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 their assemblages 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 inter-agency 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 Harbor. 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). 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 identification of declining dissolved oxygen concentrations and an expanding oxygen minimum zone (OMZ) in the Eastern North Pacific basin, and its potential 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 specifically, Bograd *et al*. (2008) identified 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-Jorda *et al*. 2009), these oscillations can be exaggerated or masked by anthropogenic impacts such as harvesting

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(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 in the primary literature 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. It was the fourth such survey conducted in the area since 1994, but only the results of the most recent survey were examined. 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, for which insufficient paired data (e.g., fish abundance with concurrent oxygen measurement) currently exists at a spatial scale similar to that of the Bight surveys.

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 (Figure 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 semi-balloon otter trawl nets fitted with 1.25-cm cod-end mesh during daylight hours. Trawls were towed along open-coast isobaths for ~10 minutes (~5 minutes in bays and harbors) at 0.8-1.0 m/second. These tows were designed to cover an estimated distance of 300 and 600 m for 5- and 10-minute

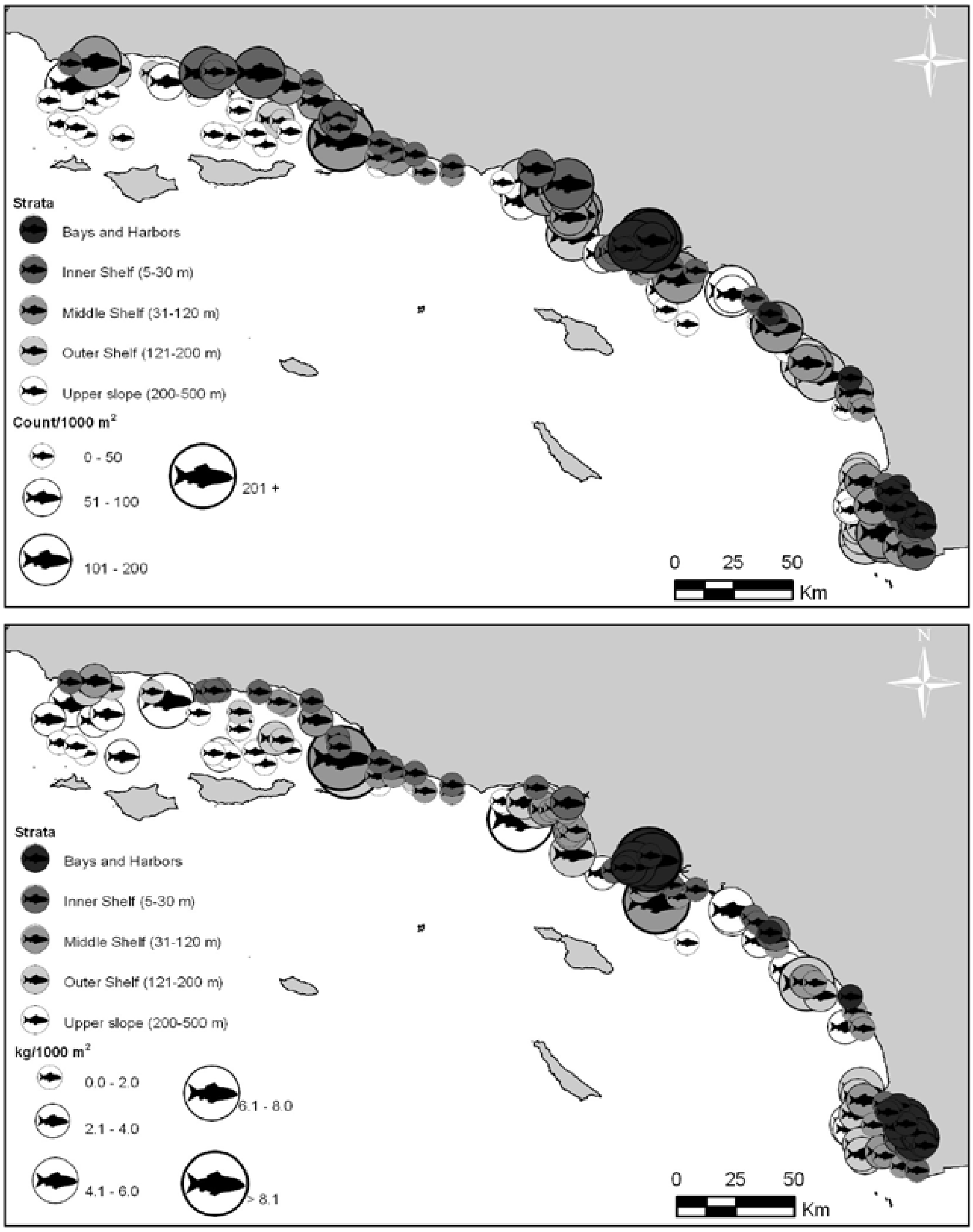


Figure 1. Demersal fish sampling stations occupied in summer 2008 distributed among the sampled shelf strata. Total sampling sites = 143. Upper panel depicts the total demersal fish abundance density (count/1000 m^2) recorded at each station per shelf strata. Lower panel depicts the total demersal fish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

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) x 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):

$$\mathbf{m} = \frac{\sum_{i=1}^{n} (\mathbf{p}_i * \mathbf{w}_i)}{\sum_{i=1}^{n} \mathbf{w}_i}, \qquad \text{Eq. 1}$$

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.

$$\textbf{Standard error (SE)} = \sqrt{\frac{\sum_{i=1}^{n} ((\mathbf{p}_i - \mathbf{m}) * \mathbf{w}_i)^2}{\left(\sum_{i=1}^{n} \mathbf{w}_i\right)^2}}, \qquad \text{Eq. 2}$$

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 * $\sum \left| A_i - B_i \right|$ where A_i and B_i are the percentages of species *i* in samples *A* and *B*, respectively. Stations were segregated into 0.2º 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 non-linear regression model. Non-metric 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 (Figure 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, in the Supplemental Information (SI), includes a master species list of all fishes caught during the 2008 sampling; Appendices B1-B5 in the SI 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 (Table 1; Figure 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; Table 1). Pockets of elevated densities (count/1000 m^2) were observed in the Santa Monica Bay, Los Angeles and Long Beach harbors, and offshore of 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. Biomass 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 area and offshore of 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 (Figure 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 (Figure 2b), resulting in a significant difference between station-specific diversity (KW, H = 37.25, df = 13, p <0.001).

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 (5-30 m)	Northern	12
	Central	13
	Southern	7
Strata Total		32
Middle Shelf (31-120 m)	Northern	9
	Central	13
	Southern	11
Strata Total		33
Outer Shelf (121-200 m)	Northern	11
	Central	3
	Southern	9
Strata Total		23
Upper Slope (200-500 m)	Northern	20
	Central	9
	Southern	4
Strata Total		33
Total Number of Stations		**143**

The SADs by block revealed community variation along a latitudinal gradient within each shelf stratum (Figure 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

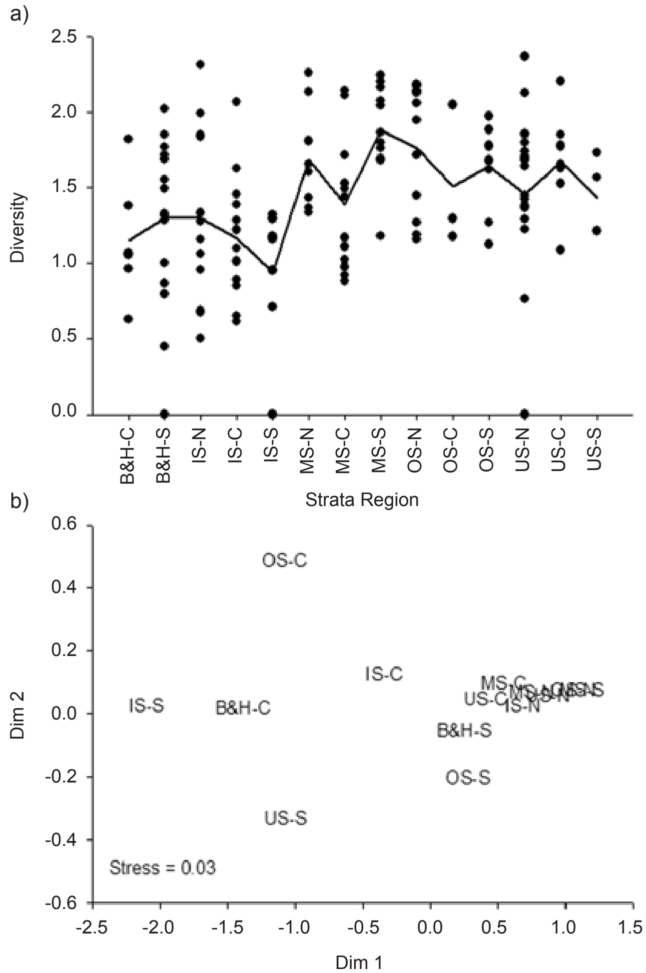


Figure 2. Shannon-Wiener species diversity index values for each station (dots) within each shelf strata-region block and the mean diversity for each shelf strata-region block (line; a). Non-metric multidimensional scaling 2D distribution of the shelf strata-region blocks based on station-specific Shannon-Wiener 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; b).

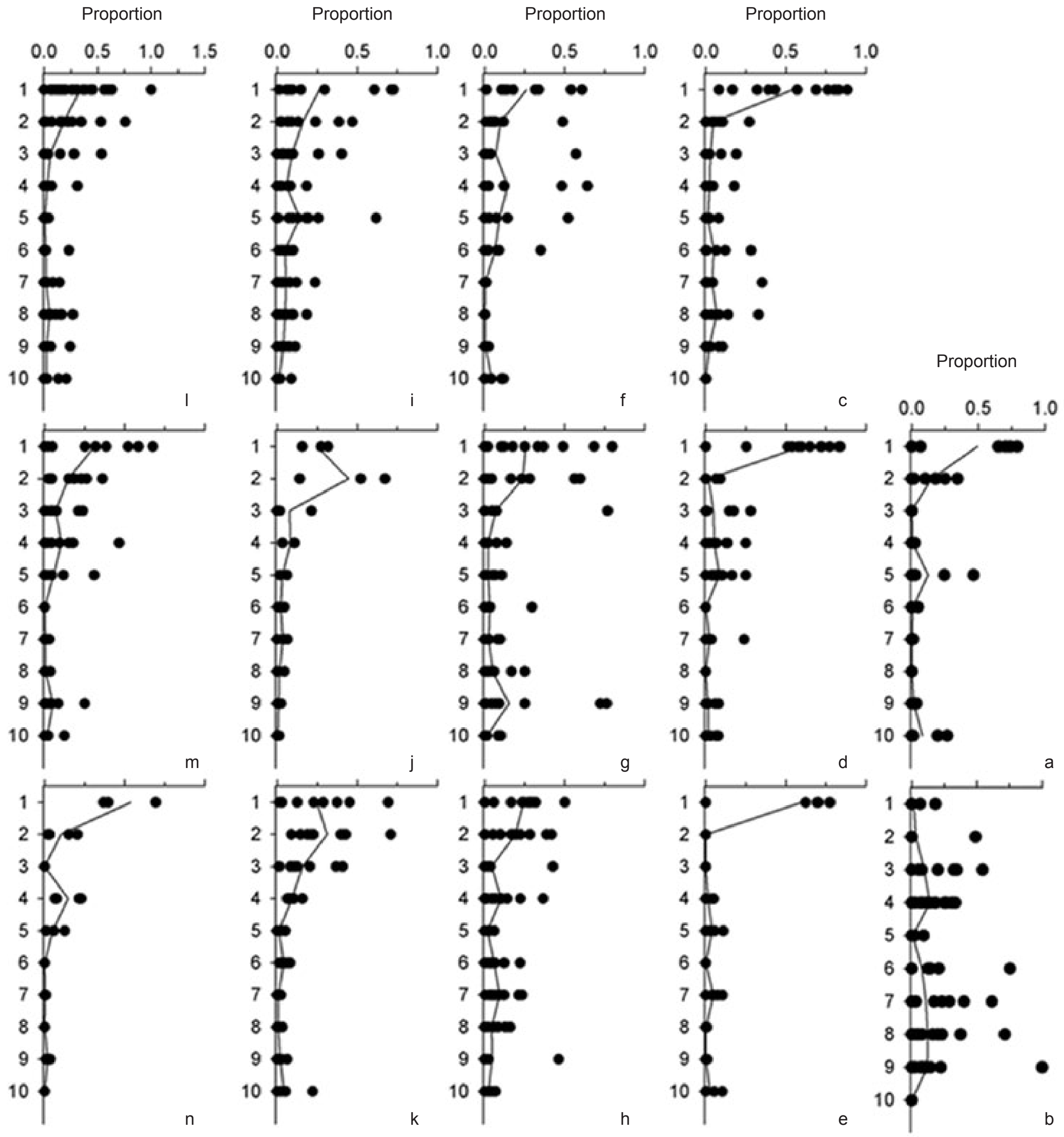
dominant form. Along the OS and US, each region significantly correlated with the next most southerly region (OS-N:OS-C, r = 0.89, p<0.01; OS-C:OS-S, r = 0.62, p = 0.05; US-N:US-C, r = 0.71, p = 0.02; US-C:US-S, r = 0.76, p < 0.001). No correlations, positive or negative, were detected between the northernmost 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 (Figure 4; Table 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 (Figure 4), ranking first in abundance and the MS and OS ICI (Appendices B-3 and B-4 in the SI). 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 in the SI). 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.

The PSI calculated across the shelf stations (IS, MS, OS) indicated limited differences along the latitudinal gradient, although a depression was observed at ~33ºN, or offshore of northern San Diego County (Figure 5a). Distance between stations did not result in a predictable pattern (Figure 5b). Stations along the north – south latitudinal gradient by shelf strata were generally overlapping in the nMDS analysis (Figure 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 (Figure 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 (Figure 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



Upper Slope
1 slender sole
2 Dover sole
3 splitnose rockfish
4 s. thornyhead
5 rex sole
6 shortbelly rockfish
7 bearded eelpout
8 blackbelly eelpout
9 Pacific hake
10 stripetail rockfish

Outer Shelf
1 Pacific sanddab
2 slender sole
3 stripetail rockfish
4 shortspine combfish
5 blackbelly eelpout
6 Dover sole
7 English sole
8 plainfin midshipman
9 blacktip poacher
10 halfbanded rockfish

Middle Shelf
1 Pacific sanddab
2 yellowchin sculpin
3 halfbanded rockfish
4 pink seaperch
5 English sole
6 longspine combfish
7 longfin sanddab
8 roughback sculpin
9 speckled sanddab
10 stripetail rockfish

Inner Shelf
1 speckled sanddab
2 Pacific sanddab
3 yellowchin sculpin
4 English sole
5 hornyhead turbot
6 pink seaperch
7 CA lizardfish
8 shiner perch
9 CA tonguefish
10 roughback sculpin

Bay & Harbor
1 white croaker
2 queenfish
3 yellowchin croaker
4 barred sand bass
5 shiner perch
6 slough anchovy
7 round stingray
8 spotted sand bass
9 CA halibut
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. Central bay & harbor (a), southern bay and harbor (b), northern inner shelf(c), central inner shelf (d), southern inner shelf (e), northern middle shelf (f), central middle shelf (g), southern middle shelf (h), northern outer shelf (i), central outer shelf (j), southern outer shelf (k), northern upper slope (l), central upper slope (m), and southern upper slope (n). See text for bounds of strata and latitudinal ranges.

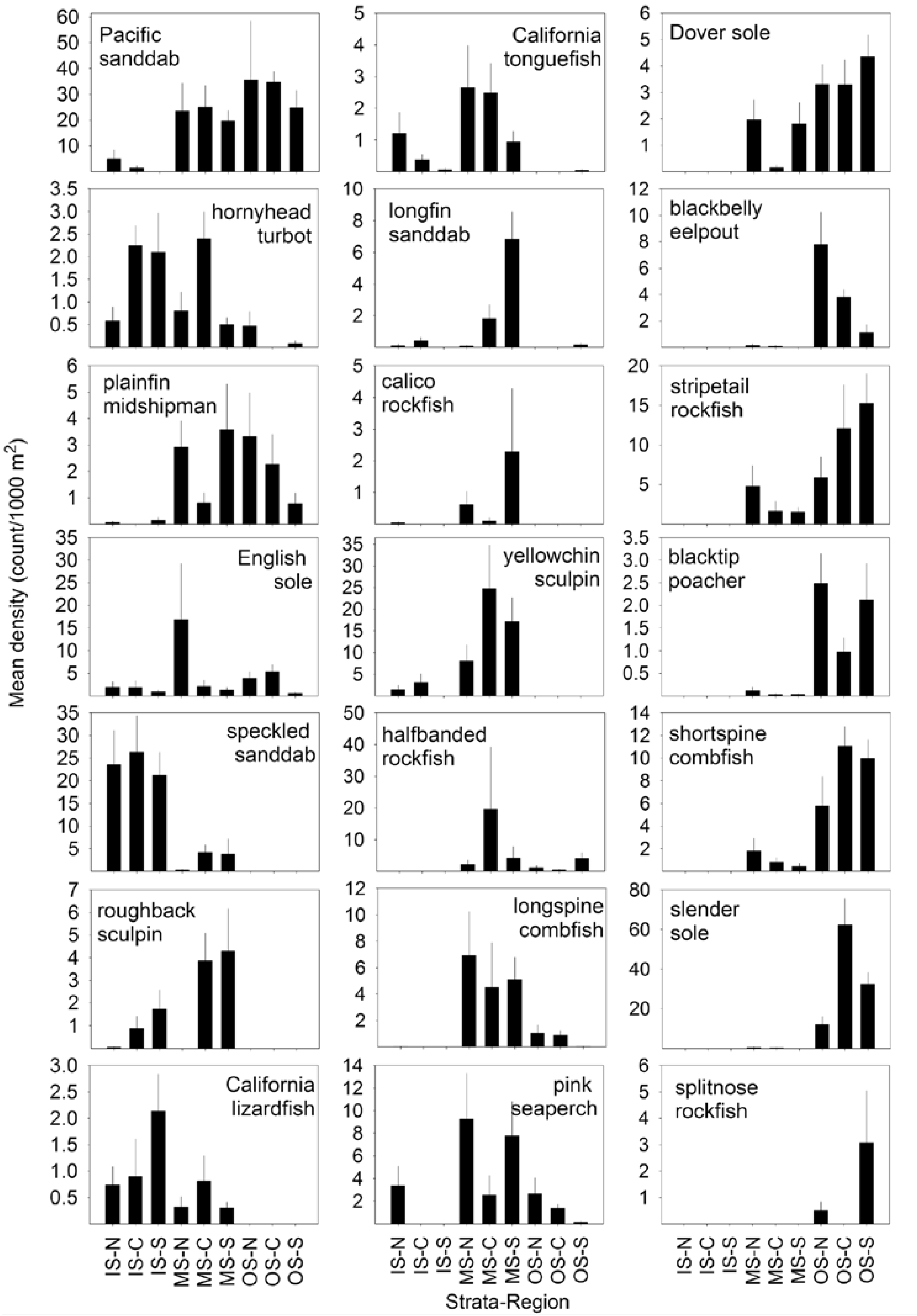


Figure 4. Area-weight adjusted mean density (fish/1000 m^2) per shelf strata-region block for the 21 most commonly occurring species in summer 2008 Southern California Bight demersal fish sampling along the inner shelf (IS), middle shelf (MS), and outer shelf (OS). Latitudinal regions are north (N),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

Table 2. Results of one-way ANOVA (ANOVA) or Kruskall-Wallis (KW) test comparing the shelf strata-region trawl caught densities (count/1000 m^2) 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
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
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

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.

Results observed during this survey were also not indicative of studies previously published in the peer-reviewed literature. For example, the Los Angeles and Long Beach harbors area was 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

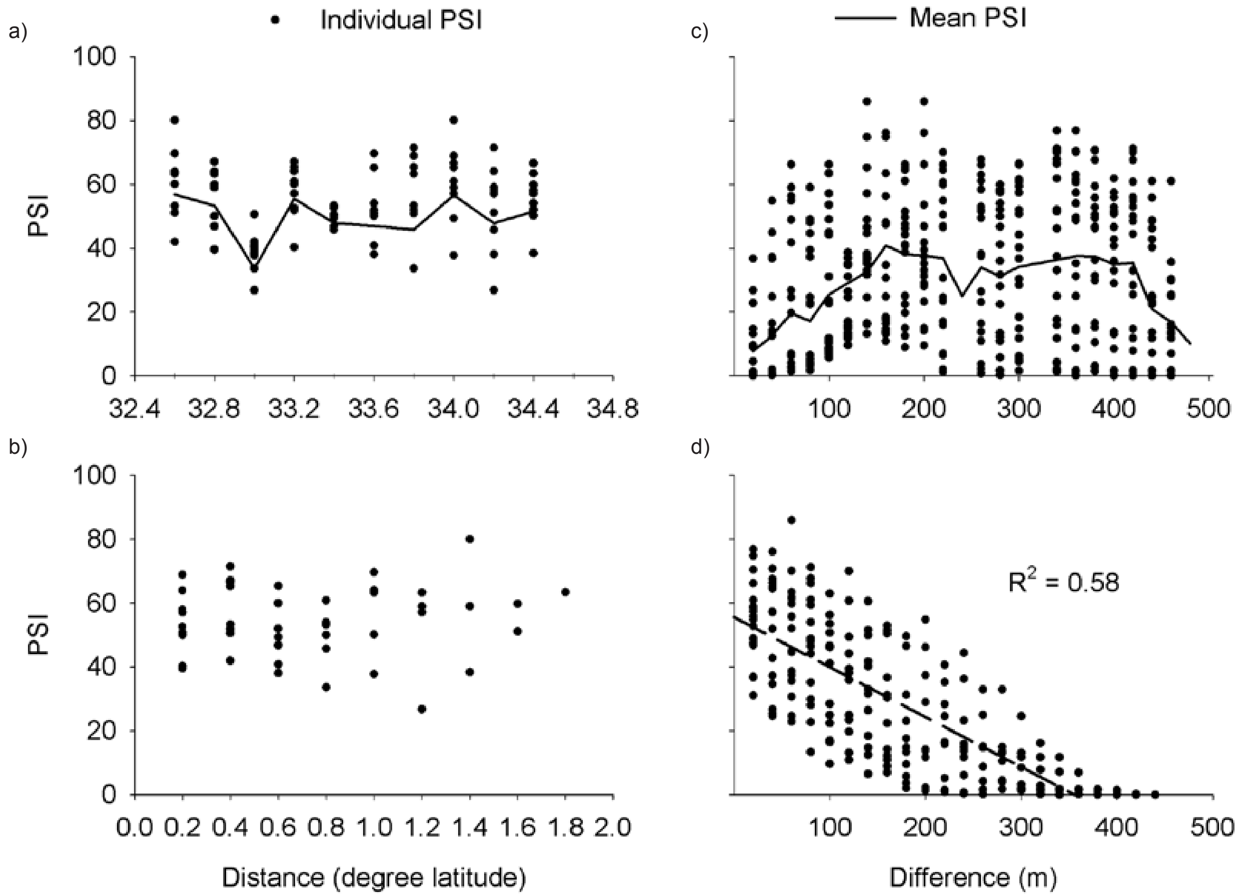


Figure 5. Percent similarity index (PSI) for the 2008 summer Southern California Bight demersal fish sampling depicting the similarity in catch composition between stations separated by 0.2° latitude bin (a), distance (degree latitude; b), 20-m depth bin (c), and difference in depth (m; d). Solid lines 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.

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). Unfortunately, no studies have examined the feeding preferences of these species over time to determine if there has been a transition in prey selection commensurate with any detectable changes in the available prey items.

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

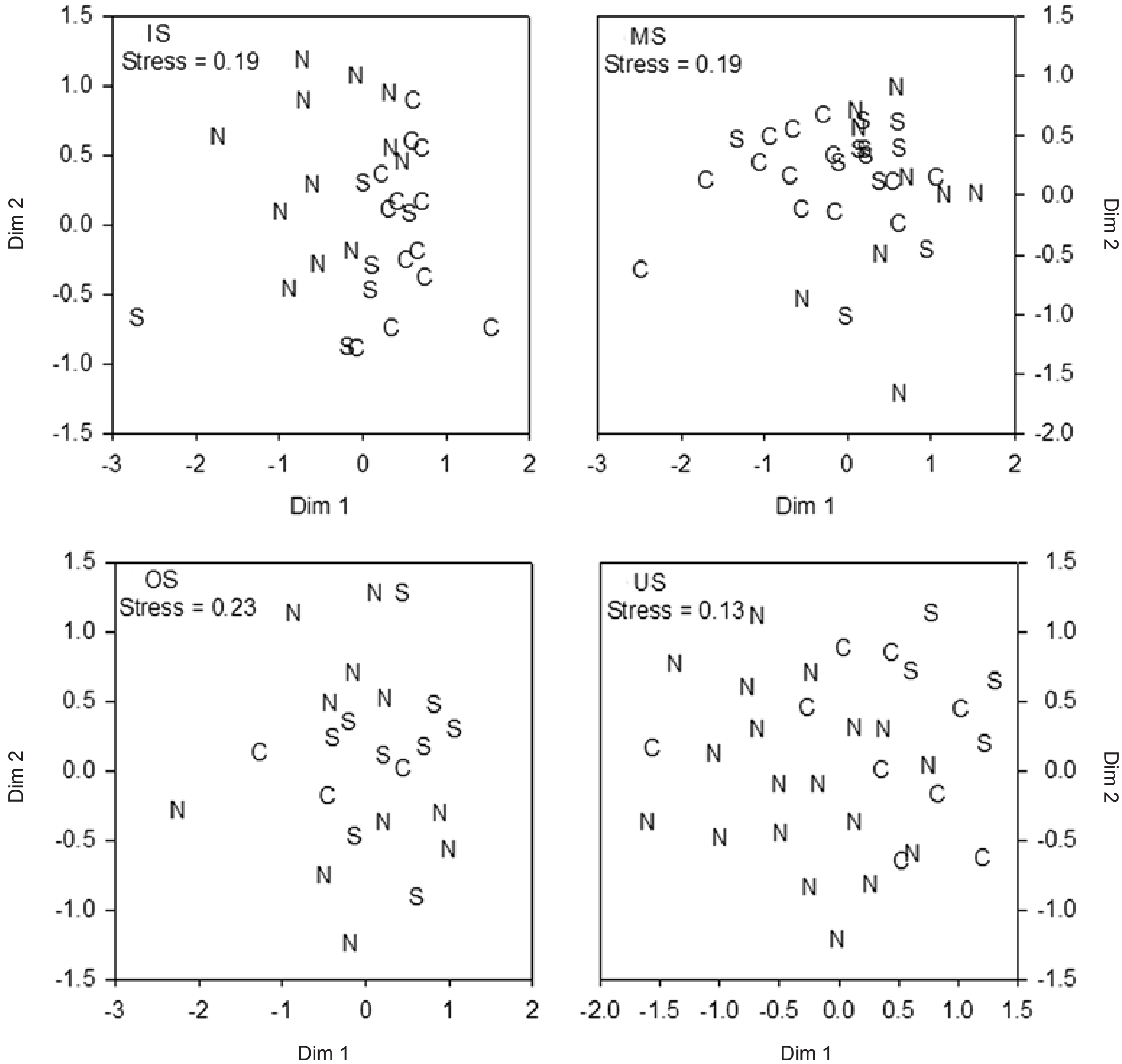


Figure 6. Non-metric multidimensional scaling 2D distribution of stations based on sampled community density at each station segregated into latitudinal group (north = N, central = C, south = S) for the inner shelf (IS), middle shelf (MS), outer shelf (OS), and upper slope (US). Letters in each plot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

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 increasingly apparent. Programs such as the Bight 2008 demersal fish study may begin to fill this void, especially if future renditions were able to pair fish sampling with concurrent dissolved oxygen concentration measurements.

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Supplemental Information

Supplemental Information avaialable at ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2011AnnualReport/ar11_SupplementalInfo_DemersalFish.pdf