Abstract. – Commercial and sport landings of white seabass have declined, particularly in southern California, and the populations now appear to be severely impacted. To provide information critical to the management of this species, settlement patterns of white seabass within the Southern California Bight were investigated for 1988–89. Data were obtained from 16 stations sampled along the southern California coastline during June–October 1988, and at 12 stations sampled along the coasts of the mainland and four Channel Islands May–August 1989. At each station, four 5-minute tows were taken with a 1.6 m beam trawl at each of two depths, 5 and 10 m.

Most young-of-the-year white seabass were <10 mm SL and had settled within 2–3 weeks of capture. Density estimates for white seabass off southern California were low, ranging from 0.3 to only 37.8 individuals per hectare. In 1988, catch-per-unit-effort (CPUE) peaked in July (1.10/tow) with differences being statistically significant among months. In 1989, CPUE peaked in June (0.45/tow) with differences being statistically significant among distance blocks from the mainland. CPUE was 15 times higher at the mainland stations compared with the island stations (0.59/tow vs. 0.04/tow). Abundance was significantly correlated with warm bottom-water temperatures in 1988, although not in 1989.

Multivariate analysis of the catches with selected environmental variables indicated that distance from the mainland and bottom temperature may have been important factors influencing settlement. However, in combination, these two variables accounted for only 5% of the total variance (R^2 0.05) in abundance. This finding implies that other factors, most notably the availability of premetamorphic larvae, probably have an influence on white seabass settlement and need to be considered in future studies.

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Abundance, distribution, and settlement of young-of-the-year white seabass *Atractoscion nobilis* in the Southern California Bight, 1988-89*

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The white seabass *Atractoscion nobilis* is the largest croaker (family Sciaenidae) occurring off southern California (Miller and Lea 1974), where it is important in both commercial and sport fisheries. Despite attempts to improve the fishery (e.g., imposing minimum size requirements and limits on sport and commercial catches; Frey 1971), landings continue to decline and the stocks appear to be severely impacted (Vojkovich and Reed 1983), particularly in southern California waters.

Despite their impacted status and economic importance, little was known about the early-life-history stages of white seabass until recently. Moser et al. (1983) described the larval development from hatchery-reared eggs. Field investigations of early-life-history stages were limited to reports of larval occurrence within California Cooperative Fisheries Investigations (CalCOFI) collections from 1950 to 1978. For example, Moser et al. (1983) found that only 15% of white seabass larvae were taken in southern California waters. Most were taken near Sebastian Viscano and San Juanico Bays, Baja California.

A few studies have provided limited information on the young-of-year (YOY) stages of white seabass. Allen and Franklin (1988) examined the abundance and distribution of juvenile white seabass in the vicinity of Long Beach harbor and developed a model for locating YOY white seabass in coastal waters. We observed that YOY white seabass were captured over sandy bottoms in shallow water near the breaker line, most often with submerged aquatic vegetation (drift algae: green, brown, and red), encrusting bryozoans, and terrestrial debris. This area seems to be the nursery grounds for white seabass. The drift material may be an important component of these nursery areas because these fish appear to be structure-oriented early in life (Allen and Franklin 1988, Margulies 1989, Donohoe 1990). Donohoe (1990), based on field collections, found that young seabass were associated with the drift, and also observed that the larvae and juveniles moved toward structures in laboratory experiments. A significant relationship was found between the mass of drift algae and the occurrence of YOY white seabass from Oceanside, California to the Mexican border, suggesting that the drift habitat may influence the distribution patterns

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of these young fish (Donohoe 1990). Margulies (1989) concluded that the visual perception of YOY seabass improves with age, and that young fish begin to avoid predators by moving to the drift.

Our studies on white seabass settlement were undertaken in southern California where the main fishery for this species still exists. The specific objectives were to (1) examine the patterns of abundance, distribution, and settlement of YOY white seabass off the coast of southern California between Point Conception and San Mateo Point and along the coastlines of four of the larger Channel Islands, and (2) identify environmental factors that may influence these patterns.

Materials and methods

YOY white seabass were captured during the summers of 1988 and 1989 as part of the Ocean Resources Enhancement and Hatchery Program (OREHP) of the California Department of Fish and Game, which emphasized studies within the Southern California Bight. Trawls were made over flat bottoms just offshore of open sand beaches, using two 5.2m whalers. At each station four 5-minute replicate tows were made in the shallow, potential nursery areas by two whalers simultaneously sampling along each of two isobaths (5 and 10m) using a 1.6m beam trawl. The trawl was comprised of 4mm mesh in the wings and 2mm knotless mesh in the codend. Calibration tows using a meter wheel indicated that a 5-minute tow covered an average of 183m of bottom, yielding a mean coverage of 293m^2. Bottom profiles were monitored using depth finders mounted in each whaler. Temperature, salinity, dissolved oxygen, and pH were monitored at the surface and bottom at each station at both isobaths, using a Hydrolab Surveyor II Water Quality Measurement System. Submerged aquatic vegetation (drift algae) captured in each tow was weighed (to nearest kg) at all stations. White seabass were measured to the nearest 0.1mm standard length (SL).

Sixteen stations were established along the coast of southern California from Point Conception to San Mateo Point in 1988 (Fig. 1). These stations were approximately 10nmi apart and were sampled from June through October. The sampling regime yielded 128 tow samples (4 tows at 2 depths at each of 16 stations) over 5 months, for a total of 640 tow samples in 1988.

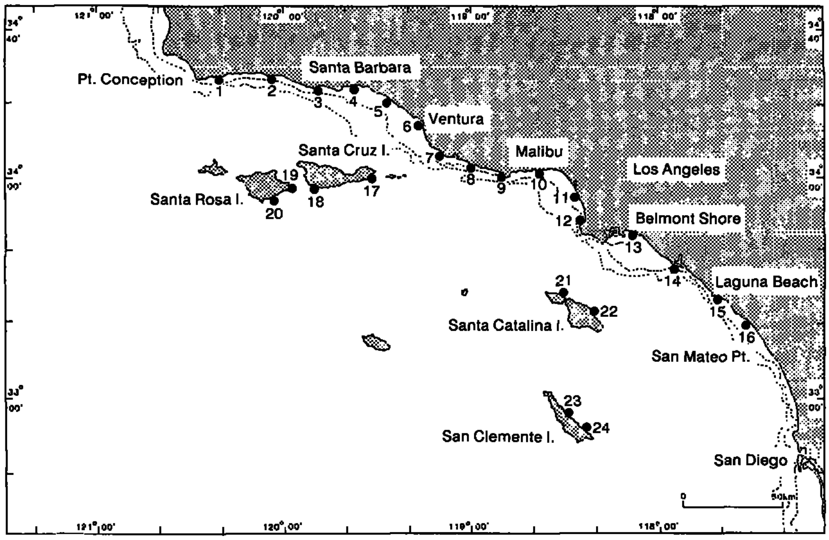

Figure 1

Map of locations of mainland and Channel Island stations sampled during the YOY white seabass *A. nobilis* survey, 1988–89.

In 1989, sampling was designed to examine the settlement patterns along the mainland and around the four largest offshore islands. Four mainland stations and eight island stations were sampled each month from May through August (Fig. 1). The mainland stations were those with the greatest consistency of catch of YOY white seabass in 1988: Stns. 6 (Ventura), 10 (Malibu), 13 (Belmont Shore), and 15 (Laguna Beach). Two new stations were established at each of four Channel Islands: Stns. 17 and 18 (Santa Cruz), 19 and 20 (Santa Rosa), 21 and 22 (Santa Catalina), and 23 and 24 (San Clemente). The twelve stations sampled in 1989 were divided subjectively into three groups of four stations based on relative distance from shore or distance blocks (DSTBLK). Stns. 6, 10, 13, and 15 were designated as being at the mainland (MAINLAND); Stns. 17, 18, 21, and 22 as near-island stations (NEAR ISL); and Stns. 19, 20, 23, and 24 as far-island stations (FAR ISL). The 1989 sampling regime yielded 96 tow samples (4 tows at 2 depths at each of 12 stations) for each month except May, when only 80 tows were made because poor weather conditions prevented sampling the Santa Rosa Island stations, for a total of 368 tows overall.

Analysis of variance, *t*-test, and correlation analyses were completed using the CSS:Statistica for desktop computers (Stat Soft, Inc., Tulsa). For 1988 data, a balanced design, three-way ANOVA was used to test the effects on catch-per-unit-effort (CPUE) of combinations of independent variables (station, month, and depth). In 1989, a similar three-way ANOVA design was used to test the effects of distance block (distance from the mainland), month, and depth on CPUE. CPUE was used in all parametric analyses in order to minimize any negative impact that the large number of zero-catch tows would have on the analysis. Since replicates had to be combined, the three-way-interaction mean square was utilized as a conservative estimate of sampling error for the 1988 ANOVA test. In 1989, the ANOVA design was unbalanced due to two missing stations in May at Santa Rosa Island. In this case, cell means estimation was utilized to overcome the imbalance. Since the three-way-interaction term was originally found to be significant in the 1989 analysis, its mean square was pooled with the within-sample error in order to partition out the effect of the interaction on the main effects of distance block, month, and depth individually. Correlations and canonical correlation analysis were utilized to examine the possible association of various environmental factors with settlement of YOY white seabass.

Results

Length-frequencies

The YOY white seabass captured during the 1988 survey ranged from 4.2 to 78 mm SL ($\bar{x}$ 9.8 mm SL). In 1989, the range was 4.5–51.7 mm SL ($\bar{x}$ 12.1 mm SL). Most YOY, however, ranged from 5 to 20 mm SL (Fig. 2). Newly settled fish (<10 mm SL) were caught from June through September. Individuals >20 mm SL were more common from July through October.

Newly settled fish (<10 mm SL) made up 75% of all YOY seabass in 1988 and 1989. Fish <20 mm SL comprised 93% of the total catch. The paucity of larger YOY in the samples (Fig. 2) from July to September indicates that our beam-trawl catch may be biased toward smaller, less-mobile fish.

Studies utilizing the daily growth rings on white seabass otoliths (Franklin and Allen, unpubl. data) indicate that fish of 5–20 mm SL are ~37–104 days old. Since settlement occurred consistently at ~5 mm SL, white seabass in this range settled at 0–68 days before capture. The majority of those <10 mm SL had settled 14–21 days before capture.

Abundance and distribution

Summer 1988 Sampling along the mainland yielded 270 YOY white seabass. Most (58%) were captured at five of the 16 stations: Stn. 2 (Refugio Beach, *n* 38), Stn. 6 (Ventura, *n* 28), Stn. 10 (Malibu, *n* 30), Stn. 13 (Belmont Shore, *n* 31), and Stn 15 (Laguna Beach, *n* 31) (Fig. 3). Mean catches (CPUE) were highest at these five stations; furthermore, the variance of these five means was also very high. This was especially true at Stn. 2 (Refugio Beach) where 36 of the 38 YOY captured were taken during a single month (July).

The CPUE for all stations was low in June 1988 (0.15 individuals/tow), peaked in July (1.10/tow), and declined to 0.08/tow in October (Fig. 4). Catches in July accounted for 52% (141 individuals) of YOY white seabass taken in 1988. In June, catch was low (19 individuals) and white seabass were collected only from southern stations (12, 13, and 15) (Fig. 5). By July,

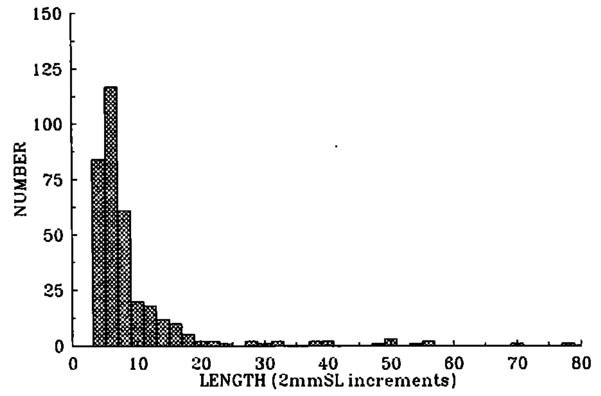

Figure 2
Length-frequencies of YOY white seabass *A. nobilis* from all samples combined, 1988–89. Length increments are 2 mm (*n* 354).

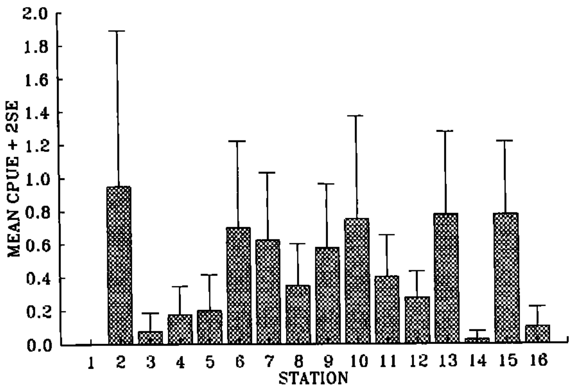

Figure 3
CPUE of YOY white seabass *A. nobilis* by station, summer 1988. Bars represent 2 SE of the mean.

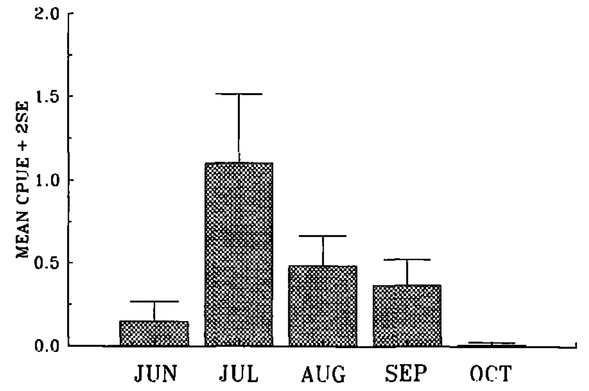

Figure 4
CPUE of YOY white seabass *A. nobilis* by month, summer 1988. Bars represent 2SE of the mean.

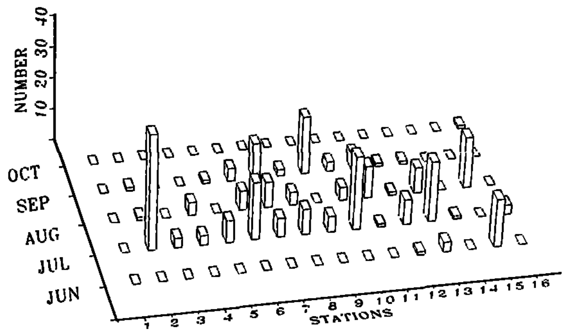

Figure 5
Abundance of YOY white seabass *A. nobilis* by station over the five months (June–October) of the 1988 survey.

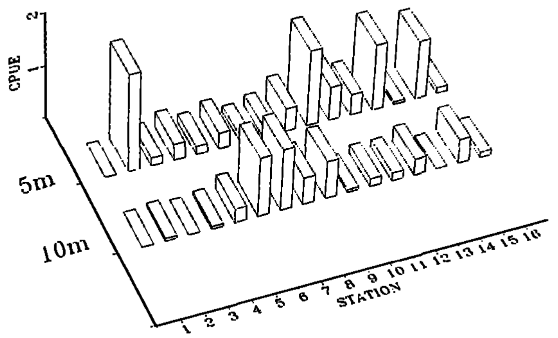

Figure 6
CPUE of YOY white seabass *A. nobilis* by station and depth for the 1988 survey.

relatively heavy settlement was observed throughout the coastal area, as far north as Stn. 2. The greatest numbers were taken off Stns. 2 (Refugio Beach), 6 (Ventura), 10 (Malibu), and 13 (Belmont Shore). None were taken at Stn. 15 (Laguna Beach) where they were most abundant a month earlier. In August, the number of recently-settled white seabass had declined from the July peak. Moderate numbers were captured at Stns. 7 (Hueneme), 11 (El Segundo), 13 (Belmont Shore), and 15 (Laguna Beach). In September, young seabass settled at the middle stations (stns. 6–11). By October, no new settlement was detected at any of the study sites (Fig. 5). The only YOY white seabass was an older fish (78mm SL) taken at Stn. 16 (San Mateo Pt.).

Sixty-three percent (170 individuals) of all YOY were taken at the 5m depth in 1988. YOY white seabass were most numerous at the 5m isobath at Stns. 2–4, 10–13, and 15, but were more abundant at 10m at Stns. 5–9 (Fig. 6).

Analysis of variance of CPUE values in 1988 indicated that only the observed monthly differences were statistically significant (Table 1). Differences in CPUE among stations and depths were not significant in 1988.

YOY white seabass densities ranged from a low of 0.3 individuals/ha in October 1988, to a high of 37.8 in July 1988. In 1988, population estimates varied greatly along the approximately 300km of coastline (excluding the offshore islands) covered in 1988. Overall density for the 5-month period yielded a population estimate of 130,000 individuals in the area of southern California covered by the sampling.

Summer 1989 Sampling from May to August 1989 along the coastlines of the mainland and the offshore islands produced 85 YOY. The catch rate at the mainland stations was 15 times higher than at island stations (CPUE 0.59/tow in 128 tows vs. 0.04/tow in 240 tows) (Fig. 7). Most (88%) of the YOY were captured at three of the mainland stations: Stns. 6 (Ventura, *n* 22), 10 (Malibu, *n* 14), and 15 (Laguna Beach, *n* 38). Five YOY were captured at Stns. 17 and 18 on Santa Cruz I., four were taken at Stn. 22 (White's Cove) on Santa Catalina I., and none were taken at Santa Rosa or San Clemente I.

The CPUE was low in May (0.14/tow), peaked in June (0.45/tow), and declined through July–August (0.14/tow) (Fig. 8). Settlement was restricted to the southern mainland stations (13 and 15) in May (Fig. 9). By June, settlement was observed as far north as Stn. 6 (Ventura) with the greatest numbers occurring off Stns. 10 (Malibu) and 15 (Laguna Beach). In July and August settlement was highly variable at the mainland stations. The five YOY white seabass taken at Santa Cruz I. (Stns. 17 and 18) were captured during June, July,

Table 1

Summary of three-way ANOVA results for catches of young-of-year white seabass *A. nobilis* during the 1988 and 1989 coastal surveys. Dependent variable in all cases was CPUE. DSTBLK = distance block; * $p<0.05$; ** $p<0.001$.

Test	Effect	df	MS	*F*	*p*
1988 Survey					
Station × Month × Depth	Station	15	0.9832	1.0086	0.4590
	Month	4	5.7207	5.8686	0.0005**
	Depth	1	1.9141	1.9635	0.1663
	S × M	60	1.0263	1.0529	0.4212
	S × D	15	1.3441	1.3788	0.1875
	M × D	4	0.9687	0.9938	0.4180
Error	S × M × D	60	0.9748	—	—
1989 Survey					
DSTBLK × Month × Depth	DSTBLK (DB)	2	2.9712	11.8180	0.0000**
	Month	3	0.6036	2.4008	0.0745
	Depth	1	0.5481	2.1801	0.1440
	DB × M	6	0.4784	1.9029	0.0915
	DB × D	2	0.3110	1.2371	0.2962
	M × D	3	0.7950	3.1623	0.0295*
Error	DB × M × D	74	0.2514	—	—

and August. Stn. 22 (White's Cove, Santa Catalina I.) was the only other Channel Island station where YOY seabass were taken (Fig. 9).

During 1989, 69% (*n* 59) of YOY white seabass were taken at 5 m, while 31% (*n* 26) were captured at 10 m. Most of the fish taken at the 10 m isobath were captured at Stns. 6 (Ventura) and 15 (Laguna Beach). Two YOY white seabass were taken at 10m off Santa Cruz I. (Stns. 17 and 18).

In 1989, catches (CPUE) were then examined according to distance block, month, and depth of capture. Analysis of variance revealed the significant effect of distance block (Table 1; Fig. 10) which was highly significant ($p<0.0001$). Although month and depth were not significant main effects, a significant month-by-depth interaction was detected in the three-way ANOVA. The month-by-depth interaction indicated that depth distributions changed significantly over the period of May–August. Catches of YOY white seabass increased at the 10 m depth stratum and decreased at 5 m over the course of the summer (Fig. 11).

The population estimate for 1989 based on mean density along $\sim$600 km of mainland and offshore islands coastland was about 118,000 individuals over the 4-month sampling.

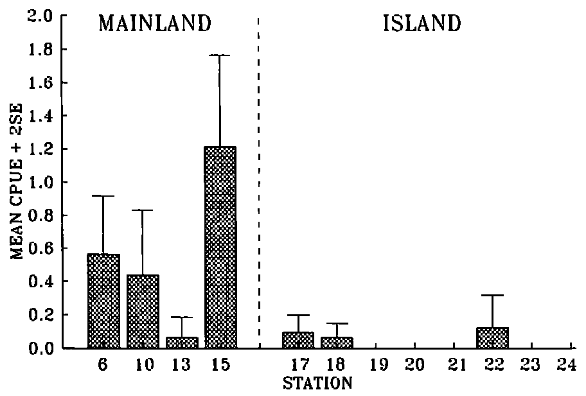

Figure 7

CPUE of YOY white seabass *A. nobilis* by station, summer 1989. Bars represent 2 SE of the mean. Stations are grouped into mainland and island sites for comparison.

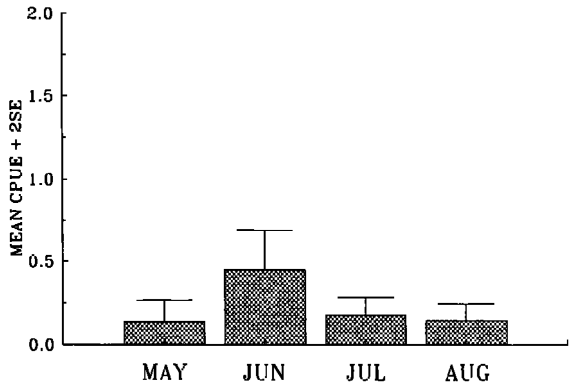

Figure 8

CPUE of YOY white seabass *A. nobilis* by month, summer 1989. Bars represent 2 SE of the mean.

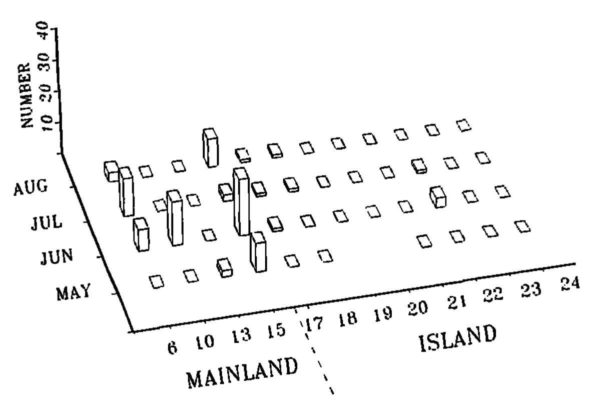

Figure 9
CPUE of YOY white seabass *A. nobilis* by station over the four months (June–October) of the 1989 survey. Stations are grouped into mainland and island sites for comparison. Stns. 19 and 20 (Santa Rosa I.) were not sampled in May due to severe weather conditions.

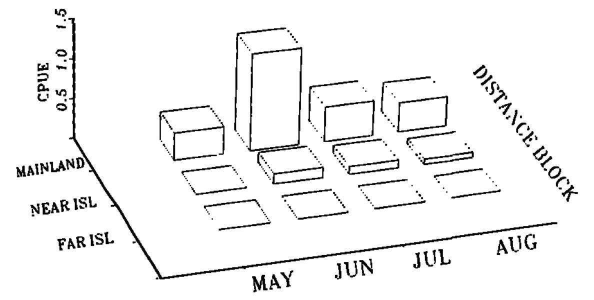

Figure 10
CPUE of YOY white seabass *A. nobilis* within stations grouped by distance block (MAINLAND = four mainland stations, NEAR ISL = four near-island stations, FAR ISL = four far-island stations) over the four months (May–August) of the 1989 survey.

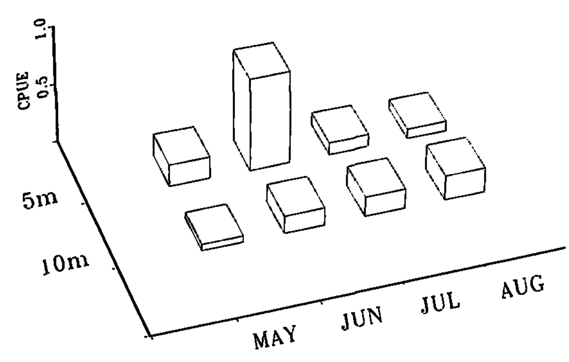

Figure 11
Abundance of YOY white seabass *A. nobilis* by depth over the four months (June–October) of the 1989 survey.

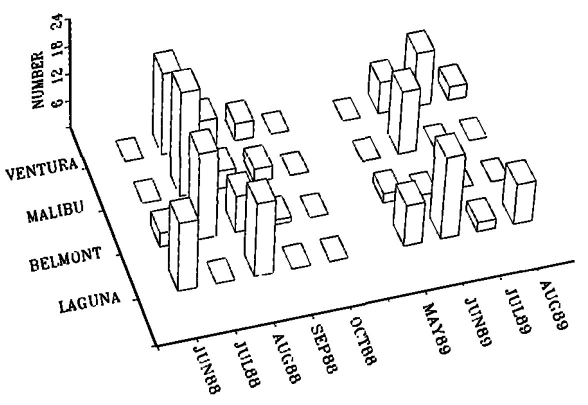

Figure 12
CPUE of YOY white seabass *A. nobilis* at each of four mainland stations by month over the summers of 1988 and 1989. (Stn. 6 = VENTURA, Stn. 10 = MALIBU, Stn. 13 = BELMONT, Stn. 15 = LAGUNA).

Comparison of 1988 and 1989 at four mainland stations

Settlement success in 1988 was compared with that in 1989 by examining the catch at the four mainland stations sampled during both years (Fig. 12). Abundance varied significantly among months over the two summers (one-way ANOVA; F 2.52; 8,27df; $p<0.05$), but not among stations. Settlement among the four stations was consistent during 1988, but highly variable in 1989. Also, CPUE was higher in 1988 (0.75/tow) than in 1989 (0.59/tow) but the difference was not significant (t-test; t 1.23; 15df; p 0.24). Catches differed most between years at Stn. 13 (Belmont Shore) where abundance dropped from 0.78/tow in 1988 to 0.06/tow in 1989, and at Stn. 15 (Laguna Beach) where abundance increased from 0.78/tow to 1.21/tow. The lack of significant differences in catches between 1988 and 1989 was probably due to the high variability and low numbers at individual stations within each year. The relatively high catch at Laguna Beach in 1989 was directly opposed to the lower catches at the other three stations.

Influence of environmental factors

Distance from the mainland Of the environmental variables examined, only the distance of the station from the mainland was significantly correlated with CPUE over both years (Table 2), and this correlation was negative. This corroborates the ANOVA results from 1989 where the effect of distance block was highly

Table 2

Correlation coefficients among catch-per-unit-effort (CPUE) of young-of-year white seabass *A. nobilis* and six environmental variables during the 1988 and 1989 coastal surveys (* $p < 0.05$, 219 df).

	CPUE	DSTMN	BTMP	BSAL	BDO	BSLOP	BALGA
CPUE	–						
DSTMN	**-0.2030***	–					
BTMP	0.0993	-0.0115	–				
BSAL	0.0513	-0.0349	-0.0279	–			
BDO	-0.0084	-0.0425	0.0674	-0.0402	–		
BSLOP	0.0967	**-0.3761***	-0.0718	-0.0365	**0.1427***	–	
BALGA	0.0357	-0.0204	-0.0139	-0.0118	-0.0305	-0.1063	–

DSTMN	Distance from mainland
BTMP	Bottom temperature
BSAL	Bottom salinity
BDO	Bottom dissoved oxygen
BSLOP	Bottom slope
BALGA	Biomass algae

significant, further emphasizing the inshore–offshore distribution pattern of white seabass settlement.

Temperature Bottom temperature ranked second among environmental variables in its correlation to CPUE over both years, although the correlation of 0.10 was not statistically significant (Table 2). The lack of significance may be due to the fact that the relationship of catch to temperature differed noticeably in the 2 years and that overall catches were lower in 1989.

In 1988, the heaviest and most widespread settlement of YOY coincided with the striking rise in coastal temperature during July in the study area, resulting in a significant correlation between log-transformed [$\log_{10}(x+1)$] abundance of YOY and bottom temperature (r 0.25, $P<0.05$, 74 df). In 1989, however, the greatest and most widespread YOY abundance was encountered in June when temperatures were generally depressed. Thus the peak settlement in 1989 occurred 1 month earlier than in 1988 and was apparently not as closely related to a rise in sea temperature as it seemed to be in 1988.

Biomass of drift algae Samples of submerged drift algae ranged from trace amounts (<50 g) to >500 kg per tow for each depth and station. No significant correlation (r 0.036; Table 2) was found between the weight of drift algae and the abundance of young white seabass. However, only two fish (both >60 mm SL) were captured without drift algae in the nets. Thus, drift algae and YOY white seabass may be related on a presence/absence rather than a quantitative basis.

Correlations of catch with other physicochemical variables were too low to warrant consideration.

Multivariate model A combination of three environmental variables—distance from the mainland, bottom temperature, and biomass of drift algae—produced a significant canonical correlation with CPUE (Table 3). Though significant, the correlation accounted for only 5% (R^2 0.052) of the variation in CPUE. A significant canonical correlation with distance and bottom temperature alone accounted for slightly less variation in CPUE (R^2 0.051).

Discussion

Density estimates for white seabass off the coast of southern California were low. Population estimates based on these densities for the Southern California Bight were only 130,000 and 118,000 individuals in 1988 and 1989, respectively. The lower value in 1989 is not surprising since catches at the island stations were extremely low (a high of five YOY at Santa Cruz I., and none at Santa Rosa and San Clemente Is.). Even if these estimates are assumed to be within an order of magnitude of the real population levels, it is obvious that settlement of white seabass was poor in southern California waters. Our data showing relatively low numbers of YOY white seabass in southern California for both sampling years present a similar picture to that presented in Moser et al. (1983) for larval white seabass. The major settlement areas for this species undoubtedly occur to the south in Mexican waters.

Catches of YOY white seabass were highly variable in space and time. Only a small portion of this variability was explained by the environmental variables measured. Monthly differences in catch were marked

Table 3

Results of canonical correlation runs with catch-per-unit-effort (CPUE) of young-of-year white seabass *A. nobilis*, 1988–89, as the dependent variable and selected environmental (independent) variables (* $p<0.05$, ** $p<0.01$).

		Successive canonical correlation runs				
Run	Variables	Canonical R	Canonical R^2	χ^2	df	P
1	DSTMNLD BTMP BALGA	0.2274	0.0517	11.495	3	0.0093**
2	DSTMNLD BTMP	0.2250	0.0506	11.274	2	0.0036**

	Canonical weights within runs	
Variables	Run 1	Run 2
DSTMNLD	-0.8848	-0.8973
BTMP	0.4287	0.4312
BALGA	0.1450	

DSTMNLD	Distance from mainland
BTMP	Bottom temperature
BALGA	Biomass algae

in both years, due to the peaks in abundance of YOY observed in both 1988 and 1989, although monthly differences were significant only in 1988. In 1989, a significant spatial pattern of catches was detected, related to distance from the mainland and depth of capture over months.

Both the distance block ANOVA from 1989 data and the overall correlation analyses strongly suggest that the abundance of YOY white seabass decreases rapidly with distance from the mainland. Other factors are less important. Nonetheless, the combination of distance, temperature, and biomass of drift algae produced a highly significant canonical correlation with distance and temperature contributing most heavily to the relationship.

The large amount of unexplained variation in the multivariate model suggests that important factors may be missing from the analysis. We believe that one such factor is the initial availability of presettlement larvae in the plankton. A dearth of premetamorphic larvae at a potential settlement site results in low settlement, no matter how favorable the environmental conditions. Population sizes off southern California might be limited largely by number of settling larvae rather than site-specific environmental factors or density-dependent survival of YOY. Only when larval input is constantly high, as we suspect is the case in Mexican waters, could the influence of environmental factors on settlement success be determined with any precision.

Factors affecting larval availability are not well known. Spawning of white seabass occurs in the summer and may be related to lunar periodicity (moon phase) (Franklin and Allen, unpubl. data) early in the reproductive period. Lunar periodicity of spawning activity coupled with adult stock size, larval transport mechanisms, and larval growth dynamics could all ultimately influence the availability of white seabass larvae.

Distance from the mainland, the strongest correlate with YOY abundance, probably reflects larval availability which may decrease with distance from coastal stocks occurring in both southern and Baja California. Island populations of adults were either not reproducing or their larvae were being carried away from settlement sites. Long-term settlement success of white seabass to islands may be sporadic and highly variable. For example, Cowen (1985) found that California sheephead (*Semicossyphus pulcher*) settled only sporadically to the offshore islands. The pattern of settlement success of sheephead over a 7–9 year period in areas without larval sources "upstream" of typical current direction was highly variable and dependent on episodic events, such as the El Niño climatic anomaly (Cowen 1985).

Warm water currents may be important to white seabass settlement for two reasons: (1) Large numbers of larvae carried northward from more southern waters by warm water currents may settle after metamorphosis and locate suitable habitat; and (2) the warm water itself may induce locally spawned larvae to settle. On a larger scale, major water movements such as the California Current, gyral circulation ("eddies"), and other mesoscale flows (e.g., internal waves) may control white seabass settlement in the Southern California Bight. Parrish et al. (1981) demonstrated that seasonal effects of the California Current and upwelling in central California had a major effect on the distribution patterns of marine fish. The spawning activities of most fishes coincide with the onshore flow which is characteristic of the late winter and early spring months and transports eggs and larvae into shallow waters. The effects of major hydrographic events on the abundance and distribution of YOY white seabass remain largely unknown.

The main geographic source of white seabass larvae that settle successfully in southern California is also unknown. Southern California populations of adults may be reduced to the point that they may be only a minor source of larvae. Since larvae remain in the plankton as long as 4–5 weeks, population centers of adults off northern Baja California may constitute the major source of southern California YOY seabass. Thus, successful settlement to southern California waters may depend largely on the northward-flowing, warm-water currents best developed in the summer months. Satellite infrared-imagery data indicated that such a large, warm-water mass moved north along the southern California coastline in early July 1988 (Jan Svedkowsky, Ocean Imaging, San Diego, pers. commun.). The resulting dramatic rise in surface and bottom temperatures may have accounted for the marked increase in settlement of white seabass between June and July of that year if the water mass also contained a sufficient number of premetamorphic larvae. Studies of subpopulation structure utilizing restriction fragment length polymorphism (RFLP) analysis of nuclear DNA are currently underway in our laboratory in an attempt to identify the source of newly-settled white seabass in southern California coastal waters. If the main parental population of these fish is located in more southerly waters, joint U.S. and Mexican management efforts may be necessary to prevent the decline of these major breeding stocks in the south.

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