
White Croaker

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Introduction

The family Sciaenidae includes croakers, drums, kingfish, and seatrout. It is a cosmopolitan family that inhabits warm, shallow, nearshore ocean waters, estuaries, and rivers. The family consists of about 250 species (Eschmeyer and others 1983), 10 of which occur in California waters (Miller and Lea 1972) and 2 in the San Francisco Estuary: the white croaker, *Genyonemus lineatus*, and the queenfish, *Seriphus politus*. San Francisco Bay represents the northern boundary of the queenfish range (Skogsberg 1939) and we have taken only a few in it. The white croaker, on the other hand, is quite abundant.

The white croaker is found in small schools (Skogsberg 1939) and ranges from Magdalena Bay, Baja California, to Mayne Bay, Vancouver Island, British Columbia (Miller and Lea 1976, Baxter 1980, Hart 1973). It is primarily a shallow water fish, but has been found as deep as 183 m (Love and others 1984). White croaker supports both commercial and sports fisheries.

White croakers spawn throughout the year in bays and estuaries (Wang 1986) but most spawning occurs in early spring (Baxter 1980). In San Francisco Bay, spawning is most intense from September through May (Wang 1986). Females probably spawn more than once a year (Baxter 1980) and larger females have longer spawning seasons (Love and others 1984). The eggs and newly hatched larvae are pelagic (Watson 1982, Wang 1986). As they grow, the larvae move shoreward and become more epibenthic (Watson 1982). White croakers grow to 391 mm and live 15 years or more (Baxter 1980). Half mature by the end of the 1st year of life and all mature in 3 to 4 years (Love and others 1984).

Methods

The plankton net catches were used to determine the spawning time of adult white croakers and the seasonal distribution of the yolk sac and post-yolk sac larvae. Fish <20 mm were considered larvae. White croakers taken in the otter trawl were divided into age-0 and age-1+ classes by visual inspection of monthly length frequencies. The monthly cutoff lengths for the separation of age-0 and age-1+ fish were 40, 45, 50, 75, 85, 100, 115, 125, 125, 135, 150, and 150 mm FL for January to December, respectively. Abundance indices were calculated using otter trawl data. Annual abundance indices for both the age-0 and age-1+ fish were calculated for February to October.

Results

Length Frequency

The consistent winter recruitment of the smallest white croaker and their apparent near constant growth rate provided for clear distinctions between age-0 and age-1+ fish (Figure 1).

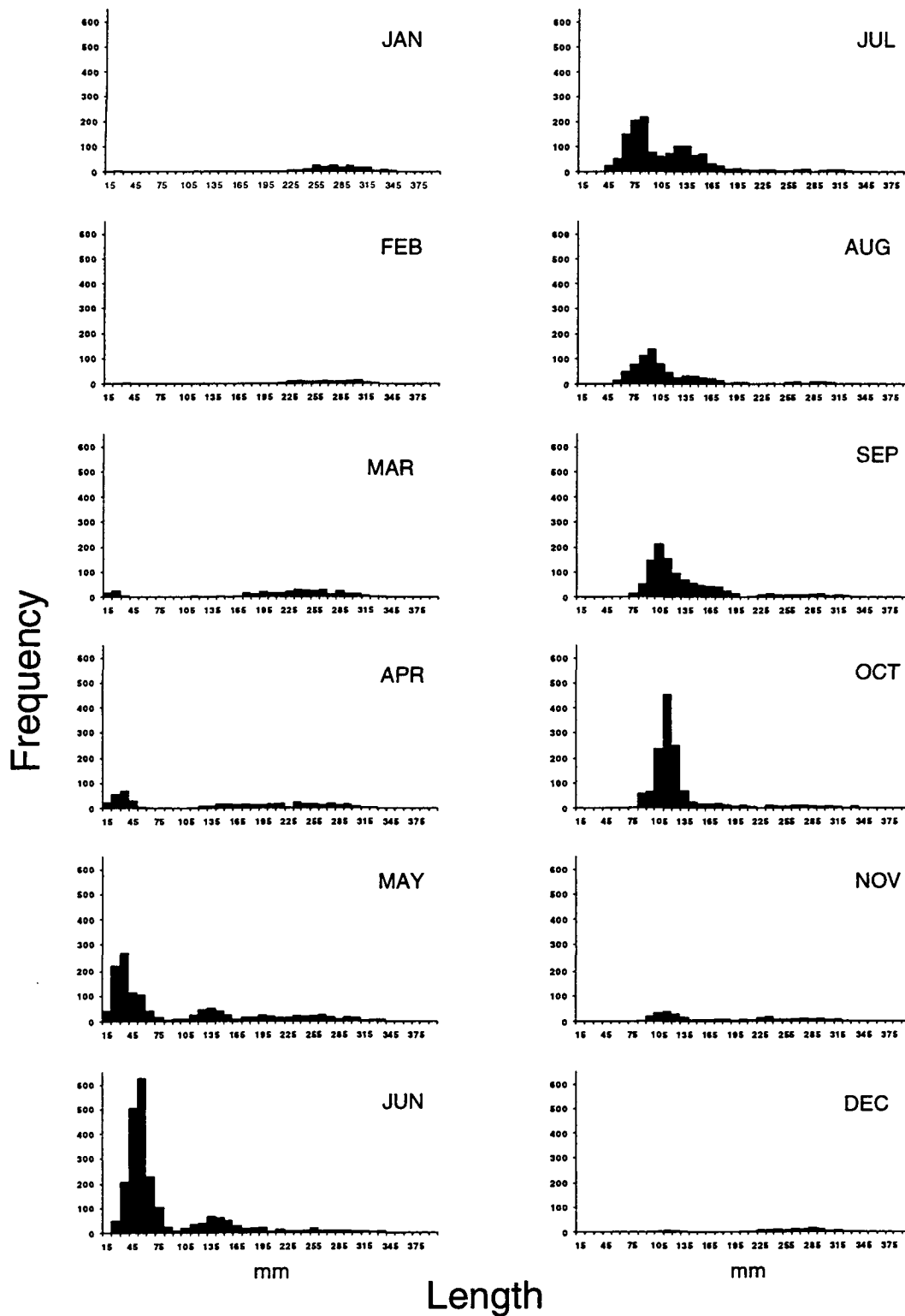


Figure 1 Length distribution of white croakers by month. Values are the sum of the catch by length (mm FL) for 1981 to 1988.

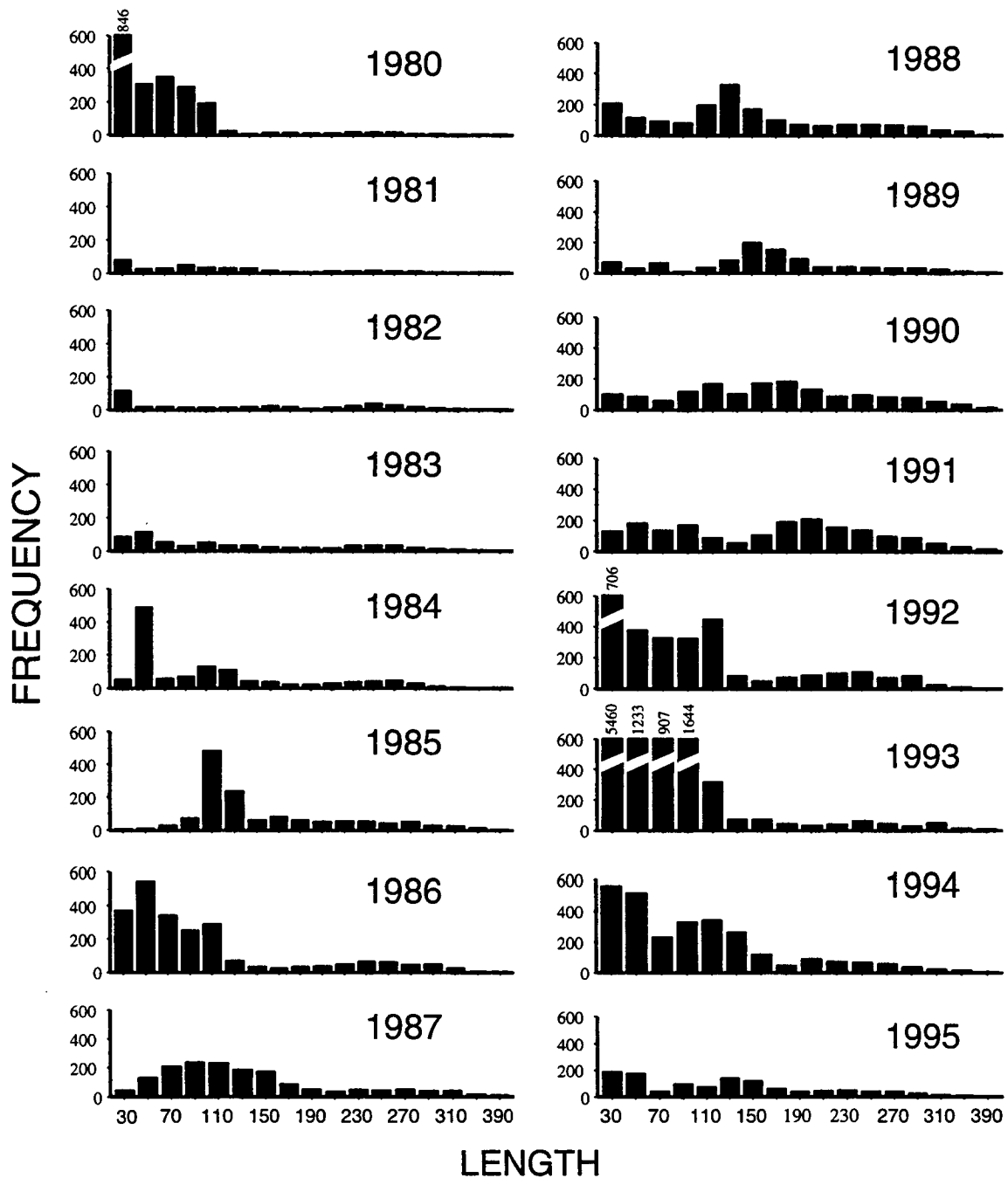


Figure 2 Annual white croaker size distribution. Values are the sum catch by length (mm FL) for each year.

The age structure of white croakers changed from year to year (Figure 2). Fish from a few strong year classes (1980, 1986, and 1993) dominated the catch in subsequent years. The 1986 year class comprised a large proportion of the subsequent annual catches until 1992. However, a strong year class was no guarantee of future abundance. The 1993 year class, which was approximately 5 times the size of the 1986 year class, did not contribute proportionally to the 1994 catch of age-1+ fish.

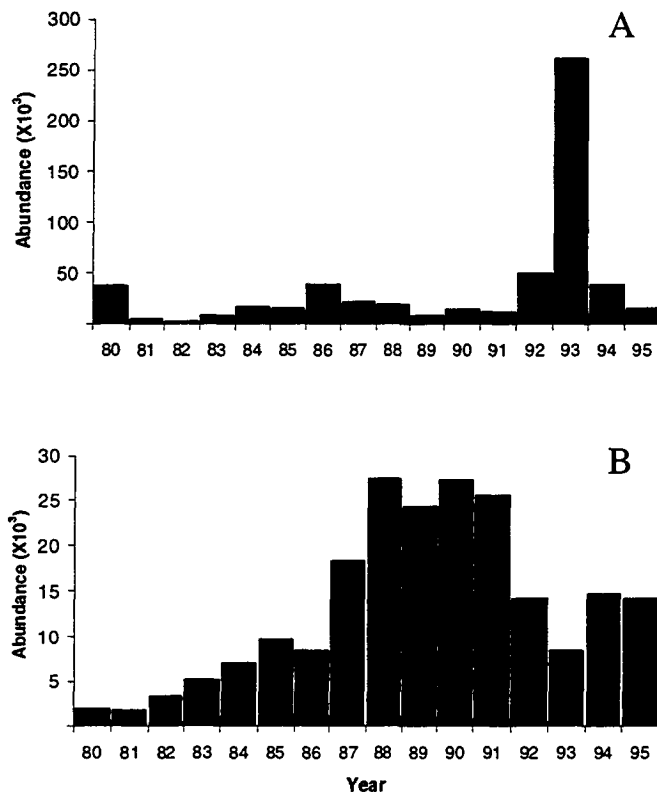


Figure 3 Annual abundance of white croaker: (A) age 0 and (B) age 1+

Abundance

The abundance of age-0 white croaker fluctuated greatly between 1980 and 1995. The annual abundance index was highest in 1993 and lowest in 1982 (Figure 3A, Table 1). The 1993 index was 5 times greater than the 1992 index and 100 times greater than the 1982 index. Age-1+ indices were low in the early 1980s, but began a sustained increase in 1982, which peaked in 1988 and remained steady through 1991 (Figure 3B, Table 2). The indices then declined through 1993 and rebounded somewhat in 1994 and 1995. The lowest age-1+ indexes were in 1980 and 1981.

Distribution

White croakers were seasonally distributed within the estuary. In early winter, most of the larvae were in Central Bay (Figure 4). As winter progressed, the larvae spread into San Pablo and South bays. The larval catch in spring declined as larvae grew into the juvenile stage. Age-0 fish were first collected in the otter trawl between February and April (Figure 5). They were collected throughout the year, and were found primarily downstream of Suisun Bay. The catch of age-0 fish peaked in spring in both South Bay and San Pablo Bay. By summer, the age-0 fish catch declined in these bays and began increasing in Central Bay. By the end of fall, all the age-0 fish along with most of the age-1+ fish had left the estuary.

Table 1 Monthly abundance indices of age-0 white croaker captured in the otter trawl from 1980 to 1995. The last column is the annual index, the mean abundance from February to October. The bottom row is the average seasonal abundance from 1981 to 1988.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Index
1980		834	284	2630	145017	34847	83910	53716	9127	13245	20335	961	38179
1981	0	463	61	1848	20016	1113	4181	4926	6658	10579	7068	194	5538
1982	0	287	235	1218	2955	12867	1274	2691	889	839	1870	222	2584
1983	0	0	271	1015	12725	32163	12544	5100	2901	10039	3712	225	8529
1984	225	0	0	3508	12636	78014	23734	4426	3084	33827	1006	0	17692
1985	0	0	425	0	113	3010	5518	8202	7479	115669	11867	843	15602
1986	119	388	4170	9038	48557	133606	45054	48092	54658	15092	8855	3305	39851
1987	610	284	664	3760	30159	49129	23240	23161	33189	32855	3935	1598	21827
1988	648	816	5225	17305	46410	31373	28342	19415	18549	3355	839	934	18977
1989	0	1269	847	2890	13678	13977	20699	6250					8516
1990		1156	1731	12929	24245	15187	9881	16728	22885	25944			14521
1991		728	1433	5544	10621	28699	30871	9376	11122	16956			12817
1992		189	564	16260	164560	61426	61203	39373	68673	33448			49522
1993		138	235	1447533	146011	154238	156865	168532	159150	120895			261511
1994		711	1166	8354	89044	69001	32487	57353	72690	18104			38768
1995	0	0	308	2342	20655	66276	6043		27461	1105	840	1695	15524
1981-1988	200	280	1381	4712	21696	42659	17986	14501	15926	27782	4894	915	

Table 2 Monthly abundance indices of age-1+ white croaker captured in the otter trawl from 1980 to 1995. The last column is the annual index, the mean abundance from February to October. The bottom row is the average seasonal abundance from 1981 to 1988.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Index
1980		637	1889	7104	1175	745	1220	2976	2010	186	742	212	1994
1981	2094	284	186	1049	2637	2618	5291	3080	768	1286	668	694	1911
1982	4820	4344	775	1948	6777	9367	1084	2855	1513	1653	3320	1983	3368
1983	474	765	3319	6577	4893	7374	10111	5038	5245	3029	4270	2773	5150
1984	2695	7021	12278	9801	9445	10466	5628	3191	4617	1650	2146	6519	7122
1985	4223	1298	18012	22855	7143	5442	2164	1319	15285	14652	9909	2962	9797
1986	9156	2631	4350	6254	21912	7448	15345	4707	4517	8171	5528	4997	8370
1987	7747	1760	3216	6542	41203	43526	15954	11096	28730	12910	5100	3197	18326
1988	13971	8878	23802	7393	21587	49122	73129	21420	35472	6180	11962	9047	27443
1989	8877	7731	7714	34843	13706	31549	41567	33799					24416
1990		14551	20602	31761	23191	24810	52944	34760	25931	16929			27275
1991		19921	33716	22438	14902	51213	46630	25603	7868	8747			25671
1992		24602	17362	27047	33758	8032	534	1360	9635	5219			14172
1993		3673	8426	6621	9382	7344	12736	16767	4239	6642			8425
1994		5512	8685	6246	13789	19199	11457	28697	30885	7722			14688
1995	9122	3791	3826	6332	12072	10911	40388		27765	8879	414	18611	14246
1981-1988	5648	3373	8242	7802	14450	16920	16088	6588	12018	6192	5363	4022	

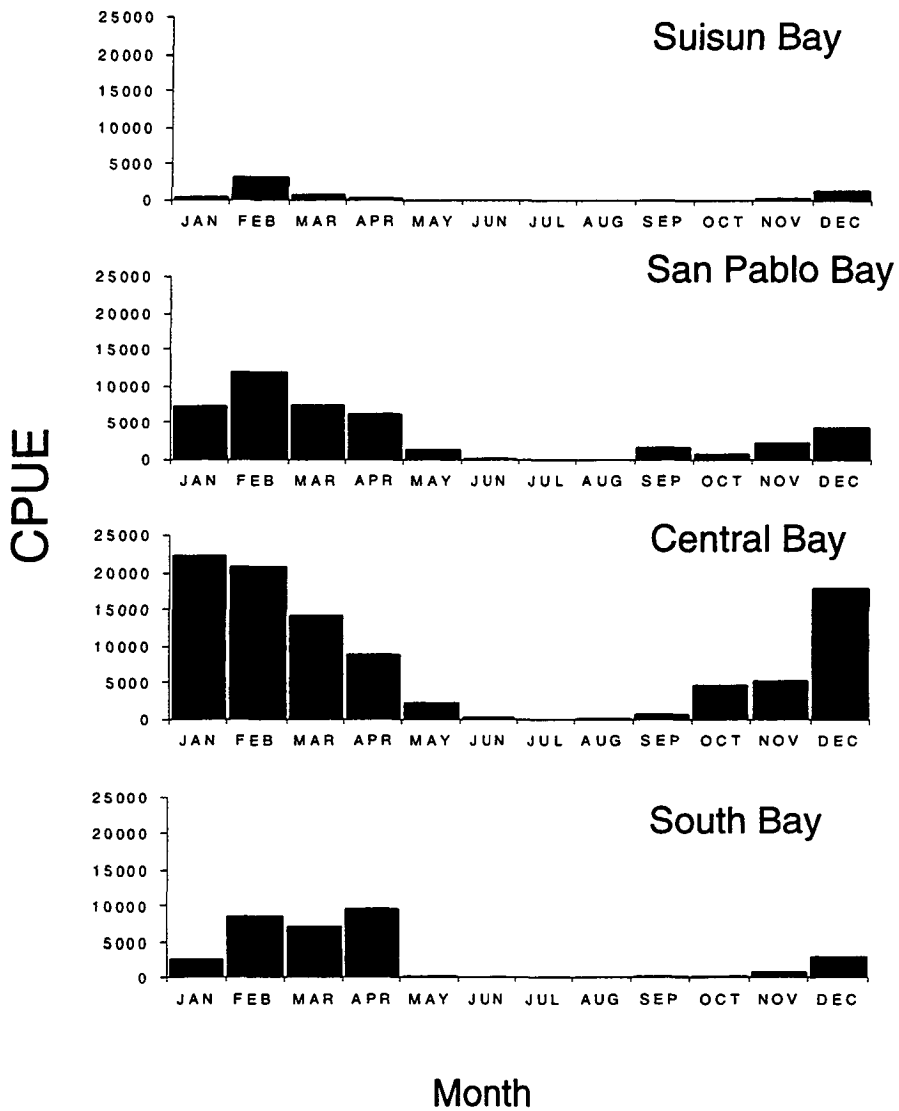


Figure 4 Seasonal distribution of white croaker larvae by region. Values are the average CPUE for 1981 to 1988.

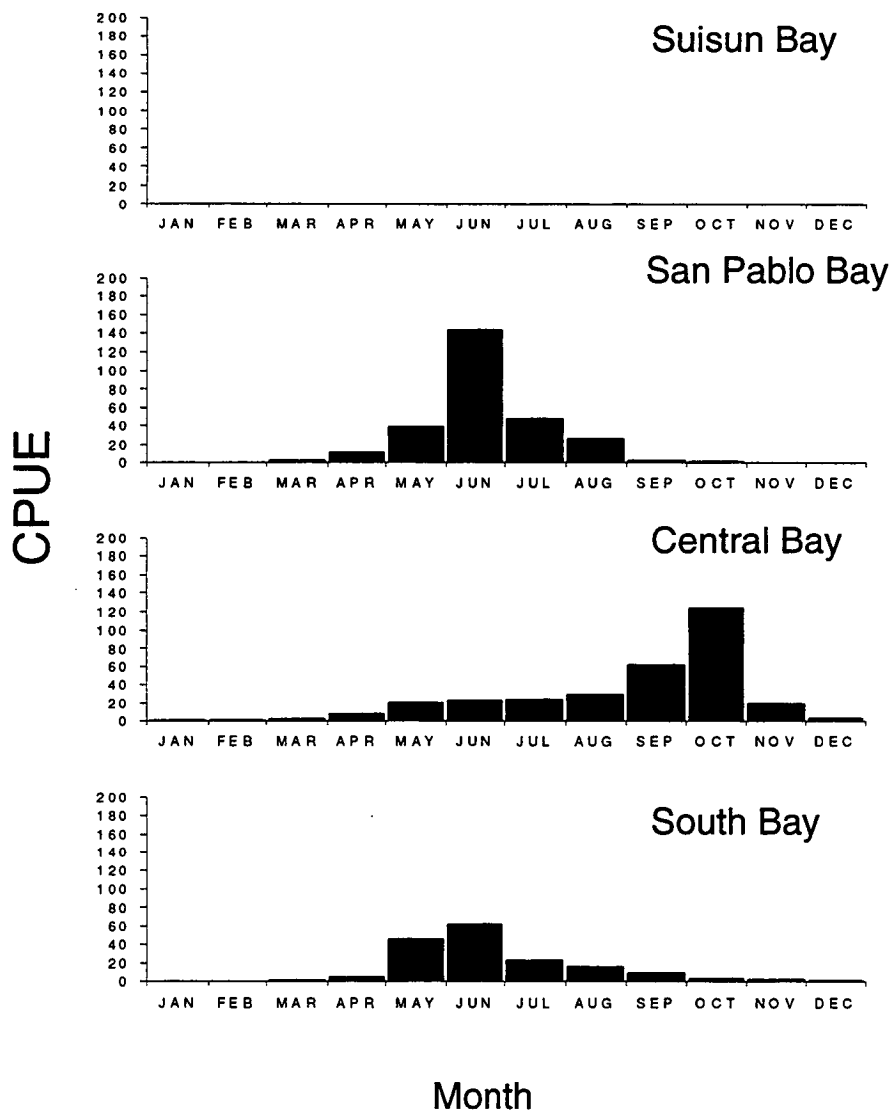


Figure 5 Seasonal distribution of age-0 white croaker by region. Values are the average CPUE for 1981 to 1988.

Age-1+ white croakers were found in Central Bay throughout the year (Figure 6). Their distribution expanded and their numbers increased to a mid-summer peak in South, Central, and San Pablo bays. In late fall and early winter, the catch of age-1+ fish decreased, first in San Pablo and South bays and then in Central Bay, as age-1+ fish moved into the ocean. The emigration was comprised primarily of fish <200 mm FL. Larger fish showed a slight increase in numbers during winter, but not enough to compensate for the decline in the smaller fish.

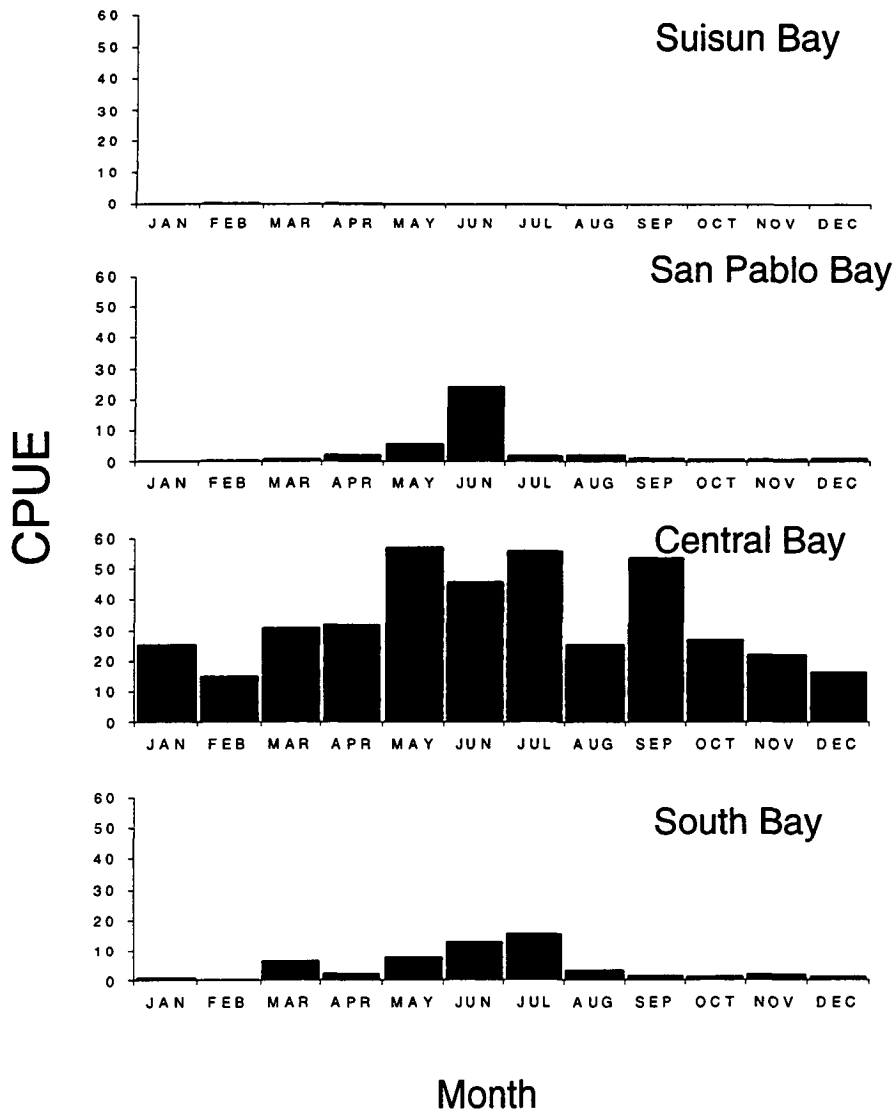


Figure 6 Seasonal distribution of age-1+ white croaker by region. Values are the average CPUE for 1981 to 1988.

The annual distribution pattern of age-0 white croaker varied with outflow (Figure 7). In most years with high winter outflows (1980, 1982, 1984, and 1986) relatively more age-0 fish were caught in San Pablo Bay than in Central or South bays. In years with low outflow, age-0 CPUE was similar in Central and South bays. The annual distributions of age-1+ fish did not vary as much as for age-0 fish. Age-1+ fish were primarily restricted to Central Bay but expanded their range to South and San Pablo bays during low outflow periods when the salinity in those bays increased (Figure 8).

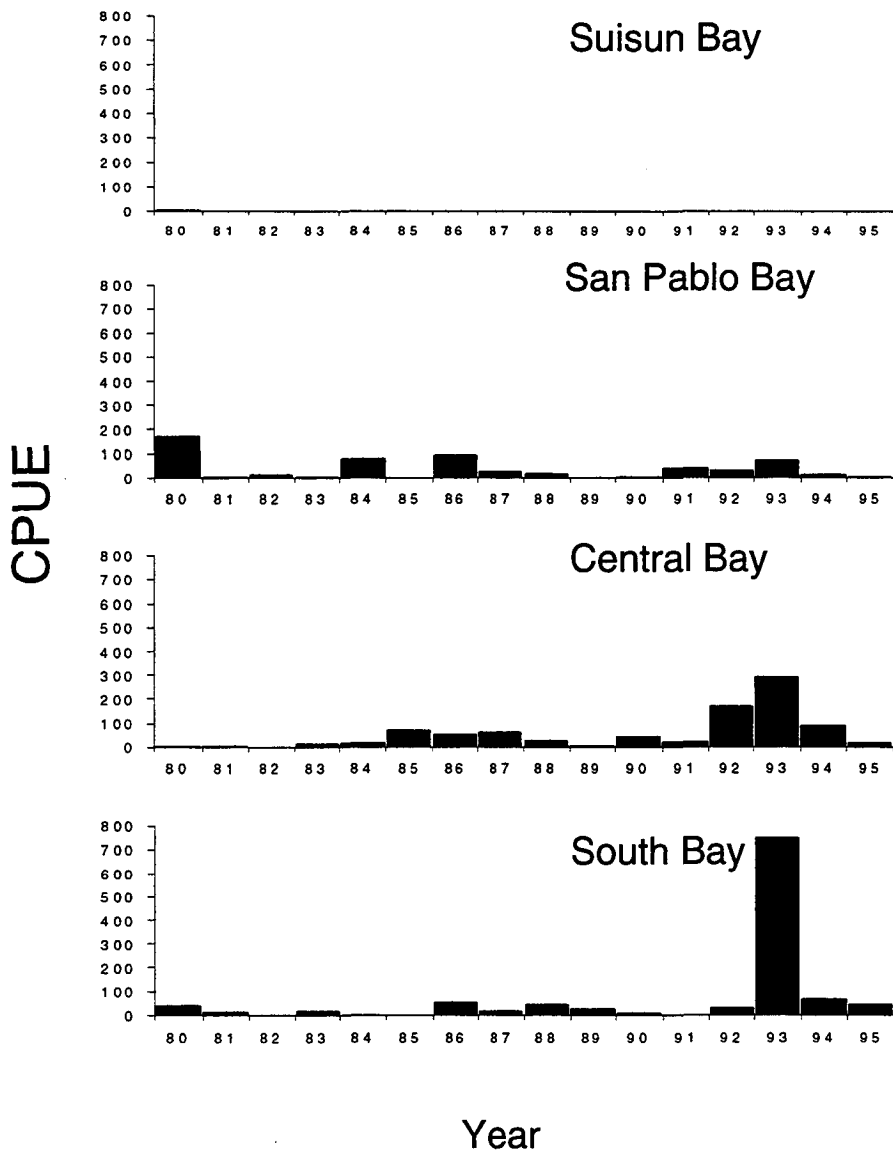


Figure 7 Annual distribution of age-0 white croaker by region. Values are the average CPUE for February to October.

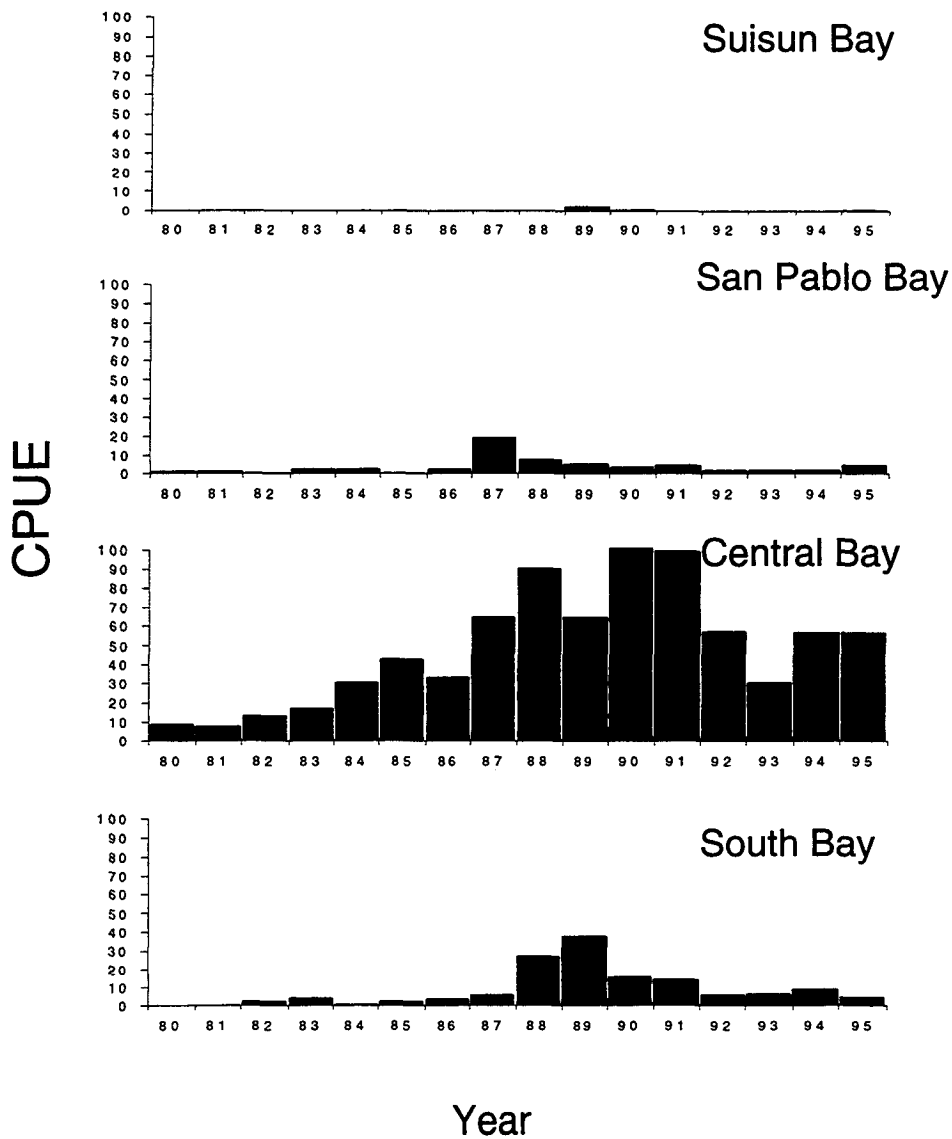


Figure 8 Annual distribution of age-1+ white croaker by region. Values are the average CPUE for February to October.

Salinity and Temperature

Both the salinity and temperature at which white croaker were found changed with size. Both age groups ranged between polyhaline and euhaline salinities but age-0 fish were found in fresher and warmer waters than older ones (Figure 9). The salinity and temperature ranges of age-1+ fish varied little.

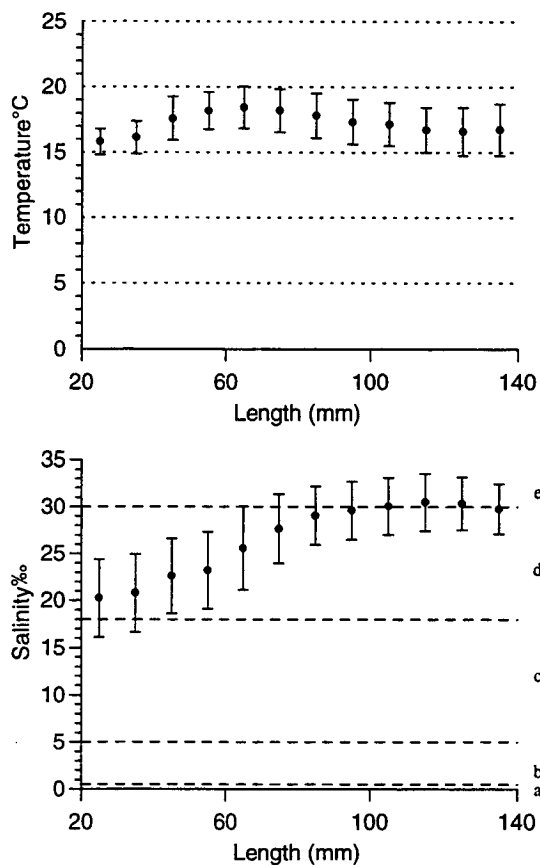


Figure 9 Temperature and salinity distributions of white croakers by length. The dots are the means and the bars are 1 standard deviation. The horizontal lines on the salinity graph mark the boundaries of the Venice system ranges: (a) limnetic, (b) oligohaline, (c) mesohaline, (d) polyhaline, and (e) euhaline.

Discussion

The white croaker is a coastal marine species that is confined mainly to the polyhaline and euhaline environments of San Pablo, Central, and South bays. It has a fairly predictable seasonal pattern of movement. Tidal transport of the young and salinity control their distribution in the estuary and their emigration to the ocean.

During winter, mature fish move shoreward to spawn and some enter the estuary. Eggs and larvae are pelagic and are most abundant in Central Bay. As the young develop, they become increasingly epibenthic and are transported by tidal currents to the polyhaline environments of San Pablo and South bays. Because of this passive transport age-0 fish are found over a greater range of salinity and have a broader distribution than age-1+ fish.

Age-1+ white croakers remain in the higher salinity areas of the estuary. An upstream expansion of the age-1+ distribution occurred during the drought when the salinity of San Pablo and South bays increased to the euhaline and upper polyhaline levels. During normal water years, high winter outflow reduced the salinity in San Pablo Bay to the lower mesohaline and upper oligohaline ranges and restricted the distribution of age-1+ fish to Central and South bays.

The seasonal movements of age–0 and age–1+ fish reflected their preferences for euhaline water. The timing of the seasonal movements corresponds with the seasonal changes in salinity that occur in each bay. From spring to midsummer the highest densities of age–0 fish were in San Pablo and South bays. As the summer progressed, the age–0 fish migrated toward the higher salinities of Central Bay. By winter they, along with the immature age–1+ fish, emigrated out of the estuary into the ocean.

The size of a year class was not an indicator of future abundance. The 1986 year class, though comparable in size to the 1980 year class and 1/4th the size of the 1993 year class, contributed to the greatest increases in age–1+ abundance. White croaker from the 1980 year class failed to make a large contribution to age–1+ abundance until the mid-1980s. Fish from the 1993 year class, the largest of record, did contribute to the 1994 and 1995 age–1+ indices, but in numbers far less than might have been expected from its size.

The drought increased the suitability of the estuary for the white croaker by increasing the salinity. The 1986 year class made greater use of the estuary during the drought. These fish still moved seasonally in and out of the estuary, but during the drought years, many more of these fish entered Central Bay from the ocean. The increased salinity however, did not appear to influence reproductive success. Although large numbers of spawners should have been produced by the maturation of the large 1986 year class in 1987 and 1989, spawning in these years did not appear to be high, judging from the small numbers of age–0 fish.

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