DESCRIPTIVE TRENDS IN SOUTHERN CALIFORNIA BIGHT DEMERSAL FISH ASSEMBLAGES SINCE 1994

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ABSTRACT

Despite intense localized monitoring, few regional assessments of demersal fish assemblages are conducted in the Southern California Bight (SCB). The goal of this study was to describe temporal changes in regional-scale SCB demersal fish assemblages (density, biomass, size class) in relation to regional environmental changes (temperature and related climate indices). Nearly 600 small otter trawls were conducted by collaborating agencies between 3 and 200 m depth during the summers of 1994, 1998, 2003, and 2008 under a standardized sampling plan. Summer water temperature at depth between 1950 and 2008 has remained relatively stable although temperatures in 1998 and 2008 were above the long-term mean while the 1994 and 2003 temperatures were at or below the mean. Mean demersal fish density increased each survey between 1994 and 2003 before declining in 2008, while mean biomass increased each survey since 1994 reaching its maximum in 2008. Based on community similarity analyses, the 1998 survey was appreciably different than the other three surveys, with 2003 and 2008 being the most similar. This could be the result of anomalously warm-water conditions recorded during the 1997–98 El Niño and the resultant temporary poleward expansion of numerous species. Although the sample size was limited to four regional surveys, the best predictors of mean demersal fish density and biomass were the Northern Pacific Gyre Oscillation and the Multivariate El Niño-Southern Oscillation Index. Increasing temperature, or similar patterns in environmental indices, resulted in reduced density and biomass. Furthermore, habitat valuation revealed a trend of increasing value with depth and latitude with the southern inner shelf areas scoring the lowest habitat value. With the addition of more data, regional surveys such as these surveys provide a good foundation on which to analyze changes in demersal fish assemblages.

INTRODUCTION

Southern California Bight (SCB) shelf demersal fish assemblages are commonly monitored by dischargers in compliance with state and federal regulatory requirements (Mearns 1979; Love et al. 1986; Stull and Tang 1996). Nearly 12,000 samples are collected annually along this 300 km coastline to assess the health of demersal fish assemblages in response to discharges (Schiff et al. 2002). Despite this level of effort, few studies have documented trends in these assemblages beyond site-specific programs. For instance, Stull and Tang (1996) identified changes in demersal fish assemblages near one outfall in Los Angeles linked to improving wastewater effluent quality and natural environmental variability.

The challenge of interpreting trends in local-scale data is that regional influences can have an enormous effect on local results. Regional scale information provides the context for local trends, helping discern true differences from background stimuli. Such spatially robust studies potentially reveal significant information including wholesale population declines (Holbrook et al. 1997), generalized overfishing impacts (Myers and Worm 2003), site-specific anthropogenic discharge impacts (or lack of impacts, Conversi and McGowan 1994), influence of hypoxic conditions (Bograd et al. 2008; McClatchie et al. 2010), and/or climatic forcing (Perry et al. 2005; Genner et al. 2010). Disentangling interactions of regional scale natural influences from local anthropogenic stressors often requires the use of spatiotemporally extensive, fisheries-independent data (Hsieh et al. 2008; Hsieh et al. 2009; Genner et al. 2010).

In the SCB, there are two monitoring programs that can be used to evaluate regional trends over the last fifteen years. The first is the SCB Regional Marine Monitoring (Bight), completed regional surveys in 1994, 1998, 2003, and 2008 (Allen et al. 2007; Miller and Schiff 2011). The second is the California Cooperative Oceanic Fisheries Investigation (CalCOFI). CalCOFI measures the hydrography of the SCB water column (Bograd and Lynn 2003) and provides environmental data from a spatial scale relevant to the Bight program, thereby filling data gaps for measurements not collected during the Bight surveys. Together, the CalCOFI hydrographic series and the Bight Program provide data sets with sufficient spatial similarity to warrant a review of the relationship between the demersal fish assemblages of the SCB shelf and physical environmental changes.

This study aims to describe and quantify temporal changes in SCB demersal fish assemblages in relation to regional environmental variability. Such an endeavor has not been attempted in southern California since Mearns (1974) evaluated fish community responses to seasonal dissolved oxygen patterns. The temporal changes in SCB demersal fish assemblages will be assessed by spatial dimensions of known importance including depth and latitude. Fish community characteristics include species distributions, abundance, biomass, fish length, and habitat value. Environmental changes include temperature and various climate indices including the Northern Pacific Gyre Oscillation (NPGO) (Di Lorenzo et al. 2008), the Pacific Decadal Oscillation (PDO) (Mantua et al. 1997), and the Multivariate El Niño-Southern Oscillation Index (MEI) (Wolter and Timlin 2012).

MATERIALS AND METHODS

Bight Sampling for Demersal Fish

The Bight Program uses a stratified probabilistic survey design (Stevens 1997). Three strata were sampled in each survey: 5–30 m = inner shelf (IS); 31–120 m = middle shelf (MS); and 121–200 m = outer shelf (OS). In addition, three latitudinal strata were sampled in each survey: 33.6°–34.2°N = Northern SCB; 33.3°–33.6°N = Central SCB; and 32.3°–33.3°N = Southern SCB. Each station was sampled once per survey by a consortium of participating agencies (publicly owned treatment works, academics, and consultants) during the summer (July–September) with a standardized 7.6 m head-rope semiballoon otter trawl net with a 1.25 cm cod-end mesh. Trawls were towed parallel to the target isobaths at each station for ≈ 10 min at 0.8–1.0 m/sec. The difference between the start and stop fishing GPS coordinates recorded on the deck of the towing vessel was used to calculate the distance trawled. Two assumptions were used: 1) the net retained contact with the bottom during the entire designated fishing period, and 2) the GPS coordinates acted as a proxy for the net's relative position. Upon retrieval, trawl catches were sorted, identified to species and measured to nearest cm (standard length [SL], total length [TL] or disc width [DW], where appropriate). All recorded lengths were rounded up to the next size class (e.g., a 6.1 cm fish = 7 cm size class).

CalCOFI Sampling for Hydrography

CalCOFI conducts quarterly hydrographic surveys of the California Current hydrography. Methods used by CalCOFI are summarized in Bograd and Lynn (2003). CalCOFI uses a fixed grid sampling design, of which data from four transects from San Diego to Point Conception (lines 83–93) from stations numbering less than 50 on each line corresponding to approximately the same sampling frame as the Bight Program were used.

Data Analysis

Abundance and biomass data were standardized to the area swept. Underwater measurements by EQA-MBC (1975) determined the 7.6 m otter trawl net spread 4.9 m on average while under tow and fishing. Thus, the area swept in this analysis represents the distance trawled (m) × 4.9 m. The Shannon-Wiener Diversity Index was calculated for each depth strata by year using the derived densities. A raw density-weighted mean latitude and depth of each survey year's catch was calculated using the coordinates (depth) where fishing started. No density or biomass transformations were made prior to weighting. Environmental indices reviewed in the analysis include mean summer temperature (°C), PDO, NPGO, and the MEI. Mean extended summer (June–September) values for each index encompass the survey year and the preceding four years. Water temperature at 70 m recorded by CalCOFI (2011) for the survey year and the preceding four years was used. Temperatures were compared against the mean latitude, depth, and overall catch for all fishes, after removing the two most common species (no *Citharichthys*), and each of the two most common species individually. Climate indices were only compared against density and biomass independent of latitude or depth of capture. Low statistical power ($\beta < 0.80$) resulting from our small sample size (n = 4 surveys) precluded advanced, significance-testing regression modeling. Therefore, conclusions were restricted to comparing coefficients of determination (R^2) rather significance at $\alpha = 0.05$ level. The sensitivity of these results to fluctuations in the dominant species were evaluated by excluding the abundant species and examining them individually as well as examining the entire catch as a whole.

Based on the probabilistic design of the Bight Program, density by stratum was area-weighted using the ratio estimator approach following Thompson (1992):

$$m = \frac{\sum_{i=1}^{n} (p_i * w_i)}{\sum_{i=1}^{n} w_i},$$

where:

m = Area-weighted mean density for stratum j.
p_i = Parameter value (e.g., density) at station i.
w_i = Area weight for station i.
n = Number of stations in population j.

The standard error of the mean was calculated using the following equation.

$$\text{Standard error (SE)} = \sqrt{\frac{\sum_{i=1}^{n}((p_i - m) * w_i)^2}{\left(\sum_{i=1}^{n} w_i\right)^2}},$$

where:
m = Area-weighted mean concentration for population j.
p_i = Parameter value (e.g., density) at station i.
w_i = Area weight for station i.
n = Number of stations in population j.

Similarities in overall community composition, as indicated by the species abundance distribution, were examined using percent similarity index (PSI, Whittaker 1952) using the equation:

$$PSI = 100 - 0.5 * \Sigma|A_i - B_i|$$

where:

A_i and B_i are the percentages of species i in samples A and B, respectively.

Fish length frequency distributions and mean lengths for each survey year were examined for shifts in the overall size structure of the whole catch and each of the four most commonly measured species. Abundance-weighted mean lengths were calculated for each comparison (i.e., year, latitude, depth). Annual mean lengths across all stations were compared using a Friedman Rank Sum Test. Furthermore, the annual total mean lengths were compared against the overall mean across all four Bight surveys to place each annual value into a long-term context. The mean length by 0.2°N latitude and 20 m depth bins were also analyzed for all species combined, and the most common species separately, to identify possible spatial variability in the catch.

Habitat values were calculated for each stratum in each year based on fish guilds described in Bond et al. (1999) and further supplemented by Pondella (2009) using a modification of the Bond et al. (1999) equation:

$$HV = \Sigma_{24}^{1} (mean\ length * F * D)^{0.5}$$

where:

F = proportional frequency of occurrence on a scale of 0–1 and
D = density (count/hectare).

The habitat valuation analysis focused on the demersal assemblages. Therefore, pelagic and midwater fishes (e.g., northern anchovy *Engraulis mordax*) were excluded as their catches likely represent sampling during midwater deployment or retrieval (Biagi et al. 2002). A listing of the 74 species used in the habitat valuation analysis (Appendix A). Habitat value differences by year, strata, and latitudinal region were compared separately using a Kruskall-Wallis (KW) analysis of variance with a Bonferroni multiple comparison test (Sokal and Rohlf 1995).

RESULTS

A total of 597 tows completed during the four Bight surveys (table 1) caught 131,961 fish weighing a total of 3541 kg and representing 160 demersal species (Appendix B). Sampling effort was greatest in 1998 and least in 2008. Distribution of sampling sites among the three shelf strata was the most equitable in 2008 when 29 (±3, standard error) stations were sampled in each shelf stratum. The sampling distribution in 1998 was the most variable with 81 (±25) stations sampled in each zone. Sampling was consistently most intense along the middle shelf followed by the inner shelf and the outer shelf, in descending order.

The 15 most common species averaged 79% of the total abundance and 77% of the total biomass across the four surveys (tables 2, 3). These patterns were most heavily influenced by the density and biomass of Pacific sanddab (*Citharichthys sordidus*), which ranked first in abundance and biomass overall. Pacific sanddab, longspine combfish (*Zaniolepis latipinnis*), and English sole (*Parophrys vetulus*) were the only species taken in all years and depth zones among the 15 most common species. Of the species ranking second through fifth in density, only halfbanded rockfish (*Sebastes semicinctus*) and stripetail rockfish (*S. saxicola*) ranked among the top ten in biomass at fifth and ninth, respectively. English sole and California halibut (*Paralichthys californicus*) ranked second and third in biomass, respectively, but English sole was only the 14th most common fish taken while California halibut was not among the 15 most commonly caught species. Not unexpectedly, highly abundant species tended to be smaller fishes as compared to those species with high biomass.

Observed differences in species abundance distributions may reflect changes in the local physiochemical structure of the waters overlying the SCB shelf. Mean annual summer seawater temperatures recorded at 50 m, 100 m, and 200 m were significantly corre-

TABLE 1
Number of successful trawl events by shelf stratum in each of the four Bight monitoring surveys (1994, 1998, 2003, and 2008).

Shelf Strata	1994	1998	2003	2008	Total
Inner (5–30 m)	32	77	43	32	184
Middle (31–120 m)	58	126	86	33	303
Outer (121–200 m)	20	40	27	23	110
Survey total	110	243	156	88	597

TABLE 2
Mean area-weighted and unadjusted (raw) density (count/1000 m²) by year and depth zone for the 15 most common species taken during the Bight program demersal surveys (1994, 1998, 2003, and 2008).

Area-Weighted Density	1994				1998				2003				2008			
Species	IS	MS	OS	Tot.	IS	MS	OS	Tot.	IS	MS	OS	Tot.	IS	MS	OS	Tot.
Citharichthys sordidus	0.2	16.8	6.7	11.2	0.4	13.1	26.6	12.9	1.3	55.6	33.4	39.4	2.5	22.9	31.3	18.2
Citharichthys stigmaeus	6.9	1.7	—	2.7	3.3	4.1	—	3.3	31.5	8.6	0.0	12.8	24.2	3.0	—	8.8
Icelinus quadriseriatus	0.3	4.1	0.0	2.5	0.0	4.7	0.0	3.1	1.7	9.6	—	6.3	1.9	17.7	—	10.1
Sebastes semicinctus	—	0.8	0.2	0.5	—	0.6	0.5	0.4	0.0	16.1	3.2	10.4	—	9.7	2.2	5.6
Sebastes saxicola	0.0	1.6	4.7	1.7	—	0.7	2.1	0.8	0.0	10.0	17.9	8.8	—	2.5	10.4	3.0
Zaniolepis latipinnis	0.2	2.6	0.0	1.6	0.0	2.1	0.4	1.4	0.8	11.1	0.3	7.0	0.0	5.4	0.6	3.0
Lyopsetta exilis	—	0.3	15.1	2.4	—	0.2	14.8	2.5	—	0.2	20.8	3.2	—	0.2	26.5	4.4
Porichthys notatus	0.0	4.3	14.8	4.8	—	2.2	2.4	1.8	0.4	2.0	1.8	1.6	0.1	2.3	2.2	1.6
Citharichthys xanthostigma	0.7	3.3	—	2.2	0.5	5.7	0.0	3.8	0.5	3.0	0.0	1.9	0.2	3.0	0.1	1.7
Microstomus pacificus	—	2.1	6.5	2.2	—	1.7	6.7	2.2	0.0	4.9	5.4	3.8	—	1.2	3.7	1.3
Zalembius rosaceus	0.8	2.1	0.1	1.5	0.0	1.1	0.4	0.8	3.8	1.9	0.4	2.1	1.3	6.1	1.5	4.0
Genyonemus lineatus	2.3	—	—	0.6	25.1	1.6	—	5.7	2.2	0.0	—	0.5	0.2	0.0	—	0.1
Zaniolepis frenata	—	0.4	2.4	0.6	—	0.6	10.3	2.0	—	1.5	10.1	2.4	—	1.0	8.1	1.8
Parophrys vetulus	0.5	0.5	0.2	0.5	0.4	0.4	1.3	0.6	1.8	1.3	1.4	1.4	1.7	5.9	2.8	4.2
Synodus lucioceps	0.6	0.5	0.1	0.5	5.2	5.6	0.0	4.7	0.8	0.2	—	0.3	1.1	0.5	—	0.6
All species combined	17.0	50.0	71.0	45.0	47.0	54.0	76.0	56.0	53.0	140.0	115.0	115.0	40.0	93.0	102.0	79.0
Number of Species	38	65	39	86	54	90	59	129	55	83	56	109	50	56	44	93
Species Diversity	2.3	2.5	2.4	2.9	1.8	2.8	2.2	3.0	1.9	2.33	2.34	2.6	1.8	2.5	2.17	2.8
Raw Density																
Citharichthys sordidus	0.1	2.5	0.8	3.3	0.1	0.9	1.5	2.5	0.3	3.7	1.7	5.7	0.4	2.2	2.1	4.7
Icelinus quadriseriatus	0.1	1.7	0.0	1.9	0.0	1.6	0.0	1.6	0.6	4.6	—	5.2	0.5	5.4	—	5.9
Citharichthys stigmaeus	1.1	0.3	—	1.4	0.4	0.3	—	0.7	4.5	0.9	0.0	5.5	3.6	0.7	—	4.4
Genyonemus lineatus	0.4	—	—	0.4	10.5	0.2	—	10.7	0.2	0.0	—	0.2	0.1	0.0	—	0.1
Sebastes saxicola	0.0	0.4	1.0	1.4	—	0.3	0.8	1.1	0.0	2.0	2.9	5.0	—	0.6	2.2	2.7
Lyopsetta exilis	—	0.2	1.6	1.8	—	0.1	2.0	2.1	—	0.0	2.9	2.9	—	0.1	2.7	2.8
Sebastes semicinctus	—	0.2	0.1	0.2	—	0.1	0.2	0.3	0.0	3.3	0.3	3.5	—	1.1	0.5	1.6
Porichthys notatus	0.0	0.8	1.4	2.2	—	0.5	0.5	1.0	0.1	0.4	0.2	0.7	0.1	0.5	0.4	0.9
Microstomus pacificus	—	0.4	0.7	1.1	—	0.3	0.9	1.2	0.0	0.7	0.7	1.5	—	0.3	0.6	0.9
Zaniolepis latipinnis	0.1	0.6	0.0	0.7	0.0	0.4	0.2	0.6	0.2	1.6	0.1	2.0	0.0	0.9	0.2	1.2
Zalembius rosaceus	0.1	0.5	0.0	0.6	0.0	0.4	0.2	0.6	0.5	0.6	0.1	1.2	0.4	1.2	0.4	2.0
Zaniolepis frenata	—	0.1	0.5	0.6	—	0.1	0.9	1.0	—	0.2	1.1	1.3	—	0.2	1.1	1.4
Synodus lucioceps	0.3	0.2	0.0	0.5	0.8	1.7	0.0	2.5	0.2	0.1	—	0.3	0.2	0.2	—	0.4
Citharichthys xanthostigma	0.3	0.6	—	0.8	0.1	1.2	0.0	1.3	0.2	0.6	0.0	0.8	0.1	0.5	0.0	0.7
Parophrys vetulus	0.1	0.2	0.1	0.4	0.1	0.2	0.3	0.5	0.4	0.3	0.3	1.0	0.4	0.7	0.4	1.5
All species combined	4.3	11.9	10.6	26.7	16.3	11.5	10.5	38.4	9.9	24.1	15.1	49.1	8.3	18.5	14.3	41.2

Note: "—" = none taken; 0.0 = < 0.05.

lated ($p < 0.05$), with correlation coefficients (r) ranging between 0.29 (50 m vs. 200 m) and 0.71 (50 m and 100 m) (figs. 1b,c,d). Summer seawater temperatures at 50 m since 1949 averaged 11.3˚C while temperatures in survey years (1994, 1998, 2003, and 2008) were both above and below the mean with 11.2˚C, 13.2˚C, 10.7˚C, and 12.3˚C, respectively. A similar pattern was observed at 100 m, albeit with less variation and mean summer temperatures of 9.4˚C, 10.4˚C, 9.1˚C, and 10.6˚C, respectively. Lastly, at 200 m, temperatures were least variable over time and each survey year was near the long-term average (8.4˚C) except 2008 when the temperature was 1.0˚C warmer at 9.4˚C. The seawater temperature during the survey year, however, often misrepresented conditions that dominated the intervening years. For example, 2008 temperatures were above average while temperatures since the 2003 survey were predominantly below average. Therefore, temperature analyses focused on the mean across the years since the previous survey to better account for intervening conditions. This same principle was applied to the climate indices NPGO, PDO, and MEI.

Comparisons of the species abundance distributions via the PSI indicated a high degree of similarity (≈ 80%) between the 2003 and 2008 catches (fig. 2). Less similarity was observed between the 2003 and 2008 surveys and the 1994 and 1998 surveys (fig. 2). The 1998 survey results were the most unique at <55% similarity to any of the other three surveys. Comparisons among the relative density of the 15 most common species helps explain the similarities and differences among Bight surveys (fig. 2). For example, Pacific sanddab accounted for ≈ 23% of total catch in all but the 2003 survey when it accounted for >30% of the catch. The most distinct difference between earlier and later surveys pertains to plainfin midshipman (*Porichthys notatus*), which was commonly taken in 1994 but not in 2003 or 2008. Catches of species ranked 6–14 were markedly higher in 1998

TABLE 3
Mean area-weighted and unadjusted (raw) biomass (kg/1000 m²) by year and depth zone for the 15 most common species taken during the Bight program demersal surveys (1994, 1998, 2003, and 2008).

Area-Weighted Biomass	1994				1998				2003				2008			
Species	IS	MS	OS	Tot.	IS	MS	OS	Tot.	IS	MS	OS	Tot.	IS	MS	OS	Tot.
Citharichthys sordidus	0.01	0.23	0.29	0.18	0.01	0.41	1.01	0.43	0.04	0.93	1.22	0.76	0.04	0.44	2.45	0.65
Parophrys vetulus	0.07	0.07	0.03	0.06	0.03	0.05	0.12	0.05	0.08	0.14	0.09	0.12	0.06	0.30	0.22	0.22
Paralichthys californicus	0.56	0.04	—	0.16	0.29	0.04	—	0.08	0.20	0.03	—	0.07	0.14	—	—	0.04
Citharichthys xanthostigma	0.05	0.11	—	0.08	0.02	0.14	0.00	0.09	0.03	0.14	0.00	0.10	0.01	0.11	0.00	0.06
Sebastes semicinctus	—	0.02	0.00	0.01	—	0.00	0.01	0.00	0.00	0.09	0.10	0.07	—	0.37	0.07	0.21
Pleuronichthys verticalis	0.12	0.06	—	0.06	0.10	0.05	0.00	0.05	0.07	0.09	0.02	0.08	0.12	0.13	0.03	0.11
Lyopsetta exilis	—	0.00	0.29	0.04	—	0.01	0.24	0.04	—	0.00	0.42	0.06	—	0.00	0.51	0.09
Genyonemus lineatus	0.19	—	—	0.05	0.44	0.11	—	0.15	0.12	0.00	—	0.03	0.01	0.00	—	0.01
Sebastes saxicola	—	0.02	0.16	0.03	—	0.02	0.07	0.02	0.00	0.08	0.43	0.11	—	0.04	0.27	0.06
Citharichthys stigmaeus	0.05	0.01	—	0.02	0.04	0.04	—	0.03	0.21	0.07	0.00	0.09	0.23	0.02	—	0.08
Microstomus pacificus	—	0.06	0.21	0.07	—	0.03	0.16	0.05	0.00	0.08	0.13	0.07	—	0.03	0.17	0.04
Porichthys notatus	—	0.09	0.31	0.10	—	0.05	0.07	0.04	0.02	0.05	0.10	0.05	—	0.03	0.09	0.03
Zaniolepis latipinnis	0.01	0.06	—	0.04	—	0.05	0.01	0.03	0.03	0.15	0.01	0.10	0.00	0.09	0.02	0.05
Scorpaena guttata	0.04	0.11	—	0.08	0.01	0.04	0.00	0.03	0.04	0.08	0.02	0.06	0.02	0.05	0.01	0.03
Synodus lucioceps	0.05	0.15	0.02	0.11	0.07	0.07	0.00	0.06	0.02	0.01	—	0.01	0.03	0.02	—	0.02
All species combined	1.43	1.31	1.73	1.40	1.47	1.52	2.27	1.63	1.19	2.56	3.49	2.37	0.83	2.00	4.42	2.05
Raw Biomass																
Citharichthys sordidus	0.01	0.29	0.28	0.58	0.00	0.24	0.87	1.11	0.06	0.90	1.05	2.01	0.04	0.44	2.45	2.93
Lyopsetta exilis	—	0.00	0.29	0.29	—	0.01	0.29	0.30	—	0.01	0.56	0.56	—	0.00	0.51	0.51
Genyonemus lineatus	0.33	—	—	0.33	1.09	0.11	—	1.20	0.07	0.00	—	0.08	0.03	0.00	—	0.04
Paralichthys californicus	0.57	0.09	—	0.66	0.28	0.15	—	0.43	0.26	0.06	—	0.31	0.14	—	—	0.14
Parophrys vetulus	0.07	0.08	0.03	0.17	0.01	0.06	0.12	0.20	0.07	0.16	0.14	0.36	0.06	0.30	0.22	0.57
Sebastes saxicola	—	0.02	0.17	0.19	—	0.03	0.09	0.11	0.00	0.07	0.42	0.49	—	0.04	0.27	0.31
Microstomus pacificus	—	0.06	0.24	0.30	—	0.03	0.15	0.18	0.00	0.08	0.13	0.21	—	0.03	0.17	0.20
Porichthys notatus	—	0.12	0.30	0.42	—	0.06	0.07	0.13	0.01	0.05	0.08	0.15	—	0.03	0.09	0.12
Citharichthys xanthostigma	0.05	0.14	—	0.19	0.01	0.23	0.01	0.26	0.07	0.17	0.00	0.24	0.01	0.11	0.00	0.12
Pleuronichthys verticalis	0.12	0.07	—	0.19	0.05	0.07	0.00	0.13	0.09	0.11	0.02	0.22	0.12	0.13	0.03	0.27
Citharichthys stigmaeus	0.05	0.01	—	0.07	0.02	0.02	—	0.04	0.24	0.05	0.00	0.28	0.23	0.02	—	0.26
Zaniolepis frenata	—	0.01	0.06	0.07	—	0.01	0.11	0.12	—	0.04	0.18	0.22	—	0.01	0.18	0.19
Sebastes semicinctus	—	0.02	0.00	0.03	—	0.00	0.02	0.02	0.00	0.07	0.05	0.12	—	0.37	0.07	0.44
Scorpaena guttata	0.05	0.09	—	0.14	0.00	0.06	0.00	0.07	0.04	0.15	0.01	0.20	0.02	0.05	0.01	0.08
Synodus lucioceps	0.05	0.12	0.03	0.20	0.05	0.14	0.00	0.19	0.01	0.02	—	0.03	0.03	0.02	—	0.04
All species combined	1.58	1.47	1.80	4.84	2.58	1.73	2.13	6.44	1.28	2.62	3.30	7.20	0.91	2.00	4.42	7.33

than the remaining years, thus resulting in the greater PSI differences.

Mean demersal fish density along the continental shelf increased slightly through 2003 before declining again in 2008, although 2008 remained above the mean density recorded in 1994 and 1998 (fig. 1a; tables 2, 3). Similarly, mean biomass increased in 2003 and 2008 from 1998. Comparisons between fish density and biomass against the average temperature at 70 m for the intervening years resulted in a pattern of decreasing density and biomass with increasing temperature (fig. 3). For all species combined, the R^2 was 0.70 for density and 0.85 for biomass. To determine the effect of the highly abundant species on this relationship, data were reanalyzed after filtering out both Pacific sanddab and speckled sanddab (*Citharichthys stigmaeus*), and then for each of these dominant species individually to examine their impact on the relationship. There was an effect of these dominant species on the overall relationship as the R^2 for both density and biomass increased with their exclusion. Speckled sanddab density and biomass exhibited a relationship with temperature similar to that described for all species. Pacific sanddab density and biomass, however, exhibited a substantially reduced relationship with temperature. Given its consistent first ranking in density across all surveys, this likely accounted for the improved relationship observed between density or biomass with temperature after removing Pacific sanddab.

The three climate indices also had relationships to regional fish density or biomass (table 4). The direction of each relationship was consistent with the general productivity characterizations of each climate index. For example, negative NPGO or positive PDO equated to low productivity periods and resulted in lower demersal fish density and biomass. Of the three climate indices, the MEI and the NPGO were the most correlated with patterns in fish community metrics; mean R^2 were 0.81 and 0.80, respectively. The PDO was the least descriptive climate index with the lowest mean $R^2 = 0.70$, but also the second highest standard error consistent with the wide variation among analysis-specific values. The NPGO was the most explanatory index for density with

TABLE 4
Coefficient of determination (R^2) of the trendline describing the relationship between each environmental index and each abundance index. Density refers to the area-weighted mean count/1000 m² and biomass represents the area-weighted mean kg/1000 m². No *Citharichthys* data set represents the data for each abundance metric after removing *C. sordidus* and *C. stigmaeus*. NPGO = North Pacific Gyre Oscillation, PDO = Pacific Decadal Oscillation, MEI = Multivariate ENSO Index, and temp = mean water temperature at 70 m. See Material and Methods for description of the mean calculation for each environmental index.

	Index			
Metric	NPGO	PDO	MEI	Temp
Density				
All species	0.99	0.92	0.85	0.70
No Citharichthys	0.98	0.79	0.94	0.83
C. sordidus	0.90	0.73	0.66	0.48
C. stigmaeus	0.99	0.92	0.93	0.82
Biomass				
All species	0.47	0.39	0.74	0.85
No Citharichthys	0.92	0.86	1.00	0.96
C. sordidus	0.17	0.12	0.41	0.56
C. stigmaeus	0.96	0.85	0.98	0.91
Mean	0.80	0.70	0.81	0.76
SE	0.11	0.10	0.07	0.06

a $R^2 > 0.90$ for all four community metrics. Temperature was the least explanatory with a $R^2 \leq 0.83$ for all four fish community metrics. Patterns in biomass, however, were best described by temperature and the MEI, including a nearly straight-line relationship between the MEI and the no *Citharichthys* group of demersal fishes. In all cases, no clear relationship between Pacific sanddab and environmental indices were observed and these comparisons consistently yielded the lowest coefficient of determination in each analysis.

Demersal fish community density and biomass generally shifted southward with increasing water temperature (fig 4). In 1994 and 1998, the relatively warmer periods, density and biomass were centered between 33.5° and 33.6°N latitude. In 2003 and 2008, the relatively cooler periods, density and biomass were centered between 33.6° and 33.7°N latitude. These latitudinal relationships using all species ($R^2 = 0.92$ for density and 0.81 for biomass) were largely driven by movement in Pacific sanddab ($R^2 = 0.83$) populations. Depth patterns in demersal fish density and biomass were variable and exhibited fewer relationships with latitude than observed for temperature. For example, a modest ($R^2 = 0.50$) rela-

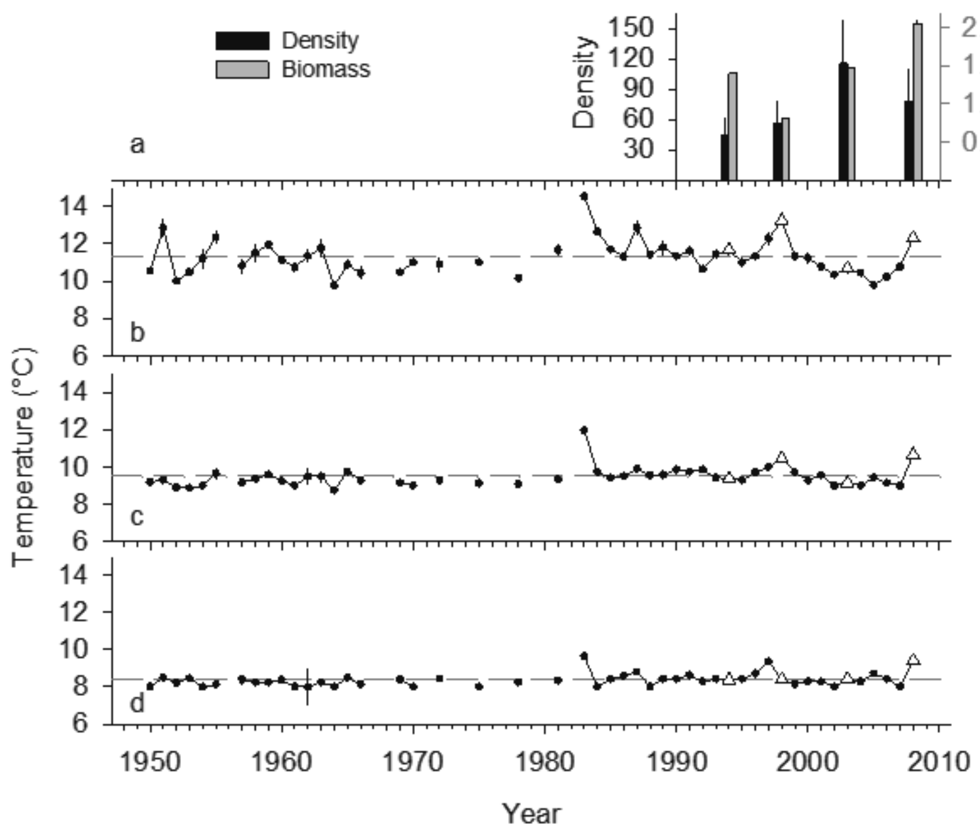

Figure 1. a) Mean annual demersal fish density (count/100 m² ± s.e.) and biomass (kg/100 m² ± s.e.) recorded during the 1994, 1998, 2003, and 2008 surveys at stations on the inner shelf, middle shelf, and outer shelf. Mean summer water temperature recorded during the CalCOFI hydrographic surveys at stations located inshore of Station 50 along survey lines 83.3, 86.7, 90.0, and 93.3 at the b) 50-, c) 100-, and d) 200-m depth strata. The four Bight Regional Monitoring survey years are denoted by the open triangles in each plot. Dashed line in each plot represents the long-term (1949–2008) mean temperature at each depth.

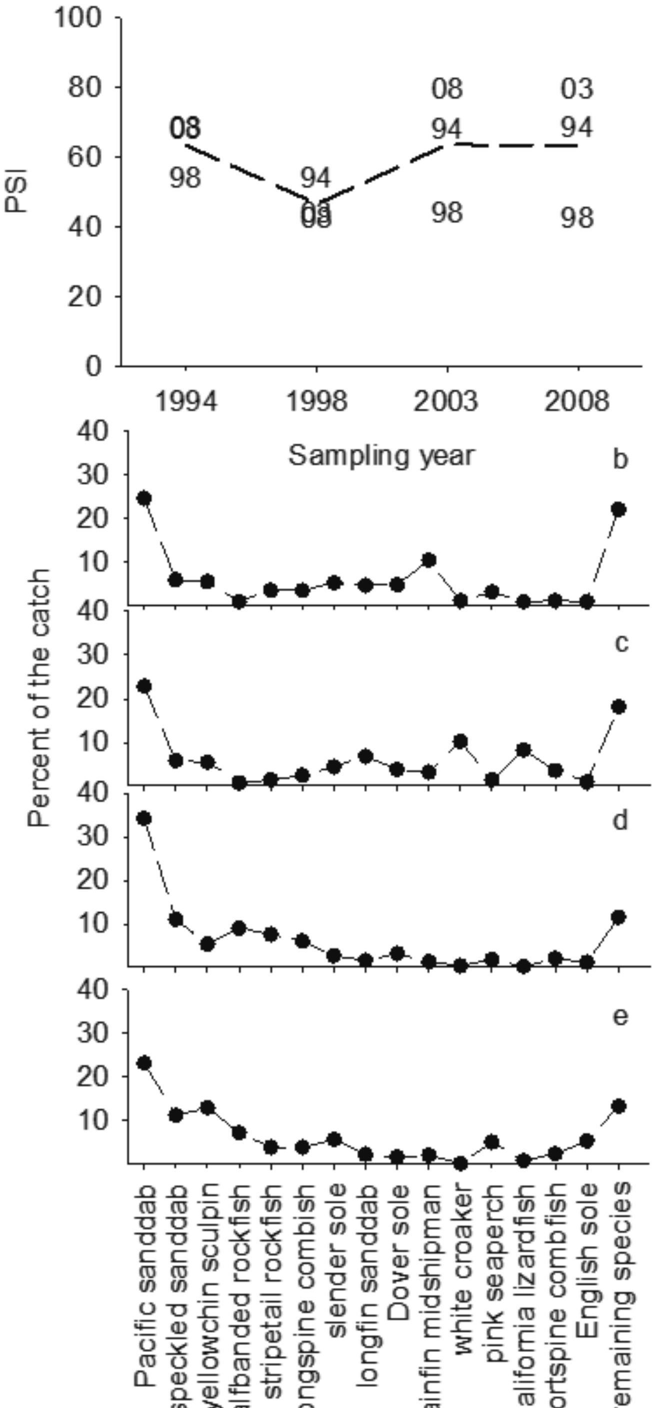

Figure 2. a). Percent similarity index (PSI) comparing the assemblages and the proportional catch by species between the four Southern California Bight demersal fish surveys (1994, 1998, 2003, and 2008) along the inner, middle, and outer shelves. Numbers represent the years compared against the base year listed on the x-axis. 2003 and 2008 overlap for the comparisons with 1994 and 1998. Species distribution of the 15 most common species, listed in order of decreasing abundance, across all four surveys, combined, plotted by survey: b) 1994, c) 1998, d) 2003, and e) 2008.

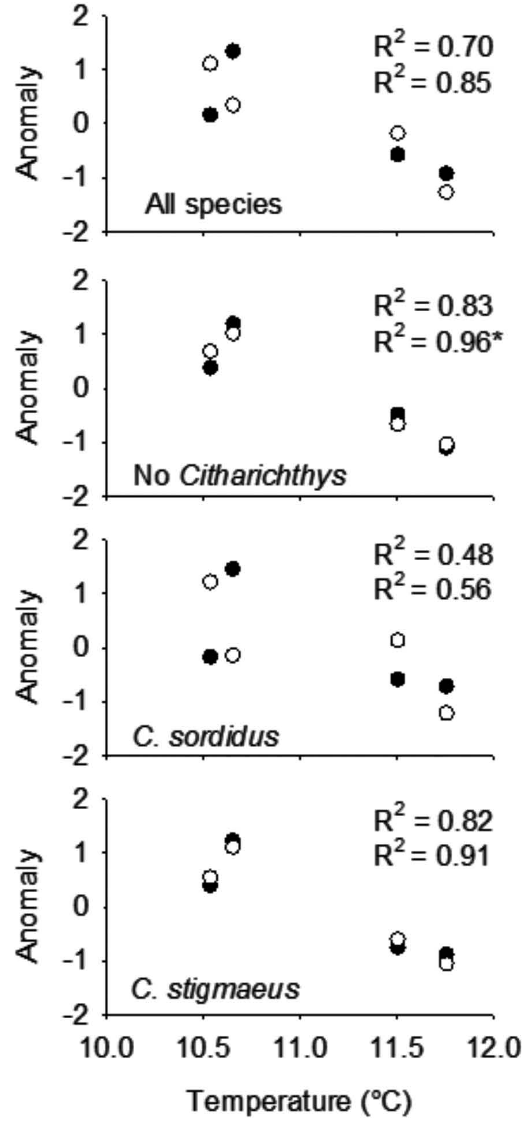

Figure 3. Standardized anomalies of annual mean density (count/100 m²; black circles – ●) and biomass (kg/100 m²; white circles – ○) versus the ~5-year running mean temperature at 70 m for all species combined, all species after excluding *Citharichthys sordidus* and *C. stigmaeus*, *C. sordidus*, and *C. stigmaeus*. Coefficient of determination (R^2) for the linear regression through each set is presented. Top R^2 reflects density and bottom R^2 reflects biomass.

tionship was observed between speckled sanddab biomass depth and latitude.

The OS demersal fish community consistently had more fish per unit area (density and biomass) than either the IS or the MS (tables 2, 3). Diversity and species richness, however, was typically greatest along the MS compared to the IS or OS. In nearly every survey, the IS recorded the lowest density, biomass, diversity, and species richness.

The seven most abundant species taken from all four surveys combined accounted for ≥69% of the total catch regardless of depth stratum (fig. 5). Eleven species-stratum combinations had increasing trends while 10

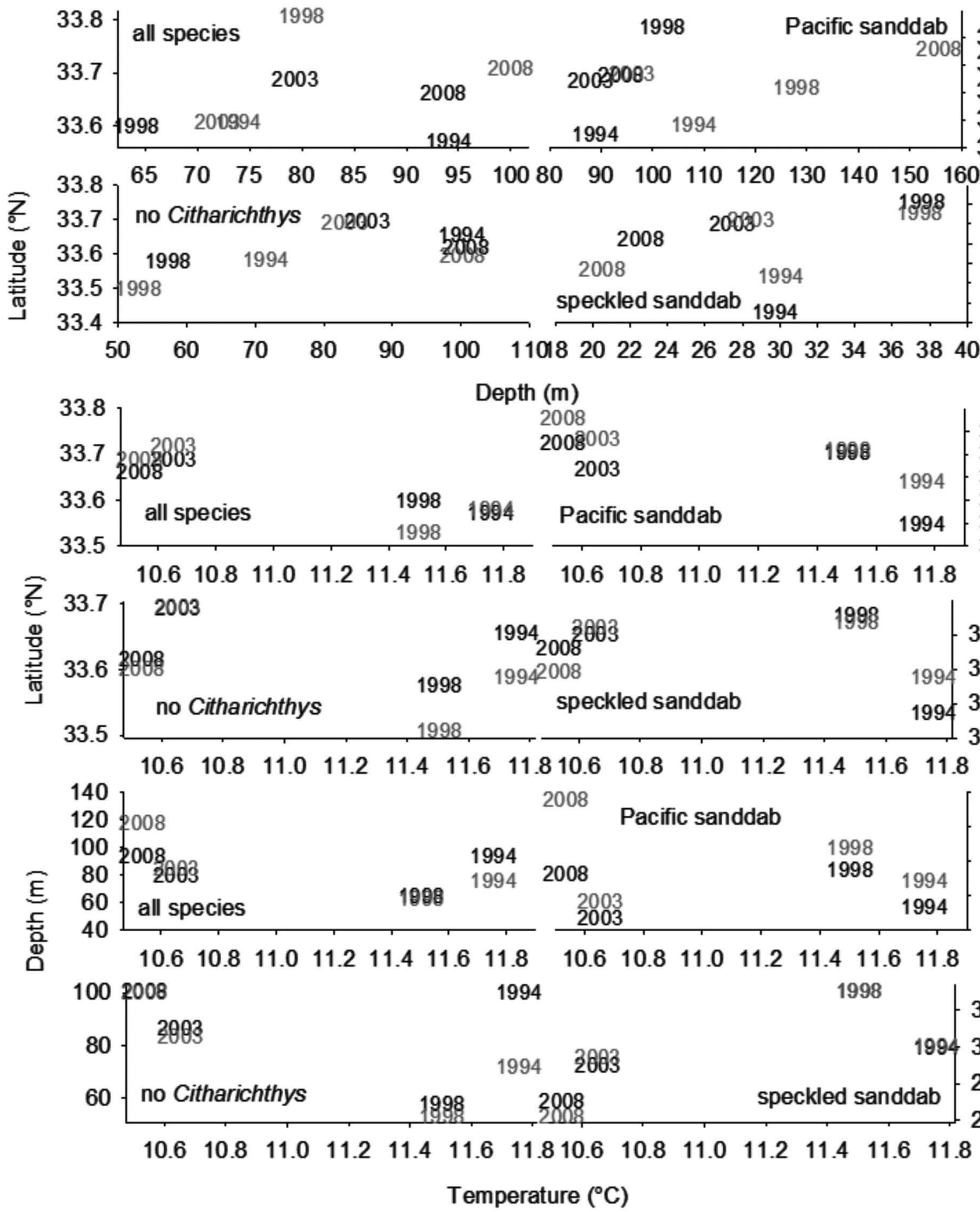

Figure 4. Area-weighted mean density (count/100 m²) and biomass (kg/100 m²) centers of distribution by latitude, depth, and latitude per temperature at 70 m. Grey = biomass and black = density. The survey year is overlaid on the data point in each figure.

species-stratum combinations declined over time. Species with substantially increasing densities during the four surveys included Pacific sanddab and speckled sanddab along the IS; yellowchin sculpin and halfbanded rockfish along the MS; and Pacific sanddab, slender sole (*Lyopsetta exilis*), and stripetail rockfish along the OS. Decreasing densities were most noticeable in many species along the IS, California lizardfish (*Synodus lucioceps*) along the MS, and plainfin midshipman and Dover sole (*Microstomus pacificus*) along the OS.

In total, all four surveys were dominated by demersal fishes in the 6 to 14 cm size classes (fig. 6). Average demersal fish lengths in 1994 and 1998 did not change much (10.5 cm and 10.7 cm, respectively). Demersal fish length frequencies were generally consistent between 1994 and 1998, with a subtle size-class mode shift from 6 and 7 cm size classes in 1994 to 7 to 10 cm size classes in 1998. In 2003, however, the mean fish length declined over 1 cm (9.5 cm) due to the influence of fishes ≤7 cm. This pattern reversed in 2008 as the catch increased in size to an average of 11.0 cm with few individuals in smaller size classes, particularly those ≤6 cm. These dif-

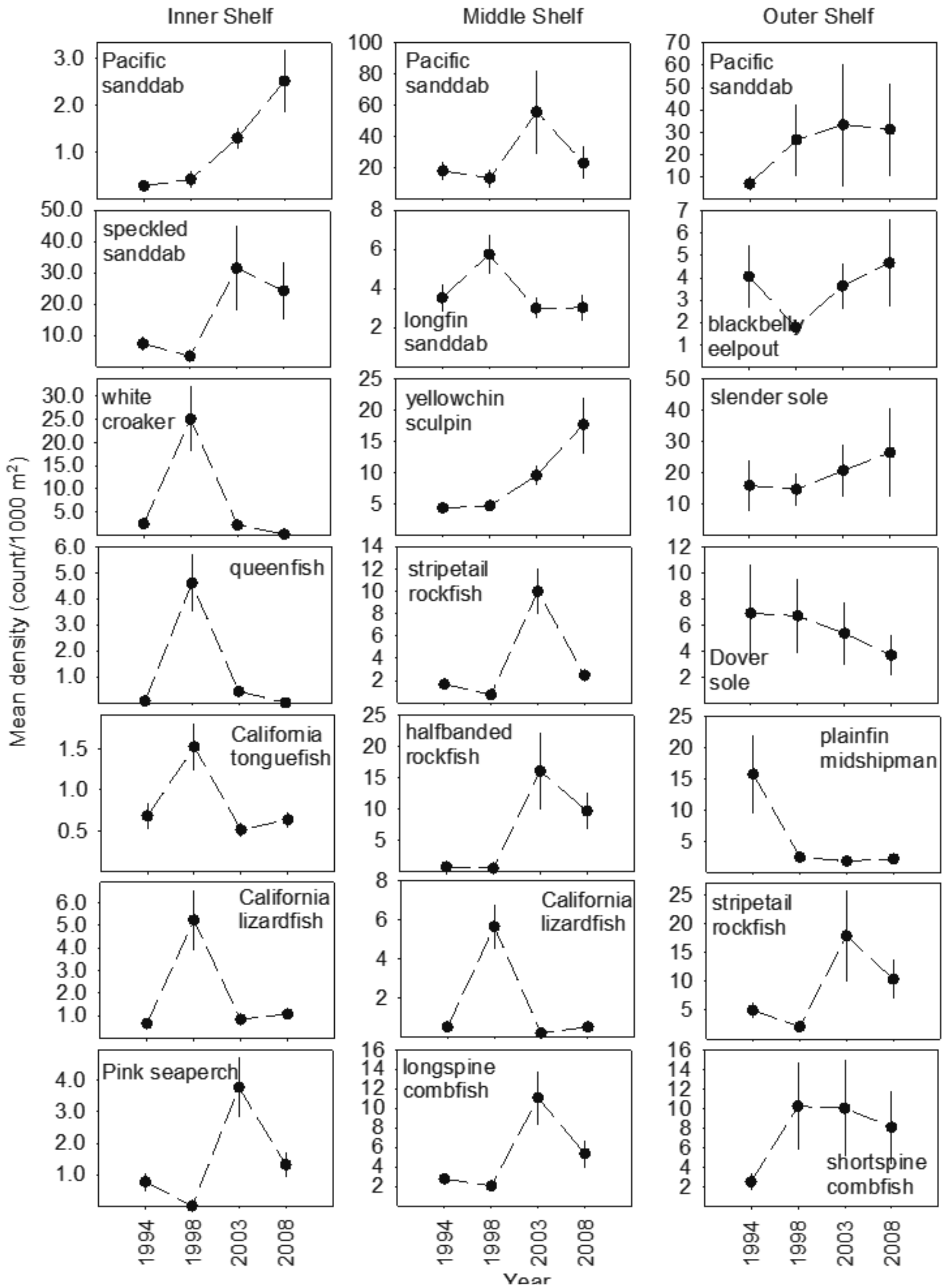

Figure 5. Mean annual density (count/1000 m²) ± standard error for the seven species most commonly taken during otter trawls in each shelf strata during the four Bight monitoring surveys (1994, 1998, 2003, and 2008).

ferences were statistically significant (Friedman Rank Sum, $\chi^2 = 27.45$, df = 3, $p < 0.001$). Differences in fish length between survey years were reflected in size class distributions for the most common species (fig. 7). In Pacific sanddab for instance, between 3% and 8% of the population was ≤4 cm size class in each of the three earliest surveys, but comprised only 2% in the 2008 survey. In contrast, 13% of the Pacific sanddab population was ≥20 cm size class in 2008, while only 6% to 10% of the population was ≥20 cm size class in each of the three earliest surveys. Similarly, length-frequency distributions in each of the four common demersal fish species exhibited smaller size classes in 2008 than was taken in 2003. Even extending to the 12 most common spe-

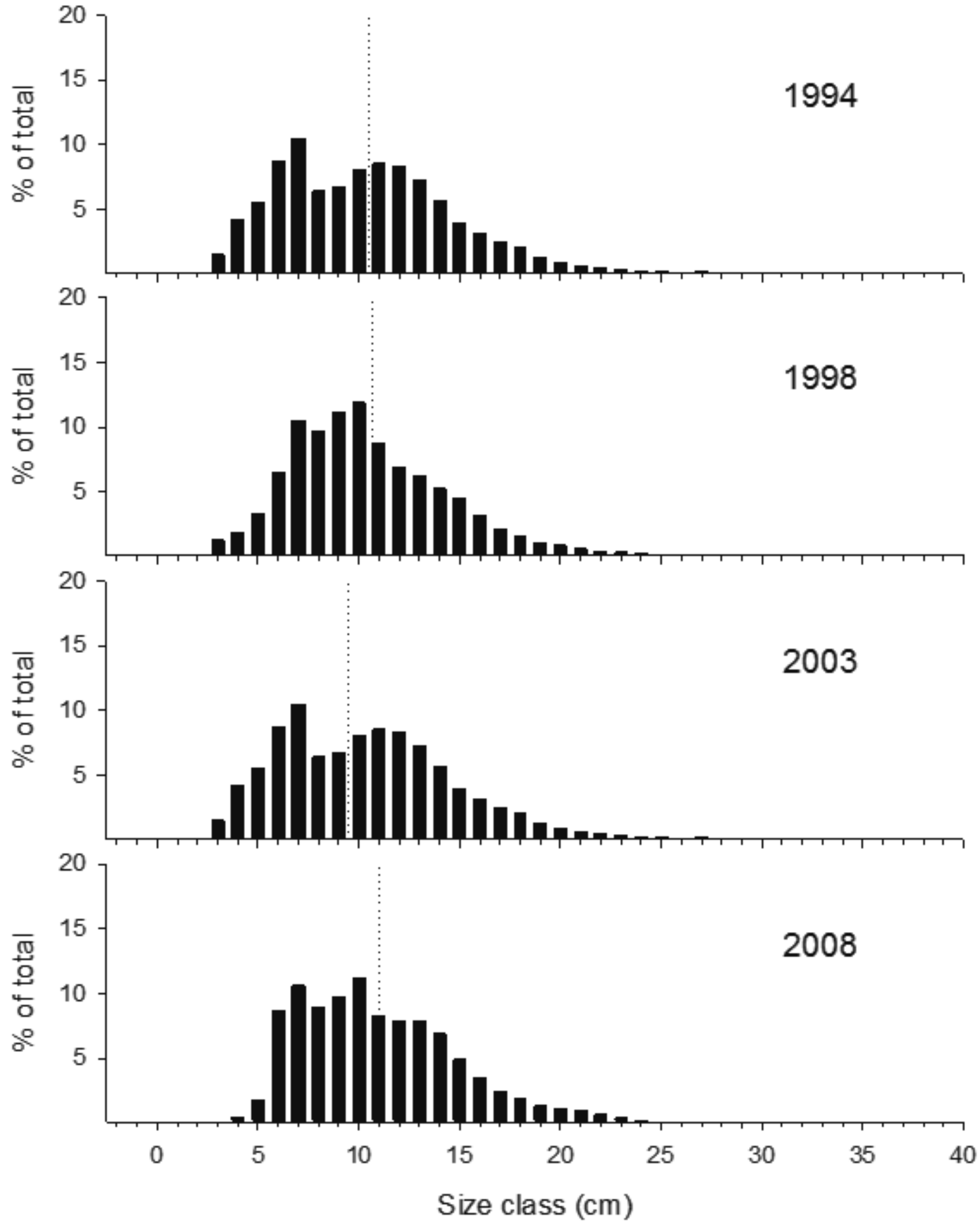

Figure 6. Length frequency distribution of all fishes (up to the 40 cm size class) taken by survey year with the mean length indicated by the vertical dashed line.

cies, mean length in 2008 was greater than, or equal to, the grand mean length observed across all four survey years (Appendix C).

Mean fish length varied with latitude and depth across surveys (fig. 8). During most survey years, the minimum mean length was taken at the southern latitudes (≤33.0°N) and then increased with increasing latitude. For example, Pacific sanddab lengths were generally >10 cm north of 33.6°N while the opposite was observed south of 33.6°N. Unlike length:latitude comparisons, the distribution of lengths by depth differed between all species combined and the dominant demersal fish species, Pacific sanddab. The maximum mean fish length occurred at the shallowest and deepest depths for all species combined consistently across surveys, with the mid-depth sampling recording the lowest mean fish length. In contrast, maximum average Pacific sanddab lengths typically increased with increasing depth consistently across surveys.

The habitat value analysis revealed differences among most years (KW, $H = 67.28$, $df = 3$, $p < 0.01$) (fig. 9). Mean habitat values derived for 1998 and 2008 were different from all other years, while those for 1994 and 2003 were different only from 1998 and 2008 but not each other. Examination by depth found the IS habitat value was significantly lower than the remaining two

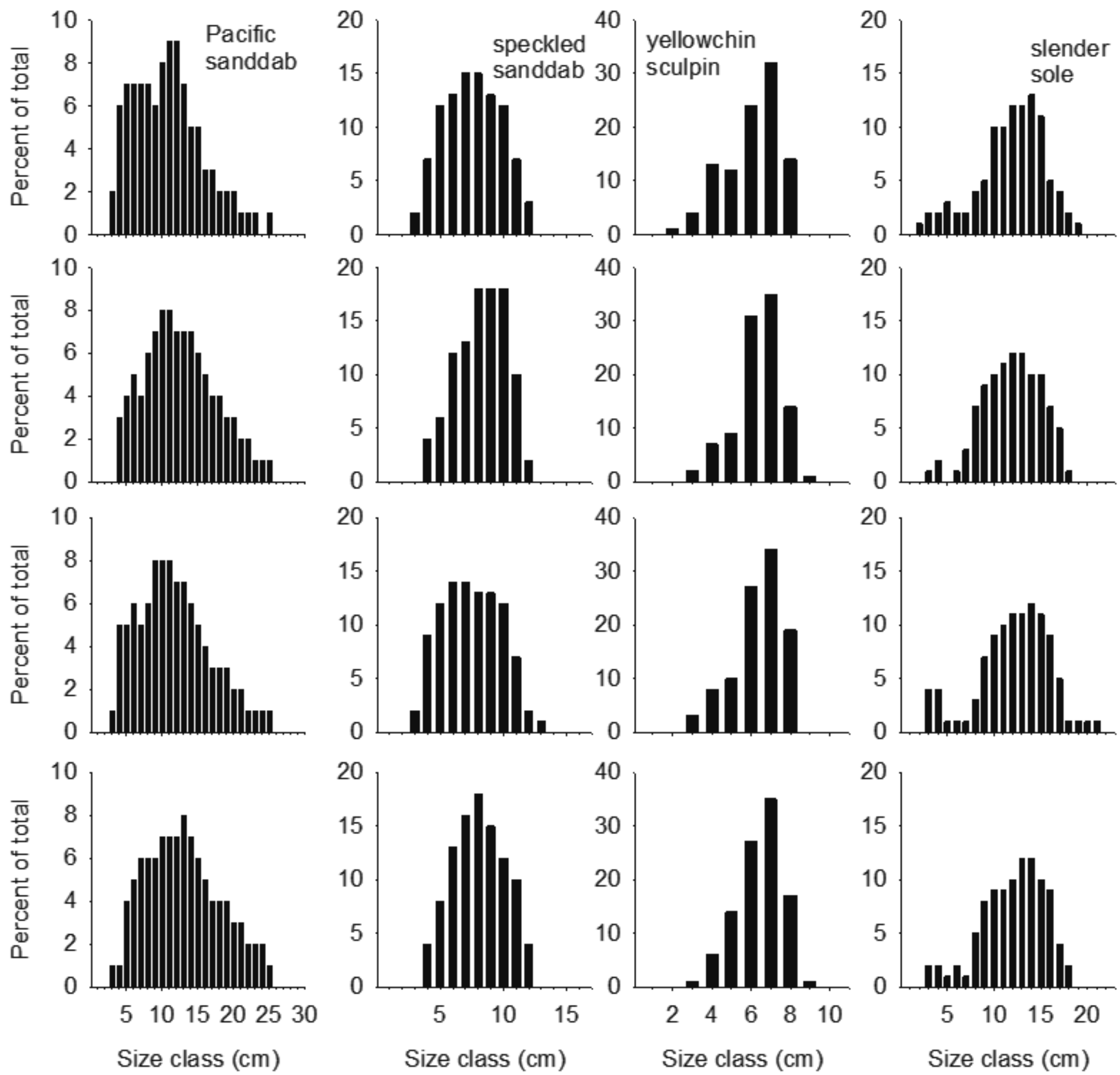

Figure 7. Length frequency histograms for the four most common species taken across all four surveys. Top row = 1994 survey; second row = 1998 survey, third row = 2003 survey, last row = 2008 survey.

areas, with no significant difference between the MS and OS (KW, $H = 79.07$, $df = 2$, $p < 0.01$). Finally, the southern area exhibited a significantly lower habitat value than either the central or northern areas (KW, $H = 12.37$, $df = 2$, $p < 0.01$).

DISCUSSION

In the SCB regional surveys between 1994 and 2008, 160 species were identified including several new to the area (Allen and Groce 2001; Groce et al. 2001; Lea et al. 2009). Comparing the regional surveys clearly indicated that these demersal fish assemblages are dynamic, changing in species composition, abundance, and biomass over time. The significance of these periodic, regionalized surveys cannot be underestimated. Localized trawl monitoring programs typically find far fewer species (Stull and Tang 1996). The regional surveys not only revealed bightwide variability in abundance of selected species, but that population movements either in latitude or depth are common, both of which could result in mistaken assumptions about species shifts at local-scale impact-based monitoring programs.

Large-scale temporal changes in the demersal fish community were evident during the SCB regional surveys. The 1998 survey was appreciably different from the other three surveys, with 2003 and 2008 being the most similar. Anomalous oceanographic conditions existed in 1998 as a result of the 1997–98 El Niño and the resultant temporary poleward expansion of numerous species (Lea and Rosenblatt 2000). In addition, many of the species

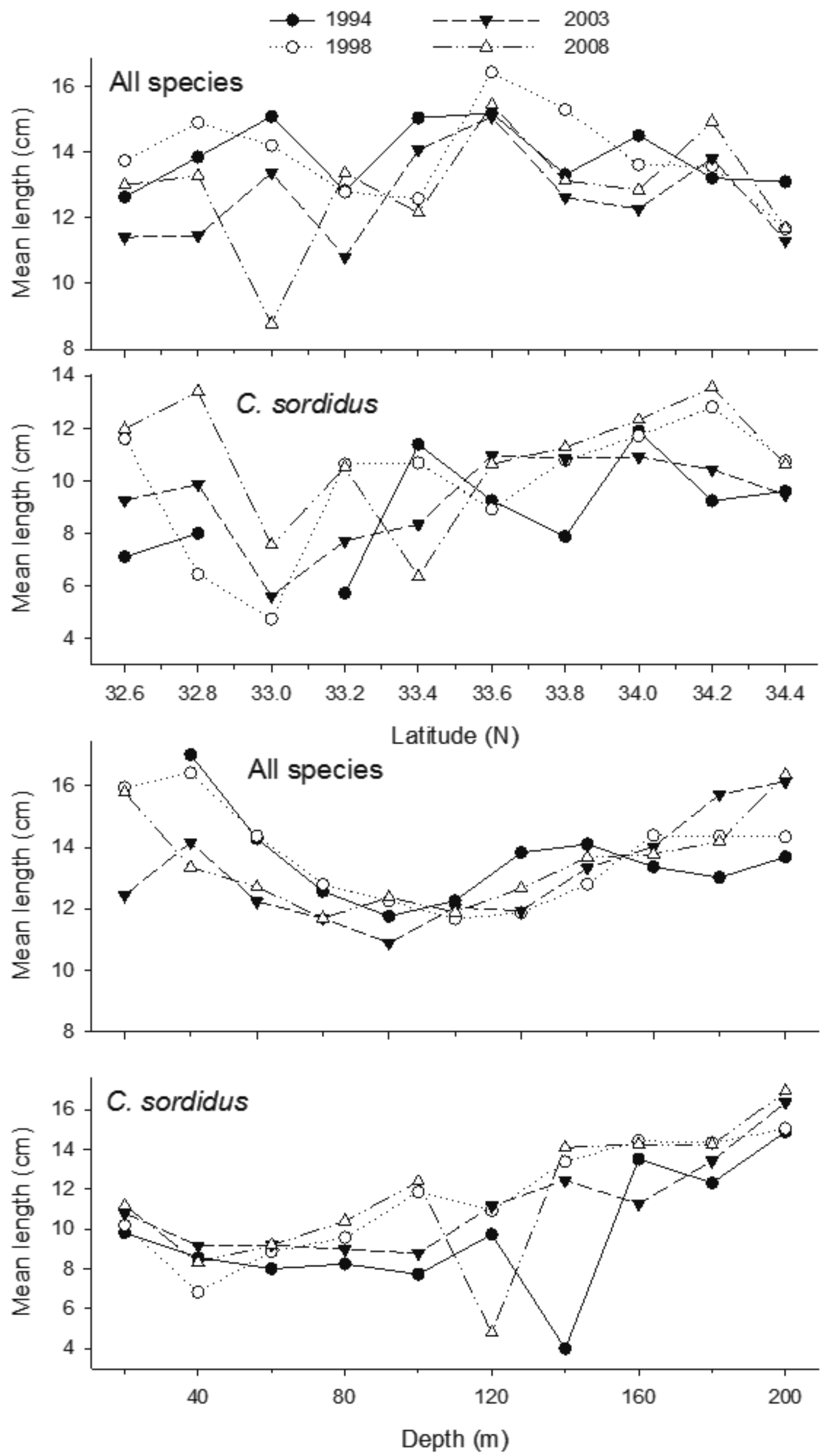

Figure 8. Abundance-weighted mean lengths by latitude and depth for all species combined and *Citharichthys sordidus* by survey year: 1994, 1998, 2003, and 2008.

that were comparatively common in 1998 were often minimally represented in the remaining surveys. Moreover, numerically dominant species during 1994, 2003, and 2008 such as Pacific and speckled sanddabs, had reduced abundance in 1998. Arguably, the fish assemblage sampled during the 1998 survey was reflective, at least partially, of the El Niño conditions.

Density, biomass, and mean fish length also indicated differences between regional surveys. The 2008 survey had the second greatest bightwide density and the single

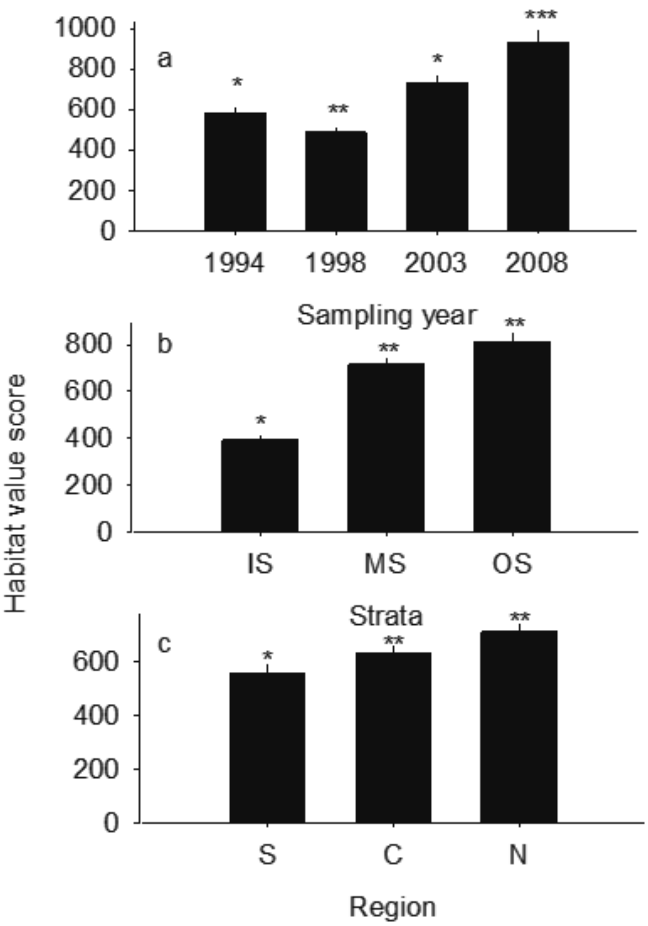

Figure 9. Mean (+ standard error) habitat value by a) survey year (all regions and shelf strata combined), b) by strata (all regions and years combined), and c) by region (all years and shelf strata combined). Asterisks denote significant differences.

greatest biomass for any of the four surveys. What precipitated this pattern is perhaps the most pressing question resulting from this analysis. Did the assemblage change resulting in this shift? The PSI indicates no appreciable change in the assemblage's species composition, with the exception of the influx of tourist species in 1998. Therefore, the increased biomass with reduced density is not likely caused by a change in the species structure, e.g., phenotypically larger fishes have not replaced smaller fishes. If the same species are there, just fewer individuals weighing more, did the average fish size change? Species-specific length analyses were consistent with a generalized increase in size across the assemblage as the 2008 mean length was larger than the preceding surveys. More importantly, reduced abundances in the smallest size classes suggest poor larval settlement (ecological recruitment) occurred between 2003 and 2008. No change in sampling protocols has occurred and the aforementioned consistency in species assemblage across surveys reinforce that these measures were not artifacts of sampling or species replacements. The SCB demersal fish assemblage information collected during the Bight surveys indicates a shift to bigger, likely older, individuals of the same suite of species that was present in 2003, and likely before, due to depressed larval settlement.

Region-wide changes in demersal fish density and biomass were correlated with environmental conditions. The NPGO and MEI were the most predictive environmental indices and the PDO was the least predictive of the demersal fish assemblage metrics. The PDO is derived from sea surface temperature (SST) anomalies (Mantua et al. 1997), and therefore correlates with only SST in the SCB with little or no relationship to other oceanographic variables in the area (Di Lorenzo et al. 2008). In response, Di Lorenzo et al. (2008) developed the NPGO from sea surface height data and found it correlated with several oceanographic variables in the SCB. The MEI represents a compilation of several disparate oceanographic metrics, including sea level pressure, SST, surface air temperature, etc. (Wolter and Timlin 2012). The inclusion of measures beyond temperature in the calculation of NPGO and MEI may be responsible for the improved correlations in our analyses of a mixed stock (species and age-structure) fish community. Each species likely responds best to a unique set of environmental conditions that is encapsulated by metrics beyond SST.

One limitation of our study is the small sample size of only four regional surveys. This limits our statistical power to detect trends. Not to disregard the overall importance of these findings, caution should be used in their interpretation. While high R^2 values were detected, this could be a function of simply lining up four dots. These results, especially for those relationships resulting in a $R^2 > 0.95$, warrant some consideration and future investigation. More emphatic conclusions can be made regarding those analyses that indicated a poor relationship, $R^2 < 0.70$. Again, more data is needed, but at this point the PDO appears to have minimal, if any, bearing on demersal fish assemblages. Moreover, the climate observations in demersal fish assemblages of the SCB is similar to reports both from within the SCB and elsewhere by others examining both extensive temporal (Holbrook et al. 1997; Perry et al. 2005) and spatial scales (Mearns 1974; Juan-Jorda et al. 2009). Clearly, more regional surveys of the SCB will be needed to support a more extensive and statistically powerful analysis of trends, including non-climate forced changes, but preliminary evaluations of these suggest a climate link with most species except Pacific sanddab.

While several unique patterns were identified with the SCB regional demersal fish surveys, at least two well-known patterns were reaffirmed. The first was depth-related spatial patterns. Depth is a well-established principal factor segregating the SCB demersal fish community (Mearns 1979; Young et al. 1980; Juan-Jorda et al. 2009; Toole et al. 2011) and the analysis of SCB regional surveys reflects this spatial pattern (Allen and Pondella 2006; Miller and Schiff 2011). The second reaffirmation was the general lack of demersal fish community impacts due to offshore discharges of treated wastewater, particularly in the MS region. Neither abundance nor biomass appeared to be degraded in the MS region. Receiving the majority of wastewater discharge, impacts from these discharges would be expected to be most clearly manifested along the MS, but no such evidence was detected. This is consistent with local trend data near the discharge outfalls that have indicated fish community recovery after increased wastewater treatment (Stull and Tang 1996) and the lack of tumors, lesions, and fin rot in comparison to conditions prior to treatment upgrades near the outfalls (Cross 1986).

Habitat value scores based on fish feeding guilds calculated during the regional surveys were dissimilar among years, depths, and latitudes. Temporal differences likely reflected the elevated density and larger mean size of fishes taken in 2008 compared to the other survey years. Lower habitat value scores in shallower, southern waters were likely due to less dense assemblages of smaller individuals relative to the MS and OS. The fact that the IS is in closer proximity to fishermen (commercial and sport) and stormwater discharges warrants further consideration (Dotson and Charter 2003; Allen 2006; Love 2006). With the notable exceptions of Pacific sanddab, English sole, California halibut, and Dover sole (*Microstomus pacificus*), the small otter trawls used in these regional surveys do not target harvested populations (Leet et al. 2001). The harvesting effect may be one cause of the lack of any definable relationship between Pacific sanddab abundance indices and climate indices. Further analysis is needed on this question.

Stormwater discharges are known to contain pollutants that accumulate in both nearshore and offshore sediments (Schiff and Bay 2003) and stormwater plumes are known to extend over large areas, often many kilometers from shore (Nezlin et al. 2005). However, the duration of these offshore plumes is short, at most lasting several days, and storm-discharged pollutants are rapidly diluted with most toxics comprising only a small fraction of the plume extent (Reifel et al. 2009). Thus, the relative impacts of both fishing and water quality on nearshore demersal fishes remains uncertain and cannot be accurately described by our data.

While the magnitude of current fishing and stormwater pollution impacts are uncertain, the future effects of large-scale oceanographic forces could be demonstrable. The SCB regional surveys identified substantial changes in demersal fish abundance and biomass seemingly correlated to subtle changes in climate. This is likely due to the fine-tuned bioenergetics of demersal species in response to declining food availability with increasing depth, especially those occupying the deeper habitats (Vetter and Lynn 1997). The ecological ramifications of oceanographic warming in cold-adapted fishes was reviewed by Pörtner et al. (2008) who found altered physiological performance in fishes including heart rate, fecundity, and growth rate. Therefore, the subtle changes in environmental conditions at depth in the SCB observed by CalCOFI may have reduced the demersal fish community's resiliency, perhaps manifesting itself in the significant shift in size structure observed by the Bight surveys. Ocean warming, even temporary, has been demonstrated to cause substantial faunal changes and biogeographic shifts to avoid physiological penalties, including in demersal/benthic assemblages (Genner et al. 2004; Schiel et al. 2004; Perry et al. 2005; Miller et al. 2011). Future renditions of the SCB regional demersal fish survey may provide critical data to evaluate these patterns.

ACKNOWLEDGEMENTS

This report was prepared under the auspices of the Bight'08 Regional Monitoring Program and includes data collected during the Bight '94, '98, and '03 programs. We would like to thank all the agencies participating in each regional survey for their collection efforts and their comments and discussion on this manuscript. Productive discussions with C. Thomas, J. Gully, and S. Walther helped frame this work. This manuscript was greatly improved by the comments of L.G. Allen and five anonymous reviewers.

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APPENDIX A
List of species and guild assignments per Bond et al. (1999) and Pondella (2009).

Water Column Guilds

Guild 2: Selective feeding, diurnal
Genyonemus lineatus <100 mm SL, *Seriphus politus* <100 mm SL
Guild 3: Nocturnal
Hyperprosopon argenteum <60 mm SL, *Seriphus politus* >100 mm SL, *Xenistius californiensis*
Guild 23: Pelagic mesocarnivores
Atherinopsis californiensis, *Squalus acanthias*

Substrate Associated Guilds

Guild 5: Water column foragers, schooling, selective feeding, usually benthic refugers, diurnal
Chromis punctipinnis,*Sebastes auriculatus*, *Sebastes dallii* <60 mm SL, *Sebastes miniatus, Sebastes saxicola* <100 mm SL, *Sebastes umbrosus*
Guild 6: Nocturnal, visual
Sebastes diploproa, *Sebastes saxicola* >100 mm SL
Guild 7: Non-schooling, non-visual
Porichthys myriaster, *Porichthys notatus*
Guild 8: Water column/benthic foragers, schooling, often benthic refuging, diurnal, pickers
Cymatogaster aggregata
Guild 9: Non-schooling, diurnal, engulfers
Anoplopoma fimbria, *Heterostichus rostratus*, *Paralabrax clathratus*, *Paralabrax maculatofasciatus*, *Paralabrax nebulifer*
Guild 10: Nocturnal
Cephaloscyllium ventriosum, *Scorpaena guttata*, *Sebastes atrovirens*, *Sebastes dallii* >100 mm SL, *Sebastolobus alascanus*
Guild 11: Benthic foragers, schooling/non-schooling, diurnal, generalists
Embiotoca jacksoni, *Hypsurus caryi*, *Phanerodon furcatus*, *Sebastes caurinus*, *Zalembius rosaceus*
Guild 12: Crushers
Halichoeres semicinctus, *Myliobatis californica*, *Rhacochilus vacca*, *Semicossyphus pulcher*
Guild 14: Nocturnal, generalists
Cheilotrema saturnum, *Genyonemus lineatus* >100 mm SL, *Menticirrhus undulatus*, *Rhacochilus toxotes*, *Umbrina roncador*
Guild 15: Burrowers
Chilara taylori, *Ophidion scrippsae*

Benthic Guilds

Guild 16: Water column/benthic foragers, mesocarnivores
Hippoglossina stomata, *Ophiodon elongatus*, *Paralichthys californicus*, *Scorpaenichthys marmoratus*, *Synodus lucioceps*
Guild 17: Substrate sitters, microcarnivores, diurnal
Citharichthys fragilis, *Citharichthys sordidus*, *Citharichthys stigmaeus*, *Citharichthys xanthostigma*, *Lyopsetta exilis*, *Oxylebius pictus*, *Zaniolepis frenata*
Guild 18: Nocturnal
Leptocottus armatus, *Squatina californica*, *Xeneretmus latifrons*
Guild 19: Hiders (in holes and crevices), diurnal
Lepidogobius lepidus, *Lythrypnus dalli*, *Lythrypnus zebra*, *Rhinogobiops nicholsii*
Guild 20: Benthic foragers, pickers and scrapers, diurnal
Rathbunella alleni, *Rathbunella hypoplecta*
Guild 21: Nocturnal, non-visual
Gibbonsia montereyensis, *Glyptocephalus zachirus*, *Symphurus atricaudus*
Guild 22: Diggers and extractors
Lycodes cortezianus, *Lycodes pacificus*, *Microstomus pacificus*, *Parophrys vetulus*, *Pleuronichthys coenosus*, *Pleuronichthys decurrens*, *Pleuronichthys guttulatus*, *Pleuronichthys ritteri*, *Pleuronichthys verticalis*, *Urobatis halleri*

APPENDIX B-1

Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the inner shelf. Values are not adjusted for area-weights.

Inner Shelf	1994		1998		2003		2008	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Agonopsis sterletus	—	—	—	—	—	—	0.01	0.01
Anarrhichthys ocellatus	—	—	—	—	0.01	0.01	—	—
Anchoa compressa	—	—	0.01	0.01	—	—	—	—
Anchoa delicatissima	—	—	0.17	0.11	—	—	—	—
Artedius notospilotus	—	—	—	—	—	—	0.01	0.01
Atherinopsis californiensis	—	—	<0.01	<0.01	—	—	—	—
Cheilotrema saturnum	—	—	0.08	0.03	—	—	—	—
Chilara taylori	—	—	—	—	0.01	0.01	—	—
Chitonotus pugetensis	0.01	0.01	<0.01	<0.01	0.09	0.04	0.22	0.09
Chromis punctipinnis	—	—	—	—	0.01	0.01	—	—
Citharichthys sordidus	0.09	0.05	0.06	0.04	0.3	0.09	0.39	0.19
Citharichthys stigmaeus	1.09	0.2	0.38	0.08	4.54	0.91	3.63	0.68
Citharichthys xanthostigma	0.25	0.06	0.08	0.02	0.2	0.05	0.11	0.05
Cymatogaster aggregata	—	—	0.12	0.06	0.38	0.23	0.21	0.11
Dasyatis dipterura	—	—	0.01	0.01	—	—	—	—
Embiotoca jacksoni	—	—	0.03	0.01	0.01	0.01	0.02	0.02
Enophrys taurina	—	—	<0.01	<0.01	—	—	—	—
Genyonemus lineatus	0.41	0.31	10.49	3.79	0.19	0.09	0.09	0.05
Gibbonsia metzi	—	—	—	—	—	—	0.01	0.01
Gibbonsia montereyensis	—	—	—	—	0.02	0.02	—	—
Halichoeres semicinctus	0.01	0.01	—	—	—	—	—	—
Heterostichus rostratus	—	—	<0.01	<0.01	0.01	0.01	0.04	0.02
Hexagrammos decagrammus	—	—	—	—	—	—	0.01	0.01
Hippocampus ingens	—	—	0.02	0.01	—	—	—	—
Hippoglossina stomata	0.08	0.03	0.02	0.01	0.09	0.02	0.04	0.02
Hyperprosopon argenteum	—	—	0.03	0.02	0.04	0.04	—	—
Hypsurus caryi	—	—	—	—	0.03	0.02	0.05	0.03
Icelinus cavifrons	—	—	—	—	—	—	0.03	0.02
Icelinus quadriseriatus	0.15	0.06	0.01	0.01	0.56	0.23	0.48	0.18
Lepidogobius lepidus	0.04	0.03	0.03	0.02	0.03	0.02	—	—
Leptocottus armatus	—	—	—	—	0.01	0.01	0.09	0.03
Menticirrhus undulatus	—	—	0.03	0.01	0.01	0.01	—	—
Microstomus pacificus	—	—	—	—	<0.01	<0.01	—	—
Mustelus californicus	—	—	<0.01	<0.01	—	—	—	—
Myliobatis californica	—	—	0.01	0.01	0.01	0.01	—	—
Odontopyxis trispinosa	—	—	—	—	0.04	0.02	0.09	0.05
Ophidion scrippsae	—	—	<0.01	<0.01	—	—	—	—
Ophiodon elongatus	—	—	—	—	0.05	0.02	—	—
Oxylebius pictus	—	—	—	—	—	—	0.01	0.01
Paralabrax clathratus	0.01	0.01	0.01	0.01	—	—	—	—
Paralabrax maculatofasciatus	—	—	0.12	0.04	—	—	—	—
Paralabrax nebulifer	0.05	0.02	0.28	0.06	0.01	0.01	0.02	0.01
Paralichthys californicus	0.21	0.03	0.31	0.04	0.13	0.03	0.13	0.03
Parophrys vetulus	0.14	0.04	0.06	0.02	0.38	0.08	0.41	0.15
Peprilus simillimus	0.01	0.01	0.07	0.04	0.06	0.04	—	—
Phanerodon furcatus	0.03	0.02	0.18	0.06	0.14	0.04	0.19	0.09
Platyrhinoidis triseriata	0.05	0.02	0.04	0.01	—	—	0.03	0.02
Pleuronichthys coenosus	—	—	<0.01	<0.01	0.01	0.01	—	—
Pleuronichthys decurrens	—	—	—	—	0.26	0.08	0.01	0.01

APPENDIX B-1 (continued)
Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the inner shelf. Values are not adjusted for area-weights.

Inner Shelf	1994		1998		2003		2008	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Pleuronichthys guttulatus	0.01	0.01	0.07	0.03	0.02	0.01	0.03	0.02
Pleuronichthys ritteri	0.17	0.04	0.2	0.04	0.05	0.02	0.11	0.03
Pleuronichthys verticalis	0.28	0.03	0.19	0.04	0.26	0.04	0.34	0.06
Porichthys myriaster	0.04	0.02	0.16	0.04	0.07	0.02	0.05	0.02
Porichthys notatus	0.02	0.01	—	—	0.06	0.02	0.05	0.03
Prionotus stephanophrys	<0.01	<0.01	—	—	—	—	—	—
Raja inornata	0.07	0.02	0.03	0.01	0.06	0.02	0.02	0.01
Rhacochilus toxotes	0.01	0.01	—	—	0.03	0.03	0.04	0.03
Rhacochilus vacca	—	—	—	—	0.01	0.01	—	—
Rhinobatos productus	—	—	0.03	0.01	0.01	0.01	0.02	0.02
Rhinogobiops nicholsii	—	—	—	—	0.01	0.01	0.01	0.01
Rimicola muscarum	—	—	—	—	—	—	0.02	0.02
Roncador stearnsii	—	—	—	—	—	—	0.02	0.02
Ruscarius creaseri	—	—	—	—	0.01	0.01	—	—
Scorpaena guttata	0.11	0.03	0.02	0.01	0.09	0.03	0.06	0.02
Scorpaenichthys marmoratus	—	—	—	—	—	—	0.02	0.02
Sebastes atrovirens	—	—	<0.01	<0.01	—	—	0.02	0.02
Sebastes auriculatus	—	—	<0.01	<0.01	—	—	—	—
Sebastes caurinus	0.01	0.01	0.01	0.01	0.16	0.1	0.06	0.03
Sebastes constellatus	0.01	0.01	—	—	—	—	—	—
Sebastes dallii	0.02	0.02	—	—	—	—	0.02	0.01
Sebastes goodei	—	—	—	—	0.27	0.27	—	—
Sebastes miniatus	0.01	0.01	—	—	0.02	0.01	0.08	0.05
Sebastes paucispinis	—	—	—	—	0.01	0.01	—	—
Sebastes saxicola	0.02	0.02	—	—	0.02	0.02	—	—
Sebastes semicinctus	—	—	—	—	0.01	0.01	—	—
Seriphus politus	0.03	0.02	1.18	0.5	0.1	0.04	0.01	0.01
Squalus acanthias	—	—	<0.01	<0.01	—	—	—	—
Symphurus atricaudus	0.17	0.06	0.58	0.16	0.08	0.03	0.17	0.05
Syngnathus californiensis	—	—	<0.01	<0.01	—	—	—	—
Syngnathus exilis	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.03
Synodus lucioceps	0.26	0.04	0.82	0.19	0.16	0.04	0.24	0.05
Trachurus symmetricus	0.01	0.01	—	—	—	—	—	—
Trichiurus nitens	—	—	<0.01	<0.01	—	—	—	—
Umbrina roncador	—	—	0.01	0.01	—	—	—	—
Urobatis halleri	—	—	0.14	0.04	—	—	—	—
Xenistius californiensis	—	—	—	—	—	—	0.02	0.02
Xystreurys liolepis	0.18	0.03	0.13	0.03	0.08	0.02	0.12	0.03
Zalembius rosaceus	0.12	0.09	0.02	0.02	0.48	0.17	0.35	0.18
Zaniolepis latipinnis	0.06	0.04	<0.01	<0.01	0.2	0.07	0.01	0.01

APPENDIX B-2

Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the middle shelf. Values are not adjusted for area-weights.

Middle Shelf	1994		1998		2003		2008	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Agonopsis sterletus	—	—	0.02	0.01	0.05	0.02	—	—
Anarrhichthys ocellatus	—	—	—	—	<0.01	<0.01	—	—
Argentina sialis	0.32	0.09	0.25	0.07	0.29	0.11	—	—
Bollmannia gomezi	—	—	—	—	0.01	0.01	—	—
Brosmophycis marginata	0.01	0.01	—	—	—	—	—	—
Caulolatilus princeps	—	—	<0.01	<0.01	—	—	—	—
Cephaloscyllium ventriosum	<0.01	<0.01	0.01	0.01	<0.01	<0.01	—	—
Chilara taylori	0.07	0.02	0.03	0.01	0.09	0.02	0.08	0.03
Chitonotus pugetensis	0.1	0.03	0.13	0.04	0.55	0.09	0.86	0.21
Citharichthys fragilis	0.04	0.02	0.14	0.03	0.01	0.01	—	—
Citharichthys sordidus	2.46	0.7	0.92	0.1	3.67	0.3	2.21	0.38
Citharichthys stigmaeus	0.35	0.09	0.33	0.08	0.95	0.2	0.74	0.28
Citharichthys xanthostigma	0.59	0.09	1.22	0.13	0.57	0.08	0.55	0.11
Clupea pallasii	—	—	<0.01	<0.01	—	—	—	—
Cryptotrema corallinum	—	—	0.03	0.02	<0.01	<0.01	—	—
Cymatogaster aggregata	—	—	0.03	0.03	0.02	0.01	0.01	0.01
Engyophrys sanctilaurentii	—	—	<0.01	<0.01	—	—	—	—
Enophrys taurina	—	—	0.01	0.01	0.06	0.02	0.04	0.04
Eopsetta jordani	—	—	0.01	<0.01	<0.01	<0.01	—	—
Eptatretus stoutii	0.01	0.01	<0.01	<0.01	—	—	—	—
Genyonemus lineatus	—	—	0.17	0.06	0.01	<0.01	0.03	0.02
Glyptocephalus zachirus	0.01	0.01	—	—	0.01	0.01	—	—
Hippoglossina stomata	0.29	0.03	0.34	0.03	0.19	0.02	0.26	0.04
Hydrolagus colliei	—	—	0.01	<0.01	<0.01	<0.01	—	—
Icelinus cavifrons	—	—	0.01	<0.01	0.09	0.07	—	—
Icelinus fimbriatus	<0.01	<0.01	—	—	<0.01	<0.01	—	—
Icelinus quadriseriatus	1.7	0.37	1.6	0.21	4.64	0.73	5.41	1.26
Icelinus tenuis	0.02	0.01	0.09	0.03	0.1	0.03	0.02	0.01
Icichthys lockingtoni	—	—	—	—	<0.01	<0.01	—	—
Kathetostoma averruncus	0.01	0.01	0.01	<0.01	<0.01	<0.01	—	—
Lepidogobius lepidus	0.6	0.14	0.33	0.09	0.43	0.07	0.23	0.13
Lepidopsetta bilineata	—	—	—	—	0.01	0.01	—	—
Lycodes pacificus	0.03	0.01	0.03	0.01	0.04	0.01	0.03	0.02
Lyconema barbatum	—	—	—	—	0.01	0.01	—	—
Lyopsetta exilis	0.2	0.09	0.07	0.02	0.05	0.02	0.08	0.04
Lythrypnus dalli	—	—	0.02	0.02	—	—	—	—
Lythrypnus zebra	—	—	<0.01	<0.01	—	—	—	—
Macroramphosus gracilis	—	—	0.01	0.01	—	—	—	—
Merluccius productus	<0.01	<0.01	0.01	<0.01	—	—	0.01	0.01
Microstomus pacificus	0.4	0.05	0.34	0.1	0.73	0.11	0.3	0.06
Mustelus henlei	—	—	<0.01	<0.01	—	—	—	—
Myliobatis californica	<0.01	<0.01	—	—	—	—	—	—
Neoclinus blanchardi	—	—	<0.01	<0.01	—	—	—	—
Odontopyxis trispinosa	0.05	0.02	0.07	0.02	0.22	0.04	0.23	0.07
Ophiodon elongatus	0.02	0.01	<0.01	<0.01	0.14	0.02	0.09	0.04
Oxylebius pictus	0.01	0.01	—	—	0.01	0.01	—	—
Paralabrax clathratus	—	—	0.01	0.01	—	—	—	—
Paralabrax nebulifer	—	—	0.01	0.01	<0.01	<0.01	—	—
Paralichthys californicus	0.01	0.01	0.09	0.02	0.03	0.01	—	—
Parophrys vetulus	0.19	0.03	0.16	0.02	0.28	0.03	0.69	0.33
Peprilus simillimus	—	—	—	—	0.01	0.01	0.01	0.01
Phanerodon furcatus	—	—	—	—	—	—	0.01	0.01
Plectobranchus evides	—	—	<0.01	<0.01	0.01	0.01	0.01	0.01
Pleuronectes bilineatus	—	—	<0.01	<0.01	—	—	—	—
Pleuronectiformes	—	—	—	—	0.01	0.01	—	—
Pleuronichthys coenosus	—	—	0.01	0.01	<0.01	<0.01	—	—
Pleuronichthys decurrens	0.03	0.02	0.04	0.01	0.14	0.03	0.01	0.01
Pleuronichthys ritteri	0.01	0.01	0.01	0.01	<0.01	<0.01	0.01	0.01
Pleuronichthys verticalis	0.2	0.02	0.24	0.02	0.29	0.03	0.36	0.04
Porichthys myriaster	0.04	0.01	0.08	0.02	0.01	0.01	0.04	0.02
Porichthys notatus	0.82	0.22	0.49	0.12	0.42	0.05	0.47	0.09
Prionotus stephanophrys	—	—	0.06	0.02	<0.01	<0.01	—	—

APPENDIX B-2 (continued)

Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the middle shelf. Values are not adjusted for area-weights.

Middle Shelf	1994		1998		2003		2008	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Radulinus asprellus	—	—	—	—	<0.01	<0.01	—	—
Raja binoculata	—	—	—	—	<0.01	<0.01	—	—
Raja inornata	0.09	0.02	0.07	0.01	0.08	0.02	0.11	0.03
Raja stellulata	0.01	0.01	<0.01	<0.01	0.01	0.01	—	—
Rathbunella alleni	0.01	0.01	<0.01	<0.01	—	—	—	—
Rathbunella hypoplecta	0.02	0.01	0.01	<0.01	0.02	0.01	0.03	0.02
Rhacochilus vacca	—	—	0.01	0.01	<0.01	<0.01	—	—
Rhinogobiops nicholsii	0.02	0.02	0.02	0.01	0.08	0.05	0.02	0.01
Scorpaena guttata	0.14	0.05	0.14	0.02	0.15	0.02	0.11	0.03
Sebastes auriculatus	<0.01	<0.01	—	—	—	—	—	—
Sebastes caurinus	<0.01	<0.01	0.01	<0.01	0.02	0.01	—	—
Sebastes chlorostictus	0.03	0.02	0.03	0.01	0.02	0.01	0.06	0.03
Sebastes constellatus	—	—	0.01	0.01	0.01	0.01	—	—
Sebastes dallii	0.07	0.04	0.06	0.06	0.04	0.02	0.31	0.18
Sebastes diploproa	0.01	0.01	0.02	0.02	<0.01	<0.01	—	—
Sebastes elongatus	0.02	0.01	0.02	0.01	0.14	0.03	0.07	0.03
Sebastes eos	0.01	0.01	0.03	0.01	0.2	0.11	0.05	0.03
Sebastes goodei	—	—	—	—	0.1	0.03	—	—
Sebastes hopkinsi	<0.01	<0.01	—	—	0.05	0.04	0.05	0.03
Sebastes jordani	—	—	<0.01	<0.01	0.4	0.29	0.01	0.01
Sebastes lentiginosus	—	—	0.01	<0.01	—	—	—	—
Sebastes levis	0.03	0.01	<0.01	<0.01	0.14	0.04	0.01	0.01
Sebastes macdonaldi	—	—	<0.01	<0.01	—	—	—	—
Sebastes miniatus	0.02	0.02	0.02	0.01	0.03	0.01	0.05	0.04
Sebastes paucispinis	—	—	—	—	0.01	0.01	—	—
Sebastes pinniger	0.01	0.01	—	—	—	—	—	—
Sebastes rosaceus	0.01	0.01	—	—	0.02	0.01	0.01	0.01
Sebastes rosenblatti	0.06	0.02	0.04	0.01	0.04	0.02	0.04	0.02
Sebastes rubrivinctus	0.01	0.01	0.01	<0.01	0.01	0.01	0.02	0.01
Sebastes rufus	—	—	—	—	—	—	0.01	0.01
Sebastes saxicola	0.45	0.1	0.29	0.06	2.03	0.39	0.57	0.16
Sebastes semicinctus	0.2	0.08	0.08	0.05	3.27	1.69	1.08	0.68
Sebastes simulator	—	—	<0.01	<0.01	—	—	—	—
Sebastes sp.	0.02	0.01	0.02	0.01	—	—	—	—
Sebastes umbrosus	0.01	0.01	<0.01	<0.01	0.01	0.01	0.02	0.02
Semicossyphus pulcher	—	—	<0.01	<0.01	<0.01	<0.01	—	—
Seriphus politus	—	—	0.04	0.02	—	—	—	—
Squalus acanthias	—	—	—	—	—	—	0.01	0.01
Squatina californica	<0.01	<0.01	<0.01	<0.01	—	—	—	—
Symphurus atricaudus	0.53	0.14	0.47	0.05	0.43	0.06	0.43	0.08
Synchiropus atrilabiatus	—	—	<0.01	<0.01	—	—	—	—
Synodus lucioceps	0.21	0.03	1.66	0.28	0.1	0.02	0.2	0.04
Torpedo californica	—	—	0.01	0.01	—	—	0.01	0.01
Trachurus symmetricus	—	—	<0.01	<0.01	—	—	—	—
Trichiurus nitens	—	—	<0.01	<0.01	—	—	—	—
Xeneretmus latifrons	0.02	0.01	<0.01	<0.01	0.03	0.02	0.03	0.02
Xeneretmus triacanthus	0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.01
Xystreurys liolepis	0.04	0.01	0.08	0.02	0.03	0.01	0.05	0.02
Zalembius rosaceus	0.48	0.06	0.35	0.05	0.55	0.05	1.18	0.31
Zaniolepis frenata	0.13	0.04	0.1	0.02	0.24	0.05	0.23	0.06
Zaniolepis latipinnis	0.61	0.14	0.42	0.08	1.63	0.22	0.95	0.24

APPENDIX B-3
Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the outer shelf. Values are not adjusted for area-weights.

Outer Shelf	1994		1998		2003		2008	
Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Anoplopoma fimbria	—	—	0.01	0.01	0.01	0.01	—	—
Argentina sialis	0.05	0.04	0.08	0.04	0.05	0.02	—	—
Argyropelecus sladeni	—	—	—	—	—	—	0.01	0.01
Bathyraja interrupta	—	—	—	—	—	—	0.02	0.02
Chilara taylori	0.07	0.03	0.19	0.06	0.21	0.07	0.19	0.04
Citharichthys fragilis	0.11	0.09	0.13	0.05	0.07	0.06	0.02	0.02
Citharichthys sordidus	0.78	0.14	1.49	0.31	1.69	0.31	2.13	0.75
Citharichthys stigmaeus	—	—	—	—	0.01	0.01	—	—
Citharichthys xanthostigma	—	—	0.02	0.02	0.02	0.02	0.02	0.02
Eopsetta jordani	0.02	0.02	0.02	0.01	0.01	0.01	0.07	0.03
Eptatretus stoutii	—	—	0.01	0.01	—	—	—	—
Glyptocephalus zachirus	0.39	0.07	0.13	0.03	0.34	0.1	0.21	0.07
Hippoglossina stomata	0.12	0.04	0.09	0.03	0.09	0.03	0.1	0.04
Hydrolagus colliei	—	—	0.04	0.02	0.09	0.03	0.08	0.04
Icelinus filamentosus	0.01	0.01	0.01	0.01	0.01	0.01	—	—
Icelinus oculatus	—	—	—	—	0.02	0.02	—	—
Icelinus quadriseriatus	0.02	0.02	0.02	0.02	—	—	—	—
Icelinus tenuis	—	—	0.23	0.1	0.15	0.08	0.01	0.01
Kathetostoma averruncus	0.03	0.03	—	—	0.01	0.01	—	—
Lepidogobius lepidus	—	—	0.01	0.01	—	—	—	—
Lycodes cortezianus	0.01	0.01	0.04	0.03	0.03	0.02	0.05	0.03
Lycodes pacificus	0.36	0.12	0.22	0.06	0.4	0.11	0.47	0.12
Lyconema barbatum	0.02	0.02	0.07	0.03	0.14	0.06	0.03	0.02
Lyopsetta exilis	1.59	0.32	1.99	0.37	2.87	0.77	2.69	0.49
Merluccius productus	0.85	0.37	0.09	0.03	0.16	0.04	0.13	0.04
Microstomus pacificus	0.71	0.13	0.87	0.18	0.74	0.14	0.58	0.05
Mustelus henlei	—	—	—	—	—	—	0.02	0.02
Odontopyxis trispinosa	—	—	—	—	0.01	0.01	—	—
Ophiodon elongatus	—	—	0.01	0.01	0.01	0.01	0.01	0.01
Parmaturus xaniurus	—	—	—	—	0.01	0.01	—	—
Parophrys vetulus	0.09	0.03	0.26	0.05	0.32	0.19	0.44	0.1
Physiculus rastrelliger	—	—	0.01	0.01	—	—	—	—
Plectobranchus evides	0.11	0.05	0.07	0.03	0.22	0.13	0.05	0.03
Pleuronectes bilineatus	—	—	0.01	0.01	—	—	—	—
Pleuronectiformes	—	—	—	—	0.01	0.01	—	—
Pleuronichthys decurrens	—	—	0.04	0.04	0.04	0.02	—	—
Pleuronichthys verticalis	—	—	0.01	0.01	0.04	0.03	0.1	0.05
Porichthys notatus	1.38	0.74	0.49	0.09	0.24	0.07	0.38	0.11
Radulinus asprellus	—	—	0.01	0.01	0.02	0.02	—	—
Raja binoculata	—	—	0.01	0.01	—	—	—	—
Raja inornata	0.01	0.01	0.03	0.02	0.06	0.03	0.04	0.02
Raja rhina	—	—	0.02	0.01	0.02	0.02	0.03	0.02
Raja stellulata	—	—	0.04	0.03	0.01	0.01	—	—
Rathbunella hypoplecta	—	—	—	—	0.01	0.01	—	—
Scorpaena guttata	—	—	0.01	0.01	0.03	0.02	0.01	0.01
Sebastes caurinus	—	—	0.02	0.02	—	—	—	—
Sebastes chlorostictus	0.06	0.03	0.09	0.04	0.05	0.04	0.08	0.03
Sebastes dallii	—	—	—	—	0.02	0.02	—	—
Sebastes diploproa	1.14	0.58	0.42	0.19	0.72	0.35	0.38	0.2

APPENDIX B-3 (continued)
Mean density (count/1000 m² area swept) by species for each of the four Bight surveys taken on the outer shelf. Values are not adjusted for area-weights.

Outer Shelf	1994		1998		2003		2008	
Species	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Sebastes elongatus	0.2	0.05	0.07	0.03	0.15	0.05	0.29	0.06
Sebastes ensifer	—	—	0.03	0.02	—	—	—	—
Sebastes eos	0.06	0.03	0.06	0.03	0.05	0.02	0.19	0.05
Sebastes goodei	—	—	0.02	0.01	0.04	0.02	0.01	0.01
Sebastes jordani	0.04	0.03	0.03	0.01	0.12	0.07	0.04	0.03
Sebastes levis	0.02	0.02	—	—	0.02	0.02	0.02	0.02
Sebastes macdonaldi	—	—	0.02	0.01	0.02	0.02	—	—
Sebastes melanostomus	—	—	—	—	—	—	0.07	0.07
Sebastes rosaceus	—	—	0.03	0.03	—	—	—	—
Sebastes rosenblatti	0.14	0.04	0.04	0.02	0.1	0.04	0.11	0.04
Sebastes rubrivinctus	0.01	0.01	0.03	0.02	0.03	0.02	0.03	0.02
Sebastes saxicola	0.96	0.2	0.77	0.18	2.93	1.12	2.16	0.53
Sebastes semicinctus	0.05	0.03	0.18	0.06	0.25	0.14	0.48	0.15
Sebastes sp.	0.05	0.03	0.02	0.02	0.01	0.01	—	—
Sebastolobus alascanus	0.04	0.02	0.01	0.01	0.03	0.02	—	—
Seriphus politus	—	—	0.01	0.01	—	—	—	—
Symphurus atricaudus	0.03	0.03	—	—	—	—	0.02	0.02
Syngnathus exilis	—	—	0.01	0.01	—	—	—	—
Synodus lucioceps	0.05	0.03	0.02	0.01	—	—	—	—
Xeneretmus latifrons	0.39	0.13	0.44	0.16	0.92	0.23	0.7	0.13
Xeneretmus triacanthus	0.03	0.02	0.09	0.03	0.13	0.04	0.09	0.04
Zalembius rosaceus	0.04	0.03	0.25	0.06	0.15	0.05	0.45	0.16
Zaniolepis frenata	0.49	0.06	0.91	0.19	1.07	0.21	1.15	0.26
Zaniolepis latipinnis	0.02	0.02	0.21	0.07	0.14	0.08	0.2	0.09

APPENDIX C

Mean length and total number measured by species for each of the four Bight surveys and the grand mean across all surveys. Shaded cells indicate a value less than the grand mean.

	Abundance Weighted Mean Length (cm)					
Species	1994	1998	2003	2008	Overall	Total Measured
Citharichthys sordidus	8.97	11.91	9.28	12.48	10.21	31,924
Citharichthys stigmaeus	7.55	8.33	7.30	8.14	7.61	11,302
Icelinus quadriseriatus	6.30	6.57	6.64	6.57	6.57	8,641
Lyopsetta exilis	11.54	11.47	12.08	11.86	11.77	7,960
Genyonemus lineatus	16.87	8.80	14.31	15.33	9.64	6,642
Sebastes saxicola	9.51	9.18	8.19	9.92	8.75	5,934
Citharichthys xanthostigma	12.02	10.22	13.13	12.24	11.20	5,827
Synodus lucioceps	20.37	10.67	16.55	15.35	11.24	5,642
Zaniolepis latipinnis	13.55	13.02	10.29	12.45	11.30	4,911
Microstomus pacificus	11.03	10.08	9.52	12.83	10.29	4,614
Porichthys notatus	11.69	11.44	12.22	13.09	11.82	4,563
Sebastes semicinctus	11.48	7.69	6.82	11.95	8.46	4,179
Zalembius rosaceus	8.08	9.32	8.24	7.77	8.25	3,254
Symphurus atricaudus	10.83	11.27	13.65	11.90	11.65	2,852
Zaniolepis frenata	13.36	12.77	12.49	12.07	12.55	2,687
Parophrys vetulus	19.93	17.96	15.39	14.52	15.78	2,425
Lepidogobius lepidus	4.26	6.21	7.15	7.56	5.80	1,401
Lycodes pacificus	12.18	17.47	15.70	16.00	15.38	1,372
Pleuronichthys verticalis	14.86	13.99	14.67	14.51	14.48	1,292
Seriphus politus	15.14	8.58	12.78	13.00	8.81	1,060
Chitonotus pugetensis	7.05	7.72	8.25	8.29	8.16	1,017
Sebastes diploproa	6.64	5.45	6.83	7.17	6.51	977
Xeneretmus latifrons	11.70	12.50	12.29	12.72	12.35	893
Hippoglossina stomata	16.00	15.62	19.59	16.24	16.53	807
Argentina sialis	6.59	5.52	6.10	—	5.89	698
Glyptocephalus zachirus	13.43	16.53	11.31	14.55	12.77	456
Pleuronichthys decurrens	12.67	10.92	9.03	7.00	9.30	428
Icelinus tenuis	8.21	9.37	9.43	8.67	9.34	417
Merluccius productus	8.24	23.23	18.46	19.85	10.47	413
Scorpaena guttata	17.32	17.30	19.63	19.36	18.41	405
Paralichthys californicus	32.39	26.61	36.36	27.00	29.62	376
Cymatogaster aggregata	—	10.35	8.02	7.40	8.60	350
Sebastes jordani	15.00	12.43	8.75	13.67	9.06	346
Chilara taylori	16.00	17.24	17.65	17.19	17.35	321
Citharichthys fragilis	12.42	10.40	15.61	16.50	12.18	270
Sebastes elongatus	11.19	12.53	7.83	12.09	10.16	261
Sebastes goodei	—	24.00	7.93	14.00	8.21	247
Odontopyxis trispinosa	7.82	7.78	7.78	7.77	7.78	244
Phanerodon furcatus	13.25	11.78	11.39	11.22	11.59	228
Xystreurys liolepis	17.92	18.50	19.80	18.03	18.50	224
Sebastes dallii	12.05	5.42	7.26	10.67	8.51	212
Sebastes rosenblatti	15.13	6.64	11.31	10.20	11.20	200
Porichthys myriaster	19.86	17.84	18.43	18.79	18.25	175
Pleuronichthys ritteri	16.43	14.41	15.00	14.70	15.07	157
Ophiodon elongatus	14.60	12.50	15.16	14.11	14.84	142
Raja inornata	31.33	38.62	30.04	27.20	32.58	132
Sebastes chlorostictus	9.19	10.63	12.67	9.50	10.80	131
Sebastes eos	9.71	9.00	4.60	9.67	7.07	118
Lyconema barbatum	14.33	14.74	14.04	15.00	14.22	113
Plectobranchus evides	9.69	10.88	11.02	10.00	10.73	101
Urobatis halleri	—	25.58	—	—	25.58	101
Sebastes caurinus	10.33	6.20	5.84	7.30	6.35	100
Xeneretmus triacanthus	11.00	13.66	12.60	13.18	12.95	93
Paralabrax nebulifer	22.57	18.51	27.00	23.00	19.13	88
Rhinogobiops nicholsii	8.00	7.27	6.65	7.67	6.97	88
Sebastes levis	7.56	6.50	7.09	9.00	7.18	80
Enophrys taurina	—	7.33	8.84	9.10	8.85	74
Sebastes miniatus	11.42	9.50	8.47	8.36	9.04	74
Anchoa delicatissima	—	6.40	—	—	6.40	60
Sebastes hopkinsi	5.00	—	7.03	14.00	9.83	59
Cryptotrema corallinum	—	8.40	6.00	—	8.36	56
Icelinus cavifrons	—	5.50	5.98	7.33	6.04	50
Paralabrax maculatofasciatus	—	20.86	—	—	20.86	50
Prionotus stephanophrys	24.00	11.14	27.00	—	11.78	45

APPENDIX C (continued)
Mean length and total number measured by species for each of the four Bight surveys and the grand mean across all surveys. Shaded cells indicate a value less than the grand mean.

	Abundance Weighted Mean Length (cm)					Total
Species	1994	1998	2003	2008	Overall	Measured
Hydrolagus colliei	—	27.82	29.79	38.67	30.32	37
Peprilus simillimus	7.00	8.63	9.67	10.00	9.32	31
Agonopsis sterletus	—	11.14	10.95	10.00	10.96	27
Sebastes rubrivinctus	11.25	14.20	12.33	11.78	12.33	27
Syngnathus exilis	24.00	18.86	22.25	19.23	19.80	25
Hypsurus caryi	—	—	8.57	8.59	8.58	24
Sebastolobus alascanus	18.00	17.00	13.00	—	15.54	24
Pleuronichthys guttulatus	20.00	19.27	20.67	16.75	19.04	23
Lycodes cortezianus	22.00	10.83	21.80	15.20	15.82	22
Rathbunella hypoplecta	13.25	11.67	11.43	13.00	12.14	21
Cheilotrema saturnum	—	17.44	—	—	17.44	18
Hyperprosopon argenteum	—	8.62	9.00	—	8.72	18
Leptocottus armatus	—	—	12.33	11.67	11.78	18
Platyrhinoidis triseriata	40.00	36.80	—	26.00	35.89	18
Sebastes melanostomus	—	—	—	6.44	6.44	18
Sebastes sp.	2.75	5.38	4.00	—	4.06	17
Eopsetta jordani	32.50	37.00	29.00	28.83	32.07	15
Rhacochilus toxotes	19.50	—	8.20	8.50	9.87	15
Sebastes rosaceus	10.00	3.57	5.50	11.00	5.27	15
Pleuronichthys coenosus	—	15.50	15.67	—	15.57	14
Sebastes ensifer	—	14.14	—	—	14.14	14
Sebastes umbrosus	16.17	17.00	3.50	9.67	11.21	14
Lythrypnus dalli	—	3.46	—	—	3.46	13
Embiotoca jacksoni	—	13.50	10.33	13.00	12.67	12
Rhinobatos productus	—	44.14	41.00	23.75	37.08	12
Physiculus rastrelliger	—	13.45	—	—	13.45	11
Rhacochilus vacca	—	8.22	18.00	—	10.00	11
Paralabrax clathratus	20.00	19.67	—	—	19.70	10
Cephaloscyllium ventriosum	32.50	31.83	66.00	—	35.78	9
Raja stellulata	15.50	16.50	21.33	—	17.89	9
Heterostichus rostratus	—	8.00	8.00	8.00	8.00	8
Kathetostoma averruncus	16.50	17.00	21.00	—	17.75	8
Lepidopsetta bilineata	—	—	19.25	—	19.25	8
Macroramphosus gracilis	—	8.00	—	—	8.00	8
Menticirrhus undulatus	—	21.83	20.50	—	21.50	8
Radulinus asprellus	—	10.00	10.57	—	10.50	8
Raja rhina	—	32.50	67.50	30.50	40.75	8
Gibbonsia montereyensis	—	—	5.43	—	5.43	7
Sebastes macdonaldi	—	8.50	5.67	—	7.29	7
Sebastes constellatus	3.00	4.33	4.00	—	4.00	6
Myliobatis californica	85.00	57.00	74.00	—	69.40	5
Oxylebius pictus	14.00	—	5.33	12.00	8.40	5
Rathbunella alleni	10.00	9.00	—	—	9.20	5
Sebastes atrovirens	—	6.00	—	9.75	9.00	5
Anchoa compressa	—	11.50	—	—	11.50	4
Eptatretus stoutii	20.50	45.00	—	—	32.75	4
Pleuronectes bilineatus	—	21.50	—	—	21.50	4
Syngnathus californiensis	—	18.50	—	—	18.50	4
Torpedo californica	—	46.33	—	23.00	40.50	4
Trichiurus nitens	—	41.50	—	—	41.50	4
Umbrina roncador	—	15.25	—	—	15.25	4
Icelinus filamentosus	16.00	16.00	10.00	—	14.00	3
Mustelus henlei	—	71.50	—	51.00	64.67	3
Sebastes auriculatus	18.00	14.00	—	—	15.33	3
Sebastes paucispinis	—	—	11.33	—	11.33	3
Anoplopoma fimbria	—	18.00	26.00	—	22.00	2
Bollmannia gomezi	—	—	9.00	—	9.00	2
Caulolatilus princeps	—	16.50	—	—	16.50	2
Hippocampus ingens	—	20.00	—	—	20.00	2
Icelinus fimbriatus	16.00	—	14.00	—	15.00	2
Icelinus oculatus	—	—	13.00	—	13.00	2
Pleuronectiformes	—	—	3.00	—	3.00	2
Raja binoculata	—	60.00	17.00	—	38.50	2
Roncador stearnsii	—	—	—	27.50	27.50	2

APPENDIX C (continued)

Mean length and total number measured by species for each of the four Bight surveys and the grand mean across all surveys. Shaded cells indicate a value less than the grand mean.

	Abundance Weighted Mean Length (cm)					Total
Species	1994	1998	2003	2008	Overall	Measured
Scorpaenichthys marmoratus	—	—	—	13.50	13.50	2
Sebastes lentiginosus	—	3.00	—	—	3.00	2
Semicossyphus pulcher	—	13.00	26.00	—	19.50	2
Squalus acanthias	—	65.00	—	101.00	83.00	2
Squatina californica	85.00	27.00	—	—	56.00	2
Trachurus symmetricus	16.00	10.00	—	—	13.00	2
Anarrhichthys ocellatus	—	—	66.00	—	66.00	1
Argyropelecus sladeni	—	—	—	3.00	3.00	1
Artedius notospilotus	—	—	—	8.00	8.00	1
Atherinopsis californiensis	—	26.00	—	—	26.00	1
Bathyraja interrupta	—	—	—	8.00	8.00	1
Brosmophycis marginata	29.00	—	—	—	29.00	1
Chromis punctipinnis	—	—	12.00	—	12.00	1
Clupea pallasii	—	14.00	—	—	14.00	1
Dasyatis dipterura	—	43.00	—	—	43.00	1
Engyophrys sanctilaurentii	—	9.00	—	—	9.00	1
Gibbonsia metzi	—	—	—	6.00	6.00	1
Halichoeres semicinctus	19.00	—	—	—	19.00	1
Hexagrammos decagrammus	—	—	—	11.00	11.00	1
Icichthys lockingtoni	—	—	3.00	—	3.00	1
Lythrypnus zebra	—	3.00	—	—	3.00	1
Mustelus californicus	—	66.00	—	—	66.00	1
Neoclinus blanchardi	—	18.00	—	—	18.00	1
Ophidion scrippsae	—	19.00	—	—	19.00	1
Parmaturus xaniurus	—	—	28.00	—	28.00	1
Rimicola muscarum	—	—	—	2.00	2.00	1
Ruscarius creaseri	—	—	5.00	—	5.00	1
Sebastes pinniger	22.00	—	—	—	22.00	1
Sebastes rufus	—	—	—	13.00	13.00	1
Sebastes simulator	—	4.00	—	—	4.00	1
Synchiropus atrilabiatus	—	6.00	—	—	6.00	1
Xenistius californiensis	—	—	—	15.00	15.00	1