SPATIAL DISTRIBUTION OF SOUTHERN CALIFORNIA BIGHT DEMERSAL FISHES IN 2008

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ABSTRACT

In an effort to better characterize the spatial dynamics of the assemblage, the demersal fish communities throughout the Southern California Bight (Point Conception, California to the United States-Mexico border) were sampled in 2008 utilizing standardized methods under an interagency program. Otter trawl sampling was conducted in habitats ranging from select bays and harbors out to the upper continental slope. Pacific sanddab (*Citharichthys sordidus*) was the most commonly caught species and contributed the greatest biomass. The catch compositions at each site generally segregated along depth gradients, but not latitudinal gradients except for within the bay/harbor strata. The largest catches were recorded in the central area, which includes the Santa Monica Bay and the Los Angeles–Long Beach harbors. Offshore densities peaked along the middle and outer shelf (30–200 m depth). Species diversity was comparatively stable and elevated along the deeper portions of the continental shelf relative to the inner shelf (<31 m depth) with the minimum diversity recorded in the southern portion of the inner shelf.

INTRODUCTION

The Southern California Bight (SCB) is a diverse area characterized by heterogeneous habitats (Dailey et al. 1993); the convergence of the cold southward flowing California Current and the warm poleward flowing California Countercurrent (Hickey 1992); a variable width continental shelf; and multiple, densely populated, metropolitan areas (e.g., Los Angeles, San Diego, etc.). Fishes within the SCB represent a transitional fauna indicative of the dynamic environmental conditions present, with species representative of the Oregonian and San Diegan biogeographic provinces commonly occurring in the area (Horn et al. 2006).

Environmental conditions can fluctuate widely on annual to decadal scales, often related to larger scale oceanographic phenomena affecting the California Current such as El Niño Southern Oscillation (ENSO) events (1997–98 ENSO; McGowan et al. 2003) or variability in the strength and position of the Aleutian Low (Bograd and Lynn 2003). Both low- and high-frequency variability has been linked to marked changes in the abundance and distribution of fishes, including demersal species (Mearns 1979; Stull and Tang 1996; Perry et al. 2005; Hsieh et al. 2009). Recent discoveries of an expanding oxygen minimum zone (OMZ) in the Eastern North Pacific basin, and its negative impact on demersal and benthic life raises additional concern (Levin 2003; Grantham et al. 2004; Powers et al. 2005; Bograd et al. 2008; Chan et al. 2008; Diaz and Rosenberg 2008; McClatchie et al. 2010). Within the SCB, Bograd et al. (2008) found areas with the highest rate of dissolved oxygen decline along the inner and middle shelves near the greater Los Angeles and Orange County, California, coastlines.

While fishes typically exhibit population level responses to environmental variation (Juan-Jordé et al. 2009), these oscillations can be exaggerated or masked by anthropogenic impacts such as harvesting (Brander 2007; Perry et al. 2010; Hidalgo et al. 2011), habitat alteration (Dayton et al. 1995), and ocean discharge from both point (e.g., wastewater discharge) and non-point sources (e.g., storm drain; Allen 2006a). Historically, SCB demersal fish community changes were traced to effects of wastewater discharge through either altered community demographics (composition, abundance, species diversity, etc.) or prevalence of tumors and other physical abnormalities (Perkins 1995; Stull and Tang 1996; Allen 2006a). While most wastewater discharge effects on the demersal fish community have subsided (Stull and Tang 1996; Allen 2006a,b), impacts of fishing and other anthropogenic interactions with the coastal waters can still be detected (Schroeder and Love 2002). Concerns over large, point-source ocean discharges resulted in permit-required demersal fish monitoring (Mearns 1979; Love et al. 1986; Stull and Tang 1996). Demographic indices (abundance, biomass, composition, etc.) on the demersal fish stocks of the SCB shelf are routinely monitored through this permit-required monitoring.

Despite the level of effort devoted to monitoring, however, little primary research documenting the soft-bottom demersal fish communities of the SCB beyond site-specific programs (see Stull and Tang 1996) has been published since Love et al. (1986), which was limited to communities inshore of the 20-m isobath. Deficits in this information at a regional scale limit the detection of population responses to large scale perturbations such as OMZ intrusion. McClatchie et al. (2010) modeled the predicted effect of OMZ on cowcod (*Sebastes levis*) habitat, but abundance information will be needed to evaluate their predictions of population-level responses. As an example, Grantham et al. (2004) was able to use previously recorded demersal species abundance data collected near an oceanographic monitoring transect to report on the catastrophic effects of hypoxia on the demersal resources off the Oregon coast.

An integrated, area-wide sampling effort utilizing standardized methods can provide the necessary robust snapshot of baseline conditions to not only provide context for site-specific monitoring results but also, after repeated surveys, provide tractable evidence of community changes (Bertrand et al. 2002). The Southern California Bight 2008 Monitoring Program (Bight 2008) was conducted to provide this general overview of the SCB demersal fish community spatial dynamics. Utilizing the Bight 2008 results, this study aims to describe the spatial pattern of the SCB soft-bottom demersal fish stocks with a specific goal of characterizing the assemblage variability between discrete depth strata and latitudinal regions, for both the community as a whole but also at species-specific levels. Such information is lacking in the recently published literature and will likely benefit future evaluations of the various anthropogenic and environmental factors previously mentioned, e.g., the expanding OMZ.

MATERIALS AND METHODS

Sampling Station Description

Demersal fish on soft-bottom habitat were sampled at 143 stations by otter trawl across the SCB at stations using a probability based design (Stevens 1997) that selects sampling sites *a priori* among areas determined to be free of obstructions (able to be sampled with an otter trawl) based on reviews of bathymetric maps (fig. 1). During the Bight 2008 planning, stations were segregated into discrete shelf (depth) strata and latitudinal groups. To account for differences between expected and actual depths at each sampling site, all open coast data were reclassified after sampling into consistent shelf strata by actual sampling depth: 5–30 m = inner shelf (IS), 31–120 m = middle shelf (MS), 121–200 m = outer shelf (OS), and >200 m = upper slope (US). Sampling results from bays and harbors remained classified into the bay/harbor (BH) shelf strata. Within each stratum, latitudinal distributions were designated as: >34°N = north, 33.5–34°N = central, and <33.5°N = south. Henceforward, shelf strata-region combinations (e.g., IS-S) are referred to as blocks (e.g., IS-S block) for simplicity.

Sampling Methods

Sampling was completed during the summer (July–September, 2008) with 7.6-m head-rope semiballoon otter trawl nets fitted with 1.25-cm cod-end mesh during daylight hours. Trawls were towed along open-coast isobaths for ~10 min (~5 min in bays and harbors) at 0.8–1.0 m/sec. These tows were designed to cover an estimated distance of 300 and 600 m for 5 and 10 min trawls, respectively. The actual trawl distance was calculated from the difference between the start and stop fishing GPS coordinates recorded on the deck of the towing vessel. These acted as a proxy for the net's relative position. It was assumed the net remained on the bottom and fishing the entire time. Upon retrieval, catches were sorted, identified to species, enumerated, and batch weighed to the nearest gram (g). Each station was sampled once per survey. Catches from sampling events aborted due to equipment malfunction or protocol violations were discarded and the station was resampled, if possible.

Data Analysis

The analysis focused on the demersal communities; therefore pelagic, midwater fishes (Allen and Pondella 2006), e.g., northern anchovy (*Engraulis mordax*), were excluded as their catches likely include sampling during midwater deployment or retrieval (Biagi et al. 2002). Underwater measurements by Environmental Quality Analysts and Marine Biological Consultants (1975) determined the 7.6-m trawl net used in all four Bight surveys spread 4.9 m, on average, while under tow and fishing. The area swept in this analysis represents the distance trawled (m) × 4.9 m. Densities represent the abundance (biomass) per area swept (m^2).

Mean density (count/1000 m^2) for each species and its frequency of occurrence in individual trawl samples were derived by shelf strata. The mean density by block (e.g. inner shelf south) for the 21 most abundant species caught across the three open coast shelf strata (inner, middle, and outer shelf). Based on the probabilistic design, 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 where the 95% confidence intervals about the mean were calculated as 1.96 times the standard error.

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

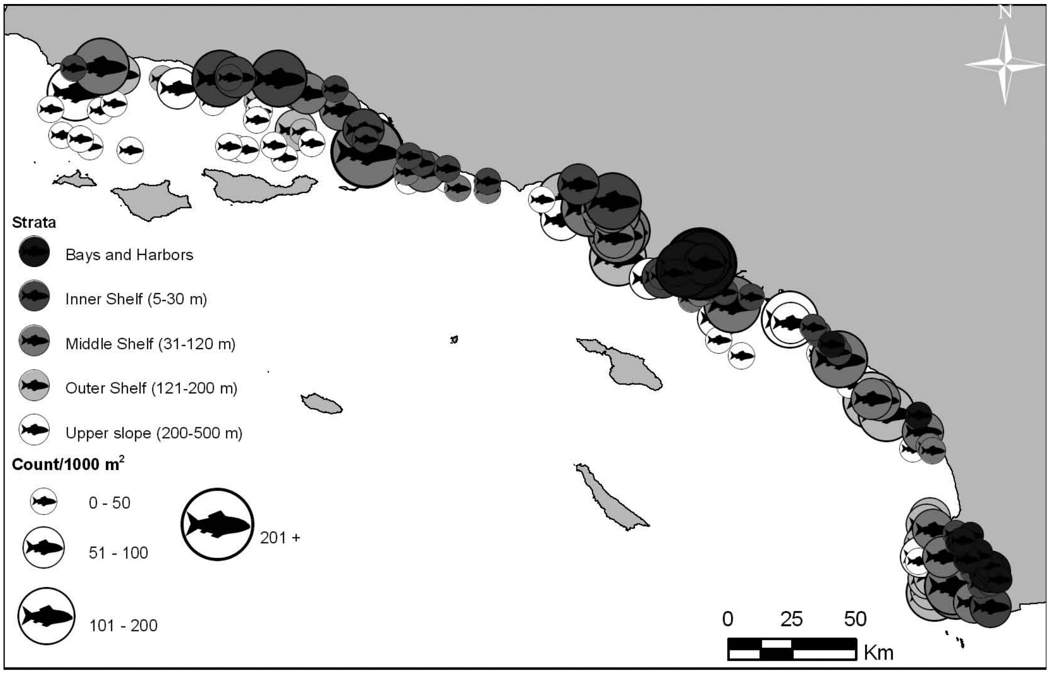
where:
m = Area-weighted mean concentration for population j.
p_i = Parameter value (e.g. density) at station i.
w_i = Area weight for station i.
n = Number of stations in population j.

Differences in the species-specific densities between blocks were compared using a one-way ANOVA with a Bonferroni multiple comparison test after Ln (x+1) transforming the data (Sokal and Rohlf 1995). The Pacific sanddab (*Citharichthys sordidus*) and hornyhead turbot (*Pleuronichthys verticalis*) distributions were the only ones to meet the parametric assumptions after transformation. A Kruskall-Wallis ANOVA, correcting for ties, (Sokal and Rohlf 1995) was used to compare block-specific patterns in the remaining 19 species. The Shannon-Wiener species diversity index (Shannon and Weaver 1962) was derived based on the raw counts by block. Species diversity by block was compared using a Kruskall-Wallis ANOVA, correcting for ties, using station-specific values. All comparisons were executed using Number Cruncher Statistical Software (Hintze 1998). Each species' significance to the shelf stratum community was described using the rank of the index of community importance (ICI; Stephens and Zerba 1981; Love et al. 1986). Differences in assemblages between regions within each shelf stratum were subjectively examined using the species abundance distributions (SAD; McGill et al. 2007) among the ten most abundant species in each shelf stratum. The station-specific proportion of the total catch in each block and the mean across all stations in each block were derived to illustrate comparative changes in the species rank abundance with latitude. Spearman rank correlation was used to compare the means among the regions within each shelf stratum with n = 10 (species included) in all comparisons.

Similarities along the full latitudinal and depth gradients sampled were characterized using percent similarity index (PSI, Whittaker 1952; Whittaker and Fairbanks 1958) 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. Stations were segregated into 0.2° latitude bins for spatial analysis and 20-m bins for depth analysis. Each PSI distribution was evaluated to determine if the pattern fit either a linear or nonlinear regression model. Nonmetric multidimensional scaling (nMDS) was used to illustrate the station groupings within each shelf strata based on the observed assemblage after the calculation of Bray-Curtis dissimilarities of fourth-root transformed species-specific densities (Clarke and Ainsworth 1993). The bay/harbor strata was excluded from the nMDS analysis due to the lack of a northern region sampling area and the general concentration of sampling in Los Angeles and Long Beach harbors within the central region (fig. 1). A similar nMDS analysis was done to visualize the relationships between the block species diversities after calculation of the Bray-Curtis dissimilarities. These data were not transformed prior to calculation of the dissimilarities. Station-specific diversities were included in the analysis, similar to the execution of the Kruskall-Wallis ANOVA, correcting for ties. All nMDS analyses were completed using SYSTAT v. 9.0 (SYSTAT 1998).

RESULTS

Appendix A includes a master species list of all fishes caught during the 2008 sampling while appendices B1–B5 list the mean density (± standard error), frequency of occurrence, and ICI rank by shelf stratum for all fishes caught. A total of 26,546 fish weighing 932.215 kg representing 133 demersal species were caught amongst 143 stations dispersed across five shelf strata spanning three designated latitudinal regions of the SCB (tab. 1 and fig. 1). Fish were caught at all but three stations, one each in the BH-S, IS-S, and US-N blocks. Sampling stations were randomly distributed over the soft-bottom habitat although some blocks were more intensively sampled (e.g., US-N) than others (e.g., OS-C; tab. 1). Pockets of elevated densities (count/1000 m^2) were observed in the Santa Monica Bay, Los Angeles and Long Beach harbors, and offshore San Diego. Additional individual sampling sites outside these areas registered elevated densities, but their occurrence was not as clustered. The Santa Monica Bay and offshore San Diego abundance hot spots were primarily from the MS and OS strata. Relatively high density catches (>101 fish/1000 m^2) were recorded at three IS stations, with two out of the three in the northern region. Similarly high density catches were also comparatively rare in the US with sampling at two stations recording densities greater than 101 fish/1000 m^2. Bio-



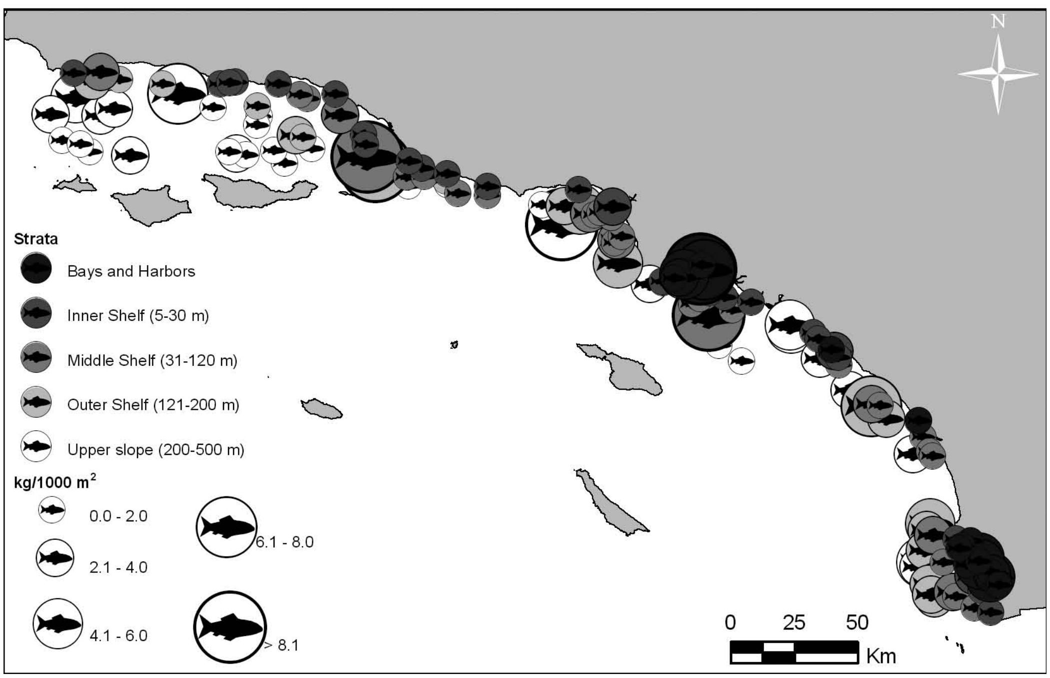


Figure 1. Demersal fish sampling stations occupied in summer 2008 distributed among the sampled shelf strata. Total sampling sites = 143. Upper panel depicts the total demersal fish abundance density (count/1000 m^2) recorded at each station per shelf strata. Lower panel depicts the total demersal fish biomass density (kg/1000 m^2) recorded at each station per shelf strata. Isobaths are depicted at 50-m intervals between the 50- and 500-m contour.

mass records (kg/1000 m^2) suggested a more dispersed pattern for the above-average catch weights, although stations in the Los Angeles and Long Beach harbor areas and offshore San Diego continued to record above average values. Species diversity ranged wildly among blocks, but was lower along the IS and BH shelf strata while relatively stable throughout the deeper sampling areas (fig. 2a). Peak diversity occurred along the MS-S with diversity at all but one station greater than 1.50 while the IS-S recorded the lowest diversity with all station-specific H´ < 1.40. Blocks with predominately H´ < 1.50 were segregated from the main grouping in the nMDS (fig. 2b), resulting in a significant difference between station-specific diversity (KW, H = 37.25, df = 13, p < 0.001).

The SADs by block revealed community variation

TABLE 1
Number of stations by shelf strata and latitudinal region sampled during the 2008 Southern California Bight monitoring survey.

Shelf Strata	Latitudinal Region	Number of Stations
Bays and Harbors	Central	6
	Southern	16
Strata Total		22
Inner Shelf	Northern	12
(5–30 m)	Central	13
	Southern	7
Strata Total		32
Middle Shelf	Northern	9
(31–120 m)	Central	13
	Southern	11
Strata Total		33
Outer Shelf	Northern	11
(121–200 m)	Central	3
	Southern	9
Strata Total		23
Upper slope	Northern	20
(200–500 m)	Central	9
	Southern	4
Strata Total		33
Total Number of Stations		143

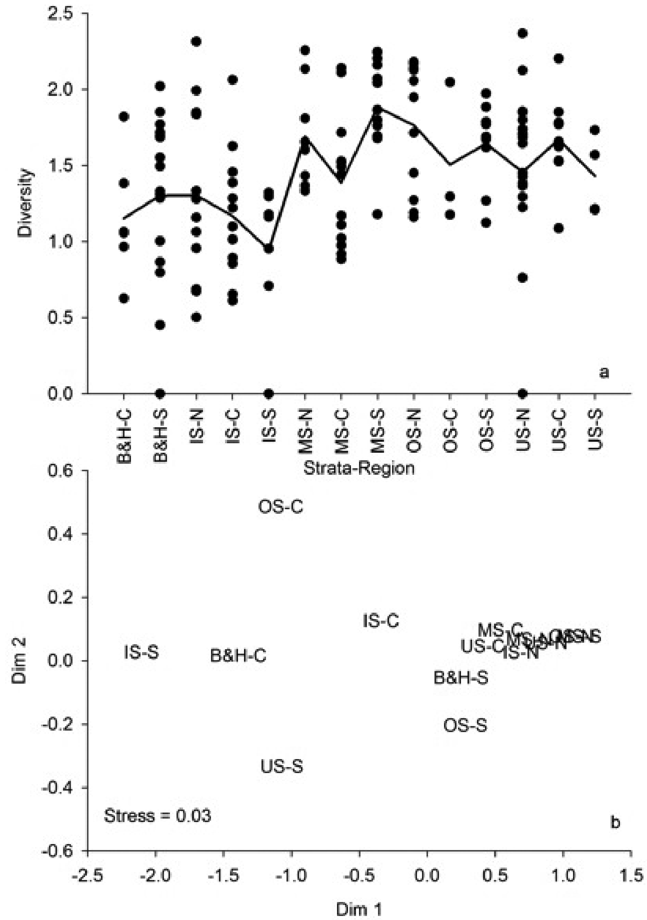
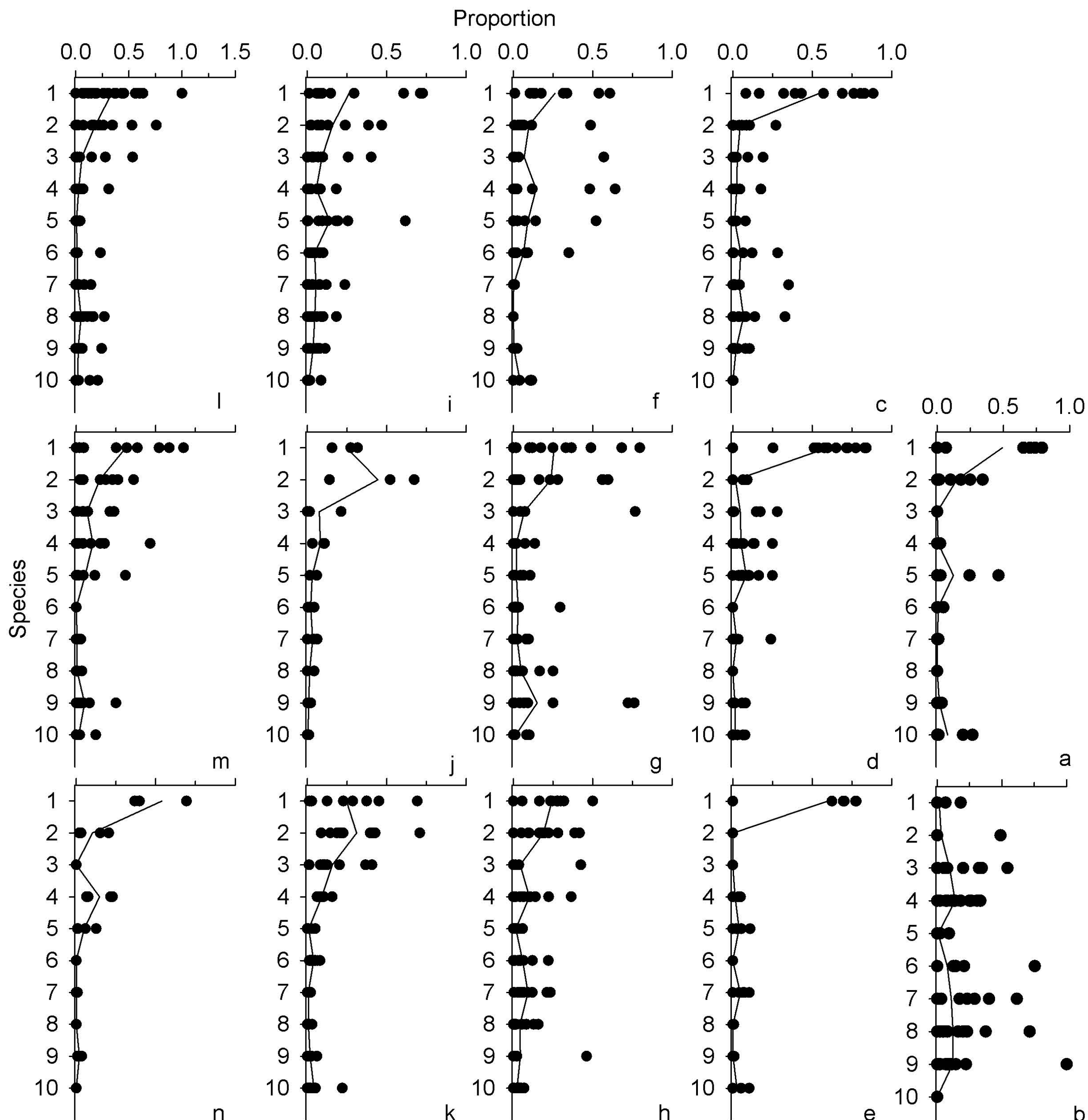


Figure 2. a) Shannon-Wiener species diversity index values for each station (dots) within each shelf strata-region block and the mean diversity for each shelf strata-region block (line). b) Nonmetric multidimensional scaling 2D distribution of the shelf strata-region blocks based on station-specific Shannon-Wiener diversity index values. Strata include: bays and harbors (BH), inner shelf (IS), middle shelf (MS), outer shelf (OS), and upper slope (US). Regions include north (N), central (C), and south (S).

along a latitudinal gradient within each shelf stratum (fig. 3). Differences between the two BH regions were the most pronounced; white croaker (*Genyonemus lineatus*) dominated the BH-C but was minimally abundant in the BH-S. This was the only shelf stratum where a negative correlation was detected between latitudinal regions ($r = -0.69$, $p < 0.02$). No significant correlations were detected for the IS between regions. This was consistent with the steady dominance of speckled sanddab (*Citharichthys stigmaeus*) throughout the stratum but variability among the lesser abundant species differentiated the regions. The same was true along the MS, except that Pacific sanddab replaced speckled sanddab as the dominant form. Along the OS and US, each region significantly correlated with the next most southerly region (OS-N:OS-C, $r = 0.89$, $p < 0.01$; OS-C:OS-S, $r = 0.62$, $p = 0.05$; US-N:US-C, $r = 0.71$, $p = 0.02$; US-C:US-S, $r = 0.76$, $p < 0.001$). No correlations, positive or negative, were detected between the northernmost and southernmost regions in any shelf stratum. Other than in the BH stratum, only the OS-C block community exhibited a substantial decline in the proportional contribution of the most abundant species across the stratum, Pacific sanddab.

Distribution of the 21 most abundant species, overall, revealed significant differences in their occurrence among the three shallowest offshore blocks (fig. 4, tab. 2). These differences were often predicated on a species complete or near-complete absence at select blocks. Four species were either entirely or largely absent outside of one stratum. Of these, splitnose rockfish (*Sebastes diploproa*) was uniquely caught in one stratum (OS), the remaining three species were represented by densities <2% of their peak block outside of their principle stratum. Only English sole (*Parophrys vetulus*) was caught in all blocks, although their peak densities were recorded in the MS-N. Pacific sanddab was the most common species (fig. 4), ranking first in abundance and the MS and OS ICI (appendices B-3 and B-4). Speckled sanddab occupied the top rank in both categories along the IS, while slender sole (*Lyopsetta exilis*) ranked first along the US in both metrics (appendix B-5). Speckled sanddab dominated the shallower IS sampling before its abundance diminished with depth where it was replaced by Pacific sanddab in the MS and OS sampling which ultimately gave way to slender sole at the greatest depths sampled.



Upper Slope	Outer Shelf	Middle Shelf	Inner Shelf	Bay & Harbor
1 slender sole	1 Pacific sanddab	1 Pacific sanddab	1 speckled sanddab	1 white croaker
2 Dover sole	2 slender sole	2 yellowchin sculpin	2 Pacific sanddab	2 queenfish
3 splitnose rockfish	3 stripetail rockfish	3 halfbanded rockfish	3 yellowchin sculpin	3 yellowfin croaker
4 s. thornyhead	4 shortspine combfish	4 pink seaperch	4 English sole	4 barred sand bass
5 rex sole	5 blackbelly eelpout	5 English sole	5 hornyhead turbot	5 shiner perch
6 shortbelly rockfish	6 Dover sole	6 longspine combfish	6 pink seaperch	6 slough anchovy
7 bearded eelpout	7 English sole	7 longfin sanddab	7 CA lizardfish	7 round stingray
8 blackbelly eelpout	8 plainfin midshipman	8 roughback sculpin	8 shiner perch	8 spotted sand bass
9 Pacific hake	9 blacktip poacher	9 speckled sanddab	9 CA tonguefish	9 CA halibut
10 stripetail rockfish	10 halfbanded rockfish	10 stripetail rockfish	10 roughback sculpin	10 speckled sanddab

Figure 3. Demersal fish species abundance distribution as the percent of the total catch by shelf strata-region block for the ten most commonly taken species along each shelf stratum. a) Central bay & harbor, b) southern bay and harbor, c) northern inner shelf, d) central inner shelf, e) southern inner shelf, f) northern middle shelf, g) central middle shelf, h) southern middle shelf, i) northern outer shelf, j) central outer shelf, k) southern outer shelf, l) northern upper slope, m) central upper slope, n) southern upper slope. See text for bounds of strata and latitudinal ranges.

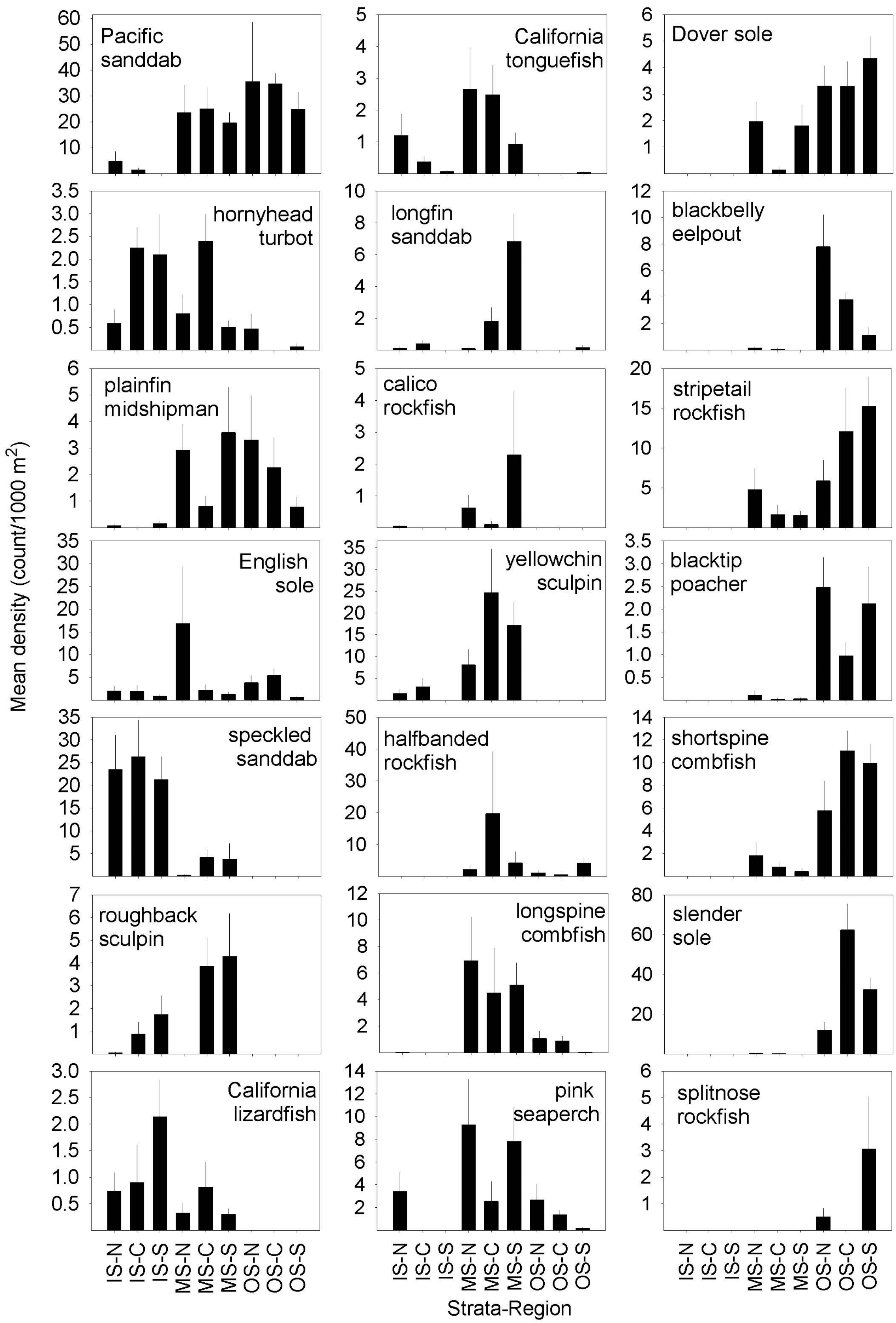


Figure 4. Area-weight adjusted mean density (fish/1000 m^2) per shelf strata-region block for the 21 most commonly occurring species in summer 2008 Southern California Bight demersal fish sampling along the inner shelf (IS), middle shelf (MS), and outer shelf (OS). Latitudinal regions are north (N), central (C), and south (S) as described in materials and methods.

TABLE 2
Results of one-way ANOVA (ANOVA) or Kruskall-Wallis (KW) test comparing the shelf strata-region trawl caught densities (count/1000 m²) for the 21 species most commoly captured during the 2008 Southern California Bight monitoring survey. Inner shelf (IS), middle shelf (MS), outer shelf (OS), north (N), central (C), and south (S). See text for depth ranges and latitudinal ranges for each shelf stratum and latitudinal region.

Species	Test	Statistic	DF	p	Significantly Differing Strata
Pacific sanddab	ANOVA	8.20	8,79	<0.001	IS: MS, OS
slender sole	KW	76.34	8	<0.001	OS: IS, MS
hornyhead turbot	ANOVA	5.71	8,79	<0.001	IS-C: MS, OS, IS-N; MS-C: OS
plainfin midshipman	KW	34.40	8	<0.001	IS-N & IS-S: MS-N, MS-S, OS-N; IS-C: MS, OS-C, OS-N
English sole	KW	8.49	8	0.39	NS
speckled sanddab	KW	54.54	8	<0.001	IS: MS, OS; MS-C: OS-N
roughback sculpin	KW	40.42	8	<0.001	MS-C: IS, OS, MS-S; MS-N: MS-C, MS-S; IS-C & IS-S: MS-S;
California lizardfish	KW	19.95	8	0.01	IS-N, IS-S, MS-C, MS-S: OS-N, OS-S
California tonguefish	KW	27.29	8	<0.001	MS-C: IS-C, IS-S, OS; MS-S: IS-S, OS-N, OS-S; OS-C & OS-N: MS
longfin sanddab	KW	46.88	8		MS-S: IS, OS, MS-N, MS-C; MS-C: IS-S, IS-N
calico rockfish	KW	19.38	8	0.01	MS-S: IS, MS-C, OS
yellowchin sculpin	KW	52.15	8	<0.001	MS: IS, OS
halfbanded rockfish	KW	21.29	8	<0.01	OS-S: IS, MS-C, MS-S
longspine combfish	KW	39.93	8	<0.01	MS: IS, MS; MS-C: OS-S; MS-N: OS-N, OS-S; MS-S: OS-N, OS-S
pink seaperch	KW	32.70	8	<0.001	IS-C: MS, IS-N, OS-N; IS-N: MS-S; IS-N: MS-C, MS-N, OS-N; MS-C: OS-S, MS-S; MS-S: OS-S
Dover sole	KW	65.58	8	<0.001	IS: OS, MS-N, MS-S; MS-C: MS-N, MS-S, OS
blackbelly eelpout	KW	47.32	8	<0.001	OS-C: IS, MS, OS-S; OS-N: IS, MS, OS-S
stripetail rockfish	KW	48.62	8	<0.001	IS: MS-N, MS-S, OS; OS-S: MS; OS-N: MS-C
blacktip poacher	KW	61.85	8	<0.001	OS: IS, MS
shortspine combfish	KW	61.81	8	<0.001	IS: OS, MS-N; MS-C:OS; MS-N: OS-S
splitnose rockfish	KW	17.92	8	<0.001	OS-N & OS-S: IS, MS

The PSI calculated across the shelf stations (IS, MS, OS) indicated limited differences along the latitudinal gradient, although a depression was observed at ~33°N, or offshore northern San Diego County (fig. 5a). Distance between stations did not result in a predictable pattern (fig. 5b). Stations along the north-south latitudinal gradient by shelf strata were generally overlapping in the nMDS analysis (fig. 6). Subtle gradients were observed in the IS and US, but stations from other regions were interspersed throughout the 2D space. Catches between ~160 and 420 m had the highest mean PSI scores (30–40%), but little similarity overall was detected with depth outside the immediately proximate depth bins (fig. 5c). Few comparisons exceeded 60% similarity, with a large proportion at <10% similarity. Similarity between depth-stratified catches declined in a linear pattern ($R^2 = 0.58$) with a negative slope ($m = -0.16$) as increasing differences in depth reduced the similarity between two catches (fig. 5d).

DISCUSSION

Demersal fish sampling in 2008 recorded a diverse and spatially distinct soft-bottom demersal community across the SCB. As expected, there was a clear difference in the species composition between the BH and offshore strata. Most species taken in BH sampling were absent or minimally present at sampling sites from the continental shelf or upper slope. Of the shelf sites, differences in species composition occurred with increasing depth. Abundance and diversity was much greater at MS and OS depths in comparison to the IS. The greatest abundance in trawl catch was observed in MS and OS depths offshore Santa Monica Bay and San Diego. In the BH straum, substantially elevated abundance was observed in the Los Angeles and Long Beach harbor. Finally, there was little difference in species composition across latitudinal gradients on the continental shelf, although shifts in species composition were observed in the BH stratum moving north to south.

The results observed during this survey were indicative of results from previous studies, such as depth stratification of the dominant flatfishes (Fager and Longhurst 1968; Biagi et al. 2002; Allen 2006b; Allen and Pondella 2006). For example, the prevalence of sanddab species, especially speckled sanddab and Pacific sanddab, has been a consistent biological feature in the SCB for over 30 years (Love et al. 1986; Stull and Tang 1996; Mearns 1979). These dominant flatfishes stratified by depth along the continental shelf in 2008; speckled sanddabs occurred shallow (<30 m), before transitioning to Pacific sanddab, and then slender sole in the deepest reaches (>200 m). This is also consistent with past survey results (Stull and Tang 1997) and Allen's (2006b) soft-bottom fish community functional structure.

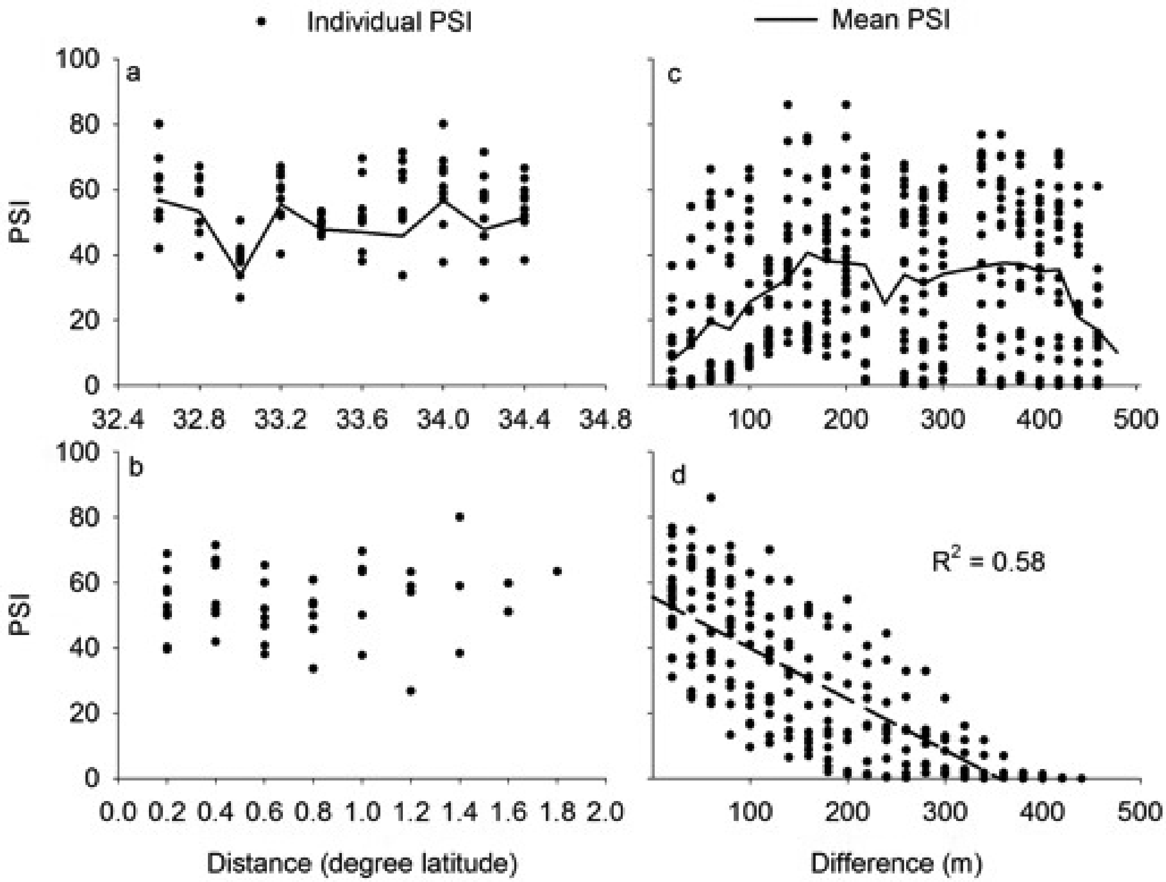


Figure 5. Percent similarity index (PSI) for the 2008 summer Southern California Bight demersal fish sampling depicting the similarity in catch composition between stations separated by a) 0.2° latitude bin, b) distance (degree latitude), c) 20-m depth bin, d) difference in depth (m). Solid lines in a and b represent the mean PSI at each x-axis value. Dashed line in d represents the best fit linear regression model (R^2 = 0.58) describing the observed pattern.

Results observed during this survey were also not indicative of previous studies. For example, the Los Angeles and Long Beach harbor areas were numerically dominated by white croaker and queenfish (*Seriphus politus*), whereas these species were caught in only 4% of the remaining SCB. The comparatively low abundances of white croaker along the open coast and in the southern BH varies dramatically from Allen (2006b) who indicated that the white croaker foraging guild occurred in >20% of all samples he examined from the IS and MS. Previously, demersal fish sampling inside of the 20-m isobaths along the SCB open coast consistently recorded both queenfish and white croaker among the most abundant species, with either one often ranking first in abundance (DeMartini and Allen 1984; Love et al. 1986). Stull and Tang (1996) first reported on the area's white croaker decline using identical techniques as the current investigation. The demise of white croaker and queenfish, especially within the central region, is consistent with the reported correlations between the planktivorous queenfish and declining nearshore zooplankton volumetric biomass beginning circa 1980 (Miller et al. 2009).

The presence of latitutinal gradients in demersal fishes has been more equivocal. For example, variations in the SADs between regional areas for each open coast shelf stratum were muted in 2008. While some community variability was detected, which may indicate some latitudinal differences within shelf stratum, it was not at a statistically significant level. However, Love et al. (1986) found significant differences with latitude, but their sampling was more intensive and focused on a limited depth range. Hence, the relatively small sample size and large spatial scale may play a role in our study, with the interaction of the two masking potential latitudinal differences.

Demonstrative conclusions regarding factors (outside of depth influences) stimulating the dispersion of soft-bottom demersal fishes in the SCB is outside the scope of one set of summer samples. These patterns, however, do provide baseline information for future comparisons. As such, these data begin to address a critical void in our ability to evaluate impacts from growing concerns, particularly at large spatial scales, such as the expanding OMZ. Given the previously documented devastating effects of nearshore hypoxia (Grantham et al. 2004), the need for baseline ecological information is becoming

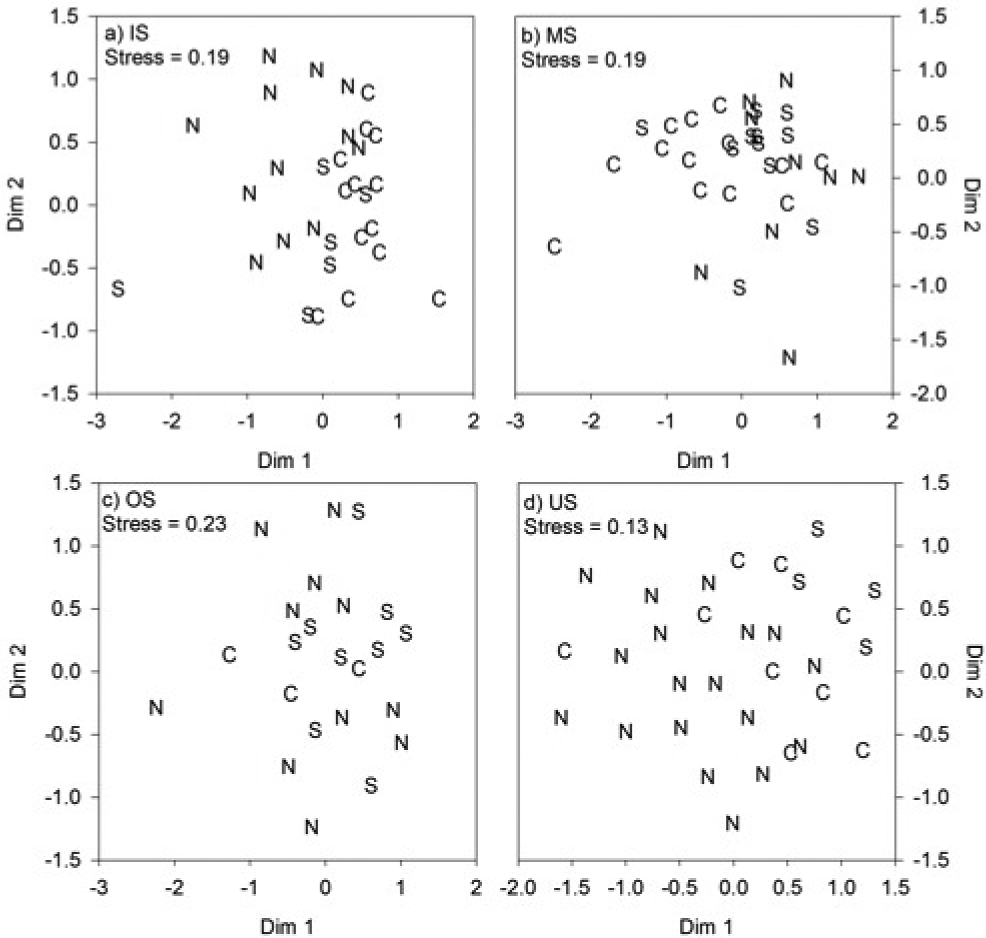


Figure 6. Nonmetric multidimensional scaling 2D distribution of stations based on sampled community density at each station segregated into latitudinal group (north = N, central = C, south = S) for the inner shelf (IS), middle shelf (MS), outer shelf (OS), and upper slope (US). Letters in each plot represent an individual station within the shelf stratum.

increasingly apparent. Programs such as the Bight 2008 demersal fish study may begin to fill this void.

Conclusions

The SCB demersal fish community was diverse and largely depth-stratified in 2008. Comparisons with previous reports indicated changes in the faunal composition have occurred, specifically the decline of the once abundant sciaenids white croaker and queenfish while various flatfish, especially sanddabs, continue to dominate the system. Bays and harbors remain unique along the SCB with several species largely limited to these areas. Likewise, the most abundant species on the upper slope were relatively uncommon along the other strata. The remaining shelf strata had a high degree of overlap amongst the species.

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LITERATURE CITED

Allen, M. J. 2006a. Pollution. *In*: The Ecology of Marine Fishes: California and Adjacent Waters, L. G. Allen, D. J. Pondella, II, and M. H. Horn, eds. University of California Press, Los Angeles, CA. pp. 595–610.

Allen, M. J. 2006b. Continental shelf and upper slope. *In*: The Ecology of Marine Fishes: California and Adjacent Waters, L. G. Allen, D. J. Pondella, II, and M. H. Horn, eds. University of California Press, Los Angeles, CA. pp. 167–202.

Allen, L. G. and D. J. Pondella, II. 2006. Ecological classifications. *In*: The Ecology of Marine Fishes: California and Adjacent Waters, L. G. Allen, D. J. Pondella, II, and M. H. Horn, eds. University of California Press, Los Angeles, CA. pp. 81–113.

Bertrand, J. A., L. G. De Sola, C. Papaconstantinou, G. Relini, and A. Souplet. 2002. The general specifications of the MEDITS surveys. Sci. Mar. 66:9–17.

Biagi, F., P. Sartor, G. D. Ardizzone, P. Belcari, A. Belluscio, and F. Serena. 2002. Analysis of demersal assemblages off the Tuscany and Latium coasts (northwestern Mediterranean). Sci. Mar. 66:233–242.

Bograd, S. J. and R. J. Lynn. 2003. Long-term variability in the Southern California Current system. Deep-Sea Res. II 50:2355–2370.

Bograd, S. J., C. G. Castro, E. Di Lorenzo, D. M. Palacios, H. Bailey, W. Gilly, and F. P. Chavez. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California current. Geophys. Res. Lett.35:L12607.

Brander, K. M. 2007. Global fish production and climate change. PNAS 104:19709–19714.

Chan, F., J. A. Barth, J. Lubchenco, A. Kirincich, H. Weeks, W. T. Peterson, and B. A. Menge. 2008. Emergence of anoxia in the California Current Large Marine Ecosystem. Science 319: 920.

Clarke, K. R. and M. Ainsworth. 1993. A method of linking multivariate community structure to environmental variables. Mar. Ecol. Prog. Ser. 92:205–219.

Dailey, M. D., J. W. Anderson, D. J. Reish, and D. S. Gorsline. 1993. The Southern California Bight: background and setting. *In:* Ecology of the Southern California Bight: a synthesis and interpretation, M. D. Dailey, D. J. Reish, and J. W. Anderson, eds. Los Angeles: University of California Press, pp. 1–18.

Dayton, P. K., S. F. Thrush, M. T. Agardy, and R. J. Hoffman. 1995. Environmental effects of marine fishing. Aquatic Conserv: Mar. Freshw. Ecosyst. 5:205–232.

DeMartini, E. E. and L. G. Allen. 1984. Diel variation in catch parameters for fishes sampled by a 7.6-m otter trawl in southern California coastal waters. Calif. Coop. Oceanic Fish. Invest. Rep. 25:119–134.

Diaz, R. J. and R. Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. Science 321:926–929.

Environmental Quality Analysts and Marine Biological Consultants. 1975. Southern California Edison Company Long Beach Generating Station marine monitoring studies: 1975 annual report volume I.

Fager, E. W., A. R. Longhurst. 1968. Recurrent group analysis of species assemblages of demersal fish in the Gulf of Guinea. J. Fish. Res. Board Can. 25:1405–1421.

Grantham, B. A., F. Chan, K. J. Nielsen, D. S. Fox, J. A. Barth, A. Huyer, J. Lubchenco, and B. A. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. Nature 429:749–754.

Hickey, B. M. 1992. Circulation over the Santa Monica-San Pedro basin and shelf. Prog. Oceanog. 30:37–115.

Hidalgo, M., T. Rouyer, J. C. Molinero, E. Massuti, J. Moranta, B. Guijarro, and N. C. Stenseth. 2011. Synergistic effects of fishing-induced demographic changes and climate variation on fish population dynamics. Mar. Ecol. Prog. Ser. 426:1–12.

Hintze, J. L. 1998. Number Cruncher Statistical Systems. Kaysville, Utah.

Horn, M. H., L. G. Allen, and R. N. Lea. 2006a. Biogeography. *In*: The Ecology of Marine Fishes: California and Adjacent Waters, L. G. Allen, D. J. Pondella, II, and M. H. Horn, eds. University of California Press, Los Angeles, CA. pp. 3–25.

Hsieh, C., H. J. Kim, W. Watson, E. Di Lorenzo, and G. Sugihara. 2009. Climate-driven changes in abundance and distribution of oceanic fishes in the southern California region. Global Change Biology 15:2137–2152.

Juan-Jordá, M. J., J. A. Barth, M. E. Clarke, and W. W. Wakefield. 2009. Groundfish species associations with distinct oceanographic habitats in the Northern California Current. Fish. Ocean. 18:1–19.

Levin, L. A. 2003. Oxygen minimum zone benthos: adaptation and community response to hypoxia. Oceanogr. Mar. Biol. Ann. Rev. 41:1–45.

Love, M. S., J. S. Stephens, Jr., P. A. Morris, M. M. Singer, M. Sandhu, T. C. Sciarrotta. 1986. Inshore soft substrata fishes in the Southern California Bight: an overview. Calif. Coop. Oceanic Fish. Invest. Rep. 27:84–104.

McClatchie, S., R. Goericke, R. Cosgrove, G. Auad, and R. Vetter. 2010. Oxygen in the Southern California Bight: multidecadal trends and implications for demersal fisheries. Geophys. Res. Lett. 37:L19602.

McGill, B. J., R. S. Etienne, J. S. Gray, D. Alonso, M. J. Anderson, H. K. Benecha, M. Domelas, B. J. Enquist, J. L. Green, F. He, A. H. Hurlbert, A. E. Magurran, P. A. Maurer, A. Ostling, C.U. Soykan, K. I. Ugland, and E. P. White. 2007. Species abundance distributions: moving beyond single prediction theories to integration within an ecological framework. Ecol. Lett. 10:995–1015.

McGowan, J. A., S. J. Bograd, R. J. Lynn, and A. J. Miller. 2003. The biological response to the 1977 regime shift in the California Current. Deep-Sea Res. II 50:2567–2582.

Mearns, A. J. 1979. Abundance, composition, and recruitment of nearshore fish assemblages on the southern California mainland shelf. Calif. Coop. Oceanic Fish. Invest. Rep. 20:111–119.

Miller, E. F., J. P. Williams, D. J. Pondella, II, and K. T. Herbinson. 2009. Life history, ecology, and long-term demographics of queenfish. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 4:187–199.

Perkins, E. M. 1995. An overview of hepatic neoplasms, putatively preneoplastic lesions, and associated conditions in fish sampled during the County Sanitation Districts of Orange County's 1986–1992 ocean monitoring program. Bull. South. Calif. Acad. Sci. 94:75–91.

Perry, R. I., P. Curry, K. Brander, S. Jennings, C. Möllmann, and B. Planque. 2010. Sensitivity of marine systems to climate and fishing: concepts, issues and management responses. J. Mar. Sys. 79:427–435.

Perry, A. L., P. J. Low, J. R. Ellis, J. D. Reynolds. 2005. Climate change and distribution shifts in marine fishes. Science 308:1912–1915.

Powers, S. P., C. H. Peterson, R. R. Christian, E. Sullivan, M. J. Powers, M. J. Bishop, and C. P. Buzzelli. 2005. Effects of eutrophication on bottom habitat and prey resources of demersal fishes. Mar. Eco. Prog. Ser. 302:233–243.

Schroeder, D. M. and M. S. Love. 2002. Recreational fishing and marine fish populations in California. Calif. Coop. Oceanic Fish. Invest. Rep. 43:182–190.

Shannon, C. H. and W. Weaver. 1962. The mathematical theory of communication. Urbana: University of Illinois Press. 117 pp.

Sokal, R. P. and F. J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research. 3rd ed. New York: W. H. Freeman and Co. 887 pp.

Stephens, J. S., Jr. and K. E. Zerba. 1981. Factors affecting fish diversity on a temperate reef. Env. Biol. Fish. 6:111–121.

Stevens, D. 1997. Variable density grid-based designs for continuous spatial populations. *Envirometrics* 8:167–195.

Stull, J. K. and C. Tang. 1996. Demersal fish trawls off Palos Verdes, Southern California, 1973–1993. California Calif. Coop. Oceanic Fish. Invest. Rep.37:211–240.

SYSTAT. 1998. Version 9. SPSS

Thompson, S. K. 1992. Sampling. J. Wiley and Sons. New York, NY.

Whittaker, R. H. 1952. A study of summer foliage insect communities in the Great Smokey Mountains. Eco. Mono. 22:1–44.

Whittaker, R. H. and C. W. Fairbanks. 1958. A study of plankton copepod communities in the Columbia Basin, southeaster Washington. Ecology 39:46–65.

APPENDIX A

Master species list of demersal fishes caught during 2008 Southern California Bight regional monitoring program.

Species	Common Name
Agonopsis sterletus	southern spearnose poacher
Anchoa compressa	deepbody anchovy
Anchoa delicatissima	slough anchovy
Anoplopoma fimbria	sablefish
Argyropelecus affinis	slender hatchetfish
Argyropelecus lychnus	silver hachetfish
Argyropelecus sladeni	lowcrest hatchetfish
Artedius notospilotus	bonyhead sculpin
Bathyagonus pentacanthus	bigeye poacher
Bathyraja interrupta	sandpaper skate
Careproctus melanurus	blacktail snailfish
Ceratoscopelus townsendi	dogtooth lampfish
Cheilotrema saturnum	black croaker
Chilara taylori	spotted cusk-eel
Chitonotus pugetensis	roughback sculpin
Citharichthys fragilis	Gulf sanddab
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	speckled sanddab
Citharichthys xanthostigma	longfin sanddab
Cymatogaster aggregata	shiner perch
Embiotoca jacksoni	black perch
Enophrys taurina	bull sculpin
Eopsetta jordani	petrale sole
Eptatretus deani	black hagfish
Eptatretus stoutii	Pacific hagfish
Facciolella equatorialis	dogface witch eel
Genyonemus lineatus	white croaker
Gibbonsia elegans	spotted kelpfish
Gibbonsia metzi	striped kelpfish
Glyptocephalus zachirus	rex sole
Gymnura marmorata	California butterfly ray
Heterostichus rostratus	giant kelpfish
Hexagrammos decagrammus	kelp greenling
Hippocampus ingens	Pacific seahorse
Hippoglossina stomata	bigmouth sole
Hydrolagus colliei	spotted ratfish
Hypsurus caryi	rainbow seaperch
Icelinus burchami	dusky sculpin
Icelinus cavifrons	pit-head sculpin
Icelinus oculatus	frogmouth sculpin
Icelinus quadriseriatus	yellowchin sculpin
Icelinus tenuis	spotfin sculpin
Ilypnus gilberti	cheekspot goby
Lepidogobius lepidus	bay goby
Leptocottus armatus	Pacific staghorn sculpin
Lestidiops ringens	slender barracudina
Leuroglossus stilbius	California smoothtongue
Lycodapus fierasfer	blackmouth eelpout
Lycodapus mandibularis	pallid eelpout
Lycodes cortezianus	bigfin eelpout
Lycodes diapterus	black eelpout
Lycodes pacificus	blackbelly eelpout
Lyconema barbatum	bearded eelpout
Lyopsetta exilis	slender sole
Merluccius productus	Pacific hake
Microstomus pacificus	Dover sole
Mustelus henlei	brown smoothhound
Myliobatis californica	bat ray
Nezumia stelgidolepis	California grenadier
Odontopyxis trispinosa	pygmy poacher
Ophiodon elongatus	lingcod
Oxylebius pictus	painted greenling
Paralabrax clathratus	kelp bass
Paralabrax maculatofasciatus	spotted sand bass
Paralabrax nebulifer	barred sand bass
Paralichthys californicus	California halibut
Parmaturus xaniurus	filetail cat shark
Parophrys vetulus	English sole
Peprilus simillimus	Pacific pompano
Phanerodon furcatus	white seaperch
Physiculus rastrelliger	hundred-fathom codling
Platyrhinoidis triseriata	thornback
Plectobranchus evides	bluebarred prickleback
Pleuronichthys decurrens	curlfin sole
Pleuronichthys guttulatus	diamond turbot
Pleuronichthys ritteri	spotted turbot
Pleuronichthys verticalis	hornyhead turbot
Porichthys myriaster	specklefin midshipman
Porichthys notatus	plainfin midshipman
Raja inornata	California skate
Raja rhina	longnose skate
Rathbunella hypoplecta	bluebanded ronquil
Rhacochilus toxotes	rubberlip seaperch
Rhacochilus vacca	pile perch
Rhinobatos productus	shovelnose guitarfish
Rhinogobiops nicholsii	blackeye goby
Rimicola muscarum	kelp clingfish
Roncador stearnsii	spotfin croaker
Scorpaena guttata	California scorpionfish
Scorpaenichthys marmoratus	cabezon
Sebastes atrovirens	kelp rockfish
Sebastes aurora	aurora rockfish
Sebastes caurinus	copper rockfish
Sebastes chlorostictus	greenspotted rockfish
Sebastes crameri	darkblotched rockfish
Sebastes dallii	calico rockfish
Sebastes diploproa	splitnose rockfish
Sebastes elongatus	greenstriped rockfish
Sebastes eos	pink rockfish
Sebastes goodei	chilipepper
Sebastes hopkinsi	squarespot rockfish
Sebastes jordani	shortbelly rockfish
Sebastes levis	cowcod
Sebastes melanostomus	blackgill rockfish
Sebastes miniatus	vermilion rockfish
Sebastes rosaceus	rosy rockfish
Sebastes rosenblatti	greenblotched rockfish
Sebastes rubrivinctus	flag rockfish
Sebastes rufus	bank rockfish
Sebastes saxicola	stripetail rockfish
Sebastes semicinctus	halfbanded rockfish
Sebastes simulator	pinkrose rockfish
Sebastes umbrosus	honeycomb rockfish
Sebastolobus alascanus	shortspine thornyhead
Sebastolobus altivelis	longspine thornyhead
Seriphus politus	queenfish
Squalus acanthias	spiny dogfish
Stenobrachius leucopsarus	northern lampfish
Symphurus atricaudus	California tonguefish
Syngnathus exilis	barcheek pipefish
Syngnathus leptorhynchus	bay pipefish
Synodus lucioceps	California lizardfish
Torpedo californica	Pacific electric ray
Umbrina roncador	yellowfin croaker
Urobatis halleri	round stingray
Xeneretmus latifrons	blacktip poacher
Xeneretmus leiops	smootheye poacher
Xeneretmus triacanthus	bluespotted poacher
Xenistius californiensis	salema
Xystreurys liolepis	fantail sole
Zalembius rosaceus	pink seaperch
Zaniolepis frenata	shortspine combfish
Zaniolepis latipinnis	longspine combfish

APPENDIX B-1

Area-weight adjusted mean density (count/1000 m^2), standard error, frequency of occurrence (FO) and Index of Community Importance (ICI) rank for the demersal fishes caught during trawl surveys in the bay & harbor areas (n = 22) during the 2008 Southern California Bight regional monitoring survey.

Species	Mean Density (count/1000 m^2)	Density Std. Err.	FO	ICI Rank
Genyonemus lineatus	22.67	9.94	7	1
Paralabrax nebulifer	1.85	0.75	15	2
Seriphus politus	7.22	2.54	6	3
Paralichthys californicus	0.79	0.16	15	4
Umbrina roncador	2.16	1.50	6	4
Paralabrax maculatofasciatus	0.75	0.26	10	6
Urobatis halleri	0.86	0.40	7	6
Cymatogaster aggregata	2.09	1.15	5	8
Anchoa delicatissima	1.65	1.31	5	9
Symphurus atricaudus	0.77	0.26	7	9
Porichthys myriaster	0.54	0.18	6	11
Cheilotrema saturnum	0.49	0.30	5	12
Citharichthys stigmaeus	0.84	0.39	3	13
Phanerodon furcatus	0.45	0.18	4	14
Heterostichus rostratus	0.08	0.13	4	15
Roncador stearnsii	0.34	0.12	3	16
Synodus lucioceps	0.30	0.15	3	16
Myliobatis californica	0.15	0.07	4	18
Embiotoca jacksoni	0.40	0.23	2	19
Hippocampus ingens	0.07	0.05	3	20
Pleuronichthys verticalis	0.11	0.05	3	20
Pleuronichthys ritteri	0.16	0.11	2	22
Pleuronichthys guttulatus	0.07	0.07	2	23
Raja inornata	0.11	0.06	2	23
Rhinobatos productus	0.09	0.06	2	23
Anchoa compressa	0.08	0.04	2	26
Icelinus quadriseriatus	0.13	—	1	26
Paralabrax clathratus	0.03	0.04	2	26
Rhinogobiops nicholsii	0.09	—	1	29
Ilypnus gilberti	0.09	—	1	30
Lepidogobius lepidus	0.07	—	1	30
Rhacochilus vacca	0.08	—	1	30
Gymnura marmorata	0.02	—	1	33
Xystreurys liolepis	0.04	—	1	33
Syngnathus leptorhynchus	0.04	—	1	33
Gibbonsia elegans	<0.01	—	1	33

APPENDIX B-2

Area-weight adjusted mean density (count/1000 m²), standard error, frequency of occurrence (FO) and Index of Community Importance (ICI) rank for the demersal fishes caught during trawl surveys in along the inner shelf (n = 32) during the 2008 Southern California Bight regional monitoring survey.

Species	Mean Density (count/1000 m²)	Density Std. Err.	FO	ICI Rank
Citharichthys stigmaeus	24.24	4.35	29	1
Pleuronichthys verticalis	1.58	0.34	21	2
Parophrys vetulus	1.74	0.67	14	3
Synodus lucioceps	1.08	0.36	17	4
Citharichthys sordidus	2.52	1.37	9	5
Icelinus quadriseriatus	1.86	0.86	9	6
Symphurus atricaudus	0.64	0.26	13	7
Cymatogaster aggregata	0.70	0.34	8	8
Paralichthys californicus	0.32	0.11	11	8
Chitonotus pugetensis	0.72	0.32	8	10
Pleuronichthys ritteri	0.28	0.10	10	11
Zalembius rosaceus	1.32	0.68	5	12
Xystreurys liolepis	0.22	0.07	11	13
Phanerodon furcatus	0.29	0.32	6	14
Citharichthys xanthostigma	0.21	0.09	7	15
Genyonemus lineatus	0.22	0.24	4	16
Leptocottus armatus	0.16	0.06	7	17
Odontopyxis trispinosa	0.23	0.15	5	17
Syngnathus exilis	0.12	0.06	6	19
Sebastes miniatus	0.23	0.13	3	20
Scorpaena guttata	0.06	0.02	6	21
Sebastes caurinus	0.23	0.13	3	21
Hypsurus caryi	0.17	0.09	4	23
Porichthys myriaster	0.09	0.04	5	23
Heterostichus rostratus	0.05	0.04	3	25
Hippoglossina stomata	0.06	0.04	3	25
Porichthys notatus	0.06	0.03	4	25
Pleuronichthys guttulatus	0.04	0.02	3	28
Rhacochilus toxotes	0.07	0.06	2	28
Platyrhinoidis triseriata	0.03	0.02	3	30
Sebastes atrovirens	0.04	0.03	2	31
Icelinus cavifrons	0.03	0.02	2	32
Paralabrax nebulifer	0.02	0.01	2	33
Raja inornata	0.02	0.01	2	33
Scorpaenichthys marmoratus	0.02	0.02	2	33
Sebastes dallii	0.02	0.01	2	33
Rhinobatos productus	0.05	—	1	37
Pleuronichthys decurrens	0.03	—	1	38
Artedius notospilotus	0.01	—	1	40
Zaniolepis latipinnis	0.01	—	1	40
Seriphus politus	0.01	—	1	40
Agonopsis sterletus	0.01	—	1	40
Rhinogobiops nicholsii	0.01	—	1	40
Gibbonsia metzi	0.01	—	1	40
Hexagrammos decagrammus	0.01	—	1	40
Oxylebius pictus	0.01	—	1	40
Embiotoca jacksoni	<0.01	—	1	40
Rimicola muscarum	<0.01	—	1	40
Roncador stearnsii	<0.01	—	1	40
Xenistius californiensis	<0.01	—	1	40

APPENDIX B-3

Area-weight adjusted mean density (count/1000 m^2), standard error, frequency of occurrence (FO) and Index of Community Importance (ICI) rank for the demersal fishes caught during trawl surveys along the middle shelf (n = 33) during the 2008 Southern California Bight regional monitoring survey.

Species	Mean Density (count/1000 m^2)	Density Std. Err.	FO	ICI Rank
Citharichthys sordidus	22.89	4.67	30	1
Icelinus quadriseriatus	17.68	4.45	30	2
Zalembius rosaceus	6.14	1.79	22	3
Zaniolepis latipinnis	5.37	1.70	23	3
Parophrys vetulus	5.90	3.95	21	5
Porichthys notatus	2.31	0.70	23	6
Pleuronichthys verticalis	1.34	0.30	27	7
Citharichthys xanthostigma	3.02	0.82	20	8
Symphurus atricaudus	2.02	0.56	22	9
Chitonotus pugetensis	2.96	0.84	18	10
Sebastes saxicola	2.48	0.96	16	11
Sebastes semicinctus	9.74	7.33	9	11
Microstomus pacificus	1.20	0.38	18	13
Citharichthys stigmaeus	3.00	1.34	11	14
Hippoglossina stomata	0.53	0.11	21	15
Zaniolepis frenata	0.97	0.39	12	16
Synodus lucioceps	0.51	0.19	16	17
Odontopyxis trispinosa	0.52	0.27	16	18
Sebastes dallii	0.97	0.71	8	19
Lepidogobius lepidus	0.56	0.28	7	20
Scorpaena guttata	0.21	0.07	10	21
Ophiodon elongatus	0.30	0.16	6	22
Raja inornata	0.11	0.03	11	22
Sebastes hopkinsi	0.23	0.17	4	24
Chilara taylori	0.11	0.05	7	25
Lyopsetta exilis	0.21	0.12	4	26
Xystreurys liolepis	0.12	0.06	5	26
Sebastes chlorostictus	0.18	0.14	4	28
Sebastes elongatus	0.10	0.05	5	28
Sebastes eos	0.08	0.05	4	30
Porichthys myriaster	0.06	0.03	4	31
Sebastes rosenblatti	0.06	0.03	4	31
Lycodes pacificus	0.07	0.04	3	33
Enophrys taurina	0.22	—	1	34
Sebastes miniatus	0.09	0.07	2	34
Xeneretmus latifrons	0.05	0.03	3	36
Sebastes rubrivinctus	0.06	0.05	2	37
Rathbunella hypoplecta	0.04	0.03	2	38
Genyonemus lineatus	0.03	0.02	2	39
Icelinus tenuis	0.02	0.01	2	40
Rhinogobiops nicholsii	0.02	0.01	2	40
Xeneretmus triacanthus	0.02	0.01	2	40
Cymatogaster aggregata	0.04	—	1	43
Sebastes umbrosus	0.04	—	1	44
Merluccius productus	0.01	—	1	45
Peprilus simillimus	0.01	—	1	45
Phanerodon furcatus	0.01	—	1	45
Plectobranchus evides	0.01	—	1	45
Pleuronichthys decurrens	0.01	—	1	45
Pleuronichthys ritteri	0.01	—	1	45
Sebastes jordani	0.01	—	1	45
Sebastes levis	0.01	—	1	45
Sebastes rosaceus	0.01	—	1	45
Sebastes rufus	0.01	—	1	45
Squalus acanthias	0.01	—	1	45
Torpedo californica	0.01	—	1	45

APPENDIX B-4

Area-weight adjusted mean density (count/1000 m²), standard error, frequency of occurrence (FO) and Index of Community Importance (ICI) rank for the demersal fishes caught during trawl surveys along the outer shelf (n = 23) during the 2008 Southern California Bight regional monitoring survey.

Species	Mean Density (count/1000 m²)	Density Std. Err.	FO	ICI Rank
Citharichthys sordidus	31.30	11.60	23	1
Lyopsetta exilis	26.54	5.60	23	2
Microstomus pacificus	3.71	0.57	23	3
Sebastes saxicola	10.36	2.56	20	4
Zaniolepis frenata	8.11	1.58	22	4
Lycodes pacificus	4.66	1.39	14	6
Parophrys vetulus	2.79	0.91	16	6
Xeneretmus latifrons	2.15	0.49	20	6
Porichthys notatus	2.19	0.90	14	9
Sebastes elongatus	1.00	0.30	15	10
Zalembius rosaceus	1.52	0.73	14	10
Sebastes semicinctus	2.16	0.93	12	12
Chilara taylori	0.48	0.15	12	13
Sebastes eos	0.33	0.10	12	14
Glyptocephalus zachirus	0.54	0.20	10	15
Sebastes diploproa	1.44	0.92	5	16
Zaniolepis latipinnis	0.64	0.30	6	16
Hippoglossina stomata	0.21	0.12	6	18
Sebastes rosenblatti	0.22	0.12	6	19
Merluccius productus	0.17	0.05	8	20
Sebastes chlorostictus	0.15	0.07	5	21
Pleuronichthys verticalis	0.25	0.17	4	22
Xeneretmus triacanthus	0.13	0.07	5	23
Eopsetta jordani	0.10	0.06	5	24
Hydrolagus colliei	0.09	0.04	5	24
Lycodes cortezianus	0.15	0.12	3	26
Sebastes melanostomus	0.28	—	1	27
Plectobranchus evides	0.09	0.07	3	28
Lyconema barbatum	0.04	0.03	3	29
Sebastes rubrivinctus	0.05	0.04	2	30
Citharichthys xanthostigma	0.06	—	1	31
Raja inornata	0.04	0.02	2	31
Raja rhina	0.03	0.02	2	31
Sebastes jordani	0.04	0.03	2	31
Citharichthys fragilis	0.04	—	1	36
Argyropelecus sladeni	0.01	—	1	37
Bathyraja interrupta	0.02	—	1	37
Icelinus tenuis	0.01	—	1	37
Mustelus henlei	0.02	—	1	37
Ophiodon elongatus	0.01	—	1	37
Scorpaena guttata	0.01	—	1	37
Sebastes goodei	0.01	—	1	37
Sebastes levis	0.02	—	1	37
Symphurus atricaudus	0.02	—	1	37

APPENDIX B-5

Area-weight adjusted mean density (count/1000 m^2), standard error, frequency of occurrence (FO) and Index of Community Importance (ICI) rank for the demersal fishes caught during trawl surveys along the upper slope (n = 33) during the 2008 Southern California Bight regional monitoring survey.

Species	Mean Density (count/1000 m^2)	Density Std. Err.	FO	ICI Rank
Lyopsetta exilis	16.18	4.12	30	1
Microstomus pacificus	5.01	1.48	30	2
Glyptocephalus zachirus	1.29	0.75	16	3
Sebastolobus alascanus	1.49	0.44	15	3
Sebastes diploproa	1.93	0.73	13	5
Merluccius productus	0.75	0.25	18	6
Lycodes pacificus	0.78	0.24	11	7
Xeneretmus latifrons	0.71	0.25	11	8
Lycodes cortezianus	0.50	0.13	14	9
Lyconema barbatum	1.02	0.80	8	9
Sebastes aurora	0.31	0.10	11	11
Facciolella equatorialis	0.42	0.17	9	12
Parophrys vetulus	0.34	0.13	8	13
Physiculus rastrelliger	0.61	0.35	6	14
Sebastes saxicola	0.77	0.55	5	15
Parmaturus xaniurus	0.19	0.07	8	16
Sebastes jordani	1.32	1.30	3	17
Nezumia stelgidolepis	0.21	0.10	7	18
Lycodes diapterus	0.28	0.12	7	19
Careproctus melanurus	0.12	0.04	10	20
Zaniolepis frenata	0.23	0.12	5	21
Sebastolobus altivelis	0.19	0.11	5	22
Stenobrachius leucopsarus	0.17	0.07	7	22
Lycodapus mandibularis	0.30	0.21	4	24
Bathyagonus pentacanthus	0.17	0.09	5	25
Raja rhina	0.08	0.03	6	26
Eptatretus stoutii	0.05	0.02	6	27
Sebastes melanostomus	0.12	0.09	3	28
Sebastes eos	0.06	0.03	4	29
Plectobranchus evides	0.03	0.01	4	30
Leuroglossus stilbius	0.07	0.05	2	31
Xeneretmus leiops	0.10	—	1	31
Icelinus burchami	0.06	—	1	33
Citharichthys sordidus	0.02	0.01	3	34
Porichthys notatus	0.02	0.02	2	34
Sebastes rosenblatti	0.04	0.03	2	34
Argyropelecus lychnus	0.07	—	1	37
Anoplopoma fimbria	0.02	0.01	2	38
Sebastes elongatus	0.02	—	1	39
Argyropelecus affinis	0.01	—	1	40
Chilara taylori	0.01	—	1	40
Argyropelecus sladeni	0.01	—	1	42
Ceratoscopelus townsendi	0.01	—	1	42
Eptatretus deani	0.01	—	1	42
Hydrolagus colliei	0.01	—	1	42
Icelinus oculatus	0.01	—	1	42
Lestidiops ringens	0.01	—	1	42
Lycodapus fierasfer	0.01	—	1	42
Sebastes crameri	0.01	—	1	42
Sebastes simulator	0.01	—	1	42