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THE SALTON SEA SPORT FISHERY

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ABSTRACT

A creel census was conducted at the Salton Sea, California, on 190 days from October 1982 through September 1983, to obtain a measure of angling quality, determine various parameters of the sportfishery, and ascertain area of angler origin. Census clerks interviewed 19,053 anglers who fished 70,756 hours and caught 103,301 sportfish for an average angler success rate of 1.46 fish per hour.

The Mozambique mouthbrooder, Tilapia mossambica, made up 41% of the total sportfish catch, followed by the bairdiella (croaker), Bairdiella icistia, and the sargo, Anisotremus davidsoni, at 28% each, and the orangemouth corvina, Cynoscion xanthulus, at 3%. This represents the first reported sportfishery for any species of Tilapia in California waters. The redbelly tilapia, Tilapia zillii, was not found during this census, even though it had occassionally been seen in anglers catches and in Department gill nets as recently as the late 1970's. Mean angler success rates were 0.60 fish per hour for tilapia, 0.41 for bairdiella and sargo, and 0.04 for corvina. Fishing pressure was highest from February through June. The data shows that the Salton Sea sportfishery is one of California's highest quality fisheries.

Origin of angler use has changed little since 1966-69. Seventy-five percent of the angler use came from outside of Imperial and Riverside counties, with Los Angeles County anglers contributing the largest percentage (37%). Length measurements together with size-at-sexual maturity information from corvina caught by sport anglers suggest that a significant portion of these corvina may have been removed prior to the onset of sexual maturity. Similar data for the tilapia, bairdiella, and sargo do not indicate premature exploitation of these species by the sportfishery.

THE SALTON SEA SPORT FISHERY

GLENN F. BLACK

INTRODUCTION

The California Department of Fish and Game initiated a year-long creel census at the Salton Sea in October of 1982. The objectives of this census were to: (i) assess the quality of angling for each species of sportfish, expressed in terms of catch per unit of effort (CPUE); (ii) determine the size (length) at which these fish were recruited into the sportfishery; (iii) establish a baseline reference of existing conditions; and (iv) ascertain to what extent the origin (county/area) of angler use had changed since the 1960's (Hulquist 1981).

This paper presents information on relative angler use, success rates, species and size composition of the catch (those fish kept by the angler), and related characteristics of the sportfishery. The study was not designed to estimate total catch, effort or angler use for the entire Salton Sea, although it is hoped that future work will be undertaken to make these quantitative estimates to fully demonstrate the value of this sportfishery. This information is necessary in order to determine the economic worth of the fishery in relation to other economic values in the region.

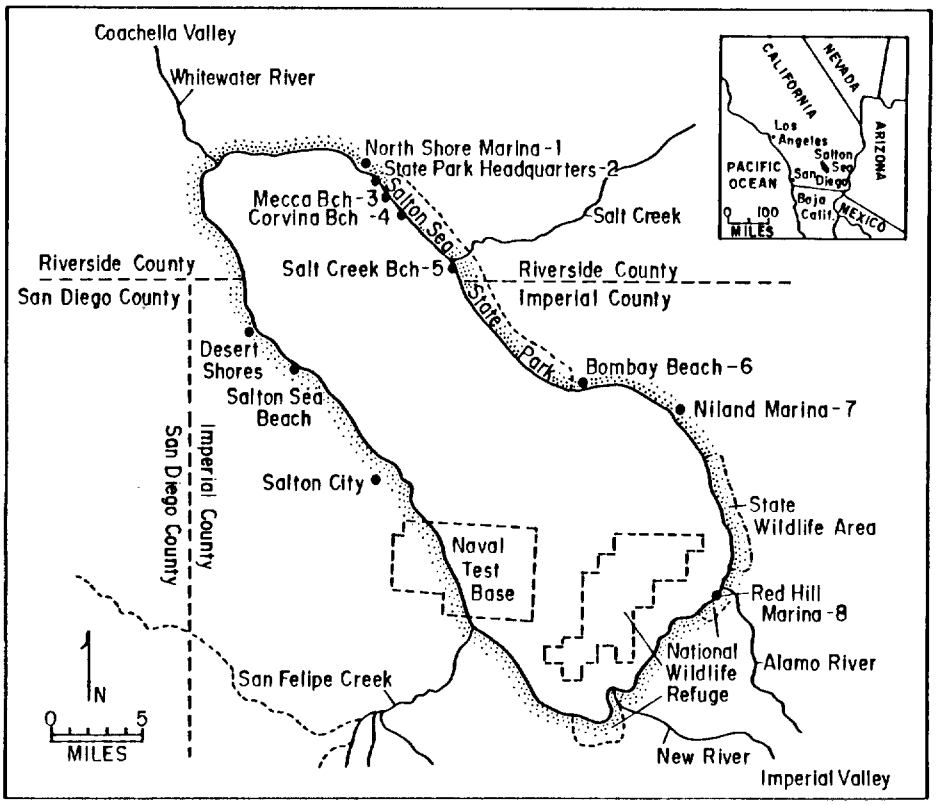

FIGURE 1. The Salton Sea and the areas sampled during 1982-83 creel census.

Physical Description of the Salton Sea

The Salton Sea, located in the southeastern counties of Riverside and Imperial, is California's largest inland water (Figure 1). It is 58 km long and 14 km to 22 km wide, encompassing approximately 930 km^2 of surface area and having 153 km of shoreline. The Sea lies in a desert basin (Salton Sink) 83 m below sea level that receives an average of 5 cm of rainfall per year (Hely et al. 1966). Information on the geologic and hydrologic history of the Salton Sink and its relationship to the Colorado River can be found in Hely et al. (1966) and Walker (1961).

The Sea's water surface elevation is maintained indirectly by the Colorado River. Water is transported to this arid area via the All American and Coachella Canals for irrigation of lands in the Coachella and Imperial Valleys (Figure 1). Agricultural wastewater, high in salt content, is collected and carried by gravity flow in an extensive network of drains which empty directly into the Sea or into one of three major tributaries (Alamo, New, and Whitewater Rivers) which in turn flow to the Sea (Figure 1). The U.S. Bureau of Reclamation (1981) estimates that the average annual precipitation at the Sea amounts to 4.3 X 10^7 m^3, or 2.5% of the total annual inflow while agricultural wastewater accounts for 1.73 X 10^9 m^3, (97.5 per cent of the annual inflow). It is important to note that there is no outlet for water entering the Sea other than through evaporation.

Due to the Sea being a "closed system", salts tend to accumulate. A 1966 hydrologic report (Hely et al. 1966) estimates that 4 million tons of minerals, predominantly sodium and chloride, flow into the Sea annually as a result of minerals that are leached from agricultural lands. At the time of the Sea's formation (1905-07), the salinity was approximately 3,600 parts per million (ppm) of total dissolved solids (TDS) but by 1936 it had risen to 43,000 ppm TDS due to increased agricultural use of surrounding desert lands (Hely et al. 1966). Due to varying amounts of agricultural drainage water entering the Sea and rainfall in the basin, the Sea's mineral content has fluctuated between 32,000 and 40,000 ppm TDS since 1942 (Black 1983a). At present, the Sea's salinity is approximately 39,000 ppm TDS.

The water elevation and depth also have undergone many fluctuations since the Sea's formation. In 1908 the elevation was approximately 60 m below sea level and the maximum depth 24 m (Hely et al. 1966). By 1925 the elevation had dropped to 76 m below sea level and the depth to 9 m. Between 1948 and the present, the Sea's elevation has risen from 73 m below sea level to 69 m and the maximum depth increased from 11 m to 16 m. The unstable elevation of the Sea has caused numerous problems for adjacent landowners.

Several physical parameters contribute to the highly eutrophic nature of the Sea. The mean depth is 8 m and the maximum depth approximately 16 m. Daily surface water

temperatures range from a minimum of 10° C in the winter (December through February) to a maximum of 36°C in the summer (June through September) (Walker 1961). An overabundance of mineral nutrients, primarily compounds of nitrogen and phosphorous, produce intense algal blooms and cause the Sea to be "objectionably eutrophic" (U.S. Dept. Interior Fed. Water Qual. Admin. 1970). The subsequent death and decomposition of large numbers of these phytoplankton often result in the creation of temporary anoxic conditions in localized areas, especially waters deeper than 9 m (Walker 1961). When these conditions exist together with high winds, for which the Sea is noted, the entire water column may become anoxic and fish trapped in these areas suffocate (U.S. Dept. Interior Fed. Water Qual. Admin. 1970). These fish kills occur to varying degrees throughout the year.

History of the Fishery

The earliest reports of fish in the Sea is by Evermann (1916) who listed 5 freshwater Colorado River species: (i) carp, Cyprinus carpio; (ii) bonytail, Gila robusta; (iii) razorback sucker, Xyrauchen texanus; (iv) rainbow trout, Salmo gairdneri, and (v) striped mullet, Mugil cephalus. Carp and mullet were said to be the most abundant of the fish species then present (Evermann 1916), but no mention was made by early authors (Evermann 1916; Thompson and Bryant 1920; Coleman 1929) of even a limited sportfishery for any of these species. By 1942 the salinity of the Sea had become 32,000 ppm TDS and all of the above-mentioned fish had disappeared from the Sea with the exception of mullet and carp (Dill and Woodhull 1942). Dill and Woodhull (1942) made the first mention of a sportfishery, and then only to say that since the close of the commercial mullet fishery in 1921 "there had been but little angling". This is probably in reference to a mullet sportfishery since these authors reported carp, catfish and a few sunfish as being present only at the mouths of the New and Alamo Rivers. However, a commercial mullet fishery existed at the Sea from 1915-21 and 1943-53 (Walker 1961). The first direct reference in the literature to a sportfishery for mullet was made by this same author (Walker 1961) when he described a fall and early winter fishery that employed the technique of snagging with a weighted treble hook around the freshwater inlets.

As early as 1929 the Department of Fish and Game attempted to establish a sportfishery at the Sea with the unsuccessful introduction of striped bass, Roccus saxatalis, (Anon. 1930). Thirty-six species of fish were stocked by the Department between 1929 and 1956, 32 of which were collected at San Felipe, Baja California and planted in the Sea from 1950-56 (Walker 1961). This "shotgun approach" resulted in the establishment of three species of sportfish which make up a major portion of the self-sustaining fishery that exists to the present -- the three species are orangemouth corvina

Cynoscion xanthulus, sargo Anisotremus davidsoni, and the bairdiella (croaker) Bairdiella icistia (Walker 1961).

Hulquist (1981) reports of attempts by the Department to document the quality of the early sportfishery present in 1958, 1963-67, and 1969. However, the amount of effort expended in acquiring angler catch and use data was extremely limited: (i) 34 days by a single creel census clerk in 1958 and (ii) 10 to 12 weekend days per year by 8 census clerks for the period 1963-67 and 1969 (Hulquist 1981). Partyboat logs for 1962-72 were examined by Black (1974) and demonstrated that the orangemouth corvina was the primary and almost exclusive target species of this type of angler. The catch of bairdiella by the partyboat angler was reported only when it was used as bait for catching corvina, or as in the case of sargo, when fishing for corvina was poor (Black 1974).

By the mid 1970's, occasional checks of anglers' creels showed that a substrate-breeding cichlid, the redbelly tilapia, Tilapia zillii, was present in the Sea. The origin of the redbelly tilapia was from Department-approved stockings of this species into irrigation canals and drains by local water districts to control aquatic plant growth that impeded water flow to agricultural lands and resultant drainage to the Sea (Pelzman 1973).

In 1979, it became apparent that another cichlid had established a breeding population in the Sea and also was providing a sportfishery. This fish is a maternal mouthbrooder whose identity has only recently been resolved through electrophoretic analysis and comparison with tilapia of known origin and identity. This other tilapia is the mozambique mouthbrooder, Tilapia mossambica (W. Courtenay, Florida Atlantic University, pers. commun. 1985). Its probable origin is from Department-approved stockings, for aquatic plant control in irrigation systems (canals and drains) of the Imperial, Palo Verde and Bard Valleys of California in the mid to late 1960's (St. Amant 1966; Hoover and St. Amant 1970) and in Yuma, Arizona in 1963 (Barrett 1983). A sportfishery in California for these two tilapia species (redbelly and mozambique mouthbrooder) has not been reported on previously.

Present Salton Sea Fish Fauna

The desert pupfish, Cyprinodon macularius, is the only fish endemic to the Salton Sink -- all others are the result of introductions (Table 1). Several of these introduced species have been implicated in the near extinction of the desert pupfish due to predation, competition for available habitat, and interference with spawning behavior (Black 1980; Matsui 1981; Schoenherr 1979). Known habitat for the desert pupfish included desert springs within the Colorado River drainage (Miller 1943) and shoreline pools adjacent to the Salton Sea (Barlow 1958). The desert pupfish has been extirpated from nearly all of its former range within

California, with the exception of San Felipe Creek, Salt Creek, and several irrigation drains and shoreline pools tributary to or part of the Salton Sea (Black 1980; K. Moore, Fishery Biologist, Cal. Fish and Game pers. commun. 1983). The precarious status of this fish's prolonged existence is such that the State of California has listed it as an endangered species in order to afford it some form of protection (Calif. Fish & Game Comm. and Dept. of Fish and Game 1980). The pupfish was proposed for Federal listing as an endangered species by the U.S. Fish and Wildlife Service in 1984.

Table 1. Present Salton Sea Fish Fauna

Game Fishes

Scientific name	Common name
Cynoscion xanthulus (Jordan & Gilbert)	Orangemouth corvina
Anisotremus davidsoni (Steindachner)	Sargo
Bairdiella icistia (Jordan & Gilbert)	Bairdiella/Croaker
Tilapia mossambica (Peters)	Mozambique mouthbrooder
Tilapia zillii (Cervais)	Redbelly tilapia

Nongame Fishes

Cyprinodon macularius (Baird & Girard)	Desert pupfish
Gillichthys mirabilis (Cooper)	Longjaw mudsucker
Gambusia affinis affinis (Baird & Girard)	Mosquitofish
Dorosoma petenense (Gunther)	Threadfin shad
Poecilia latapinna (Le Sueur)	Sailfin molly
Cyprinus carpio Linnaeus	Common carp

In 1961, Walker reported on the probable origin of several nongame species introductions into the Salton Sea. These include the threadfin shad, Dorosoma petenense, the longjaw mudsucker, Gillichthys mirabilis, and the mosquitofish, Gambusia affinis affinis (Table 1). Another species, the sailfin molly, Poecilia latapinna became established in several irrigation drains in the mid-1950's as a result of escapees from local tropical fish hatcheries (St. Amant, Fishery Biologist, Calif. Fish and Game, pers.

commun. 1984). The sailfin molly has since expanded its range to include the Salton Sea (Moyle 1976). All four of these introduced nongame species are found in the nearshore waters with the latter three also present in the shoreline pools. The common carp is included in Table 1 because although it does not inhabit the main body of the Sea, I have found it regularly in gill nets set within the brackish waters of the deltas of the New and Alamo Rivers. There is no reported nor known sportfishery for the carp in the Sea, so I consider it to be a nongame species.

The five introduced game fishes and their origin were discussed in the previous section and are listed in Table 1. The striped mullet was considered by Walker (1961) to be "virtually extinct" in 1961, and monthly Department gill-netting surveys from 1979-81 support the contention that this species is no longer present in the Sea. These surveys also demonstrated that the redbelly tilapia had extremely limited distribution within the Sea and that the Mozambique mouthbrooding tilapia was abundant throughout the Sea year-round and spawned in the nearshore waters.

Fishing Regulations at Salton Sea

Walker (1961) recommended "high rates of harvest" and no season closures for the three sport fish species present at that time. That management philosophy towards the Sea's sportfishery persists even today. The only regulation on the take of any of the five sportfish is a bag limit of nine on orangemouth corvina.

METHODS

The Sea has 8 marinas with boat launching facilities, several fishing jetties and numerous access points along its 95 miles of shoreline from which to shore fish or launch a car-top boat (Figure 1). Due to the large number of angler access points and limited funding for creel clerks, it was decided that the roving creel census method used by Von Geldern and Tomlinson (1973) was the most appropriate to obtain estimates of angling quality.

In formulating a sampling design, it was known that all areas could not be sampled adequately due to the great amount of travel time required to drive around (3 hours) or circumnavigate (5 hours) the Sea. Previous weekend creel census efforts conducted by Hulquist from 1963-69 (Hulquist 1981) showed that anglers fishing in the area from North Shore Marina to Red Hill Marina were representative of all areas at the Sea (Figure 1) and could be adequately censused by two creel clerks. Therefore, this geographic area was selected for sampling. Eight general sampling areas on the eastern side of the Sea were selected. These included 4 marinas and 3 fishing jetties; from north to south they were North Shore Marina, Salton Sea State Park Headquarters, Mecca Beach, Corvina Beach, Salt Creek, Bombay Beach, Niland Marina, and Red Hill Marina (Figure 1). All of the 8 sampling locations provided fishing for shore anglers and all

but one (Mecca Beach) allowed access for at least car-top boats (Figure 1).

Sampling days were randomly chosen based on the ratio of weekend days and holidays to weekdays for each month. Four major holidays were excluded from sampling -- Christmas, New Years, Easter, and Thanksgiving. Sixteen sampling days were selected each month during the 12-month census (October 1982 through September 1983). For example, if the month had 31 days, and of this 8 days were weekend days/holidays and the remaining 23 were weekdays, then the ratio of the former to the latter was approximately 3:1. Thus of the 16 days randomly selected for sampling by the creel clerks, 12 days would be weekdays and 4 days would be weekend days/holidays. The duration of a sampling day ranged from 8 to 9 hours and began approximately 0800 hours and continued until 1700-1800 hours during the late fall, winter and early spring months. Due to the extremely warm mid-day air temperatures in the late spring, summer, and early fall months that resulted in a lack of angling pressure, a routine census day was divided into two interview periods; an early morning census from 0700 hours until approximately 1200 hours and a late afternoon census beginning about 1700 hours and ending at 2000 hours. If the weather (wind or rain) did not permit censusing, then the missed sample day was made up by selection of another similar day (weekend day/holiday or weekday) during the same month. However, if the missed sample occurred near the end of the month, it was not always possible to substitute another day, so the sample was missed. Censusing was not done at night because local anglers had indicated that relatively little fishing effort occurred after dusk.

Census clerks interviewed all anglers encountered. One clerk interviewed anglers in the northern four locations and the other clerk in the southern four areas on the same day (Figure 1). Interviews were conducted by driving to the various census locations and walking the shoreline or jetty. Usually, censuses were conducted twice each day at each location -- once in the a.m. and again in the p.m.

Information obtained and recorded on census sheets for each angler censused included the following: (i) date; (ii) location; (iii) type of angler (shore, jetty, boat); (iv) number of each fish species in creel (fish kept); (v) angler's sex; (vi) county/location of residence; (vii) angler's beginning fishing time; (viii) time of interview; (ix) whether the angler was through fishing for the day, and (x) the number of anglers in the group. In addition, the total length (TL) of orangemouth corvina, bairdiella and tilapia and the fork length (FL) of sargo in millimeters (mm) was recorded for each fish in the angler's creel. Since anglers could be encountered more than once during a sampling day, each angler or angling party initially censused that day who had not completed fishing was given a numbered card for identification purposes on subsequent interviews. For that same reason, each fish measured was given a caudal fin clip.

RESULTS AND DISCUSSION

Area of Angler Origin

Creel census interviews of approximately 12,500 Salton anglers for 26 weekend days during 1966-69 showed that 78% of of the anglers had permanent residences outside of the counties of Riverside and Imperial (Hulquist 1981). Table 2 shows that during the 1982-83 creel census, 75% of the almost 19,000 anglers lived outside of these two counties -- an insignificant change in the past 15 years. Hulquist (1981) reported that Los Angeles County anglers contributed the largest percentage of use (39%); followed by San Bernardino (15%), San Diego (14%), Riverside (12%), Imperial (10%), Orange (8%), other California counties (1%), and out of state (1%). Information from the 1982-83 (Table 2) census shows that there have not been any major changes in the origin of angler use at the Sea since 1966-69. A shift toward increased use was detected for California anglers residing further away than the six southern counties within a 2 to 3 hour drive of the Sea; 8% of the 1982-83 anglers were from these other California counties as compared to only 1% during 1966-69 (Hulquist 1981). Angler use at the Sea each month by residents of the six southern counties is quite variable as evidenced by the variation in use by Los Angeles County residents -- 29% of the total use in December of 1982 as compared to 55% in September of 1983.

Angler Categories

Anglers were apportioned into three distinct categories: shore, jetty, and boat. Each of the three angler types were capable of catching any of the five sportfish in the Sea. The 10,993 shore anglers censused during the year made up the biggest percentage (58%) of anglers from any of the categories (Figure 2). Shore angler use was the lowest in August 1983 (406) and the highest in April (1,729) of the same year. Twenty-five percent (4,748) of the anglers encountered by creel clerks fished from jetties. The month of heaviest use was February 1983 (656 anglers), while the month of least use was again August (92 anglers). The 3,312 boat anglers who were censused made up 17% of the total anglers interviewed. The percentage of boat anglers censused to shore and jetty anglers censused probably gives a biased picture (on the low side) of relative boat angler use at the Sea due to the roving land clerk having less of a chance of encountering a boat fisherman than the stationary-type of fisherman (jetty and shore). Creel clerks censused the most boat anglers in November 1982 (647) and April 1983 (640), while the least number were interviewed in July 1983 (26). From Figure 2 it is apparent that relative use of the Sea by all angler groups is greatest during the fall, late winter, and early spring months. This is probably a result of more favorable climatic conditions occurring at that time of year rather than a measure of the quality of the fishing.

Table 2. Area of Origin for Anglers Using the Salton Sea Creel Census - October 1982 through September 1983

Origin Area	Los Angeles Co.		San Diego Co.		Riverside Co.		San Bernardino Co.		Imperial Co.		Orange Co.		Other Calif. Co.		Out of State		Foreign country		Total Anglers
Months	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Oct.	977	44	259	12	361	16	275	12	105	5	67	3	106	5	55	2	---	---	2205
Nov.	919	42	317	14	318	14	281	13	129	6	92	4	75	3	45	2	14	<1	2190
Dec.	315	29	136	13	196	18	132	12	84	8	21	2	117	11	67	6	8	<1	1076
Jan.	351	32	65	6	162	15	152	14	31	3	26	2	246	22	59	5	3	<1	1095
Feb.	590	31	203	11	308	16	173	9	132	7	108	6	269	14	92	5	9	<1	1884
Mar.	648	30	253	12	327	15	186	8	344	16	68	3	267	12	75	3	11	<1	2179
Apr.	862	33	434	16	430	16	333	13	218	8	136	5	185	7	43	2	1	<1	2642
May	681	37	236	13	292	16	241	13	111	6	114	6	109	6	44	2	---	---	1828
June	578	40	149	10	262	18	161	11	140	10	62	4	75	5	8	<1	---	---	1435
July	371	38	104	11	282	29	99	10	94	10	15	2	16	2	---	---	---	---	981
Aug.	250	47	48	9	147	28	30	6	34	6	18	3	---	---	2	<1	---	---	529
Sept.	502	55	56	6	184	20	75	8	50	5	16	2	31	3	6	<1	---	---	920
Total No.	7044		2260		3269		2138		1472		743		1496		496		46		*18,964
% of Total yr.	37		12		17		11		8		4		8		3		<1		

*This total differs from total number of anglers in Table 4 due to missing angler origin information for 89 anglers

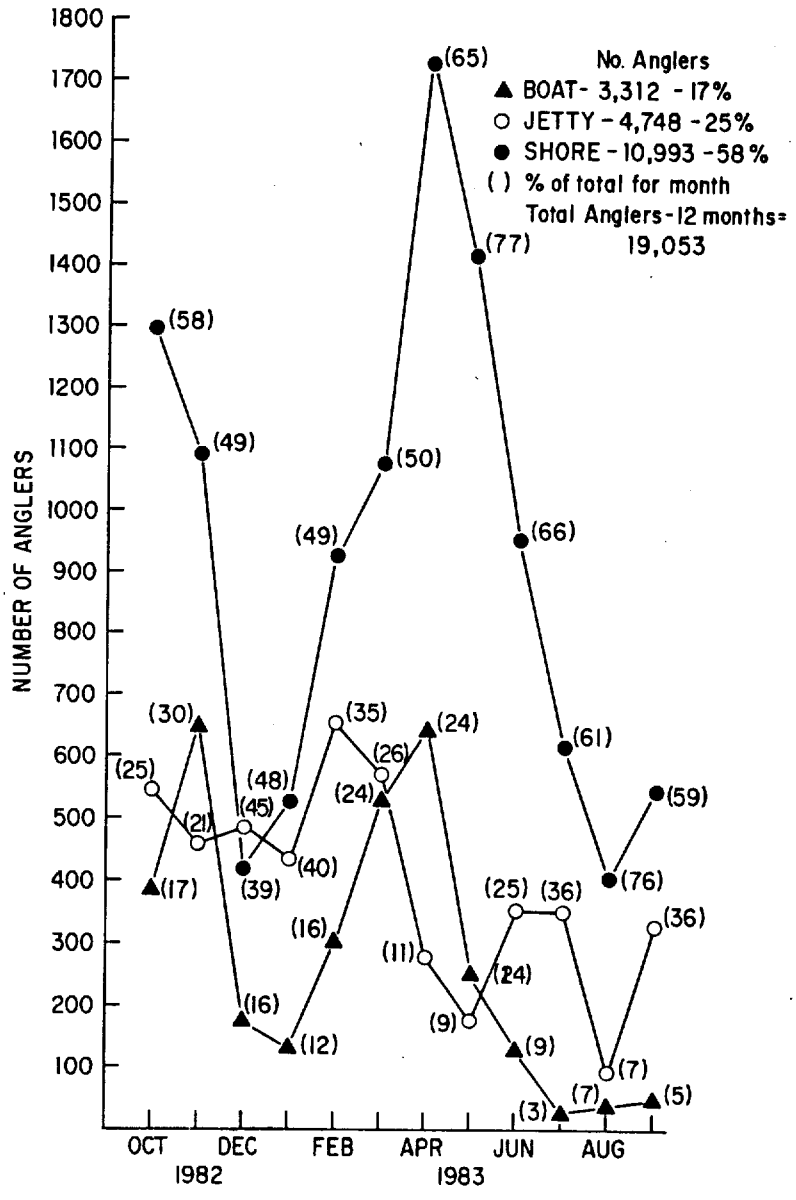

FIGURE 2. Number of boat, jetty, and shore anglers interviewed each month during Salton Sea creel census -- October 1982 through September 1983.

Average Duration of Angler Day

Completed trip information was used to determine the average length of an angler day for each angler category (Table 3). Jetty anglers spent the most time fishing per day, an average of 5.0 hours, but the monthly values varied the most, from 2.4 to 6.7 hours. Shore and boat anglers had similar mean values for the average length of a completed fishing day, 4.2 hours and 4.4 hours, respectively. The monthly average shore angler day fluctuated between 3.1 hours and 4.8 hours, while the average boat angler day ranged between 2.8 hours and 6.6 hours per month.

Table 3. Average Duration of a Completed Angler Day by Category and Month During Salton Sea Creel Census 1982-83

Month	No. completed trips by angler type	No. Hrs. Fished	Avg. No. Hrs. Fished
Oct.	Shore - 104	500.75	4.8
	Boat - 240	1103.25	4.6
	Jetty - 69	417.75	6.0
Nov.	Shore - 86	280.75	3.3
	Boat - 350	1583.50	4.5
	Jetty - 34	152.75	4.5
Dec.	Shore - 22	97.00	4.4
	Boat - 99	405.00	4.1
	Jetty - 25	59.00	2.4
Jan.	Shore - 36	163.00	4.5
	Boat - 53	147.50	2.8
	Jetty - 26	125.75	4.8
Feb.	Shore - 65	202.50	3.1
	Boat - 130	459.00	3.5
	Jetty - 54	274.50	5.1
Mar.	Shore - 56	258.50	4.6
	Boat - 383	1752.75	4.6
	Jetty - 111	570.00	5.1
Apr.	Shore - 50	215.00	4.8
	Boat - 299	1425.25	4.3
	Jetty - 21	98.00	6.7
May	Shore - 34	224.50	4.4
	Boat - 68	302.25	6.6
	Jetty - 9	30.50	3.4
June	Shore - 0		
	Boat - 12	59.75	5.0
	Jetty - 0		
July	No Information Recorded		
Aug.	No Information Recorded		
Sept.	Shore - 43	120.50	3.2
	Boat - 18	58.50	2.8
	Jetty - 54	308.00	5.7
All Year	Shore - 496	2062.50	4.2
	Boat - 1652	7296.75	4.4
	Jetty - 403	2036.25	5.0

Species Composition of Catch by Angler Category

Boat Anglers

Interviews of boat anglers showed that they caught 29,564 fish in 15,177 hours of fishing for a success rate of 1.95 fish per hour during the 1982-83 census. The 13,263 mouthbrooding tilapia caught by boat anglers during the census comprised 45% of the total sportfish catch by this angler category (Figure 3).[1] This fish accounted for as much as 77% (November 1982) and as little as 8% (March 1983) of the total monthly catch. Peak months for the catch of tilapia by boat anglers were October and November of 1982 when 2,624 and 6,857 fish were creeled, respectively. The lowest catches were recorded from July through September 1983 when less than 100 tilapia were caught in each of these months. The low catches during these months appear to be a result of the decreased fishing pressure from boat anglers (Figure 2). Tilapia were the most numerous sportfish caught by boat anglers in half of the months sampled.

The second most numerous fish in the boat anglers' creel was the sargo, which accounted for 8,683 fish and 29% of the overall catch (Figure 3). From December 1982 through April 1983 sargo made up 35% to 57% of the monthly catch and for February, March, and April it was the most numerous of the four sportfish caught by boat anglers. The largest numbers of sargo were taken in October and November of 1982 and February and March of 1983. Sargo were creeled in the lowest numbers from May through September when the fishing pressure from boat anglers was the lowest (Figure 2).

The catch of bairdiella ranked third in the total catch by boat fishermen -- 5,939 fish made up 20% of the year's catch (Figure 3). The boat anglers' catch was very low during the months of November through January when a total of only 231 bairdiella were creeled; bairdiella contributed to no more than 3% of the total sportfish catch in these months. Beginning in February and continuing through June there was an overall trend toward an increase in the catch of bairdiella, with the highest catches occurring in May (1,488 fish) and June (1,171 fish). During these two months, bairdiella comprised 58% and 59%, respectively, of the boat anglers' total sportfish catch.

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1) No redbelly tilapia were identified from the anglers catch during the census. It appears that they may no longer provide a sportfishery in the Sea. All subsequent references to tilapia in this report are for the Mozambique mouthbrooder, hereafter referred to as tilapia.

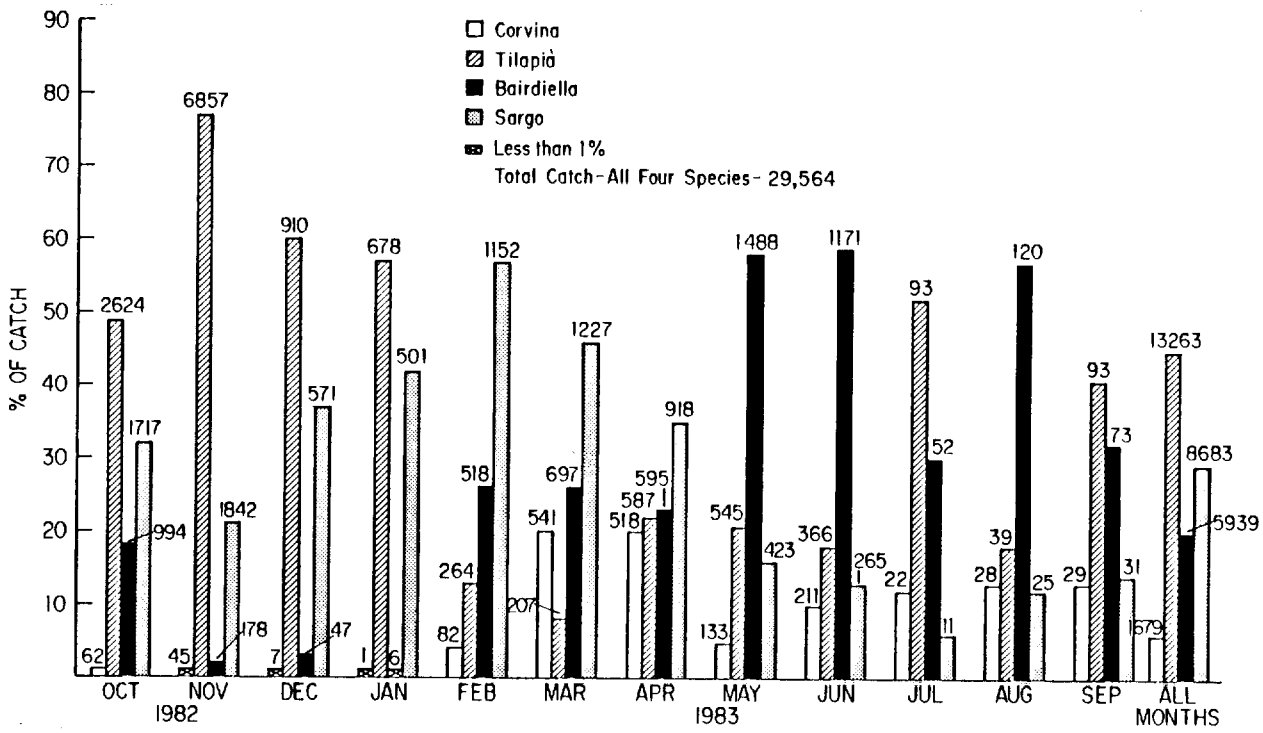

FIGURE 3. Species composition (percent and numbers) of sportfish caught by boat anglers each month during Salton Sea creel census -- October through September 1983.

The least abundant fish creeled by boat anglers during the 12 month census was the corvina. This fish numbered 1,679 and accounted for only 6% of the boat anglers' catch during the year (Figure 3). From October through January corvina made up 1% or less of the total monthly catch of sportfish -- only 115 fish were sampled during this time period. Boat fishermen caught the most corvina in March (541) and April (518) when this fish comprised 20% of the catch each month. Only 79 corvina were censused from the boat anglers' creel during July through September, probably due to very low fishing pressure from this group of anglers (Figure 2).

Jetty Anglers

The census of jetty anglers demonstrated that 36,014 fish were caught in 18,156 hours of angling, for an average success rate of 1.98 fish per hour. The most numerous fish caught by jetty anglers during the year-long creel census was the sargo; 13,336 sargo comprised 37% of the sportfish kept by this angler group (Figure 4). Sargo ranked as the most abundant sportfish caught by jetty anglers during half of the months censused. Jetty anglers caught 1,000 or more sargo in seven of the 12 months; the highest catches were in February (2,075 fish), June (2,035 fish), and July (1,805 fish). The

percentage of sargo in the monthly catch by jetty fishermen ranged from 16% (March) to 81% (November). The catch of sargo by jetty anglers was more consistent throughout the year than that by boat anglers.

Bairdiella was the second most abundant fish caught by jetty anglers; 11,455 bairdiella contributed to 32% of the total censused catch (Figure 4). Jetty angler catches of bairdiella totalled more than 2,000 fish in March (2,809 fish), June (2,920 fish), and July (2,063 fish) and was the most numerous sportfish in their catch during March and May. This fish made up as much as 71% of the monthly catch (May) and for three months as little as 3% or less (November through January). In this latter time period only 45 bairdiella were censused from the jetty anglers' creel; the extremely low catch of bairdiella during these months was also evident in the boat anglers' catch.

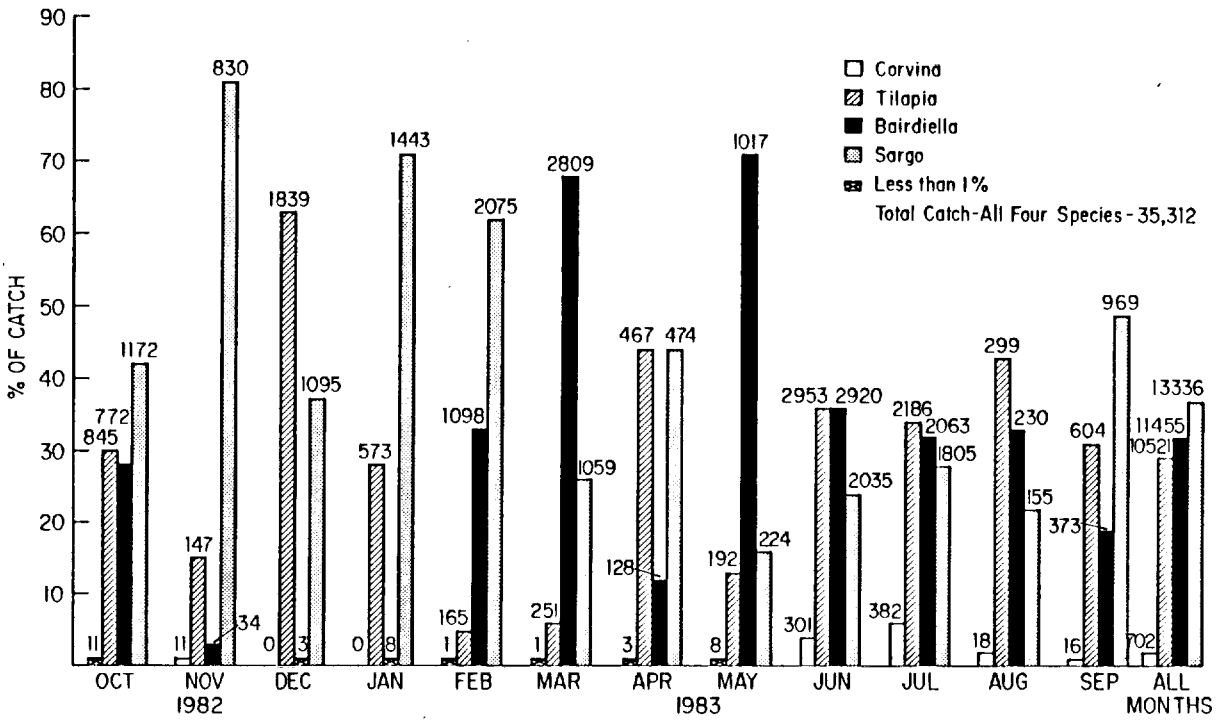

FIGURE 4. Species composition (percent and numbers) of sportfish caught by jetty angler each month during Salton Sea creel census -- October 1982 through September 1983.

The catch of tilapia ranked third in the censused annual take of sportfish by jetty anglers; 10,521 tilapia comprised 29% of the sportfish catch (Figure 4). Tilapia were the most abundant sportfish in the jetty anglers' catch during four of the months sampled (December, June-August); more than 1,000 tilapia were caught in December (1,839), June (2,953), and July (2,186). This species made up as much as 63% (December) and as little as 5% (February) of the sportfish caught during

a month. With the exception of January through April when tilapia catches were consistently low, the catch of tilapia by jetty anglers was sporadic.

As in the sportfish catch by boat anglers, corvina were the least numerous fish taken by jetty anglers; the 702 corvina they caught represented only 2% of the censused sportfish catch by this category of angler (Figure 4). Corvina comprised 1% or less of the sportfish catch for 9 of the 12 months sampled. The highest catches were recorded in June (301) and July (332) by jetty anglers.

Shore Anglers

Interviews of shore anglers revealed that they creeled 37,723 fish in 37,423 hours of fishing for an average annual success rate of 1.01 fish per hour. Tilapia (18,300 fish) comprised almost one half (49%) of the 37,723 sportfish caught by shore anglers during the census (Figure 5). They were the most numerous of the four sportfish in the shore anglers' catch in all but 3 of the 12 months sampled (March, April, and July) and made up 50% or more of the catch in half of the months censused. The lowest shore angler catches of tilapia occurred from November through April -- this was also evident in the jetty angler catches of this fish. The highest catches of tilapia by shore anglers occurred from May through September: somewhat similar to the months of highest catch by jetty anglers.

The bairdiella ranked as the next most numerous sportfish in the shore anglers' catch, accounting for 11,640 or 31% of the total catch during the census (Figure 5). Shore anglers caught the most bairdiella from April through August when 89% of the total annual catch was made; conversely, October through March accounted for only 11%. This trend in the high and low catches of bairdiella was exhibited in some but not all of the monthly catches by boat and jetty anglers.

The third most numerous fish in the shore anglers' catch for the year was sargo; the 7,202 sargo comprised 19% of the total catch (Figure 5). Approximately 52% of these sargo were caught during the months of June and July. This is contrary to the peak catch months for boat and jetty anglers of December through April.

As occurred in the sportfish catch by boat and jetty anglers, the least numerous fish creeled by shore fishermen was the corvina; it accounted for only 1% (581 fish) of the censused catch during the year (Figure 5). Eighty-six percent of these fish were caught during the months of June and July, the same months as when jetty anglers caught the most corvina.

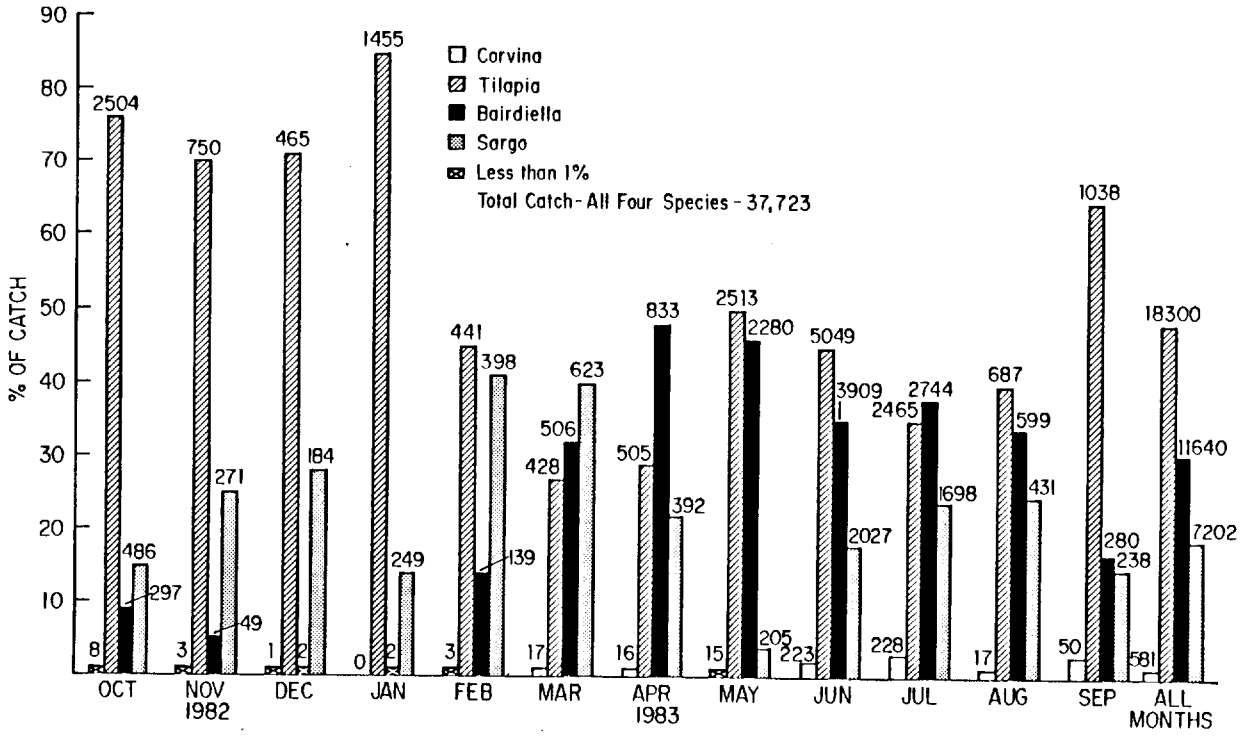

FIGURE 5. Species composition (percent and numbers) of sportfish caught by shore anglers each month during Salton Sea creel census -- October 1982 through September 1983.

Catch Rates by Angler Category and Species

Boat Anglers

Boat anglers were most successful in catching tilapia at an average rate of 0.88 fish per hour over the 12 month census (Figure 6). This success rate was the highest reported by any of the three angler groups for any of the four sportfish caught in the Sea (Figures 6-8). Monthly catch rates for tilapia by boat anglers fluctuated widely; they ranged from a low of 0.08 fish per hour (March) to a high of 2.28 fish per hour (November). Figure 6 shows that catch rates for tilapia were very high from October through January, extremely low from February through April, and rose somewhat from May through September.

Sargo ranked as the fish that boat anglers had the second most success in catching; boat anglers averaged 0.58 sargo per angler hour during the 12 month census (Figure 6). Monthly boat angler success rates ranged from 0.08 fish per hour (July) to 1.08 fish per hour (January), with the greatest amount of success achieved during the months of October through February.

Boat anglers averaged 0.39 bairdiella per hour of fishing during the census with success rates ranging from

0.01 fish per hour (January) to 1.42 (June) fish per hour (Figure 6). Overall, boat anglers appeared to have more success per hour of fishing in catching bairdiella during the late spring and summer months than during the winter and early spring.

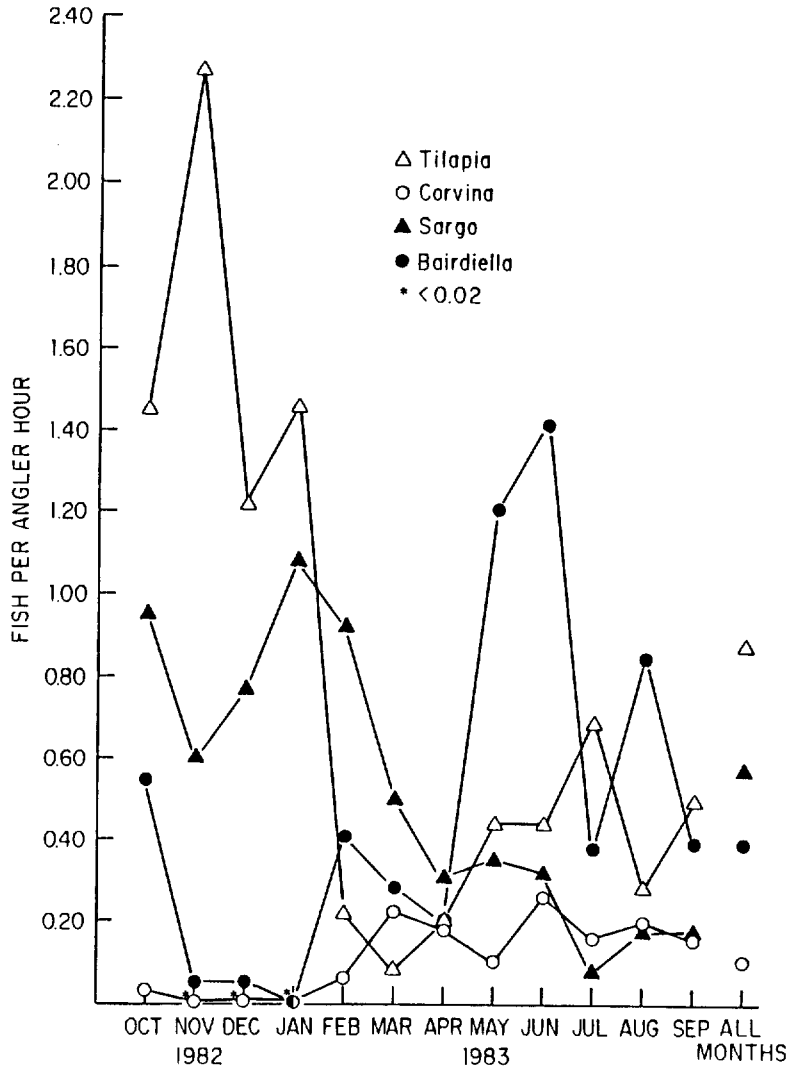

FIGURE 6. Boat angler catch per hour for Salton Sea sportfish during 1982-83 creel census.

Corvina were caught with the least amount of success by boat fishermen at an annual rate of 0.10 fish per hour (Figure 6). However, this was the highest annual success rate by any of the three angler groups in the creel of corvina (Figures 6-8). Monthly success rates for corvina ranged from 0.001 fish per hour (December) to 0.26 fish per hour (June); boat anglers were the most successful in the time they spent fishing for corvina during the months of March through September.

Jetty Anglers

The sportfish caught with the most success by jetty anglers was the sargo, with an average catch per angler hour

of 0.73 fish for the entire year (Figure 7). Monthly success rates ranged from 0.25 (May) to 1.41 (July) sargo per angler hour. Overall, jetty anglers were more successful in catching sargo than either boat or shore anglers (Figures 6-8). Figure 7 shows that the highest success rates were attained January-February and June-July.

Jetty anglers caught bairdiella at an average annual success rate of 0.64 fish per angler hour (Figure 7). This was the highest success rate obtained by any of the three angler categories in catching bairdiella (Figures 6-8). Jetty angler success rates for bairdiella fluctuated widely -- they ranged from 0.002 fish per hour (December) to 1.69 fish per hour (June). The highest monthly success rates for the capture of bairdiella were shown to be in March, and May through August. Boat anglers also had the highest success in the capture of bairdiella during these latter months.

Tilapia ranked third in jetty angler catch success with an average rate for the year of 0.54 fish caught per hour of fishing (Figure 7). Catch rates for tilapia varied widely from 0.08 (February) to 1.72 (June) fish per hour and were highest in December and June through August. Jetty anglers achieved the least success in the creel of tilapia when compared with both boat and shore anglers (Figures 6-8).

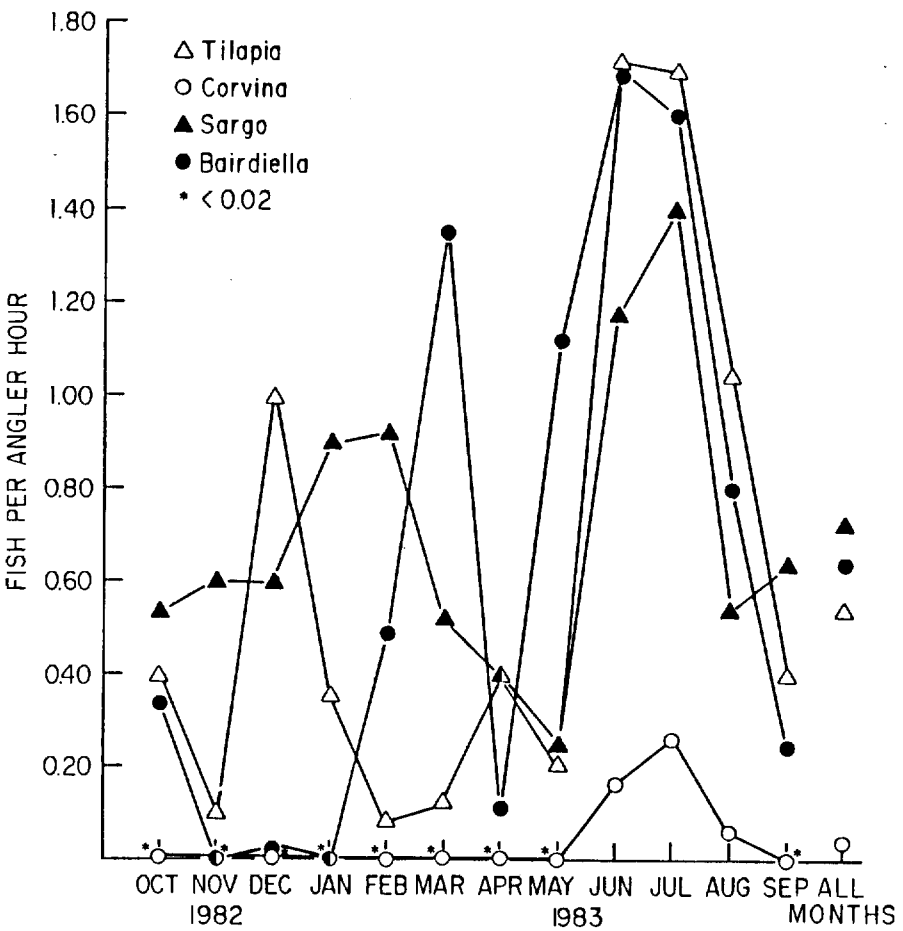

FIGURE 7. Jetty angler catch per hour for Salton Sea sportfish during 1982-83 creel census.

Anglers who fished from jetties were the least successful in the catch of corvina, averaging only 0.04 corvina per hour of fishing during the census (Figure 7). This rate of success for corvina ranked between that achieved by boat (0.10) and shore (0.01) anglers (Figures 6-8). Success rates varied from no success (December and January) to 0.26 corvina per angler hour (July). The highest catch rates by jetty anglers for corvina occurred during the summer months (June through August).

Shore Anglers

Of the four sportfish, tilapia were caught with the highest degree of success by shore anglers. They were caught at an annual rate of 0.58 tilapia per angler hour; monthly rates ranged from 0.08 (April) to 1.31 (June) fish per hour (Figure 8). Success rates were highest in January, and June through September. These are similar to the success rates of jetty anglers in their catch of tilapia (Figure 7).

Shore anglers were not as accomplished in catching bairdiella as boat and jetty anglers -- they were brought into the creel at a rate of 0.31 fish per hour (Figure 8). Monthly rates of success for bairdiella varied from 0.001 (January) to 1.07 (July) fish per hour. The lowest catch rates were from October through January, which is fairly consistent with the months of lowest rate of success for boat and jetty anglers. June and July were the months of greatest shore angler success and this was somewhat comparable to the peak months for boat and jetty angler success for this fish.

Sargo ranked third in the average annual catch rates for fish caught by shore anglers; they were caught at a rate of 0.18 fish per hour (Figure 8). This was the lowest catch rate reported for sargo by any of the three angler categories. Catch rates fluctuated very little for the eight months from October 1982 through May 1983, when rates ranged from 0.04 to 0.16 sargo per hour. Shore angler catch rates for sargo were relatively constant compared to rates by boat and jetty anglers. Success rates were highest from June through August, as they were for jetty anglers (Figures 6 and 7).

Shore anglers were the least successful of the three categories of anglers in the catch of corvina -- their annual success rate for corvina was 0.01 (Figure 8). Monthly rates varied from no success (January) to 0.09 corvina per hour in July. The months of the highest shore angler catch rates were June and July; the same months of high success as for jetty anglers (Figure 7).

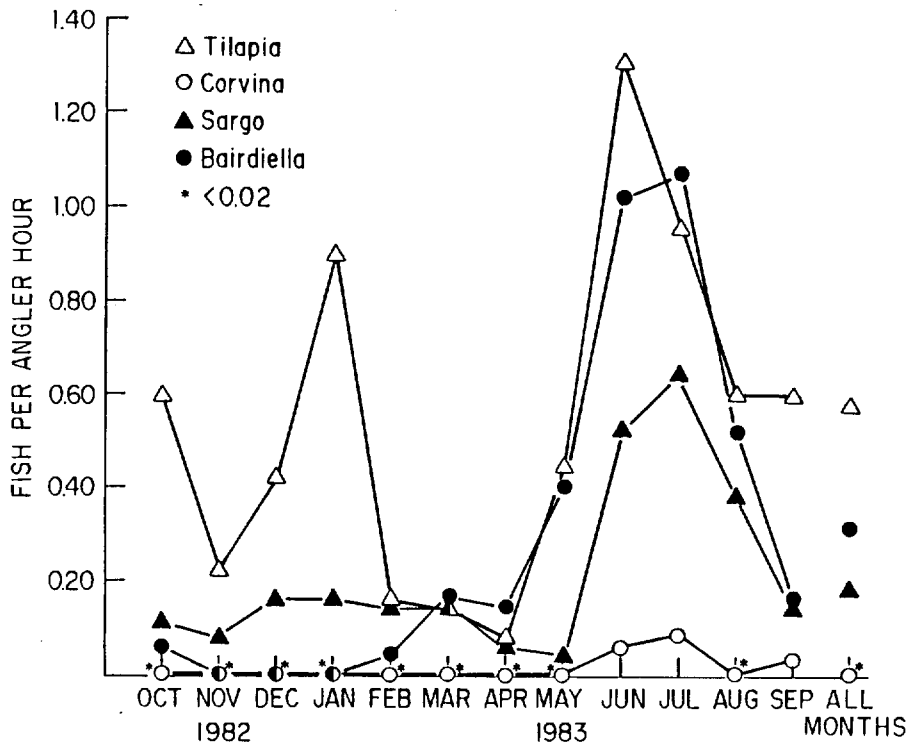

FIGURE 8. Shore angler catch per hour for Salton Sea sportfish during 1982-83 creel census.

Combined Angler Use, Catch, Effort, and Success By Month

Census clerks interviewed 19,053 anglers from October 1982 through September 1983, who fished 70,756 hours and caught 103,301 sportfish for an annual catch rate of 1.46 fish per angler hour (Table 4). Sampling was conducted on 190 days, of which 133 were weekdays and 57 were weekends and holidays.

Table 4 shows that the majority of angling use (anglers) and effort (angler hours) (53% and 54%, respectively) was expended during the five months of February through June. Forty-five percent of the angler use and 46% of the fishing effort occurred during interviews conducted on weekends and holidays (not in a table or graph). More than half (56%) of the total censused sportfish catch by all anglers was creeled during the months of June, July, October and November.

Forty-one percent of the total sportfish catch by all anglers was made up of mouthbrooding tilapia during 1982-83 (Table 4). The months of June, July, October, and November contributed to 64% of the tilapia caught, while February and

March made up only 4%. Water temperatures as low as 12°C caused a massive die-off of tilapia during February and March of 1982 and probably was responsible for the extremely low catches those months (G. Black, Calif. Dept. Fish Game, Region 5 memorandum 3/16/83). The months of highest angler success (catch per angler hour) corresponded to the months of the largest (numbers) catches, with the reverse also true for low success rates and catches. Monthly catch rates for tilapia by all angler categories ranged from 0.11 fish per hour (March) to 1.16 fish per hour (June); the annual catch rate for tilapia during the census was 0.60 fish per hour.

Bairdiella and sargo each made up 28% of the total sportfish catch by all angler categories during the year and each had an annual catch rate of 0.41 fish per angler hour (Table 4). Bairdiella were caught in the greatest numbers (23,512) during the months of March through July; the catch during these five months comprised 80% of the total bairdiella catch. The months of peak catch seem to coincide with the inshore movement of bairdiella for spawning (Walker 1961). The poorest catches of bairdiella occurred from November through January when only 329 fish were tallied by census clerks, and comprised 1% of the total annual catch. Combined angler catch rates for bairdiella fluctuated between 0.02 (December) and 1.38 (June) fish per angler hour. Angler catches of sargo (numbers) showed no seasonal trend as did bairdiella or tilapia. The months of highest catch for sargo were February, June, July, and October; 14,841 sargo creeled during these months accounted for 51% of the catch. The fewest sargo were censused during May (852) and August (611) and together made up only 5% of the catch. Compared to the other sportfish, the catch rates for sargo during the census period were relatively stable, fluctuating from 0.21 (May) to 0.72 (July) fish per angler hour.

The 2,962 corvina tallied from the boat, jetty and shore anglers' catch during the census comprised 3% of the total censused sportfish catch (Table 4). The highest catches of corvina occurred from March through July when 87% of the corvina were caught. Unusually high winds and rain probably contributed to the meager catch in August and September; most local fishermen consider these to be two of the best months for corvina. The catch rates for these two months indicate that if the weather had been better, the catches might have been higher. Catch rates were highest from March through September; catch per angler hour values during this time ranged from 0.04 to 0.17 corvina per angler hour. The annual angler success rate for corvina was 0.04 fish per hour. Black (1974) reported that partyboat fishermen at the Sea from 1962-72 encountered the most success in the creel of corvina from July through October each year. As with bairdiella, the increase in the angler's take of corvina seems to coincide with the inshore movement of this fish and the onset of the spawning season (Calif. Dept. Fish Game, unpub. data).

Table 4. Summary of Salton Sea Angler Use, Catch, and Effort by Month From October 1982 Through September 1983

Months	No. Anglers	No. Hrs. Fished	No. Fish	No. ORC	ORC per Angler Hr.	No. TIL	TIL per Angler Hr.	No. BAR	BAR per Angler Hr.	No. SAR	SAR Per Angler Hr.
Oct.	2,218	8286.75	11,492	81	0.01	5,973	0.81	2,063	0.32	3,375	0.53
Nov.	2,190	7827.25	11,017	59	0.01	7,754	0.86	261	0.03	2,943	0.43
Dec.	1,082	3717.75	5,124	8	0.002	3,214	0.86	52	0.02	1,850	0.51
Jan.	1,095	3658.00	4,916	1	0.0003	2,706	0.91	16	0.01	2,193	0.71
Feb.	1,884	6201.00	6,336	86	0.02	870	0.15	1,755	0.32	3,625	0.67
Mar.	2,180	7974.75	8,366	559	0.07	886	0.11	4,012	0.60	2,909	0.40
Apr.	2,648	10082.75	5,436	537	0.06	1,559	0.23	1,556	0.15	1,784	0.26
May	1,846	7662.25	9,043	156	0.04	3,250	0.37	4,785	0.92	852	0.21
June	1,450	6394.00	21,430	735	0.16	8,368	1.16	8,000	1.38	4,327	0.68
July	1,000	3975.75	13,699	582	0.17	4,744	1.12	4,859	1.02	3,514	0.72
Aug.	536	1571.75	2,648	63	0.09	1,025	0.64	949	0.73	611	0.36
Sept.	924	3403.75	3,794	95	0.06	1,735	0.50	726	0.27	1,238	0.32
Total	19,053	70,756	103,301	2,962	0.04	42,084	0.60	29,034	0.41	29,221	0.32

Total No. Fish Per Angler Hour - All Species 1.46

Species Composition of Catch and Angler Success Rates by Area

Monthly catch rates for corvina showed no discernible pattern when analyzed by catch locations (Table 5). Angler success varied greatly between areas within the same month and also within a specific area from one month to the next. Area 8 in the southern end of the Sea (Figure 1) had the highest angler success rate for corvina (0.085), while Areas 6 and 7, also in the southern part, had the lowest rates (0.012 and 0.006, respectively). Success rates for corvina within Area 8 may be misleading because 97% of the fish counted there were caught by boat anglers who could have caught these fish in other areas of the Sea. In comparison, Area 2, the next best area for angler success in the catch of corvina, had only 36% of the corvina landed by boat anglers. Seventy-four percent of the total censused corvina catch came from Areas 2 and 8 (37% from each area).

Table 5. Orangemouth Corvina Catch and Catch Per Hour by Month and Area - All Angler Categories

	Area 1				Area 2			
Month	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	17	2	0.022	2	50	1	0.019	3
November	6	4	0.005	3	10	2	0.003	5
December	--	8	--	8	--	8	--	8
January	--	8	--	8	--	8	--	8
February	--	8	--	8	3	2	0.001	2
March	2	5	0.018	3	24	2	0.014	4
April	33	4	0.084	2	145	2	0.041	4
May	4	5	0.027	5	60	1	0.021	6
June	18	5	0.040	7	442	1	0.199	3
July	10	7	0.312	2	309	1	0.476	1
August	--	8	--	8	26	1	0.096	1
September	--	8	--	8	32	1	0.090	2
All Months	90	6	0.027	5	1101	1	0.049	2
	Area 3				Area 4			
October	--	8	--	8	3	4	0.017	4
November	--	8	--	8	1	6	0.001	6
December	--	8	--	8	--	8	--	8
January	--	8	--	8	--	8	--	8
February	--	8	--	8	--	8	--	8
March	--	8	--	8	4	4	0.013	5
April	1	6	0.037	5	47	3	0.174	1
May	--	8	--	8	14	4	0.152	2
June	15	6	0.075	6	125	2	0.078	5
July	9	8	0.057	4	182	2	0.259	3
August	--	8	--	8	2	5	0.005	3

September	8	4	0.038	4	31	2	0.024	6
All months	33	7	0.034	4	409	3	0.039	3
		Area 5				Area 6		
October	7	3	0.030	1	1	5	<0.001	6
November	3	5	0.010	1	31	1	0.041	1
December	1	2	0.001	2	--	8	--	8
January	1	1	0.050	1	--	8	--	8
February	--	8	--	8	1	3	<0.001	3
March	5	3	0.030	2	2	5	0.006	6
April	4	5	0.008	6	--	8	--	8
May	--	8	--	8	28	3	0.150	3
June	54	4	0.110	4	2	8	0.020	5
July	22	3	0.039	7	22	3	0.043	5
August	4	4	0.037	3	5	3	0.032	4
September	5	5	0.031	5	1	7	0.007	7
All Months	106	4	0.013	6	93	5	0.012	7

	Area 7				Area 8			
Months	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	--	8	--	8	3	4	0.003	5
November	--	8	--	8	8	3	0.004	4
December	--	8	--	8	7	1	0.008	1
January	--	8	--	8	--	8	--	8
February	--	8	--	8	82	1	0.058	1
March	--	8	--	8	522	1	0.119	1
April	--	8	--	8	307	1	0.072	3
May	3	6	0.040	4	47	2	0.251	1
June	9	7	0.500	1	70	3	0.201	2
July	13	6	0.019	8	15	5	0.037	6
August	1	6	0.007	5	25	2	0.077	2
September	4	6	0.039	3	14	3	0.047	2
All Months	30	8	0.006	8	1100	2	0.085	1

The highest annual success rates for tilapia were achieved by anglers who fished in the three most northern areas censused; annual catch rates in these three areas ranged from 0.710 tilapia per angler hour (Area 2) to 1.097 tilapia per angler hour (Area 1, Table 6). These three areas ranked as the areas of greatest angler success for tilapia in 8 of the 12 months censused. Forty-nine percent of the annual catch of tilapia came from these areas; reasons for this are not known. Area 2 ranked as the best producer (numbers) of tilapia to the angler's creel in 10 of the 12 months sampled; 38% of the tilapia catch for the year was from this area. Monthly angler success rates for tilapia showed no general trends or patterns within or between geographic areas.

Table 6. Tilapia Catch and Catch Per Hour by Month and Area - All Angler Categories

Month	Area 1 Catch	Rank	Catch/hr	Rank	Area 2 Catch	Rank	Catch/hr	Rank
October	780	4	1.525	2	1237	2	0.771	5
November	1104	3	1.235	2	4174	1	1.611	1
December	238	3	1.149	2	595	2	0.742	4
January	500	2	3.607	1	1606	1	1.289	2
February	30	4	0.050	5	674	1	0.392	1
March	6	7	0.021	7	446	1	0.189	3
April	60	5	0.124	5	732	1	0.318	2
May	134	6	0.421	5	840	1	0.347	6
June	586	7	0.788	6	2733	1	1.307	2
July	142	8	2.390	2	1942	1	2.992	1
August	14	6	3.500	1	433	1	0.947	3
September	14	8	0.325	5	514	1	0.265	7
All Months	3608	5	1.097	1	15926	1	0.710	3
	Area 3				Area 4			
October	7	8	0.114	8	89	7	0.134	7
November	3	8	0.750	6	44	7	0.536	7
December	--	8	--	8	231	4	2.110	1
January	--	8	--	8	253	4	0.783	3
February	11	6	0.047	6	47	3	0.054	4
March	--	8	--	8	47	5	0.117	4
April	--	8	--	8	31	6	0.049	7
May	8	8	1.333	1	90	7	0.197	8
June	399	8	2.007	1	1034	2	0.310	8
July	187	6	1.187	4	1298	2	1.847	3
August	52	4	1.733	2	297	2	0.796	4
September	296	3	1.440	1	198	5	0.309	6
All Months	963	8	0.989	2	3659	4	0.352	8
	Area 5				Area 6			
October	528	6	0.644	6	1193	3	2.047	1
November	361	4	0.914	4	245	5	0.328	8
December	107	5	0.181	6	50	6	0.314	5
January	10	6	0.016	6	254	3	0.426	4
February	21	5	0.031	7	7	8	0.010	8
March	19	6	0.030	6	112	4	0.043	5
April	76	4	0.111	6	280	3	0.320	1
May	665	3	0.840	2	325	5	0.287	7
June	1005	3	0.988	4	983	4	0.700	7
July	221	5	0.394	7	174	7	0.342	8
August	8	8	0.074	7	11	7	0.070	8
September	21	7	0.131	8	51	6	0.382	4
All Months	3042	6	0.378	7	3685	3	0.466	6

	Area 7				Area 8			
Month	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	756	5	1.060	4	1383	1	1.318	3
November	80	6	0.759	5	1743	2	0.921	3
December	2	7	0.035	7	1991	1	1.083	3
January	--	9	--	8	83	5	0.369	5
February	8	7	0.062	3	72	2	0.211	2
March	127	3	0.365	2	129	2	0.460	1
April	29	7	0.184	4	351	2	0.273	3
May	437	4	0.683	3	751	2	0.495	4
June	654	6	0.997	3	974	5	0.985	5
July	349	4	0.510	6	431	3	0.637	5
August	48	5	0.347	6	162	3	0.461	5
September	249	4	0.636	3	392	2	1.022	2
All Months	2739	7	0.586	5	8462	2	0.651	4

Areas 3, 2, and 6 ranked as the three best areas of angler success in the catch of bairdiella, with values of 0.876, 0.566, and 0.562 fish per hour, respectively (Table 7). The annual catch of bairdiella from the latter two areas contributed 59% of the catch from all 8 areas. Anglers in Area 8 were the least successful of all anglers in the annual rate of catch for bairdiella (0.074); this area ranked 7th in catch with only 3% of the total censused bairdiella catch. No discernible patterns were evident from examination of the monthly catches or success rates within or between areas.

Table 7. Bairdiella Catch and Catch Per Hour by Month and Area - All Angler Categories

	Area 1				Area 2			
Month	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	343	2	0.707	1	983	1	0.325	3
November	36	2	0.070	4	119	1	0.094	3
December	20	1	0.104	2	11	3	0.012	3
January	--	8	--	8	5	2	0.004	4
February	--	8	--	8	667	2	0.271	4
March	48	6	0.386	5	1380	2	0.555	4
April	38	6	0.066	5	662	1	0.242	3
May	156	3	0.497	3	3053	1	1.235	1
June	513	5	0.637	4	3271	1	1.506	3
July	177	7	2.765	1	1752	1	2.699	2
August	16	7	4.000	1	383	1	0.873	2
September	--	8	--	8	400	1	0.163	5
All Months	1347	6	0.410	5	12686	1	0.566	2
	Area 3				Area 4			
October	6	8	0.097	6	105	6	0.053	8

November	--	8	--	8	35	3	0.358	1
December	--	8	--	8	--	8	--	8
January	--	8	--	8	4	3	0.019	2
February	137	3	3.186	1	130	4	0.798	3
March	5	8	0.180	6	199	3	0.715	3
April	8	7	0.131	4	528	2	0.321	2
May	90	4	1.151	2	1320	2	0.474	4
June	344	7	1.730	1	1773	2	1.726	2
July	214	6	1.358	4	1174	2	1.671	3
August	24	5	0.800	4	304	2	0.815	3
September	25	6	0.121	6	51	4	0.192	3
All months	853	8	0.876	1	5623	2	0.541	3

	Area 5				Area 6			
October	110	5	0.382	2	306	3	0.250	4
November	23	5	0.105	2	20	6	0.023	5
December	12	2	0.283	1	--	8	--	8
January	1	4	0.050	1	6	1	0.009	3
February	18	6	0.067	6	776	1	0.868	2
March	74	4	0.073	7	2219	1	1.817	1
April	191	3	0.602	1	65	4	0.050	6
May	61	5	0.035	6	18	8	0.012	8
June	740	3	0.575	5	686	4	0.350	8
July	506	4	0.092	8	291	5	0.572	6
August	7	8	0.064	8	23	6	0.147	7
September	7	7	0.043	7	35	5	0.262	2
All Months	1750	4	0.217	5	4445	3	0.562	2

	Area 7				Area 8			
Month	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	24	7	0.063	7	186	4	0.183	5
November	--	8	--	8	28	4	0.014	6
December	--	8	--	8	9	4	0.011	4
January	--	8	--	8	--	8	--	8
February	24	5	0.197	5	3	7	0.002	7
March	52	5	0.880	2	35	7	0.006	8
April	8	7	0.011	8	56	5	0.016	7
May	31	7	0.030	7	56	6	0.054	5
June	451	6	0.390	6	222	8	0.385	7
July	583	3	0.853	5	162	8	0.169	7
August	64	4	0.462	5	128	3	0.390	6
September	136	2	0.853	1	72	3	0.182	4
All Months	1373	5	0.294	4	957	7	0.074	7

Table 8 indicates that sargo were caught in the largest numbers in three of the four most northern areas sampled (Areas 1, 2, and 4). Sixty-six percent of the annual sargo catch came from Area 2. Monthly catches from this area showed that it ranked first in the number of sargo caught

during each of the 12 months censused. Boat and jetty anglers caught 92% of the sargo in area 2, 30% and 62% respectively. The high catches of sargo from this area by boat and jetty anglers may be due to the close proximity of underwater and partly submerged structures (trees, buildings, powerline poles, tire reef) to jetty angler and boat angler access. Gill-netting surveys at the Sea have shown that sargo are more abundant around submerged structures than any of the other sportfish in the Sea (Calif. Dept. Fish Game, unpub. data). Annual angler success rates for sargo in the four northernmost areas ranged from 0.278 fish per hour (Area 4) to 0.860 fish per hour (Area 2), whereas rates in Areas 5 through 8 varied from 0.081 to 0.171 fish per hour.

Table 8. Sargo Catch and Catch Per Hour by Month and Area - All Angler Categories

	Area 1				Area 2			
Month	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	404	3	0.799	1	1782	1	0.600	2
November	332	3	0.532	4	1557	1	0.586	3
December	257	2	1.189	1	1363	1	0.859	2
January	121	2	0.843	2	1943	1	0.091	1
February	318	2	0.762	2	2985	1	1.173	1
March	148	2	0.549	3	2610	1	1.207	2
April	250	2	0.516	2	1334	1	0.514	3
May	84	2	0.508	1	622	1	0.236	3
June	436	3	0.845	2	2033	1	0.729	3
July	149	4	2.328	2	1754	1	2.702	1
August	3	6	0.750	1	300	1	0.643	3
September	--	8	--	8	995	1	0.364	1
All Months	2502	3	0.761	2	19278	1	0.860	1
	Area 3				Area 4			
October	6	8	0.097	7	93	6	0.047	8
November	11	8	2.750	1	109	6	1.295	2
December	--	8	--	8	31	4	0.287	4
January	2	6	0.084	6	84	3	0.498	3
February	37	7	0.538	3	65	4	0.379	4
March	19	5	1.268	1	85	3	0.412	4
April	16	6	0.571	1	79	3	0.958	6
May	4	8	0.347	2	32	5	0.011	6
June	311	4	1.564	1	890	2	0.266	5
July	199	3	1.263	4	1128	2	1.605	3
August	15	4	0.500	4	266	2	0.713	2
September	21	5	0.103	5	31	4	0.252	3
All Months	641	8	0.658	3	2893	2	0.278	4
	Area 5				Area 6			
October	88	7	0.214	6	323	4	0.431	5

November	84	7	0.176	8	266	4	0.347	6
December	27	6	0.063	6	4	7	0.025	7
January	4	5	0.151	4	2	6	0.003	7
February	49	6	0.218	6	56	5	0.230	5
March	19	5	0.020	6	21	4	0.016	7
April	64	4	0.099	5	17	5	0.103	4
May	40	4	0.022	5	16	6	0.011	6
June	220	5	0.171	6	184	6	0.094	8
July	52	7	0.092	7	38	8	0.074	8
August	1	7	0.009	7	1	7	0.006	8
September	5	6	0.031	6	2	7	0.014	7
All Months	653	7	0.081	8	930	5	0.117	6

	Area 7				Area 8			
Months	Catch	Rank	Catch/hr	Rank	Catch	Rank	Catch/hr	Rank
October	265	5	0.557	3	414	2	0.519	4
November	114	5	0.403	5	470	2	0.248	7
December	30	5	0.755	3	138	3	0.149	5
January	--	8	--	8	37	4	0.101	5
February	27	8	0.218	6	88	3	0.059	8
March	4	7	0.053	5	3	8	<0.001	8
April	3	8	0.004	7	16	6	0.004	7
May	8	7	0.007	8	46	3	0.039	4
June	111	8	0.096	7	142	7	0.274	4
July	104	5	0.152	5	90	6	0.117	6
August	5	5	0.036	6	20	3	0.059	5
September	126	2	0.360	2	58	3	0.126	4
All Months	797	6	0.171	5	1522	4	0.117	6

SPORTFISH LENGTHS AND WEIGHTS

Orangemouth Corvina

Overall, 2,951 corvina were measured during the 12 month census. These fish ranged from 15 cm to 108 cm in TL with a mean TL of 59 cm (Figure 9). Fish were not weighed; however, a length-weight relationship established from 1,634 gill-net caught fish sampled during 1979-82 was used to estimate the weight range and mean weight of corvina caught during the creel census (Calif. Dept. Fish Game, unpub. data). From this, it is estimated that the smallest corvina in the anglers' creel weighed approximately 0.035 kg, the largest approximately 12.0 kg, and the average size fish approximately 2.0 kg. More than half (55%) of the corvina caught by anglers were in the 45 cm to 60 cm TL range. Twenty-nine percent were less than 50 cm in TL, which is the approximate length at which full recruitment to the sportfishery occurs (location of mode, Figure 9). Information collected by the Department of Fish and Game from 1979-81 on the size at which sexual maturity is attained by corvina shows that approximately 83% of the males are capable of spawning by the time they reach a total length of 50 cm,

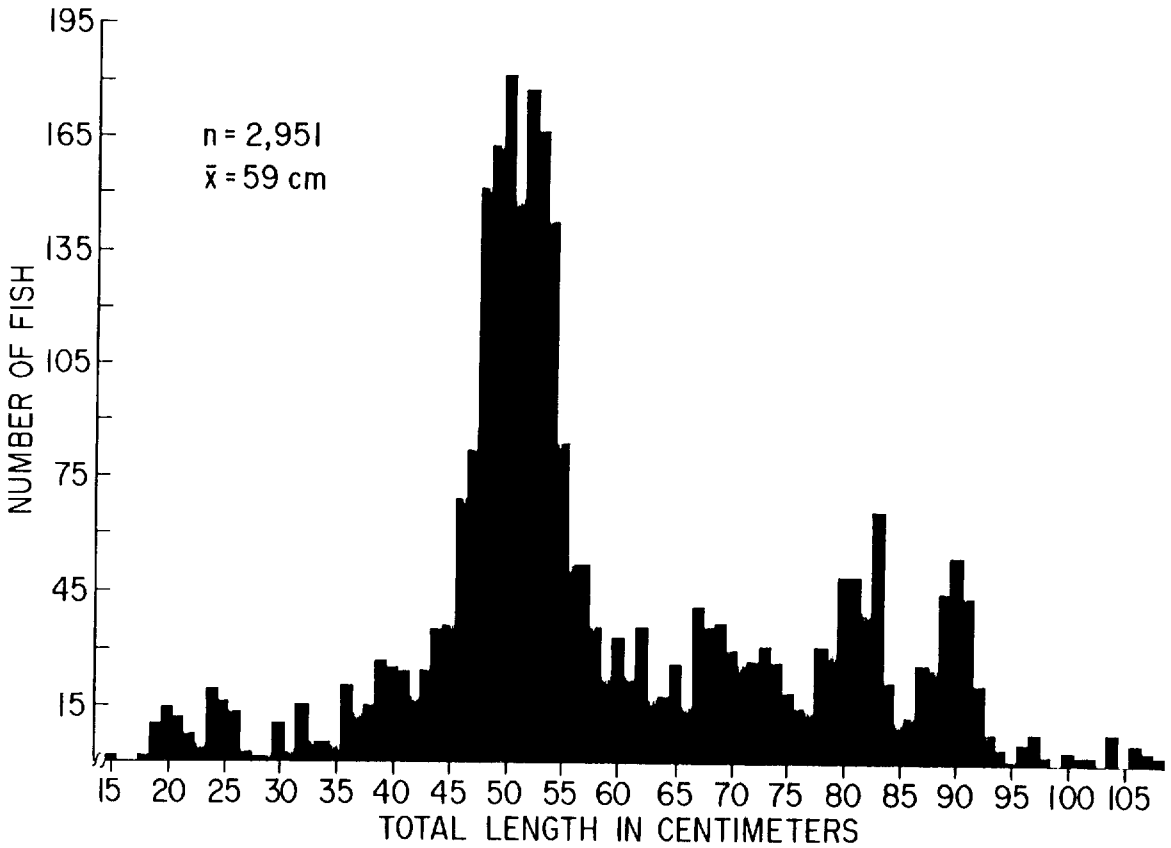

FIGURE 9. Number of corvina measured at each centimeter during 1982-83 creel census.

but only 49% of the females of the same size have this capability (Calif. Dept. Fish Game, unpub data).

Figure 10 shows that the mean length of sport caught corvina averaged 41 cm TL in October 1982 and increased to 75 cm TL by August of the following year. Corvina caught during the months of July and August were on the average 20 cm larger than those caught in June. This could be due to the movement of spawning fish closer to shore where they are more vulnerable to all categories of anglers. Unpublished Department records indicate that spawning activity by corvina of this size occurs during July and August.

Tilapia

The 33,850 tilapia measured during the creel census averaged 27 cm in TL; tilapia from 6 cm in TL to 45 cm in TL were kept by anglers (Figure 11). A length-weight relationship was determined from 1,594 tilapia sampled in gill nets from 1979-82 and was used to approximate the range and mean weight of tilapia sampled during the creel census. (Calif. Dept. Fish Game, unpub. data). It is estimated that the smallest tilapia in the anglers' catch probably weighed

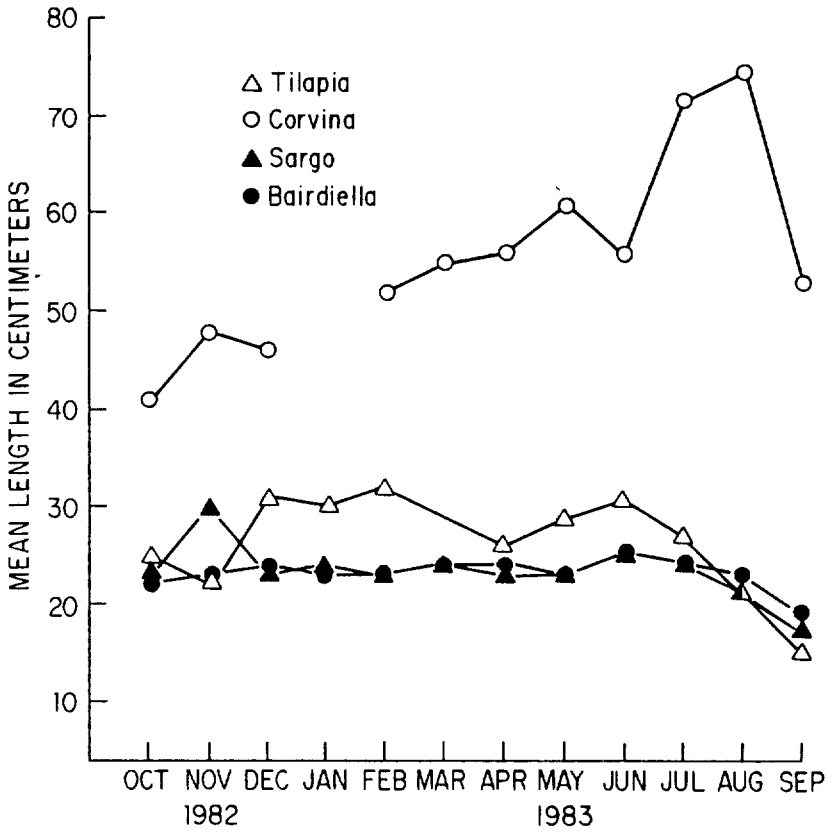

FIGURE 10. Mean length of Salton Sea sportfish measured during 1982-83 creel census.

0.005 kg, the largest tilapia 1.58 kg, and the average weighed 0.375 kg. Two distinct modes are apparent from examination of the length frequencies of sport caught tilapia, a relatively small group of fish with a mode at 13 cm in TL and a large group of tilapia with a mode at 33 cm in TL (Figure 11). Sixty-nine percent of the anglers catch of this fish was between 24.0 cm and 37.9 cm in TL. Figure 11 indicates that tilapia may not be fully recruited into the sportfishery until they are larger than 24 cm in TL. Approximately 28% of the sport anglers catch of tilapia was 24 cm or less in TL. Unpublished Department information concerning the size at which sexual maturity is attained shows that 42% of the male and 52% of the female tilapia have spawned by the time they have grown to this size. The average size tilapia caught by anglers each month was as low as 15 cm in TL during September 1983 and as high as 32 cm in TL during February of the same year (Figure 10). With the exception of September, the average size of sport-caught tilapia was greater than 20 cm during the remainder of the year.

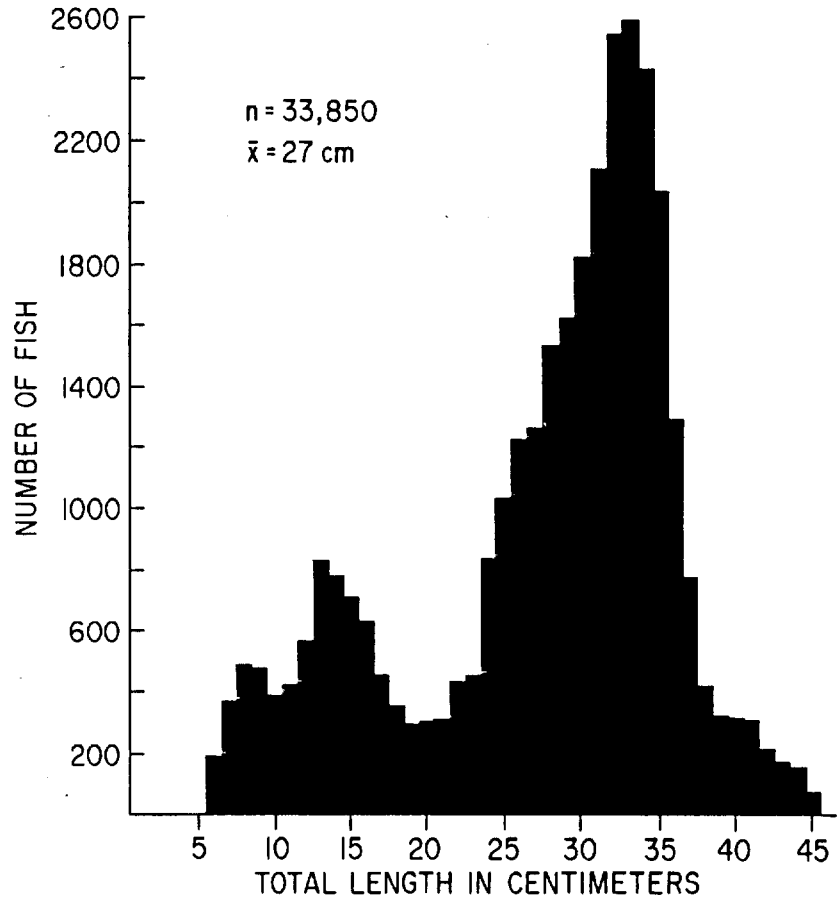

FIGURE 11. Number of sargo measured at each centimeter during 1982-83 Salton Sea creel census.

Bairdiella

Creel census clerks measured 28,939 bairdiella from the anglers' catch during 1982-83; these fish ranged in size from 6 cm in TL to 41 cm in TL, with an average size of 24 cm in TL (Figure 12). As in the two previously mentioned species, no bairdiella were weighed; however, a length to weight association was determined from lengths and weights taken from 2,265 bairdiella caught in gill nets during 1979-82 (Calif. Dept. Fish Game, unpub. data). Based upon this association, weight estimates were made for angler-caught bairdiella during 1982-83 which inferred that the smallest fish weighed approximately 0.003 kg, the largest fish 0.760 kg, and the average-size fish 0.160 kg. A plot of the number of bairdiella caught at each centimeter showed that two modes were present, a small mode of fish at 9 cm in TL and a large mode of fish at 22 cm in TL (Figure 12). Slightly more than three-quarters (77%) of the sport catch of bairdiella ranged in size from 19.0 cm to 27.9 cm in TL. Figure 12 indicates

that bairdiella are fully recruited into the sportfishery at approximately 19 cm in TL; only 7% of the total catch was less than this size. Information on the size at which bairdiella become sexually mature indicates that 78% of the males but only 28% of the females have spawned by the time they have reached 19 cm (Calif. Dept. Fish Game, unpub. data).

During 11 months of the census (October 1982-August 1983), the average size of bairdiella caught fluctuated only within a 4 cm range between 22.0 cm TL and 25.9 cm TL (Figure 10). Bairdiella caught during the month of September 1983 decreased in average size to 19 cm.

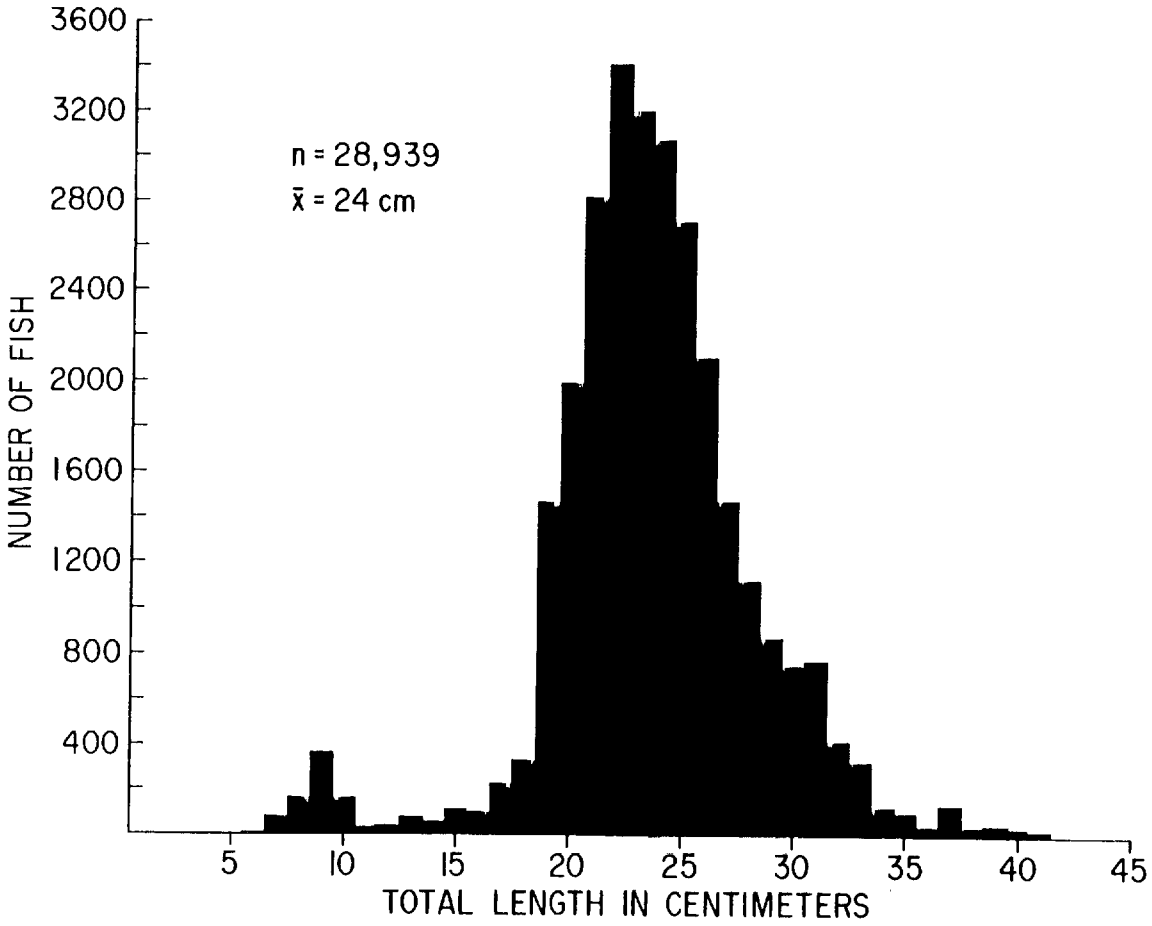

FIGURE 12. Number of bairdiella measured at each centimeter during 1982-83 Salton Sea creel census.

Figure 13 shows that 28,343 sargo were measured from the sport angler's catch during 1982-83 and that these fish varied in size from 5 cm in FL to 35 cm in FL, with an average size of 23 cm in FL. A length to weight relationship was established from 1,519 sets of length and weight data gathered from sargo sampled in gill nets during 1979-82

(Calif. Dept. Fish Game, unpub. data). Estimates made from this data and applied to sargo caught during the creel census showed that the smallest sargo probably weighed 0.002 kg, the largest sargo 1.01 kg, and the average size sargo weighed approximately 0.280 kg. Eighty-two percent of all sargo censused ranged in size from 20.0 cm to 27.9 cm in FL. Figure 13 demonstrates that sargo are not fully recruited into the sportfishery until they have achieved a size of 20 cm in FL: only 8% of the sargo measured from the anglers catch were less than 20 cm in FL. Unpublished information collected by the Department during 1979-81 on the size at which sargo reach sexual maturity shows tht 34% of the males and 17% of the females less than 20 cm are capable of spawning. Unlike the other three species of sportfish, only one mode of sport-caught sargo was apparent from a plot of lengths of fish measured at each centimeter and this was at 23 cm, the same as the mean. Average length determined each month for sargo demonstrated that the average size fluctuated very little (2 cm) for eight months (December 1982-July 1983). Similar to the other three species, on an average the smallest sargo (17 cm) were caught during the month of September (Figure 10). It is not known why this phenomenon occurred in all four species during the same month of the year.

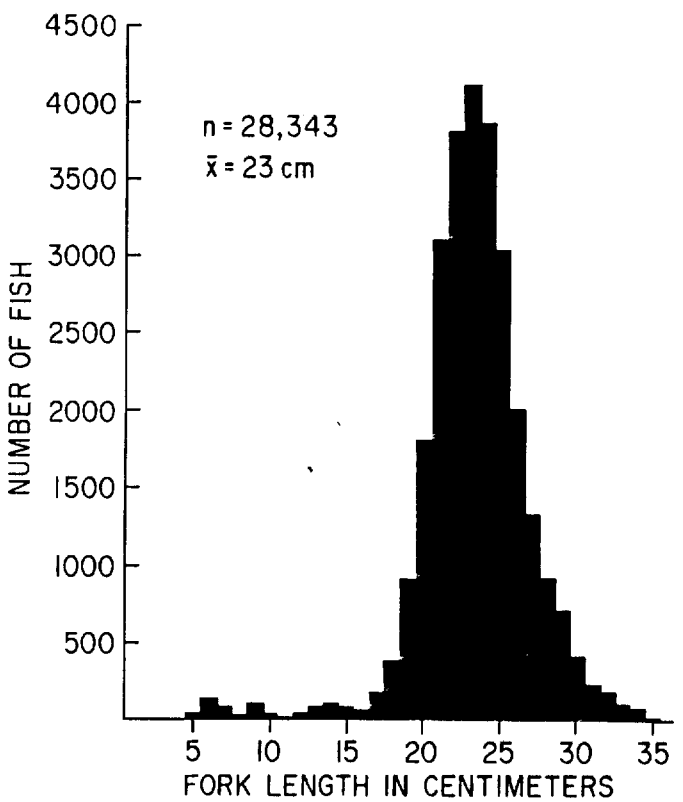

FIGURE 13. Number of sargo measured at each centimeter during 1982-83 Salton Sea creel census.

ANGLING QUALITY RELATIVE TO OTHER REPORTED SPORTFISHERIES IN THE STATE

It is obvious that the sportfishery at the Salton Sea is unique, therefore, it is not possible to draw direct comparisons with other fisheries in California. The closest indirect comparisons that can be made are for warmwater reservoirs and marine fisheries. Catch-per-angler hour rates for all four Salton Sea species combined resulted in an average rate for the year-long creel census of 1.46 fish per hour. Boat fishermen averaged 1.95 fish per hour, jetty fishermen 1.98 fish per hour, and shore fishermen 1.01 fish per hour at the Salton Sea.

Catch-per-angler hour values have been reported for several California reservoirs. Hayden (1966) reported a catch-per-angler hour value of 1.22 for 6 species of fish at Lake Isabella during 1964-65, while Hashagen (1973) calculated an angler success rate of 0.58 for 14 fish species at Merle Collins Reservoir during 1966. Three warmwater reservoirs in San Diego County have had angler success rates determined for the warmwater fisheries they support. The highest angler success rate reported for San Vicente was 0.92 (Bell 1959) in 1957, the El Capitan fishery showed a rate of 1.50 fish per angler hour during 1962 (Fast 1966), and the fishery at Sutherland during 1960 was reported at 0.87 fish per angler hour (La Faunce, Kimsey, and Chadwick 1964). The latter three reservoirs are intensively managed and are stocked on occasion, whereas the sportfishery at the Salton Sea has been totally self-sustaining since 1956 with little management other than a low level of monitoring.

Numerous articles have been written on various aspects of marine recreational fisheries off the California coast. Southern California pier and jetty anglers for 1963 had a success rate of 0.36 fish per hour for 49 species (Pinkas, Thomas, and Hanson 1967). Shore anglers in southern California during 1965-66 achieved a success rate of 0.30 fish per hour for 43 species (Pinkas, Oliphant, Haugen 1968) and surf anglers in Monterey Bay caught 0.71 fish per hour in 1979 (Spratt 1982). The former report and several by Wine (1978, 1979a, 1979b, 1982) have documented the southern California marine sportfishery by private boat anglers; boat angler success rates ranged from 0.31 (1964) to 0.46 (1975-76) fish per hour for between 68 and 193 marine species.

CONCLUSIONS

This paper has presented information gathered from interviews of more than 19,000 anglers who fished the Salton Sea from October 1, 1982 through September 30, 1983. The data reveal that relative use of the Sea by anglers from the

six surrounding counties has not changed significantly since 1966-69. The largest change in the origin of angler use has been an increase in relative use by anglers from counties in California more distant than the six closest counties. Despite the opening of four major new reservoirs (Perris, Silverwood, Castaic, and Pyramid) for fishing within southern California since the early to mid 1970's, anglers are still willing to drive a considerable distance to fish at the Salton Sea. Los Angeles County was the origin of 37 percent of the anglers censused.

Use of the Sea by boat, jetty, and shore anglers was greatest during the fall, late winter, and early spring months. This use pattern appeared to reflect the most desirable climatic conditions rather than represent a measure of angling quality. The average duration of a boat, jetty, and shore angler's completed fishing trip was 4.4, 5.0, and 4.2 hours, respectively.

The tilapia (Mozambique mouthbrooder) made up the largest percentage of the four species caught by boat (45%) and shore(49%) anglers, but ranked only third in the total catch by jetty anglers (29%). Catch rates for this fish averaged 0.88 per hour for boat anglers, 0.58 for shore anglers, and 0.54 for jetty anglers. Tilapia comprised 41% of the total sportfish catch by all angler groups with an annual catch rate of 0.60 fish per hour. Sixty-four percent of the total tilapia catch occurred during the months of June, July, October, and November. For some unknown reason, tilapia were caught in the greatest numbers and with the most success in the three most northern areas sampled in the census. The average size of a tilapia measured in the survey was 27 cm in TL and is estimated to have weighed 0.375 Kg. Tilapia appear to be fully recruited into the sportfishery when they are 24 cm in TL. Approximately one out of every four tilapia in the sportcatch was less than 24 cm. Size-at-sexual maturity information indicates that of these fish probably less than one-half (42%) of the males and slightly more than one-half (52%) of the females may have been sexually mature. This may not have detrimental affects on the tilapia population at the Sea because it may remove enough of the population such that "stunting" is avoided (Gwahaba 1973).

Bairdiella, once considered to be the most numerous of the original three sportfish (Walker 1961), ranked second in the total sportfish catch by jetty and shore anglers and third by boat anglers; contributing to 32%, 31% and 20% of the catch, respectively. Jetty anglers creeled bairdiella at a rate of 0.64 fish per hour, shore anglers at 0.31, and boat anglers at 0.39. Twenty-eight percent of the total sportfish catch by all three angler groups combined was of this species. The annual catch rate for bairdiella was at 0.41 fish per angling hour, with 80% of the catch occurring from March through July. This seems to be related to the inshore movement of large numbers of bairdiella at that time for spawning. Three sampling areas (3, 2, and 6) contributed to

59% of the angler's take; reasons for this are not known. Bairdiella averaged 24 cm in TL during the census and it is estimated a fish of this size weighed approximately 0.160 kg. Full recruitment into the sportfishery appears to occur at 19 cm in TL. Since only 7% of the total catch measured less than this, the possibility tht only one out of four female bairdiella (28%) were sexually mature would probably have little or no significant affect on the population.

The sargo was the most numerous of the four sportfish in the creel of jetty fishermen, contributing to 37% of their catch. Sargo was second in the boat angler's catch and third in the shore fishermen's catch, comprising 29% and 19% of the catch, respectively. Success rates for sargo averaged 0.73 fish per angler hour for jetty fishermen, 0.58 fish per angler hour for boat fishermen, and 0.18 fish per angler hour for shore fishermen. The contributions from sargo in the composition of the total sportfish catch (28%) and the catch rate for this fish (0.41 fish per angler hour) were identical to those found for bairdiella. Monthly catches (numbers) of sargo showed no seasonal trends, however, 51% of the censused catch occurred during the months of February, June, July, and October. An analysis of the sargo catch-by-area information shows that sargo were predominantly caught in areas of partly or completely submerged structures (eg. trees, buildings, powerline poles, tire reef, etc.). Sixty-six percent of the total take of sargo came from Area 2 which is in close proximity to these submerged items. The average size of a sargo in the angler's creel was 23 cm in FL and the estimated average weight was approximately 0.280 Kg. Length-frequency analysis shows that sargo are fully recruited into the sportfishery at 20 cm in FL. Sargo less than 20 cm in FL made up only 8% of the total censused catch. Size-at-sexual maturity information indicates that approximately one out of three males (34%) and less than one out of five females (17%) is capable of spawning at less than 20 cm in FL. It is doubtful that the removal of these sexually immature sargo from the spawning population would have a detrimental affect on the sportfishery Because of the relatively small percentages of fish that this represents in the sportcatch.

The least numerous fish in the boat, jetty, and shore angler's creel was the orangemouth corvina, accounting for 6%, 2%, and 1% of their total catch, respectively. Success rates during the year for corvina averaged 0.10 for boat anglers, 0.04 for jetty anglers, and 0.01 for shore anglers. Corvina accounted for only 3% of the overall catch by the three types of anglers during the year and were caught at an average success rate of 0.04 fish per hour. These values for percentage of overall catch and success rates for a chief predator fish like the corvina are similar to data collected for largemouth bass, Micropterus salmoides, at San Vicente and El Capitan Reservoirs during 1956-57 at the former and 1960-62 at the latter (Fast 1966; Bell 1959).

The highest catches achieved by anglers were in the months of March through July when 87% of the corvina were caught. Inclement weather affected the catches during August and September, as evidenced by good success rates but relatively poor catches for this time of year. Catches of corvina appear to improve as these

fish move inshore at the onset of the spawning season. Monthly catch rates for corvina showed no discernible pattern when analyzed by catch locations. The highest angler success rates came from area 8(0.085), but 97% of the fish censused there were caught by boat anglers who could have been fishing other areas of the Sea. The corvina measured in the angler's creel averaged 59 cm in TL and it is estimated the average weight was 2.0 Kg. Full recruitment of corvina to the sportfishery appears to occur at 50 cm in TL; 29% of the corvina measured during the census were less than 50 cm in TL. Size-at-sexual maturity information indicates that about 83 percent of the males are capable of spawning at this length and only about half of the females, thus indicating a possible problem of corvina removal from the population before the attainment of sexual maturity.

The information presented in this paper documents that the existing sportfishery at the Salton Sea is one of California's highest quality fisheries. The loss of this self-sustaining sportfishery, due to an increase in the salt content of the Sea and resultant detrimental affect on survival of the eggs and larvae of Salton Sea sportfish, has been predicted for many years. Methods for salinity and water elevation control have been previously proposed (Pomeroy et al. 1965; U.S.D.A. and Calif. Res. Agency 1969 and 1974). The fishery exists today only because of higher than average freshwater inflows to the Sea during the past 15 years due to increased precipitation and agricultural use of excess Colorado River water (Black 1983a, 1983b). These conditions may soon change if water is diverted from entering the Sea by energy developers and an inter-basin water transfer made possible by water conservation measures in the Imperial Valley (Black 1983a, 1983b). The California Fish and Game Commission recognized the value of this sportfishery when it adopted a policy in 1982 which urged that a program be designed to stabilize salinity and water elevation at levels which would sustain this recreational and natural resource, while recognizing the needs of agriculture and energy development. Without the design and implementation of such a venture, the demise of the Sea's sportfishery is inevitable.

Management Recommendations

I. The creel census survey reported in this paper has established that the Salton Sea sportfishery (1982-83) is of exceptionally high quality. However, the survey was not designed to generate estimates of total angler use or harvest. Proposed geothermal development and water conservation measures in and surrounding the Salton Sea may have serious adverse impacts on the sport fishes and ultimately their use and harvest by sport fishermen. I believe it is necessary, through the initiation of a multi-year intensive creel census, to establish and document the amount of angler use this fishery sustains and the numbers of fish harvested. This information will be used to demonstrate to government entities (county, state, and federal) and project developers the

relative values of the sportfishery and the necessity to offset or mitigate adverse impacts to it. At present, these values are viewed to be "insignificant" by most government entities and project developers.

II. Information presented in this paper, on the size at which corvina are fully recruited into the sportfishery and from unpublished Department records on the size at which corvina attain sexual maturity suggests that there may be a significant portion of the population being removed before it has the opportunity to spawn. Therefore, I recommend that a program be initiated to assess whether this is an occasional occurrence or a continuing problem with the corvina fishery. If it is a continuous trend in the fishery, there may be justification for establishing a minimum size limit to insure an adequate spawning population and a more stable fishery.

III. An analysis of sargo catch by geographic area reveals that these fish are more accessible to the anglers in areas where there are submerged structures than in areas where these structures do not exist. I recommend that submerged concrete reefs be placed in areas heavily utilized by shore and jetty anglers. This will serve to attract sargo to these areas and make them more accessible to this category of angler.

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