of California's marine fisheries. The Biostatistical Section, California Department of Fish and Game, abstracted and tabulated pertinent white seabass data, and project personnel made computations from these tabulations.

2.2. Explanation of Effort Terms

Under the pink ticket system, fish buyers report catches only. From these data we computed the catch-per-month and catch-per-trip. These terms then do not have the usual connotation, because there was no measure of unsuccessful effort. In order to rectify this situation, a separate log-book system or a revision of the pink ticket system was needed. Unfortunately, because of time limitations, neither improvement could be instituted, so we used the data at hand.

The term "trip" also needs clarification. No detailed information was available concerning how long a trip lasted. A survey of commercial fishermen revealed that a trip might be from 1 to 5 days, although more than 50% of these fishermen made 1-day trips. If different fish buyers at a port purchased white seabass from the same boat on the same day, then there were two or more pink tickets for this boat on the given day. When this occurred, poundages were totaled and tallied as one trip. This situation occurred because of the fluctuations of supply and demand in the fresh fish markets. Catch-per-trip was analyzed with caution and only in comparison with catch-per-month, which tended to eliminate the error from length of trips and number of deliveries in 1 day.

2.3. Selection of Representative Commercial Gill-net Boats

For this study, I selected individual gill-net boats that had fished over a number of years. In this way, there was some degree of uniformity in gear and fisherman experience. To meet these standards, gill-net boats that fished 4 or more months each year from 1951 through 1960 were selected. Only eight boats met these requirements, but these combined vessels landed 10% to 33% of the total white seabass catch within each year of the study. For comparison purposes, I compiled the annual total fleet catch-and-effort information.

In addition to the catch-and-effort analysis, the price-per-pound paid to fishermen was considered in order to determine its effect on the fishery.

2.4. Data Compilation Methods

2.4.1. Selected Boats, 1951 Through 1960

The catch-per-unit-of-effort data of each boat were compiled by: (i) tabulating the catch-per-month and then summing these values by year, (ii) dividing the boat's total catch by the number of months fished for each year to produce the average catch-per-month-per-year, (iii) tabulating the number of trips-per-month and then summing these values by year, and (iv) dividing the monthly catch by the number of trips for each month fished to obtain the average catch-per-trip-per-month, and then dividing the boat's total catch by its total trips for the year to produce the average catch-per-trip-per-year.

The catch-per-unit-of-effort data of the combined eight boats were compiled by: (i) calculating the average catch-per-month-per-year similar to the individual boat compilations, and (ii) calculating the average catch-per-trip-per-month, then by year, similar to the individual boat compilations.

The price-per-pound paid to the eight boats was compiled by: (i) dividing the monthly and yearly income by the pounds of fish caught to obtain the average price-per-pound by month and year for individual boats, and then dividing the yearly income of the combined eight boats by the annual landings to yield the average price-per-pound paid to the group.

2.4.2. Total Boats, 1951 Through 1960

Catch-per-unit-of-effort data for all boat landings was compiled by: (i) tabulating the total catch and number of boats for each year, (ii) dividing the total catch by the number of boats to obtain the average catch-per-boat, and (iii) dividing the total income by the total catch to yield the average price-per-pound for each year.

2.4.3. Boat Poundage Regulation, May 1 to August 31

These data were compiled from the peak catch of 1959 by: (i) counting the number of boat trips that exceeded a catch of 1,000 pounds during the 4-month period, and (ii) dividing this number by the total fleet and multiplying by 100 to yield a percentage for the same time period.

2.5. Discussion of Catch Areas of the Selected Eight Boats

Six of the selected eight boats fished in the 700 catch block series (Figure 3) during the 10-year period, and delivered their catches to the San Pedro fresh fish markets. The seventh fished in the 700 series for 8 consecutive years, and then moved northward to fish in the 600 series during 1959 and 1960. This boat delivered its catches to the Morro Bay fish markets for those 2 years. The remaining boat fished in the 800 series during the 10 years and delivered its catches to the San Diego fish markets. These eight boats should give a good cross-section of the white seabass catch in California waters.

2.6. Discussion of the Catch-Per-Unit-of-Effort Analysis

Catch-per-month and catch-per-trip values for each of the eight selected boats were similar, so I combined them to yield an average catch-per-month and catch-per-trip for this group for each year.

There was a fair relationship between the combined eight-boat average catch-per-month-per-year and the total catch during most years of the study. However, a marked anomaly occurred in 1959. In this year, commercial

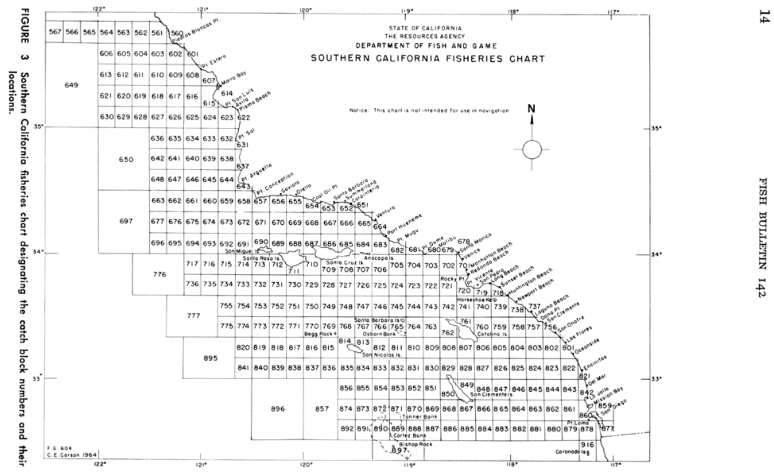

FIGURE 3 Southern California fisheries chart designating the catch block numbers and their locations

fishermen caught the largest tonnage of white seabass ever reported from California waters, yet the eight-boat catch-per-unit-of-effort values declined for that year, after reaching their highest peak in 1958 (Figure 4) .

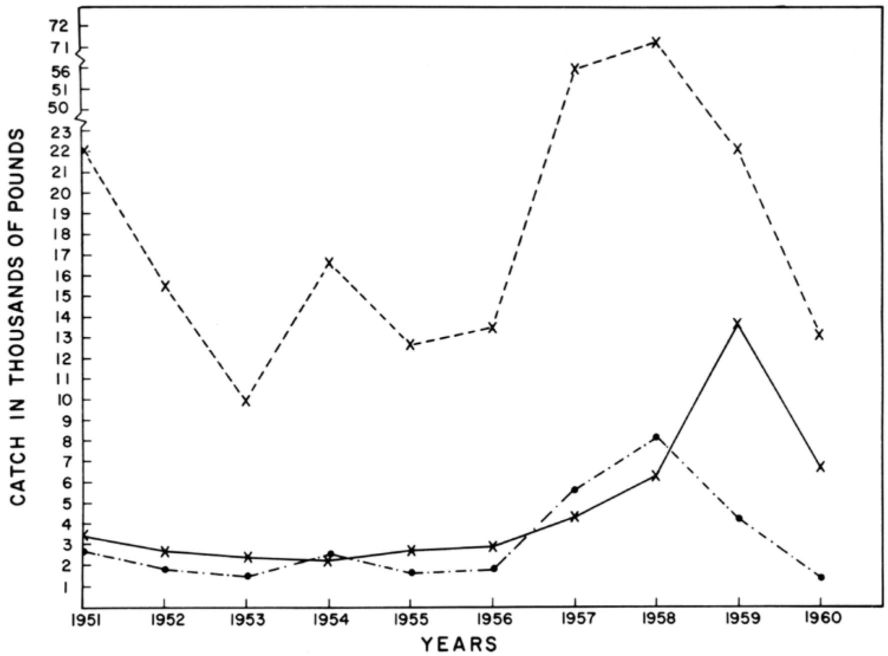

FIGURE 4 White seabass catch-per-unit-of-effort values, 1951 through 1960, showing the marked anamoly in 1959 (solid line = total boats, average catch-per-boat; broken line = eight boats, average catch-per-boat; dot and dash line = eight boats, average catch-per-month-per-year).

FIGURE 4 White seabass catch-per-unit-of-effort values, 1951 through 1960, showing the marked anamoly in 1959 (solid line = total boats, average catch-per-boat; broken line = eight boats, average catch-per-boat; dot and dash line = eight boats, average catch-per-month-per-year)

A special analysis of the eight-boat average annual catch from 1956 through 1960 was made by comparing the average price-per-pound by month and year with the catch for these periods. This revealed that the eight boats fished an identical total of 80 months during 1958 and 1959, with 850 and 823 trips respectively. However, during the high-catch months of July and August, the eight boats made 134 fewer trips in 1959 than in 1958. Yet in 1959 the catch of the entire fleet showed that July and August were still the high-catch months. I attributed the eight-boat effort change to a marked decline in the average price-per-pound during July and August of 1959 (Figures [5] and [6]). It is possible that these fishermen, who made a good income in 1958 and the first half of 1959, could afford to fish with reduced effort during the 2 months of depressed prices in 1959.

The combined eight-boat average catch-per-month-per-year closely follows the yearly mean ocean temperature, except for 1959. Manpower and time considerations made it impossible to pursue this relationship further in terms of management implications.

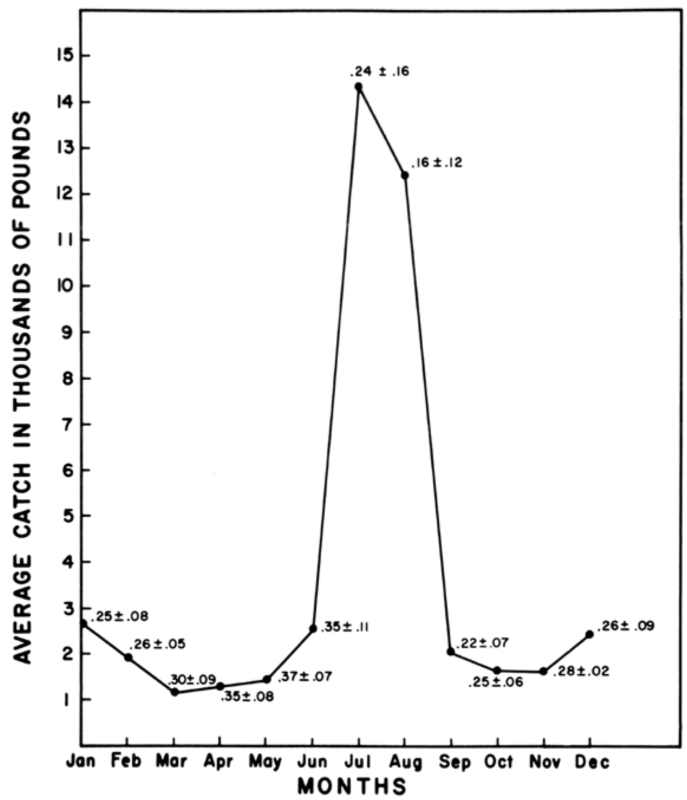

FIGURE 5 The average catch-per-month for the combined eight boats with average price-per-pound, including standard deviation, paid to the fishermen from 1956 through 1960.

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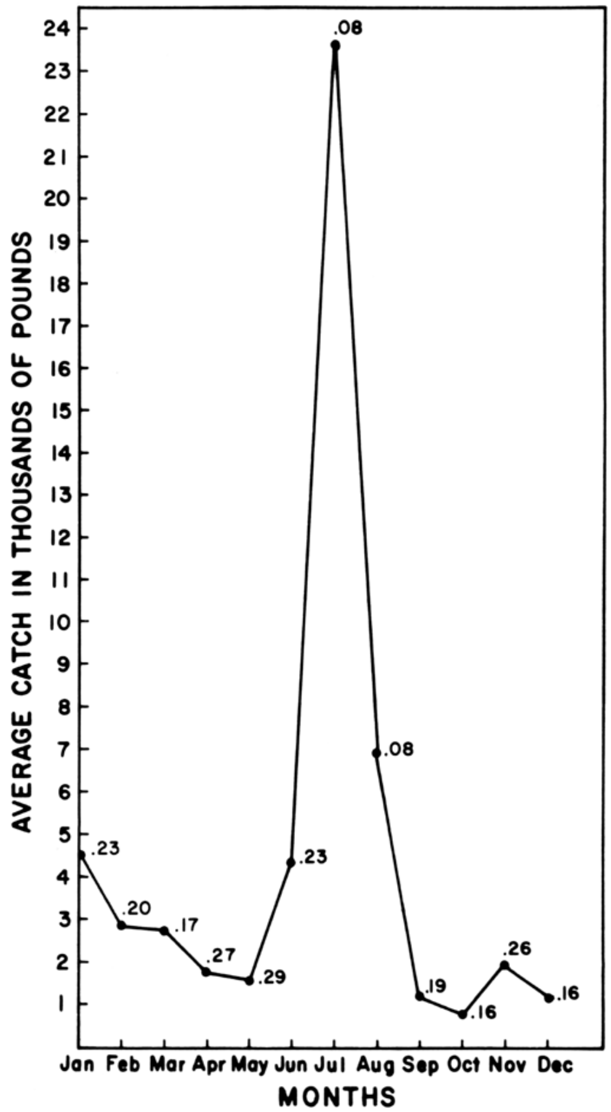

FIGURE 6 The average catch-per-month for the combined eight boats with average price-per-pound paid to these fishermen in 1959.

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TABLE 2

Actual White Seabass Weight-Length Data from Commercial and Project Gill Nets During 1961

Length (mm)	Weight round (grams)	Weight dressed head-on (grams)	Sex[1]
79	3	--	J
119	15	13	J
159	37	--	J
259	165	150	J
262	196	166	J
274	205	185	J
277	222	193	J
282	521	478	J
283	284	229	J
286	218	203	J
288	310	260	J
326	315	295	J
330	342	303	F
336	387	349	J
338	826	695	F
339	372	333	M
344	437	388	J
349	395	365	F
355	451	388	F
368	485	440	F
372	511	472	M
385	542	500	J
386	482	449	J
387	625	565	M
391	594	560	M
396	611	552	M
405	651	617	M
407	730	655	F
413	649	610	F
414	668	624	M
419	746	641	M
420	711	660	F
421	650	610	M
422	854	758	F
423	746	675	F
431	730	--	M
432	745	625	F
434	852	732	F
556	1,851	1,476	M
564	1,520	1,423	F
565	--	1,538	F
565	1,665	1,516	F
566	1,667	1,511	F
566	1,642	1,492	F
568	1,727	1,586	F
569	1,663	1,536	F
570	1,560	1,432	F
573	1,809	1,577	F
573	1,862	1,684	M
573	1,072	972	M
576	1,717	1,464	F
579	1,991	1,789	F
580	2,066	1,788	F
581	1,949	1,776	F
582	1,833	1,595	M
595	1,851	1,712	F
596	1,722	1,627	F
607	1,973	1,782	F
608	2,192	1,963	F
611	1,774	1,682	M
616	2,370	2,135	F
620	2,182	2,031	F
641	2,384	2,172	F
641	2,280	2,118	F
651	2,228	--	M
436	771	704	F
442	839	772	F
448	942	811	M
450	755	687	M
464	1,130	964	F
467	961	867	F
468	1,792	1,560	F
472	1,063	946	M
475	1,010	859	F
475	990	880	M
475	814	779	F
476	1,130	1,007	M
476	1,054	959	M
487	903	847	M
489	979	892	M
490	1,161	915	M
491	1,164	1,024	F
492	1,090	984	F
493	1,167	1,080	M
496	1,284	1,125	F
496	1,199	1,079	F
499	1,146	1,035	F
499	1,442	1,263	M
500	1,068	984	M
506	1,206	1,123	M
507	926	875	F
510	1,230	1,122	M
515	1,241	1,112	F
518	1,339	1,214	M
519	1,238	1,166	F
521	1,158	1,066	F
523	1,363	1,200	F
525	1,420	1,287	M
526	1,524	1,325	M
528	1,419	1,207	F
534	1,414	1,281	F
540	1,347	1,223	M
543	1,362	1,396	F
544	1,479	1,279	M
552	1,662	1,482	F
555	1,445	1,342	F
946	7,711	6,917	F
986	11,340	10,319	F
987	8,845	7,938	M
1001	9,979	9,412	M
1011	7,598	7,258	M
1014	10,886	10,433	M
1031	11,907	11,000	M
1034	11,000	10,319	M
1044	11,340	10,433	M
1045	11,113	10,093	F
1053	10,546	9,752	F
1054	13,154	12,020	F
1057	12,134	11,340	M
1089	11,567	10,773	M
1100	11,907	11,000	M
1109	12,020	11,113	M
1116	14,515	13,835	M
1118	--	11,680	F
1140	13,608	12,474	F
1149	11,113	10,206	F
1157	15,196	13,721	F
1160	13,154	--	F
1186	14,175	13,154	F
1191	16,443	15,082	F
1197	14,515	13,495	M

TABLE 2

Actual White Seabass Weight-Length Data from Commercial and Project Gill Nets During 1961

TABLE 2—Continued

Actual White Seabass Weight-Length Data from Commercial and Project Gill Nets During 1961

Length (mm)	Weight round (grams)	Weight dressed head-on (grams)	Sex[1]	Length (mm)	Weight round (grams)	Weight dressed head-on (grams)	Sex[1]
657	2,499	2,287	M	1200	16,897	15,196	F
665	2,596	2,333	F	1205	14,855	13,608	M
665	1,375	1,120	M	1215	17,804	16,103	F
				1231	15,536	13,835	F
714	3,175	--	M	1247	18,824	16,103	F
715	3,353	2,991	F	1255	20,072	17,690	F
717	3,353	3,055	F	1272	16,670	15,082	F
719	3,376	3,060	F	1274	16,556	14,969	F
754	4,049	3,671	F	1278	18,598	17,010	F
792	3,809	3,516	F				
805	5,219	4,530	F	1352	22,226	19,958	F
805	5,219	4,530	F				
893	5,557	4,990	M				
894	6,350	5,897	F				
			Total Numbers	153	151	147	153

[1] J = Juvenile; M = Male; F = Female

84 F
53 M
16 J

TABLE 2

Actual White Seabass Weight-Length Data from Commercial and Project Gill Nets During 1961

2.7. Results

The regulation limiting the trip catch to 5,000 pounds per boat and 1,000 pounds per person from May 1 to August 31 is unnecessary. In fact, during the peak catch months in 1959, only 15% of the total boat trips achieved a catch of 1,000 pounds. The exact reason for this regulation has become obscured. In any event, whether it was biological, socio-economic, or a combination of these factors, the analysis showed this regulation hasn't achieved its purpose in any category.

3. WEIGHT-LENGTH RELATIONSHIP

Clark (1930) initially calculated the white seabass weight-length relationship. In her publication she stated, "Because of many difficulties encountered, the data were very inadequate and they are presented here only as a rough guide for protection for the white seabass". Clark could collect only 44 white seabass for this relationship.[2] No fish was shorter than 400 mm TL and just 12 exceeded 700 mm. For these reasons, project personnel undertook a new analysis in 1961.

3.1. Methods

Some of our 1961 weight-length data was collected by sampling the commercial catch at several ports in southern California, but because these fishermen usually use gill nets with 6-inch stretched mesh, there were no small white seabass. To fill this gap project gill nets with variable mesh sizes ranging from 1 to 6 inches were fished in the Long Beach-Los Angeles harbor. Most of the samples come from the latter activity.

[2] Clark's original data sheets indicated that only 44 fish were used for the weight-length calculations. The 78 fish noted in her paper applies only to the maturity studies.

Many of the commercial sampling problems described by Clark (1930) were inherent in this study. In addition, over 90% of the present-day commercial fishermen sell eviscerated fish (dressed head-on) as opposed to whole fish (round). Therefore, the samplers either asked these fishermen to bring in round fish, or rode the commercial boats to obtain weights before the fish were eviscerated. The problems of weighing fish at sea on a rolling 30- to 40-foot boat often invalidated samples, if not the sampler. Many commercial fishermen consented to bring in round fish, but frequently, after the samplers waited at the dock for several hours, the boats would return with few or no fish. Consequently, I obtained only 153 fish for the weight-length relationship from commercial and project gill nets throughout 1961 (Table 2). Total lengths were measured in millimeters from the tip of the lower jaw to the end of the upper caudal lobe by means of a measuring board. Fish weights were determined by two procedures: (i) small fish (79 to 699 mm TL) were weighed to the nearest gram, and (ii) large fish (700 to 1,352 mm TL) to the nearest one-quarter pound, which were then converted to the nearest gram.

I submitted these data to Norman J. Abramson, California Department of Fish and Game, because he had developed a weight-length computer program. This program, for the I.B.M. 7090 computer, fitted the logarithmic transformation of the equation $W=aL^b$ by the method of least squares. The program calculated six weight-length curves using round weights of males, females, and sexes combined, then dressed head-on weights in the same three categories. Juvenile fish were eliminated from these calculations, thereby reducing the number of fish to 135 (round) and 133 (dressed head-on).

The dressed head-on weight-length relationship was computed because the average ratio value often used to convert to either round or dressed head-on weight is not accurate along the entire range of lengths. With round and dressed head-on curves it is possible at any given length to convert to either weight more accurately.

The selective gear, gill nets, possibly did not catch fish representative of the normal white seabass population, even though variable mesh sizes were used. Any statements made concerning the population should be understood to mean the population caught by these gill nets.

3.2. Results

I tested the calculated regression curves for each sex with analysis of variance. Differences between sexes, round or dressed weight, were not significant; therefore, the curves by sex were combined for each weight category. The derived equation, round weight, was: $W = .000015491\ L^{2.92167}$ (Figure 7, solid line). The 95 percent confidence limits on the slope or "*b*" value placed the upper limit at 2.98713 and the lower at 2.85621. This means that 95 percent of the time the population slope value would fall within these confidence limits. The derived equation, dressed head-on weight, was $W = .000012267\ L^{2.94252}$ (Figure 7, broken line). The 95 percent confidence limits on the slope value placed the upper limit at 3.00676 and the lower at 2.87827.

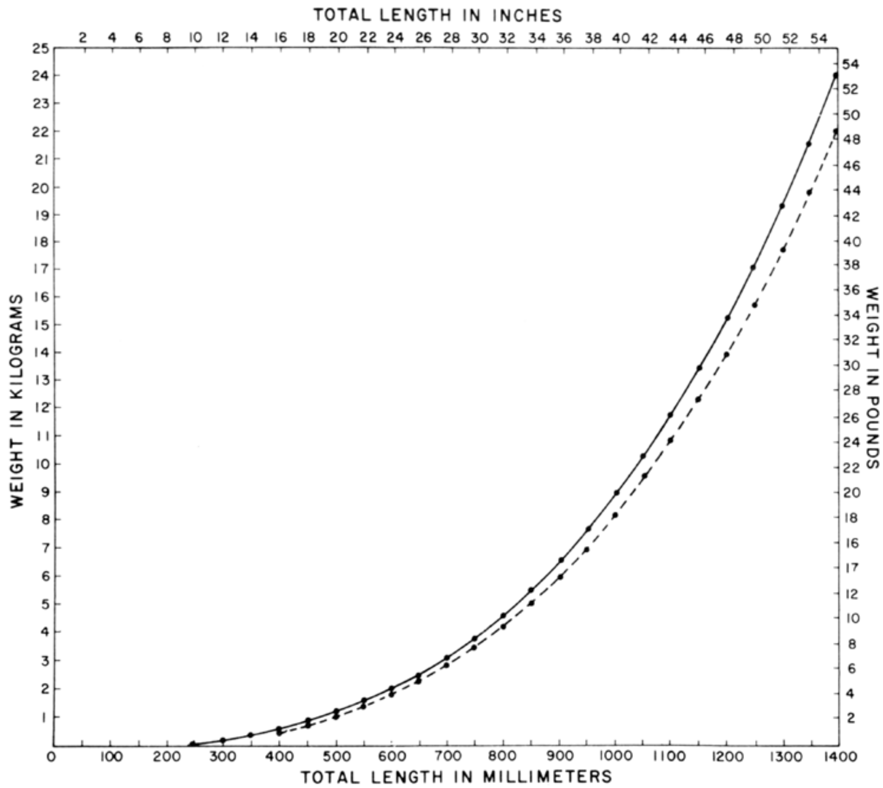

FIGURE 7 Calculated weight-length relationship of white seabass (solid line—round weight, $W = .000015491\ L^{2.92167}$; broken line—dressed head-on weight, $W = .000012267\ L^{2.94252}$).

FIGURE 7 Calculated weight-length relationship of white seabass (solid line—round weight, W = .000015491 L 2.92167; broken line—dressed head-on weight, W = .000012267 $L^{2.94252}$)

4. AGE AND GROWTH

There have been no publications on age and growth of white seabass from California waters. Project personnel decided in 1958 to use scales (Figure 8) for this study because they found a good relationship between the number of observed annuli on the scales of white seabass and the total lengths of these fish. In addition, Nesbit (1954) and Joseph (1962) have demonstrated the validity of using scales of sciaenids to determine age. However, I must point out that John E. Fitch (pers. commun.), using otoliths of white seabass to determine age, obtained considerably older ages for large fish (over 1,250 mm) than we read from scales. This situation will not have an effect on the present analysis because all fish older than age XIII (1,217 mm mean length) were grouped into one category in order to determine the population parameters.

I identified and counted annuli on these ctenoid scales if: (i) they formed entirely around the anterior and lateral fields, (ii) they possessed two or more straightened circuli in the anterior field, and (iii) they were clearly distinct from one another and did not intersect at

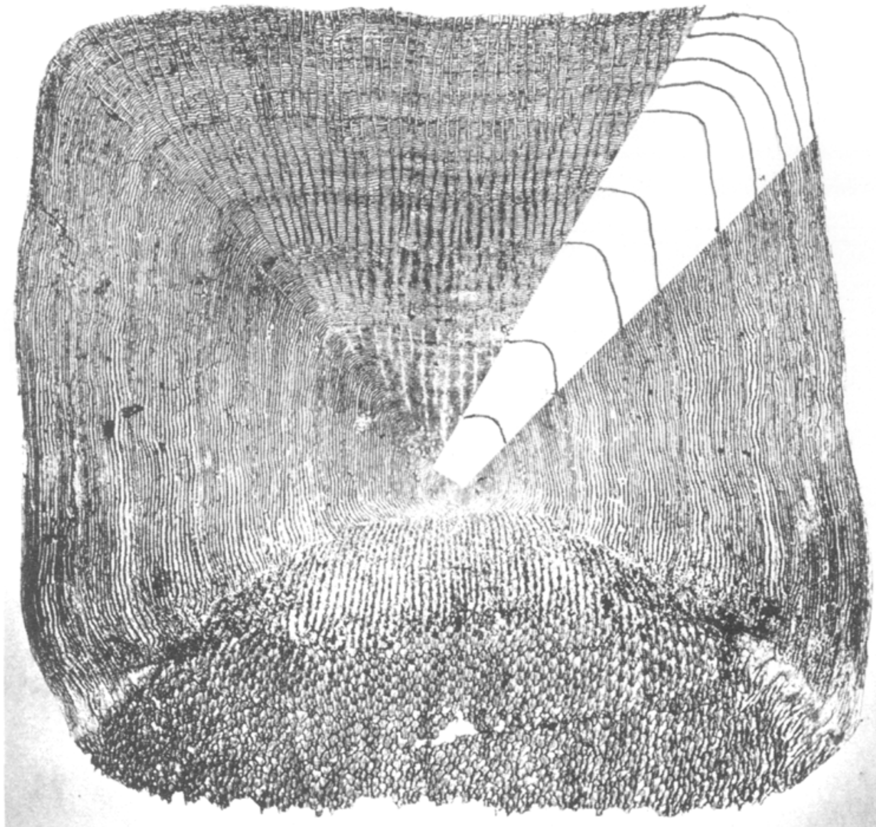

FIGURE 8 Scale from a 995 mm white seabass showing 9 annual rings. *Photograph by Leo Pinkas.*

FIGURE 8 Scale from a 995 mm white seabass showing 9 annual rings. Photograph by Leo Pinkas

any point. of course, the above criteria were not unique to this study; Carlisle, Schott, Abramson (1960) and Joseph (1962) elaborated upon them.

4.1. Methods and Materials

Project personnel examined scales from the entire body surface and decided the most suitable were from the area immediately posterior to the insertion of the pectoral fin. Seasonal employees cleaned the scales and mounted six to eight of them from each fish between two glass slides. The scales were magnified to 30 diameters with a scale projector described by Pinkas (1966).

Age determinations were made without pertinent size and catch information on the numbered slides; however, this did not eliminate reader bias because scale size possibly suggests age.

Project personnel selected scale samples from white seabass that were caught by different types of fishing gear in order to enumerate all possible age groups. These types of gear were: (i) gill nets (commercial), (ii) lampara (bait-boats), (iii) specially constructed variable mesh gill nets, and (iv) trawl nets. During 1961 we collected most of the samples with project gear (iii and iv).

To correlate lengths with ages, a series of length frequency bar charts were compiled from the commercial data. I tried different millimeter groupings (10, 20, 50, 70, 100) and found that the 50-mm grouping showed an ascending and descending step-like progression over the entire range of fish lengths. Next I lettered each 50-mm length group of 1958 alphabetically and moved individual letters to the next highest 50-mm grouping within each of the following 2 years of data. After completing the age analysis in 1962, I superimposed the mean lengths at age on the lettered 50-mm bar charts (essentially the Petersen method). This methodology should aid in assessing the validity of determining white seabass ages by means of their scales.

For the growth analysis, I fitted the white seabass age-length data to the von Bertalanffy growth equation by the procedure of Tomlinson and Abramson (1961).

4.2. Results and Conclusions

Ages of the 2,831 fish sampled from the 1858–60 commercial white seabass catch ranged from III through XVI (Table 3). Scales from fish older than 13 years were difficult to interpret; fortunately, the majority were less than 13 years old. Gill-net mesh size selectivity strongly influenced the age composition, thus full exploitation during these years occurred at age IX and above.

TABLE 3

Age Composition of the Commercial White Seabass Catch Off California

Age group	Numbers of Fish					
	1958		1959		1960	
	Nos.	Percent	Nos.	Percent	Nos.	Percent
III					2	0.52
IV			3	0.21	1	0.26
V	3	0.29	3	0.21	6	1.55
VI	14	1.36	23	1.63	14	3.62
VII	105	10.19	109	7.71	19	4.91
VIII	225	21.85	256	18.11	48	12.40
IX	293	28.45	385	27.23	91	23.51
X	202	19.61	338	23.90	67	17.31
XI	96	9.32	161	11.39	53	13.70
XII	66	6.41	81	5.73	41	10.59
XIII	17	1.65	41	2.90	18	4.65
XIV	8	0.78	11	0.78	13	3.36
XV	1	0.10	3	0.21	2	0.52
XVI					1	0.26
Totals	1,030	100.01	1,414	100.01	387	97.16

TABLE 3

Age Composition of the Commercial White Seabass Catch off California

The mean lengths at age and the 50-mm length-frequency bar charts (based on the 3,773 fish lengths sampled from the commercial fishery) maintained a fairly consistent relationship from 1958 through 1960 (Figure 9) . Comparing lettered bar charts with the corresponding age groups for successive years certainly lends validity to the ages determined from scales.

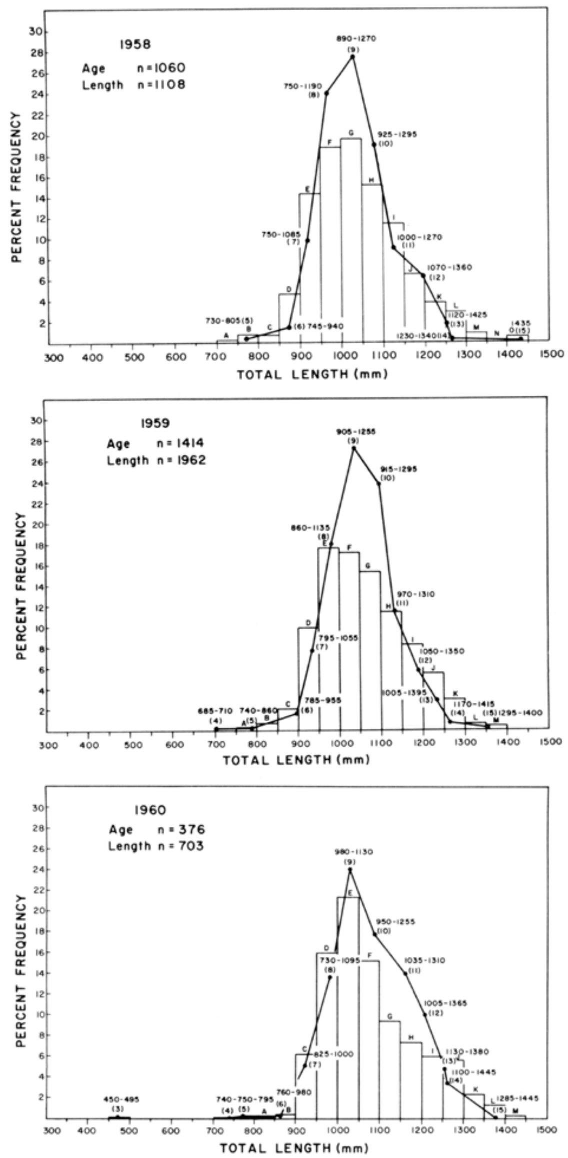

FIGURE 9 The relationship between mean lengths at age and 50 mm length frequency bar charts, compiled by year, 1958–1960: numbers with parentheses designate the age groups; dots represent the mean lengths for each age; numbers separated by a hyphen represent the range of lengths for each age.

FIGURE 9 The relationship between mean lengths at age and 50 mm length frequency bar charts, compiled by year, 1958–1960: numbers with parentheses designate the age groups; dots represent the mean lengths for each age; numbers separated by a hyphen represent the range of lengths for each age

TABLE 4

Systematically Selected Total Lengths in Millimeters by Age Groups of White Seabass

	Age Groups												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
	275	280	460	520	705	865	905	930	970	1025	1075	1145	1250
	270	270	555	595	740	885	855	950	1000	1060	1110	1175	1275
	260	320	530	640	805	785	885	970	1025	1095	1165	1210	1005
	150	320	445	680	840	870	905	990	1060	1135	1240	1255	1165
	180	385	465	570	755	900	920	1005	1110	955	1030	1065	1185
	190	335	475	540	795	910	940	1030	955	1015	1070	1125	1215
	160	325	345	495	740	935	975	1085	980	1045	1105	1160	1235
	165	350	525	535	685	805	845	1000	1005	1070	1140	1190	1285
	180	310	480	505	720	885	900	995	1030	1095	1165	1240	1315
	290	355	495	580	560	940	925	910	1055	1120	1225	1295	1155
	215	350	385	565	600	760	940	930	1080	1155	1285	1115	1225
	325	340	390	610	805	795	960	950	1120	1210	1120	1210	1295
	270	380	480	580	600	850	980	970	975	1020	1245	1305	1165
	270	380	480	495	695	890	1045	990	1055	1130	1090	1160	1210
	270	340	500	660	800	920	955	1015	1070	950	1100	1255	1270
Sum	3470	5040	7010	8570	10845	12995	13935	14720	15490	16080	17165	17905	18250
Mean	231.33	336.00	467.33	571.33	723.00	866.33	929.00	981.33	1032.67	1072.00	1144.33	1193.67	1216.67
Standard error of the mean	14.52	8.69	14.74	15.06	21.74	14.54	13.20	11.56	13.26	18.80	19.28	17.64	19.91

Size of sample 195

TABLE 4
Systematically Selected Total Lengths in Millimeters by Age Groups of White Seabass

From the project and bait-boat samples (1958–1961), we determined ages for 385 fish. I combined these with the commercial age-length data and systematically selected 15 fish samples from each age group (Table 4) in order to fit the von Bertalanffy growth equation (Figure 10) .

The equation used and parameters were:

$$l_t = L_\infty [1 - e^{-K(t-t_0)}]$$
$$L_\infty = 1465.3882 \text{ mm}$$
$$K = .1280$$
$$t_0 = -.2805$$

where:

L_∞ = maximum expected length

K = constant proportional to the catabolic rate

t = actual age

t_0 = hypothetical age at zero length

EQUATION

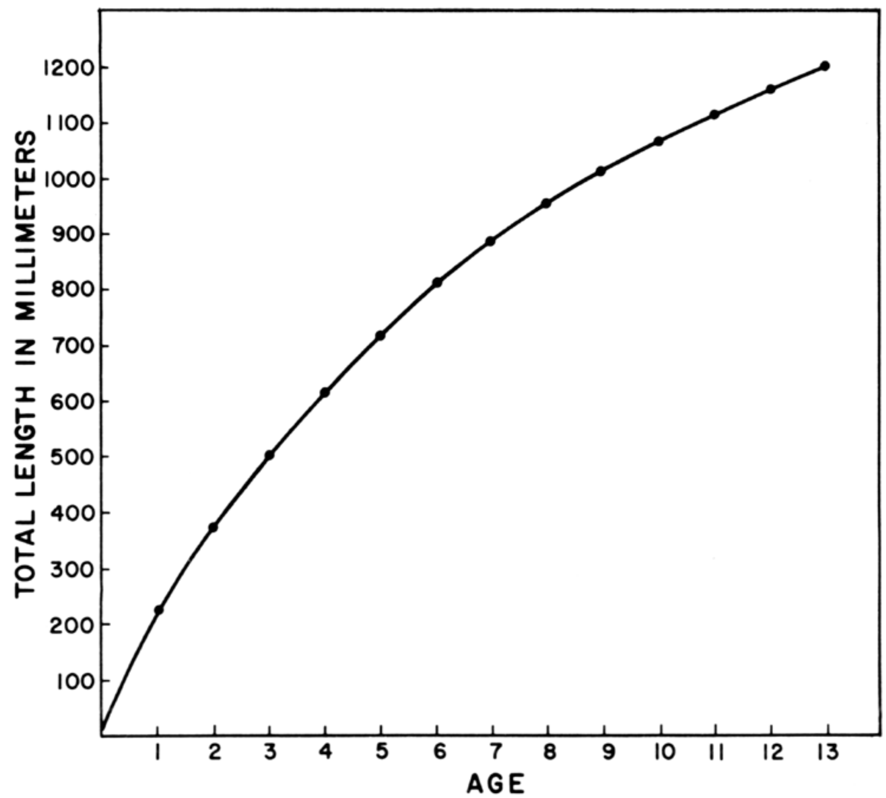

FIGURE 10 Growth rate of white seabass, fitted by the von Bertalanffy growth equation.

FIGURE 10 Growth rate of white seabass, fitted by the von Bertalanffy growth equation

The 95 percent confidence intervals for [L8] and *K* were 102.404 and .0206. The mean total lengths in millimeters for age groups I through XIII were: I—231; II—336; III—467; IV—571; V—723; VI—866; VII—929; VIII—981; IX—1,033; X—1,072; XI—1,144; XII—1,194; and XIII—1,217.

5. POPULATION PARAMETERS

Estimations of mortality and survival rates are essential to scientific fishery management. For each age group we might consider growth during consecutive years a "plus" value and mortality a "minus" value. At some point during these years the growth and mortality within a year-class counterbalance each other so that neither one is in excess. We might term this juncture, optimum yield. Herrington and Nesbit (1943) published an excellent discussion concerning this subject and the field of fisheries management in general.

I calculated the various fishing rates by basically following the method of Silliman (1943). Ricker (1958), elaborating on the technique, wrote that Silliman's method could be used with 2 adjacent years of age data at each level of effort with even recruitment. Beverton (1963) also discussed this method and its application. I used Silliman's method with only 1959 and 1960 white seabass age data and with different effort between years (Table 3). Robson and Chapman (1961) also developed a method to compute survival rates; the values, calculated by the two methods, were similar.

5.1. Results

Mortality rates indicate commercial fishermen have not over-harvested white seabass; for example, during the peak commercial catch in 1959 there was a total mortality of 56% with 44% of the population off California surviving (Table 5).

Within the 56% total mortality there was a fishing mortality of 39.8% and a natural mortality of 26.8%. These two percentages, when added, exceed the total mortality value because their solution allows the same fish to die twice. This is corrected by subtracting the product of fishing and natural mortality values from their sum.

Ricker (1958) developed a method to convert the above rates into instantaneous values (Table 6), and we calculated these values for use in determining yield.

TABLE 5

Values of the Various Rates Calculated by Silliman's Method

	Values of various rates:				
Year	Total mortality (*a*)	Survival (*s.r.*)	Fishing mortality (*m*)	Natural mortality (*n*)	Exploitation (fraction of stock caught by fishery) (μ)
1960	.43	.57	.221	.268	.19
1959	.56	.44	.398	.268	.33

TABLE 5

Values of the Various Rates Calculated by Silliman's Method

TABLE 6

Estimated Survival and Instantaneous Mortality Rates of the White Seabass Resource Off California

Year	Survival rate S	Instantaneous Mortality rates		
		Total i	Fishing p	Natural q
1958	.41	.892	.589	.303
1959	.44	.821	.518	.303
1960	.57	.562	.259	.303
Average	.473	.758	.455	.303

TABLE 6

Estimated Survival and Instantaneous Mortality Rates of the White Seabass Resource off California

6. YIELD ESTIMATES

The yield equation developed by Beverton and Holt (1957) was used to calculate a biological minimum size limit. These authors made an assumption that growth is isometric (b = 3). The white seabass slope

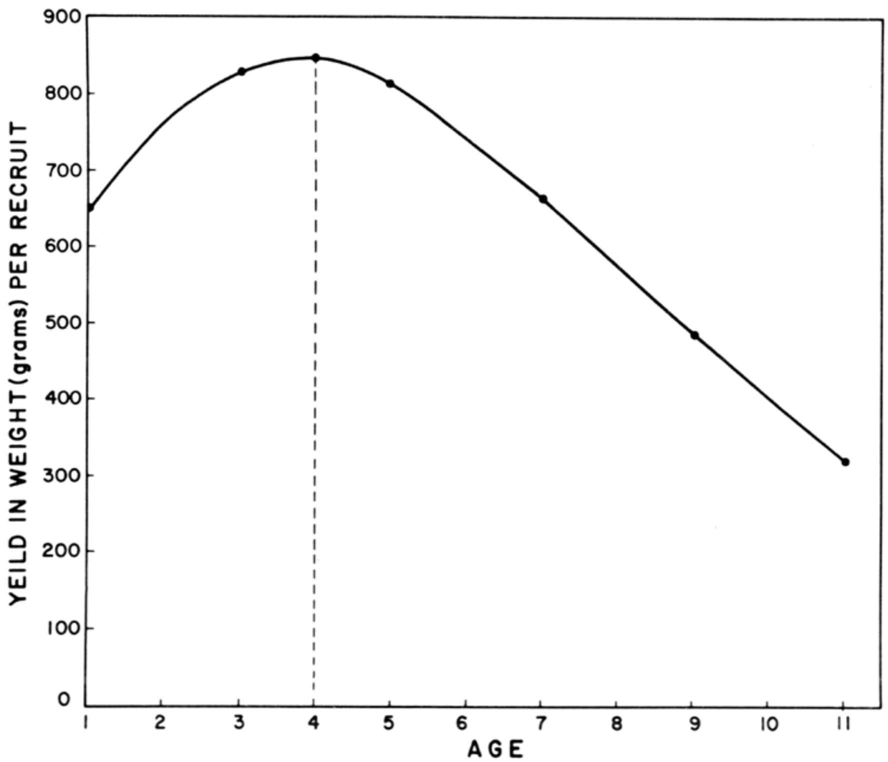

FIGURE 11 Yield in grams-per-recruit by age group.

FIGURE 11 Yield in grams-per-recruit by age group

or "*b*" value was significantly different from 3; therefore, the subsequent values were calculated from a binomial expansion of the equation for yield in weight per recruit Y_w/r. Norman J. Abramson, California Department of Fish and Game, provided the following expanded equation:

$$\frac{Y_w}{r} = W_\infty p e^{-q\rho} \Big[\frac{1}{p+q} - \frac{b}{p+q+K} e^{-K(t_{p'}-t_0)} + \frac{b(b-1)}{2(p+q+2K)} e^{-2K(t_{p'}-t_0)} - \frac{b(b-1)(b-2)}{6(p+q+3K)} e^{-3K(t_{p'}-t_0)} + \frac{b(b-1)(b-2)(b-3)}{24(p+q+4K)} e^{-4K(t_{p'}-t_0)}\Big]$$

EQUATION

I used the same symbols as those in the preceding sections and not strictly those of Beverton and Holt (1957). Values of the parameters were:

b	$= 2.922$	(from weight-length equation)
W_∞	$= 26{,}970$	(from growth equation)
K	$= .128$	(from growth equation)
t_0	$= -.281$	(from growth equation)
i	$= .562$	(from mortality calculations)
p	$= .259$	(from mortality calculations)
q	$= .303$	(from mortality calculations)
t_p	$= 1$	(age when fish first on fishing grounds)
$t_{p'}$	$=$ I through XX	(exploited ages of fish)
ρ	$= t_{p'} - t_p$	

EQUATION

Also yield isopleths were computed to determine the effects of simultaneous variation of fishing mortality (*p*) and recruitment age (t_p') on yield. Beverton and Holt (1957) described a method for making these calculations; however, Norman J. Abramson learned that Gerald J. Paulik, University of Washington, had developed a computer program for such analyses. Professor Paulik kindly consented to process the white seabass data.

6.1. Results

The yield in weight per recruit by age group with fishing and natural mortality constant (.259 and .303) demonstrated the white seabass harvest should start at age IV corresponding to a 22-inch TL minimum size limit (Figure 11) .

Yield isopleth values with varying rates of fishing mortality (natural mortality constant) showed that white seabass harvest should start at age IV to achieve the greatest yield. With the estimated fishing mortality of .259, the fishermen would obtain the best yield of 800 grams per recruit again with age group IV (Figure 12 , point P) rather than their current yield of 500 grams per recruit.

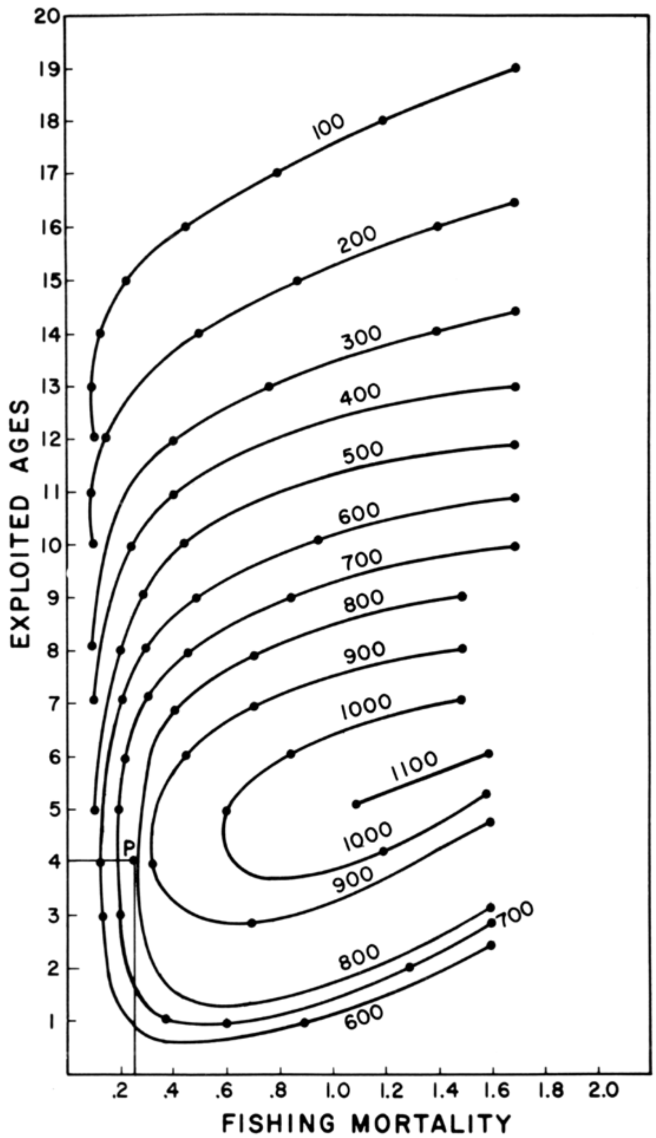

FIGURE 12 Yield isopleth for white seabass. Graph shows the yield in grams-per-recruit for any combination of instantaneous fishing mortality and exploited age.

FIGURE 12 Yield isopleth for white seabass. Graph shows the yield in grams-per-recruit for any combination of instantaneous fishing mortality and exploited age

7. CONCLUSIONS AND RECOMMENDATIONS

Considering the limitations of this study, I believe it is unwise to advocate a change to a 22-inch minimum size limit. The theory for the best harvest of white seabass could be tested without changing the minimum size limit for white seabass or the minimum mesh size regulation. If commercial fishermen would voluntarily use 4-inch mesh gill nets for 2 or more years we would then have some idea if the yield in weight is increasing. However, the normal fluctuations in the white seabass catch might obscure the measurements. To determine the true effect then, the new yield should be compared with past harvest trends and cycles. If the theory is correct, during the period of the experiment there should be a 15% to 50% increase in yield with similar environmental and population conditions.

The 5,000 pounds per boat and 1,000 pounds per person limitation from May 1 to August 31 of each year should be eliminated.

Some important facets of white seabass life history are unknown or at best fragmentary, e.g., fecundity, nursery areas, and food habits.

A tagging study would also be extremely beneficial, not only to evaluate mortality estimates but also to determine the amount of migration and if our assumption of one population is correct.

To answer the questions regarding: (i) the unknown life history factors, (ii) the migratory behavior and population parameters (as supporting evidence for the current study), and (iii) the effects of the voluntary use of gill nets with a 4-inch mesh size and would require initiating a new white seabass research project.

8. SUMMARY

1) The white seabass ranges from Juneau, Alaska, to Magdalena Bay, Baja California, and also occurs in the northern portions of the Gulf of California. On the outer coast it is most abundant from Point Conception, California, to Ballenas Bay, Baja California.

2) Commercial fishermen landed most of the total catch from April through September in each year, 1951–1960.

3) Catch-per-unit-of-effort values indicated that commercial fishermen have not over-harvested the white seabass population. A price analysis helped explain the market anomaly in the 1959 catch-effort data.

4) The limitation of 5,000 pounds per boat and 1,000 pounds per person from May 1 to August 31 is deemed unnecessary.

5) We found no significant difference in the weight-length relationship between sexes, round or dressed head-on weight; therefore, we combined the curves by sex for each weight category. The derived equations were: $W = .000015491\, L^{2.92167}$ (round weight); $W = .000012267\, L^{2.94252}$ (dressed head-on weight).

6) We determined white seabass ages by means of their scales through the 16th year; however, ages of fish beyond 13 years are difficult to determine. The mean total lengths in millimeters for age groups I through

XIII were: I—231; II—336; III—467; IV—571; V—723; VI—886; VII—929; VIII—981; IX—1,033; X—1,072; XI—1,144; XII—1,194; XIII—1,217. Length frequency distributions compared favorably with our age analysis.

7) The age-length data fitted by von Bertalanffy's growth equation became:

$$l_t = 1465.3882[1 - e^{-.1280(t+.2805)}].$$

EQUATION

8) Our estimated survival and total mortality rates were: survival, 57% (1960) and 44% (1959); total mortality, 43% (1960) and 56% (1959). The instantaneous mortality rates were: total, .562 (1960) and .821 (1959); fishing, .259 (1960) and .518 (1959); natural, .303 for both years.

9) To achieve a better yield, white seabass fishermen should voluntarily decrease the mesh size of their nets, preferably to 4-inches between knots, stretched.

9. REFERENCES

Ayres, W. O. 1863. Johnius nobilis (Ayres) *In* On new fishes of the California coast. Calif. Acad. Sci., Proc., 1858–62, 2:77–80, 1 fig.

Barnhart, Percy Spencer. 1936. Marine fishes of southern California. Berkeley. Univ. of Calif. Press, 209 p.

Beverton, R. J. H. 1963. Course in methods of population analysis. Notes and examples prepared for course to be given on behalf of ICES at Lowestoft, 73 p.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Min. Agric. Fish and Food, Fish. Invest., serv. 2, 19:533 p.

California Department of Fish and Game. 1952. The commercial fish catch of California for the year 1950 with a description of methods used in collecting and compiling statistics. Calif. Dept. Fish and Game, Fish Bull. (86) : 11–73.

Carlisle, John G. Jr., Jack W. Schott, and Norman J. Abramson. 1960. The barred surfperch (Amphistichus argenteus Agassiz) in southern California. Calif. Dept. Fish and Game, Fish Bull. (109) : 79 p.

Clark, Frances N. 1930. Size at first maturity of the white seabass (Cynoscion nobilis) . Calif. Fish and Game. 16(4) : 319–323.

Clark, Frances N. 1939. Measures of abundance of the sardine, Sardinops caerulea, in California waters. Calif. Dept. Fish and Game, Fish Bull. (53) : 45 p.

Clemens, W. A., and G. V. Wilby. 1946. Fishes of the Pacific coast of Canada. Bull. Fish. Res. Bd. Canada, (68) : 145–146.

Croker, R. S. 1932. The white seabass and related species that are sold in California fish markets. Calif. Fish and Game, 18(4) : 318–327.

Croker, R. S. 1937. White seabass. *In* The Commercial fish catch of California for the year 1935. Calif. Dept. Fish and Game, Fish Bull. (49) : 73.

Fitch, John E. 1949. White seabass, *In* The commercial fish catch of California for the year 1947 with an historical review 1916–1947. Calif. Div. Fish and Game, Fish Bull. (74) : 126–128.

Fitch, John E. 1958. offshore fishes of California. Sacramento. Calif. Dept. Fish and Game, 80 p.

Herrington, William C., and Robert A. Nesbit. 1944. Some methods of fishery management and their usefulness in a management program. Biological and economic problems of fishery management. U.S. Fish and Wildl. Serv., Spec. Sci. Rept., (18) : 69 p.

Jordan, David Starr, and Barton Warren Evermann. 1898. The fishes of north and middle America. Bull. U.S. Nat. Mus., (48), pt 3:

Joseph, David C. 1962. Growth characteristics of two southern California surffishes, the California corbina and spotfin croaker, family Sciaenidae. Calif. Dept. Fish and Game, Fish Bull. (119) : 54 p.

Limbaugh, Conrad. 1955. Investigation of fish life in the kelp beds and the effect of kelp harvesting on fish. Univ. of Calif., Instit. of Marine Res., (55–9) : 82–83.

Nesbit, Robert A. 1954. Weakfish migration in relation to its conservation. U.S. Fish and Wildl. Serv., Spec. Sci. Rept., (115) : 81 p.

Pinkas, Leo. 1960. White seabass. *In* California ocean fisheries resources to the year 1960. Sacramento, Calif. Dept. Fish and Game : 49–51.

Pinkas, Leo. 1966. A management study of the California barracuda (Sphyraena argentea) Girard. Calif. Dept. Fish and Game, Fish Bull. (134) : 58 p.

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. (112) : 62 p.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada, Bull. (119) : 300 p.

Robson, D. S., and D. G. Chapman. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc., 90(2) : 181–189.

Roedel, Phil M. 1948. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. (68) : 67 p.

Rounsefell, George A., and W. Harry Everhardt. 1953. Fishery science, its methods and applications. New York. John Wiley and Sons, 444 p.

Scripps Institution of Oceanography. 1958. Daily surface water temperatures and salinities at shore stations on California and Washington coasts 1945–1961. Univ. of Calif. preliminary unofficial report, issued by Data Archives, 28 Oct. 1958, revised 1 May 1962.

Silliman, R. P. 1943. A method of computing mortalities and replacements. *In* Studies on the Pacific pilchard or sardine (Sardinops caerulea) . U.S. Fish and Wild. Serv., Spec. Sci. Report, (24) : 10 p.

Skogsberg, Tage. 1925. White seabass. *In* Preliminary investigations of the purse seine industry of southern California. Calif. Div. Fish and Game, Fish Bull. (9) : 53–63.

Skogsberg, Tage. 1939. The fishes of the family Sciaenidae (croakers) of California. Calif. Div. Fish and Game, Fish Bull. (54) : 62 p.

Starks, Edwin Chapin. 1919. The fishes of the croaker family (Sciaenidae) of California. Calif. Fish and Game, 5(1) : 1–8.

Tomlinson, Patrick K., and Norman J. Abramson. 1961. Fitting a von Bertalanffy growth curve by least squares including tables of polynomials. Calif. Dept. Fish and Game, Fish Bull. (116) : 69 p.

Walford, Lionel A. 1931. Handbook of common commercial and game fishes of California. Calif. Div. Fish and Game, Fish Bull. (28) : 93.

Walford, Lionel A. 1937. Marine game fishes of the Pacific coast from Alaska to the equator. Berkeley. Univ. of Calif. Press, 205 p.

Whitehead, S. S. 1930a. White seabass. *In* The commercial fish catch of California for the year 1928. Calif. Div. Fish and Game, Fish Bull. (20) : 48.

Whitehead, S. S. 1930b. Analysis of boat catches of white seabass (Cynoscion nobilis) at San Pedro, California. Calif. Div. Fish and Game, Fish Bull. (21) : 27.

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