Influence of Climate Patterns on Southern California Fish Communities

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ABSTRACT

During the past 35 years, changing ocean conditions in the Southern California Bight (SCB), due largely to the Pacific Decadal Oscillation (PDO) and two major El Niños, have variably affected the abundance of different fishes. Less well-known are bathymetric changes in species distribution and community organization occurring during these periods. Regional surveys of demersal fishes in the SCB during this period have provided data for assessing changes in fish abundance, bathymetric distribution, and for describing the functional organization of communities. This study describes bathymetric shifts in the functional organization of demersal fish communities on the continental shelf during a PDO cycle and an El Niño. The study is based on results of four large-scale surveys of the demersal fish fauna of the southern California shelf (10-200 m depth) conducted in 1972-1973 (cold regime), 1994 (warm regime), 1998 (El Niño), and 2003 (cold regime). The latter three studies are compared to a baseline model of the functional organization of the communities developed by the author using 1972-1973 data. The functional organization is described in terms of the occurrence of 18 foraging guilds and their dominant members across the shelf. Although the order of depth displacing species within a given guild relative to depth generally did not change, the relative portion of the shelf occupied by a guild dominant often did change, as well as a variety of pattern shifts. Changes in depth displacement patterns in these oceanic periods varied by guild. El Niño effects on these patterns included expansions or contractions of depth ranges of some guild members, retreats of some guilds to deeper water, and intrusions of new dominant guild members from the south. Changes between cold and warm regime periods were generally less pronounced but some gradual declines in the occurrence of deep-living guild members during the warm regime were apparent, suggesting decreased recruitment from the north. Patterns of several guilds were identical or nearly so in the two cold regimes, suggesting a resilient return to baseline cold-regime patterns. Examination of depth displacement patterns within foraging guilds provides a unique perspective for understanding disruptive effects and resilient responses of demersal fish communities to changing ocean conditions. Understanding how fish populations and communities change in response to natural changes in ocean conditions will contribute to ecosystem management of anthropogenic effects (due to fishing, pollution, habitat alteration) on southern California fish populations and communities.

INTRODUCTION

Changing ocean conditions during the past 35 years have affected the abundance of many fish species in the Southern California Bight (SCB). These changes are largely related to the Pacific Decadal Oscillation (PDO) and two major El Niño events. Most studies have focused on the overall abundance of a species or on its occurrence (e.g., Allen et al. 2004). Less is known about bathymetric changes in species distributions and community organization during these periods. Knowledge of these changes provides the basis for 1) distinguishing between natural and anthropogenic effects on demersal fish populations and communities, and 2) managing populations and communities in a changing oceanic environment. Regional surveys of demersal fishes in the SCB during the past 35 years have provided data for assessing changes in 1) fish abundance, 2) bathymetric distribution of species, and 3) functional organization of communities. The goal of this study is to determine bathymetric changes in functional organization in demersal fish communities on the southern California shelf during a PDO cycle and an El Niño event. Specific objectives are 1) to assess changes in bathymetric distribution of fish of fish foraging guilds across the shelf, and 2) to assess the bathymetric distribution of expected guild dominants in different foraging guilds.

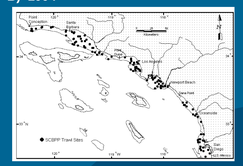
MATERIALS AND METHODS

This study is based on results of four large-scale regional trawl surveys of the demersal fish fauna on the southern California shelf (10-200 m in depth) (Figure 1).

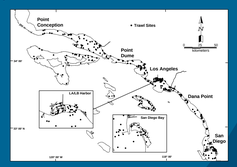
A)	1972-1973	PDO Cold Regime	342 Samples (Allen 1982)
B)	1994	PDO Warm Regime	114 Samples (Allen et al. 1998)
C)	1998	El Niño	314 Samples (Allen et al. 2002)
D)	2003	PDO Cold Regime	210 Samples (Allen et al. 2007)

A) 1972-1973

B) 1994



C) 1998



D) 2003

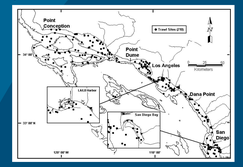


Figure 1. Maps of regional trawl surveys of the southern California shelf used in study.. All used 7.6 m head rope nets, 1.3 cm cod-end mesh, towed for 10 minutes.

MATERIALS AND METHODS (continued)

The 1994, 1998, and 2003 survey results (Figure 1) are compared to a baseline model of the functional organization of demersal fish communities on the southern California shelf using 1972-1973 trawl data (Allen 1982).

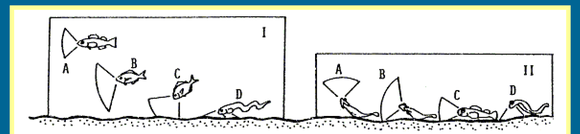
In Allen (1982), different demersal fish species that lived together in the same recurrent group foraged differently and hence played different roles in the community. Species that foraged similarly occurred in different recurrent groups at different depths.

Foraging Guild – a group of species that forage for food in a similar manner, and hence are likely to feed on similar prey if found in the same environment. For demersal fishes, the orientation of foraging with respect to the bottom (e.g., feeding in water column, feeding on bottom, or both) was the basis for defining the foraging guilds (Figure 2).

In southern California demersal fish communities, species comprising a foraging guild consist of a set of ecological counterparts, with each species performing the same role in communities at different depths but only occurring together in a small region of overlap.

Functional Structure of Community – is described in terms of the occurrence 18 foraging guilds and their dominant members across the shelf (Figures 3).consists of the number and type of foraging guilds and the dominant species of each foraging guild that occur together in an area (or depth zone) (Figure 3).The depth range where a guild occurs in 20% or more of the samples from each 20-m depth zone is shown by a box. The dominant species at a 20-m depth zone for each guild is represented by an abbreviation of the species name (with names given in footnote).

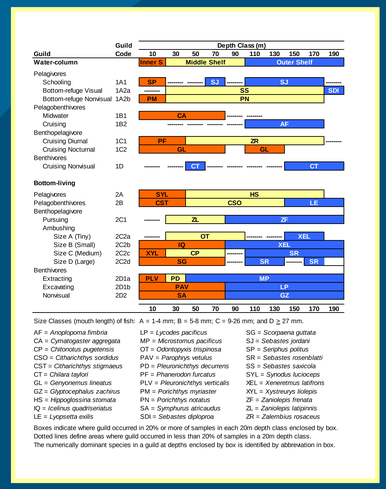
It provides an expected bathymetric occurrence for each guild and for dominant guild members (Figure 3). The expected pattern for each guild is compared with the observed pattern for each oceanic regime.



I. Water-column Fishes
- A. Pelagivores
  - 1. Schooling
  - 2. Bottom-refuge
    - a. Visual
    - b. Nonvisual
- B. Pelagobenthivores
- C. Benthopelagivores (Cruising)
  - 1. Diurnal
  - 2. Nocturnal
- D. Benthivores (Cruising Nonvisual)

II. Bottom-living Fishes
- A. Pelagivores
- B. Pelagobenthivores
- C. Benthopelagivores
  - 1. Pursuing
  - 2. Ambushing
- D. Benthivores
  - 1. Visual
    - a. Extracting
    - b. Excavating
  - 2. Nonvisual

Figure 2. Foraging guilds of soft-bottom fishes on the southern California shelf (from Allen 1982, 2006)



Size Classes (mouth length) of fish: A = 1-4 mm; B = 5-8 mm; C = 9-26 mm; and D ≥ 27 mm.

AF = *Anoplopoma fimbria*	LP = *Lycodes pacificus*	SG = *Scorpaena guttata*
CA = *Cymatogaster aggregata*	MP = *Microstomus pacificus*	SJ = *Sebastes jordani*
CP = *Chilonotus pugetensis*	OT = *Odontopsis trispinosa*	SP = *Seriphus politus*
CSO = *Citharichthys sordidus*	PAV = *Parophrys vetulus*	SR = *Sebastes rosenblatti*
CST = *Citharichthys stigmaeus*	PD = *Pleuronichthys decurrens*	SS = *Sebastes saxicola*
CT = *Chilara taylori*	PF = *Pharerodon furcatus*	SYL = *Synodus lucioceps*
GL = *Genyonemus lineatus*	PLV = *Pleuronichthys verticalis*	XEL = *Xeneretmus latifrons*
GZ = *Glyptocephalus zachirus*	PM = *Porichthys myriaster*	XYL = *Xystreurys liolepis*
HS = *Hippoglossina stomata*	PN = *Porichthys notatus*	ZF = *Zaniolepis frenata*
IQ = *Icelinus quadriseriatus*	SA = *Symphurus atricaudus*	ZL = *Zaniolepis latipinnis*
LE = *Lyopsetta exilis*	SDI = *Sebastes diploproa*	ZR = *Zalembius rosaceus*

Boxes indicate where guild occurred in 20% or more of samples in each 20m depth class enclosed by box.
Dotted lines define areas where guild occurred in less than 20% of samples in a 20m depth class.
The numerically dominant species in a guild at depths enclosed by box is identified by abbreviation in box.

Figure 3. Functional structure of the soft-bottom fish community of the southern California shelf in 1972-1973 (Allen 1982, 2006).

RESULTS AND DISCUSSION

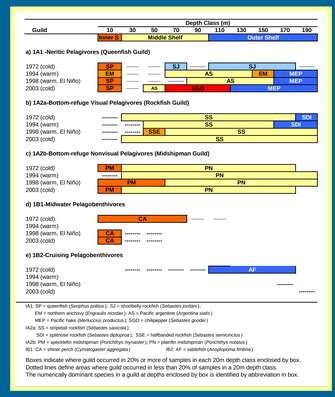


Figure 4. Comparison of changes in depths of common occurrence of foraging guilds 1A1 to 1B2 of demersal fish communities on the southern California shelf in 1972-1973,1994, 1998, and 2003 (Allen 1982; Allen et al. 1998, 2002, 2007, respectively).

Figure 5. Comparison of changes in depths of common occurrence of foraging guilds 1C1 to 2B of demersal fish communities on the southern California shelf in 1972-1973, 1994, 1998, and 2003 (Allen 1982; Allen et al. 1998, 2002, and 2007, respectively).

Figure 6. Comparison of changes in depths of common occurrence of foraging guilds 2C1 to 2C2d of demersal fish communities on the southern California shelf in 1972-1973, 1994, 1998, and 2003 (Allen 1982; Allen et al. 1998, 2002, and 2007, respectively).

RESULTS AND DISCUSSION (continued)

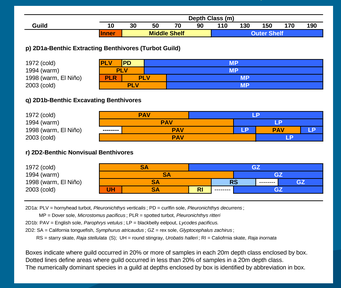


Figure 7. Comparison of changes in depths of common occurrence of foraging guilds 1D1a to 2D2 of demersal fish communities on the southern California shelf in 1972-1973, 1994, 1998, and 2003 (Allen 1982; Allen et al. 1994, 1998, 2002, and 2007, respectively).

CONCLUSIONS

- Although the order of depth replacing species within a given guild relative to depth generally did not change between the surveys, the relative portion of the shelf occupied by a numerically dominant guild members often did change, as well as a variety of pattern shifts. Changes in depth replacement patterns in these oceanic periods varied by guild.
- El Niño effects on these patterns included expansions or contractions of depth ranges of some guild members, retreats of some guilds or guild members to deeper water, and intrusions of new dominant guild members from the south.
- Changes between cold and warm regime periods were generally less pronounced but some gradual declines in the occurrence of deep-living guild members during the warm regime were apparent, suggesting decreased recruitment from the north.
- Patterns of several guilds were identical (sanddab, midshipman, combfish) in the two cold regimes (1972, 2003), suggesting a resilient return to baseline cold-regime patterns
- Examination of depth replacement patterns within foraging guilds provides a unique perspective for understanding disruptive effects and resilient responses of demersal fish communities to changing ocean conditions.
- Understanding how fish populations and communities change in bathymetric distribution in response to natural changes in ocean conditions will contribute to evaluation of anthropogenic (fishing, pollution, habitat alteration) effects on southern California fish populations and communities.

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