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Development of Biointegrity Indices for Marine Demersal Fish and Megabenthic Invertebrate Assemblages of Southern California

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Erratum

The IRI *p* table in Appendix B3 was updated by Bob Smith shortly after this report was originally submitted to EPA in February 2001. All but two *p* values were changed from the original table. The following table includes the updated *p* values for Appendix B3.

Appendix B3. Invertebrate Response Index (IRI) pollution-gradient position (p_i) for invertebrate species on the mainland shelf (9-215 m) in southern California demersal fish and invertebrate biointegrity index study.

Species	p_i
Acanthodoris brunnea	41.897
Adelogorgia phyllosclera	9.446
Allocentrotus fragilis	25.337
Amphichondrius granulatus	20.205
Amphiodia urtica	25.380
Amphiura arcystata	-1.403
Antiplanes catalinae	39.906
Aphrodita japonica	25.180
Armina californica	38.689
Asterina miniata	64.719
Astropecten armatus	65.558
Astropecten ornatissimus	9.891
Astropecten verrilli	21.793
Babelomurex oldroydi	-10.499
Balanus nubilus	-2.745
Balanus pacificus	22.083
Brisaster latifrons	21.291
Brissopsis pacifica	23.901
Calinaticina oldroydii	86.167
Calliostoma tricolor	18.349
Calliostoma turbinum	21.915
Cancellaria cooperi	12.905
Cancellaria crawfordiana	52.400
Cancer antennarius	107.888
Cancer anthonyi	112.186
Cancer gracilis	56.126
Cancer jordani	9.304
Cancer productus	99.747
Chlamys hastata	5.222
Cidarina cidaris	-23.450
Ciona intestinalis	14.529
Conus californicus	137.473
Corynactis californica	45.284
Crangon alaskensis	55.509
Crangon nigromaculata	98.804
Crepidula onyx	130.415
Crossata californica	1.701
Diaulula sandiegensis	-20.440
Doriopsilla albopunctata	9.155
Dromalia alexandri	32.699
Erileptus spinosus	23.136
Eualus herdmani	-27.145
Eugorgia rubens	20.975
Eugyra arenosa californica	29.199
Euvola diegensis	6.720
Flabellina iodinea	29.039
Florometra serratissima	-3.023
Fusinus barbarensis	-4.431
Gastropteron pacificum	70.283
Gorgonocephalus eucnemis	-14.862
Hamatoscalpellum californicum	22.859

Appendix B3 (continued)

Species	**p_i**
Havelockia benti	21.798
Hemisquilla ensigera californiensis	7.446
Henricia leviuscula	12.241
Heptacarpus stimpsoni	36.713
Heterocrypta occidentalis	32.020
Heterogorgia tortuosa	15.977
Isocheles pilosus	0.442
Kelletia kelletii	9.392
Lamellaria diegoensis	17.599
Laqueus californianus	-23.450
Leptasterias hexactis	-2.614
Leptopecten latiauratus	7.969
Leucilla nuttingi	7.870
Livoneca californica	21.939
Livoneca vulgaris	36.598
Loligo opalescens	34.043
Lophogorgia chilensis	38.388
Lopholithodes foraminatus	56.221
Lophopanopeus bellus	41.522
Lovenia cordiformis	0.198
Loxorhynchus crispatus	3.397
Loxorhynchus grandis	35.830
Luidia armata	18.775
Luidia asthenosoma	15.750
Luidia foliolata	23.993
Lysmata californica	80.265
Lytechinus pictus	9.425
Mediaster aequalis	7.108
Megasurcula carpenteriana	20.805
Metacrangon spinosissima	38.628
Metridium farcimen	28.464
Muricea californica	158.060
Nassarius insculptus	84.581
Nassarius mendicus	127.921
Nassarius perpinguis	55.109
Neocrangon communis	37.607
Neocrangon resima	41.588
Neocrangon zacae	39.872
Neosabellaria cementarium	17.969
Neosimnia aequalis	5.573
Neosimnia loebbeckeana	32.116
Neptunea tabulata	15.404
Nerocila acuminata	102.027
Neverita reclusiana	49.619
Nymphon pixellae	19.392
Octopus californicus	22.960
Octopus rubescens	25.048
Octopus veligero	26.533
Ophionereis eurybrachiplax	-19.711
Ophiopholis bakeri	6.067
Ophiopteris papillosa	12.389
Ophiothrix spiculata	17.192
Ophiura luetkenii	24.267

Appendix B3 (continued)

Species	p_i
Orthopagurus minimus	24.008
Paguristes bakeri	1.888
Paguristes turgidus	16.074
Paguristes ulreyi	12.352
Pagurus spilocarpus	29.210
Pandalus danae	54.582
Pandalus jordani	65.870
Pandalus platyceros	54.612
Paracyathus stearnsii	9.295
Paralithodes californiensis	20.572
Paralithodes rathbuni	27.465
Parapagurodes laurentae	2.422
Parapagurodes makarovi	4.478
Parastichopus californicus	27.637
Philine alba	-2.146
Phimochirus californiensis	5.881
Pisaster brevispinus	25.554
Platydoris macfarlandi	8.876
Platymera gaudichaudii	87.050
Pleurobranchaea californica	52.984
Pleuroncodes planipes	89.160
Podochela hemphillii	28.184
Podochela lobifrons	14.915
Pododesmus macrochisma	24.768
Euspira draconis	72.511
Portunus xantusii	69.876
Protula superba	-6.292
Pteropurpura macroptera	0.907
Pteropurpura vokesae	84.292
Ptilosarcus gurneyi	13.315
Pycnopodia helianthoides	26.451
Pyromaia tuberculata	27.377
Randallia ornata	39.908
Rathbunaster californicus	31.252
Renilla kollikeri	36.561
Rossia pacifica	42.972
Schmittius politus	44.048
Sclerasterias heteropaes	-7.864
Sicyonia ingentis	61.654
Spatangus californicus	13.494
Spirontocaris holmesi	83.564
Spirontocaris sica	54.512
Strongylocentrotus franciscanus	9.788
Strongylocentrotus purpuratus	27.250
Styela gibbsii	21.854
Stylasterias forreri	16.883
Stylatula elongata	39.074
Terebra pedroana	-2.356
Terebratalia occidentalis	-8.773
Triopha maculata	3.538
Tritonia diomedea	33.837
Tritonia festiva	13.770
Virgularia bromleyi	19.527
Virgularia galapagensis	24.868

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EXECUTIVE SUMMARY

During the past decade, much attention has been focused on development of biointegrity indices for assessing anthropogenic impacts to fish assemblages. However, most of this attention has been focused in the estuarine environment with relatively little effort expended on the coastal marine environment. The Southern California Bight is the perfect area for developing biocriteria for demersal fish populations in the coastal marine environment. It has one of the best defined historically contaminated areas in coastal waters on the Palos Verdes Shelf. In addition, there is a large historical trawl survey data base for the region, some of which has focused on assessing pollution effects on fish and invertebrate assemblages. These studies have identified some potential indicators of pollution effects on fish assemblages. However, although individual indicators are important in identifying anthropogenically altered habitats, a more valuable indicator of impacts to fish assemblages can be developed by combining these indicators into an index.

The goal of this study is to determine if an effective demersal fish and/or a megabenthic invertebrate biointegrity index for assessing pollution impacts can be developed for the southern California shelf. Our objectives are to evaluate two approaches to index development: 1) multivariate weighted-averaging, and 2) multimetric.

Both approaches required development of index calibration (development) and validation data bases. The calibration data base consisted of 259 trawl samples collected from 10 to 200 m on the mainland shelf of southern California from 1973 to 1994. The validation data base consisted of 190 stations at a depth of 60 m. It focused on a spatial model and a temporal model of sediment contamination along the 60-m isobath off southern California. The former was based on information from a 1977 survey and the latter on temporal changes from 1973 to 1994 at outfall and control sites for the Palos Verdes Shelf. These data bases included abundances of 122 species of fish and 333 species of invertebrates collected in trawl surveys in southern California.

The multivariate weighted-averaging approach began with an ordination analysis of the calibration species abundance data. This analysis determined a vector in ordination space that corresponded to the pollution gradient. Then all calibration observations were projected onto the pollution-effects gradient vector in the biological ordination space, rescaled, and species tolerance scores (i.e., species positions along the gradient vector) were determined. From this, the index value for an observation (station-time) is the abundance weighted-average pollution tolerance of all the species in the observation.

In the multimetric approach, candidate metrics were identified and adjusted by habitat. We compared 31 population attribute and guild metrics at impact and reference sites. The seven metrics that differed significantly between reference and impact sites were then combined into indices.

For both approaches, the resulting indices in both were evaluated based on their conformity to the spatial and historical validation models. We developed promising multivariate weighted-averaging indices for demersal fishes (at inner, middle, and outer shelf zones), megabenthic

invertebrates (entire shelf), and trawl organisms (demersal fishes and invertebrates combined; entire shelf) and a promising multimetric index for the middle shelf based on foraging guild metrics.

All multivariate weighted-averaging indices (fish, invertebrate, and trawl organism) showed relatively good correspondence to spatial and historical models of contaminant trends based on sediment chemistry and the Benthic Response Index (BRI) at 60-m on the southern California shelf. The Fish Response Index (FRI) followed the spatial and temporal trend models more closely than did the Invertebrate Response Index (IRI) and the Trawl Response Index (TRI). The multimetric Fish Foraging Guild index (FFG) showed similar spatial and temporal trend patterns as did sediment chemistry, BRI, and FRI indices.

Based on overall performance in this study, the FRI index appears to be an effective fish index, particularly in the middle shelf zone. The FFG index may have value in interpreting the ecological meaning of the FRI index response. The FFG index measures the relative importance of benthic pelagivore, benthic pelagobenthivore, and benthic extracting benthivore guilds along the pollution gradient, which in turn reflect changes in the relative abundance of polychaetes and pericarid crustaceans (mysids and gammarid amphipods) along the gradient. Although the IRI and TRI indices performed less well, they are the only attempt to produce indices for southern California using megabenthic invertebrates and fish and invertebrates combined. Their poor performance was likely due to anomalous species abundances following the 1982-1983 El Niño.

Comparison of reference thresholds among the BRI, FRI, and FFG indices suggests that demersal fish indices depart from reference where BRI values at the site indicate a loss of community function. Based on the guild shifts occurring in the FFG when this occurs (i.e., increased abundance of polychaete-feeding fishes and a decreased abundance of pericarid crustacean-feeding fishes), this suggest that the loss of community function is a shift in epibenthic community dominants from crustaceans to polychaetes.

We intend to apply these indices, and hopefully develop an inner shelf index, to data collected in 1998 throughout the shelf of the Southern California Bight (including bays and harbors, and islands). Thus this effort provides important first steps in demersal fish and megabenthic invertebrate index development for the southern California shelf.

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SECTION 1 – INTRODUCTION AND GENERAL APPROACH

Introduction

Southern California is one of the most rapidly changing coastal environments in the country. The human population in the coastal basin has increased from 11 million (SCCWRP 1973) to 17 million (CDF,DRU 1995) during the past 25 years, with urbanization of the coast increasing in proportion to this change. This has resulted in increased recreational, commercial, and industrial use of the southern California coastal ocean. As a result, it has been monitored extensively to determine impacts of these activities on populations of marine organisms. Fish are an important component of these monitoring programs because of their trophic importance in marine ecology, their sensitivity to fishing and pollution effects, and their recreational and commercial value to humans.

The soft-bottom habitat is the most extensive benthic fish habitat along the southern California coast. Demersal fishes occupying this habitat are the species most subjected to wastewater discharge from deepwater outfalls and other human activities. While demersal fish populations have been monitored extensively for pollution impacts in the Southern California Bight (SCB) for many years, they have not been used to their full potential as assessment tools. Most assessments have been limited to site-specific evaluations, comparing one site to another or following temporal trends at sites, although one regional survey of demersal fish assemblages has been analyzed (Allen *et al.* 1998) and a second is in progress.

In earlier studies, fin erosion in flatfishes (and other species) was identified as an excellent indicator of contaminated areas on the southern California shelf (Mearns and Sherwood 1977, Stull 1995, Allen *et al.* 1998). It occurred in virtually all samples in contaminated areas of the Palos Verdes Shelf (the most contaminated area of the shelf) and was virtually absent away from there. As sediment contamination levels decreased going since the 1970s, fin erosion prevalence decreased and is virtually absent now (Stull 1995, Allen *et al.* 1998).

Other than the prevalence of fin erosion, which was a good indicator of wastewater impact conditions in the 1970s, biocriteria for assessing the health of the fish assemblages have not been defined. Without biocriteria defining reference and impact conditions, it is difficult to distinguish between differences due to habitats or natural stressors, or those due to anthropogenic stressors. Because reference biocriteria have not been established for demersal fish populations in southern California, the extent of anthropogenically altered assemblages is not clearly defined. Thus there is a need to develop biocriteria for these populations so that their health and the integrity of their assemblages throughout the region can be appropriately assessed.

The United States Environmental Protection Agency (USEPA) has invested much effort in development of biocriteria for fish, but most of it has been focused in the estuarine environment. The coastal marine environment has received little attention although development of biocriteria there is a goal of the USEPA (Gibson *et al.* 2000). The SCB is the perfect area for developing biocriteria for demersal fish populations in the coastal marine environment. There is a large historical trawl survey data base for the region consisting of about 3,000 samples collected during the past 30 years on the mainland shelf (depths of 10-200 m) of the SCB from Point Conception, California, to the United States-Mexico international border. This data base includes data from sites representing different levels of impact, including reference, moderately impacted and highly impacted sites. All samples were collected using standard protocol and methods (i.e., 10 min trawls along isobaths using 7.6-m headrope otter trawls with 1.25 cm cod-end mesh. Demersal fish data from each site consists of species abundance, biomass, length frequencies, and prevalence of anomalies; megabenthic invertebrate data is the same except for lacking length frequency information. Physical (e.g., water temperature, sediment type, sediment chemistry, etc.) and benthic infaunal data also exists for much of the trawl data. This large data base provides an ideal opportunity to determine if biocriteria can be established for coastal marine fish populations. While individual indicators are important in identifying anthropogenically altered habitats, a more valuable indicator of impacts to fish assemblages can be developed by combining these indicators into an index.

The goal of this study is to determine if an effective demersal fish and/or a megabenthic invertebrate biointegrity index for assessing pollution impacts can be developed for the southern California shelf. This study focuses on index development steps in defined in a USEPA bioassessment and biocriteria guidance document (Gibson *et al.* 2000) and in a successful benthic (infaunal) response index study for the same area (Smith *et al.* 1998, in press). Our objectives are to evaluate two approaches to index development: 1) multivariate weighted-averaging, and 2) multimetric. The latter will be tested for the first time in southern California while the former was used to develop a benthic response index for assessing pollution effects on the infauna of the shelf (Smith *et al.* 1998, in press). Indices developed by these two approaches are described and evaluated to determine the most effective index or indices for southern California.

This study is organized into four sections: 1) Introduction and General Approach; 2) The Response Index Approach (A Multivariate Weighted-averaging Approach) by the second author of this report; 3) Multimetric Index Approach by the first and third authors of this report; and 4) Evaluation of Index Development Approaches. The second and third sections are treated as separate studies with authors, introduction, methods, results, and discussion sections.

General Approach

The approach that we used generally followed that of Weisberg *et al.* (1997). It included several discrete steps (Figure 1-1) that were, in general, used in both index development approaches. First, an index calibration data set of stations and species abundances was created. Candidate metrics were then identified and adjusted by habitat. After this, we determined combinations of candidate measures that discriminate between nondegraded and degraded sites. Then, indices were formed, adjusted, and validated. If appropriate, information from this process was used to readjust the index to improve its utility. The next step, not included here, would be to apply the index to survey data.

However, after the index data bases were developed, our study branched through two different approaches: 1) multivariate weighted-averaging; and 2) multimetric. In the first approach, species abundance relationships were used to determine what stations (and their characteristics) best define assemblage level effects along a pollution gradient. The index value for an observation (a station-time) was the abundance weighted- average pollution tolerance of the species in the observation. In the second approach, metrics were tested between reference and impact sites to identify candidate metrics for index development. These were then scored into impact categories, formed into indices with different combinations of metrics. The index value was the average score of the index metrics. As both methods used a common data base of information, the two approaches were evaluated at the end of the study.

Data Bases

We created two data bases, a calibration data base for index development and a validation data base for index validation. The trawl data in both data sets included abundances of fish and invertebrate species collected at each station. The two data sets included a total of 122 species of fish from 46 families and 3 classes were collected in these samples (Appendix A1). In addition, there were 333 invertebrate species, representing 168 families, 25 classes, and 12 phyla (Appendix A2).

Calibration Data Base

We created an index calibration data set based on historical trawl data set with 259 trawl samples collected from 10 to 200 m on the mainland shelf of southern California from May to September in 1973, 1977, 1985, 1990, and 1994 (Figure 1-2, Appendix A3). This period spans a time period that ensures inclusion of highly contaminated sites (from the 1970s) with less contaminated sites. Each of the trawl stations had sediment chemistry data from grab samples collected at approximately the same time as the trawl sample collection. The presence or absence of fin erosion or tumors in any fish was also reported for each trawl station. Fin erosion in particular was a known indicator of contaminated conditions (Mearns and Sherwood 1977).

Stations were then divided into three categories (reference, intermediate, and impact) based on sediment chemistry criteria (Table 1-1). These criteria included sediment concentrations of selected contaminants relative to the environmental response low (ERL) level (i.e., 10th percentile) and environmental response median (ERM) level (i.e., 50th percentile) of each (Long *et al.* 1995). Levels of a contaminant below the ERL, between the ERL and ERM, and above the ERM are rarely, occasionally, and frequently, respectively, associated with adverse effects. Impacted sites had six of eight selected contaminants (Cu, Pb, Ni, Zn, Cd, Cr, PCB, and DDT) above the ERM for each contaminant in Southern California Bight Pilot Project (SCBPP) data of 1994 or all six metals above the ERM in historical data (Table 1-2). Reference sites consisted of stations lying outside the POTW monitoring areas defined for the SCBPP survey and with no more than one selected contaminant above the ERL for a contaminant. Intermediate stations were inside or outside of the POTW areas, had more than one contaminant above the ERL, and no contaminant above the ERM.

For habitats, we used the Entire Shelf (9-215 m) as well as three ecologically important depth zones on the shelf for analysis: Inner Shelf (9-40 m), Middle Shelf (30-120 m), and Outer Shelf (100-215 m). These depth zones were shown to be important habitats in a previous regional survey of the southern California shelf (Allen *et al.* 1998). The Entire Shelf (9-215 m) also used as a habitat. The depth zones overlapped somewhat to allow for standardization of depth-related indices across depth zones. It should be noted that reference and intermediate sites (based on the chemical criteria used above) were found in all depth zones. However, chemically defined impact sites were found only in the middle shelf and outer shelf zones; impact sites were missing in the Inner Shelf zone.

Validation Data Base

The index validation data set was more limited. In all there were 192 validation stations; of these 24 represented impact conditions and 105 represented reference conditions (Appendix A4). This data set focused on two station degradation models at 60-m that had chemistry data and known impact and reference areas.

The first model, the spatial model, was based on a survey conducted along the 60-m isobath of the mainland shelf of southern California from Point Conception to the U. S.-Mexico International Border in 1977 (Word *et al.* 1977, Word and Mearns 1979) (Figure 1-3). The 60-m isobath was the isobath along which the four major POTWs discharged wastewater at that time. Along this isobath, sediment chemistry categories (using the impact in Santa Monica Bay, San Pedro Bay, and off San Diego (Figure 1-4). All four of these were areas of wastewater discharge from the major POTWs. Much of the remaining above criteria for impact, intermediate, and reference), showed a well-defined impact area on the Palos Verdes Shelf in the central part of the mainland shelf, intermediate area was classified as reference. Validation stations matched the pattern of adjacent calibration stations. The BRI index pattern was similar to that of the sediment chemistry.

The second model, the temporal model, describes historical trends at three 60-m sites (Figure 1-5). The first was a site (trawl station T4-61 and grab station 6C) on the Palos Verdes Shelf with samples extending from 1973 to 1994. This site was classed as impact in the 1970s but it improved to intermediate by 1985 and thought the 1990s. The second site (trawl station T0-61 and grab station 0C) on the Palos Verdes Shelf had samples from 1980 to 1994. This site was classed as intermediate in the 1980s and as reference in the 1990s. A third site (trawl station T5, becoming T11, and grab station 'control') on the San Pedro Bay shelf with samples from 1973 to 1994. This site was classified as reference throughout this period. As with the spatial model, validation stations matched the pattern of adjacent calibration stations and the BRI index pattern was similar to that of the sediment chemistry.

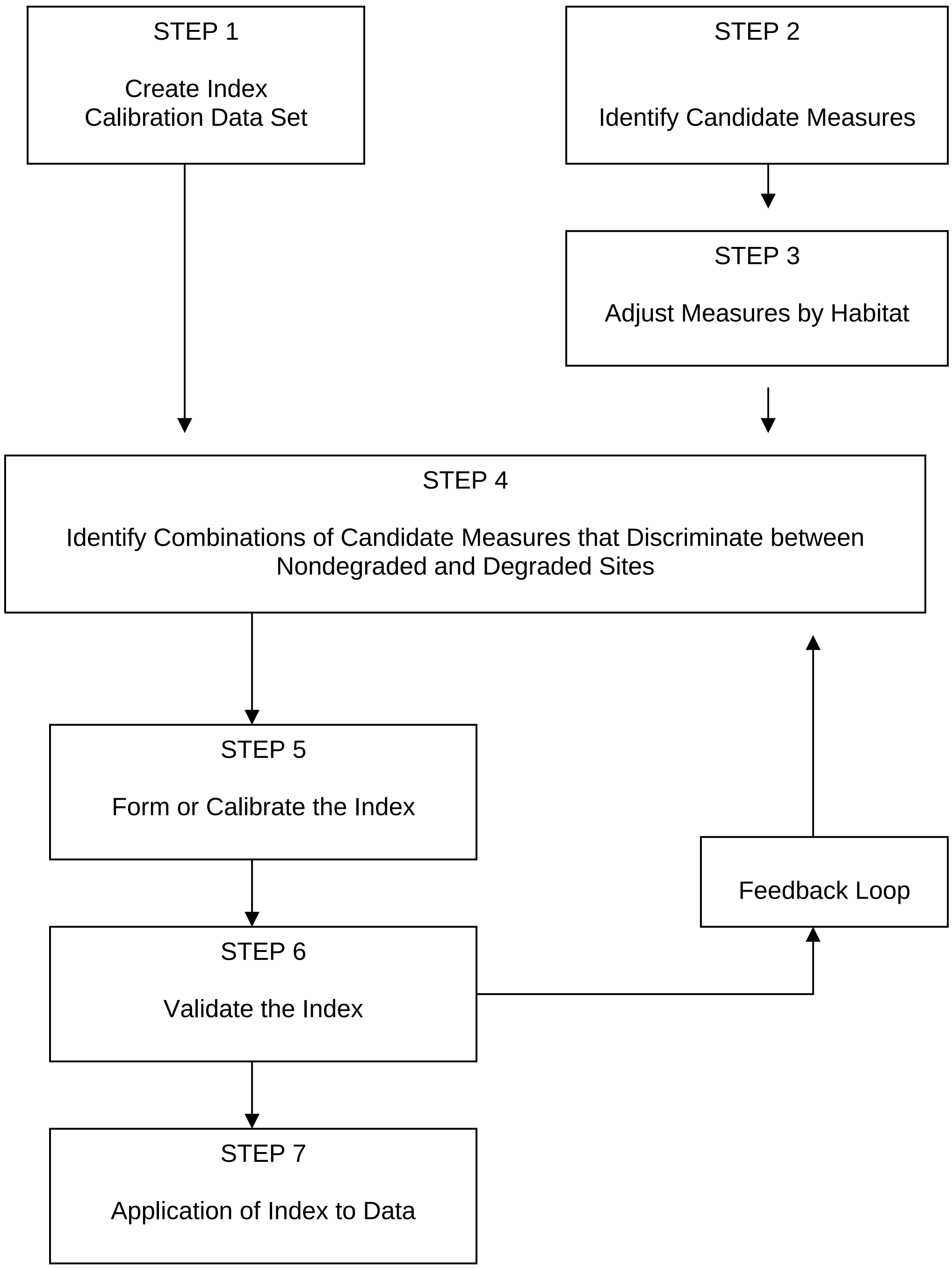


Figure 1-1. General steps used to develop a biointegrity indices for demersal fishes and/or invertebrates on the mainland shelf of southern California.

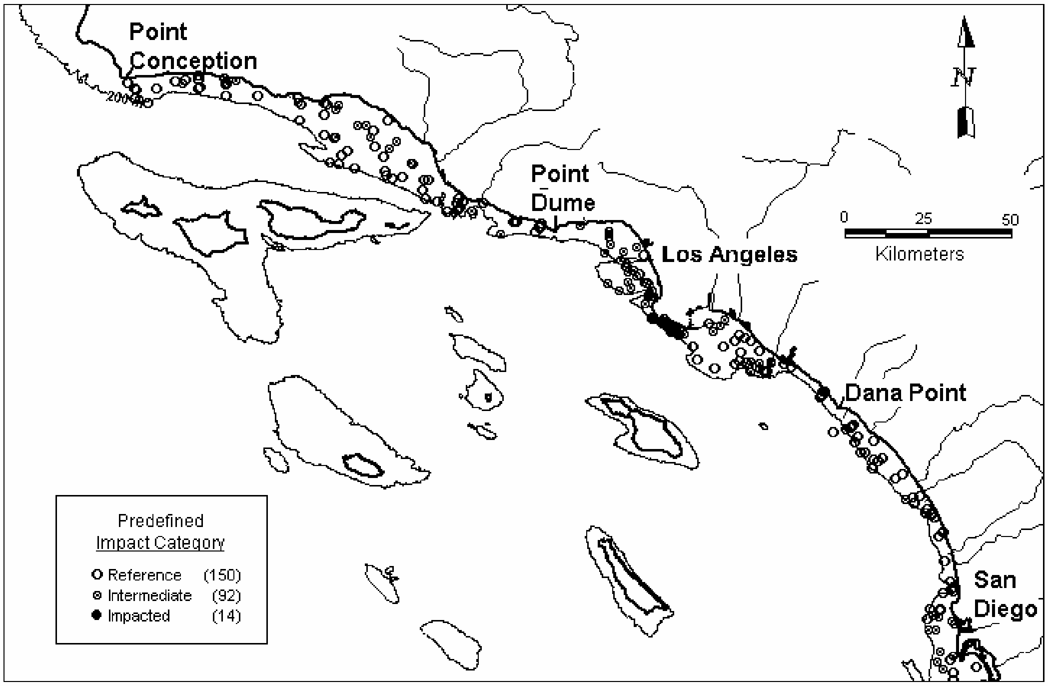


Figure 1-2. Location of trawl stations sampled from 1973 to 1994 on the mainland shelf of southern California at depths of 10-200 m in calibration data base for demersal fish and/or invertebrate biointegrity indices.

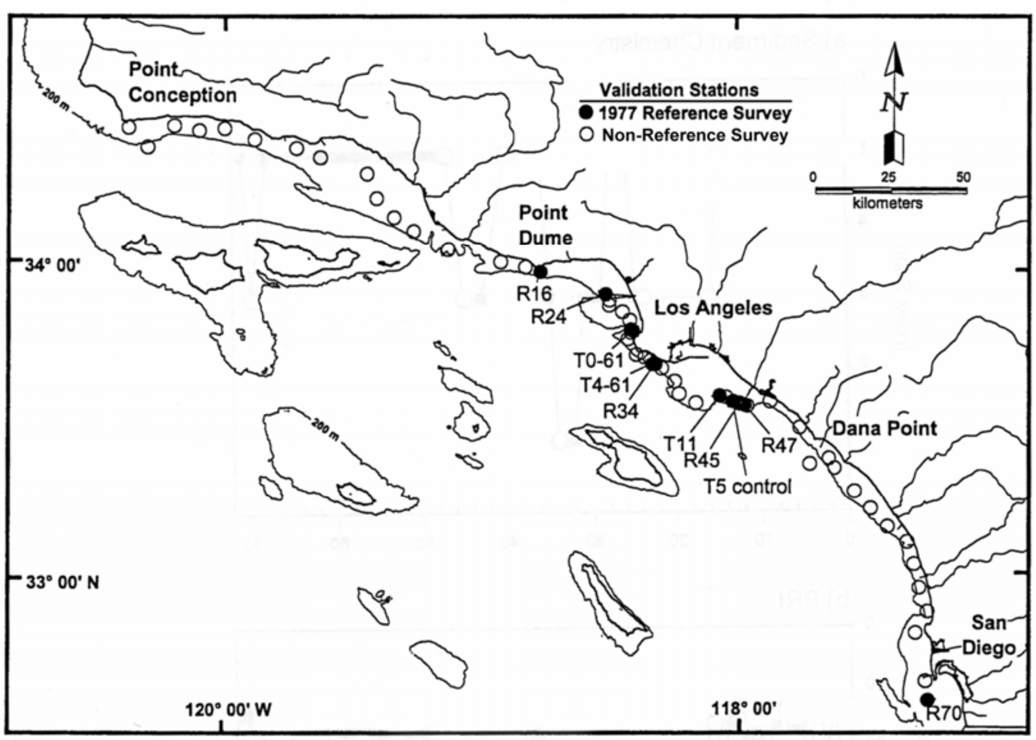


Figure 1-3. Location of trawl stations sampled from 1973 to 1994 on the mainland shelf of southern California at depths of 60 m in validation data set for demersal fish and/or invertebrate biointegrity index study.

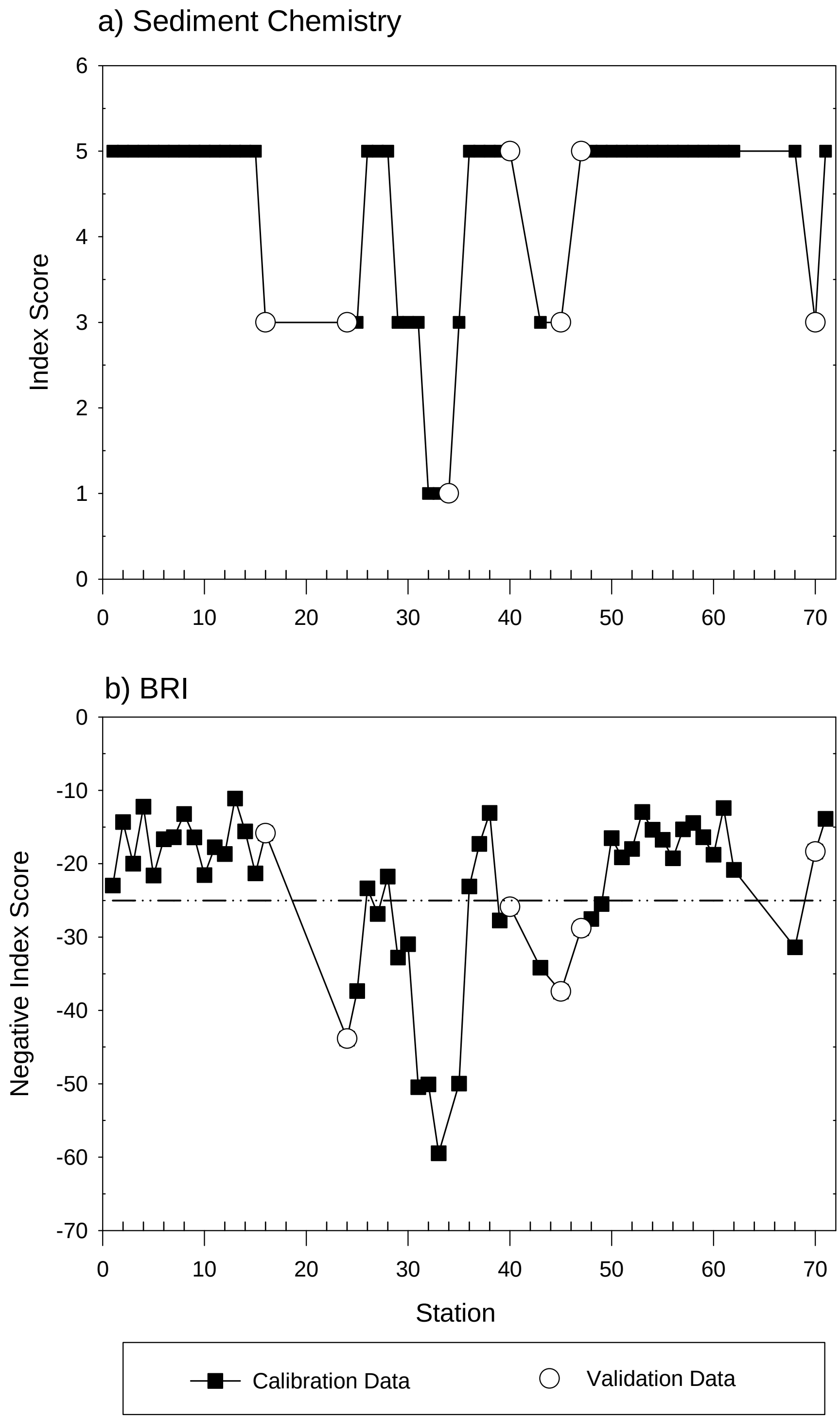


Figure 1-4. Spatial distribution of station degradation along the 60-m isobath of southern California in 1977 based on a) sediment chemistry and b) benthic response index (BRI) (Smith 1998, in press). Horizontal line is BRI reference threshold.

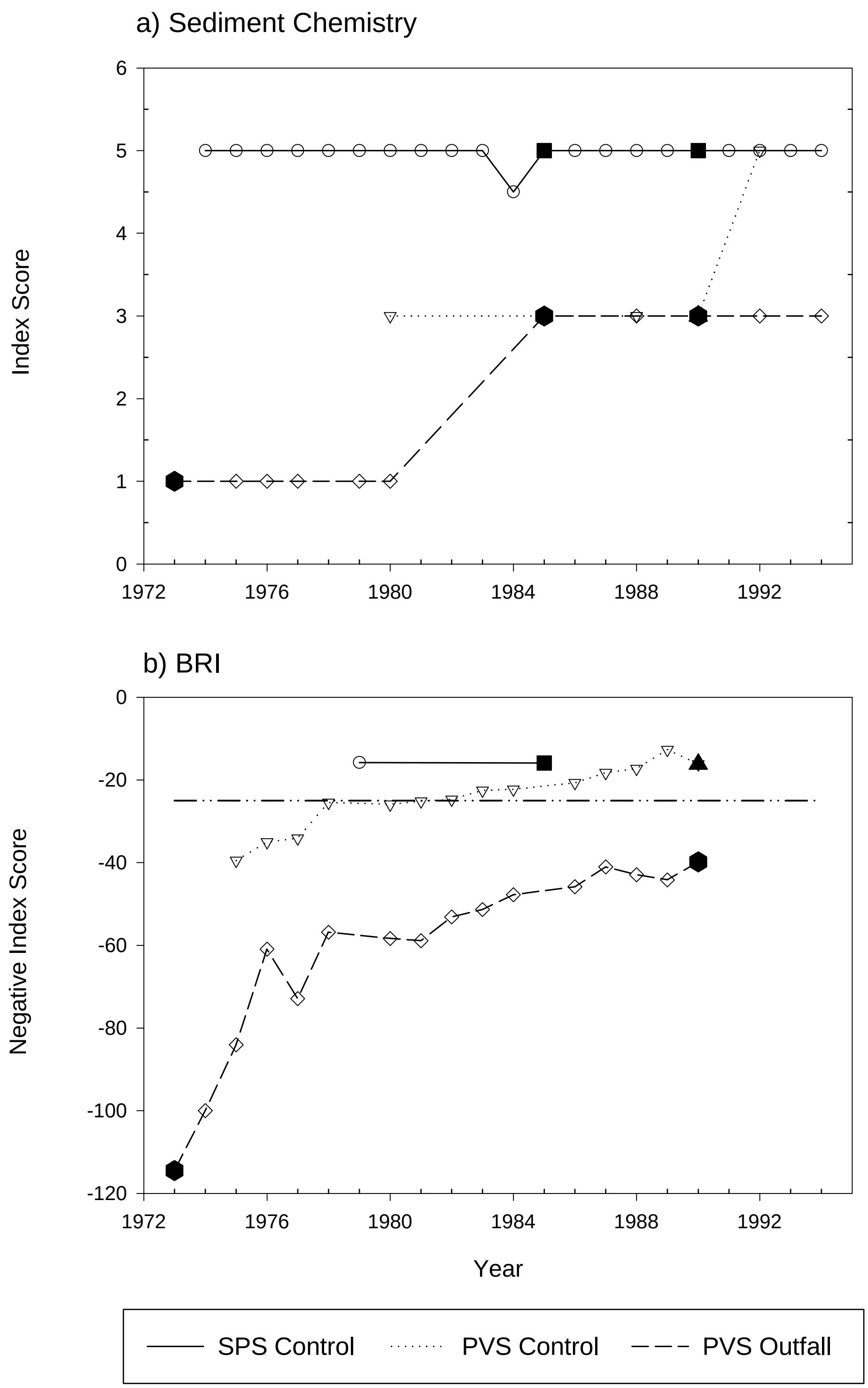


Figure 1-5. Temporal distribution of station degradation at 60-m isobath on the Palos Verdes Shelf (PVS) (outfall and control sites) and San Pedro Shelf (SPS) (control site) from 1973 to 1994 based on a) sediment chemistry and b) benthic response index (BRI) (Smith 1998, in press). The filled symbols represent calibration data and the open symbols represent validation data. Horizontal line is BRI reference threshold. Validation symbols on BRI graph represent validation sites rather than samples.

Table 1-1. Sediment quality guidelines for trace metals and chlorinated hydrocarbons used for classifying calibration data set sites for southern California demersal fish biointegrity index study.

	Contaminant	Guideline[1] ERL	Guideline[1] ERM
a) Trace Metals (ppm, dry wt)			
	Cadmium	1.2	9.6
	Chromium-T	81.0	370.0
	Copper	34.0	270.0
	Lead	46.7	218.0
	Nickel	20.9	51.6
	Zinc	150.0	410.0
b) Chlorinated Hydrocarbons (ppb, dry wt)			
	DDT - Total	1.6	46.1
	PCB - Total	22.7	180.0

[1]Based on Long *et al.* (1995)

ER-L = Effects range low (i.e., lower 10th percentile).

ER-M = Effects range median (i.e., 50th percentile).

SECTION 2 – THE RESPONSE INDEX APPROACH: A MULTIVARIATE WEIGHTED-AVERAGING APPROACH (ROBERT W. SMITH)

Introduction

Abundance weighted-average tolerance scores of species found in a sample has been successfully used as a pollution indicator in the biotic indices of Hilsenhoff (1977) and Lenat (1993), the Infaunal Trophic Index (ITI) of Word (1978, 1980a, 1980b, 1990), and the Benthic Response Index (BRI) of Smith *et al.* (1998, in press). The species' tolerance scores for the biotic indices were obtained from "expert opinions" of ecologists. The tolerance scores for the ITI were based on knowledge of the feeding types and their relationships to pollution gradients. The BRI tolerance scores were empirically derived from a calibration dataset where samples were objectively given a position on a pollution gradient, and then, given the observed distributions of the species along this gradient, pollution tolerance scores were computed for each species.

Here we apply the BRI approach of Smith *et al.* (1998, in press) to trawl data taken from the same station/surveys used to derive the BRI index. Three separate indices were developed: a Fish Response Index (FRI); an Invertebrate Response Index (IRI); and a fish plus invertebrate or Trawl Response Index (TRI).

Methods

Index Data Sets

First, index calibration and index validation data sets were created that included stations (see Section 1, Figure 1-2, 1-3; Appendices A3, A4) and species abundances for fishes and invertebrates (Appendices A1, A2).

General Index Formula

The index value for an observation (a station-time) is the abundance weighted- average pollution tolerance of the species in the observation. The general formula for the index weighted average is

$$I_s = \frac{\sum_{i=1}^{n} a_{si}^{f} p_i}{\sum_{i=1}^{n} a_{si}^{f}}, \qquad (1)$$

where I_s is the index value for observation s, n is the number of species in the observation s, p_i is the position for species i on the pollution gradient (an indicator of the pollution tolerance of the species), and a_{si} is the abundance of species i in observation s. The exponent f allows for transformation the abundance weights to prevent overemphasis on extreme abundances. Equation (1) is discussed further in Appendix B1.

The index development process involves using a calibration dataset of trawl data to compute the p_i values for the species, and to find optimal value for the f parameter in equation (1). The method is briefly summarized below. Steps 1-4 involve defining the gradient of community changes that correspond to pollution. Once the gradient is quantified for each observation, the p_i and f values can be computed (Step 5).

Step 1. Ordination analysis of the calibration species abundance data.

The ordination analysis produces a multidimensional space. The observations (station-times) in the calibration data are represented by points in this space. The distances between pairs of points are proportional to the dissimilarity of the communities found in the corresponding pairs of observations. Different gradients of community change are represented by vectors projected into different directions in the space. Often gradients of species change are caused by gradients in the environment. For example, species distributions often correspond to gradients in water depth. Thus, it would not be surprising to find a community gradient vector in the ordination space that would be highly correlated with the water depths of the observations.

Step 2. Find the vector in the ordination space corresponding to the pollution gradient.

The calibration observations were chosen to include data spanning a fairly strong environmental gradient of pollution. If the pollution caused changes in the fish (and invertebrate) communities, then there should be a vector in the ordination space that correlates with the pollution gradient.

In the development of the BRI, the infaunal species pollution gradient in the ordination space was found by a) choosing a group of observations known to be toward the polluted end of the pollution gradient; b) choosing a group of observations known to be toward the clean or unpolluted end of the pollution gradient; c) compute the average positions of the two groups of observations; and d) connect the two average positions by a line. This line will be the vector representing the fish gradient caused by the pollution gradient.

Since benthic infaunal data were sampled at all the station-times present in the fish calibration dataset, it was possible to compute BRI index values for all station-times. Given these BRI values, we have pollution gradient information on all observations, not just information on groups of observations toward the extremes of the pollution gradient. In addition, other data correlated with pollution effects were available for the observations. Included here were ERMQ, PELQ, and presence/absence data on fish fin erosion (FINEROS) and fish tumors (TUMOR).

Since pollution-effects data were available for all calibration observations, a different technique (than used for BRI) was used to find the fish pollution gradient in the ordination space. Canonical correlation analysis (Cooley and Lohnes 1971) is a multivariate technique that produces optimally correlated pairs of vectors from two separate multidimensional spaces. For the present application, one multidimensional space was built from the pollution-effects data (with BRI, ERMQ, and PELQ as dimensions of the space), and the other multidimensional space was the biological (fish and/or invertebrates) ordination space. Given that all the variables making up the pollution-effects space are indicators of pollution, the canonical correlation analysis will produce a vector in the biological ordination space that optimally correlates with the pollution gradient.

Step 3. Project all calibration observations onto the pollution-effects gradient vector in the biological ordination space.

The canonical correlation analysis produces these projections, which are called scores. *These projections will be numerical values corresponding to the position of each observation on the pollution gradient*. Note that the projections are from the ordination space, thus the gradient is based on changes in the biological communities. These changes correlate with pollution-effects data, but are still measures of biological community change.

Step 4. Rescale the projections.

For simplicity and consistency in the following steps, the projections were scaled from 0 to 100, with the "cleanest" observation represented by 0, and the "most-polluted" observation represented by 100.

Step 5. Compute species tolerance scores (p_i) as species positions along the gradient vector.

The species positions are the p_i values used in Equation (1). The projections computed in step 4 give each calibration observation a position on the pollution gradient defined by the species. The p_i (species tolerance scores) and f parameters (Equation 1) are computed simultaneously as part of an optimization procedure described in Appendix B1.

Index Development by Depth Zones

Preliminary analyses showed that the invertebrate (IRI) and fish plus invertebrate (TRI) indices could be produced from ordination spaces including all depths. However, for the fish index, it was not feasible to produce a single index that would apply to the entire depth range of the calibration dataset (9-215 m). This was because the directions of the pollution vectors in the ordination space were not parallel for observations from different depth zones. Thus, the data for the fish index (FRI) were divided into three subsets by depth zone and a separate index was developed for each depth zone. The depth zones used were Inner Shelf (9-40 m), Middle Shelf (30-120 m), and Outer Shelf (100-215 m).

The depth zones were made to overlap somewhat to allow for standardization of the indices across depth zones. Also, having overlapping depth zones allows for a more gradual transition in fish index values between the depth zones. This is accomplished by computing two index values for stations in the overlapping part of two depth zones (an index value for each zone). The final index value will be the average of the two index values.

Rescaling Index Values

Two types of rescaling were applied to original index values. First, where necessary, the index values were rescaled to standardize index values across the depth zones. Secondly, the index values were rescaled so that the calibration index values ranged between 0 and 100.

A regression method was initially used to standardize the index values among the different depth zones (as in Smith *et al.* 1998, in press). The resulting standardization did not work well for the deep depth zone. This was apparently due to the fact that there was only a narrow range of index values in the overlapping parts of the depth zones. Therefore, the fish index values for the three depth zones were standardized (with regression) to correspond to the index values for the TRI in the respective depth zones. This could be done since the TRI index was derived from a single ordination space, and the TRI values will be comparable across all depths. After the standardization across depth zones, similar index values from different depth zones should indicate similar levels of pollution.

The general form of the regression equation used for standardization is

$$TRI_d = a_d + b_d (FRI_d) , \qquad (2)$$

where the intercept a_d and slope b_d are computed from the (original) FRI and TRI values in a single depth zone (d). The regression equation is then used to rescale all the FRI values by computing TRI_d predictions from the original FRI_d values. The resulting TRI_d predictions are the rescaled FRI values, which will be a linear transformation of the original FRI_d values to reflect the scale of the TRI_d values.

After any standardization by depth zone, we rescaled the index values so that the final calibration index values would be scaled from 0 to 100, with the most polluted sampling unit having a scale value of 100. The formula for this rescaling is

$$R_s = 100 \frac{I_s - I_{\min}}{I_{\max} - I_{\min}} , \qquad (3)$$

where R_s is the rescaled index value for observation s, I_s is the unscaled index value for observation s, I_{max} is the maximum unscaled index value in the calibration dataset, and I_{min} is the minimum unscaled index value in the calibration dataset.

Rather than applying the rescaling and depth standardizations and rescaling to the computed index values, rescalings, and standardizations were accomplished by scaling the p_i values appropriately. Rescaling the p_i values simplifies the computations since the final index values are then obtained directly from the Index equation without any further rescaling computations.

To rescale the FRI p_i values to reflect the depth standardization, the formula

$$p_{i,rescaled} = a_d + b_d\, p_{i,original} \qquad (4)$$

was used. Here a_d and b_d were the regression parameters computed in equation (2).

To rescale the index values so that the calibration index values range from 0-100, the formula

$$p_{i,rescaled} = 100 \frac{p_{i,original} - I_{\min}}{I_{\max} - I_{\min}} \qquad (5)$$

was used, where the symbols are the same as in equation (3). For the FRI index, the $p_{i,original}$ values will be the depth standardized $p_{i,rescaled}$ values computed with equation (4).

Index Threshold for Reference Conditions

In Smith *et al.* (in press), a threshold index value distinguishing reference conditions from more polluted conditions was computed as a 90% tolerance interval of all index values from stations found in relatively uncontaminated reference areas. We do the same here. Since there is both spatial and temporal variation in the index values, the computational method described in Smith (in press) is used to compute the upper 90% tolerance interval bound for reference observations. Reference observations in this study are defined as observations with BRI values less than 25, which was the BRI reference threshold value.

Results

Index Development

Optimization

The optimum *e, t,* and *f* values for the different indices and depth ranges are summarized in Table 2-1. The relatively high correlations show that by using these parameter values, the weighted averages from Equation (1 and x1) accurately reproduce the pollution gradients extracted from the ordination spaces. The values for the *f* parameter in Table 2-1 provide the index formulae shown in Table 2-2.

For the FRI, the rescaled and standardized p_i values for the species in the different depth zones are shown in Appendix B2 and, the respective p_i values for the TRI and IRI are found in Appendices B3 and B4.

Index Values

Using formulae in Table 2-2, the index values were computed for each calibration observation (Appendix B5).

Patterns Along the Index (Pollution) Gradient

The nature of the gradients defined by the indices can be illustrated by plots of index values vs. pertinent parameters. In Appendices B6, B7, and B8, the index values are plotted against species abundances, community parameters, sediment measurements, fish abnormalities, BRI, and the pollution ordination vector projections. Separate plots are shown for each depth zone.

Index Thresholds

Figures 2-1 to 2-3 show plots of the index values vs. the BRI values, with the BRI thresholds represented by the vertical dashed lines, and the new index thresholds indicated by the horizontal dashed line. These plots should indicate to what extent the trawl organisms and benthic infauna show corresponding changes along the pollution gradient.

In Figure 2-1 (FRI), it can be seen that the average fish index values in each threshold range (between the dashed lines) increases as the pollution level increases. The fish could be responding to changes in the benthic infauna, the physical conditions, or both. Although BRI values between reference (25) and loss of community function (44) are associated with generally elevated FRI values, there is still complete overlap with the FRI values in the reference areas.

Almost all observations with FRI values above the FRI reference threshold (45) are found above the "loss of community function" BRI threshold. This indicates that the fish community response to the pollution effects is less sensitive than the infaunal community response.

Figure 2-2 (IRI) also shows a similar pattern, although the scatter below the reference threshold is the greatest, and the differentiation of values between the first three thresholds seems to be the least. Thus, it appears that invertebrates alone do not provide the same sensitivity as fish alone, or fish plus invertebrates. Again, IRI values above the IRI reference threshold (46) are mostly associated with BRI values greater than those associated with "loss of community function".

Figure 2-3 (TRI) shows a similar pattern, but with a little less scatter below the reference threshold and between loss of community function and defaunation. Also, the index values between the first three BRI thresholds seem to be better differentiated. Similar to the FRI, the TRI values above the TRI reference threshold (51) are almost always associated with BRI values greater than those associated with "loss of community function" threshold.

Validation

To demonstrate whether the indices can be applied beyond the calibration dataset, we compute index values for additional data (to be called the *validation* data).

<u>60-Meter Survey – Spatial Pattern</u>

The first data to be applied are from the 60-Meter Survey data (Word and Mearns 1979) taken in 1977 (Figure 1-4). The survey involved 71 stations at 60 m depth extending from Point Conception to the Mexican Border. Trawl data from this survey were also part of the calibration data for the FRI, TRI, and IRI indices; however 7 stations were not included in the calibration dataset and are used for validation.

Figure 2-4 shows the index values for the survey. The BRI in the top graph goes above the reference threshold (dotted line) in the vicinity of each of the major outfalls. The highest BRI values are found at stations near the County Sanitation Districts of Los Angeles County (CSDLAC) outfall on the Palos Verdes Shelf.

The trawl indices only go above their reference thresholds for the CSDLAC outfall stations. The validation index values (filled squares in the graphs) follow a pattern consistent with what would be expected given the adjacent calibration index values.

<u>Los Angeles and Orange County Outfalls – Temporal Patterns</u>

Figures 1-5 and 2-5 show the temporal patterns at three stations from two outfalls. All the stations are at approximately 60 m depth. Two stations from the CSDLAC outfall on the Palos Verdes Shelf are shown, one station close to the outfall (PVS Outfall), and one farthest from the outfall (PVS Control). One station from the Orange County Sanitation District (OCSD) outfall on the San Pedro Shelf (SPS Control) is also shown. This station is distant from the outfall and is considered to be uncontaminated.

It is known that the effluent quality at both outfalls has been improving over the years, and this is reflected in the decreasing BRI values over time at the CSDLAC outfall stations (PVS Control and PVS Outfall). Stations within the influence of the outfall show decreases in index values over time, with the rate of change greater for the more affected stations. The station least affected by the outfall (SPS Control) shows a relatively flat response over time. These patterns shown by the BRI are what we would expect.

The trawl indices all show the same expected patterns over time, with the most contaminated station showing the most change over time, and the least contaminated station showing the least change over time. The FRI in general fits into a smooth, mostly monotonic pattern of change over time, and the FRI validation stations fit nicely into the pattern.

The IRI and TRI show an unexpected increase in 1985 at the PVS Outfall validation station. Both indices also show an unexpected downward movement starting in 1990. If the outfall effluents are in fact improving consistently over time, the FRI pattern over time best reflects this fact (compared to IRI and TRI).

Note that the FRI values continue to decrease even after the reference threshold is crossed (Figure 2-5). Also note that the vertical order of stations in the Figure 2-5 FRI plot is in the expected order with the least polluted and the most polluted stations bracketing the moderately polluted station. This is the case even when the three stations have index values lower than the reference threshold. This is discussed further in the discussion section

Discussion

Index-Defined Pollution Gradient Patterns

The plots in Appendices B6, B7, and B8 show the following.

The species distributions along the index gradient show which species favor, avoid, or are indifferent to the different levels of pollution along the gradient. This pattern of the species distributions along a pollution gradient is the raw material on which the index is built.

The projections onto the ordination pollution vector (ORDINATION VECTOR in the plots) show a good correlation with the index values, showing that the index formulae (Table 2-2) effectively reproduce the ordination pollution gradient. (Also see Table 2-1 for correlations.) This means that the index formulae can effectively approximate a position of a new observation on the ordination pollution gradient without performing a new ordination analysis.

The pollution indicator variables ERMQ, PELQ, BRI, the presence of fish fin erosion (FINEROS) and tumors (TUMOR) tend to increase at higher index values. This confirms that the index correlates with external environmental and biological measures of pollution, even though these variables were not used in the final index calculations. The depth (DEPTH) parameter does not show a consistent pattern of change along the index gradient. This means that pollution effects as measured by the index should not be confounded with depth.

For the sediment size (FINES) parameter, the highest index values (for all indices) are all found in finer sediments in the 30-120 m and 100-215 m depth ranges. However, the finer sediments are also found at lower index values, so it is clear that the indices are not just measuring sediment size. Some of the community parameters (diversity parameters, dominance, eveness) show a slight pattern of change along the gradient. However, the scatter of values toward the unpolluted end of the index gradient is very wide, indicating that these parameters by themselves may not be very sensitive indicators.

Figures 2-1 to 2-3 show that FRI, TRI, and IRI values above their respective reference thresholds are mostly associated with an highly altered benthic infaunal community (“the BRI “loss of community function” threshold).

Evaluation of the Indices

Figures 2-1 to 2-3 hint that the most sensitive index might be the TRI, which includes both the fish and invertebrates. On the other hand, the FRI seemed to perform better in the validation procedure demonstrating temporal patterns in index values (Figure 2-5). The temporal pattern of FRI at the outfall station was more consistent over time, with or without the inclusion of the validation stations.

Also, in Figure 2-5 the FRI plot showed that the FRI was sensitive to pollution effects even within the range of values below the reference threshold. This contradicts the seemingly low sensitivity of the index to low and moderate pollution effects demonstrated in Figure 2-1. Taken together, these results indicate that the FRI may be quite sensitive to the more complete range of pollution effects when comparing the same site over time or when the sampling sites are confined to a somewhat more limited geographic extent or habitat type.

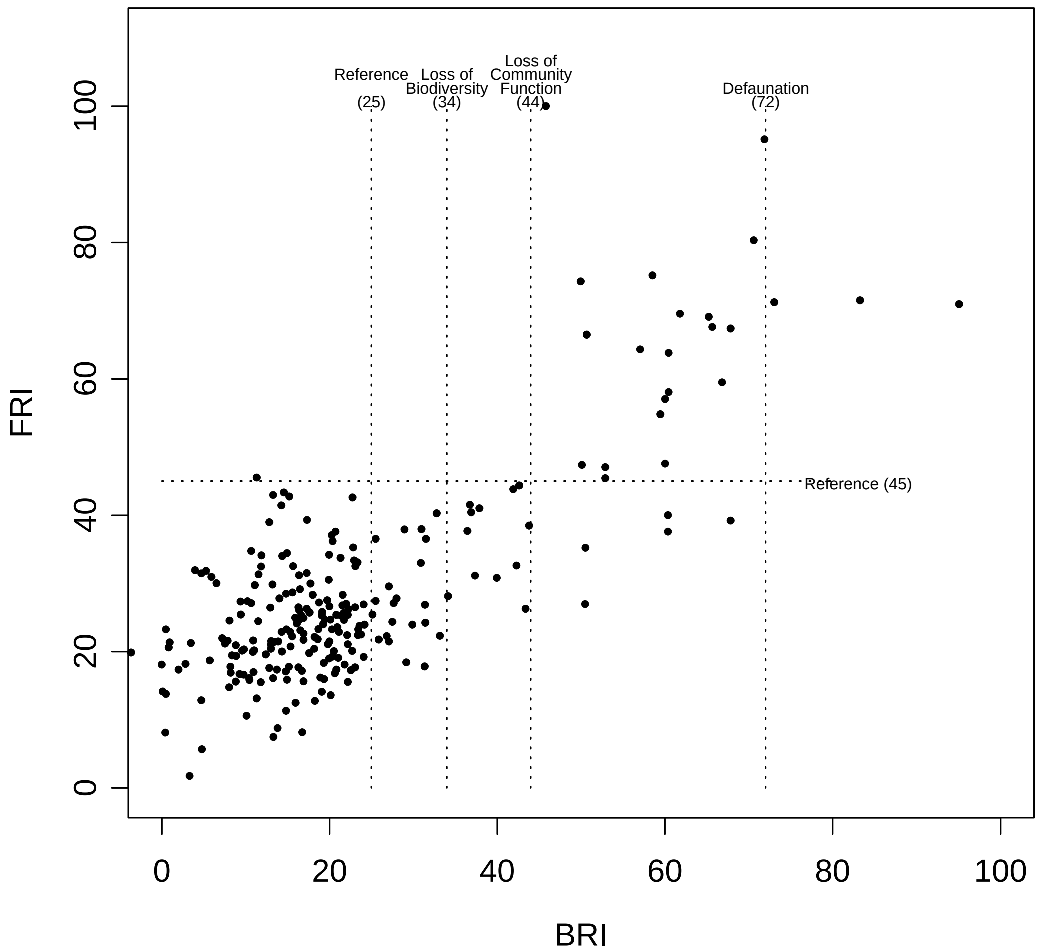


Figure 2-1. FRI values vs. the BRI values for the calibration data. The BRI thresholds are represented by the vertical dashed lines, and the FRI reference threshold is indicated by the horizontal dashed line.

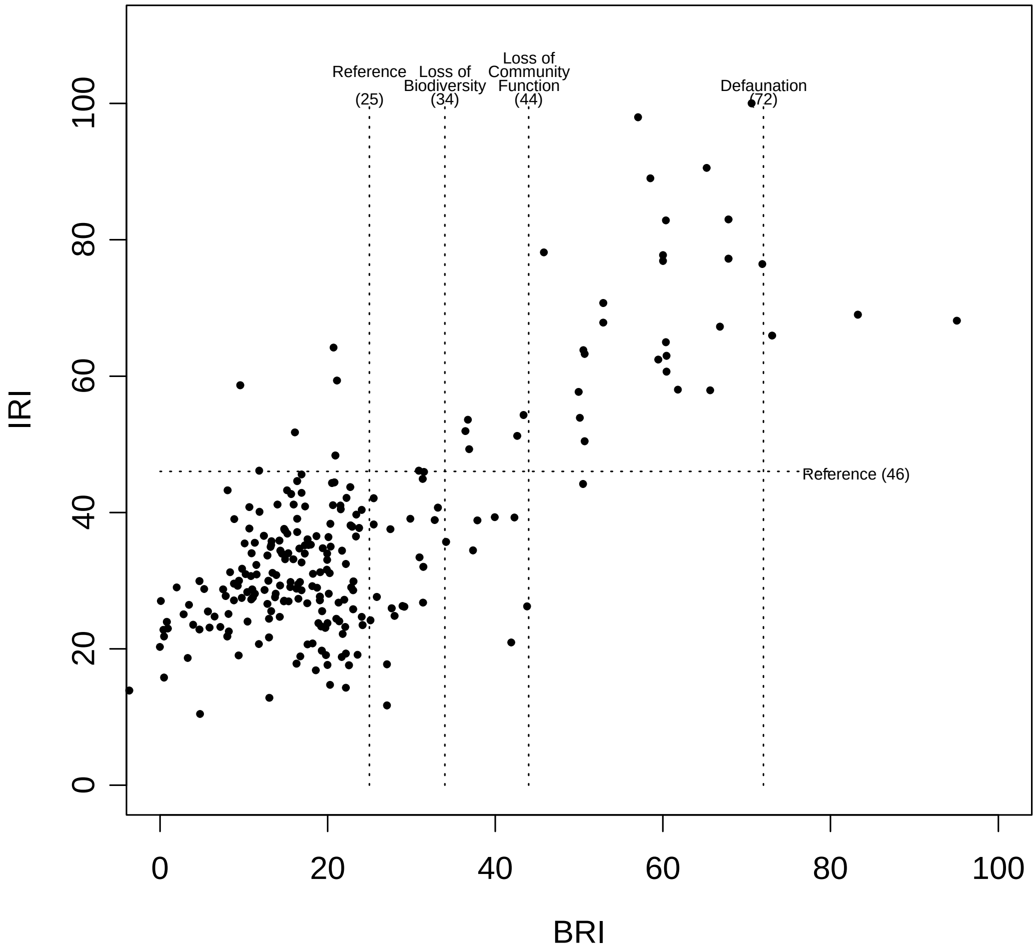


Figure 2-2. IRI values vs. the BRI values for the calibration data. The BRI thresholds are represented by the vertical dashed lines, and the IRI reference threshold is indicated by the horizontal dashed line.

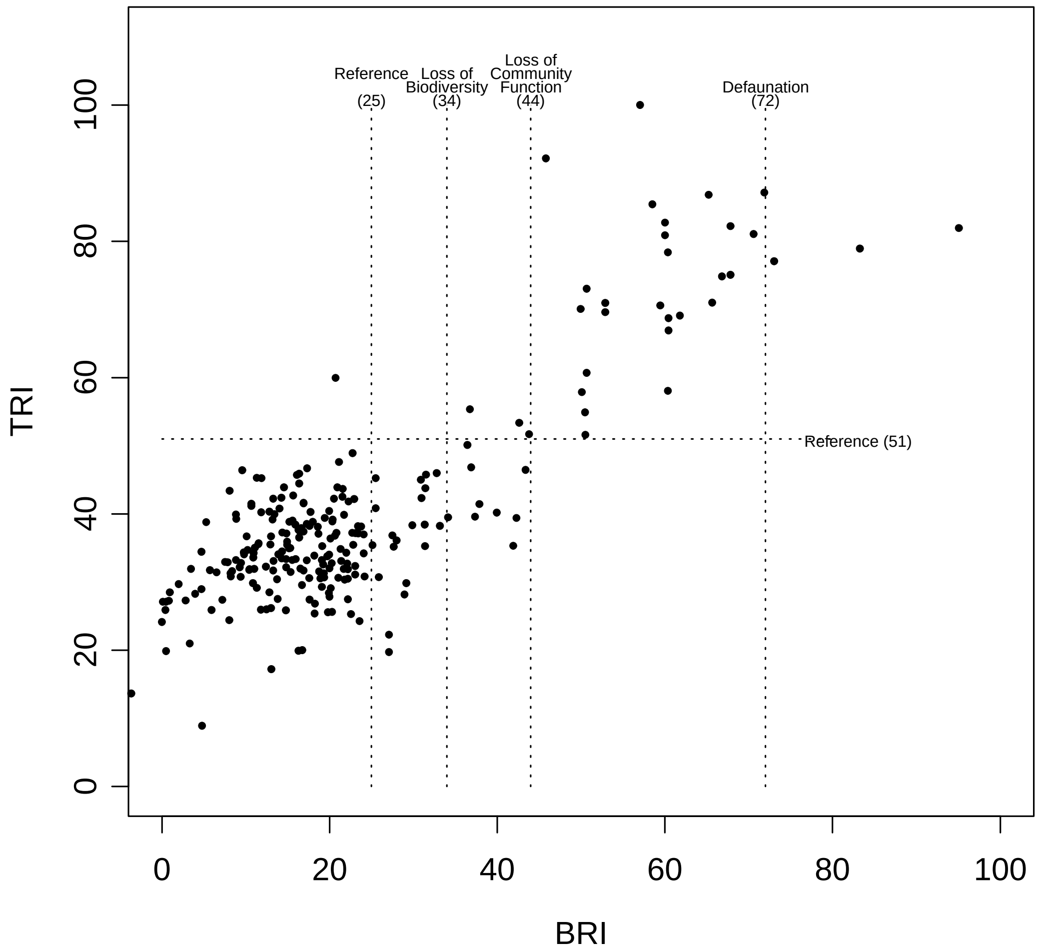


Figure 2-3. TRI values vs. the BRI values for the calibration data. The BRI thresholds are represented by the vertical dashed lines, and the TRI reference threshold is indicated by the horizontal dashed line.

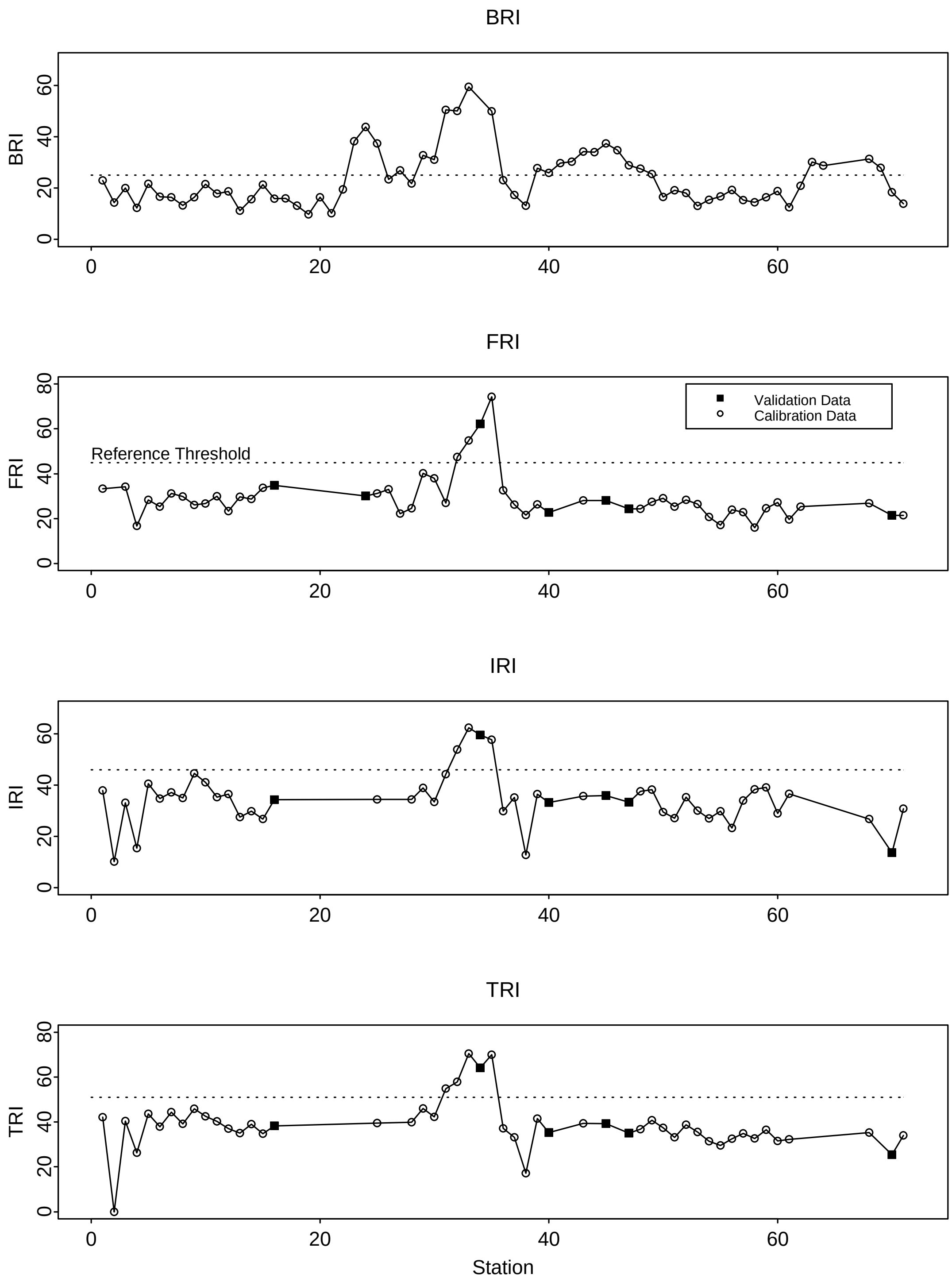


Figure 2-4. Index results for the 60-Meter survey data. The stations are numbered between 1 and 71, with station 1 to the northwest and station 71 to the southeast.

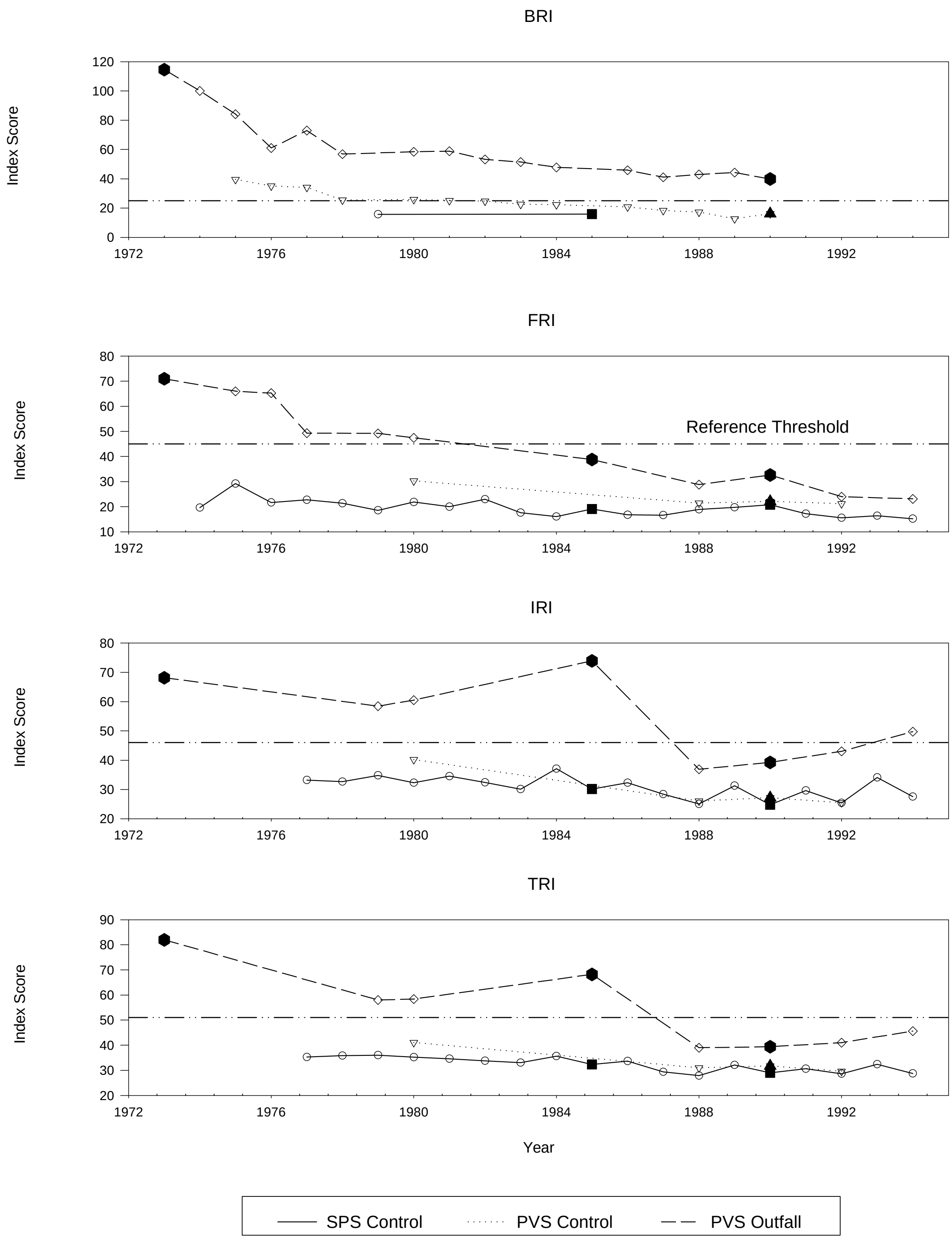


Figure 2-5. Temporal distribution of index results at 60-m isobath on the Palos Verdes Shelf (PVS) (outfall and control sites) and San Pedro Shelf (SPS) (control site) from 1973 to 1994. The filled symbols represent calibration data and the open symbols represent validation data.

Table 2-1. Optimum values for the parameters in Equations (x1) and (x2) in Appendix B1 for response indices at particular depth zones.

Index	Depth Range	*e*	*t*	*f*	Correlation
FRI	9-40 m	0	57	0	.87
FRI	30-120 m	0	15	.25	.84
FRI	100-215 m	1	26	.50	.92
TRI	9-215 m	0	60	.25	.94
IRI	9-215 m	0	57	.25	.94

Table 2-2. Index formulae for response indices at particular depth zones.

Index	Depth Range	Formula
FRI	9-40 m	$FRI_{s,shallow} = \frac{\sum_{i=1}^{n} p_i}{\sum_{i=1}^{n} n}$
FRI	30-120 m	$FRI_{s,mid} = \frac{\sum_{i=1}^{n} a_{si}^{.25} p_i}{\sum_{i=1}^{n} a_{si}^{.25}}$
FRI	100-215 m	$FRI_{s,deep} = \frac{\sum_{i=1}^{n} \sqrt{a_{si}}\, p_i}{\sum_{i=1}^{n} \sqrt{a_{si}}}$
TRI	9-215 m	$TRI = \frac{\sum_{i=1}^{n} a_{si}^{.25} p_i}{\sum_{i=1}^{n} a_{si}^{.25}}$
IRI	9-215 m	$IRI = \frac{\sum_{i=1}^{n} a_{si}^{.25} p_i}{\sum_{i=1}^{n} a_{si}^{.25}}$

SECTION 3 – MULTIMETRIC INDEX APPROACH (M. JAMES ALLEN AND VALERIE RACO-RANDS)

Introduction

The multimetric index approach has been successfully used as a pollution indicator in the many biotic studies of infauna (e.g., Barbour *et al.* 1996, Weisberg *et al.* 1997, Hyland *et al.* 1998), freshwater fish assemblages (Karr *et al.* 1986, Barbour *et al.* 1996, 1999), and estuarine fish assemblages (Deegan *et al.* 1997). It has seldom been applied to marine fish assemblages, although biocriteria have been defined in some areas (e.g., Eaton and Dinnel 1993). Some studies (give examples). The soft-bottom fish fauna of the southern California shelf presents a good situation to attempt development of such an index using a multimetric approach. This fauna has been extensively sampled throughout the southern California shelf (10-200 m) for 30 years (SCCWRP 1973, Allen 1982, Stull and Tang 1996, Allen *et al.* 1998). It also has well-defined areas of pollution (Mearns et al. 1976, Allen 1977, Stull 1995, Stull and Tang 1996), indications of pollution impact to these assemblages (Allen 1977, Stull 1995, Stull and Tang 1996), and extensive information on the distributional and feeding ecology of this fauna (Allen 1982).

The objective of this study is to determine if an effective demersal fish biointegrity index for assessing pollution impacts in southern California using the multimetric index approach. This study focuses on multimetric index development steps defined in a USEPA bioassessment and biocriteria guidance document (Gibson *et al.* 2000). The steps followed are similar to those used in Weisberg *et al.* (1997).

Methods

First, we assembled index calibration and index validation data sets that included stations (see Section1, Figures 1-2, 1-3; Appendices A3, A4) and species abundances for fishes and invertebrates (Appendices A1, A2). We then identified candidate metrics and adjusted them by habitat (i.e., depth). After this, we determined combinations of candidate measures that discriminate between reference and impact sites. Then, we formed, adjusted, and validated indices. If appropriate, we used information from this process to readjust the index to improve its utility. The resulting indices were evaluated based on their conformity to two validation models. The next step, not included here, would have been to apply the index to survey data.

Index Development Steps

Index Data Sets

Index data sets are described in the general methods section for this report (see Section1, Figures 1-2, 1-3; Appendices A1, A2, A3, A4).

Metric Identification

Fish population and assemblage metrics were identified that ideally should work over all depths. We identified 49 candidate metrics for evaluation (Table 3-1). These included five population attribute measures (e.g., abundance, species richness, diversity, evenness, and dominance), 18 fish foraging guilds (defined in Allen 1982), and four additional groups of species based on diet or morphology (defined differently than in Allen 1982). For the guilds and species groups, we examined overall abundance and % fish abundance (which brought the total examined to 48). We did not include fin erosion because it is a known indicator of contamination on the Palos Verdes Shelf (Mearns and Sherwood 1977, Stull 1995) and because its inclusion would likely mask the behavior of any metrics with which it was combined.

Metric Testing

Next we tested these metrics for their responsiveness to impact and reference conditions. Metrics were compared between impact and reference sites within three depth-related habitats (see Calibration Data Base in Section 1) to determine metrics that are most responsive to impact. Because impact sites were missing in the inner shelf zone, these metrics were not compared for the Inner Shelf. Differences between impact and reference sites were tested using Mann-Whitney Ranked Sums Test.

Box-and-whisker plots of significantly different metrics were plotted to compare interquartile ranges and upper and lower decile values at reference and impact sites. Metrics were selected that had nonoverlapping interquartile ranges.

Metric Scoring

Based on these box-and-whisker plots at reference sites only, metric responses were scored following Gibson *et al.* (2000) (Figure 3-1). The range of values of responsive metrics was then divided into three categories: impact, intermediate, and reference. Scores for these categories were given as 1, 3, and 5, respectively. Metrics were scored differently depending on whether the metric was higher or lower at the reference sites relative to the impact sites. For metrics that were higher at the reference sites, 25% and above were scored as 5. The range of values between 0 and 25% was then divided in half and the lower half was given the score of 1 and the upper half 3. For metrics that were lower at the reference sites, sites up to 75% were scored as 5. The range of values between 75% and the maximum reference value was then divided in half, with the lower half given a score of 3 and the upper half 1. Ranges of values representing these scores were then defined for each of the responsive metrics.

Index Formation

Combinations of responsive metrics were then combined to form indices. Each index was mean of the metric scores of the index (i.e., the sum of the scores of each component metric divided by the number of metrics in the index) or

$$MI = \frac{\sum_{i=1}^{n} MS}{n}, \qquad (1)$$

where MI = multimetric index, MS = metric score, and n = number of metrics in index.

Determination of Index-defined Reference Thresholds

Reference (and impact) thresholds were then defined for each index following Gibson *et al.* 2000). A box-and-whisker plot of each index at the chemically defined reference sites was then divided and scored as was done for scoring metrics for index formation. Index scores at 25% and above at reference sites were scored as 5 (reference). The range of values between 0 and 25% were then divided in half and the lower half was given the score of 1 (impact) and the upper half 3 (intermediate).

Index Evaluation

The indices were then evaluated by determining their overall agreement to chemically defined impact sites for the combined calibration and validation data bases (and for individual data bases) and two models: spatial (Figure 1-4), and temporal (Figure 1-5). The indices were also compared to the response of the Benthic Response Index (BRI) (Smith *et al.* 1998, in press) in the spatial and temporal models (Figures 1-4 and 1-5). We then determined percent agreement between index-determined and chemically determined reference and impact categories in the calibration, validation, and calibration+validation data bases for all the data in a depth zone, for the spatial model and temporal model. The mean percent agreement for reference and impact success rather than total percent agreement for all data combined, because it is equally important that the index successfully identify reference and impact sites. Because of the relatively few chemically defined impact sites, total percent agreement for all data combined would emphasize success at estimating reference sites at the expense of any success at estimating impact sites.

Results

Index Development

Initially, 49 metrics were tested for significant responses between reference and impact sites. Comparison of box-and-whisker plots showed that the miscellaneous species groups overlapped strongly in species composition with some of the foraging guilds (e.g., bottom-living polychaete-feeders with benthic extracting benthivores; bottom-living gammarid feeders with benthic pelagobenthivores; schooling planktivores with schooling pelagivores; and sculpins/poachers with moderately small benthic ambushing benthopelagivores). Thus the miscellaneous groups were discarded in favor of the foraging guilds (which were based on a community functional organization model which focused specifically on defining foraging guilds for this area; Allen 1982).

Similarly, it was decided to drop the '% abundance' metrics in favor of the 'actual abundance' metrics. Whereas '% abundance' would make better sense if sampling methods varied, the trawl sampling methods used to collect the samples in the data base have been standard (7.6-m headrope otter trawls, 1.2 cm cod-end mesh, 10 min trawl at 1.0 m/sec along isobaths) for the past 30 years and hence the samples are all comparable. In contrast, schools or aggregations of ecologically different species can distort the metric abundance value if based on the percent of total fish. For instance, the abundance a benthic guild may be high but be perceived as low if large numbers of schooling planktivores are present in the catch.

Eliminating these metrics (26 total) left 23 metrics that were tested for significance in all three depth zones (Appendix C1). This resulted in 7 responsive metrics that differed significantly between impact and reference stations (Table 3-2). The population attribute metrics did not differ significantly between reference and impact categories (Appendix C-1). However, 30% of all foraging guilds showed significant differences. The seven responsive metrics were Guild 1A1 (schooling pelagivores), Guild 2A1a (bottom-refuge visual pelagivores), Guild 2A1b (bottom-refuge nonvisual pelagivores), Guild 1B1 (midwater pelagobenthivores), Guild 2A (benthic pelagivores), Guild 2B (benthic pelagobenthivores), and Guild 2D1a (benthic extracting benthivores). Five of these were responsive in the middle shelf zone, four in the outer shelf zone, and one for the entire shelf. On the middle shelf, these were Guild 1A1, Guild 1B1, Guild 2A, Guild 2B, and Guild 2D1a, and on the outer shelf, Guild 2A1a, Guild 2A1b, Guild 2B, and Guild 2D1a. Guild 2D1a was the only responsive metric for the entire shelf.

Ranges of abundance characterizing different impact categories differed among these guilds, both in absolute value and direction of change (Table 3-3, Figures 3-2, 3-3, 3-4). Metrics that were higher at impact sites included Guilds 1A1, 1A2a, 1B1, and 2D1a. Metrics that were lower at impact sites included Guilds 1A2b, 2A, and 2B. For three guilds, simple presence (Guild 1B1) or absence (Guild 1A2b, 2A) could determine impact conditions.

A total of 31 indices were developed from the five responsive metrics on the middle shelf, 15 for the outer shelf, and one for the entire shelf (Table 3-4). On the middle shelf, five were comprised of single metrics, 10 of two metrics, 10 of three metrics, five of four metrics, and one of five metrics. On the outer shelf, four were comprised of single metrics, six of two metrics, four of three metrics, and one of four metrics. The only index for the entire shelf was based on Guild 2D1a.

Reference and impact thresholds varied among metrics (Table 3-4). Thresholds for reference ranged from 3.00 to 5.00 and those for impact ranged from 1.00 to 2.50. Reference thresholds were lowest (3.00) for indices 2A+2B and 2A+2D1a on the middle shelf and 1A2a+1A2b, 1A2b+2B, and 1A2b+2D1a on the outer shelf. Impact thresholds were highest (2.50) for indices 1B1+2B and 1B1+2D1a on the middle shelf.

Index Validation

Index validation focused on the middle-shelf indices as our validation models were for this zone (Figures 1-4, 1-5). This was also the zone where chemically determined impact sites were highest. Validation of the outer shelf and entire shelf will be done in a future study.

Percent Agreement

The indices varied in their percent agreement between index-determined and chemically determined reference and impact categories in the calibration, validation, and calibration+validation data bases. For the middle shelf data as a whole (Table 3-5), the indices with the highest percent agreement for mean reference and impact sites in these data bases were index 1A1+2D1a (78%) in the calibration data base, and index 1B1 for the validation and calibration+validation data bases (81 and 79%, respectively). For the spatial model (Table 3-6), the indices with the highest percent agreement for mean reference and impact sites in these data bases were index 2B for the calibration data base. For the validation data base, indices

1A1+2D1a, 2A+2D1a, 2B+2D1a, 1A1+2A+1B1, and 2A+2B+2D1a, had 100% agreement. Note, however, that there was only one impact site in this data base. In the combined data base (calibration+validation), index 2A+2D1a was highest (80%). In the temporal model, 15 indices were found at the only calibration sample (an impact site). Index 1B1 was highest in the validation and calibration+validation data bases (82 and 83%, respectively) (Table 3-7).

Comparison of percent agreement for the spatial and temporal models showed that only three single-guild indices (2A, 2B, 2D1a) agreed with at least one chemically determined impact sites in both models (Table 3-6 and 3-7). Thus we chose to examine indices based on these three guilds for graphical comparisons to the two models.

Spatial Model Comparison

Graphically, the indices varied in their similarity to the spatial model sediment chemistry and BRI data (Figure 3-5). Three indices picked up the impact sites on the Palos Verdes Shelf (central part of graph) and did not have false impact sites (at least relative to the chemistry classification) away from the Palos Verdes Shelf. These included indices 2A+2D1a, 2B+2D1a, and 2A+2B+2D1a. Of these, indices 2B+2D1a and 2A+2B+2D1a also picked up a pattern of intermediate values in Santa Monica Bay (to the left of the primary impact zone at Palos Verdes). The single-guild indices 2A and 2B showed many false positives, particularly in the north, whereas 2D1a showed fewer false positives and these were to the south.

Temporal Model Comparison

Similarly, the indices varied in their comparability to the temporal model for the PV Outfall Station with other stations (PV Control and CSDOC Control) being not following closer to chemistry trends (Figure 3-5). Index 2B showed a false positive (relative to sediment chemistry) in the 1980s and did not follow the sediment chemistry or BRI patterns closely. Of the remaining indices, indices 2A and 2A+2B+2D1a showed the most similar trends to those of sediment chemistry and BRI at the Palos Verdes outfall site. Although Index 2A had two impact samples in 1973 and 1976 before rising steeply to reference. Index 2A+2B+2D1a showed a more gradual increase from 1973 to 1985 but did not get into the impact zone on this graph. However, this graph shows mean values where multiple samples were collected at a site and thus does not show one impact sample shown in the spatial model (Figure 3-5). The index value at this site in 1977 was 1.67, which falls below the impact threshold of 1.83 (Table 3-4).

Discussion

The indices produced showed considerable variability in their percent agreement in estimating reference and impact sites (Tables 3-5, 3-6, and 3-7), and in their agreement to the spatial and temporal models (Figure 3-5). The two indices that showed the most promise are 2A and 2A+2B+2D1a. The former consists of the benthic pelagivore guild (e.g., bigmouth sole, *Hippoglossina stomata*; California lizardfish). The latter also consists of this guild plus the benthic pelagobenthivore guild (e.g., Pacific sanddab, *Citharichthys sordidus*; longfin sanddab, *Citharichthys xanthostigma*) and the benthic extracting benthivore guild (e.g., hornyhead turbot, *Pleuronichthys verticalis*; curlfin sole, *Pleuronichthys decurrens*; and Dover sole, *Microstomus pacificus*).

We evaluated the two indices by comparing their relative percent success at indicating reference and impact sites and their relative correspondence to the graphical models. Of the two indices, index 2A was more successful at indicating both reference and impact sites (i.e., mean percent success for reference and impact sites) for calibration, validation, and combined data sets for the middle shelf as a whole (Table 3-5) and for the historical model (Table 3-7). Index 2A+2B+2D1a was more successful for the spatial model (Table 3-6). However, although index 2A followed the historical trends model somewhat better (Figure 3-5), index 2A+2B+2D1a followed the spatial model much more closely. Index 2A showed a high percentage of false positives to the north (to the left in Figure 3-5). This seems to be a much less desirable trait than the lower success of 2A+2B+2D1a in the overall and historical data bases. Index 2A is based the occurrence of very few individuals (e.g., 0 for reference, >1 for impact) and there is some natural along-coast variation of the occurrence of this guild on the mainland shelf. In 1994, this guild occurred in 75% of the area of the mainland shelf in southern California (Allen *et al.* 1998). Because of its potential natural absence in some areas, its use as an indicator would lead to some false positives.

Based on these arguments, index 2A+2B+2D1a appears to be the best choice for an index using this method. In general it shows relatively good correspondence to sediment chemistry and BRI for both the spatial model and the temporal model (Figure 3-5). This index will be called the Fish Foraging Guild (FFG) index in the rest of this report.

Given this choice, the index can be interpreted as follows from information in Allen (1982). All are benthic species and hence have direct contact with the sediments. 2A species are sit-and-wait ambushers, feeding largely on mysids, which occur very near the bottom during the day. 2B species are more generalized, feeding on mysids, euphausiids, gammaridean amphipods, and epibenthic prey. 2D1a species feed predominantly on tube-dwelling polychaetes, clam siphons, and echiurid probosces. In reference sites, 2A and 2B species are abundant and 2D1a species are not, whereas in outfall areas 2D1a species are abundant and 2A and 2B species are not. This relationship reflects infaunal conditions with deposit-feeding polychaete and clam species (largely the prey of 2D1a fish species) occurring where total organic carbon is high near outfall areas, with gammaridean amphipods and mysids (the prey of 2a and 2B species) being more abundant in reference areas.

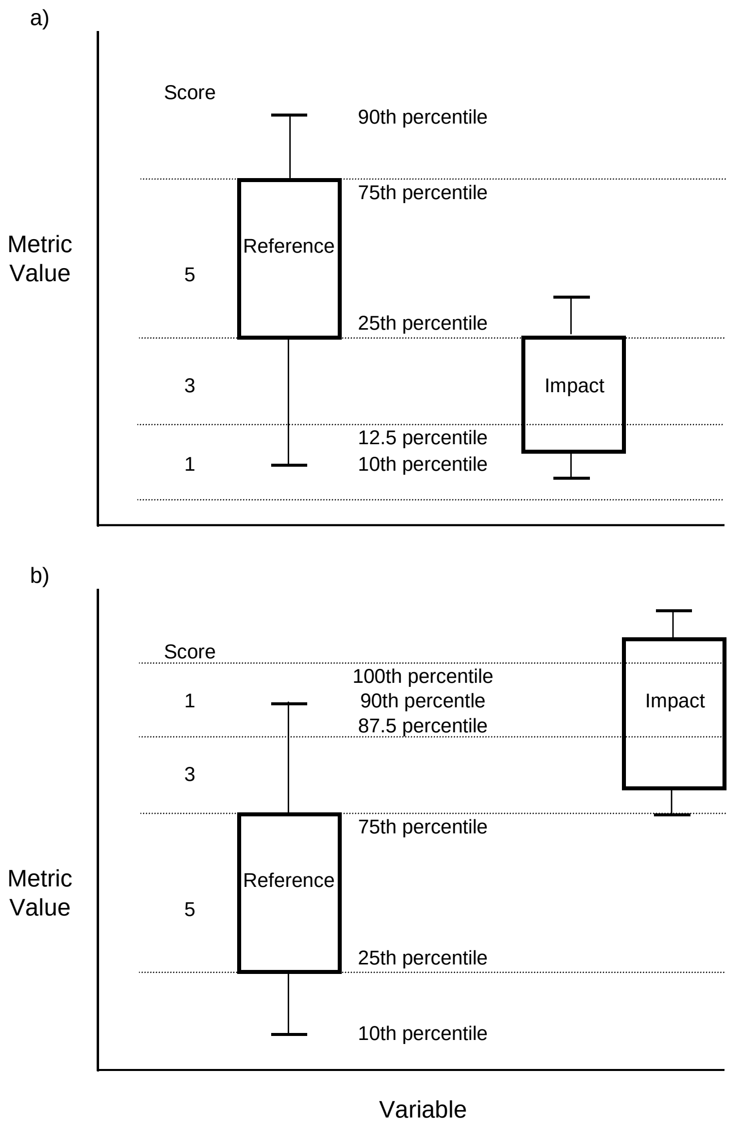


Figure 3-1. Degradation state scoring approach for metrics that are a) lower at reference sites than at impacted sites and b) those that are higher at reference sites.

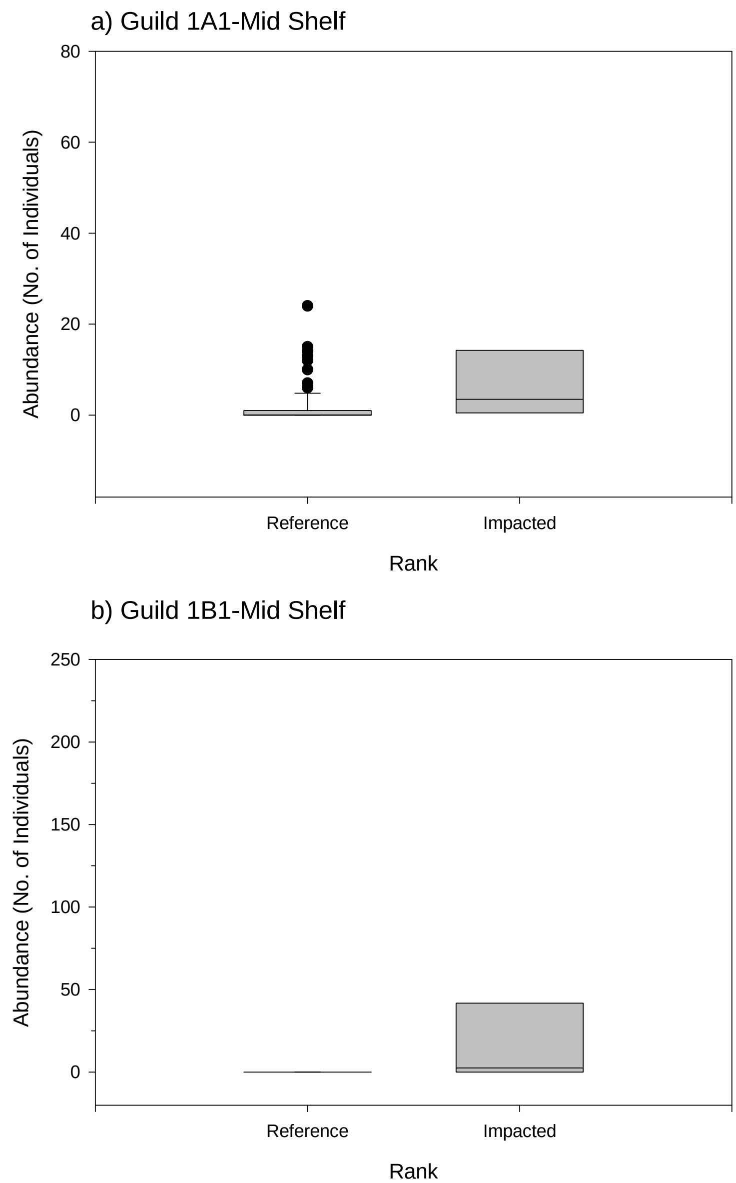


Figure 3-2. Box-and-whisker plots of metrics showing significant differences in abundance (number of individuals) between reference and impact sites on the middle shelf (30-120 m) in southern California demersal fish biointegrity index study: a) Guild 1A1, b) Guild 1B1, c) Guild 2A, d) Guild 2B, and e) Guild 2D1a.

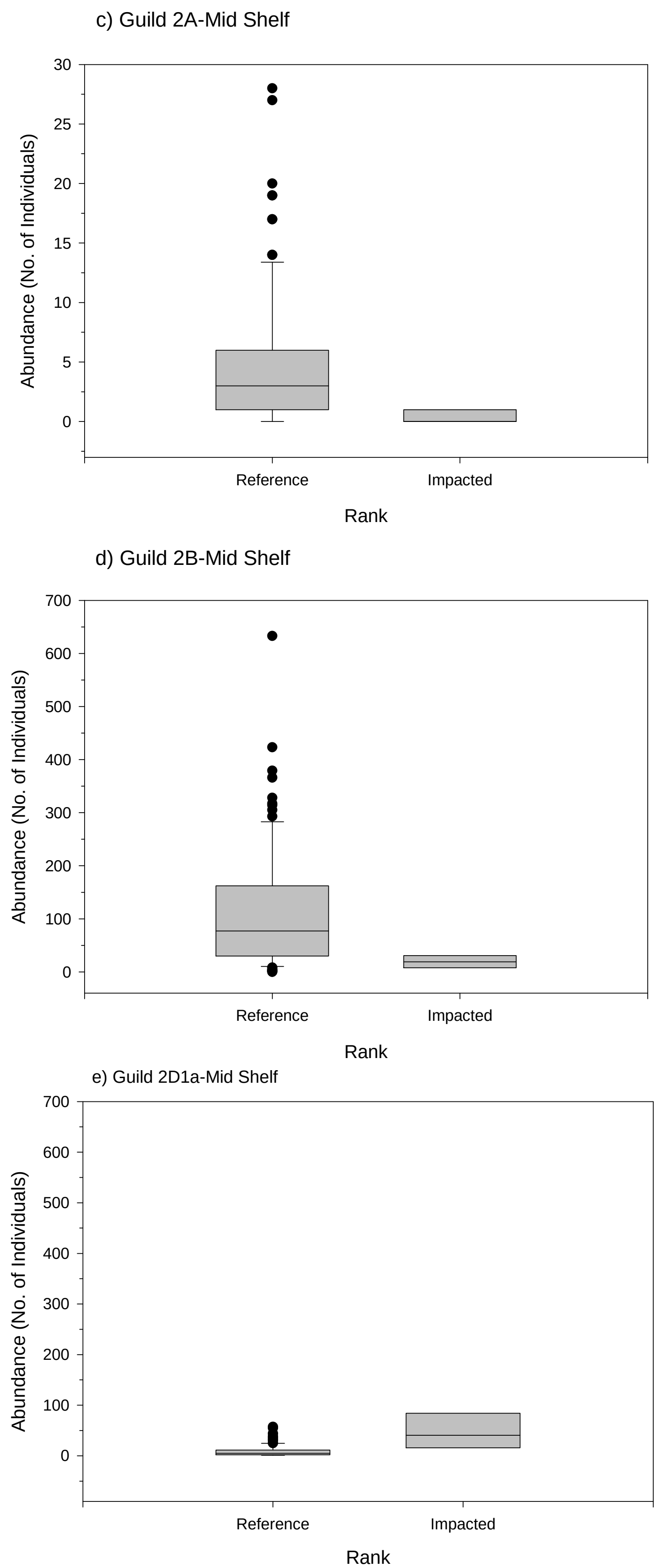
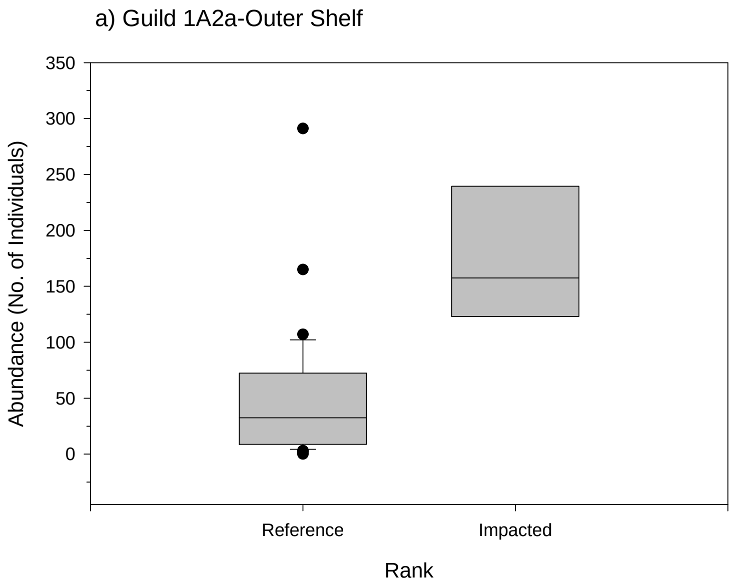


Figure 3-2. Continued.



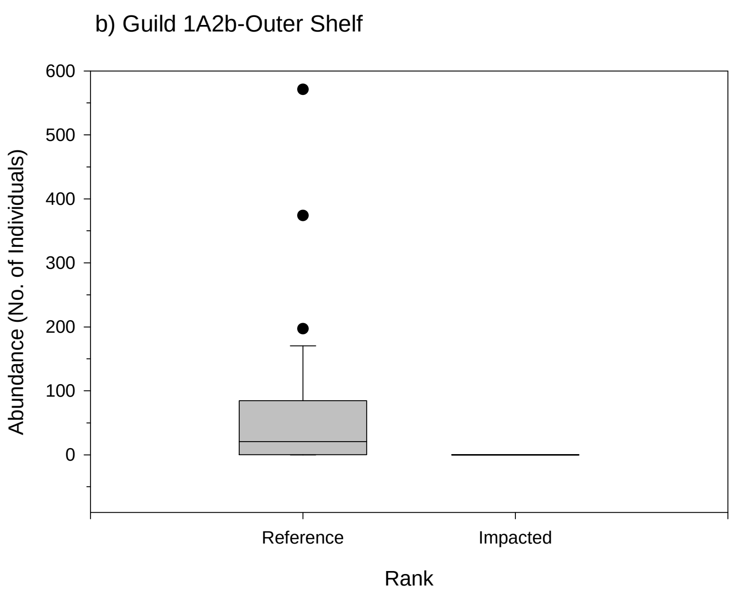
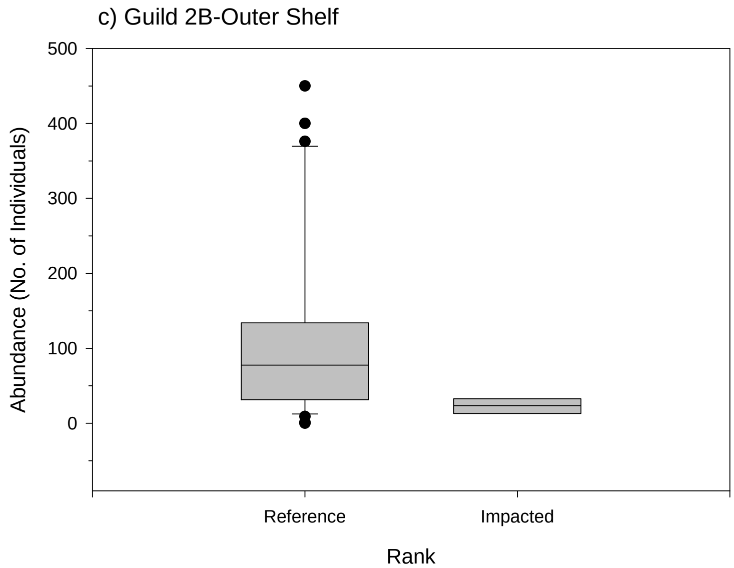


Figure 3-3. Box-and-whisker plots of metrics showing significant differences between reference and impact sites on the outer shelf (100-215m) in southern California demersal fish biointegrity index study: a) Guild 1A2a, b) Guild 1A2b, c) Guild 2B, and d) Guild 2D1a.



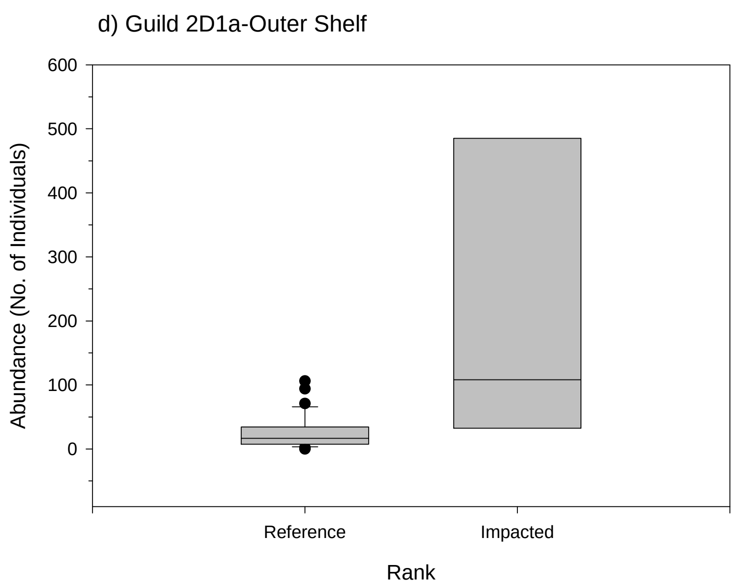


Figure 3-3. Continued.

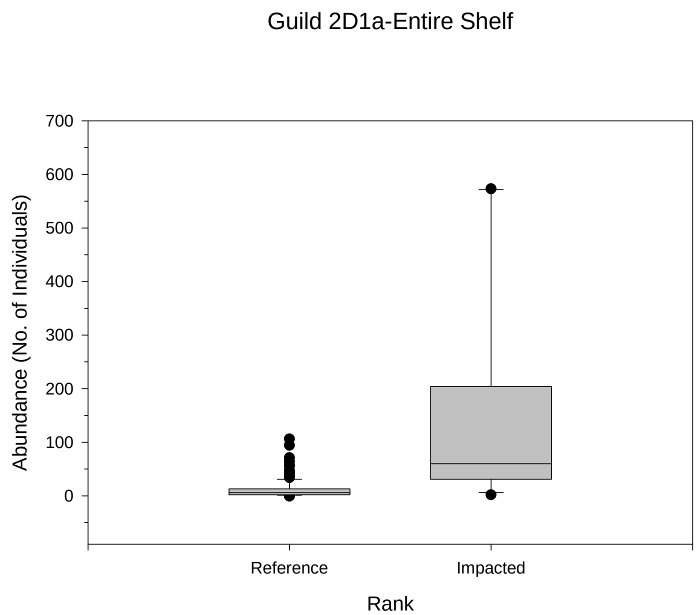


Figure 3-4. Box-and-whiskers plot of Guild 2D1a, which was significantly different between reference and impact sites on the entire shelf (9-215 m) in southern California demersal fish biointegrity index study.

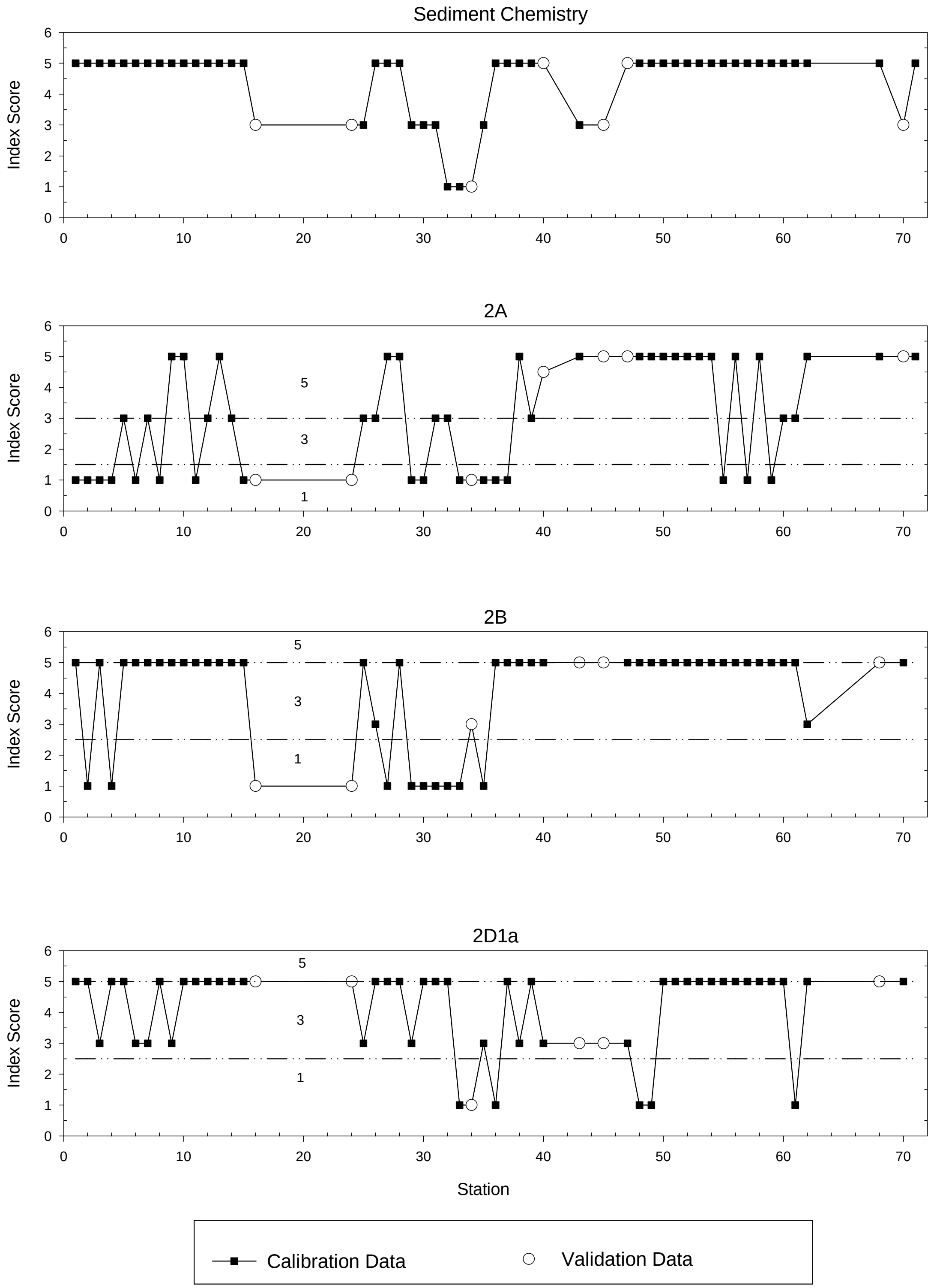


Figure 3-5. Comparison of middle shelf multimetric index responses for indices with responses most similar to sediment chemistry conditions in spatial (60-m survey) model: Mid shelf as a whole and Indices 2A, 2B, and 2D1a. Horizontal lines are reference and impact thresholds of indices.

Table 3-1. Metrics tested in comparisons of reference and impact sites in southern California demersal fish biointegrity index study.

Population/Assemblage Metrics

Fish Abundance
No. Fish Species
Diversity (Shannon-Wiener)
Evenness (Pielou's)
Dominance (Simpson's)

Miscellaneous Metrics

Abundance
bottom-living polychaete-feeders
bottom-living gammarid-feeders
schooling planktivores
sculpins/poachers

% Fish Abundance
bottom-living polychaete-feeders
bottom-living gammarid-feeders
schooling planktivores
sculpins/poachers

Guild Metrics (based on Allen 1982)

Abundance
Schooling pelagivores (IA1)
Bottom-refuge visual pelagivores (IA2a)
Bottom-refuge nonvisual pelagivores (IA2b)
Midwater pelagobenthivores (IB1)
Cruising pelagobenthivores (IB2)
Cruising diurnal benthopelagivores (IC1)
Cruising nocturnal benthopelagivores (IC2)
Cruising benthivores (ID)
Benthic pelagivores (IIA)
Benthic pelagobenthivores (IIB)
Benthic ambushing benthopelagivores, small (IIC2a)
Benthic ambushing benthopelagivores, moderatelly small (IIC2b)
Benthic ambushing benthopelagivores, moderately large (IIC2c)
Benthic ambushing benthopelagivores, large (IIC2d)
Benthic pursuing benthopelagivores (IIC2)
Benthic extracting benthivores (IID1a)
Benthic excavating benthivores (IID1b)
Benthic nonvisual benthivores (IID2)

% Fish Abundance
Schooling pelagivores (IA1)
Bottom-refuge visual pelagivores (IA2a)
Bottom-refuge nonvisual pelagivores (IA2b)
Midwater pelagobenthivores (IB1)
Cruising pelagobenthivores (IB2)
Cruising diurnal benthopelagivores (IC1)
Cruising nocturnal benthopelagivores (IC2)
Cruising benthivores (ID)
Benthic pelagivores (IIA)
Benthic pelagobenthivores (IIB)
Benthic ambushing benthopelagivores, small (IIC2a)
Benthic ambushing benthopelagivores, moderatelly small (IIC2b)
Benthic ambushing benthopelagivores, moderately large (IIC2c)
Benthic ambushing benthopelagivores, large (IIC2d)
Benthic pursuing benthopelagivores (IIC2)
Benthic extracting benthivores (IID1a)
Benthic excavating benthivores (IID1b)
Benthic nonvisual benthivores (IID2)

Table 3-2. Median, percentiles, and Mann-Whitney summed ranks test results for metrics showing significant responses between reference and impacted conditions in southern California demersal fish biointegrity index study.

Metric		n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
Middle Shelf (30-120 m)										
1A1								614.5	0.015	<0.05
	Reference	95	24	32	0	0	1			
	Impact	8	68	75	3.5	1	13.5			
1B1								606	0.019	<0.05
	Reference	95	0	0	0	0	0			
	Impact	8	231	50	2.5	0	30.5			
2A								171	0.003	<0.01
	Reference	95	28	78	3	1	6			
	Impact	8	1	38	0	0	1			
2B								198.5	0.007	<0.05
	Reference	95	633	98	77	30	161.5			
	Impact	8	163	88	19	8.5	27.5			
2D1a								692.5	<0.001	<0.001
	Reference	95	57	93	4	2	10			
	Impact	8	571	100	40.5	21	82.5			
Outer Shelf (100-215 m)										
1A2a								223.5	<0.001	<0.001
	Reference	36	291	97	32.5	9.5	71			
	Impact	6	202	100	157.5	135	223			
1A2b								53	0.007	<0.01
	Reference	36	571	75	20.5	0.5	83.5			
	Impact	6	1	17	0	0	0			
2B								55	0.008	<0.01
	Reference	36	450	97	77.5	32	131			
	Impact	6	34	100	23.5	15	30			
2D1a								218	0.001	<0.01
	Reference	36	106	17	16.5	7.5	32.5			
	Impact	6	539	583	108	33	457			
Entire Shelf (9-215 m)										
2D1a								1948	<0.001	<0.001
	Reference	147	106	92	6	2	13			
	Impact	14	571	100	60	31	120			

Table 3-3. Scoring ranges of significant demersal fish metrics used in southern California demersal fish biointegrity index study.

Zone	Guild	Score 1	Score 3	Score 5	Remarks
Middle Shelf (30-120 m)	1A1	>=12	2-11	0-1	
	1B1	>0	-	0	
	2A	0	1	>1	*Adjusted for 3 scores
	2B	0-15	16-29	>=30	
	2D1a	>=33	11-32	0-10	
Outer Shelf (100-215 m)	1A2a	>=181	72-180	0-71	
	1A2b	0	1	>1	**Adjusted for 3 scores
	2B	0-16	17-31	>=32	
	2D1a	>=69	33-68	0-32	
Entire Shelf (9-215 m)	2D1a	>=60	14-59	0-13	

*Original calculated values were the following:1(0-0.5); 3(>0.5-<1); and 5(>=1). Values were adjusted to whole and shifted slightly to give a value for each score (i.e., 1(0), 3(1), 5(>1).

** Original calculated values were the following: 1(0-0.25); 3(>0.25-<0.50); and 5(>=0.5). Values were adjusted to whole and shifted slightly to give a value for each score (i.e., 1(0), 3(1), 5(>1).

Table 3-4. Alternative indices created from responsive metrics on the middle, outer, and entire shelf zones, with reference and impact thresholds.

	Index	Threshold Index Value	
		Reference	Impact
Middle shelf			
	1A1_Score	5.00	1.00
	1B1_Score	5.00	1.00
	2A_Score	5.00	1.00
	2B_Score	5.00	1.00
	2D1a_Score	5.00	1.00
	1A1+1B1	5.00	2.50
	1A1+2A	3.00	1.50
	1A1+2B	4.00	2.00
	1A1+2D1a	4.00	2.00
	1B1+2A	4.00	2.00
	1B1+2B	5.00	2.50
	1B1+2D1a	5.00	2.50
	2A+2B	3.00	1.50
	2A+2D1A	3.00	1.50
	2B+2D1a	4.00	2.00
	1A1+1B1+2D1a	4.33	2.17
	1A1+1B1+2B	4.33	2.17
	1A1+1B1+2A	3.67	1.83
	1A1+2A+2D1a	3.67	1.83
	1A1+2A+2B	3.70	1.85
	1A1+2B+2D1a	3.67	1.83
	1B1+2A+2B	3.67	1.83
	1B1+2A+2D1a	3.67	1.83
	1B1+2B+2D1a	4.33	2.17
	2A+2B+2D1a	3.67	1.83
	1A1+1B1+2A+2B	4.00	2.00
	1A1+1B1+2A+2D1a	4.00	2.00
	1A1+1B1+2B+2D1a	4.00	2.00
	1A1+2A+2B+2D1a	3.50	1.75
	1B1+2A+2B+2D1a	4.00	2.00
	All5_Index	3.80	1.90
Outer shelf			
	1A2a_Score	5.00	1.00
	1A2b_Score	5.00	1.00
	2B_Score	5.00	1.00
	2D1a_Score	5.00	1.00
	1A2a+1A2b	3.00	1.50
	1A2a+2B	4.00	2.00
	1A2a+2D1a	4.00	2.00
	1A2b+2B	3.00	1.50
	1A2b+2D1a	3.00	1.50
	2B+2D1a	4.00	2.00
	1A2a+1A2b+2B	3.67	1.83
	1A2a+1A2b+2D1a	3.67	1.83
	1A2a+2B+2D1a	3.67	1.83
	1A2b+2B+2D1a	3.67	1.83
	All4	4.00	2.00
Entire shelf			
	2D1a_Score	5.00	1.00

Table 3-5. Success of multimetric indices in estimating chemically determined reference and impact sites in calibration, validation, and combined data sets for the middle shelf zone as a whole.

	Calibration Database			Validation Database			Calibration + Validation		
Index	% Ref (95)	% Impact (8)	Ave. (2)	% Ref (89)	% Impact (18)	Ave. (2)	% Ref (184)	% Impact (26)	Ave. (2)
1A1_Score	73	38	55	79	6	42	78	15	47
1B1_Score	95	50	73	100	61	81	100	58	79
2A_Score	61	63	62	99	50	74	81	54	67
2B_Score	72	38	55	92	39	66	84	38	61
2D1a_Score	72	63	67	92	33	63	84	42	63
1A1+1B1	73	50	62	79	17	48	78	27	52
1A1+2A	91	25	58	99	6	52	97	12	54
1A1+2B	75	38	56	92	11	52	85	19	52
1A1+2D1a	80	75	78	91	11	51	88	31	59
1B1+2A	74	50	62	99	44	72	88	46	67
1B1+2B	72	25	49	92	44	68	84	38	61
1B1+2D1a	72	50	61	92	22	57	84	31	57
2A+2B	85	13	49	99	22	61	94	19	57
2A+2D1A	90	38	64	100	17	58	97	23	60
2B+2D1a	75	38	56	98	17	57	88	23	56
1A1+1B1+2D1a	80	50	65	91	0	46	88	15	51
1A1+1B1+2B	75	25	50	92	11	52	85	15	50
1A1+1B1+2A	91	38	64	99	6	52	97	15	56
1A1+2A+2D1a	82	63	72	99	11	55	92	27	60
1A1+2A+2B	80	25	53	92	6	49	88	12	50
1A1+2B+2D1a	87	25	56	100	0	50	96	8	52
1B1+2A+2B	85	25	55	99	28	63	94	27	60
1B1+2A+2D1a	90	50	70	100	11	56	97	23	60
1B1+2B+2D1a	75	13	44	98	0	49	88	4	46
2A+2B+2D1a	78	38	58	99	11	55	90	19	55
1A1+1B1+2A+2B	80	38	59	99	17	58	91	23	57
1A1+1B1+2A+2D1a	82	50	66	99	11	55	92	23	58
1A1+1B1+2B+2D1a	87	50	69	100	6	53	96	19	57
1A1+2A+2B+2D1a	84	13	48	99	0	49	93	4	49
1B1+2A+2B+2D1a	78	50	64	99	28	63	90	35	62
All5_Index	84	38	61	99	6	52	93	15	54

Table 3-6. Success of multimetric indices in estimating chemically determined reference and impact sites in calibration, validation, and combined data sets for the spatial (60-m survey) model. Ref. = Reference.

	Calibration Database			Validation Database			Calibration + Validation		
	% Ref.	% Impact	Ave.	% Ref.	% Impact	Ave.	% Ref.	% Impact	Ave.
Index	**(39)**	**(2)**	**(2)**	**(5)**	**(1)**	**(2)**	**(44)**	**(3)**	**(2)**
1A1_Score	69	0	35	80	0	40	70	0	35
1B1_Score	100	0	50	100	0	50	100	0	50
2A_Score	46	50	48	80	100	90	50	67	58
2B_Score	87	100	94	100	0	50	89	67	78
2D1a_Score	74	50	62	80	100	90	75	67	71
1A1+1B1	69	0	35	80	0	40	70	0	35
1A1+2A	92	0	46	100	0	50	93	0	47
1A1+2B	85	50	67	100	0	50	86	33	60
1A1+2D1a	79	50	65	100	100	100	82	67	74
1B1+2A	67	0	33	100	0	50	70	0	35
1B1+2B	87	0	44	100	0	50	89	0	44
1B1+2D1a	74	0	37	80	0	40	75	0	38
2A+2B	95	50	72	100	0	50	95	33	64
2A+2D1A	92	50	71	100	100	100	93	67	80
2B+2D1a	82	50	66	100	100	100	84	67	75
1A1+1B1+2D1a	79	0	40	100	0	50	82	0	41
1A1+1B1+2B	85	0	42	100	0	50	86	0	43
1A1+1B1+2A	92	0	46	100	0	50	93	0	47
1A1+2A+2D1a	77	50	63	100	100	100	80	67	73
1A1+2A+2B	85	50	67	100	0	50	86	33	60
1A1+2B+2D1a	90	50	70	100	0	50	91	33	62
1B1+2A+2B	95	0	47	100	0	50	95	0	48
1B1+2A+2D1a	92	0	46	100	0	50	93	0	47
1B1+2B+2D1a	82	0	41	100	0	50	84	0	42
2A+2B+2D1a	87	50	69	100	100	100	89	67	78
1A1+1B1+2A+2B	85	0	42	100	0	50	86	0	43
1A1+1B1+2A+2D1a	77	0	38	100	0	50	80	0	40
1A1+1B1+2B+2D1a	90	0	45	100	0	50	91	0	45
1A1+2A+2B+2D1a	85	50	67	100	0	50	86	33	60
1B1+2A+2B+2D1a	87	50	69	100	0	50	89	33	61
All5_Index	85	0	42	100	0	50	86	0	43

Table 3-7. Success of multimetric indices in estimating chemically determined reference and impact sites in calibration, validation, and combined data sets for the temporal (historical) model. Ref. = Reference.

	Development Database			Validation Database			Development	Validation	Development	Validation	Development + Validation		
	% Ref.	% Impact	Ave.	% Ref.	% Impact	Ave.	Ref.	Ref.	Impact	Impact	% Ref.	% Impact	Ave.
Index	(0)	(1)	(1)	(88)	(17)	(2)	Count	Count	Count	Count	(88)	(18)	(2)
1A1_Score	-	100	100	78	6	42	-	69	1	1	78	11	45
1B1_Score	-	100	100	100	65	82	-	88	1	11	100	67	83
2A_Score	-	100	100	97	47	72	-	85	1	8	97	50	73
2B_Score	-	0	0	92	41	67	-	81	0	7	92	39	65
2D1a_Score	-	100	100	93	29	61	-	82	1	5	93	33	63
1A1+1B1	-	100	100	78	18	48	-	69	1	3	78	22	50
1A1+2A	-	100	100	99	6	52	-	87	1	1	99	11	55
1A1+2B	-	0	0	92	12	52	-	81	0	2	92	11	52
1A1+2D1a	-	100	100	91	6	48	-	80	1	1	91	11	51
1B1+2A	-	100	100	99	47	73	-	87	1	8	99	50	74
1B1+2B	-	0	0	92	47	70	-	81	0	8	92	44	68
1B1+2D1a	-	100	100	93	24	58	-	82	1	4	93	28	60
2A+2B	-	0	0	99	24	61	-	87	0	4	99	22	61
2A+2D1A	-	100	100	100	12	56	-	88	1	2	100	17	58
2B+2D1a	-	0	0	98	12	55	-	86	0	2	98	11	54
1A1+1B1+2D1a	-	100	100	91	0	45	-	80	1	0	91	6	48
1A1+1B1+2B	-	0	0	92	12	52	-	81	0	2	92	11	52
1A1+1B1+2A	-	100	100	99	6	52	-	87	1	1	99	11	55
1A1+2A+2D1a	-	100	100	99	6	52	-	87	1	1	99	11	55
1A1+2A+2B	-	0	0	99	6	52	-	87	0	1	99	6	52
1A1+2B+2D1a	-	0	0	100	0	50	-	88	0	0	100	0	50
1B1+2A+2B	-	0	0	99	29	64	-	87	0	5	99	28	63
1B1+2A+2D1a	-	100	100	100	12	56	-	88	1	2	100	17	58
1B1+2B+2D1a	-	0	0	98	0	49	-	86	0	0	98	0	49
2A+2B+2D1a	-	0	0	99	6	52	-	87	0	1	99	6	52
1A1+1B1+2A+2B	-	100	0	99	18	58	-	87	1	3	99	22	61
1A1+1B1+2A+2D1a	-	100	100	99	12	55	-	87	1	2	99	17	58
1A1+1B1+2B+2D1a	-	100	0	100	6	53	-	88	1	1	100	11	56
1A1+2A+2B+2D1a	-	0	0	99	0	49	-	87	0	0	99	0	49
1B1+2A+2B+2D1a	-	100	0	99	29	64	-	87	1	5	99	33	66
All5_Index	-	100	0	99	6	52	-	87	1	1	99	11	55

SECTION 4 – EVALUATION OF INDEX DEVELOPMETN APPROACHES

We used two approaches (multivariate weighted-averaging and multimetric) to create demersal fish and/or invertebrate biointegrity indices for the mainland shelf of southern California. Here we evaluate these approaches with regard to their thresholds and their general characteristics.

Thresholds

Comparison of BRI, FRI, IRI, and TRI Indices

The response index approach followed Smith *et al.* (1998, in press) to develop a reference index threshold value that distinguishes reference conditions from more polluted conditions. This approach computed a 90% tolerance interval for all index values from stations found in relatively uncontaminated reference areas. Reference observations in this part of our study (i.e., Section 2) were defined as observations with BRI values less than 25 (Figures 2-1, 2-2, 2-3). Thus it was based on BRI reference threshold values rather than sediment chemistry categories. The reference thresholds for the indices produced in Section 2 are FRI (45), IRI (46), and TRI (51).

Compared to the BRI reference threshold line in the spatial model (Figure 2-4), the FRI, IRI, and TRI indices only identified stations from the Palos Verdes Shelf area as departing from reference. In contrast, the BRI index identified stations on the Santa Monica, San Pedro, and San Diego Shelves as also departing from reference, although not so much as at Palos Verdes. This suggests that demersal fishes and megabenthic invertebrates are less sensitive to sediment contamination than infauna, and respond only when conditions are very bad.

In the temporal model results, all PVS outfall observations and three PVS control observations prior to 1978, departed from reference conditions (Figure 2-5). All SPS control observations and later PVS control observations fell within the reference range. In contrast, Palos Verdes outfall observations for IRI and TRI before 1987, and those for FRI before 1982 departed from reference. This suggests an earlier return to reference by the fish than by the invertebrates.

In developing the BRI index, impact categories were further divided according to type of impact to the assemblage: loss of biodiversity, BRI = 34; loss of community function, BRI = 44; and defaunation, BRI = 72 (Smith *et al.* 1998, in press).

In the spatial model results (of 1977), none of the sites in the BRI graph showed benthic defaunation (Figure 2-4). However, one site on the Santa Monica Shelf and four sites at Palos Verdes were above the loss of community function threshold, and these and another Santa Monica Shelf site and two San Pedro Shelf sites showed loss of infaunal biodiversity. Given these descriptors, the FRI, IRI, and TRI index values below the reference threshold at Palos Verdes generally fell within the BRI loss of infaunal community function category (one TRI value fell in the loss of biodiversity category). FRI values above reference corresponded to BRI categories of reference, intermediate, and loss of biodiversity.

In the temporal model results (Table 2-5), most BRI observations at the Palos Verdes outfall site before 1978 corresponded to defaunation conditions whereas most of the observations since then showed a loss of community function. For the FRI, the observations before 1976 corresponded to infaunal defaunation whereas those between 1976 and 1981 corresponded to loss of community function. Although IRI and TRI followed roughly this pattern prior to 1982, both indices approached 1973 levels in the 1985 observations at Palos Verdes. In 1985, there was a very large catch (15,000) of pelagic red crab (*Pleuroncodes planipes*) and a large catch of ridgeback rock shrimp (*Sicyonia ingentis*). The high abundance of both species was probably related to the 1982-1983 El Niño and likely the cause of the anomalous index values.

Application of the multimetric approach for determining reference and impact thresholds (Figure 3-1) to the FRI, IRI, and TRI results, showed that all of these indices had a 100% success rate in identifying predetermined impact sites on the middle shelf as a whole, and for the spatial and temporal models (Table 4-1). In contrast, the FFG index had a low success rate for estimating impact sites for the overall data base and historical but was relatively high (67%) for the spatial model.

From these comparisons, the fish assemblages do not depart from reference until infaunal community function is altered and they returned to reference earlier than did the megabenthic invertebrate assemblages. However, without the anomalous abundances in 1985, the invertebrate and trawl index responses might have been more comparable to the FRI response.

Comparison of Sediment Chemistry, BRI, FRI, and FFG Responses

Comparison of sediment chemistry and FFG index values to BRI impact categories provided additional insight into meaning of the spatial and temporal trends (Figures 4-1, 4-2). In the spatial model (Figure 4-1), the all or none sediment chemistry classification into three categories restricts fine scale interpretation of sites by comparison to the BRI. Although the Palos Verdes sites largely reflect loss of infaunal community function, the Santa Monica, San Pedro, and San Diego Shelf sites with intermediate sediment chemistry values represent loss of infaunal biodiversity, intermediate, and reference BRI conditions. The FFG (2A+2B+2D1a) index sites below the FFG impact threshold generally indicate loss of infaunal community function. Most of the sites above the FFG reference threshold correspond to the BRI reference and FRI threshold conditions. However, some FFG sites ranged across BRI loss of biodiversity, intermediate, and reference conditions, with the latter in the north. The FFG agreed with the FRI in identifying loss of function impact sites at Palos Verdes but whereas the FRI indicated that almost all change to the fish assemblages occurred at Palos Verdes, the FFG and BRI picked up some intermediate effect in Santa Monica Bay.

In the temporal model (Figure 4-2), the BRI suggests that the infaunal effect changed from infaunal defaunation prior to 1976 to loss of community function to about 1986. Due to the three category classification, a gradual change in sediment chemistry during this period is not shown but rather Palos Verdes sites were impact sites prior to 1982 and intermediate after. For the FFG index, all the sites before 1985 were regarded as intermediate with none (except one replicate in 1977 incorporated in the mean) fell below the impact threshold. In spite of not going into the impact zone, the general slope of the FFG closely follows that of the FRI and somewhat less closely that of the BRI. Based on BRI categories for the observations shown, these FFG intermediate values would represent infaunal defaunation and lack of community function – both regarded as high levels of impact.

Although the FFG impact threshold corresponded well to results of other thresholds in the spatial model (Figure 4-1), it did not work do well in the temporal model (Figure 4-2). If the impact threshold were raised from 1.8 to 3.0, it would identify the worst sites in the temporal model as impact. If so, it would also classify some northern stations, the Santa Monica Shelf stations, and more Palos Verdes stations as impact. The present location of the threshold appears appropriate for the spatial model but not for the temporal model.

General Characteristics of the Approaches

Response Index Approach

The response index approach uses a large number of species and determines their average position along a pollution gradient. As a number of environmental variables change along the gradient it, the position of different species on this gradient may be do to different variables (Appendices B6, B7, B8). For instance, the pollution gradient describes changes in contaminants, but may also correspond to changes in sediment particle size, total organic carbon, and planktonic, epibenthic, and infaunal organisms. The position of any species along the gradient might be related to one or more of these variables. However, the possibility does exist that it may be directly due to chemical contaminants. Because of the large number of species involved in creating the index, it is difficult to interpret without detailed analysis just what species, and hence environmental variables, are driving the index. However, the plots of species and other variables along the index gradient provide the basis for interpreting the results (Appendices B6, B7, and B8).

The inclusion of a large number of species in this analysis has potential positive and negative consequences. On the one hand, inclusion of a large number of species allows the index to be applied in different years or areas from those included in the calibration data base. Some relatively large portions of the species are likely to occur in the new data base. Thus it probably provides a robustness to the method. Smith *et al.* (1998, in press) removed the 10 most abundant species from the BRI index data base with little effect on the index performance. Many of the species included in the analysis may not be naturally important components of the shelf assemblage within a depth zone, but rather may be incidental species which are more commonly (and appropriately) found on different habitats or depths (Allen 1982). It is not known how removal of these generally less common species would affect the index performance.

Multimetric Approach

While the multimetric index approach may also be applied in such a way that direct responses of organisms to contaminants are emphasized, this would probably require use of single species or diseases (some of which might be more or less sensitive to contaminants) as metrics. We purposely did not include fin erosion as it is already well known to be a good single indicator of contaminated conditions (Mearns and Sherwood 1977, Stull 1995) and its presence would probably mask the influence of the other metrics. Groupings of species, particularly trophic groupings or habitat (e.g., sediment type) groupings will demonstrate responses of species to other noncontaminant variables along the gradient. The metrics used in this study, other than the population attributes (catch parameters), involved trophic groupings of species. As a result, any index produced would give information on trophic changes in the type of prey organisms available along the pollution gradient but do not necessarily give information on the sensitivity of species to contaminants. However, the use of these metrics gives an easily interpreted result.

Unfortunately, several guilds (e.g., pursuing benthopelagivore and ambushing benthopelagivore guilds) that were expected to be good indicators of outfall conditions (due to their repeated absence or low abundance at the Palos Verdes outfall area for many years; Allen 1977, 1987, 1990; Stull and Tang 1996) did not perform well using this approach because they were patchily distributed (i.e., variably present or abundant) in reference areas. Within the context of 20 years of sampling fixed stations around the Palos Verdes outfall, some of the species of these groups (e.g., longspine combfish, *Zaniolepis latipinnis*) showed persistent absence or low abundance nearest the outfall but were commonly found in higher abundance at adjacent stations (Stull and Tang 1996). Thus if zero abundances are included in the metric testing (as they were in this study), these guilds are excluded because they do not consistently occur at many reference sites also. The guilds used in this study varied in percent area of occurrence on the mainland shelf of southern California in 1994 from 0% (Guild 1B1) to 96% (Guild 2B), with 10 being greater than 50% (Allen *et al.* 1998). The guilds forming the FFG index are the three most frequently occurring guilds on the mainland shelf of southern California. Guilds 2B, 2D1a, and 2A occurred in 96, 92, and 75%, respectively, of the shelf area in 1994.

In developing a multimetric index, we may have not chosen the appropriate metrics. Other metrics that might be useful, including prevalence of diseases, percent expected guilds, percent expected species (both from Allen 1982, Allen *et al.* 1998), and single species rather than guilds. Individual guilds were used for possible insight into functional changes and because the results might be generally applicable to areas outside of the Southern California Bight.

Most Effective Index

Based on the overall performance, the FRI index appears to be an effective fish index, particularly in the middle shelf zone. Although not so effective, the FFG approach index may have value in interpreting the FRI index. Because the combination of guilds (2A+2B+2D1a) in the FFG index formed the only multimetric index with similar behavior as the FRI index in the spatial and temporal models, it may give insight into which guilds or species are driving the FRI response. Although the IRI and TRI indices performed less well, they are the only attempt to produce indices for southern California using megabenthic invertebrates and fish and invertebrates combined. Removal of the species with anomalously high abundances in 1985 (possibly resulting from the 1982-1983 El Niño) might improve the performance of these indices.

Comparison of reference thresholds among the BRI, FRI, and FFG indices suggests that demersal fish indices depart from reference where BRI values at the site indicate a loss of community function. Based on the guild shifts occurring in the FFG when this occurs (i.e., increased abundance of polychaete-feeding fishes and a decreased abundance of pericarid crustacean-feeding fishes), this suggest that the loss of community function is a shift in epibenthic community dominants from small crustaceans to polychaetes.

Future Work

The multivariate weighted-averaging approach produced fish indices for each of the three depths and invertebrate and trawl indices for the entire shelf. In the multimetric index approach, we produced indices for the middle shelf, outer shelf, and entire shelf. We did not fully explore the outer shelf and entire shelf index potential for the multimetric index due to time and effort constraints. Neither did we validate the inner shelf and outer shelf multivariate indices due to lack of appropriate validation models. We have also not applied these indices (multivariate and multimetric) to a data set for assessment. However, we will be continuing to examine these indices and, hopefully develop effective inner and outer shelf fish indices from data collected in 1998 throughout the shelf of the Southern California Bight (including bays and harbors, and islands). Application of these indices to these data will increase our understanding of their value and to adjust them, as appropriate, to be more effective. Thus this effort provides important first steps in demersal fish and megabenthic invertebrate index development for the southern California shelf.

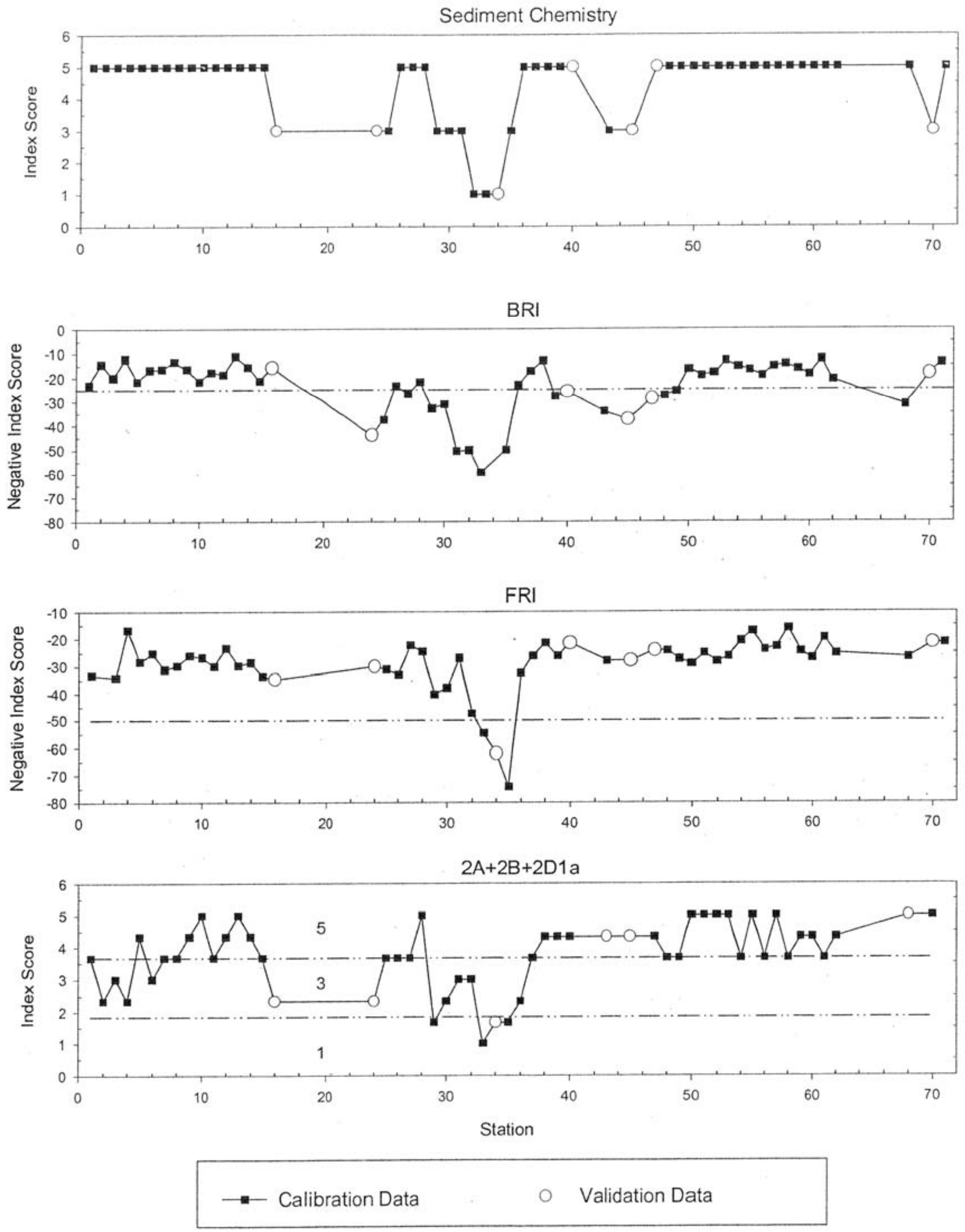


Figure 4-1. Comparison of middle shelf index responses to sediment chemistry conditions in spatial (60-m survey) model. Horizontal lines are thresholds (reference for BRI and FRI, reference and impact for 2A+2B+2D1a).

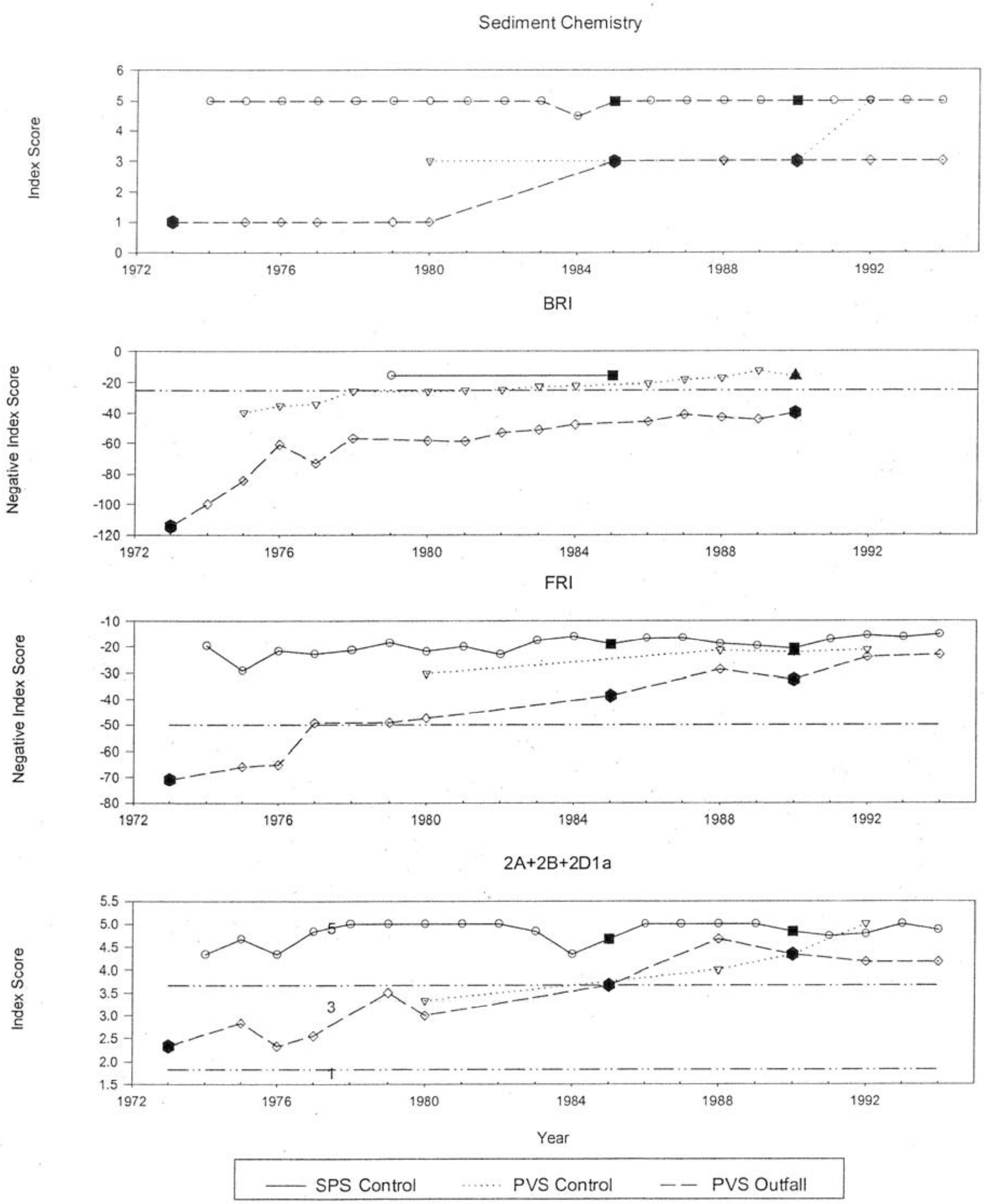


Figure 4-2. Comparison of middle shelf index responses to sediment chemistry conditions in temporal (historical) model at 60 m for Palos Verdes Shelf (PVS) and San Pedro Shelf (SPS). Horizontal lines are thresholds (reference for BRI and FRI, reference and impact for 2A+2B+2D1a).

Table 4-1. Success of ordination indices in estimating predertermined impact sites on spatial and temporal model site.

	Calibration Database						Validation Database						Calibration + Validation					
Index	% R	n	% I	n	Ave.	n	% R	n	% I	n	Ave.	n	% R	n	% I	n	Ave.	n
FRI[a]																		
60m	61	38	100	2	80	2	80	5	100	1	90	2	63	43	100	3	81	2
Historical	100	3	100	1	100	2	92	88	100	17	96	2	92	91	100	18	96	2
Overall[b]	75	96	100	8	88	2	92	89	100	13	96	2	83	185	100	26	92	2
IRI[c]																		
60m	53	36	100	2	76	2	75	4	100	1	88	2	55	40	100	3	78	2
Historical	100	3	100	1	100	2	74	76	100	8	87	2	75	79	100	9	87	2
Overall	75	95	100	8	87	2	74	77	100	9	87	2	74	172	100	17	87	2
TRI[d]																		
60m	47	36	100	2	74	2	75	4	100	1	88	2	50	40	100	3	75	2
Historical	100	3	100	1	100	2	82	77	100	8	91	2	83	80	100	9	91	2
Overall	75	95	100	8	87	2	82	78	100	9	91	2	78	173	100	17	89	2

R = Reference
I = Impacted

[a]Thresholds for FRI: reference criteria <=26.938, impact criteria >=32.413.
[b]Overall = combined calibration and validation data sets for the middle shelf as a whole.
[c]Thresholds for IRI: reference criteria <=34.595, impact criteria >=39.581.
[d]Thresholds for TRI: reference criteria <=36.418, impact criteria >=61.779.

CONCLUSIONS

1. We developed multivariate weighted-averaging indices for demersal fishes (at inner, middle, and outer shelf zones), megabenthic invertebrates (entire shelf), and trawl organisms (demersal fishes and invertebrates combined; entire shelf) and a multimetric index for the middle shelf based on foraging guild metrics.

2. All multivariate weighted-averaging indices (fish, invertebrate, and trawl organism) showed relatively good correspondence to spatial and historical models of contaminant trends based on sediment chemistry and the Benthic Response Index (BRI) at 60-m on the southern California shelf..

3. The Fish Response Index (FRI) followed the spatial and temporal tends more closely than did the Invertebrate Response Index (IRI) and the Trawl Response Index (TRI).

4. The multimetric Fish Foraging Guild (FFG) index showed similar spatial and temporal trend patterns as did sediment chemistry, BRI, and FRI indices.

5. The FRI index (a multivariate index) has the potential of including species that might be directly responding to contaminants along a pollution gradient, whereas the FFG index gives insight into trophic changes affecting fish populations along a pollution gradient.

6. The FFG index measures the relative importance of benthic pelagivore, benthic pelagobenthivore, and benthic extracting benthivore guilds along the pollution gradient, which in turn reflect changes in the relative abundance of polychaetes and pericarid crustaceans (mysids and gammarid amphipods) along the gradient.

7. Based on overall performance the FRI index appears to be an effective fish index, particularly in the middle shelf zone.

8. The FFG index may have value in interpreting the ecological meaning of the FRI index response.

9. Comparison of reference thresholds among the BRI, FRI, and FFG indices suggests that demersal fish indices depart from reference where BRI values at the site indicate a loss of community function.

10. Based on the guild shifts occurring in the FFG when this occurs, the loss of community function appears to be a shift in epibenthic community dominants from crustaceans to polychaetes.

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Appendix A1. Taxonomic list of demersal fish species collected in trawl samples (1973-1994) used in the calibration and validation data bases for developing fish and trawl biointegrity indices for the mainland shelf (9-215 m depth) of southern California.

Taxon/Species	Author	Common Name
MYXINI		HAGFISHES
--MYXINIFORMES		
Myxinidae		HAGFISHES
Eptatretus stoutii	(Lockington 1878)	Pacific hagfish
CHONDRICHTHYES		CARTILAGINOUS FISHES
--CHIMAERIFORMES		
Chimaeridae		CHIMAERAS
Hydrolagus colliei	(Lay & Bennett 1839)	spotted ratfish
-- HETERODONTIFORMES		
Heterodontidae		BULLHEAD SHARKS
Heterodontus francisci	(Girard 1854)	horn shark
-- CARCHARHINIFORMES		
Scyliorhinidae		CAT SHARKS
Cephaloscyllium ventriosum	(Garman 1880)	swell shark
Triakidae		HOUNDSHARKS
Mustelus henlei	(Gill 1862)	brown smoothhound
--SQUALIFORMES		
Squalidae		DOGFISH SHARKS
Squalus acanthias	Linnaeus 1758	spiny dogfish
-- SQUATINIFORMES		
Squatinidae		ANGEL SHARKS
Squatina californica	Ayres 1859	Pacific angel shark
-- RAJIFORMES		
Torpedinidae		ELECTRIC RAYS
Torpedo californica	Ayres 1855	Pacific electric ray
Rhinobatidae		GUITARFISHES
Platyrhinoidis triseriata	(Jordan & Gilbert 1880)	thornback
Rhinobatos productus	(Ayres 1854)	shovelnose guitarfish
Rajidae		SKATES
Raja binoculata	Girard 1854	big skate
Raja inornata	Jordan & Gilbert 1881	California skate
Raja stellulata	(Jordan & Gilbert 1880)	starry skate
Myliobatidae		EAGLE RAYS
Myliobatis californica	Gill 1865	bat ray
ACTINOPTERYGII		RAY-FINNED FISHES
-- CLUPEIFORMES		
Engraulidae		ANCHOVIES
Engraulis mordax	Girard 1854	northern anchovy
Clupeidae		HERRINGS
Sardinops sagax	(Jenyns 1842)	Pacific sardine

Appendix A1 (continued)

Taxon/Species	Author	Common Name
-- OSMERIFORMES		
Argentinidae		ARGENTINES
Argentina sialis	Gilbert 1890	Pacific argentine
--STOMIIFORMES		
Sternoptychidae		HATCHETFISHES
Argyropelecus sladeni	Regan 1908	lowcrest hatchetfish
-- AULOPIFORMES		
Synodontidae		LIZARDFISHES
Synodus lucioceps	(Ayres 1855)	California lizardfish
--OPHIDIIFORMES		
Ophidiidae		CUSK-EELS
Chilara taylori	(Girard 1858)	spotted cusk-eel
Bythitidae		VIVIPAROUS BROTULAS
Brosmophycis marginata	(Ayres 1854)	red brotula
-- GADIFORMES		
Moridae		CODLINGS
Physiculus rastrelliger	Gilbert 1890	hundred-fathom codling
Merlucciidae		MERLUCCID HAKES
Merluccius productus	(Ayres 1855)	Pacific hake
-- BATRACHOIDIFORMES		
Batrachoididae		TOADFISHES
Porichthys myriaster	Hubbs & Schultz 1939	specklefin midshipman
Porichthys notatus	Girard 1854	plainfin midshipman
-- GASTEROSTEIFORMES		
Syngnathidae		PIPEFISHES
Syngnathus californiensis	Storer 1845	kelp pipefish
Syngnathus exilis	(Osburn & Nichols 1916)	barcheek pipefish
-- SCORPAENIFORMES		
Scorpaenidae		SCORPIONFISHES
Scorpaena guttata	Girard 1854	California scorpionfish
Sebastes auriculatus	Girard 1854	brown rockfish
Sebastes caurinus	Richardson 1845	copper rockfish
Sebastes chlorostictus	(Jordan & Gilbert 1880)	greenspotted rockfish
Sebastes constellatus	(Jordan & Gilbert 1880)	starry rockfish
Sebastes crameri	(Jordan 1897)	darkblotched rockfish
Sebastes dallii	(Eigenmann & Beeson 1894)	calico rockfish
Sebastes diploproa	(Gilbert 1890)	splitnose rockfish
Sebastes elongatus	Ayres 1859	greenstriped rockfish
Sebastes eos	(Eigenmann & Eigenmann 1890)	pink rockfish
Sebastes goodei	(Eigenmann & Eigenmann 1890)	chilipepper
Sebastes hopkinsi	(Cramer 1895)	squarespot rockfish
Sebastes jordani	(Gilbert 1896)	shortbelly rockfish
Sebastes levis	(Eigenmann & Eigenmann 1889)	cowcod
Sebastes macdonaldi	(Eigenmann & Beeson 1893)	Mexican rockfish
Sebastes miniatus	(Jordan & Gilbert 1880)	vermilion rockfish
Sebastes mystinus	(Jordan & Gilbert 1881)	blue rockfish
Sebastes paucispinis	Ayres 1854	boccacio

Appendix A1 (continued)

Taxon/Species	Author	Common Name
Scorpaenidae (continued)		
Sebastes pinniger	(Gill 1864)	canary rockfish
Sebastes rosaceus	Girard 1854	rosy rockfish
Sebastes rosenblatti	Chen 1971	greenblotched rockfish
Sebastes rubrivinctus	(Jordan & Gilbert 1880)	flag rockfish
Sebastes saxicola	(Gilbert 1890)	stripetail rockfish
Sebastes semicinctus	(Gilbert 1897)	halfbanded rockfish
Sebastes serranoides	(Eigenmann & Eigenmann 1890)	olive rockfish
Sebastes umbrosus	(Jordan & Gilbert 1882)	honeycomb rockfish
Sebastolobus alascanus	Bean 1890	shortspine thornyhead
Triglidae		SEAROBINS
Prionotus stephanophrys	Lockington 1881	lumptail searobin
Anoplopomatidae		SABLEFISHES
Anoplopoma fimbria	(Pallas 1814)	sablefish
Hexagrammidae		GREENLINGS
Ophiodon elongatus	Girard 1854	lingcod
Oxylebius pictus	Gill 1862	painted greenling
Zaniolepis frenata	Eigenmann & Eigenmann 1889	shortspine combfish
Zaniolepis latipinnis	Girard 1857	longspine combfish
Cottidae		SCULPINS
Chitonotus pugetensis	(Steindachner 1876)	roughback sculpin
Icelinus cavifrons	Gilbert 1890	pit-head sculpin
Icelinus filamentosus	Gilbert 1890	threadfin sculpin
Icelinus fimbriatus	Gilbert 1890	fringed sculpin
Icelinus quadriseriatus	(Lockington 1880)	yellowchin sculpin
Icelinus tenuis	Gilbert 1890	spotfin sculpin
Leptocottus armatus	Girard 1854	Pacific staghorn sculpin
Radulinus asprellus	Gilbert 1890	slim sculpin
Agonidae		POACHERS
Agonopsis sterletus	(Gilbert 1898)	southern spearnose poacher
Agonopsis vulsa	(Jordan & Gilbert 1880)	northern spearnose poacher
Odontopyxis trispinosa	Lockington 1880	pygmy poacher
Xeneretmus latifrons	(Gilbert 1890)	blacktip poacher
Xeneretmus triacanthus	(Gilbert 1890)	bluespotted poacher
-- PERCIFORMES		
Serranidae		SEA BASSES
Paralabrax clathratus	(Girard 1854)	kelp bass
Paralabrax nebulifer	(Girard 1854)	barred sand bass
Malacanthidae		TILEFISHES
Caulolatilus princeps	(Jenyns 1842)	ocean whitefish
Carangidae		JACKS
Trachurus symmetricus	(Ayres 1855)	jack mackerel
Sciaenidae		DRUMS
Genyonemus lineatus	(Ayres 1855)	white croaker
Seriphus politus	Ayres 1860	queenfish

Appendix A1 (continued)

Taxon/Species	Author	Common Name
Kyphosidae		SEA CHUBS
Girella nigricans	(Ayres 1860)	opaleye
Medialuna californiensis	(Steindachner 1875)	halfmoon
Embiotocidae		SURFPERCHES
Cymatogaster aggregata	Gibbons 1854	shiner perch
Embiotoca jacksoni	Agassiz 1853	black perch
Hypsurus caryi	(Agassiz 1853)	rainbow seaperch
Phanerodon atripes	(Jordan & Gilbert 1880)	sharpnose seaperch
Phanerodon furcatus	Girard 1854	white seaperch
Rhacochilus toxotes	Agassiz 1854	rubberlip seaperch
Rhacochilus vacca	(Girard 1855)	pile perch
Zalembius rosaceus	(Jordan & Gilbert 1880)	pink seaperch
Pomacentridae		DAMSELFISHES
Chromis punctipinnis	(Cooper 1863)	blacksmith
Labridae		WRASSES
Halichoeres semicinctus	(Ayres 1859)	rock wrasse
Semicossyphus pulcher	(Ayres 1854)	California sheephead
Bathymasteridae		RONQUILS
Rathbunella alleni	Gilbert 1904	rough ronquil
Rathbunella hypoplecta	(Gilbert 1890)	stripedfin ronquil
Zoarcidae		EELPOUTS
Lycodes cortezianus	(Gilbert 1890)	bigfin eelpout
Lycodopsis pacifica	(Collett 1879)	blackbelly eelpout
Lyconema barbatum	Gilbert 1896	bearded eelpout
Stichaeidae		PRICKLEBACKS
Plectobranchus evides	Gilbert 1890	bluebarred prickleback
Uranoscopidae		STARGAZERS
Kathetostoma averruncus	Jordan & Bollman 1890	smooth stargazer
Clinidae		CLINIDS
Heterostichus rostratus	Girard 1854	giant kelpfish
Neoclinus blanchardi	Girard 1858	sarcastic fringehead
Gobiidae		GOBIES
Coryphopterus nicholsii	(Bean 1882)	blackeye goby
Lepidogobius lepidus	(Girard 1858)	bay goby
Stromateidae		BUTTERFISHES
Peprilus simillimus	(Ayres 1860)	Pacific pompano
-- PLEURONECTIFORMES		
Paralichthyidae		WHIFFS
Citharichthys fragilis	Gilbert 1890	gulf sanddab
Citharichthys sordidus	(Girard 1854)	Pacific sanddab
Citharichthys stigmaeus	Jordan & Gilbert 1882	speckled sanddab
Citharichthys xanthostigma	Gilbert 1890	longfin sanddab
Hippoglossina stomata	Eigenmann & Eigenmann 1890	bigmouth sole
Paralichthys californicus	(Ayres 1859)	California halibut
Xystreurys liolepis	Jordan & Gilbert 1880	fantail sole
Pleuronectidae		
Eopsetta jordani	(Lockington 1879)	petrale sole

Appendix A1 (continued)

Taxon/Species	Author	Common Name
Pleuronectidae (continued)		RIGHTEYE FLOUNDERS
Glyptocephalus (= Errex) zachirus	Lockington 1879	rex sole
Lyopsetta (= *Eopsetta*) *exilis*	(Jordan & Gilbert 1880)	slender sole
Microstomus pacificus	(Lockington 1879)	Dover sole
Parophrys vetula (= *Pleuronectes vetulus*)	Girard 1854	English sole
Pleuronichthys coenosus	Girard 1854	C-O sole
Pleuronichthys decurrens	Jordan & Gilbert 1880	curlfin sole
Pleuronichthys guttulatus (*Hypsopsetta guttulata*)	Girard 1856	diamond turbot
Pleuronichthys ritteri	Starks & Morris 1907	spotted turbot
Pleuronichthys verticalis	Jordan & Gilbert 1880	hornyhead turbot
Cynoglossidae		TONGUEFISHES
Symphurus atricauda	(Jordan & Gilbert 1880)	California tonguefish

Taxonomic arrangement (Nelson 1994); scientific and common names generally from Robins *et al*. 1991; pleuronectid scientific names updated according to Cooper and Chapleau (1998).

Appendix A2. Taxonomic list of megabenthic invertebrate species collected in trawl samples (1973-1994) in calibration and validation data bases for developing invertebrate and trawl biointegrity indices for the southern California mainland shelf (9-215 m depth).

Taxon/Species	Author	Common Name
PORIFERA		
Porifera unid.		sponge, unid.
CALCAREA		
--SCYCETTIDA		
Grantiidae		
Leucandra heathi	Urban 1905	spiny vase sponge
Amphoriscidae		
Leucilla nuttingi	(Urban 1902)	urn sponge
HEXACTINELLIDA		
Hexactinellida unid.		glass sponge, unid.
DEMOSPONGIAE		
Demospongiae unid.		frame sponge, unid.
--Spirophorida		
Tetillidae		
Tetilla arb	de Laubenfels 1930	gray puffball sponge
--HADROMERIDA		
Suberitidae		
Suberites suberea	(Johnston 1842)	"sponge"
Spirastrellidae		
Spheciospongia confoederata	de Laubenfels 1930	gray moonsponge
Tethyidae		
Tethya aurantium	(Pallas 1766)	orange puffball sponge
--AXINELLIDA		
Raspailiidae		
Hemectyon hyle	de Laubenfels 1932	bushy sponge
--POECILOSCLERIDA		
Poecilosclerida unid.		variegated sponge, unid.
Myxillidae		
Myxilla incrustans	(Esper 1805-1814)	scallop sponge
Myxilla fimbriata	(Bowerbank 1864)	sponge
CNIDARIA		
HYDROZOA		
Hydrozoa unid.		hydrozoan, unid.
--ATHECATAE		
Tubulariidae		
Tubularia crocea	(L. Agassiz 1862)	pink-mouth hydroid
--THECATAE		
Campanulariidae		
Obelia longissima	(Pallas 1766)	hydroid
Aglaopheniidae		
Aglaophenia sp.		feather hydroid, unid.
Plumulariidae		
Plumulariidae unid.		plumulariid hydrozoan, unid.

Appendix A2 (continued)

Taxon/Species	Author	Common Name
--SIPHONOPHORA		
Rhodaliidae		
Dromalia alexandri	Bigelow 1911	sea strawberry
ANTHOZOA		
Anthozoa unid.		anthozoan, unid.
--ALCYONACEA		
Gorgonacea unid.		gorgonian, unid.
Clavulariidae		
Telesto sp.		soft coral, unid.
Gorgoniidae		
Adelogorgia phyllosclera	Bayer 1958	orange gorgonian
Eugorgia sp.		gorgonian, unid.
Eugorgia rubens	Verrill 1868	purple gorgonian
Heterogorgia sp.		gorgonian, unid.
Heterogorgia tortuosa	Verrill 1868	"gorgonian"
Lophogorgia chilensis	(Verrill 1868)	pink sea whip
Muriceidae		
Muricea californica	Aurivillius 1931	golden gorgonian
Thesea sp.		sea twig, unid.
Thesea sp. B	Ljubenkov 1986	yellow sea twig
--PENNATULACEA		
Pennatulacea unid.		sea pen, unid.
Renillidae		
Renilla koellikeri	Pfeffer 1886	purple sea pansy
Virgulariidae		
Acanthoptilum sp.		trailtip sea pen, unid.
Stylatula elongata	(Gabb 1862)	slender sea pen
Stylatula sp. A	Ljubenkov 1991	"sea pen"
Virgularia sp.		"sea pen"
Virgularia agassizii	Studer 1894	"sea pen"
Virgularia californica	Pfeffer 1886	"sea pen"
Pennatulidae		
Pennatula phosphorea	Linnaeus 1758	"sea pen"
Ptilosarcus gurneyi	(Gray 1860)	fleshy sea pen
--CERIANTHARIA		
Ceriantharia unid.		tube anemone, unid.
--SCLERACTINIA		
Caryophylliidae		
Coenocyathus bowersi	Vaughan 1906	"cup coral"
Desmophyllum dianthus	(Esper 1794)	"cup coral"
Paracyathus stearnsii	Verrill 1869	brown cup coral
--ACTINIARIA		
Actinaria sp. 25		anemone #25
Actinaria sp. 83		anemone #83
Actiniidae		
Epiactis prolifera	Verrill 1869	brooding anemone

Hormathiidae		
Amphianthus sp. OC2		"anemone"

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Metridiidae		
Metridium senile Cmplx		"clonal plumose anemone"
--CORALLIMORPHARIA		
Corallimorphidae		
Corynactis californica	Carlgren 1936	strawberry corallimorpharian
--Zoanthidea		
Zoanthidea sp. 5		zoanthid #5
PLATYHELMINTHES		
Platyhelminthes unid.		Platyhelminthes, unid.
MOLLUSCA		
POLYPLACOPHORA		
Polyplacophora unid.		chiton, unid.
--NEOLORICATA		
Lepidopleuridae		
Hanleya hanleyi	(Bean 1844)	eastern hanleya
Ischnochitonidae		
Callistochiton palmulatus	Carpenter in Dall 1879	big-end chiton
Lepidozona mertensii	(Middendorff 1847)	Merten chiton
Lepidozona sinudentata	(Carpenter in Pilsbry 1892)	whitestripe chiton
Mopaliidae		
Dendrochiton thamnoporus	(Berry 1911)	"bushy chiton"
GASTROPODA		
Gastropoda unid.		gastropod, unid.
--VETIGASTROPODA		
Fissurellidae		
Cranopsis multistriata	Dall 1914	many-rib puncturella
Diodora aspera	(Rathke 1833)	rough keyhole limpet
Turbinidae		
Lithopoma undosum	(Wood 1828)	wavy turban
Trochidae		
Calliostoma sp.		topsnail, unid.
Calliostoma canaliculatum	(Lightfoot 1786)	channeled topsnail
Calliostoma tricolor	Gabb 1865	tricolor topsnail
Calliostoma turbinum	Dall 1896	spindle topsnail
Cidarina cidaris	(Carpenter 1864)	Adam spiny margarite
Norrisia norrisi	(Sowerby II 1838)	norrissnail
--NEOTAENIOGLOSSA		
Cerithiidae		
Lirobittium sp.		"horn shell"
Calyptraeidae		
Calyptraea fastigiata	Gould 1856	Pacific Chinese-hat
Crepidula sp.		slippersnail unid.
Crepidula glottidiarum	Dall 1905	"slippersnail"

Crepidula onyx	Sowerby I 1824	onyx slippersnail
Crepidula perforans	(Valenciennes 1846)	

Appendix A2 (continued)

Taxon/Species	**Author**	**Common Name**
Ovulidae		
Neosimnia aequalis	(Sowerby I 1832)	Vidler simnia
Neosimnia loebbeckeana	(Weinkauff 1881)	"simnia"
Lamellariidae		
Lamellaria sp.		
Lamellaria diegoensis	Dall in Orcutt 1885	San Diego lamellaria
Naticidae		
Calinaticina oldroydii	(Dall 1897)	delicate moonsnail
Neverita reclusiana	(Deshayes 1839)	southern moonsnail
Polinices draconis	(Dall 1903)	Drake moonsnail
Polinices lewisii	(Gould 1847)	Lewis moonsnail
Sinum scopulosum	(Conrad 1849)	fat baby-ear
Bursidae		
Crossata californica	(Hinds 1843)	California frogsnail
Epitoniidae		
Epitonium sp.		wentletrap, unid.
Epitonium tinctum	(Carpenter 1865)	tinted wentletrap
Eulimidae		
Polygireulima rutila	(Carpenter 1864)	auburn eulima
--NEOGASTROPODA		
Muricidae		
Boreotrophon bentleyi	Dall 1908	"trophon"
Ceratostoma sp.		thornmouth, unid.
Maxwellia santarosana	(Dall 1905)	Santa Rosa murex
Pteropurpura sp.		murex, unid.
Pteropurpura festiva	(Hinds 1844)	festive murex
Pteropurpura macroptera	(DeShayes 1839)	frill-wing murex
Pteropurpura trialata	(G. B. Sowerby II 1834)	three-wing murex
Pteropurpura vokesae	Emerson 1964	wrinkle-wing murex
Coralliophilidae		
Babelomurex oldroydi	(I. S. Oldroyd 1929)	Olyroyd coralsnail
Columbellidae		
Alia carinata	(Hinds 1844)	carinate dovesnail
Amphissa undata	(Carpenter 1864)	Carpenter amphissa
Amphissa versicolor	Dall 1871	variagate amphissa
Buccinidae		
Kelletia kelletii (=*kelletti*)	(Forbes 1850)	Kellet whelk
Neptunea tabulata	(Baird 1863)	tabled whelk
Nassariidae		
Nassarius sp.		nassa, unid.
Nassarius fossatus	(Gould 1849)	channeled nassa
Nassarius insculptus		smooth western nassa
Nassarius mendicus	(Gould 1849)	lean nassa

Nassarius perpinguis	(Hinds 1844)	fat western nassa
Fasciolariidae		
Fusinus sp.		spindle, unid.
Fusinus barbarensis	(Trask 1855)	Santa Barbara spindle

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Mitridae		
Mitra idae	Melvill 1893	half-pitted miter
Cancellariidae		
Cancellaria cooperi	Gabb 1865	Cooper nutmeg
Cancellaria crawfordiana	Dall 1891	Crawford nutmeg
Conidae		
Conus californicus	Hinds 1844	California cone
Ophiodermella cancellata	(Carpenter 1864)	cancellate snakeskin-snail
Terebridae		
Terebra pedroana	Dall 1908	San Pedro auger
Turridae		
Antiplanes sp.		"turrid"
Antiplanes catalinae	(Raymond 1904)	Catalina turrid
Antiplanes thalea	(Dall 1902)	"turrid"
Crassispira semiinflata	(Grant & Gale 1931)	California drillia
Megasurcula carpenteriana	(Gabb 1865)	tower snail
Megasurcula stearnsiana	(Raymond 1904)	Stearns turrid
--HETEROSTROPHA		
Pyramidellidae		
Turbonilla sp.		"turbonille"
--ANASPIDEA		
Aplysiidae		
Aplysia sp.		seahare, unid.
Aplysia californica	J. G. Cooper 1863	California seahare
--CEPHALASPIDEA		
Philinoidea unid.		phyllinoid sea slug, unid.
Aglajidae		
Aglaja ocelligera	(Bergh 1893)	
Navanax inermis	(Cooper 1862)	California aglaja
Philinidae		
Philine sp.		paperbubble, unid.
Philine alba	Mattox 1958	white paperbubble
Gastropteridae		
Gastropteron pacificum	Bergh 1893	Pacific batwing sea slug
--NOTASPIDEA		
Pleurobranchaeidae		
Berthella californica	(Dall 1900)	California sidegill slug
Pleurobranchaea californica	MacFarland 1966	California sea slug
--NUDIBRANCHIA		
Doridoidea unid.		doridoid nudibranch, unid.
Cadlinidae		
Cadlina flavomaculata	MacFarland 1905	
Cadlina modesta	MacFarland 1966	modest cadlina

Archidorididae		
Archidoris montereyensis	(J. G. Cooper 1863)	Monterey sea-lemon
Discodorididae		
Anisodoris nobilis	(MacFarland 1905)	Pacific sea-lemon
Diaulula sandiegensis	(J. G. Cooper 1863)	ringed doris

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Platydorididae		
Platydoris macfarlandi	Hanna 1951	California flat doris
Onchidorididae		
Acanthodoris brunnea	MacFarland 1905	brown spiny doris
Acanthodoris rhodoceras	Cockerell in Cockerell & Elliot 1905	black-tipped spiny doris
Notodorididae		
Aegires albopunctatus	MacFarland 1905	salt-and-pepper doris
Polyceratidae		
Triopha maculata	MacFarland 1905	maculated triopha
Dendrodorididae		
Dendrodoris fulva	(MacFarland 1905)	yellow porostome
Doriopsilla albopunctata	(J. G. Cooper 1863)	salted yellow doris
Tritoniidae		
Tritonia diomedea	Bergh 1894	rosy tritonia
Tritonia festiva	(Stearns 1873)	diamondback tritonia
Dendronotidae		
Dendronotus iris	J. G. Cooper 1863	giant frond-aeolis
Arminidae		
Armina californica	(J. G. Cooper 1863)	California armina
Flabellinidae		
Flabellina iodinea	J. G. Cooper 1863	purple aeolis
Flabellina pricei	(MacFarland 1966)	smooth-tooth aeolis
Facelinidae		
Hermissenda crassicornis	(Eschscholtz 1831)	hermissenda
BIVALVIA		
--MYTILOIDA		
Mytilidae		
Modiolus sp.		horsemussel, unid.
Modiolus neglectus	Soot-Ryen 1955	neglected horsemussel
Modiolus sacculifer	(Berry 1953)	bag horsemussel
Mytilus galloprovincialis	Lamarck 1819	Mediterranean mussel
Solamen columbianum	(Dall 1897)	British Columbia crenella
--LIMOIDA		
Limidae		
Limaria hemphilli	(Hertlein & Strong 1946)	Hemphill fileclam
--OSTREOIDA		
Pectinidae		
Chlamys hastata	(G. B. Sowerby II 1843)	spiny scallop
Crassadoma gigantea	(J. E. Gray 1825)	giant rock scallop
Delectopecten vancouverensis	(Whiteaves 1893)	Vancouver scallop

Euvola diegensis	(Dall 1898)	San Diego scallop
Leptopecten latiauratus	(Conrad 1837)	kelp scallop
Anomiidae		
Anomia peruviana	d'Orbigny 1846	Peruvian jingle
Pododesmus macroschisma	(Deshayes 1839)	Alaska falsejingle

Appendix A2 (continued)

Taxon/Species	Author	Common Name
--VENEROIDA		
Chamidae		
Chama arcana	Bernard 1976	secret jewelbox
Pseudochama granti	Strong 1934	Grant jewelbox
--MYOIDA		
Hiatellidae		
Hiatella arctica	(Linnaeus 1767)	Arctic hiatella
CEPHALOPODA		
--SEPIOIDEA		
Sepiolidae		
Rossia pacifica	Berry 1911	eastern Pacific bobtail
--TEUTHOIDEA		
Loliginiidae		
Loligo opalescens	Berry 1911	California market squid
Histioteuthidae		
Histioteuthis heteropsis	(Berry 1913)	"umbrella squid"
--OCTOPODA		
Opisthoteuthidae		
Opisthoteuthis sp. A	Hochberg 1976 §	"flapjack octopus"
Octopodidae		
Octopus sp.		octopus, unid.
Octopus californicus	(Berry 1911)	orange bigeye octopus
Octopus rubescens	Berry 1953	red octopus
Octopus veligero	Berry 1953	short arm octopus
ECHIURA		
ECHIURA		
--ECHIUROINEA		
Thalassematidae		
Listriolobus pelodes	Fisher 1946	spoonworm
ANNELIDA		
POLYCHAETA		
--SPIONIDA		
Spionidae		
Prionospio lighti	Maciolek 1985	"spionid polychaete"
--PHYLLODOCIDA		
Aphroditidae		
Aphrodita sp.		sea mouse, unid.
Aphrodita armifera	Moore 1910	copper sea mouse
Aphrodita castanea	Moore 1910	chestnut sea mouse

Aphrodita japonica	Marenzeller 1879	black sea mouse
Aphrodita refulgida	Moore 1910	green sea mouse
Polynoidae		
Arctonoe pulchra	(Johnson 1897)	"scaleworm"
Halosydna latior	Chamberlin 1919	"scaleworm"
Hololepida magna	Moore 1905	beercan worm

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Nereididae		
Platynereis bicanaliculata	(Baird 1863)	"clam worm"
Glyceridae		
Glycera americana	Leidy 1855	"blood worm"
--EUNICIDA		
Onuphidae		
Hyalinoecia juvenalis	Moore 1911	"onuphid tubeworm"
--TEREBELLIDA		
Ampharetidae		
Amphicteis scaphobranchiata	Moore 1906	"ampharetid tubeworm"
--SABELLIDA		
Serpulidae		
Protula superba	Moore 1909	chalktube worm
HIRUDINEA		
Hirudinea unid.		leech, unid.
ARTHROPODA		
PYCNOGONIDA		
--PEGMATA		
Nymphonidae		
Nymphon pixellae	Scott 1913	"sea spider"
CIRRIPEDIA		
Cirripedia unid.		barnacle, unid.
--THORACICA		
Scalpellidae		
Hamatoscalpellum californicum	(Pilsbry 1907)	California blade barnacle
Archaeobalanidae		
Conopea galeata	(Linnaeus 1771)	"barnacle"
Balanidae		
Balanus sp.		acorn barnacle, unid.
Balanus nubilus	Darwin 1854	giant acorn barnacle
Balanus pacificus	Pilsbry 1916	Pacific acorn barnacle
MALACOSTRACA		
--STOMATOPODA		
Hemisquillidae		
Hemisquilla ensigera californiensis	Stephenson 1967	blueleg mantis shrimp
Pseudosquillidae		
Pseudosquillopsis marmorata	(Lockington 1877)	"mantis shrimp"

Squillidae		
Schmittius politus	(Bigelow 1891)	polished mantis shrimp
-MYSIDACEA		
Mysidae		
Holmesiella anomala	Ortmann 1908	"mysid"
Neomysis kadiakensis	Ortmann 1908	"mysid"

Appendix A2 (continued)

Taxon/Species	Author	Common Name
--ISOPODA		
Aegidae		
Rocinela angustata	Richardson 1904	"fish louse"
Corallanidae		
Excorallana truncata	(Richardson 1899)	"fish louse"
Cymothoidae		
Elthusa (=Livoneca) californica	Schioedte and Meinert 1881	California fish louse
Elthusa (=Livoneca) vulgaris	Stimpson 1857	Pacific fish louse
Nerocila acuminata	Schioedte and Meinert 1881	"fish louse"
--DECAPODA		
Decapoda unid.		decapod, unid.
Brachyura unid.		crab, unid.
Solenoceridae		
Solenocera mutator	Burkenroad 1938	"humpback shrimp"
Penaeidae		
Penaeus californiensis	Holmes 1900	yellowleg shrimp
Sicyoniidae		
Sicyonia sp.		rock shrimp, unid.
Sicyonia ingentis	(Burkenroad 1938)	ridgeback rock shrimp
Sicyonia penicillata	Lockington 1879	target shrimp
Pandalidae		
Pandalus danae	Stimpson 1857	dock shrimp
Pandalus jordani	Rathbun 1902	ocean shrimp
Pandalus platyceros	Brandt 1851	spot shrimp
Alpheidae		
Alpheopsis equidactylus	(Lockington 1877)	"snapping shrimp"
Alpheus sp.		snapping shrimp, unid.
Alpheus clamator	Lockington 1877	twistclaw pistol shrimp
Synalpheus lockingtoni	(Coutiere 1909)	littoral pistol shrimp
Hippolytidae		
Eualus herdmani	(Walker 1898)	Herdman eualid
Heptacarpus brevirostris	(Dana 1852)	stout coastal shrimp
Heptacarpus palpator	(Owen 1839)	intertidal coastal shrimp
Heptacarpus sitchensis	(Brandt 1851)	Sitka coastal shrimp
Heptacarpus stimpsoni	Holthuis 1947	Stimpson coastal shrimp
Heptacarpus tenuissiumus	Holmes 1900	slender coastal shrimp
Lysmata californica	(Stimpson 1866)	red rock shrimp
Spirontocaris sp.		blade shrimp, unid.
Spirontocaris holmesi	Holthuis 1947	slender blade shrimp

Spirontocaris sica	Rathbun 1902	offshore blade shrimp
Spirontocaris snyderi	Rathbun 1902	Snyder blade shrimp
Crangonidae		
Crangon sp.		bay shrimp, unid.
Crangon alaskensis	Lockington 1877	Alaska bay shrimp
Crangon alba	Holmes 1900	stout crangon
Crangon nigricauda	Stimpson 1856	blacktail bay shrimp
Crangon nigromaculata	Lockington 1877	blackspotted bay shrimp
Mesocrangon munitella	(Walker 1898)	miniature spinyhead

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Crangonidae (continued)		
Metacrangon spinosissima	(Rathbun 1902)	southern spinyhead
Neocrangon communis	(Rathbun 1899)	gray shrimp
Neocrangon resima	(Rathbun 1902)	flagnose bay shrimp
Neocrangon zacae	(Chace 1937)	shortkeel bay shrimp
Palaemonidae		
Pseudocoutierea elegans	Holthuis 1951	gorgonian shrimp
Palinuridae		
Panulirus interruptus	Randall 1839	California spiny lobster
Axiidae		
Calocarides spinulicauda	(Rathbun 1902)	keeled mud lobster
Diogenidae		
Isocheles pilosus	(Holmes 1900)	moon snail hermit
Paguristes sp.		hermit, unid.
Paguristes bakeri	Holmes 1900	digger hermit
Paguristes turgidus	(Stimpson 1857)	slenderclaw hermit
Paguristes ulreyi	Schmitt 1921	furry hermit
Paguridae		
Paguridae unid.		
Enallopaguropsis guatemoci	(Glassell 1937)	"hermit"
Orthopagurus minimus	(Holmes 1900)	tubicolous hermit
Pagurus sp.		hermit, unid.
Pagurus sp. 5		"hermit"
Pagurus armatus	(Dana 1851)	armed hermit
Pagurus redondoensis	Wicksten 1982	bandclaw hermit
Pagurus retrorsimanus	Wicksten & McLaughlin 1998	"hermit"
Pagurus spilocarpus	Haig 1977	spotwrist hermit
Parapagurodes sp.		hermit, unid.
Parapagurodes laurentae	McLaughlin & Haig 1973	spinypalm hermit
Parapagurodes makarovi	McLaughlin & Haig 1973	smoothpalm hermit
Phimochirus californiensis	(Benedict 1892)	Calirornia hermit
Parapaguridae		
Sympagurus haigae	(de Saint Laurent 1972)	"deepwater hermit crab"
Lithodidae		
Glyptolithodes cristatipes	(Faxon 1893)	"stone crab"
Lopholithodes foraminatus	(Stimpson 1859)	brown box crab
Paralithodes californiensis	(Benedict 1894)	California king crab
Paralithodes rathbuni	(Benedict 1894)	forknose king crab

Galatheidae		
Galathea californiensis	Benedict 1902	California squat lobster
Pleuroncodes planipes	Stimpson 1860	pelagic red crab
Dromiidae		
Cryptodromiopsis larraburei	(Rathbun 1910)	"sponge crab"
Calappidae		
Platymera gaudichaudii	Milne Edwards 1837	armed box crab
Leucosiidae		
Randallia ornata	(Randall 1839)	globose sand crab

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Majidae		
Majidae unid.		spider crab, unid.
Chorilia longipes	Dana 1851	longhorn decorator crab
Erileptus spinosus	Rathbun 1893	shortneck pear crab
Loxorhynchus sp.		masking crab, unid.
Loxorhynchus crispatus	Stimpson 1857	moss crab
Loxorhynchus grandis	Stimpson 1857	sheep crab
Mimulus foliatus	Stimpson 1860	foliate kelp crab
Podochela sp.	Garth 1958	crab
Podochela hemphillii	(Lockington 1877)	Hemphill kelp crab
Podochela lobifrons	Rathbun 1893	thinbeak neck crab
Pugettia sp.		kelp crab, unid.
Pugettia dalli	Rathbun 1893	spined kelp crab
Pugettia producta	(Randall 1839)	northern kelp crab
Pyromaia tuberculata	(Lockington 1877)	tuberculate pear crab
Majidae (continued)		
Scyra acutifrons	Dana 1851	sharpnose crab
Parthenopidae		
Heterocrypta occidentalis	(Dana 1854)	sandflat elbow crab
Cancridae		
Cancer sp.		rock crab, unid.
Cancer amphioetus	Rathbun 1898	bigtooth rock crab
Cancer antennarius	Stimpson 1856	Pacific rock crab
Cancer anthonyi	Rathbun 1879	yellow rock crab
Cancer branneri	Rathbun 1926	furrowed rock crab
Cancer gracilis	Dana 1852	graceful rock crab
Cancer jordani	Rathbun 1900	hairy rock crab
Cancer productus	Randall 1839	red rock crab
Portunidae		
Portunus xantusii	(Stimpson 1860)	Xantus swimming crab
Xanthidae		
Xanthidae unid.		
Lophopanopeus sp.		crestley crab, unid.
Lophopanopeus bellus	(Stimpson 1860)	blackclaw crestleg crab
Paraxanthias taylori	(Stimpson 1861)	lumpy rubble crab
Pilumnus spinohirsutus	(Lockington 1876)	retiring hairy crab
Pinnotheridae		

Pinnotheridae unid.		pea crab, unid.
Pinnixa sp.		pea crab, unid.
Pinnixa franciscana	Rathbun 1918	innkeeper pea crab
Pinnixa occidentalis	Rathbun 1893	spoonworm pea crab
Pinnixa tubicola	Holmes 1894	tubeworm pea crab
Palicidae		
Palicus cortezi	(Crane 1937)	Cortez stilt crab
ECHINODERMATA		
CRINOIDEA		
Crinoidea unid.		sea lily, unid.

Appendix A2 (continued)

Taxon/Species	**Author**	**Common Name**
--COMATULIDA		
Antedonidae		
Florometra serratissima	(A. H. Clark 1907)	feather star
ASTEROIDEA		
Asteroidea unid.		sand star, unid.
--PAXILLOSIDA		
Luidiidae		
Luidia sp.		velvet sand star, unid.
Luidia armata	Ludwig 1905	mosaic sand star
Luidia asthenosoma	Fisher 1906	fringed sand star
Luidia foliolata	Grube 1866	gray sand star
Astropectinidae		
Astropecten sp.		margined sand star, unid.
Astropecten armatus	Gray 1840	spiny sand star
Astropecten ornatissimus	Fisher 1906	orange sand star
Astropecten verrilli	de Loriol 1899	California sand star
--VALVATIDA		
Goniasteridae		
Mediaster aequalis	Stimpson 1857	red sea star
Asterinidae		
Asterina miniata	(Brandt 1835)	bat star
--SPINULOSIDA		
Echinasteridae		
Henricia leviuscula	(Stimpson 1857)	blood star
--FORCIPULATIDA		
Asteriidae		
Leptasterias hexactis	(Stimpson 1853)	knobless six-rayed sea star
Pisaster brevispinus	(Stimpson 1857)	shortspined sea star
Pisaster giganteus capitatus	(Stimpson 1862)	giant-spined sea star
Pycnopodia helianthoides	(Brandt 1835)	sunflower star
Rathbunaster californicus	Fisher 1906	sun star
Sclerasterias sp.		sea star, inid.
Sclerasterias heteropaes	Fisher 1924	banded sea star
Stylasterias forreri	(de Loriol 1887)	fish-eating sea star
OPHIUROIDEA		
Ophiuroidea unid.		ophiuroid, unid.

--PHRYNOPHIURIDA		
Gorgonocephalidae		
Gorgonocephalus eucnemis	(J. Müller & Troschel 1842)	basket star
--OPHIURIDA		
Ophiacanthidae		
Ophiacantha diplasia	Clark 1911	"spinyarm brittlestar"
Ophiacantha phragma	Ziesenhenne 1940	fragile spinyarm brittlestar
Ophiactidae		
Ophiopholis bakeri	McClendon 1909	roughspine brittlestar

Appendix A2 (continued)

Taxon/Species	**Author**	**Common Name**
Amphiuridae		
Amphiuridae unid.		amphiurid brittlestar, unid.
Amphichondrius granulatus	(Lutken & Mortensen 1899)	roughdisk brittlestar
Amphiodia psara	H. L. Clark 1935	"brittlestar"
Amphiodia urtica	(Lyman 1860)	red brittlestar
Amphipholis squamata	(Delle Chiaje 1828)	holdfast brittlestar
Amphiura arcystata	H. L. Clark 1911	"brittlestar"
Dougaloplus amphacanthus	(McClendon 1909)	"brittlestar"
Ophiotricidae		
Ophiothrix spiculata	Le Conte 1851	Pacific spiny brittlestar
Ophiocomidae		
Ophiopteris papillosa	(Lyman 1875)	flatspine brittlestar
Ophionereidae		
Ophionereis eurybrachiplax	H. L. Clark 1911	"brittlestar"
Ophiuridae		
Ophiura luetkeni	(Lyman 1860)	brokenspine brittlestar
ECHINOIDEA		
--TEMNOPLEUROIDA		
Toxopneustidae		
Lytechinus pictus	(Verrill 1867)	white sea urchin
--ECHINOIDA		
Strongylocentrotidae		
Allocentrotus fragilis	(Jackson 1912)	fragile sea urchin
Strongylocentrotus sp.		sea urchin, unid.
Strongylocentrotus franciscanus	(Agassiz 1863)	red sea urchin
Strongylocentrotus purpuratus	(Stimpson 1857)	Pacific purple urchin
--CLYPEASTEROIDA		
Dendrasteridae		
Dendraster excentricus	(Eschscholtz 1831)	Pacific sand dollar
Dendraster terminalis	(Grant & Hertlein 1938)	
--SPATANGOIDA		
Schizasteridae		
Brisaster latifrons	(A. Agassiz 1898)	northern heart urchin
Brissidae		
Brissopsis pacifica	(A. Agassiz 1898)	Pacific heart urchin

Spatangidae		
Spatangus californicus	H. L. Clark 1917	California heart urchin
Loveniidae		
Lovenia cordiformis	A. Agassiz 1872	sea porcupine
HOLOTHUROIDEA		
Holothuroidea unid.		sea cucumber, unid.
--DENDROCHIROTIDA		
Psolidae		
Psolidium bidiscum	Lambert 1996	"sea cucumber"
Psolus chitonoides	H. L. Clark 1901	slipper sea cucumber
Sclerodactylidae		
Pachythyone rubra	(H. L. Clark 1901)	redback sea cucumber

Appendix A2 (continued)

Taxon/Species	Author	Common Name
Phyllophoridae		
Havelockia benti	(Deichmann 1937)	"hooked cucumber"
Pentamera sp.		hooked cucumber, unid.
Pentamera populifera	(Stimpson 1857)	bent hooked cucumber
Pentamera pseudocalcigera	Deichmann 1938	southern hooked cucumber
Pentamera pseudopopulifera	Deichmann 1938	"hooked cucumber"
Cucumariidae		
Cucumaria salma	Yingst 1972	salmon sea cucumber
Cucumaria piperata	(Stimpson 1864)	"sea cucumber"
Pseudocnus sp.		"sea cucumber"
--ASPIDOCHIROTIDA		
Stichopodidae		
Parastichopus sp.		"sea cucumber"
Parastichopus californicus	(Stimpson 1857)	California sea cucumber
--ELASIPODIDA		
Laetmogonidae		
Pannychia moseleyi	Théel 1882	"sea cucumber"
BRACHIOPODA		
INARTICULATA		
--LINGULIDA		
Lingulidae		
Glottidia albida	(Hinds 1844)	burrowing lampshell
ARTICULATA		
--TEREBRATULIDA		
Cancellothyrididae		
Terebratulina crossei	Davidson 1882	white lamp shell
Laqueidae		
Laqueus californianus	Koch 1847	California lamp shell
Terebratalia occidentalis	(Dall 1871)	ribbed lamp shell
ECTOPROCTA		
Ectoprocta unid.		ectoproct, unid.
GYMNOLAEMATA		

--CTENOSTOMATA		
Alcyonidiidae		
Alcyonidium sp. A	MEC 1991 §	"bryozoan"
CHORDATA		
Urochordata unid.		Urochordate, unid.
ASCIDIACEA		
Ascidiacea unid.		tunicate, unid.
--PHLEBOBRANCHIATA		
Cionidae		
Ciona intestinalis	(Linnaeus 1767)	transluscent tunicate
Ascidiidae		
Ascidia ceratodes	(Huntsman 1912)	horned tunicate

Appendix A2 (continued)

Taxon/Species	**Author**	**Common Name**
Corellidae		
Chelyosoma sp.		tunicate, unid.
Corella willmeriana	Herdman 1898	icy tunicate
--STOLIDOBRANCHIATA		
Styelidae		
Polyandrocarpa sp.		sea squirt, unid.
Styela sp.		sea squirt, unid.
Styela sp. A		"sea squirt"
Styela coriacea	(Alder & Hancock 1848)	pimpled sea squirt
Styela gibbsii	(Stimpson 1864)	wrinkled sea squirt
Styela montereyensis	(Dall 1872)	longstalk sea squirt
Styela plicata	(Lesueur 1823)	cobblestone sea squirt
Pyuridae		
Boltenia villosa	(Stimpson 1864)	spiny-headed tunicate
Halocynthia igaboja	Oka 1906	spiny sea peach
Microcosmos squamiger	Hartmeyer & Michaelsen 1926	scaly tunicate
Molgulidae		
Molgulidae unid.		tunicate, unid.
Eugyra arenosa californica	Van Name 1945	sandflat tunicate
Molgula sp.		"sea grape"
Molgula regularis	Ritter 1907	"sea grape"

Taxonomic order and scientific names largely from SCAMIT (1998)

Appendix A3. Characteristics of trawl stations on the mainland shelf of southern California used for the demersal fish and/or invertebrate index calibration data base.

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
T1-023	LA	1973	23	33	44.42	118	25.06	Intermediate	45.8	No	Yes
T1-061	LA	1973	61	33	44.18	118	25.18	Impacted	65.6	Yes	Yes
T1-137	SC	1973	134	33	40.97	118	19.13	Intermediate	50.7	-	-
T1-137	LA	1973	137	33	44.00	118	25.29	Intermediate	50.7	Yes	No
T2-023	LA	1973	23	33	44.08	118	22.50	Intermediate	58.5	No	No
T2-061	LA	1973	61	33	43.75	118	23.00	Impacted	67.9	Yes	No
T2-061	LA	1973	61	33	43.75	118	23.00	Impacted	67.9	Yes	No
T2-137	LA	1973	137	33	43.00	118	23.00	Intermediate	61.8	Yes	No
T3-023	LA	1973	23	33	43.75	118	25.25	Intermediate	57.0	No	No
T3-061	LA	1973	61	33	43.00	118	22.50	Impacted	71.9	Yes	No
T3-137	LA	1973	137	33	42.58	118	22.00	Impacted	66.8	Yes	No
T4-023	LA	1973	23	33	42.48	118	20.26	Intermediate	65.2	Yes	No
T4-061	LA	1973	61	33	42.18	118	20.43	Impacted	95.1	Yes	No
T4-137	LA	1973	137	33	41.54	118	21.01	Impacted	83.3	Yes	Yes
T5-023	LA	1973	23	33	42.18	118	19.00	Intermediate	70.6	Yes	No
T5-061	LA	1973	61	33	41.33	118	19.23	Impacted	73.0	Yes	Yes
T5-137	LA	1973	137	33	41.13	118	19.37	Impacted	60.5	Yes	No
T5-137	SC	1973	146	33	43.80	118	25.40	Impacted	60.5	-	-
R01	SC	1977	62	34	25.75	120	26.75	Reference	23.0	No	No
R02	SC	1977	59	34	22.08	120	22.00	Reference	14.3	No	No
R03	SC	1977	59	34	26.47	120	15.92	Reference	20.0	No	Yes
R04	SC	1977	81	34	25.67	120	10.00	Reference	12.2	No	No
R05	SC	1977	61	34	26.25	120	4.03	Reference	21.6	No	No
R06	SC	1977	67	34	24.27	119	56.80	Reference	16.6	No	Yes
R07	SC	1977	61	34	22.83	119	46.91	Reference	16.4	No	No
R08	SC	1977	61	34	21.17	119	41.25	Reference	13.2	No	No
R09	SC	1977	64	34	18.25	119	30.00	Reference	16.4	No	No
R10	SC	1977	59	34	13.50	119	27.49	Reference	21.5	No	No
R11	SC	1977	58	34	9.83	119	23.17	Reference	17.8	No	No
R12	SC	1977	53	34	7.25	119	18.34	Reference	18.7	No	No
R13	SC	1977	65	34	3.83	119	9.94	Reference	11.1	No	No
R14	SC	1977	58	34	1.67	118	57.41	Reference	15.6	No	No
R15	SC	1977	58	34	0.75	118	51.53	Reference	21.3	No	No
R25	SC	1977	60	33	54.60	118	31.50	Intermediate	37.3	No	No
R26	SC	1977	60	33	53.55	118	31.50	Reference	23.3	No	No
R27	SC	1977	60	33	52.33	118	28.33	Reference	26.8	No	No
R28	SC	1977	80	33	50.70	118	26.60	Reference	21.7	No	No
R29	SC	1977	59	33	48.25	118	26.25	Intermediate	32.8	No	No
R30	SC	1977	57	33	47.00	118	27.00	Intermediate	31.0	No	No
R31	SC	1977	59	33	43.90	118	24.90	Intermediate	50.5	Yes	No

Appendix A3 (continued)

				Station Coordinates[b]				Impact		Fin	
Station	Agency[a]	Year	Depth (m)	Lat No (dm)		Long W (dm)		Category	BRI[c]	Erosion	Tumor
R32	SC	1977	58	33	43.42	118	22.95	Impacted	50.1	Yes	No
R33	SC	1977	59	33	42.80	118	21.50	Impacted	59.5	Yes	No
R35	SC	1977	55	33	41.30	118	18.90	Intermediate	50.0	Yes	No
R36	SC	1977	56	33	38.75	118	15.85	Reference	23.1	No	No
R37	SC	1977	55	33	36.33	118	14.80	Reference	17.3	No	No
R38	SC	1977	60	33	34.60	118	10.84	Reference	13.1	No	No
R39	SC	1977	58	33	35.80	118	3.82	Reference	27.7	No	No
R43	SC	1977	59	33	34.75	118	0.83	Intermediate	34.2	No	No
R48	SC	1977	60	33	34.38	117	59.59	Reference	27.5	No	No
R49	SC	1977	60	33	34.22	117	58.95	Reference	25.5	Yes	No
R50	SC	1977	59	33	35.17	117	53.53	Reference	16.5	No	No
R51	SC	1977	60	33	30.10	117	46.50	Reference	19.1	No	No
R52	SC	1977	57	33	22.93	117	44.00	Reference	18.0	No	No
R53	SC	1977	55	33	24.10	117	39.50	Reference	12.9	No	No
R54	SC	1977	55	33	22.13	117	38.15	Reference	15.4	No	No
R55	SC	1977	59	33	17.60	117	33.50	Reference	16.7	No	No
R56	SC	1977	59	33	14.20	117	29.75	Reference	19.2	No	No
R57	SC	1977	60	33	10.60	117	25.80	Reference	15.3	No	No
R58	SC	1977	60	33	7.60	117	21.30	Reference	14.4	No	No
R59	SC	1977	60	33	3.20	117	19.70	Reference	16.4	No	No
R60	SC	1977	60	32	58.50	117	18.50	Reference	18.8	No	No
R61	SC	1977	62	32	53.75	117	16.50	Reference	12.4	No	No
R62	SC	1977	64	32	49.50	117	19.20	Reference	20.8	No	No
R68	SC	1977	62	32	39.83	117	16.85	Reference	31.4	No	No
R71	SC	1977	60	32	36.00	117	16.25	Reference	13.9	No	No
R04	SC	1985	150	34	25.14	120	10.26	Reference	22.8	No	No
R04	SC	1985	30	34	27.71	120	10.50	Reference	21.7	No	No
R04	SC	1985	60	34	26.99	120	10.35	Reference	16.9	No	No
R05	SC	1985	150	34	24.12	120	3.93	Reference	17.3	No	No
R05	SC	1985	60	34	26.56	120	4.33	Reference	16.3	No	No
R05	SC	1985	30	34	27.30	120	4.43	Reference	22.1	No	No
R08	SC	1985	60	34	21.11	119	41.29	Reference	11.6	No	No
R08	SC	1985	150	34	17.38	119	41.34	Reference	19.4	No	No
R08	SC	1985	30	34	23.22	119	41.31	Reference	24.1	No	No
R13	SC	1985	30	34	5.30	119	9.08	Reference	19.4	No	No
R13	SC	1985	60	34	3.77	119	10.20	Reference	10.2	No	No
R13	SC	1985	150	34	3.58	119	10.36	Reference	14.4	No	No
R50	SC	1985	60	33	29.88	117	46.51	Reference	15.0	No	No
R50	SC	1985	30	33	30.61	117	46.05	Reference	25.1	No	No
R50	SC	1985	150	33	29.43	117	46.84	Reference	20.7	No	No
R52	SC	1985	150	33	23.60	117	40.95	Reference	21.1	No	No

Appendix A3 (continued)

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
R52	SC	1985	60	33	23.72	117	39.90	Reference	15.2	No	No
R52	SC	1985	30	33	24.29	117	39.26	Reference	25.9	No	No
R54	SC	1985	60	33	17.42	117	33.53	Reference	11.3	No	No
R54	SC	1985	30	33	18.12	117	32.69	Reference	21.8	No	No
R54	SC	1985	150	33	15.97	117	34.76	Reference	10.1	No	No
R57	SC	1985	60	33	7.37	117	21.55	Reference	23.8	No	No
R57	SC	1985	30	33	6.81	117	20.84	Reference	20.0	No	No
R57	SC	1985	150	33	7.61	117	22.83	Reference	20.9	No	No
R60	SC	1985	150	32	54.80	117	17.01	Reference	31.5	No	No
R60	SC	1985	60	32	53.32	117	16.66	Reference	22.2	No	No
R60	SC	1985	30	32	53.68	117	16.13	Reference	18.3	No	No
R61	SC	1985	150	32	49.50	117	21.72	Reference	13.0	No	No
R61	SC	1985	60	32	49.29	117	19.21	Reference	12.5	No	No
R71	SC	1985	30	32	32.52	117	11.41	Reference	23.6	No	No
R71	SC	1985	150	32	34.27	117	19.33	Intermediate	10.7	No	No
R71	SC	1985	60	32	33.12	117	15.82	Reference	8.1	No	No
T0-023	LA	1985	23	33	48.13	118	25.02	Intermediate	22.2	No	No
T0-023	LA	1985	23	33	48.13	118	25.02	Intermediate	22.2	No	No
T0-137	LA	1985	137	33	48.47	118	26.21	Intermediate	36.7	No	No
T1-061	LA	1985	61	33	44.18	118	25.18	Intermediate	43.4	Yes	No
T11	MEC	1985	55	33	36.04	118	5.32	Intermediate	21.4	No	No
T11	MEC	1985	55	33	36.04	118	5.32	Intermediate	21.4	No	No
T4-061	LA	1985	61	33	42.18	118	20.43	Intermediate	60.4	Yes	No
T4-061	LA	1985	61	33	42.18	118	20.43	Intermediate	60.4	Yes	No
T4-137	LA	1985	137	33	41.54	118	21.01	Intermediate	60.0	Yes	No
T4-137	LA	1985	137	33	41.54	118	21.01	Intermediate	60.0	Yes	No
T5-023	LA	1985	23	33	42.18	118	19.00	Intermediate	43.8	No	No
T5-061	LA	1985	61	33	41.33	118	19.23	Intermediate	50.5	Yes	No
T5-137	LA	1985	137	33	41.13	118	19.37	Impacted	52.9	Yes	Yes
T5-137	LA	1985	137	33	41.13	118	19.37	Impacted	52.9	No	Yes
R13	SC	1990	30	34	5.30	119	9.08	Reference	16.5	No	No
R13	SC	1990	150	34	3.58	119	10.36	Reference	14.3	No	No
R13	SC	1990	60	34	4.20	119	9.58	Reference	13.0	No	No
R15	SC	1990	150	33	59.88	118	52.30	Reference	14.8	No	No
R15	SC	1990	30	34	1.47	118	51.11	Reference	22.0	No	No
R15	SC	1990	60	34	1.13	118	51.38	Reference	20.0	No	No
R50	SC	1990	150	33	29.43	117	46.84	Reference	15.7	No	Yes
R50	SC	1990	30	33	30.44	117	46.11	Reference	28.0	No	No
R50	SC	1990	60	33	29.64	117	46.63	Reference	13.8	No	No
R52	SC	1990	60	33	23.72	117	39.90	Reference	13.3	No	No
R52	SC	1990	30	33	24.29	117	39.26	Reference	20.3	No	No

Appendix A3 (continued)

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
R52	SC	1990	150	33	23.53	117	40.96	Reference	14.1	No	No
R60	SC	1990	30	32	53.68	117	16.13	Reference	19.3	No	No
R60	SC	1990	150	32	54.80	117	17.01	Reference	25.5	No	No
R60	SC	1990	60	32	53.32	117	16.66	Reference	14.9	No	No
R61	SC	1990	150	32	49.50	117	21.72	Reference	13.3	No	No
R61	SC	1990	60	32	49.29	117	19.21	Reference	16.8	No	No
R71	SC	1990	150	32	34.27	117	19.33	Reference	9.4	No	No
R71	SC	1990	30	32	32.52	117	11.41	Reference	27.7	No	No
R71	SC	1990	60	32	33.12	117	15.82	Reference	16.3	No	No
T0-023	LA	1990	23	33	48.13	118	25.02	Intermediate	27.1	No	No
T0-023	LA	1990	23	33	48.13	118	25.02	Intermediate	27.1	No	No
T0-061	LA	1990	61	33	48.34	118	25.50	Intermediate	23.1	No	No
T0-061	LA	1990	61	33	48.34	118	25.50	Intermediate	23.1	No	No
T0-137	LA	1990	137	33	48.47	118	26.21	Intermediate	30.9	No	Yes
T11	MEC	1990	55	33	36.04	118	5.32	Intermediate	19.8	No	No
T4-023	LA	1990	23	33	42.48	118	20.26	Intermediate	36.9	No	No
T4-061	LA	1990	61	33	42.18	118	20.43	Intermediate	42.3	Yes	Yes
T4-137	LA	1990	137	33	41.54	118	21.01	Intermediate	42.6	No	Yes
T5-023	LA	1990	23	33	42.18	118	19.00	Intermediate	41.9	No	No
T5-061	LA	1990	61	33	41.33	118	19.23	Intermediate	40.0	No	No
T5-137	LA	1990	137	33	41.13	118	19.37	Intermediate	36.5	No	Yes
0016	SC	1994	26	34	27.18	120	1.90	Intermediate	22.8	No	No
0032	SC	1994	62	34	26.83	120	13.58	Reference	14.9	No	No
0038	SC	1994	53	34	26.63	120	3.91	Intermediate	17.6	No	No
0059	SC	1994	73	34	26.23	120	14.00	Intermediate	7.9	No	No
0115	SC	1994	71	34	24.97	120	20.15	Reference	4.0	No	No
0122	SC	1994	74	34	24.71	120	25.09	Reference	9.4	No	No
0150	SC	1994	78	34	24.47	120	24.60	Reference	4.7	No	No
0161	SC	1994	18	34	24.27	119	47.31	Reference	24.2	No	No
0228	SC	1994	50	34	23.33	119	47.58	Intermediate	22.3	No	No
0234	SC	1994	38	34	23.13	119	40.75	Reference	28.9	No	No
0245	SC	1994	132	34	22.83	120	25.09	Reference	2.7	No	No
0252	SC	1994	42	34	23.05	119	38.14	Intermediate	23.9	No	No
0255	SC	1994	175	34	22.81	120	23.85	Intermediate	6.0	No	No
0289	SC	1994	51	34	22.16	119	38.84	Intermediate	20.5	No	No
0366	SC	1994	20	34	20.24	119	26.80	Reference	30.1	No	No
0381	SC	1994	156	34	19.87	119	47.01	Reference	14.8	No	No
0398	SC	1994	54	34	19.39	119	31.77	Intermediate	16.9	No	No
0407	SC	1994	62	34	19.25	119	33.64	Intermediate	8.9	No	No
0474	SC	1994	71	34	17.25	119	30.72	Intermediate	8.1	No	No
0480	SC	1994	104	34	17.01	119	38.42	Intermediate	5.8	No	No

Appendix A3 (continued)

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
0499	SC	1994	113	34	16.67	119	38.79	Reference	8.2	No	No
0502	SC	1994	33	34	16.51	119	24.61	Intermediate	33.2	No	No
0537	SC	1994	43	34	15.24	119	26.11	Intermediate	20.7	No	No
0542	SC	1994	69	34	15.26	119	29.63	Reference	10.7	No	No
0577	SC	1994	105	34	14.34	119	35.91	Reference	4.7	No	No
0604	SC	1994	160	34	13.62	119	37.12	Reference	10.5	No	No
0652	SC	1994	24	34	12.54	119	21.04	Intermediate	23.4	No	No
0665	SC	1994	24	34	12.37	119	20.91	Reference	29.9	No	No
0670	SC	1994	203	34	12.14	119	39.77	Reference	17.3	No	No
0682	SC	1994	203	34	11.82	119	37.87	Reference	2.0	No	No
0708	SC	1994	185	34	11.05	119	33.92	Reference	10.9	No	No
0714	SC	1994	100	34	10.61	119	27.11	Reference	9.8	No	No
0739	SC	1994	150	34	9.78	119	26.64	Reference	3.3	No	No
0753	SC	1994	156	34	9.36	119	25.54	Reference	-3.6	No	No
0758	SC	1994	19	34	9.28	119	17.00	Reference	16.9	No	No
0759	SC	1994	21	34	9.20	119	18.05	Reference	19.9	No	No
0814	SC	1994	25	34	5.79	119	10.10	Reference	17.6	No	No
0815	SC	1994	193	34	5.79	119	17.66	Reference	0.5	No	No
0820	SC	1994	9	34	5.15	119	4.35	Reference	11.9	No	No
0823	SC	1994	107	34	5.20	119	15.04	Reference	8.8	No	No
0830	SC	1994	41	34	4.94	119	10.35	Reference	7.2	No	No
0846	SC	1994	63	34	3.82	119	7.10	Intermediate	6.5	No	No
0859	SC	1994	192	34	3.31	119	12.59	Reference	5.3	No	No
0890	SC	1994	41	34	1.75	118	56.70	Reference	11.5	No	No
0902	HYes	1994	19	34	1.35	118	42.24	Intermediate	19.7	No	No
0943	HYes	1994	42	34	0.41	118	35.59	Intermediate	19.1	No	No
0960	HYes	1994	50	33	59.92	118	35.58	Intermediate	10.4	No	No
0976	SC	1994	163	33	59.58	119	0.19	Intermediate	11.8	No	No
0993	HYes	1994	58	33	59.32	118	35.45	Intermediate	9.8	No	No
1028	HYes	1994	128	33	57.90	118	35.28	Intermediate	20.3	No	No
1042	HYes	1994	23	33	57.42	118	29.03	Intermediate	20.3	No	No
1046	HYes	1994	14	33	56.00	118	27.60	Reference	8.2	No	No
1049	HYes	1994	53	33	56.62	118	32.28	Intermediate	18.2	No	No
1052	HYes	1994	215	33	56.32	118	36.36	Intermediate	37.9	No	No
1072	HYes	1994	66	33	54.90	118	32.67	Intermediate	20.0	No	No
1108	HYes	1994	58	33	53.03	118	29.68	Intermediate	20.2	No	No
1109	HYes	1994	57	33	52.75	118	30.98	Intermediate	18.2	No	No
1126	HYes	1994	83	33	51.97	118	29.19	Intermediate	15.9	No	No
1142	LA	1994	75	33	51.08	118	27.52	Intermediate	8.4	No	No
1148	HYes	1994	100	33	50.96	118	30.96	Intermediate	23.4	No	No
1152	HYes	1994	171	33	50.66	118	35.46	Intermediate	10.9	No	No

Appendix A3 (continued)

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
1159	LA	1994	127	33	50.54	118	26.14	Intermediate	20.4	No	No
1169	LA	1994	135	33	49.90	118	30.39	Intermediate	14.9	No	No
1173	LA	1994	62	33	49.41	118	25.31	Intermediate	15.6	No	No
1175	LA	1994	208	33	49.21	118	32.87	Intermediate	15.2	No	No
1208	LA	1994	13	33	44.02	118	8.87	Intermediate	36.1	No	No
1222	LA	1994	16	33	43.34	118	12.27	Reference	16.1	No	No
1227	LA	1994	19	33	43.07	118	9.79	Intermediate	24.1	No	No
1256	LA	1994	23	33	41.91	118	11.29	Intermediate	14.4	No	No
1267	LA	1994	44	33	41.26	118	17.85	Intermediate	31.3	No	No
1272	OC	1994	16	33	41.20	118	5.37	Reference	16.0	No	No
1287	OC	1994	15	33	40.67	118	3.98	Reference	20.8	No	No
1300	OC	1994	24	33	39.97	118	6.44	Reference	21.1	No	No
1306	OC	1994	14	33	39.95	118	2.82	Reference	18.3	No	No
1332	LA	1994	32	33	38.78	118	8.89	Reference	19.1	No	No
1348	OC	1994	16	33	38.10	118	0.84	Reference	18.9	No	No
1355	OC	1994	33	33	37.90	118	5.04	Reference	16.9	No	No
1401	OC	1994	21	33	36.32	117	58.24	Intermediate	29.2	No	No
1406	OC	1994	35	33	36.18	118	2.79	Intermediate	13.7	No	No
1415	OC	1994	33	33	35.87	118	0.80	Intermediate	17.6	No	No
1417	OC	1994	30	33	35.88	117	58.08	Intermediate	31.4	No	No
1418	OC	1994	97	33	35.69	118	6.48	Reference	11.0	No	No
1424	OC	1994	22	33	35.66	117	55.18	Reference	20.1	No	No
1426	OC	1994	44	33	35.60	118	3.01	Intermediate	12.8	No	No
1469	OC	1994	162	33	34.25	118	2.72	Intermediate	14.3	No	No
1550	OC	1994	14	33	21.35	117	34.80	Reference	22.7	No	No
1551	OC	1994	174	33	21.13	117	38.83	Reference	14.6	No	No
1571	OC	1994	188	33	19.21	117	37.59	Reference	11.9	No	No
1574	OC	1994	95	33	19.01	117	36.64	Reference	3.5	No	No
1585	OC	1994	72	33	17.86	117	34.75	Reference	6.6	No	No
1617	OC	1994	17	33	15.10	117	28.03	Reference	15.3	No	No
1650	OC	1994	16	33	10.84	117	23.93	Reference	16.0	No	No
1655	OC	1994	197	33	10.51	117	27.47	Intermediate	13.3	No	No
1662	OC	1994	176	33	9.46	117	25.43	Reference	12.8	No	No
1667	OC	1994	65	33	8.50	117	22.54	Reference	10.9	No	No
1684	OC	1994	15	33	4.05	117	18.92	Reference	3.0	No	No
1734	SD	1994	49	32	52.84	117	16.32	Reference	7.6	No	No
1737	SD	1994	187	32	52.67	117	18.87	Reference	11.3	No	No
1767	SD	1994	85	32	48.30	117	20.81	Intermediate	0.0	No	No
1769	SD	1994	70	32	48.07	117	19.67	Intermediate	2.8	No	No
1774	SD	1994	104	32	47.50	117	22.30	Reference	4.8	No	No
1776	SD	1994	24	32	47.21	117	16.88	Intermediate	13.4	No	No

Appendix A3 (continued)

Station	Agency[a]	Year	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Fin Erosion	Tumor
1780	SD	1994	15	32	46.89	117	16.04	Intermediate	8.8	No	No
1794	SD	1994	97	32	45.59	117	21.92	Intermediate	0.5	No	No
1797	SD	1994	86	32	45.57	117	20.26	Intermediate	1.0	No	No
1833	SD	1994	91	32	41.53	117	19.30	Intermediate	0.1	No	No
1839	SD	1994	41	32	40.62	117	16.46	Intermediate	22.6	No	No
1850	SD	1994	110	32	39.50	117	19.76	Intermediate	0.4	No	No
1867	SD	1994	17	32	38.58	117	11.18	Reference	9.6	No	No
1871	SD	1994	89	32	38.21	117	18.62	Intermediate	0.8	No	No
1892	SD	1994	62	32	37.37	117	16.37	Reference	9.3	No	No
1944	SD	1994	18	32	35.29	117	9.65	Reference	18.6	No	No
2001	SD	1994	43	32	32.46	117	13.87	Reference	6.8	No	No

[a]Agencies

HY = City of Los Angeles, Environmental Monitoring Division
LA = County Sanitation Districts of Los Angeles County
OC = County Sanitation Districts of Orange County
SC = Southern California Coastal Water Research Project
SD = City of San Diego, Metropolitan Wastewater Department
MEC = MEC Analytical Systems, Inc.

[b]Station Coordinates

Lat N (dm) = Latitude North (degree minutes)
Long W (dm) = Longitude West (degree minutes)

[c]BRI = Benthic Response Index (Smith *et al*. 1998)

Appendix A4. Characteristics of trawl stations on the mainland shelf of southern California used in validation database for demersal fish and/or invertebrate biointegrity index study.

				Depth	Station Coordinates[b]				Impact			
Station	Agency[a]	Date	Rep	(m)	Lat No (dm)		Long W (dm)		Category	BRI[c]	Erosion	Tumor
nT5	OC	7/1/74	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/74	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/75	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/75	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/75	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/75	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/76	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/76	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/76	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/76	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/77	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/78	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/78	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/78	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/78	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/79	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/79	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/79	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/79	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/80	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/80	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/80	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/80	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/81	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/81	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/81	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/81	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/82	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/82	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/82	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/82	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/83	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/83	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	7/1/83	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/83	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/84	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/84	1	61	33	35.00	118	2.20	ntermediat	-	-	-
nT5	OC	7/1/84	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	10/1/84	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	1/1/85	1	61	33	35.00	118	2.20	Reference	-	-	-
nT5	OC	4/1/85	1	61	33	35.00	118	2.20	Reference			
R16	SC	4/28/77	1	60	33	59.92	118	47.92	ntermediat	15.84	-	-
R24	SC	8/9/77	1	60	33	55.70	118	32.42	ntermediat	43.84	-	-

Appendix A4 (continued)

Station	Agency[a]	Date	Rep	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Erosion	Tumor
R34	SC	5/18/77	1	61	33	42.10	118	20.30	Impacted	-	-	-
R45	SC	5/2/77	1	60	33	34.57	118	0.53	ntermediat	37.42	No	Yes
R47	SC	5/2/77	1	60	33	34.38	117	59.59	Reference	28.81	No	No
R70	SC	6/22/77	1	60	32	36.00	117	16.25	ntermediat	18.33	-	-
T0-137	LA	6/19/74	1	137	33	48.83	118	26.36	ntermediat	-	Yes	Yes
T0-137	LA	11/25/74	1	137	33	48.83	118	26.36	ntermediat	-	Yes	No
T0-137	LA	3/10/80	1	137	33	48.83	118	26.36	ntermediat	-	No	Yes
T0-137	LA	5/28/80	1	137	33	48.83	118	26.36	ntermediat	-	Yes	No
T0-137	LA	7/30/80	1	137	33	48.83	118	26.36	ntermediat	-	Yes	Yes
T0-137	LA	12/18/80	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	2/23/88	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	5/4/88	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	8/17/88	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	11/22/88	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	2/20/92	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	5/21/92	1	137	33	48.83	118	26.36	ntermediat	-	No	Yes
T0-137	LA	8/20/92	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-137	LA	11/11/92	1	137	33	48.83	118	26.36	ntermediat	-	No	No
T0-23	LA	3/10/80	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	5/28/80	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	7/30/80	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	12/18/80	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	2/23/88	1	23	33	48.19	118	25.04	ntermediat	-	No	No
T0-23	LA	5/4/88	1	23	33	48.19	118	25.04	ntermediat	-	No	No
T0-23	LA	8/17/88	1	23	33	48.19	118	25.04	ntermediat	-	No	No
T0-23	LA	11/17/88	1	23	33	48.19	118	25.04	ntermediat	-	No	No
T0-23	LA	2/20/92	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	5/21/92	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	8/20/92	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-23	LA	11/11/92	1	23	33	48.19	118	25.04	Reference	-	No	No
T0-61	LA	3/10/80	1	61	33	48.57	118	25.84	ntermediat	-	Yes	No
T0-61	LA	5/28/80	1	61	33	48.57	118	25.84	ntermediat	-	Yes	No
T0-61	LA	7/30/80	1	61	33	48.57	118	25.84	ntermediat	-	Yes	Yes
T0-61	LA	12/18/80	1	61	33	48.57	118	25.84	ntermediat	-	No	No
T0-61	LA	2/23/88	1	61	33	48.57	118	25.84	ntermediat	-	No	No
T0-61	LA	5/4/88	1	61	33	48.57	118	25.84	ntermediat	-	No	No
T0-61	LA	8/17/88	1	61	33	48.57	118	25.84	ntermediat	-	No	No
T0-61	LA	11/17/88	1	61	33	48.57	118	25.84	ntermediat	-	No	No
T0-61	LA	2/20/92	1	61	33	48.57	118	25.84	Reference	-	No	No
T0-61	LA	5/21/92	1	61	33	48.57	118	25.84	Reference	-	No	No
T0-61	LA	8/20/92	1	61	33	48.57	118	25.84	Reference	-	No	No
T0-61	LA	11/11/92	1	61	33	48.57	118	25.84	Reference	-	No	No
T11	MEC	1/13/86	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/13/86	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/29/86	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/29/86	3	55	33	36.04	118	5.32	Reference	-	-	-

Appendix A4 (continued)

Station	Agency[a]	Date	Rep	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Erosion	Tumor
T11	MEC	1/12/87	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/12/87	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/14/87	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/14/87	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/14/88	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/14/88	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	9/23/88	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	9/23/88	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/18/89	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/18/89	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/17/89	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/17/89	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/19/90	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/19/90	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/11/90	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/11/91	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/11/91	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/17/91	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/17/91	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/17/91	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/22/92	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/22/92	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/22/92	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/16/92	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/16/92	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/16/92	4	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/27/93	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/27/93	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/27/93	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/15/93	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/15/93	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/15/93	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/26/94	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/26/94	2	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	1/26/94	3	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/25/94	1	55	33	36.04	118	5.32	Reference	-	-	-
T11	MEC	7/25/94	2	55	33	36.04	118	5.32	Reference	-	-	-
T4-137	LA	5/31/74	1	137	33	42.06	118	21.05	Impacted	-	Yes	No
T4-137	LA	11/26/74	1	137	33	42.06	118	21.05	Impacted	-	Yes	No
T4-137	LA	3/5/80	1	137	33	42.06	118	21.05	Impacted	-	Yes	Yes
T4-137	LA	5/27/80	1	137	33	42.06	118	21.05	Impacted	-	Yes	Yes
T4-137	LA	7/29/80	1	137	33	42.06	118	21.05	Impacted	-	Yes	Yes
T4-137	LA	12/17/80	1	137	33	42.06	118	21.05	Impacted	-	Yes	No
T4-137	LA	2/22/88	1	137	33	42.06	118	21.05	ntermediat	-	No	No
T4-137	LA	5/3/88	1	137	33	42.06	118	21.05	ntermediat	-	Yes	No

Appendix A4 (continued)

				Depth	Station Coordinates[b]				Impact			
Station	**Agency[a]**	**Date**	**Rep**	**(m)**	**Lat No (dm)**		**Long W (dm)**		**Category**	**BRI[c]**	**Erosion**	**Tumor**
T4-137	LA	8/16/88	1	137	33	42.06	118	21.05	ntermediat	-	Yes	No
T4-137	LA	11/16/88	1	137	33	42.06	118	21.05	ntermediat	-	No	No
T4-137	LA	2/18/92	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	5/22/92	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	8/19/92	1	137	33	42.06	118	21.05	ntermediat	-	No	No
T4-137	LA	11/10/92	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	2/8/94	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	5/10/94	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	8/4/94	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-137	LA	11/1/94	1	137	33	42.06	118	21.05	ntermediat	-	No	Yes
T4-23	LA	3/5/80	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	5/27/80	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	7/30/80	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	12/18/80	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	2/23/88	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	5/4/88	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	8/17/88	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	11/29/88	1	27	33	42.79	118	20.48	ntermediat	-	No	No
T4-23	LA	2/20/92	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	5/20/92	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	8/18/92	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	11/10/92	1	27	33	42.79	118	20.48	Reference	-	No	Yes
T4-23	LA	2/11/94	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	5/11/94	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	8/5/94	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-23	LA	11/3/94	1	27	33	42.79	118	20.48	Reference	-	No	No
T4-61	LA	6/18/75	1	61	33	42.25	118	20.71	Impacted	-	No	No
T4-61	LA	6/18/75	2	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	6/18/75	3	61	33	42.25	118	20.71	Impacted	-	No	No
T4-61	LA	12/3/75	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	5/5/76	1	61	33	42.25	118	20.71	Impacted	-	Yes	No
T4-61	LA	12/7/76	1	61	33	42.25	118	20.71	Impacted	-	Yes	No
T4-61	LA	5/18/77	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	9/30/77	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	12/14/77	1	61	33	42.25	118	20.71	Impacted	-	No	No
T4-61	LA	3/6/79	1	61	33	42.25	118	20.71	Impacted	-	No	No
T4-61	LA	5/30/79	1	61	33	42.25	118	20.71	Impacted	-	Yes	No
T4-61	LA	7/25/79	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	11/20/79	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	3/5/80	1	61	33	42.25	118	20.71	Impacted	-	Yes	No
T4-61	LA	5/28/80	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	7/29/80	1	61	33	42.25	118	20.71	Impacted	-	Yes	Yes
T4-61	LA	12/17/80	1	61	33	42.25	118	20.71	Impacted	-	No	No
T4-61	LA	2/24/88	1	61	33	42.25	118	20.71	ntermediat	-	No	No

Appendix A4 (continued)

Station	Agency[a]	Date	Rep	Depth (m)	Station Coordinates[b] Lat No (dm)		Long W (dm)		Impact Category	BRI[c]	Erosion	Tumor
T4-61	LA	5/3/88	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	8/16/88	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	11/16/88	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	2/18/92	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	5/19/92	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	8/18/92	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	11/10/92	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	2/8/94	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T4-61	LA	5/10/94	1	61	33	42.25	118	20.71	ntermediat	-	No	Yes
T4-61	LA	8/5/94	1	61	33	42.25	118	20.71	ntermediat	-	No	Yes
T4-61	LA	11/1/94	1	61	33	42.25	118	20.71	ntermediat	-	No	No
T5 control	OC	1/5/77	1	61	33	35.00	118	2.20	Reference	-	-	-
T5 control	OC	7/6/77	1	61	33	35.00	118	2.20	Reference	-	-	-
T5 control	OC	10/5/77	1	61	33	35.00	118	2.20	Reference	-	-	-

[a]Agencies
- HY = City of Los Angeles, Environmental Monitoring Division
- LA = County Sanitation Districts of Los Angeles County
- OC = County Sanitation Districts of Orange County
- SC = Southern California Coastal Water Research Project
- SD = City of San Diego, Metropolitan Wastewater Department
- MEC = MEC Analytical Systems, Inc.

[b]Station Coordinates
- Lat N (dm) = Latitude North (degree minutes)
- Long W (dm) = Longitude West (degree minutes)

[c]BRI = Benthic Response Index (Smith *et al.* 1998)

Appendix B1

Optimization Procedure for Index Development

To produce the final formulation of our index, three factors needed to be determined, one factor for calculating the index (Equation 1, x1) and two factors for calculating the positions (p_i values) of the species on the pollution gradient (Equation x2). For the index, it was necessary to determine the optimal weighting factor for the abundance. To calculate the p_i values for the species, it was necessary to determine the optimal weighting factor for the abundance and the number of values to be used in the calculation.

Since the pollution gradient from the ordination space is the "standard" upon which the index is based, the degree to which index values correlate with this standard is a measure of the success of the index. In other words, the success of the weighting and other factors used to compute the index can be evaluated by how well the index values for the *calibration* samples correlate with their gradient positions along the pollution gradient (i.e., canonical correlation scores) defined in the ordination space. Thus, a Pearson correlation coefficient can be used to determine the optimal configuration of factors in the equation. Our strategy was to vary the factors used to compute the index and the species positions on the gradient and to evaluate each formulation with the resulting correlation coefficient. The optimal approach will have the highest correlation coefficient. Since all three factors affect the final outcome, the factors were optimized concurrently.

The general form of the index weighted average (same as Equation 1) is

$$I_s = \frac{\sum_{i=1}^{n} a_{si}^{f} p_i}{\sum_{i=1}^{n} a_{si}^{f}}, \qquad \text{(x1)}$$

where I_s is the index value for sample *s*, *n* is the number of species in the sample *s*, p_i is the position for species *i* on the gradient, and a_{si} is the abundance of species *i* in sample *s*. The exponent *f* is for transforming the abundance weights. For example, if *f=1*, the raw abundance values are used. If *f=0*, I_s is the arithmetic average of the p_i values greater than zero (all $a_{si}^{f} = 1$), and if *f=0.5*, the square root of the abundances are used. Species in the sample without species positions are ignored, and species with abundances of zero are not used in the sum when *f=0*. In the optimization procedure, different values of the abundance weight transformation parameter *f* in Equation (x1) are tested.

The general form of the equation to compute the species positions on the gradient is

$$p_i = \frac{\sum_{j=1}^{t} a_{ij}^{e} g_j}{\sum_{j=1}^{t} a_{ij}^{e}}, \qquad \text{(x2)}$$

where e is a variable exponent for transforming the abundance, and t is the number of samples to be used in the sum, with only the sampling units with highest t species abundance values included. Thus, if $t=4$, j will range from 1 to 4. When $j=1$, j signifies the sample with the highest abundance count for species i; when $j=2$, j signifies the sample with the second highest abundance count for species i; and so on up to the fourth highest abundance value. The g_j is the position on the ordination gradient for sample j, and a_{ij} is the abundance of species i in sample j.

In the optimization procedure, the two parameters that can be varied in Equation (x2) are t and e. The t value is used to adjust the number of samples used in the weighted average, with precedence given to the samples with higher abundances. The e parameter is used to transform the abundance weights and avoid overemphasis on one or a few relatively high abundance values.

Since the combined values set for e and t in Equation (x2) and f in Equation (x1) will all affect the index values computed with Equation (a1), the optimization procedure must involve testing different combinations of e, t, and f values for the maximum correlation. In the optimization, we computed correlation coefficients for all combinations of $e = 0, 1, 0.5, 0.33, 0.25$, and $t=1$ to 100 in Equation (x2), and $f = 0, 1, 0.5, 0.33, 0.25$ in Equation (x1).

Appendix B2. Fish Response Index (FRI) pollution gradient position (pi) values for fish species by depth zone on the mainland shelf (9-215 m) in southern California demersal fish and invertebrate biointegrity index study.

	p_i by depth zone		
Species Name	**9-40 m**	**30-120 m**	**100-215 m**
Anoplopoma fimbria		56.97	93.25
Argentina sialis		-4.50	-22.52
Brosmophycis marginata		22.04	
Cephaloscyllium ventriosum		10.20	
Chilara taylori	181.26	-13.10	-2.46
Chitonotus pugetensis	25.10	12.38	
Citharichthys fragilis		6.06	11.83
Citharichthys sordidus	59.29	19.29	-21.71
Citharichthys stigmaeus	24.83	29.81	
Citharichthys xanthostigma	10.71	-13.87	17.41
Coryphopterus nicholsii		-18.40	
Cymatogaster aggregata	169.84	160.68	
Engraulis mordax	15.87	63.14	-29.61
Lyopsetta exilis		16.83	32.28
Eopsetta jordani		1.51	-4.18
Errex zachirus		17.88	71.27
Genyonemus lineatus	58.20	54.39	42.07
Hippoglossina stomata	24.50	17.31	30.56
Hydrolagus colliei		66.81	98.73
Icelinus filamentosus			-25.00
Icelinus quadriseriatus	17.59	1.66	34.29
Icelinus tenuis		-7.92	-66.58
Kathetostoma averruncus		120.76	55.12
Lepidogobius lepidus	41.35	1.79	-10.43
Lycodes cortezianus			87.00
Lycodopsis pacifica		21.66	43.34
Lyconema barbatum			27.98
Merluccius productus		-18.77	13.51
Microstomus pacificus	102.34	70.58	87.20
Odontopyxis trispinosa		18.96	
Ophiodon elongatus		2.53	29.16
Paralabrax nebulifer	10.60	9.08	
Paralichthys californicus	11.63	20.87	
Peprilus simillimus		17.42	
Phanerodon furcatus	72.37		
Physiculus rastrelliger			105.45
Platyrhinoidis triseriata	-3.03	2.08	
Plectobranchus evides			39.28
Parophrys vetula	49.63	48.13	-10.29
Pleuronichthys coenosus	121.93		
Pleuronichthys decurrens	92.94	71.21	
Pleuronichthys ritteri	13.12	78.46	
Pleuronichthys verticalis	21.12	16.29	-2.34

Appendix B2 (continued)

Species Name	p_i by depth zone 9-40 m	30-120 m	100-215 m
Porichthys myriaster	10.47	33.91	
Porichthys notatus	17.89	21.54	22.10
Raja binoculata	22.20	31.61	
Raja inornata	11.13	20.13	-13.32
Rathbunella hypoplecta		-8.02	
Rhacochilus vacca	137.71		
Sardinops sagax			-33.01
Scorpaena guttata	26.07	86.99	7.59
Sebastes auriculatus	18.99	29.71	
Sebastes caurinus	11.59	18.43	
Sebastes chlorostictus		-25.76	-0.12
Sebastes crameri		196.71	78.14
Sebastes dallii	11.59	50.23	45.40
Sebastes diploproa		-11.77	68.00
Sebastes elongatus		-10.16	36.56
Sebastes eos		-21.72	4.83
Sebastes goodei	169.84	108.27	
Sebastes hopkinsi		86.25	87.58
Sebastes jordani		191.72	86.45
Sebastes levis		44.31	57.83
Sebastes macdonaldi			105.48
Sebastes miniatus	90.18	46.66	
Sebastes mystinus		81.93	
Sebastes paucispinis		20.73	86.21
Sebastes pinniger		-10.38	
Sebastes rosaceus		13.66	
Sebastes rosenblatti		18.24	36.41
Sebastes rubrivinctus		9.89	
Sebastes saxicola	65.88	44.38	49.19
Sebastes semicinctus		9.86	-19.36
Sebastes serranoides		85.11	
Sebastolobus alascanus		33.38	53.18
Seriphus politus	35.83		
Symphurus atricauda	37.14	3.33	35.62
Synodus lucioceps	16.23	27.24	-5.21
Torpedo californica		118.08	
Xeneretmus latifrons		10.05	22.27
Xeneretmus triacanthus		6.39	-7.08
Xystreurys liolepis	13.55	32.12	
Zalembius rosaceus	49.94	28.92	-19.96
Zaniolepis frenata		10.27	16.19
Zaniolepis latipinnis	21.71	30.19	-11.28

Appendix B3. Invertebrate Response Index (IRI) pollution-gradient position ($p_{i)}$ for invertebrate species on the mainland shelf (9-215 m) in southern California demersal fish and invertebrate biointegrity index study.

Species	p_i
Acanthodoris brunnea	41.4
Adelogorgia phyllosclera	25.3
Allocentrotus fragilis	29.3
Amphichondrius granulatus	25.5
Amphiodia urtica	27.9
Amphiura arcystata	23.0
Antiplanes catalinae	33.9
Aphrodita japonica	31.3
Armina californica	35.8
Asterina miniata	49.8
Astropecten armatus	41.9
Astropecten ornatissimus	22.6
Astropecten verrilli	31.0
Babelomurex oldroydi	23.3
Balanus nubilus	16.9
Balanus pacificus	34.1
Brisaster latifrons	28.1
Brissopsis pacifica	29.2
Calinaticina oldroydii	54.8
Calliostoma tricolor	30.8
Calliostoma turbinum	29.0
Cancellaria cooperii	26.4
Cancellaria crawfordiana	35.9
Cancer antennarius	61.3
Cancer anthonyi	64.1
Cancer gracilis	45.4
Cancer jordani	41.0
Cancer productus	61.5
Chlamys hastate	26.0
Cidarina cidaris	8.1
Ciona intestinalis	32.2
Conus californicus	
Corynactis californica	38.9
Crangon alaskensis	42.2
Crangon nigromaculata	54.4
Crepidula onyx	78.0
Crossata californica	23.7
Diaulula sandiegensis	30.2
Doriopsilla albopunctata	29.3
Dromalia alexandri	37.4
Erileptus spinosus	34.5
Eualus herdmani	19.4
Eugorgia rubens	28.4
Eugyra arenosa californica	34.2
Euvola diegensis	28.2

Appendix B3 (continued)

Species	p_i
Flabellina iodinea	31.0
Florometra serratissima	13.6
Fusinus barbarensis	15.0
Gastropteron pacificum	52.8
Gorgonocephalus eucnemis	14.3
Hamatoscapellum californicum	31.4
Havelockia benti	29.6
Hemisquilla ensigera californiensis	22.3
Henricia leviuscula	15.8
Heptacarpus stimpsoni	40.9
Heptacarpus tenuissimus	59.6
Heptacarpus tenuissiumus	22.8
Heterocrypta occidentalis	32.0
Heterogorgia tortuosa	25.5
Isocheles pilosus	28.8
Kelletia kelletii (=kelletti)	29.2
Lamellaria diegoensis	33.3
Laqueus californianus	8.1
Leptasterias hexactis	17.9
Leptopecten latiauratus	32.0
Leucilla nuttingi	25.7
Livoneca californica	25.1
Livoneca vulgaris	38.5
Loligo opalescens	34.5
Lophogorgia chilensis	39.0
Lopholithodes foraminatus	40.5
Lophopanopeus bellus	47.8
Lovenia cordiformis	29.6
Loxorhynchus crispatus	25.0
Loxorhynchus grandis	32.3
Luidia armata	29.1
Luidia asthenosoma	26.8
Luidia foliolata	29.0
Lysmata californica	47.5
Lytechinus pictus	24.5
Mediaster aequalis	26.2
Megasurcula carpenteriana	28.9
Metacrangon spinosissima	30.0
Metridium farcimen	29.2
Muricea californica	77.0
Nassarius insculptus	63.3
Nassarius mendicus	73.1
Nassarius perpinguis	39.3
Neocrangon communis	35.4
Neocrangon resima	33.0
Neocrangon zacae	33.6

Appendix B3 (continued)

Species	p_i
Neosabellaria cementarium	27.8
Neosimnia aequalis	24.3
Neosimnia loebbeckeana	37.6
Neptunea tabulata	19.0
Nerocila acuminata	72.3
Neverita reclusiana	40.8
Nymphon pixellae	31.6
Octopus californicus	29.3
Octopus rubescens	29.4
Octopus veligero	23.8
Ophionereis eurybrachiplax	14.5
Ophiopholis bakeri	19.4
Ophiopteris papillosa	22.9
Ophiothrix spiculata	28.9
Ophiura luetkenii	29.2
Orthopagurus minimus	36.6
Paguristes bakeri	18.1
Paguristes turgidus	23.9
Paguristes ulreyi	32.3
Pagurus spilocarpus	30.7
Pandalus danae	48.5
Pandalus jordani	44.7
Pandalus platyceros	40.7
Paracyathus stearnsii	21.3
Paralithodes californiensis	25.9
Paralithodes rathbuni	34.8
Parapagurodes laurentae	20.1
Parapagurodes makarovi	20.6
Parastichopus californicus	31.7
Pegea confoederata	39.4
Philine alba	16.4
Phimochirus californiensis	26.3
Pisaster brevispinus	30.0
Platydoris macfarlandi	21.2
Platymera gaudichaudii	57.0
Pleurobranchaea californica	41.5
Pleuroncodes planipes	54.0
Podochela hemphillii	35.4
Podochela lobifrons	25.1
Pododesmus macroschisma	32.6
Euspira draconis	59.0
Portunus xantusii	64.8
Protula superba	20.2
Pteropurpura macroptera	12.4
Pteropurpura vokesae	58.2
Ptilosarcus gurneyi	26.3
Pycnopodia helianthoides	39.9

Appendix B3 (continued)

Species	**p_i**
Pyromaia tuberculata	33.8
Randallia ornata	31.0
Rathbunaster californicus	31.6
Renilla koellikeri	28.3
Rossia pacifica	35.4
Schmittius politus	29.4
Sclerasterias heteropaes	14.1
Sicyonia ingentis	45.2
Spatangus californicus	26.1
Spirontocaris holmesi	50.8
Spirontocaris sica	43.7
Strongylocentrotus franciscanus	26.4
Strongylocentrotus purpuratus	31.9
Styela gibbsii	31.8
Stylasterias forreri	24.4
Stylatula elongata	35.4
Terebra pedroana	24.1
Terebratalia occidentalis	13.5
Triopha maculata	29.9
Tritonia diomedea	36.3
Tritonia festiva	33.5
Virgularia bromleyi	28.0
Virgularia galapagensis	30.2

Appendix B4. Trawl Response Index (TRI) pollution-gradient position (p_i) values for fishes (F) and invertebrates (I) on the mainland shelf (9-215 m) in southern California demersal fish and invertebrate biointegrity study.

Species	Category	p_i
Acanthodoris brunnea	I	60.646
Adelogorgia phyllosclera	I	4.804
Allocentrotus fragilis	I	18.526
Amphichondrius granulatus	I	5.633
Amphiodia urtica	I	13.861
Amphiura arcystata	I	-3.081
Anoplopoma fimbria	F	159.400
Antiplanes catalinae	I	34.540
Aphrodita japonica	I	25.550
Argentina sialis	F	20.631
Armina californica	I	41.228
Asterina miniata	I	89.938
Astropecten armatus	I	62.340
Astropecten ornatissimus	I	-4.744
Astropecten verrilli	I	24.514
Babelomurex oldroydi	I	-2.246
Balanus nubilus	I	-24.352
Balanus pacificus	I	35.450
Brisaster latifrons	I	14.644
Brissopsis pacifica	I	18.260
Brosmophycis marginata	F	-30.970
Calinaticina oldroydii	I	107.449
Calliostoma tricolor	I	23.832
Calliostoma turbinum	I	17.567
Cancellaria cooperi	I	8.546
Cancellaria crawfordiana	I	41.567
Cancer antennarius	I	129.857
Cancer anthonyi	I	139.622
Cancer gracilis	I	74.773
Cancer jordani	I	59.414
Cancer productus	I	130.573
Cephaloscyllium ventriosum	F	45.537
Chilara taylori	F	41.257
Chitonotus pugetensis	F	28.501
Chlamys hastata	I	7.169
Cidarina cidaris	I	-54.841
Ciona intestinalis	I	28.755
Citharichthys fragilis	F	25.016
Citharichthys sordidus	F	15.572
Citharichthys stigmaeus	F	39.530
Citharichthys xanthostigma	F	18.036
Conus californicus	I	158.704
Corynactis californica	I	51.922
Coryphopterus nicholsii	F	9.332
Crangon alaskensis	I	63.460

Appendix B4 (continued)

Species	Category	p_i
Crangon nigromaculata	I	106.013
Crepidula onyx	I	188.002
Crossata californica	I	-0.670
Cymatogaster aggregata	F	167.488
Diaulula sandiegensis	I	21.961
Doriopsilla albopunctata	I	18.720
Dromalia alexandri	I	46.883
Engraulis mordax	F	36.593
Eopsetta exilis	F	43.355
Eopsetta jordani	F	2.931
Erileptus spinosus	I	36.882
Errex zachirus	F	40.469
Eualus herdmani	I	-15.865
Eugorgia rubens	I	15.644
Eugyra arenosa californica	I	35.860
Euvola diegensis	I	14.765
Flabellina iodinea	I	24.435
Florometra serratissima	I	-35.876
Fusinus barbarensis	I	-31.127
Gastropteron pacificum	I	100.480
Genyonemus lineatus	F	89.954
Gorgonocephalus eucnemis	I	-33.610
Hamatoscapellum californicum	I	25.909
Havelockia benti	I	19.828
Hemisquilla ensigera californiensis	I	-5.740
Henricia leviuscula	I	-28.378
Heptacarpus stimpsoni	I	59.135
Heptacarpus tenuissimus	I	124.127
Heptacarpus tenuissiumus	I	-3.827
Heterocrypta occidentalis	I	27.970
Heterogorgia tortuosa	I	5.444
Hippoglossina stomata	F	38.155
Hydrolagus colliei	F	95.329
Icelinus filamentosus	F	-9.071
Icelinus quadriseriatus	F	30.084
Icelinus tenuis	F	-43.720
Isocheles pilosus	I	16.937
Kathetostoma averruncus	F	109.628
Kelletia kelletii (=kelletti)	I	18.340
Lamellaria diegoensis	I	32.409
Laqueus californianus	I	-54.841
Lepidogobius lepidus	F	30.453
Leptasterias hexactis	I	-21.106
Leptopecten latiauratus	I	28.100
Leucilla nuttingi	I	6.279
Livoneca californica	I	3.975

Appendix B4 (continued)

Species	Category	p_i
Livoneca vulgaris	I	50.673
Loligo opalescens	I	36.872
Lophogorgia chilensis	I	52.365
Lopholithodes foraminatus	I	57.620
Lophopanopeus bellus	I	82.994
Lovenia cordiformis	I	19.716
Loxorhynchus crispatus	I	3.567
Loxorhynchus grandis	I	29.155
Luidia armata	I	18.119
Luidia asthenosoma	I	9.865
Luidia foliolata	I	17.727
Lycodes cortezianus	F	84.649
Lycodopsis pacifica	F	63.664
Lyconema barbatum	F	14.323
Lysmata californica	I	81.795
Lytechinus pictus	I	1.899
Mediaster aequalis	I	8.010
Megasurcula carpenteriana	I	17.407
Merluccius productus	F	50.573
Metacrangon spinosissima	I	21.250
Metridium senile	I	18.307
Microstomus pacificus	F	64.816
Muricea californica	I	184.340
Nassarius insculptus	I	136.721
Nassarius mendicus	I	170.833
Nassarius perpinguis	I	53.492
Neocrangon communis	I	40.032
Neocrangon resima	I	31.526
Neocrangon zacae	I	33.594
Neosabellaria cementarium	I	13.595
Neosimnia aequalis	I	1.397
Neosimnia loebbeckeana	I	47.346
Neptunea tabulata	I	-17.101
Nerocila acuminata	I	167.996
Neverita reclusiana	I	58.804
Nymphon pixellae	I	26.829
Octopus californicus	I	18.608
Octopus rubescens	I	19.108
Octopus veligero	I	-0.322
Odontopyxis trispinosa	F	28.141
Ophiodon elongatus	F	37.600
Ophionereis eurybrachiplax	I	-32.880
Ophiopholis bakeri	I	-15.682
Ophiopteris papillosa	I	-3.624
Ophiothrix spiculata	I	17.373
Ophiura luetkenii	I	18.309
Orthopagurus minimus	I	44.102

Appendix B4 (continued)

Species	Category	p_i
Paguristes bakeri	I	-20.328
Paguristes turgidus	I	-0.144
Paguristes ulreyi	I	28.975
Pagurus spilocarpus	I	23.517
Pandalus danae	I	85.484
Pandalus jordani	I	71.704
Paracyathus stearnsii	I	-9.291
Paralabrax nebulifer	F	34.527
Paralichthys californicus	F	28.520
Paralithodes californiensis	I	6.684
Paralithodes rathbuni	I	37.643
Parapagurodes laurentae	I	-13.452
Parapagurodes makarovi	I	-11.475
Parastichopus californicus	I	27.046
Pegea confoederata	I	53.662
Peprilus simillimus	F	44.712
Phanerodon furcatus	F	73.802
Philine alba	I	-26.200
Phimochirus californiensis	I	8.231
Physiculus rastrelliger	F	120.653
Pisaster brevispinus	I	20.987
Platydoris macfarlandi	I	-9.410
Platymera gaudichaudii	I	114.797
Platyrhinoidis triseriata	F	36.896
Plectobranchus evides	F	33.573
Pleurobranchaea californica	I	61.116
Pleuroncodes planipes	I	104.407
Pleuronectes vetulus	F	53.322
Pleuronichthys coenosus	F	188.566
Pleuronichthys decurrens	F	94.670
Pleuronichthys ritteri	F	27.466
Pleuronichthys verticalis	F	28.779
Podochela hemphillii	I	39.864
Podochela lobifrons	I	4.222
Pododesmus macroschisma	I	30.302
Polinices draconis	I	121.873
Porichthys myriaster	F	30.057
Porichthys notatus	F	34.852
Portunus xantusii	I	141.936
Protula superba	I	-12.958
Pteropurpura macroptera	I	-39.890
Pteropurpura vokesae	I	119.071
Ptilosarcus gurneyi	I	8.203
Pycnopodia helianthoides	I	55.537
Pyromaia tuberculata	I	34.226
Raja binoculata	F	28.502
Raja inornata	F	29.956

Appendix B4 (continued)

Species	Category	***p*** $_i$
Randallia ornata	I	24.487
Rathbunaster californicus	I	26.499
Rathbunella hypoplecta	F	-10.923
Renilla koellikeri	I	15.091
Rhacochilus vacca	F	141.968
Rossia pacifica	I	39.795
Sardinops sagax	F	-44.255
Schmittius politus	I	19.098
Scorpaena guttata	F	57.510
Sebastes auriculatus	F	44.405
Sebastes caurinus	F	38.225
Sebastes chlorostictus	F	23.681
Sebastes constellatus	F	-2.538
Sebastes crameri	F	149.249
Sebastes dallii	F	36.472
Sebastes diploproa	F	79.982
Sebastes elongatus	F	41.364
Sebastes eos	F	9.445
Sebastes goodei	F	140.688
Sebastes hopkinsi	F	92.953
Sebastes jordani	F	119.310
Sebastes levis	F	71.981
Sebastes macdonaldi	F	155.200
Sebastes miniatus	F	68.806
Sebastes mystinus	F	82.783
Sebastes paucispinis	F	95.451
Sebastes pinniger	F	-3.531
Sebastes rosaceus	F	12.277
Sebastes rosenblatti	F	46.583
Sebastes rubrivinctus	F	2.190
Sebastes saxicola	F	66.083
Sebastes semicinctus	F	28.185
Sebastes serranoides	F	80.724
Sebastolobus alascanus	F	46.807
Seriphus politus	F	60.930
Sicyonia ingentis	I	73.770
Spatangus californicus	I	7.380
Spirontocaris holmesi	I	93.462
Spirontocaris sica	I	68.888
Strongylocentrotus franciscanus	I	8.745
Strongylocentrotus purpuratus	I	27.592
Styela gibbsii	I	27.214
Stylasterias forreri	I	1.754
Stylatula elongata	I	39.864
Symphurus atricauda	F	31.444
Syngnathus exilis	F	-13.962
Synodus lucioceps	F	36.372

Appendix B5. Fish, invertebrate, and trawl index values for calibration data set stations for southern California demersal fish and invertebrate biointegrity index study.

Station	Depth	Year	Replicate	FRI	IRI	TRI
16	26	1994	1	35.235	28.962	35.458
32	62	1994	1	23.224	37.418	37.089
38	53	1994	1	25.682	36.034	38.200
59	73	1994	1	21.556	27.728	32.886
115	71	1994	1	31.888	23.518	28.248
122	74	1994	1	25.417	29.966	32.791
150	78	1994	1	31.445	29.917	34.417
161	18	1994	1	23.948	23.447	30.812
228	50	1994	1	26.190	42.138	41.789
234	38	1994	1	37.887	26.240	28.148
245	132	1994	1	19.224	0.000	0.893
252	42	1994	1	18.370	38.542	38.597
255	175	1994	1	30.924	23.107	25.855
289	51	1994	1	20.049	44.315	42.211
366	20	1994	1	31.767	56.386	51.793
381	156	1994	1	28.482	27.020	32.123
398	54	1994	1	21.690	42.862	41.521
407	62	1994	1	19.320	39.009	39.239
474	71	1994	1	24.549	43.219	43.381
480	104	1994	1	18.658	25.470	31.734
499	113	1994	1	17.761	25.098	31.262
502	33	1994	1	22.316	40.692	38.216
537	43	1994	1	16.776	41.061	36.765
542	69	1994	1	27.090	40.793	41.130
577	105	1994	1	12.848	22.804	28.928
604	160	1994	1	15.807	23.956	31.867
652	24	1994	1	23.213	39.665	37.100
665	24	1994	1	23.948	39.069	38.304
670	203	1994	1	31.508	33.955	38.490
682	203	1994	1	17.314	28.969	29.669
708	185	1994	1	21.619	27.229	33.593
714	100	1994	1	16.588	27.475	34.325
739	150	1994	1	1.752	18.633	20.957
753	156	1994	1	19.851	13.866	13.612
758	19	1994	1	22.634	45.572	41.587
759	21	1994	1	30.528	31.561	28.391
814	25	1994	1	25.723	20.627	27.401
815	193	1994	1	23.225	21.768	27.078
820	9	1994	1	32.486	46.117	40.211
823	107	1994	1	15.579	27.059	33.217
830	41	1994	1	21.944	23.170	27.350
846	63	1994	1	30.004	24.732	31.402
859	192	1994	1	31.800	28.739	38.768
890	41	1994	1	24.443	32.290	35.538
902	19	1994	1	27.479	23.050	33.768

Appendix B5 (continued)

Station	Depth	Year	Replicate	FRI	IRI	TRI
943	42	1994	1	14.103	27.639	29.276
960	50	1994	1	16.063	28.311	31.769
976	163	1994	1	15.496	20.672	25.941
993	58	1994	1	20.301	31.736	34.050
1028	128	1994	1	37.079	31.077	32.731
1042	23	1994	1	19.256	38.303	38.855
1046	14	1994	1	16.850	22.534	30.798
1049	53	1994	1	20.421	29.175	33.843
1052	215	1994	1	41.020	38.818	41.402
1072	66	1994	1	26.628	23.735	27.826
1108	58	1994	1	13.580	28.059	29.073
1109	57	1994	1	22.111	20.756	25.354
1126	83	1994	1	24.931	33.118	38.429
1142	75	1994	1	19.408	31.215	31.577
1148	100	1994	1	22.397	36.469	38.192
1152	171	1994	1	19.939	30.649	29.835
1159	127	1994	1	36.187	34.986	39.166
1169	135	1994	1	34.418	33.095	35.894
1173	62	1994	1	22.187	29.014	33.208
1175	208	1994	1	42.735	36.853	38.832
1208	13	1994	1	27.829	54.859	51.093
1222	16	1994	1	24.115	51.738	45.683
1227	19	1994	1	19.187	40.332	36.952
1256	23	1994	1	19.968	29.249	34.447
1267	44	1994	1	17.790	44.887	38.391
1272	16	1994	1	12.484	41.150	33.365
1287	15	1994	1	17.313	44.397	37.182
1300	24	1994	1	19.036	24.385	30.586
1306	14	1994	1	12.722	30.997	26.793
1332	32	1994	1	25.773	31.226	35.230
1348	16	1994	1	16.157	23.733	30.527
1355	33	1994	1	15.636	28.570	31.683
1401	21	1994	1	18.397	26.155	29.797
1406	35	1994	1	17.343	27.553	30.378
1415	33	1994	1	19.749	26.668	30.574
1417	30	1994	1	24.191	32.003	43.739
1418	97	1994	1	20.179	28.688	31.893
1424	22	1994	1	24.662	36.386	36.350
1426	44	1994	1	17.579	26.570	28.460
1469	162	1994	1	41.445	35.849	42.373
1550	14	1994	1	20.058	43.676	37.191
1551	174	1994	1	43.339	33.928	43.895
1571	188	1994	1	34.090	40.074	45.212
1574	95	1994	1	21.241	26.454	31.908
1585	72	1994	1	11.376	24.660	26.005
1617	17	1994	1	13.462	21.793	33.733
1650	16	1994	1	15.368	21.793	34.425

Appendix B5 (continued)

Station	Depth	Year	Replicate	FRI	IRI	TRI
943	42	1994	1	14.103	27.639	29.276
1655	197	1994	1	42.937	35.188	42.217
1662	176	1994	1	38.966	33.674	40.314
1667	65	1994	1	16.958	34.011	34.246
1684	15	1994	1	22.376		
1734	49	1994	1	21.157	28.701	32.915
1737	187	1994	1	45.520	35.532	45.271
1767	85	1994	1	18.057	20.262	24.132
1769	70	1994	1	18.152	25.039	27.274
1774	104	1994	1	5.636	10.426	8.879
1776	24	1994	1	21.406	31.098	39.951
1780	15	1994	1	20.926	29.541	39.903
1794	97	1994	1	13.770	15.762	19.848
1797	86	1994	1	21.321	22.957	28.475
1833	91	1994	1	14.151	27.007	27.094
1839	41	1994	1	17.235	17.551	25.265
1850	110	1994	1	8.100	22.751	25.877
1867	17	1994	1	20.107	58.642	46.367
1871	89	1994	1	20.591	23.909	27.228
1892	62	1994	1	16.701	29.206	32.145
1944	18	1994	1	21.777	16.806	38.087
2001	43	1994	1	16.503	20.482	25.751
R01	62	1977	1	33.366	37.914	42.182
R02	59	1977	1		10.115	0.000
R03	59	1977	1	34.176	33.024	40.397
R04	30	1985	1	25.657	18.778	31.926
R04	60	1985	1	24.900	32.631	37.364
R04	81	1977	1	16.724	15.375	26.264
R04	150	1985	1	42.599	38.086	48.876
R05	30	1985	1	22.411	23.179	32.691
R05	60	1985	1	26.492	28.788	37.614
R05	61	1977	1	28.303	40.461	43.667
R05	150	1985	1	39.266	40.881	46.688
R06	67	1977	1	25.291	34.676	37.878
R07	61	1977	1	31.147	37.087	44.436
R08	30	1985	1	26.904	24.675	34.196
R08	60	1985	1	31.326	30.910	35.668
R08	61	1977	1	29.836	34.943	39.142
R08	150	1985	1	24.651	34.730	39.393
R09	64	1977	1	26.055	44.567	45.878
R10	59	1977	1	26.738	41.007	42.494
R11	58	1977	1	29.971	35.216	40.272
R12	53	1977	1	23.290	36.496	37.074
R13	30	1985	1	15.926	25.518	30.655
R13	30	1990	1	23.078	27.315	31.938
R13	60	1985	1	27.378	30.944	34.715
R13	60	1990	1	20.994	24.370	26.134
R13	65	1977	1	29.734	27.490	35.034

Appendix B5 (continued)

Station	Depth	Year	Replicate	FRI	IRI	TRI
943	42	1994	1	14.103	27.639	29.276
R13	150	1985	1	33.985	34.348	37.238
R13	150	1990	1	22.861	24.646	33.458
R14	58	1977	1	28.657	29.767	38.986
R15	30	1990	1	26.971	27.182	34.253
R15	58	1977	1	33.698	26.760	34.840
R15	60	1990	1	18.980	33.931	34.007
R15	150	1990	1	17.040	26.958	25.815
R25	60	1977	1	31.142	34.393	39.557
R26	60	1977	1	33.058		
R27	60	1977	1	22.267		
R28	80	1977	1	24.629	34.351	39.867
R29	59	1977	1	40.253	38.866	45.973
R30	57	1977	1	37.940	33.408	42.281
R31	59	1977	1	26.925	44.175	54.899
R32	58	1977	1	47.375	53.849	57.836
R33	59	1977	1	54.766	62.384	70.555
R35	55	1977	1	74.272	57.664	70.047
R36	56	1977	1	32.516	29.849	37.140
R37	55	1977	1	26.226	35.163	33.157
R38	60	1977	1	21.521	12.803	17.198
R39	58	1977	1	26.299	36.474	41.534
R43	59	1977	1	28.085	35.669	39.461
R48	60	1977	1	24.357	37.539	36.823
R49	60	1977	1	27.395	38.201	40.833
R50	30	1985	1	25.434	24.170	35.376
R50	30	1990	1	27.789	24.813	36.099
R50	59	1977	1	29.123	29.461	37.392
R50	60	1985	1	15.840	37.334	35.455
R50	60	1990	1	8.763	28.046	27.480
R50	150	1985	1	37.564	64.159	59.945
R50	150	1990	1	32.518	42.673	42.683
R51	60	1977	1	25.268	27.078	33.210
R52	30	1985	1	21.723	27.593	30.710
R52	30	1990	1	23.250	14.671	25.573
R52	57	1977	1	28.278	35.269	38.845
R52	60	1985	1	17.730	43.219	34.924
R52	60	1990	1	7.438	35.773	33.058
R52	150	1985	1	22.853	59.356	47.614
R52	150	1990	1	27.768	41.160	40.787
R53	55	1977	1	26.434	29.982	35.497
R54	30	1985	1	18.083	22.157	30.344
R54	55	1977	1	20.716	26.931	31.427
R54	60	1985	1	13.132	28.034	29.111
R54	150	1985	1	10.570	35.458	36.699
R55	59	1977	1	17.143	29.771	29.536
R56	59	1977	1	23.986	23.260	32.552
R57	30	1985	1	21.462	17.624	31.998

Appendix B5 (continued)

Station	Depth	Year	Replicate	FRI	IRI	TRI
943	42	1994	1	14.103	27.639	29.276
R57	60	1977	1	22.839	34.001	34.970
R57	60	1985	1	22.486	37.696	38.130
R57	150	1985	1	23.565	48.335	43.892
R58	60	1977	1	16.020	38.315	32.617
R59	60	1977	1	24.618	39.041	36.524
R60	30	1985	1	13.843	25.276	31.982
R60	30	1990	1	18.320	19.687	31.238
R60	60	1977	1	27.160	28.957	31.544
R60	60	1985	1	15.539	32.410	30.492
R60	60	1990	1	11.288	37.552	33.368
R60	150	1985	1	36.513	45.933	45.759
R60	150	1990	1	36.511	42.085	45.221
R61	60	1985	1		28.630	25.950
R61	60	1990	1	8.160	18.875	19.959
R61	62	1977	1	19.577	36.557	32.235
R61	150	1985	1	20.410	21.639	36.674
R61	150	1990	1	16.067	25.511	31.674
R62	64	1977	1	25.363		
R68	62	1977	1	26.852	26.768	35.268
R71	30	1985	1	23.751	19.083	24.259
R71	30	1990	1	27.102	25.904	35.156
R71	60	1977	1	21.450	30.811	34.026
R71	60	1985	1	14.722	21.788	24.385
R71	60	1990	1	17.651	17.821	19.867
R71	150	1985	1	34.732	37.606	41.462
R71	150	1990	1	27.298	18.986	30.727
T0-023	23	1985	1	21.049	14.258	27.469
T0-023	23	1985	2	25.362	19.272	31.848
T0-023	23	1990	1	21.444	17.719	22.278
T0-023	23	1990	2	29.532	11.682	19.684
T0-061	61	1990	1	26.487	25.796	32.338
T0-061	61	1990	2	17.668	28.550	31.068
T0-137	137	1985	1	41.510	53.579	55.336
T0-137	137	1990	1	32.985	46.087	44.991
T1-023	23	1973	1	100.000	78.117	92.136
T1-061	61	1973	1	67.600	57.890	70.977
T1-061	61	1985	1	26.243	54.265	46.445
T1-137	134	1973	1	66.421	63.237	73.020
T1-137	137	1973	1	66.473	50.446	60.663
T11	55	1985	1	25.205	24.016	33.053
T11	55	1985	2	17.337	21.335	25.580
T11	55	1990	1	21.044	19.061	25.530
T2-023	23	1973	1	75.158	88.978	85.402
T2-061	61	1973	1	67.386	77.225	82.210
T2-061	61	1973	2	39.217	82.964	75.078
T2-137	137	1973	1	69.526	57.968	69.064
T3-023	23	1973	1	64.294	97.946	100.000

Appendix B5 (continued)

Station	Depth	Year	Replicate	FRI	IRI	TRI
943	42	1994	1	14.103	27.639	29.276
T3-061	61	1973	1	95.139	76.432	87.139
T3-137	137	1973	1	59.470	67.216	74.832
T4-023	23	1973	1	69.101	90.507	86.829
T4-023	23	1990	1	40.418	49.249	46.815
T4-061	61	1973	1	70.927	68.127	81.922
T4-061	61	1985	1	39.989	82.797	78.371
T4-061	61	1985	2	37.569	64.963	58.058
T4-061	61	1990	1	32.589	39.227	39.398
T4-137	137	1973	1	71.506	68.987	78.916
T4-137	137	1985	1	57.029	76.892	82.734
T4-137	137	1985	2	47.555	77.735	80.854
T4-137	137	1990	1	44.364	51.210	53.344
T5-023	23	1973	1	80.336	100.000	81.059
T5-023	23	1985	1	38.432	26.199	51.678
T5-023	23	1990	1	43.792	20.924	35.292
T5-061	61	1973	1	71.219	65.930	77.049
T5-061	61	1985	1	35.224	63.812	51.600
T5-061	61	1990	1	30.775	39.288	40.160
T5-137	137	1973	1	63.813	60.628	66.912
T5-137	137	1985	1	47.035	70.695	69.608
T5-137	137	1985	2	45.407	67.849	70.937
T5-137	137	1990	1	37.649	51.930	50.103
T5-137	146	1973	1	58.027	62.963	68.719

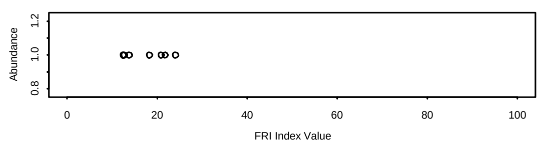
FRI = Fish response index
IRI = Invertebrate response index
TRI = Trawl response index (fish and invertebrates combined)

Appendix B6. Patterns of selected variables along the pollution gradient in calibration data base as defined by the Fish Response Index (FRI) values for southern California demersal fish species and other ecological variables.

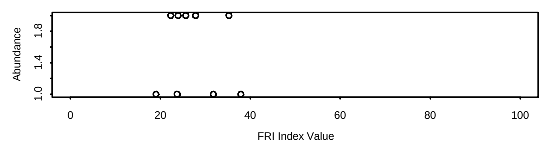
The nature of the gradient defined by the Fish Response Index (IRI) values is shown by plotting pertinent variables vs. the index values for the calibration observations. The variables plotted include community parameters, environmental variables, BRI, and the projections onto the pollution vector in the ordination space (ORDINATION VECTOR). The FINES parameter is the percent of silt plus clay in the sediment. In addition, the abundance of each fish species is plotted in the order of the p_i values, which shown are shown above each graph. No p_i value was computed for species occurring only once in the calibration data at the depth range in question. Data for each depth range (inner shelf, 9-40 m; middle shelf, 30-120 m; and 100-215 m) is plotted separately.

Inner Shelf (9-40 m)

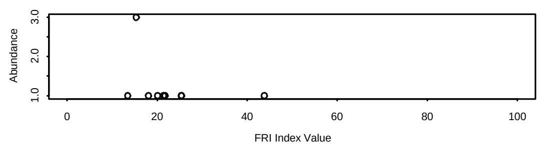
1. Platyrhinoidis triseriata - f P=-3 9-40 m



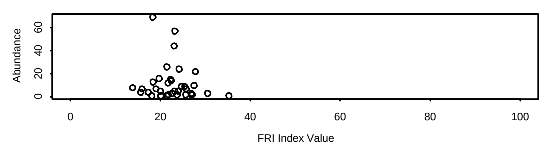
2. Porichthys myriaster - f P=10.5 9-40 m



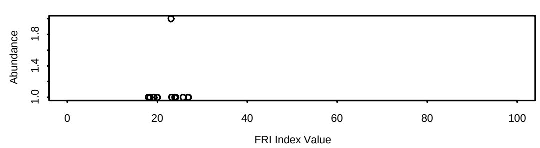
3. Paralabrax nebulifer - f P=10.6 9-40 m



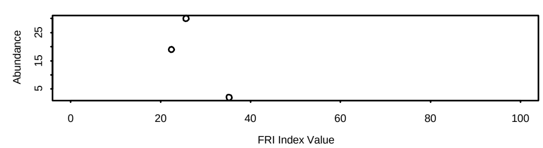
4. Citharichthys xanthostigma - f P=10.7 9-40 m



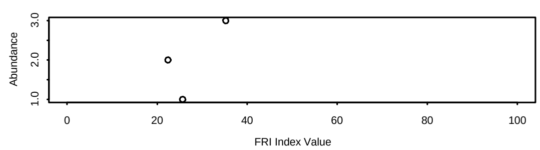
5. Raja inornata - f P=11.1 9-40 m



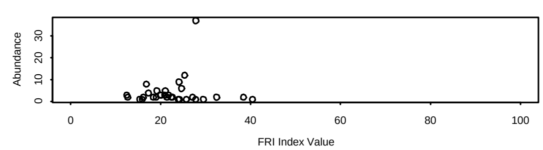
6. Sebastes caurinus - f P=11.6 9-40 m



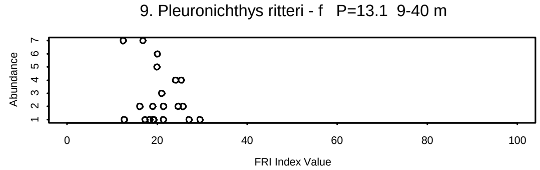
7. Sebastes dallii - f P=11.6 9-40 m



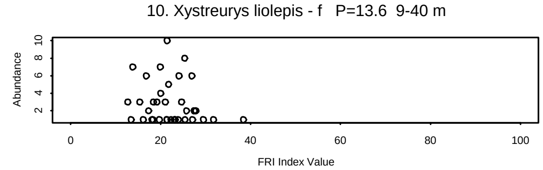
8. Paralichthys californicus - f P=11.6 9-40 m



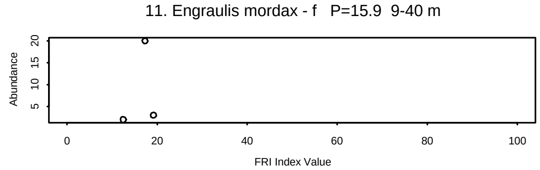
9. Pleuronichthys ritteri - f P=13.1 9-40 m



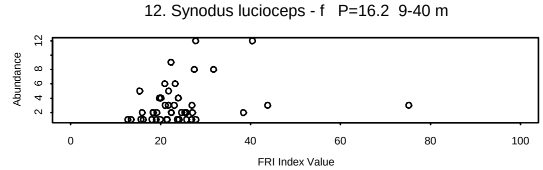
10. Xystreurys liolepis - f P=13.6 9-40 m



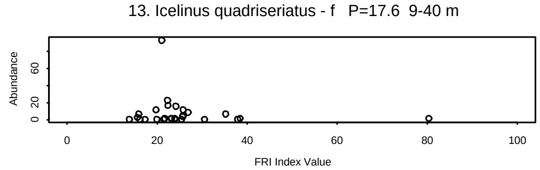
11. Engraulis mordax - f P=15.9 9-40 m



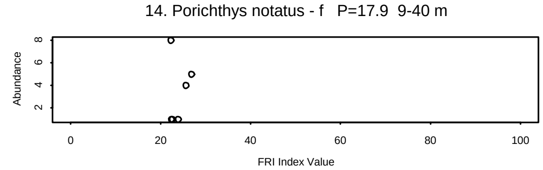
12. Synodus lucioceps - f P=16.2 9-40 m



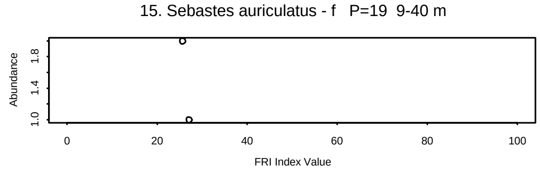
13. Icelinus quadriseriatus - f P=17.6 9-40 m



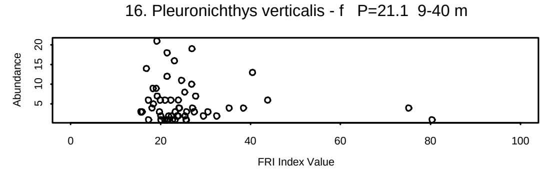
14. Porichthys notatus - f P=17.9 9-40 m



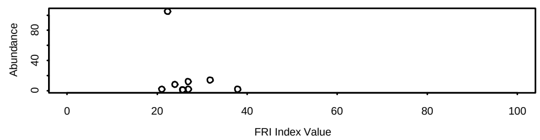
15. Sebastes auriculatus - f P=19 9-40 m



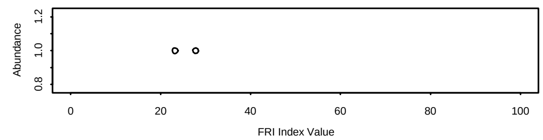
16. Pleuronichthys verticalis - f P=21.1 9-40 m



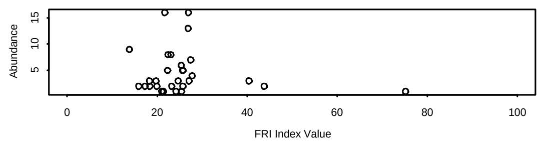
17. Zaniolepis latipinnis - f P=21.7 9-40 m



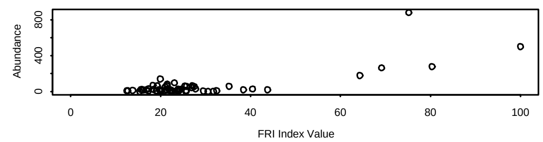
18. Raja binoculata - f P=22.2 9-40 m



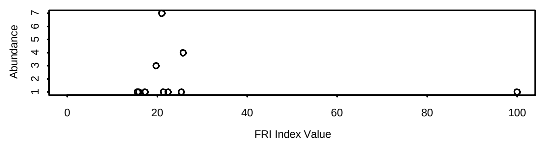
19. Hippoglossina stomata - f P=24.5 9-40 m



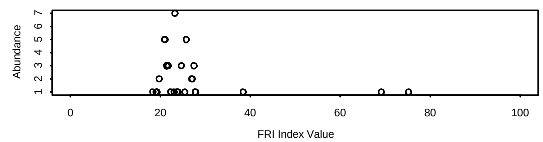
20. Citharichthys stigmaeus - f P=24.8 9-40 m



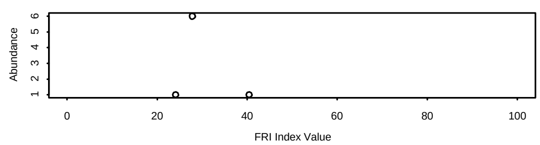
21. Chitonotus pugetensis - f P=25.1 9-40 m



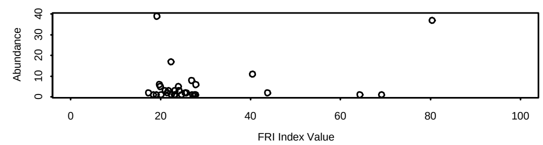
22. Scorpaena guttata - f P=26.1 9-40 m



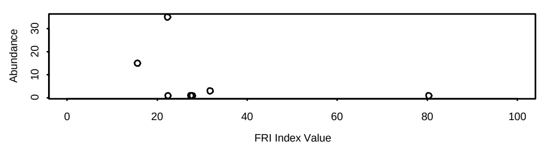
23. Seriphus politus - f P=35.8 9-40 m



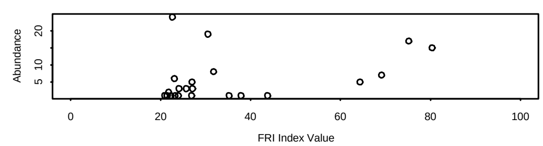
24. Symphurus atricauda - f P=37.1 9-40 m



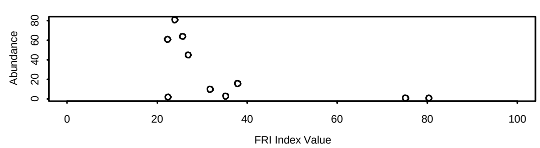
25. Lepidogobius lepidus - f P=41.3 9-40 m



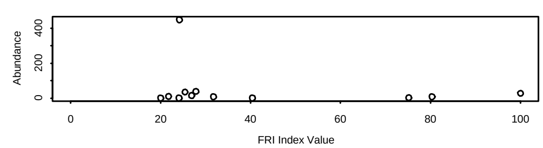
26. Parophrys vetula - f P=49.6 9-40 m



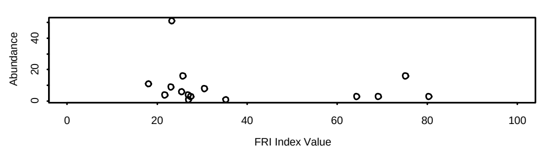
27. Zalembius rosaceus - f P=49.9 9-40 m



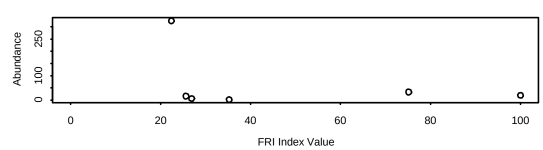
28. Genyonemus lineatus - f P=58.2 9-40 m



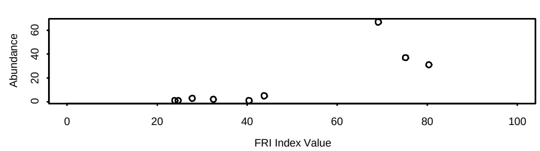
29. Citharichthys sordidus - f P=59.3 9-40 m



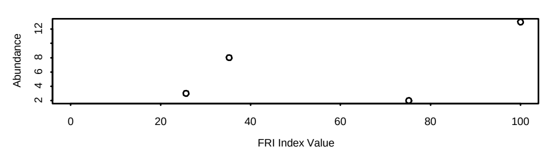
30. Sebastes saxicola - f P=65.9 9-40 m



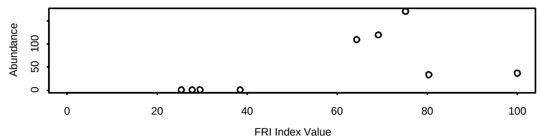
31. Phanerodon furcatus - f P=72.4 9-40 m



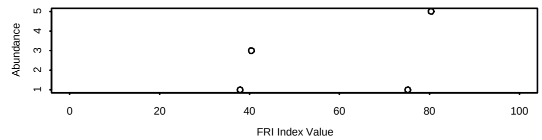
32. Sebastes miniatus - f P=90.2 9-40 m



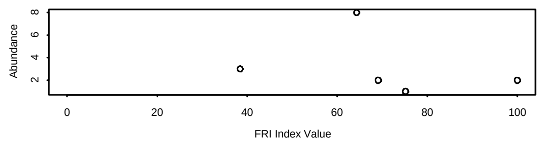
33. Pleuronichthys decurrens - f   P=92.9 9-40 m



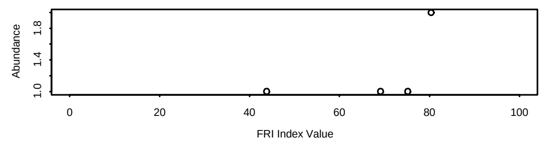
34. Microstomus pacificus - f   P=102.3 9-40 m



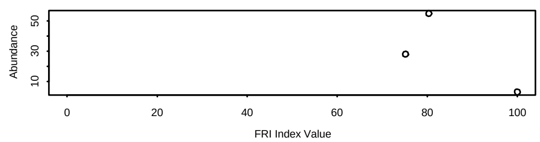
35. Pleuronichthys coenosus - f   P=121.9 9-40 m



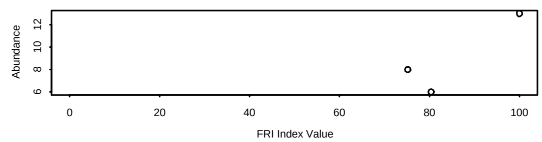
36. Rhacochilus vacca - f   P=137.7 9-40 m



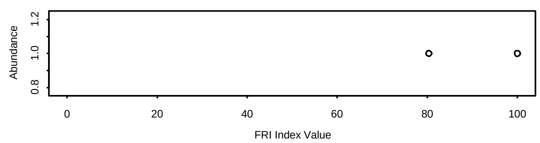
37. Cymatogaster aggregata - f   P=169.8 9-40 m



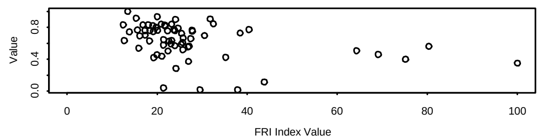
38. Sebastes goodei - f   P=169.8 9-40 m



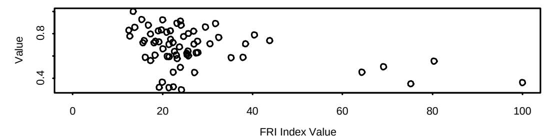
39. Chilara taylori - f   P=181.3 9-40 m



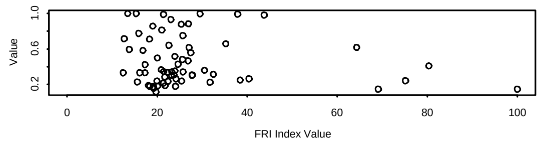
1. EVENNESS - fish + inv 9-40 m



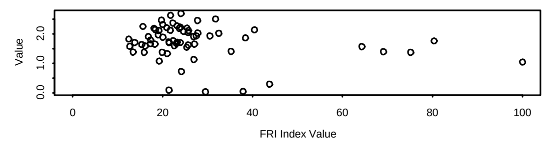
2. EVENNESS - fish 9-40 m



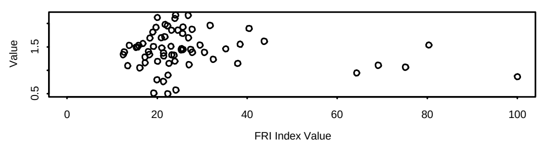
3. SIMPSON DOMINANCE INDEX - invert 9-40 m



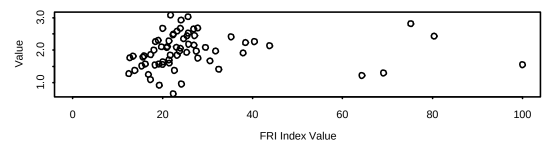
4. SHANNON-WIENER DIVERSITY - fish + inv 9-40 m



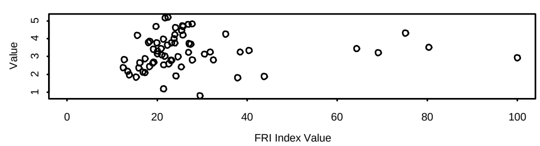
5. SHANNON-WIENER DIVERSITY - fish 9-40 m



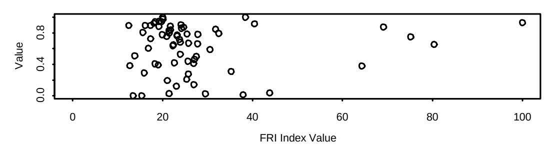
6. GLEASON RICHNESS DIVERSITY - fish 9-40 m



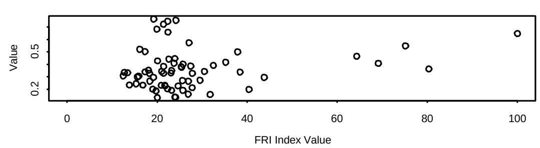
7. GLEASON RICHNESS DIVERSITY - fish + inv 9-40 m



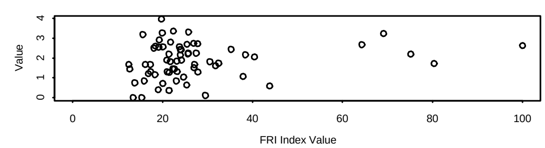
8. EVENNESS - invert 9-40 m



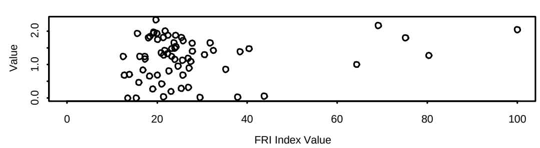
9. SIMPSON DOMINANCE INDEX - fish 9-40 m



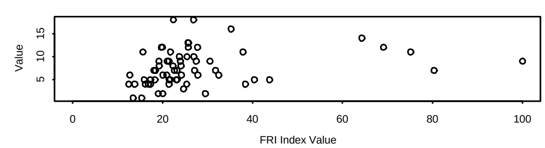
10. GLEASON RICHNESS DIVERSITY - invert 9-40 m



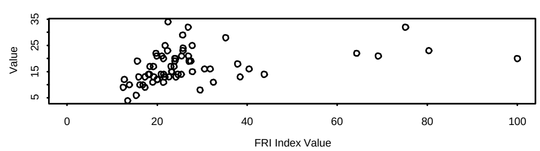
11. SHANNON-WIENER DIVERSITY - invert 9-40 m



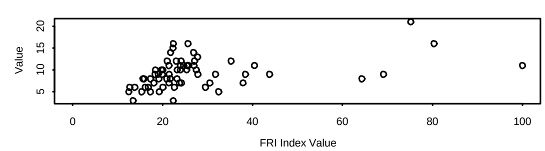
12. NO. OF SPECIES - invert 9-40 m



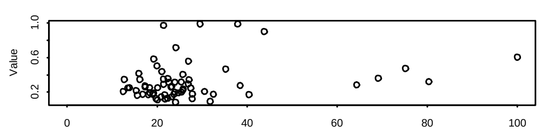
13. NO. OF SPECIES - fish + inv 9-40 m



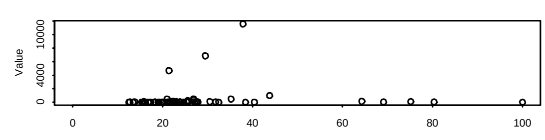
14. NO. OF SPECIES - fish 9-40 m

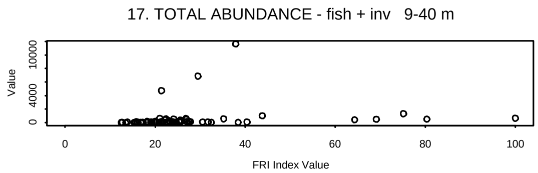


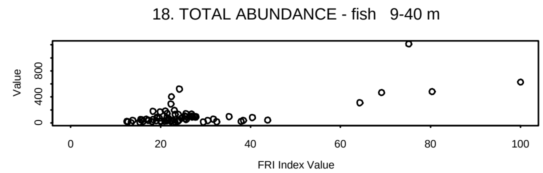
15. SIMPSON DOMINANCE INDEX - fish + inv 9-40 m

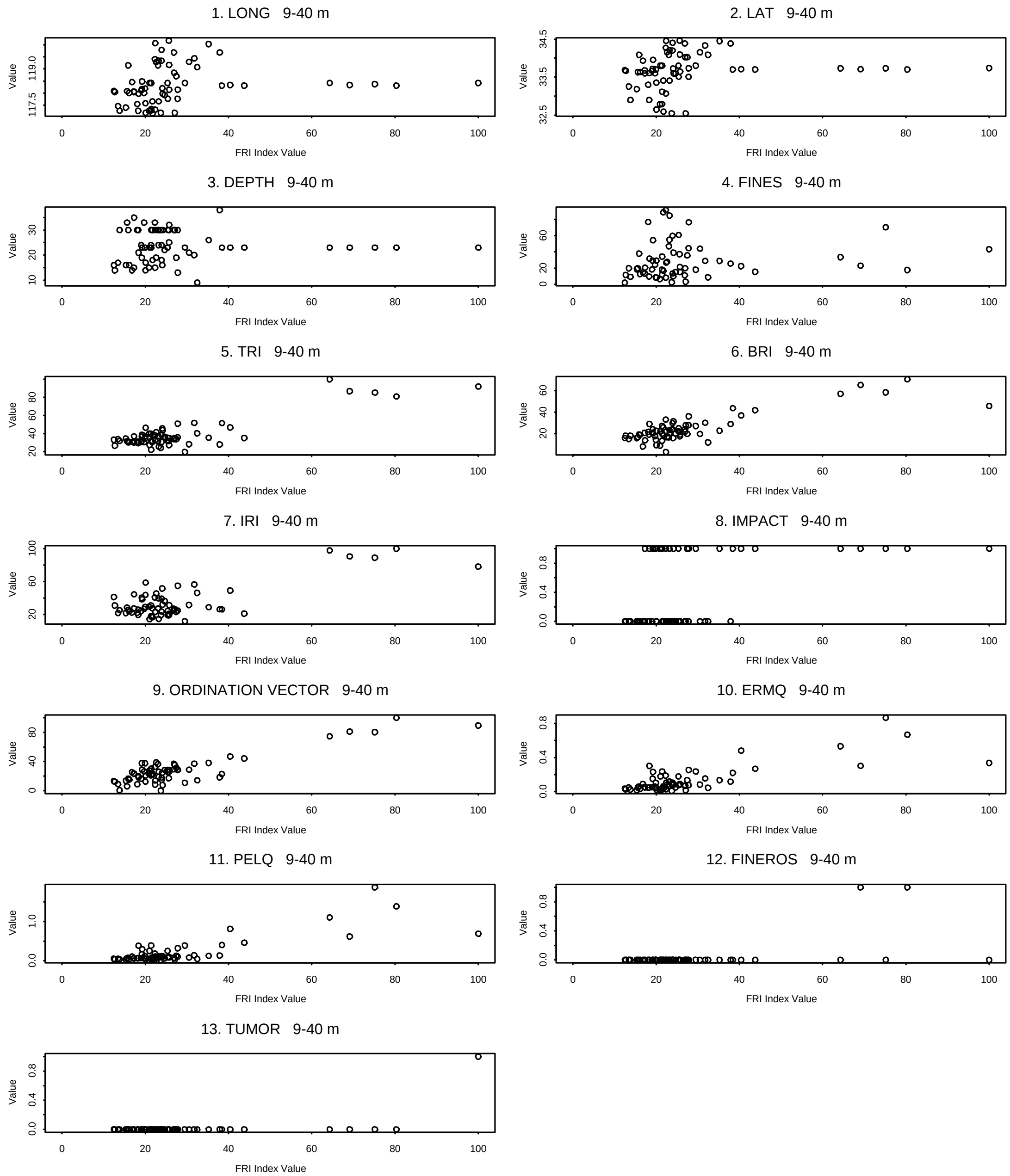


16. TOTAL ABUNDANCE - invert 9-40 m



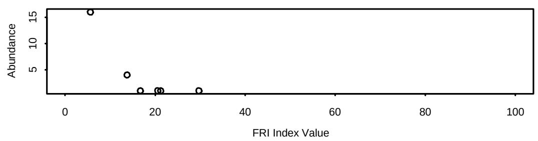

17. TOTAL ABUNDANCE - fish + inv 9-40 m
Value
0
4000
10000
0
20
40
60
80
100
FRI Index Value


18. TOTAL ABUNDANCE - fish 9-40 m
Value
0
400
800
0
20
40
60
80
100
FRI Index Value

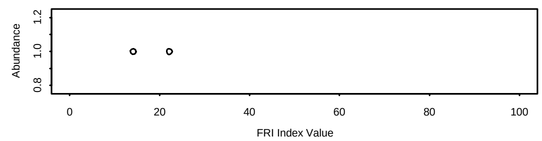

1. LONG 9-40 m
2. LAT 9-40 m
3. DEPTH 9-40 m
4. FINES 9-40 m
5. TRI 9-40 m
6. BRI 9-40 m
7. IRI 9-40 m
8. IMPACT 9-40 m
9. ORDINATION VECTOR 9-40 m
10. ERMQ 9-40 m
11. PELQ 9-40 m
12. FINEROS 9-40 m
13. TUMOR 9-40 m
Value
FRI Index Value
0 20 40 60 80 100

Middle Shelf (30-120 m)

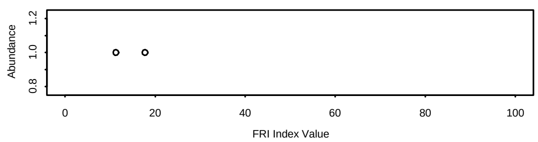
1. Sebastes chlorostictus - f   P=-25.8 30-120 m



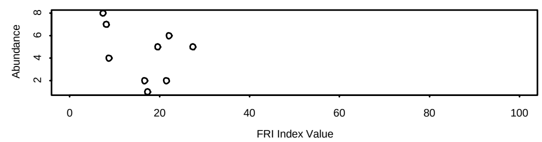
2. Sebastes eos - f   P=-21.7 30-120 m



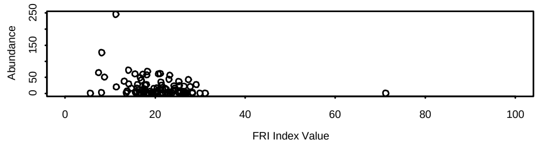
3. Merluccius productus - f   P=-18.8 30-120 m



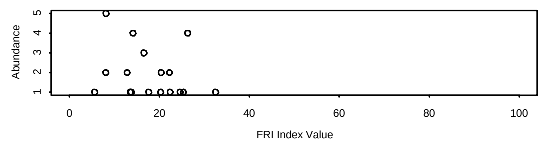
4. Coryphopterus nicholsii - f   P=-18.4 30-120 m



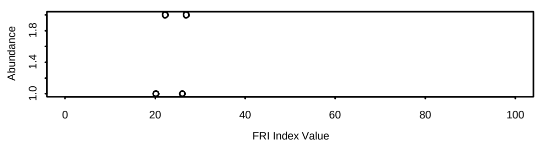
5. Citharichthys xanthostigma - f   P=-13.9 30-120 m



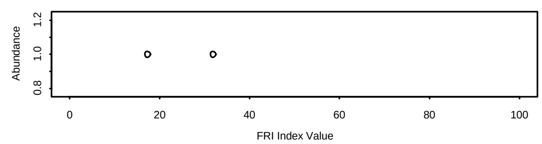
6. Chilara taylori - f   P=-13.1 30-120 m



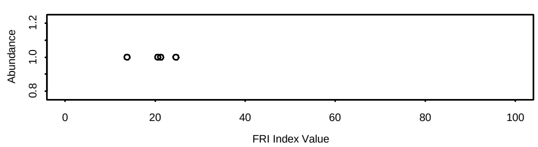
7. Sebastes diploproa - f   P=-11.8 30-120 m



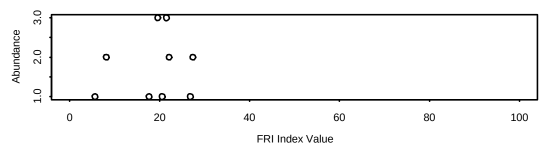
8. Sebastes pinniger - f   P=-10.4 30-120 m



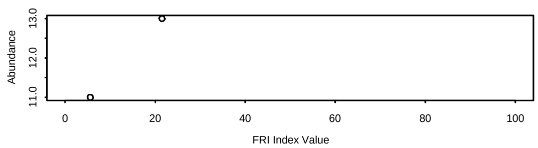
9. Sebastes elongatus - f   P=-10.2 30-120 m



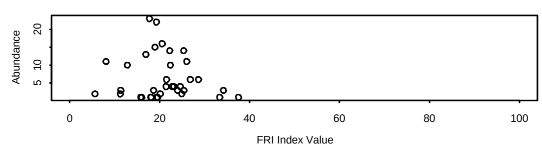
10. Rathbunella hypoplecta - f   P=-8 30-120 m



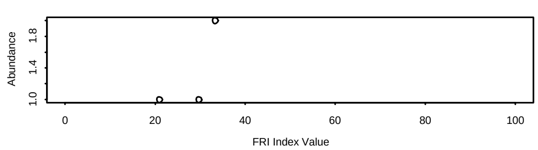
11. Icelinus tenuis - f   P=-7.9 30-120 m



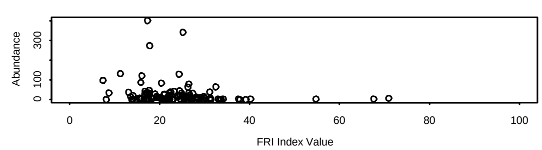
12. Argentina sialis - f   P=-4.5 30-120 m



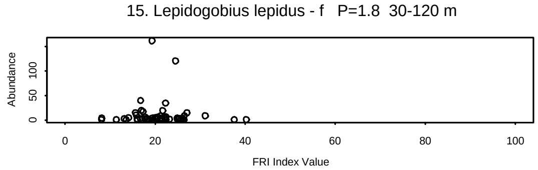
13. Eopsetta jordani - f   P=1.5 30-120 m



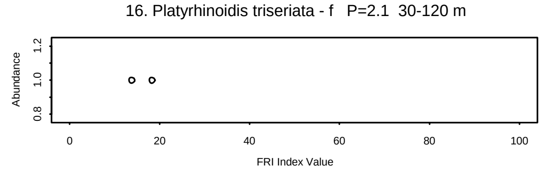
14. Icelinus quadriseriatus - f   P=1.7 30-120 m



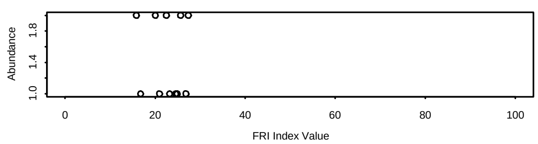
15. Lepidogobius lepidus - f   P=1.8 30-120 m



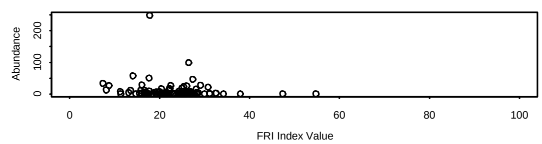
16. Platyrhinoidis triseriata - f   P=2.1 30-120 m



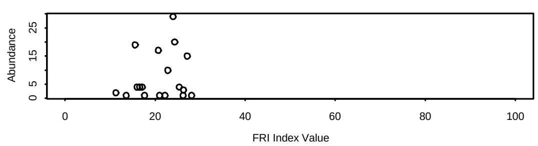
17. Ophiodon elongatus - f P=2.5 30-120 m



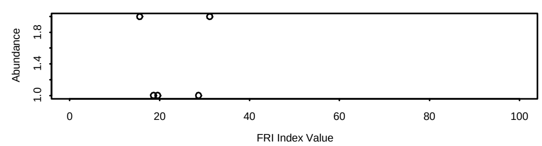
18. Symphurus atricauda - f P=3.3 30-120 m



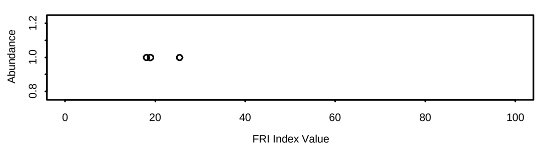
19. Citharichthys fragilis - f P=6.1 30-120 m



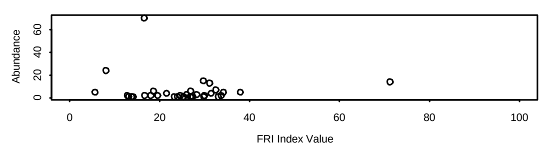
20. Xeneretmus triacanthus - f P=6.4 30-120 m



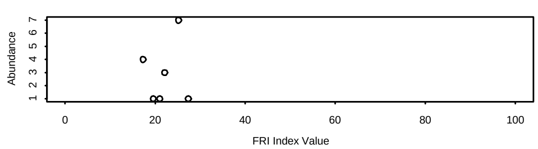
21. Paralabrax nebulifer - f P=9.1 30-120 m



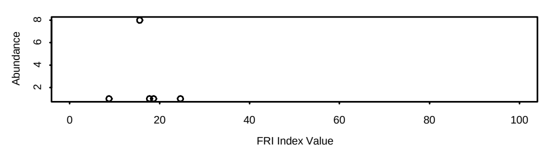
22. Sebastes semicinctus - f P=9.9 30-120 m



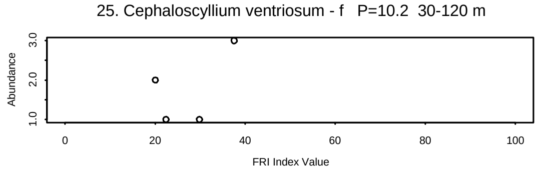
23. Sebastes rubrivinctus - f P=9.9 30-120 m



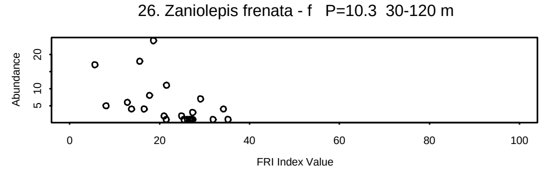
24. Xeneretmus latifrons - f P=10.1 30-120 m



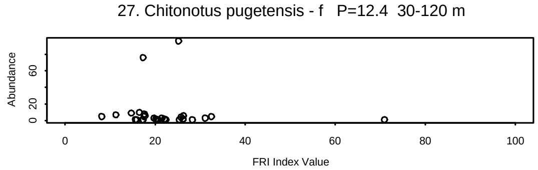
25. Cephaloscyllium ventriosum - f P=10.2 30-120 m



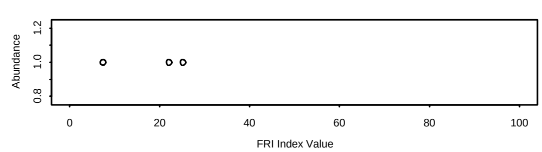
26. Zaniolepis frenata - f P=10.3 30-120 m



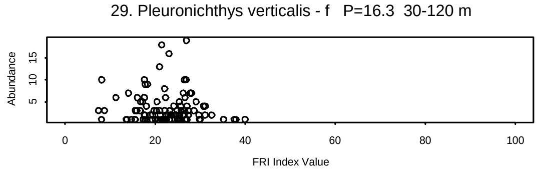
27. Chitonotus pugetensis - f P=12.4 30-120 m



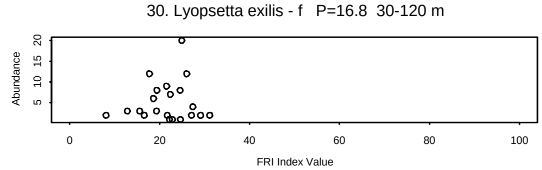
28. Sebastes rosaceus - f P=13.7 30-120 m



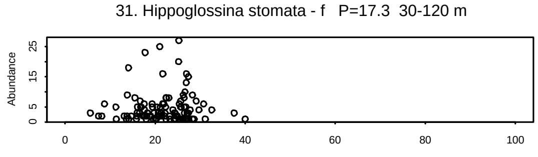
29. Pleuronichthys verticalis - f P=16.3 30-120 m



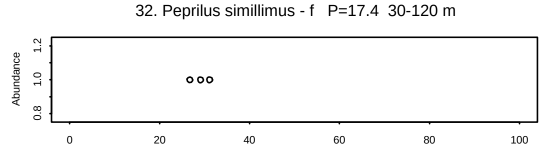
30. Lyopsetta exilis - f P=16.8 30-120 m



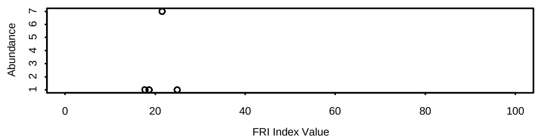
31. Hippoglossina stomata - f P=17.3 30-120 m



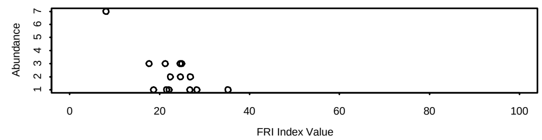
32. Peprilus simillimus - f P=17.4 30-120 m



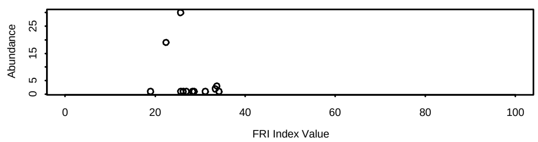
33. Errex zachirus - f   P=17.9 30-120 m



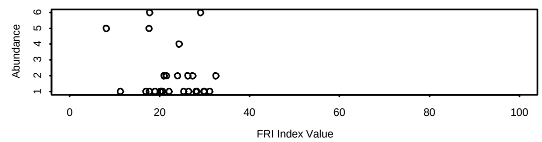
34. Sebastes rosenblatti - f   P=18.2 30-120 m



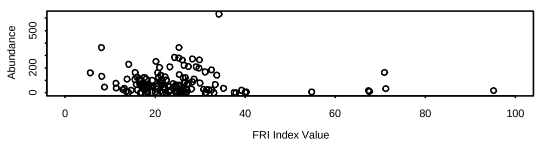
35. Sebastes caurinus - f   P=18.4 30-120 m



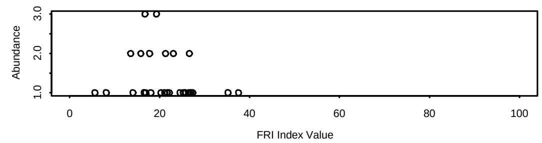
36. Odontopyxis trispinosa - f   P=19 30-120 m



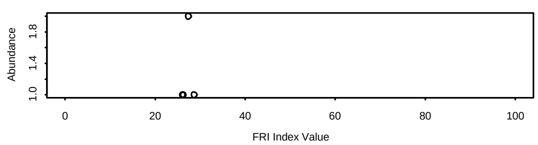
37. Citharichthys sordidus - f   P=19.3 30-120 m



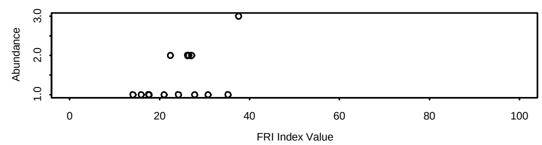
38. Raja inornata - f   P=20.1 30-120 m



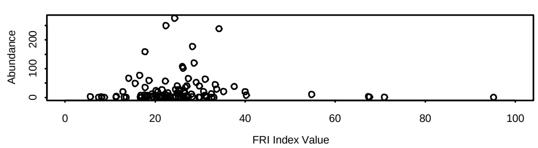
39. Sebastes paucispinis - f   P=20.7 30-120 m



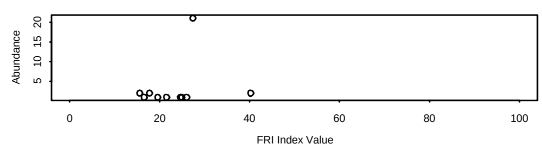
40. Paralichthys californicus - f   P=20.9 30-120 m



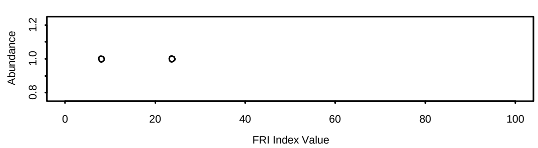
41. Porichthys notatus - f   P=21.5 30-120 m



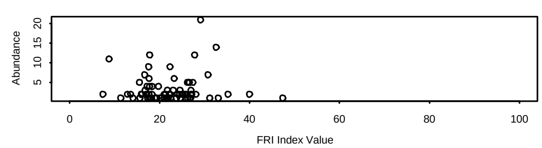
42. Lycodopsis pacifica - f   P=21.7 30-120 m



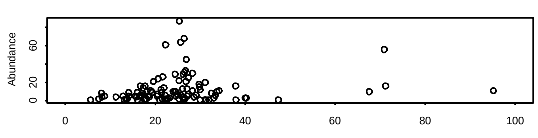
43. Brosmophycis marginata - f   P=22 30-120 m



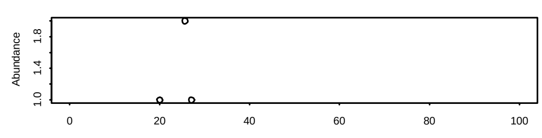
44. Synodus lucioceps - f   P=27.2 30-120 m



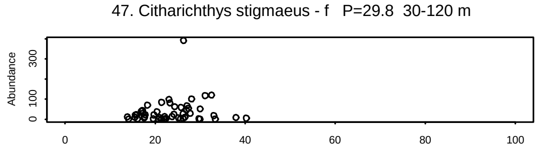
45. Zalembius rosaceus - f   P=28.9 30-120 m



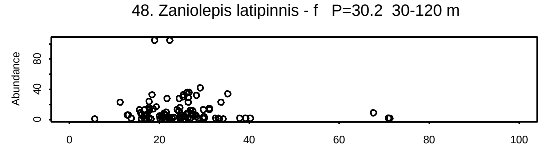
46. Sebastes auriculatus - f   P=29.7 30-120 m



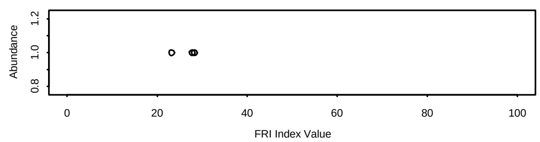
47. Citharichthys stigmaeus - f   P=29.8 30-120 m



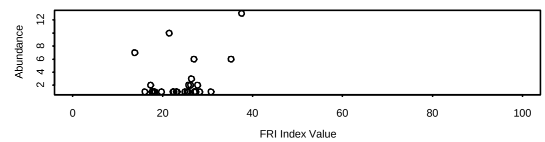
48. Zaniolepis latipinnis - f   P=30.2 30-120 m



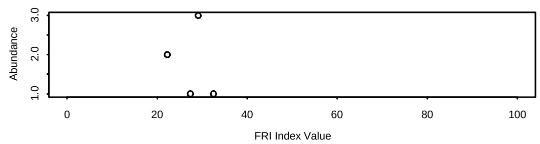
49. Raja binoculata - f   P=31.6 30-120 m



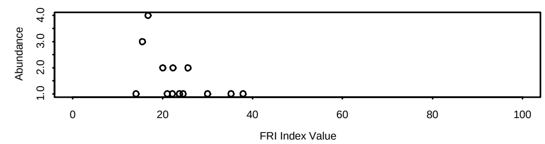
50. Xystreurys liolepis - f   P=32.1 30-120 m



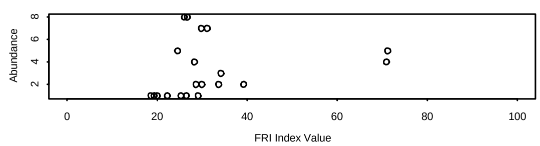
51. Sebastolobus alascanus - f   P=33.4 30-120 m



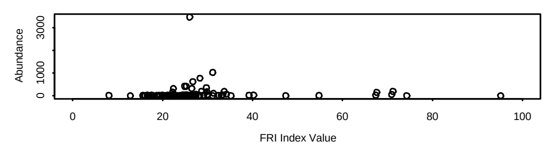
52. Porichthys myriaster - f   P=33.9 30-120 m



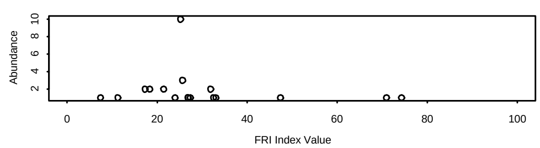
53. Sebastes levis - f   P=44.3 30-120 m



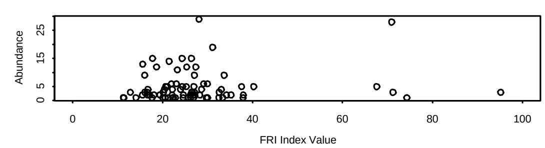
54. Sebastes saxicola - f   P=44.4 30-120 m



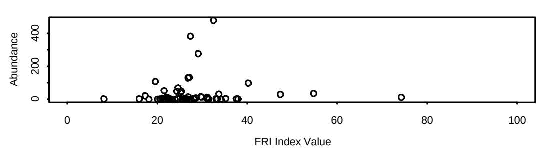
55. Sebastes miniatus - f   P=46.7 30-120 m



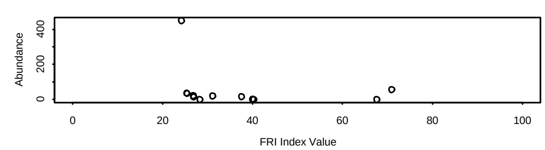
56. Parophrys vetula - f   P=48.1 30-120 m



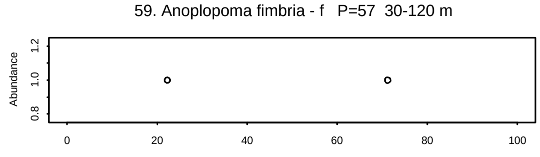
57. Sebastes dallii - f   P=50.2 30-120 m



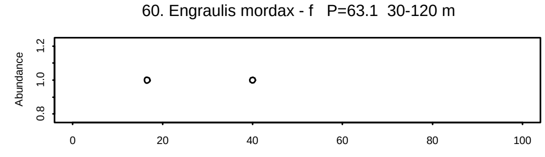
58. Genyonemus lineatus - f   P=54.4 30-120 m



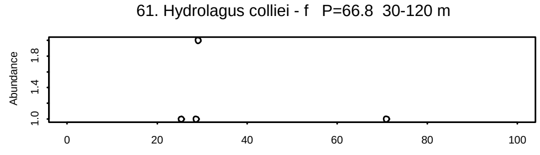
59. Anoplopoma fimbria - f   P=57 30-120 m



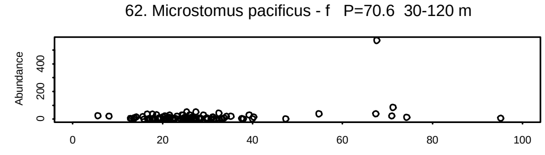
60. Engraulis mordax - f   P=63.1 30-120 m



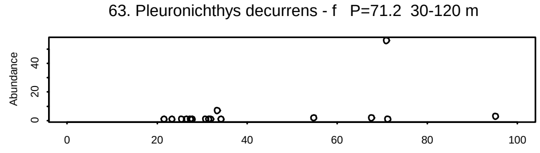
61. Hydrolagus colliei - f   P=66.8 30-120 m



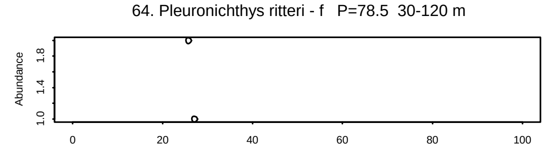
62. Microstomus pacificus - f   P=70.6 30-120 m



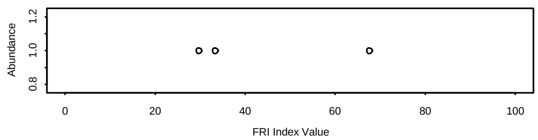
63. Pleuronichthys decurrens - f   P=71.2 30-120 m



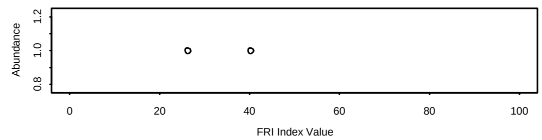
64. Pleuronichthys ritteri - f   P=78.5 30-120 m



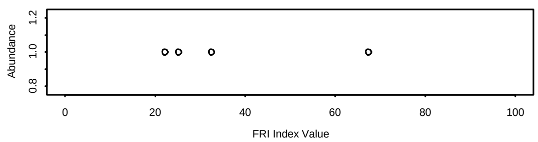
65. Sebastes mystinus - f   P=81.9 30-120 m



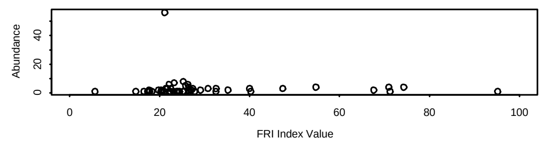
66. Sebastes serranoides - f   P=85.1 30-120 m



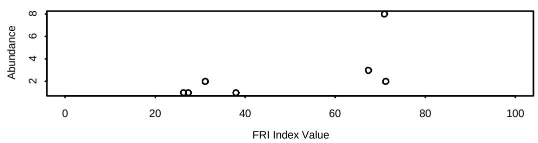
67. Sebastes hopkinsi - f   P=86.3 30-120 m



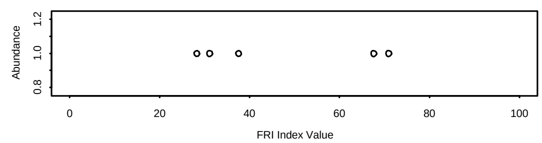
68. Scorpaena guttata - f   P=87 30-120 m



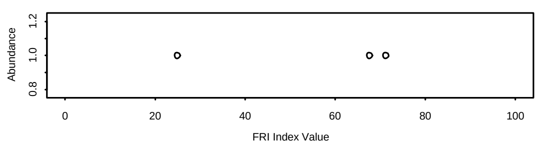
69. Sebastes goodei - f   P=108.3 30-120 m



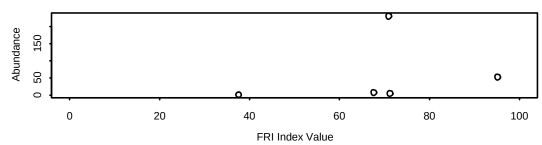
70. Torpedo californica - f   P=118.1 30-120 m



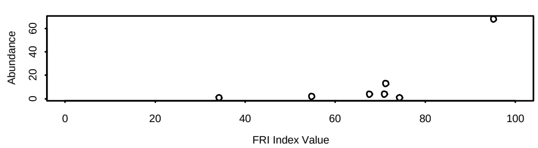
71. Kathetostoma averruncus - f   P=120.8 30-120 m



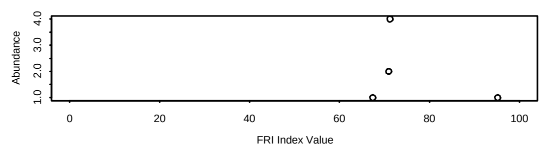
72. Cymatogaster aggregata - f   P=160.7 30-120 m



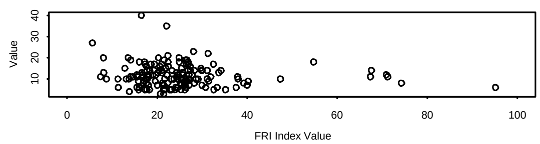
73. Sebastes jordani - f   P=191.7 30-120 m



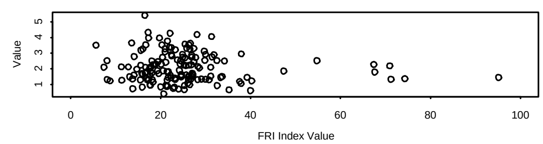
74. Sebastes crameri - f   P=196.7 30-120 m



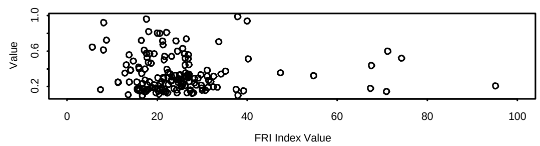
1. NO. OF SPECIES - invert 30-120 m



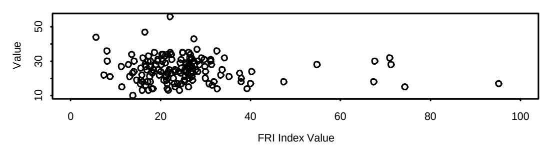
2. GLEASON RICHNESS DIVERSITY - invert 30-120 m



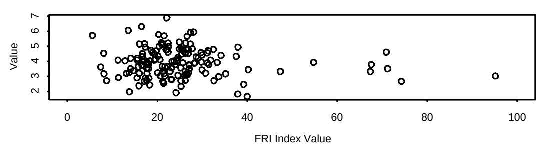
3. SIMPSON DOMINANCE INDEX - fish + inv 30-120 m



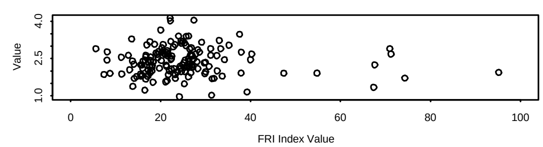
4. NO. OF SPECIES - fish + inv 30-120 m



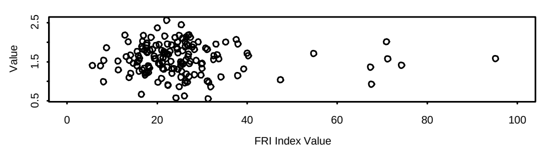
5. GLEASON RICHNESS DIVERSITY - fish + inv 30-120 m



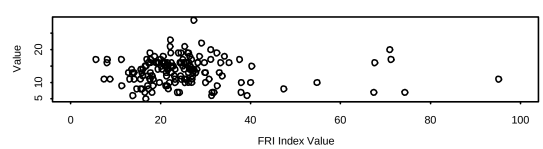
6. GLEASON RICHNESS DIVERSITY - fish 30-120 m



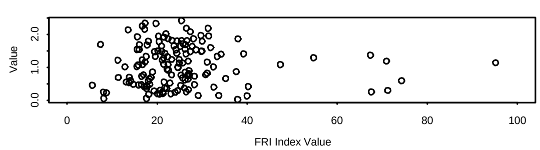
7. SHANNON-WIENER DIVERSITY - fish 30-120 m



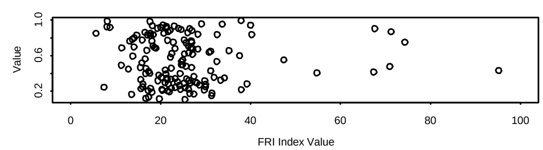
8. NO. OF SPECIES - fish 30-120 m



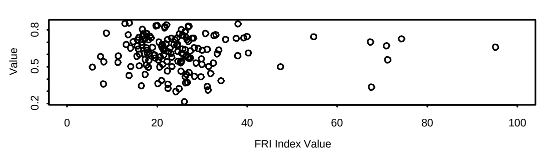
9. SHANNON-WIENER DIVERSITY - invert 30-120 m



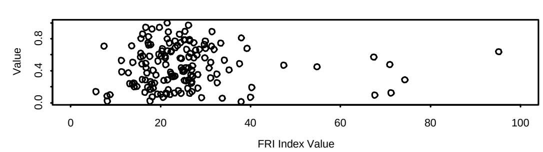
10. SIMPSON DOMINANCE INDEX - invert 30-120 m



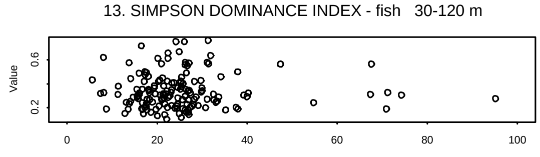
11. EVENNESS - fish 30-120 m



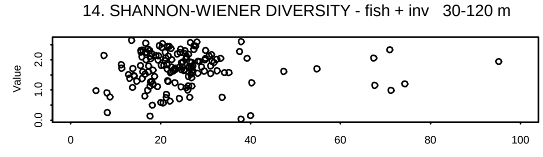
12. EVENNESS - invert 30-120 m



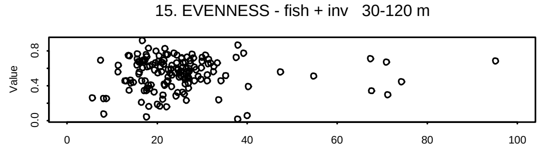
13. SIMPSON DOMINANCE INDEX - fish 30-120 m



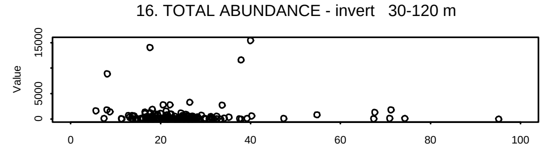
14. SHANNON-WIENER DIVERSITY - fish + inv 30-120 m

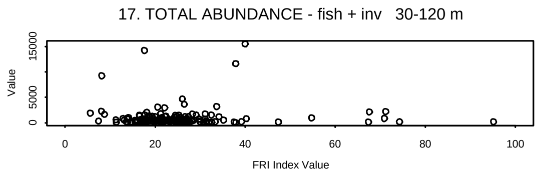


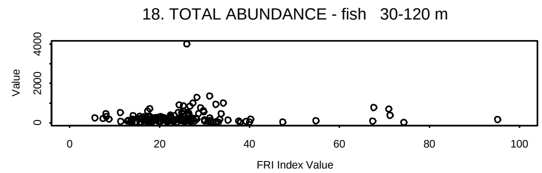
15. EVENNESS - fish + inv 30-120 m



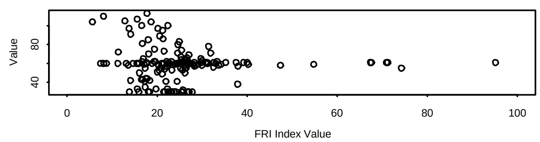
16. TOTAL ABUNDANCE - invert 30-120 m



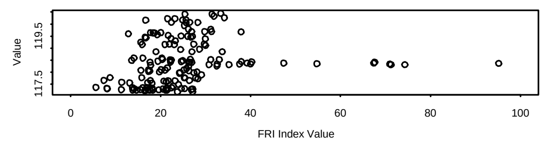

17. TOTAL ABUNDANCE - fish + inv   30-120 m
Value
0
5000
15000
0
20
40
60
80
100
FRI Index Value


18. TOTAL ABUNDANCE - fish   30-120 m
Value
0
2000
4000
0
20
40
60
80
100
FRI Index Value

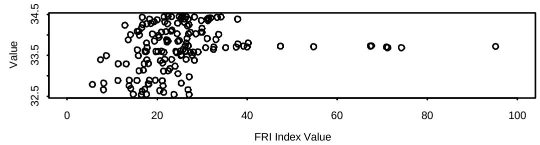
1. DEPTH 30-120 m



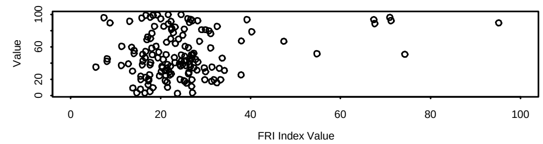
2. LONG 30-120 m



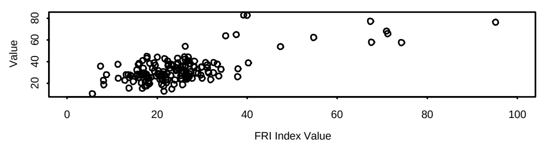
3. LAT 30-120 m



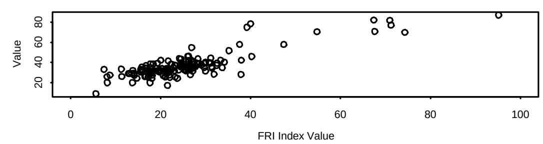
4. FINES 30-120 m



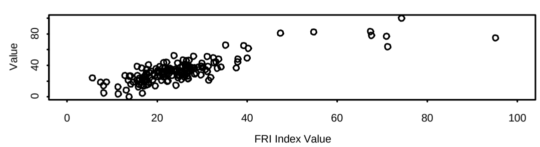
5. IRI 30-120 m



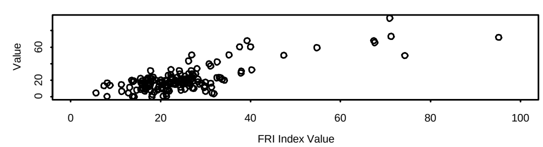
6. TRI 30-120 m



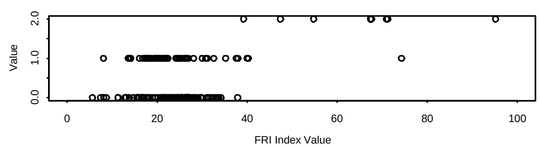
7. ORDINATION VECTOR 30-120 m



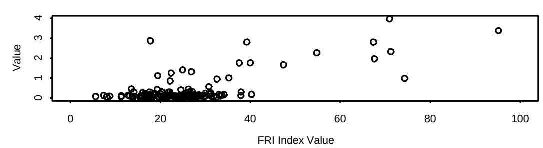
8. BRI 30-120 m



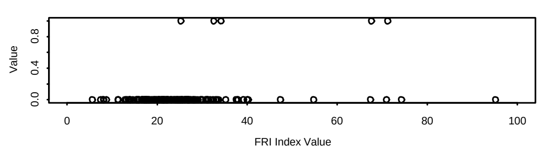
9. IMPACT 30-120 m



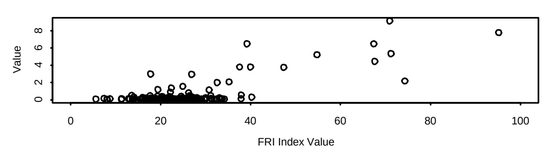
10. ERMQ 30-120 m



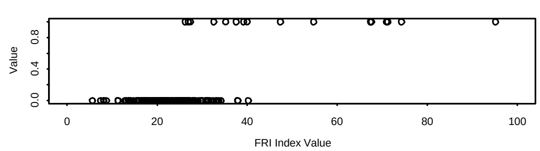
11. TUMOR 30-120 m



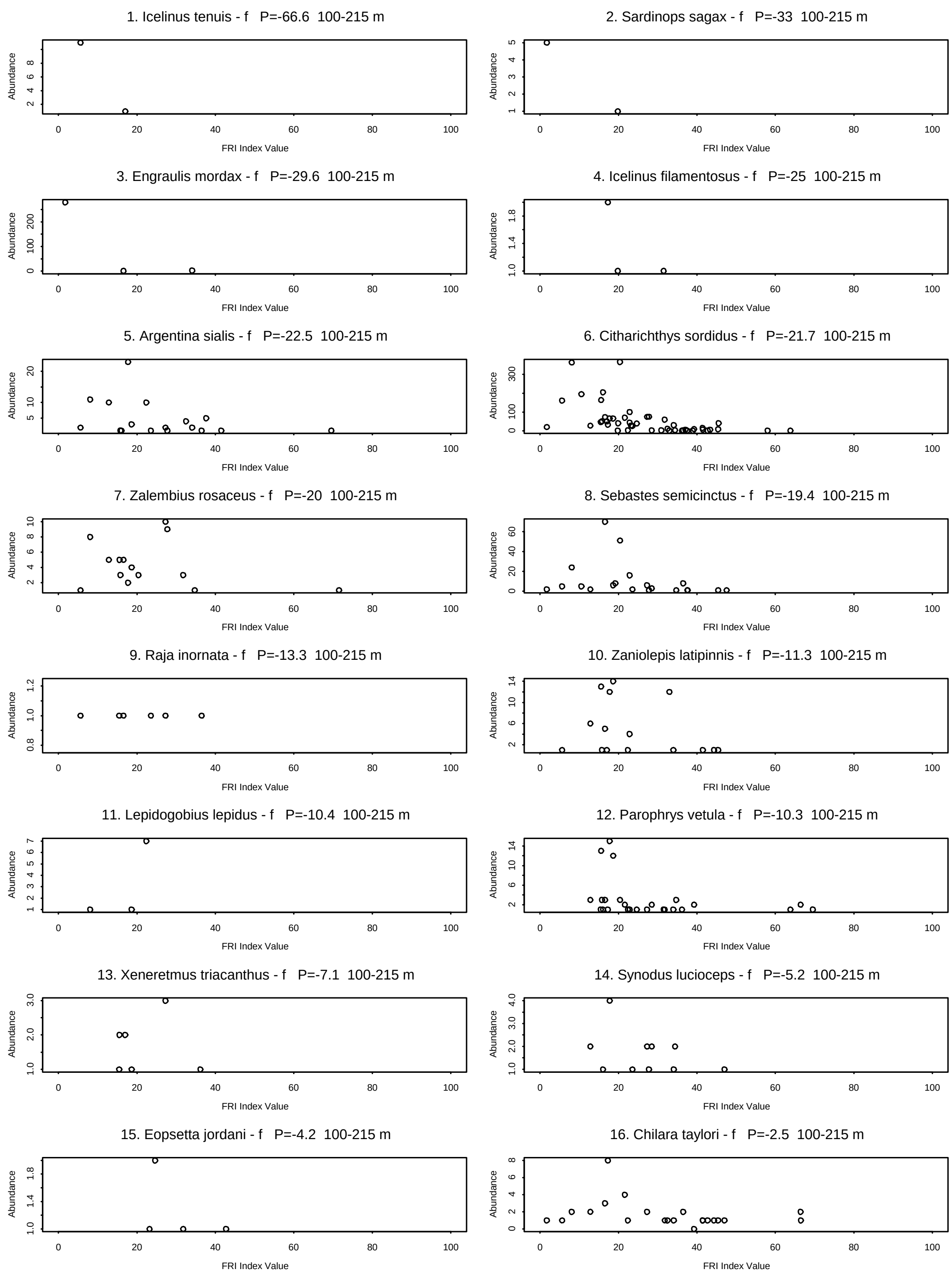
12. PELQ 30-120 m



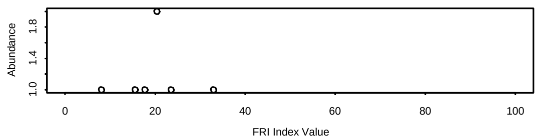
13. FINEROS 30-120 m



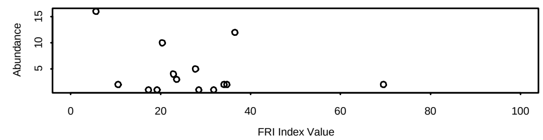
Outer Shelf (100-215 m)



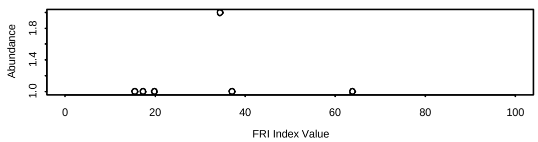
17. Pleuronichthys verticalis - f P=-2.3 100-215 m



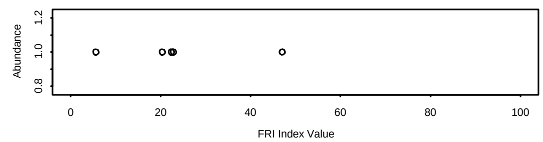
18. Sebastes chlorostictus - f P=-0.1 100-215 m



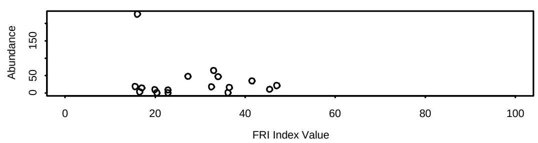
19. Sebastes eos - f P=4.8 100-215 m



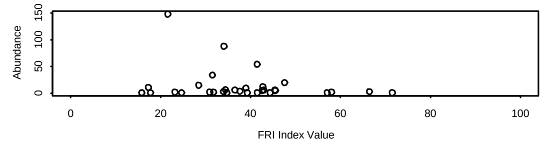
20. Scorpaena guttata - f P=7.6 100-215 m



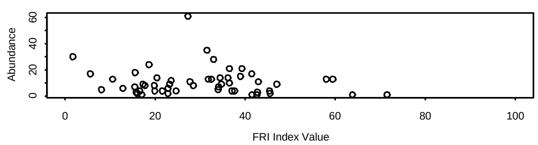
21. Citharichthys fragilis - f P=11.8 100-215 m



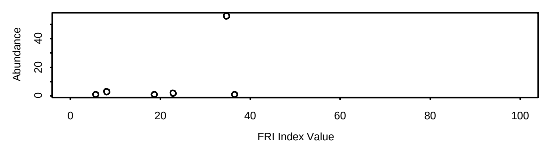
22. Merluccius productus - f P=13.5 100-215 m



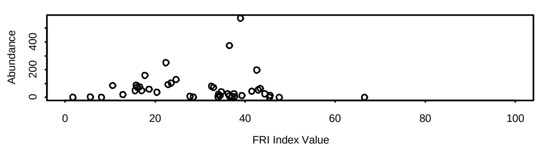
23. Zaniolepis frenata - f P=16.2 100-215 m



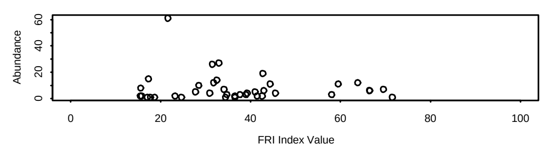
24. Citharichthys xanthostigma - f P=17.4 100-215 m



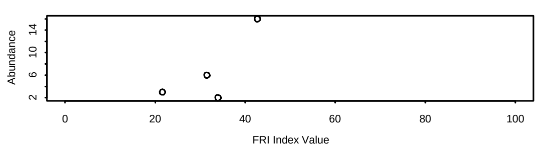
25. Porichthys notatus - f P=22.1 100-215 m



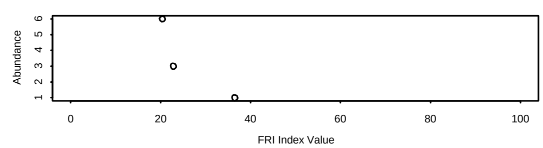
26. Xeneretmus latifrons - f P=22.3 100-215 m



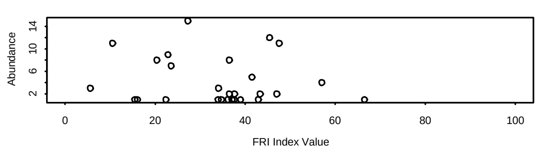
27. Lyconema barbatum - f P=28 100-215 m



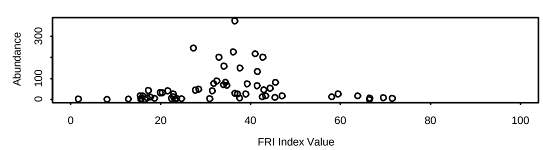
28. Ophiodon elongatus - f P=29.2 100-215 m



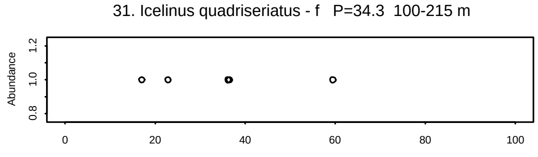
29. Hippoglossina stomata - f P=30.6 100-215 m



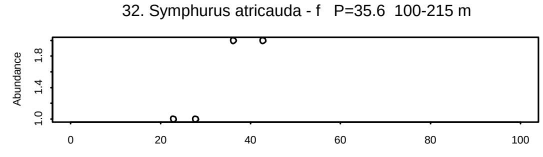
30. Lyopsetta exilis - f P=32.3 100-215 m



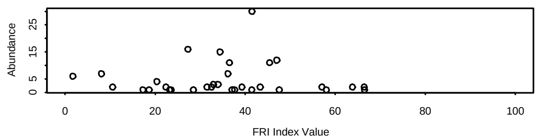
31. Icelinus quadriseriatus - f P=34.3 100-215 m



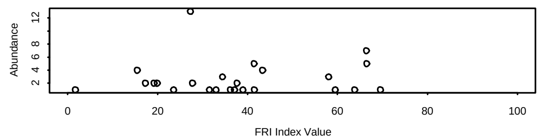
32. Symphurus atricauda - f P=35.6 100-215 m



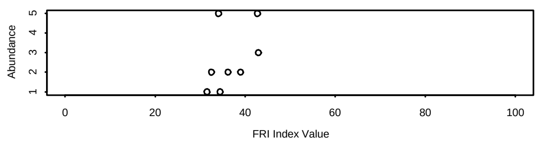
33. Sebastes rosenblatti - f P=36.4 100-215 m



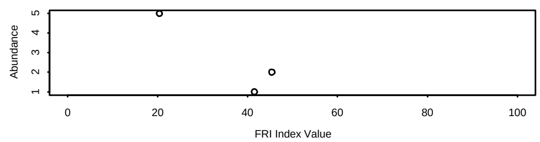
34. Sebastes elongatus - f P=36.6 100-215 m



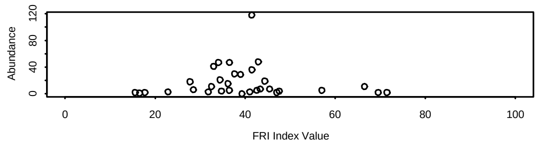
35. Plectobranchus evides - f P=39.3 100-215 m



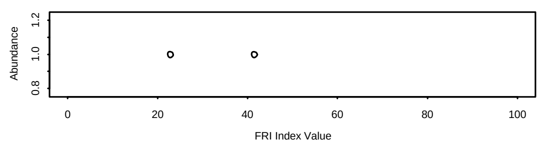
36. Genyonemus lineatus - f P=42.1 100-215 m



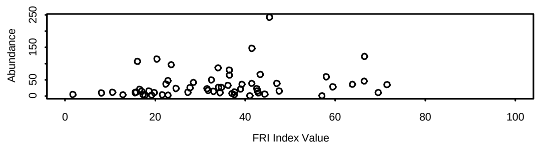
37. Lycodopsis pacifica - f P=43.3 100-215 m



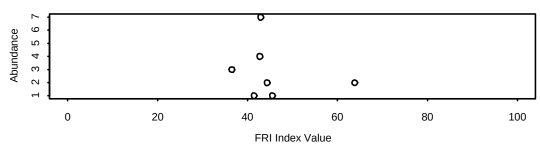
38. Sebastes dallii - f P=45.4 100-215 m



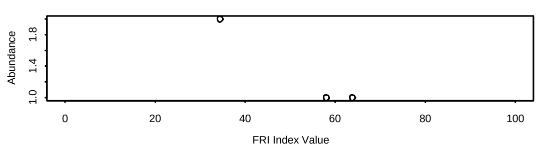
39. Sebastes saxicola - f P=49.2 100-215 m



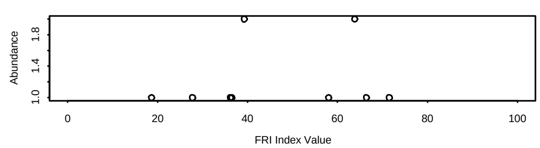
40. Sebastolobus alascanus - f P=53.2 100-215 m



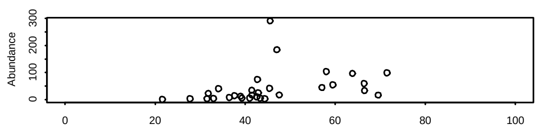
41. Kathetostoma averruncus - f P=55.1 100-215 m



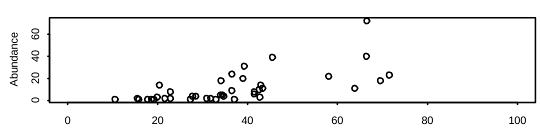
42. Sebastes levis - f P=57.8 100-215 m



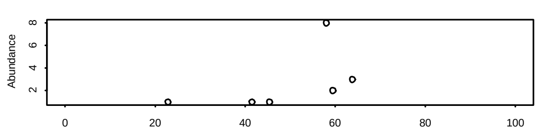
43. Sebastes diploproa - f P=68 100-215 m



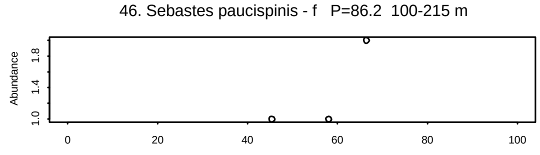
44. Errex zachirus - f P=71.3 100-215 m



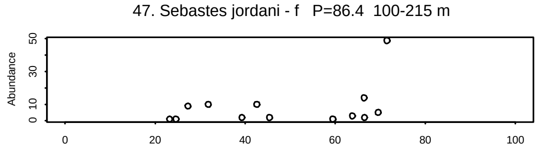
45. Sebastes crameri - f P=78.1 100-215 m



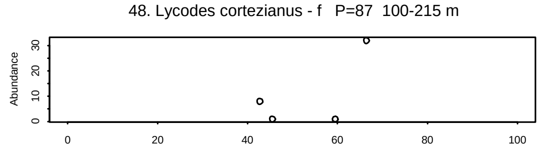
46. Sebastes paucispinis - f P=86.2 100-215 m



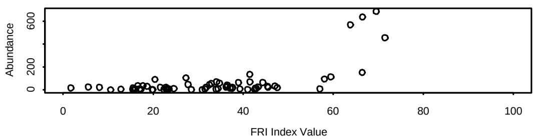
47. Sebastes jordani - f P=86.4 100-215 m



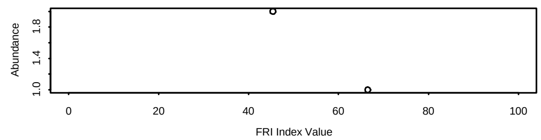
48. Lycodes cortezianus - f P=87 100-215 m



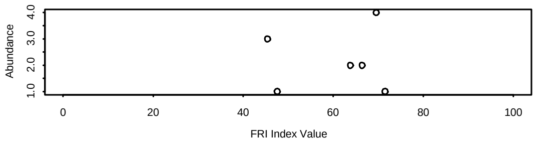
49. Microstomus pacificus - f   P=87.2 100-215 m



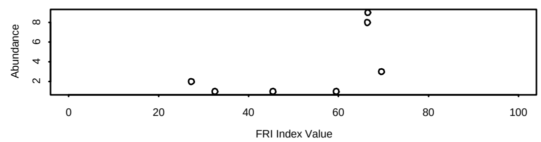
50. Sebastes hopkinsi - f   P=87.6 100-215 m



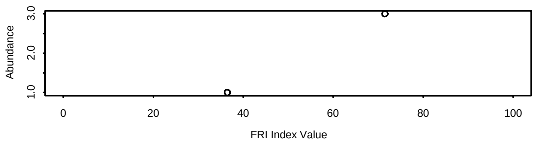
51. Anoplopoma fimbria - f   P=93.2 100-215 m



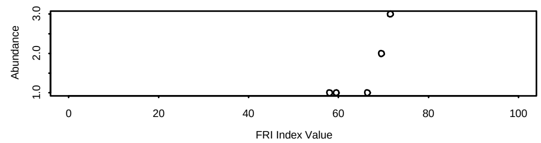
52. Hydrolagus colliei - f   P=98.7 100-215 m



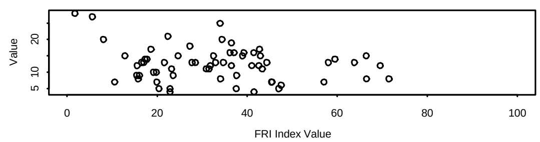
53. Physiculus rastrelliger - f   P=105.4 100-215 m



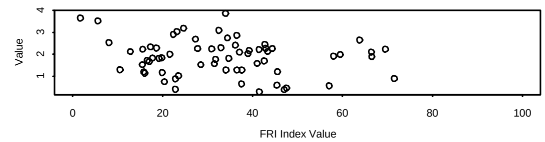
54. Sebastes macdonaldi - f   P=105.5 100-215 m



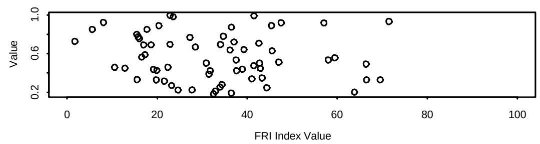
1. NO. OF SPECIES - invert   100-215 m



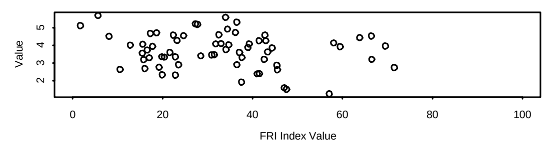
2. GLEASON RICHNESS DIVERSITY - invert   100-215 m



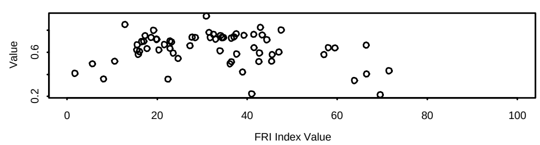
3. SIMPSON DOMINANCE INDEX - invert   100-215 m



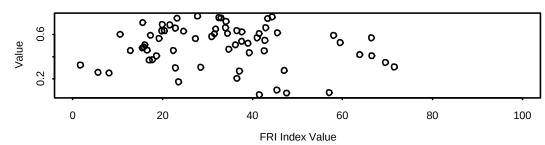
4. GLEASON RICHNESS DIVERSITY - fish + inv   100-215 m



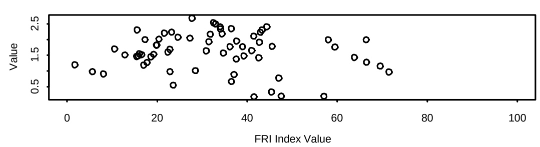
5. EVENNESS - fish   100-215 m



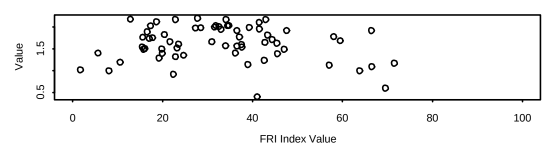
6. EVENNESS - fish + inv   100-215 m



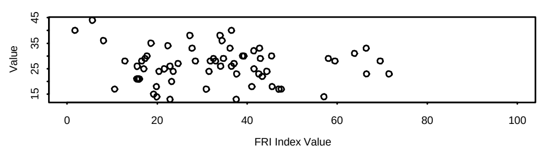
7. SHANNON-WIENER DIVERSITY - fish + inv   100-215 m



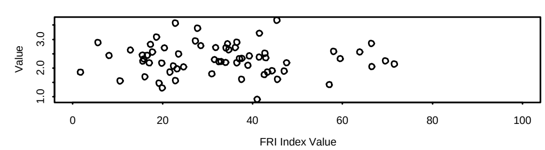
8. SHANNON-WIENER DIVERSITY - fish   100-215 m



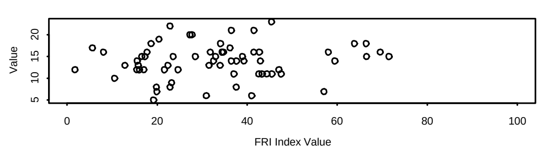
9. NO. OF SPECIES - fish + inv   100-215 m



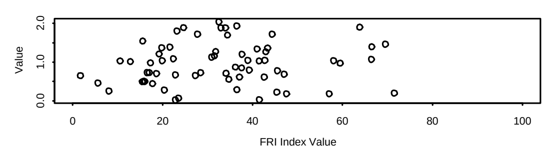
10. GLEASON RICHNESS DIVERSITY - fish   100-215 m



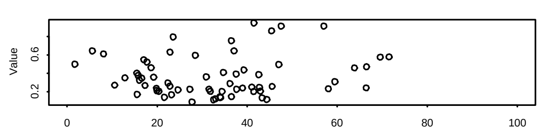
11. NO. OF SPECIES - fish   100-215 m



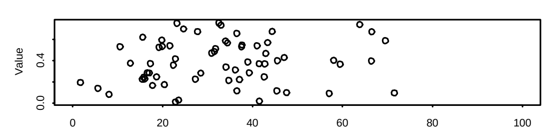
12. SHANNON-WIENER DIVERSITY - invert   100-215 m



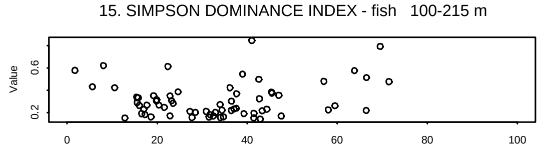
13. SIMPSON DOMINANCE INDEX - fish + inv   100-215 m



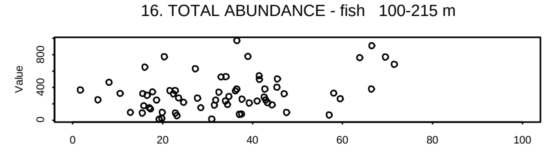
14. EVENNESS - invert   100-215 m

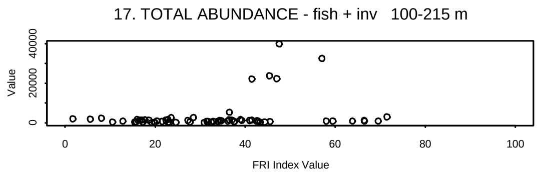


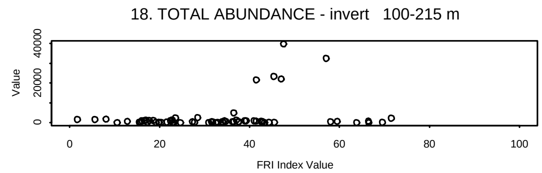
15. SIMPSON DOMINANCE INDEX - fish   100-215 m



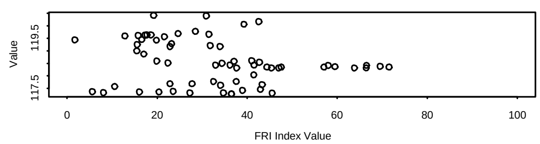
16. TOTAL ABUNDANCE - fish   100-215 m



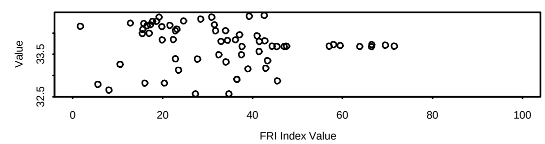

17. TOTAL ABUNDANCE - fish + inv 100-215 m
Value
0
20000
40000
0
20
40
60
80
100
FRI Index Value


18. TOTAL ABUNDANCE - invert 100-215 m
Value
0
20000
40000
0
20
40
60
80
100
FRI Index Value

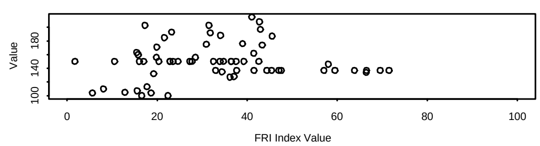
1. LONG   100-215 m



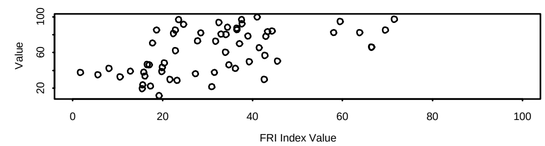
2. LAT   100-215 m



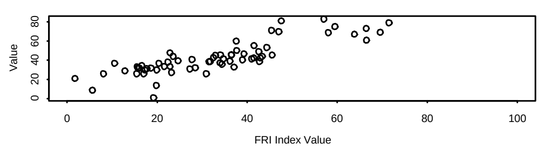
3. DEPTH   100-215 m



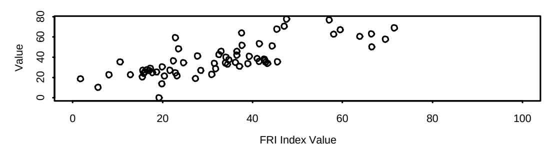
4. FINES   100-215 m



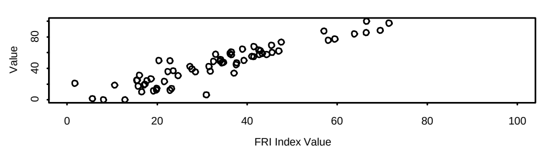
5. TRI   100-215 m



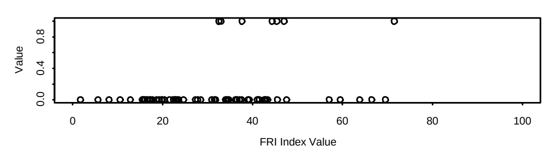
6. IRI   100-215 m



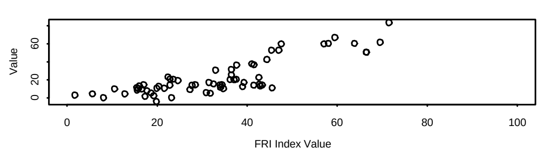
7. ORDINATION VECTOR   100-215 m



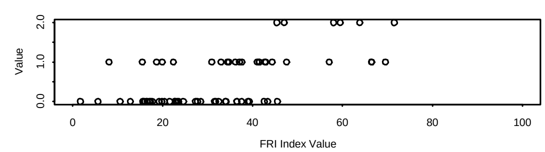
8. TUMOR   100-215 m



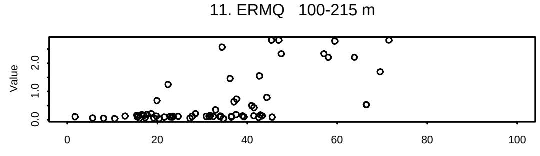
9. BRI   100-215 m



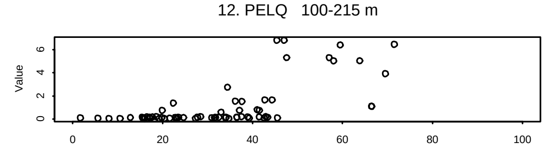
10. IMPACT   100-215 m



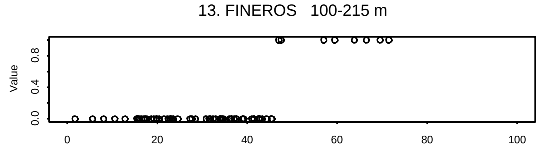
11. ERMQ   100-215 m



12. PELQ   100-215 m



13. FINEROS   100-215 m

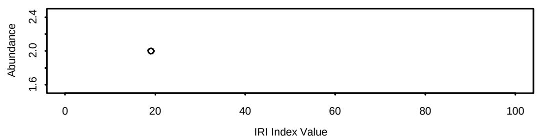


Appendix B7. Patterns of selected variables along the pollution gradient in calibration data base as defined by the Invertebrate Response Index (IRI) values for southern California megabenthic invertebrate species and other ecological variables.

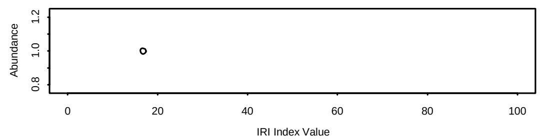
The nature of the gradient defined by the Invertebrate Response Index (IRI) values is shown by plotting pertinent variables vs. the index values for the calibration observations. The variables plotted include community parameters, environmental variables, BRI, and the projections onto the pollution vector in the ordination space (ORDINATION VECTOR). The FINES parameter is the percent of silt plus clay in the sediment. In addition, the abundance of each invertebrate species is plotted in the order of the p_i values, which shown are shown above each graph. No p_i value was computed for species occurring only once in the calibration data at the depth range in question. Data for each depth range (inner shelf, 9-40 m; middle shelf, 30-120 m; and 100-215 m) is plotted separately.

Inner Shelf (9-40 m)

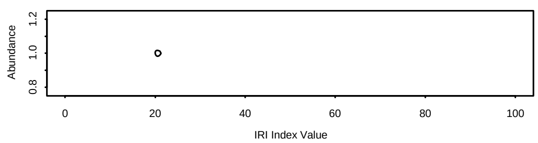
1. Eualus herdmani - i   P=-27.1 9-40 m



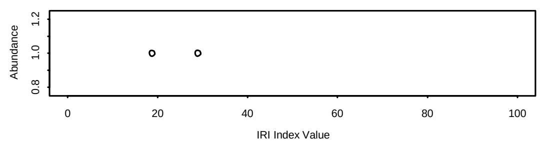
2. Diaulula sandiegensis - i   P=-20.4 9-40 m



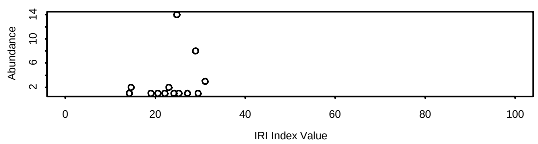
3. Terebra pedroana - i   P=-2.4 9-40 m



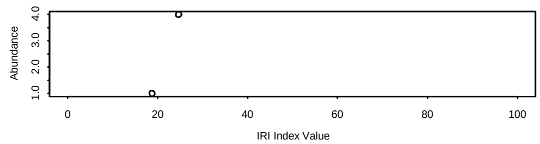
4. Amphiura arcystata - i   P=-1.4 9-40 m



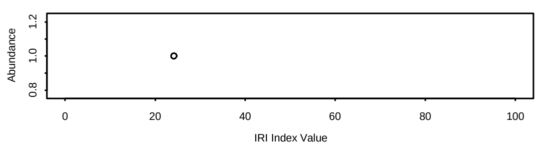
5. Lovenia cordiformis - i   P=0.2 9-40 m



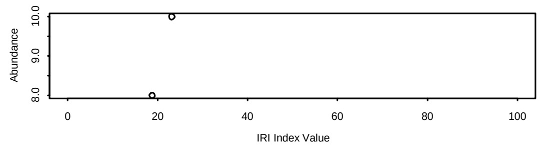
6. Isocheles pilosus - i   P=0.4 9-40 m



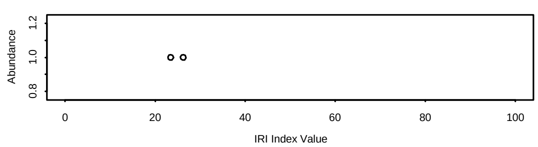
7. Loxorhynchus crispatus - i   P=3.4 9-40 m



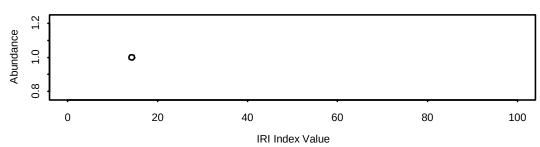
8. Triopha maculata - i   P=3.5 9-40 m



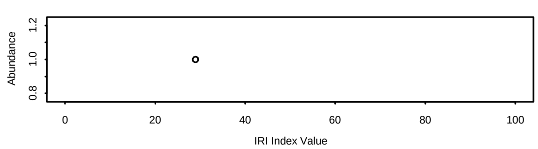
9. Neosimnia aequalis - i   P=5.6 9-40 m



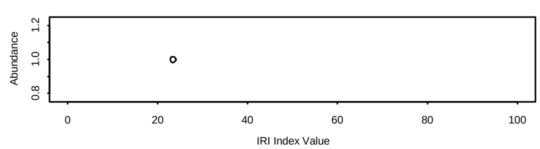
10. Phimochirus californiensis - i   P=5.9 9-40 m



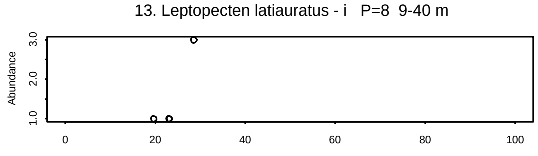
11. Euvola diegensis - i   P=6.7 9-40 m



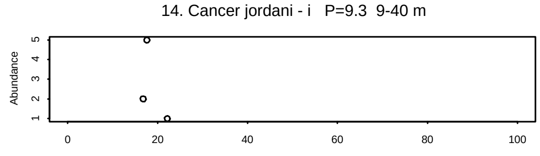
12. Hemisquilla ensigera californiensis - i   P=7.4 9-40 m



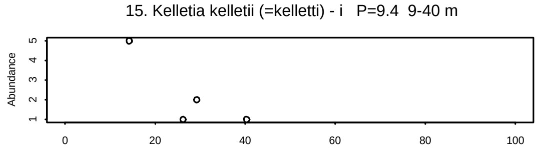
13. Leptopecten latiauratus - i   P=8 9-40 m



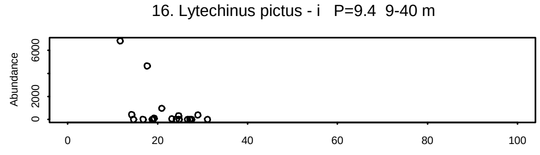
14. Cancer jordani - i   P=9.3 9-40 m



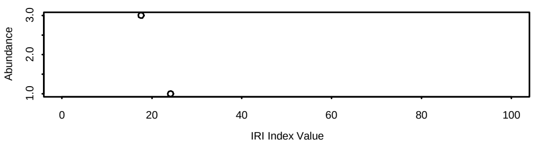
15. Kelletia kelletii (=kelletti) - i   P=9.4 9-40 m



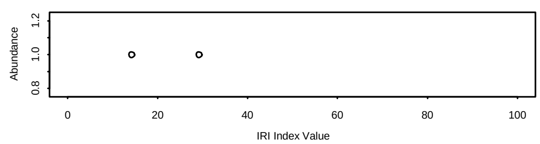
16. Lytechinus pictus - i   P=9.4 9-40 m



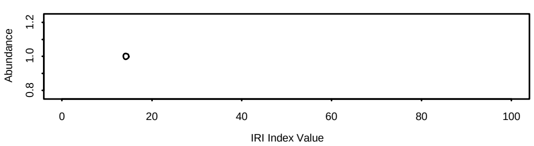
17. Strongylocentrotus franciscanus - i   P=9.8 9-40 m



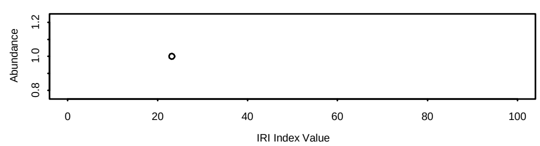
18. Paguristes ulreyi - i   P=12.4 9-40 m



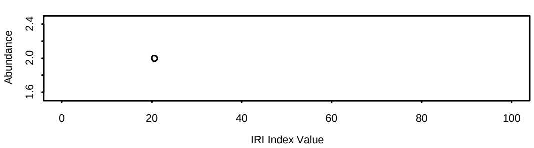
19. Tritonia festiva - i   P=13.8 9-40 m



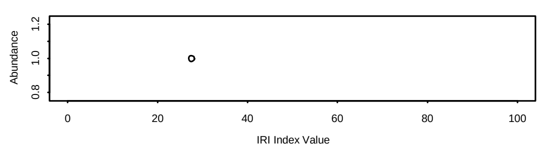
20. Ciona intestinalis - i   P=14.5 9-40 m



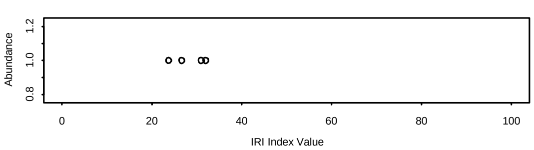
21. Podochela lobifrons - i   P=14.9 9-40 m



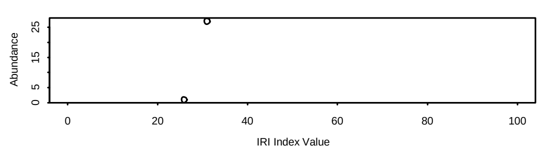
22. Luidia asthenosoma - i   P=15.7 9-40 m



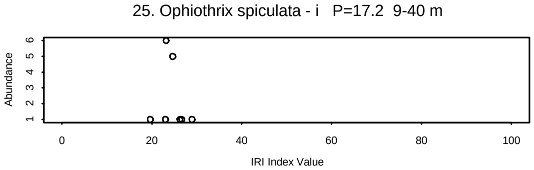
23. Heterogorgia tortuosa - i   P=16 9-40 m



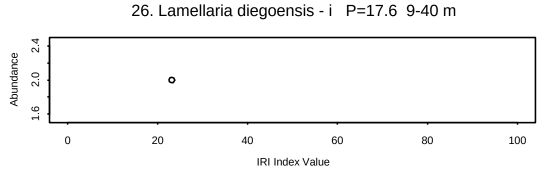
24. Paguristes turgidus - i   P=16.1 9-40 m



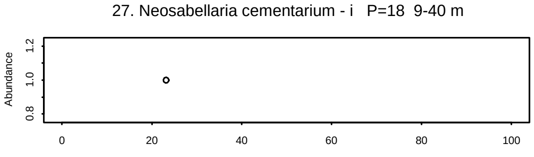
25. Ophiothrix spiculata - i   P=17.2 9-40 m



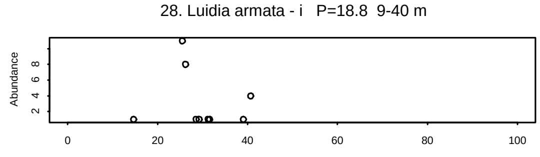
26. Lamellaria diegoensis - i   P=17.6 9-40 m



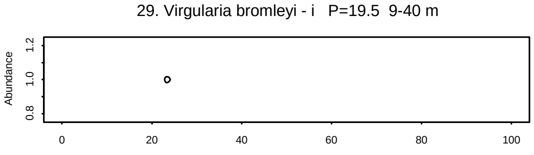
27. Neosabellaria cementarium - i   P=18 9-40 m



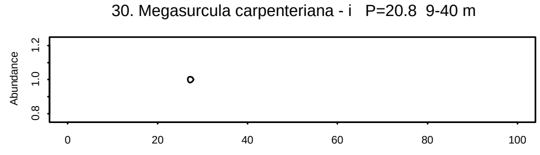
28. Luidia armata - i   P=18.8 9-40 m



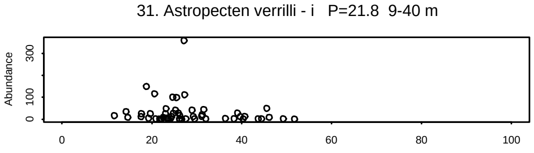
29. Virgularia bromleyi - i   P=19.5 9-40 m



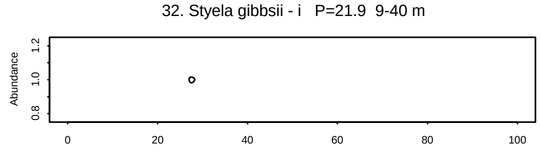
30. Megasurcula carpenteriana - i   P=20.8 9-40 m



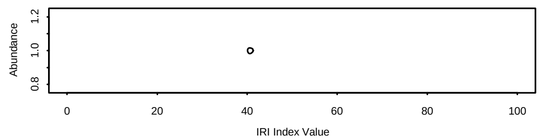
31. Astropecten verrilli - i   P=21.8 9-40 m



32. Styela gibbsii - i   P=21.9 9-40 m



33. Calliostoma turbinum - i   P=21.9 9-40 m

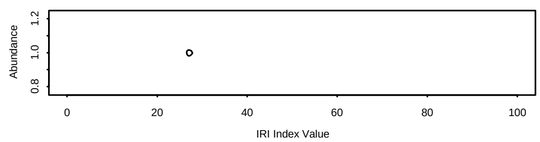


34. Livoneca californica - i   P=21.9 9-40 m

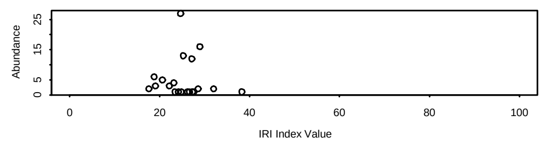
35. Balanus pacificus - i   P=22.1 9-40 m

36. Hamatoscapellum californicum - i   P=22.9 9-40 m

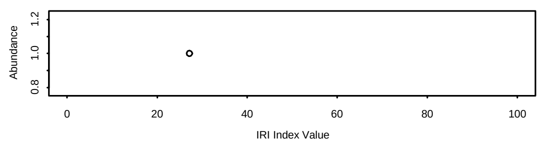
37. Erileptus spinosus - i   P=23.1 9-40 m



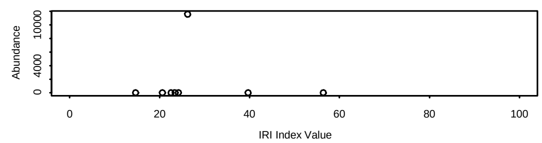
38. Luidia foliolata - i   P=24 9-40 m



39. Orthopagurus minimus - i   P=24 9-40 m

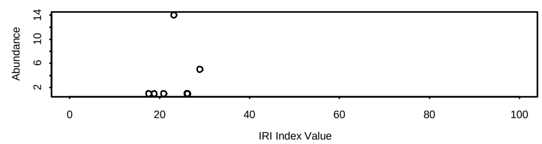


40. Ophiura luetkenii - i   P=24.3 9-40 m

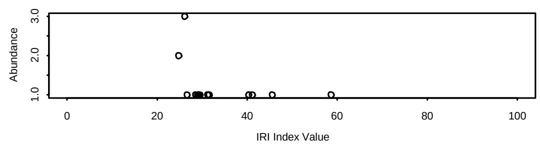


41. Virgularia galapagensis - i   P=24.9 9-40 m

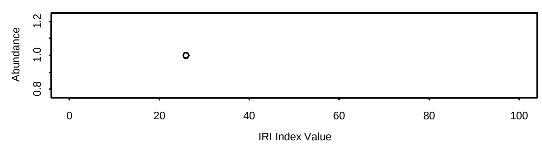
42. Octopus rubescens - i   P=25 9-40 m



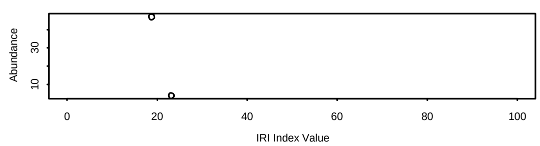
43. Pisaster brevispinus - i   P=25.6 9-40 m



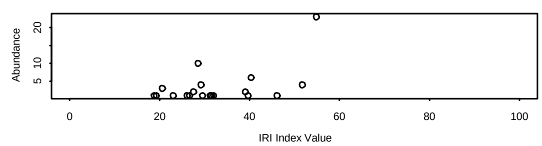
44. Pycnopodia helianthoides - i   P=26.5 9-40 m



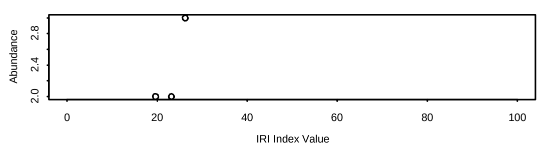
45. Strongylocentrotus purpuratus - i   P=27.2 9-40 m



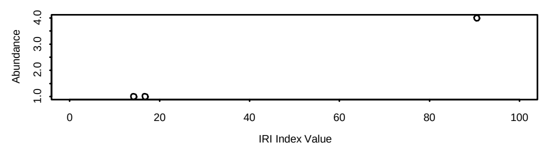
46. Pyromaia tuberculata - i   P=27.4 9-40 m



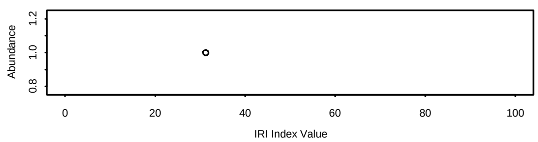
47. Parastichopus californicus - i   P=27.6 9-40 m



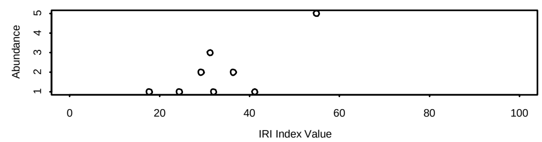
48. Podochela hemphillii - i   P=28.2 9-40 m



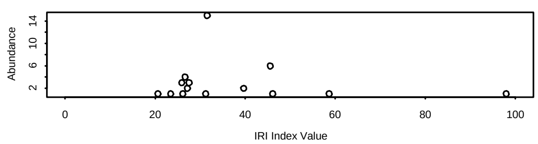
49. Flabellina iodinea - i P=29 9-40 m



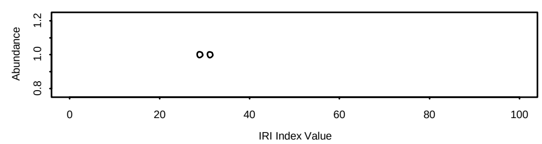
50. Pagurus spilocarpus - i P=29.2 9-40 m



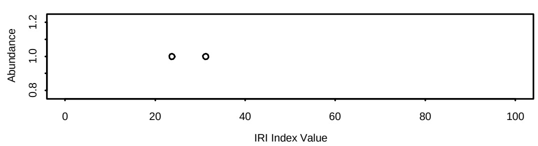
51. Heterocrypta occidentalis - i P=32 9-40 m



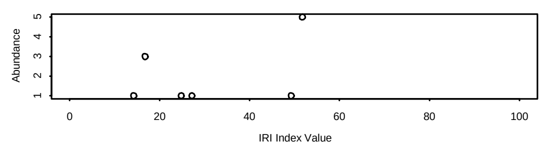
52. Tritonia diomedea - i P=33.8 9-40 m



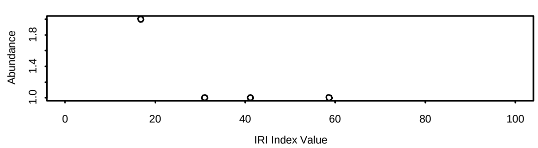
53. Loligo opalescens - i P=34 9-40 m



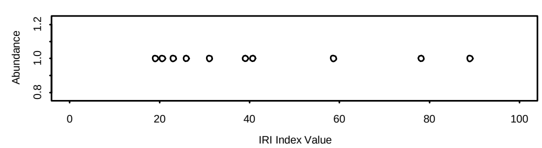
54. Loxorhynchus grandis - i P=35.8 9-40 m



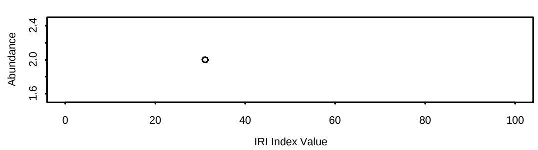
55. Renilla koellikeri - i P=36.6 9-40 m



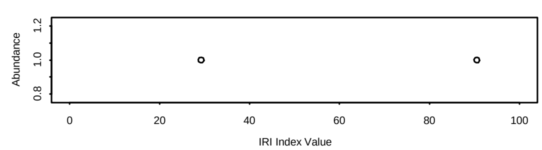
56. Livoneca vulgaris - i P=36.6 9-40 m



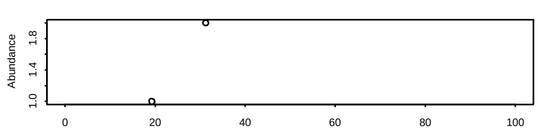
57. Heptacarpus stimpsoni - i P=36.7 9-40 m



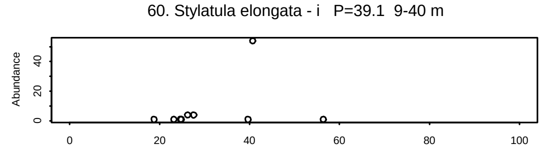
58. Lophogorgia chilensis - i P=38.4 9-40 m



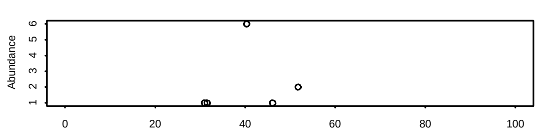
59. Armina californica - i P=38.7 9-40 m



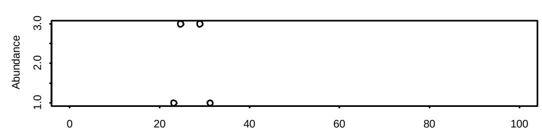
60. Stylatula elongata - i P=39.1 9-40 m



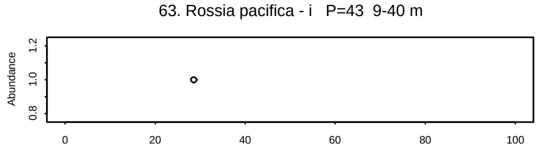
61. Randallia ornata - i P=39.9 9-40 m



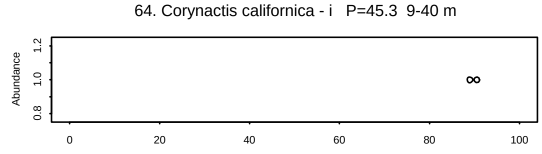
62. Acanthodoris brunnea - i P=41.9 9-40 m



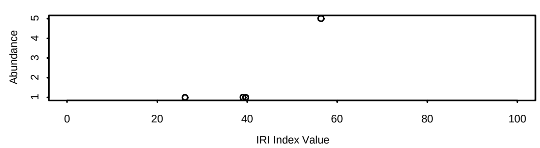
63. Rossia pacifica - i P=43 9-40 m



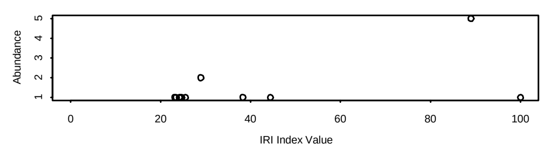
64. Corynactis californica - i P=45.3 9-40 m



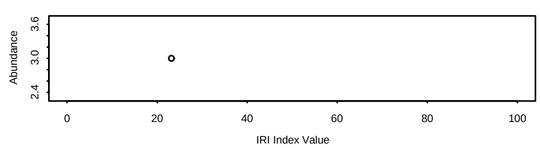
65. Neverita reclusiana - i P=49.6 9-40 m



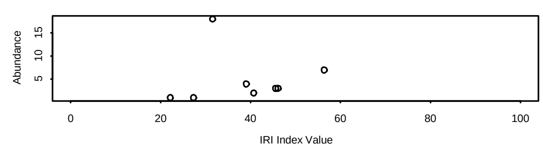
66. Pleurobranchaea californica - i P=53 9-40 m



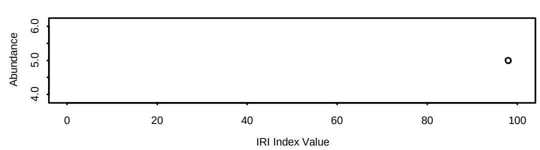
67. Pandalus platyceros - i P=54.6 9-40 m



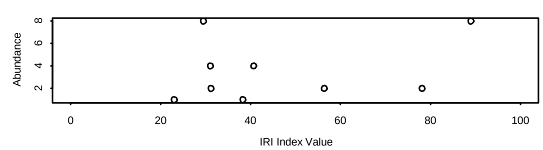
68. Nassarius perpinguis - i P=55.1 9-40 m



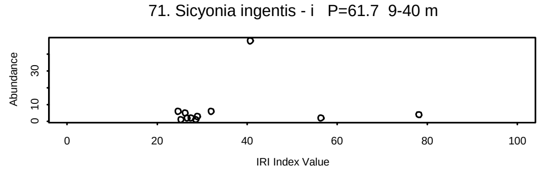
69. Crangon alaskensis - i P=55.5 9-40 m



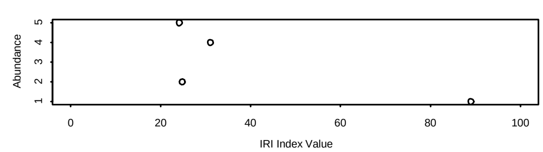
70. Cancer gracilis - i P=56.1 9-40 m



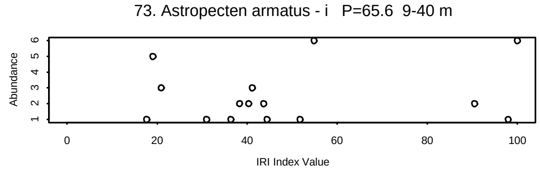
71. Sicyonia ingentis - i P=61.7 9-40 m



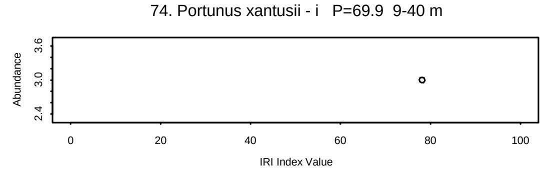
72. Asterina miniata - i P=64.7 9-40 m



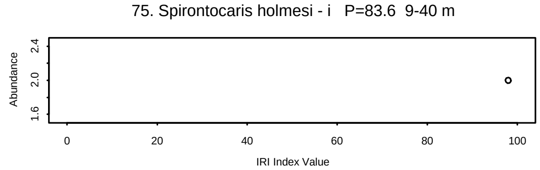
73. Astropecten armatus - i P=65.6 9-40 m



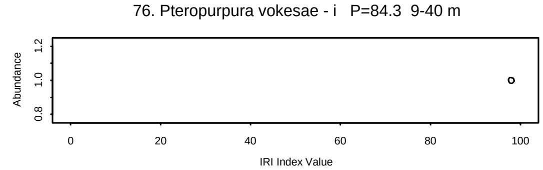
74. Portunus xantusii - i P=69.9 9-40 m



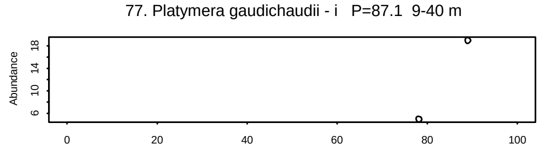
75. Spirontocaris holmesi - i P=83.6 9-40 m



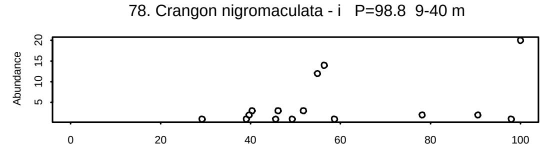
76. Pteropurpura vokesae - i P=84.3 9-40 m



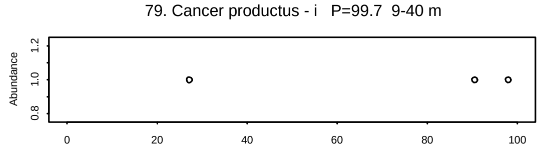
77. Platymera gaudichaudii - i P=87.1 9-40 m



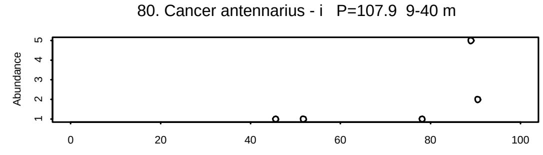
78. Crangon nigromaculata - i P=98.8 9-40 m



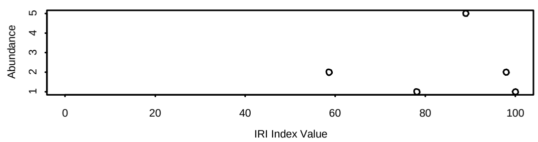
79. Cancer productus - i P=99.7 9-40 m



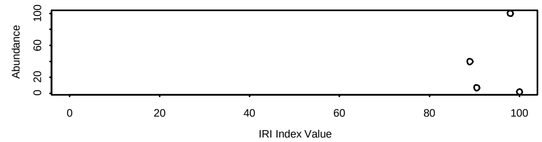
80. Cancer antennarius - i P=107.9 9-40 m



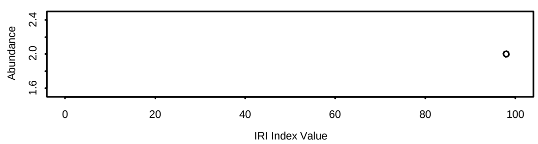
81. Cancer anthonyi - i   P=112.2 9-40 m



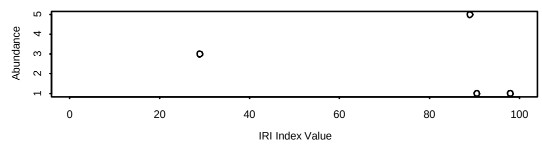
82. Nassarius mendicus - i   P=127.9 9-40 m



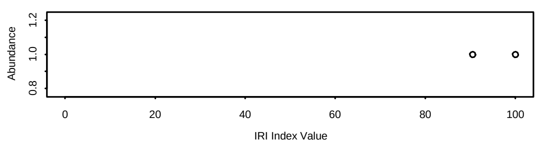
83. Crepidula onyx - i   P=130.4 9-40 m



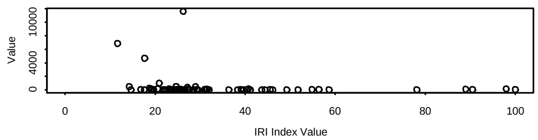
84. Conus californicus - i   P=137.5 9-40 m



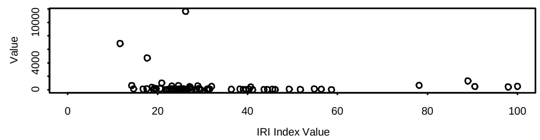
85. Muricea californica - i   P=158.1 9-40 m



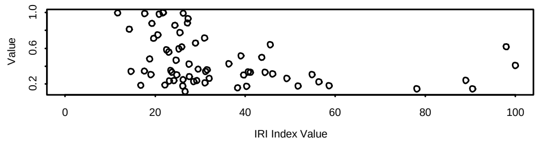
1. TOTAL ABUNDANCE - invert 9-40 m



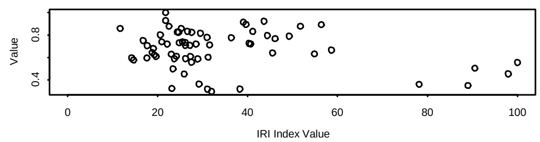
2. TOTAL ABUNDANCE - fish + inv 9-40 m



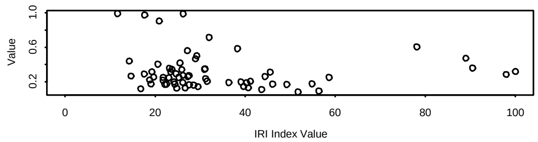
3. SIMPSON DOMINANCE INDEX - invert 9-40 m



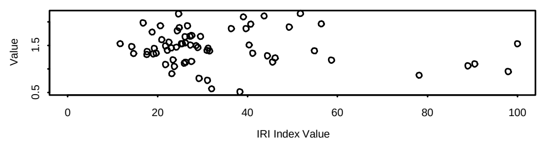
4. EVENNESS - fish 9-40 m



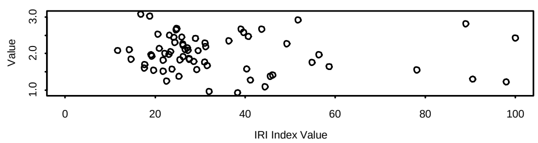
5. SIMPSON DOMINANCE INDEX - fish + inv 9-40 m



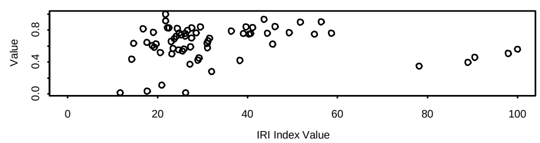
6. SHANNON-WIENER DIVERSITY - fish 9-40 m



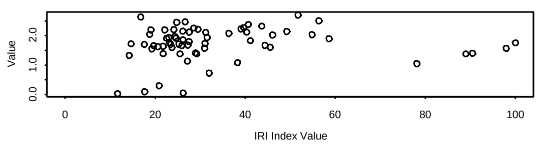
7. GLEASON RICHNESS DIVERSITY - fish 9-40 m



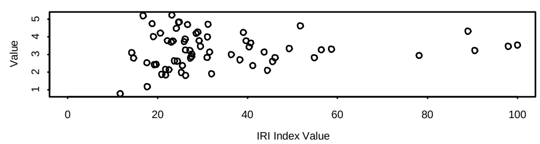
8. EVENNESS - fish + inv 9-40 m



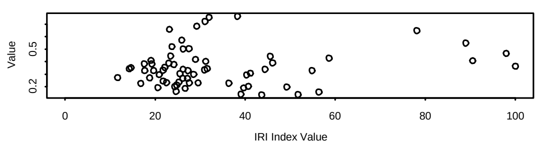
9. SHANNON-WIENER DIVERSITY - fish + inv 9-40 m



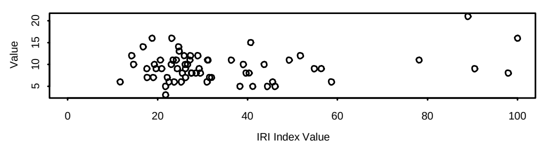
10. GLEASON RICHNESS DIVERSITY - fish + inv 9-40 m



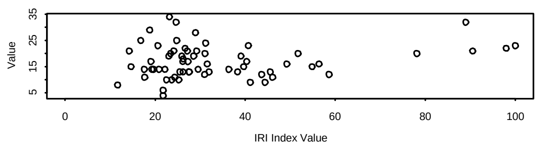
11. SIMPSON DOMINANCE INDEX - fish 9-40 m



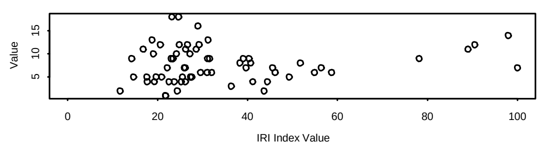
12. NO. OF SPECIES - fish 9-40 m



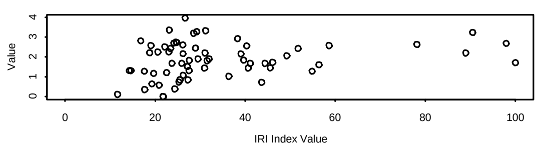
13. NO. OF SPECIES - fish + inv 9-40 m



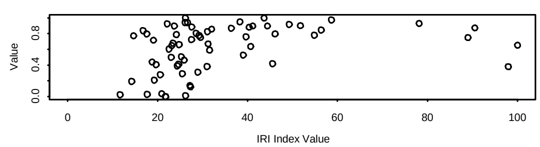
14. NO. OF SPECIES - invert 9-40 m



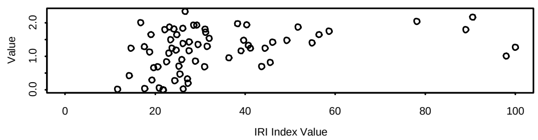
15. GLEASON RICHNESS DIVERSITY - invert 9-40 m



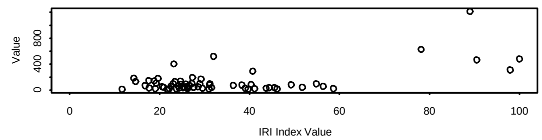
16. EVENNESS - invert 9-40 m

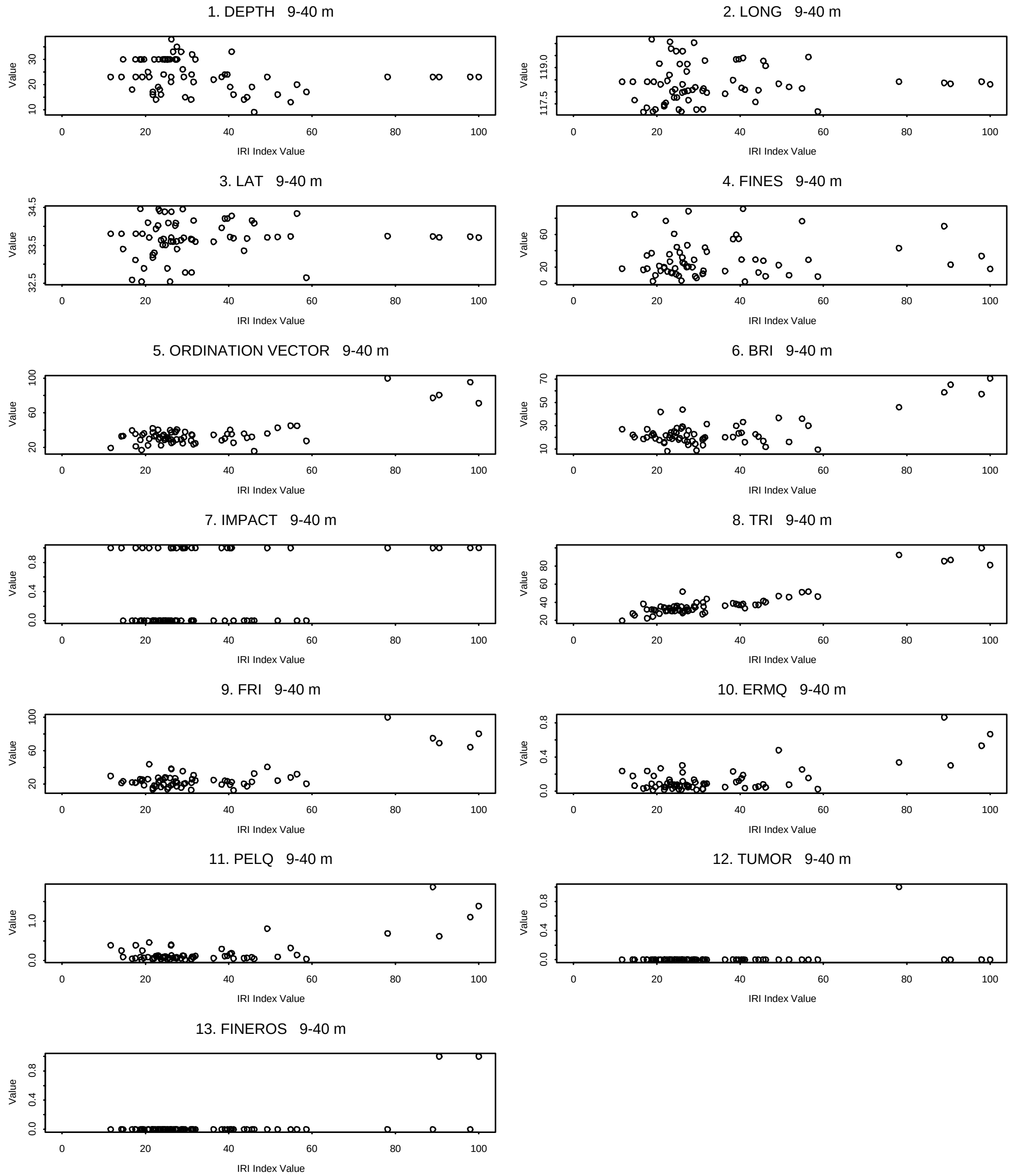


17. SHANNON-WIENER DIVERSITY - invert 9-40 m



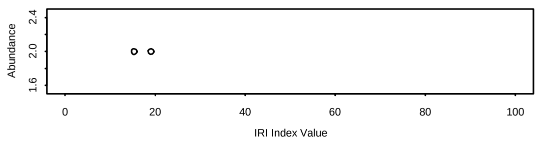
18. TOTAL ABUNDANCE - fish 9-40 m



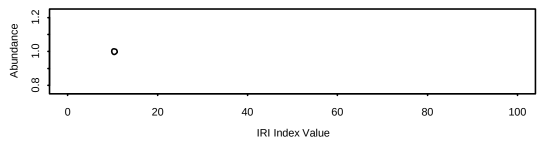

1. DEPTH 9-40 m
2. LONG 9-40 m
3. LAT 9-40 m
4. FINES 9-40 m
5. ORDINATION VECTOR 9-40 m
6. BRI 9-40 m
7. IMPACT 9-40 m
8. TRI 9-40 m
9. FRI 9-40 m
10. ERMQ 9-40 m
11. PELQ 9-40 m
12. TUMOR 9-40 m
13. FINEROS 9-40 m
Value
IRI Index Value

Middle Shelf (30-120 m)

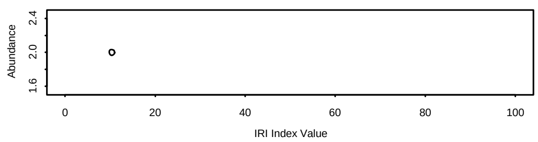
1. Eualus herdmani - i P=-27.1 30-120 m



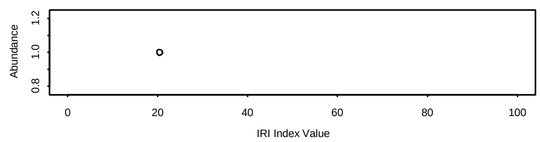
2. Cidarina cidaris - i P=-23.5 30-120 m



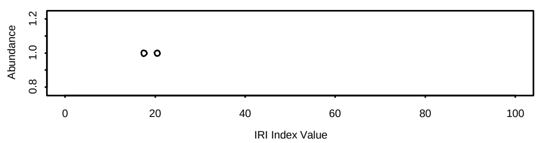
3. Laqueus californianus - i P=-23.5 30-120 m



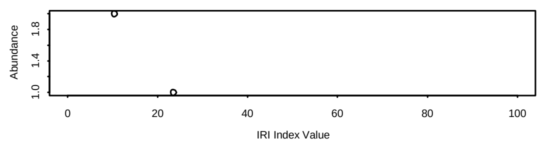
4. Diaulula sandiegensis - i P=-20.4 30-120 m



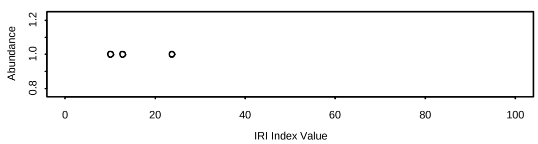
5. Babelomurex oldroydi - i P=-10.5 30-120 m



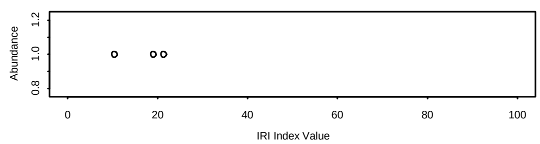
6. Terebratalia occidentalis - i P=-8.8 30-120 m



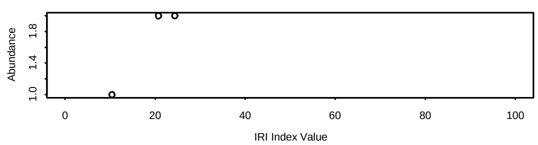
7. Sclerasterias heteropaes - i P=-7.9 30-120 m



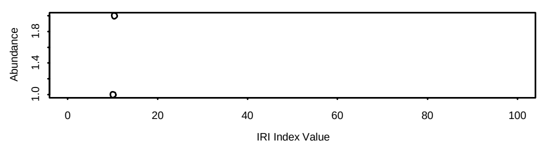
8. Protula superba - i P=-6.3 30-120 m



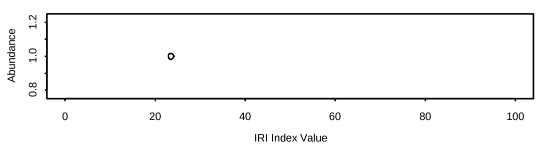
9. Fusinus barbarensis - i P=-4.4 30-120 m



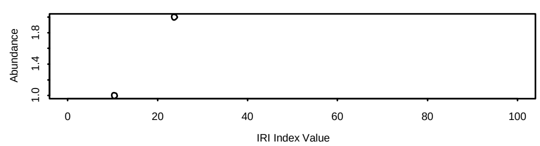
10. Florometra serratissima - i P=-3 30-120 m



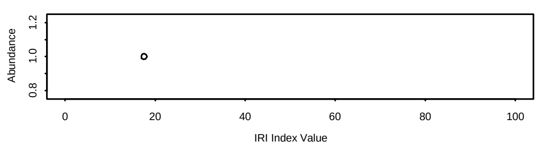
11. Balanus nubilus - i P=-2.7 30-120 m



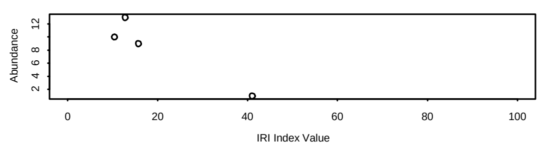
12. Leptasterias hexactis - i P=-2.6 30-120 m



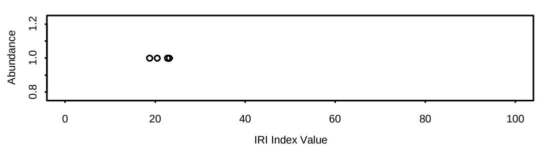
13. Terebra pedroana - i P=-2.4 30-120 m



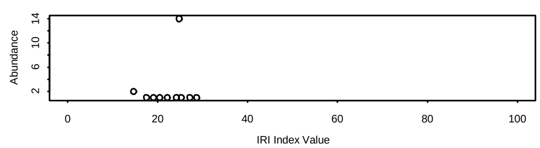
14. Philine alba - i P=-2.1 30-120 m



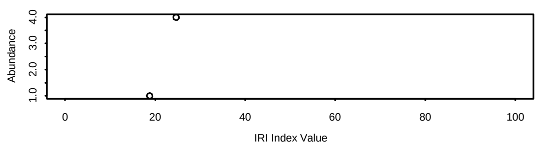
15. Amphiura arcystata - i P=-1.4 30-120 m



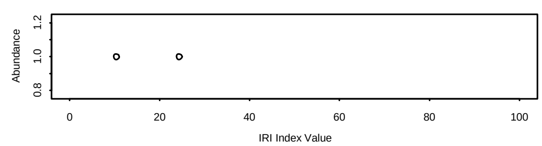
16. Lovenia cordiformis - i P=0.2 30-120 m



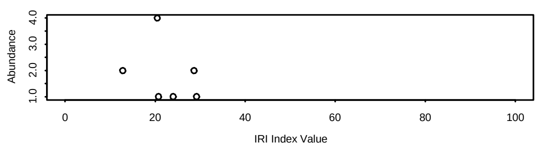
17. Isocheles pilosus - i P=0.4 30-120 m



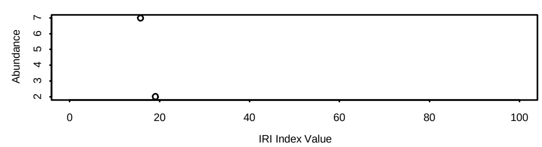
18. Pteropurpura macroptera - i P=0.9 30-120 m



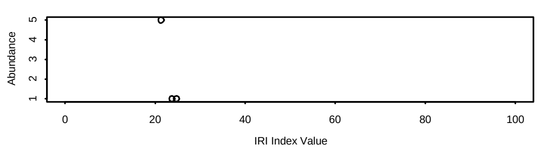
19. Crossata californica - i P=1.7 30-120 m



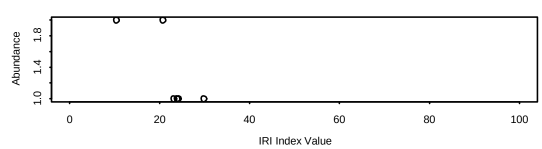
20. Paguristes bakeri - i P=1.9 30-120 m



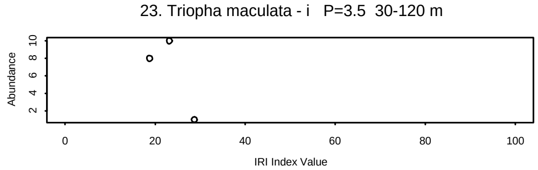
21. Parapagurodes laurentae - i P=2.4 30-120 m



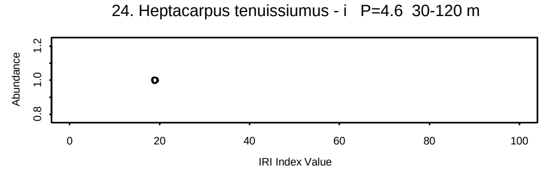
22. Loxorhynchus crispatus - i P=3.4 30-120 m



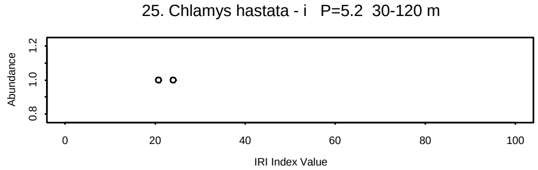
23. Triopha maculata - i P=3.5 30-120 m



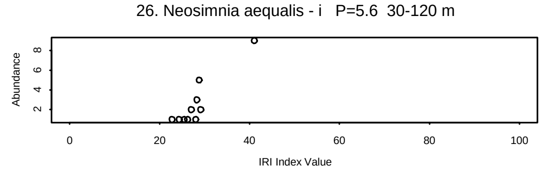
24. Heptacarpus tenuissiumus - i P=4.6 30-120 m



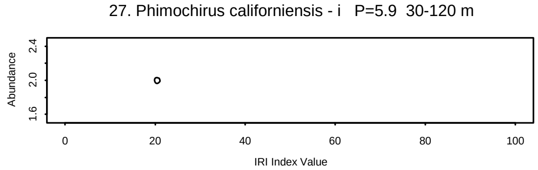
25. Chlamys hastata - i P=5.2 30-120 m



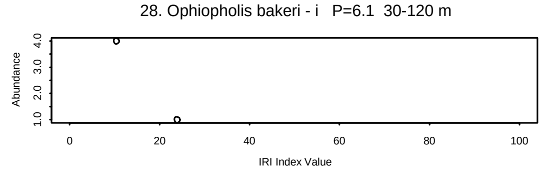
26. Neosimnia aequalis - i P=5.6 30-120 m



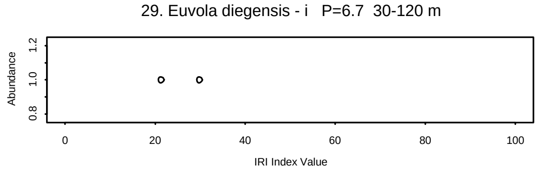
27. Phimochirus californiensis - i P=5.9 30-120 m



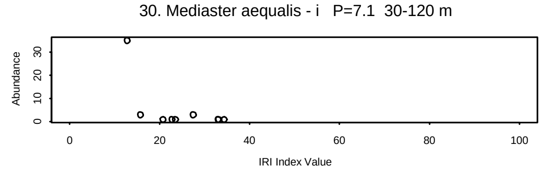
28. Ophiopholis bakeri - i P=6.1 30-120 m



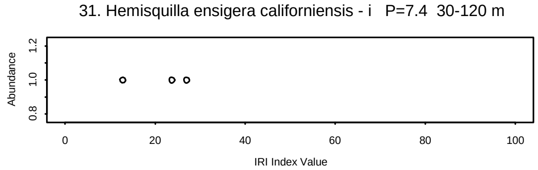
29. Euvola diegensis - i P=6.7 30-120 m



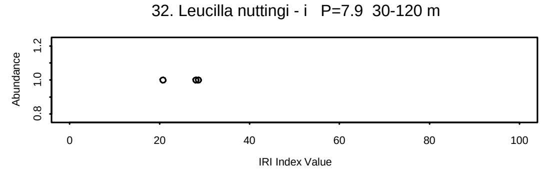
30. Mediaster aequalis - i P=7.1 30-120 m



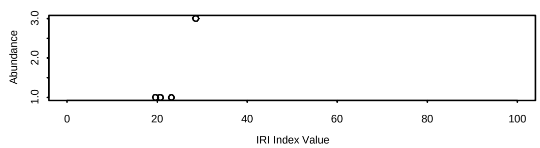
31. Hemisquilla ensigera californiensis - i P=7.4 30-120 m



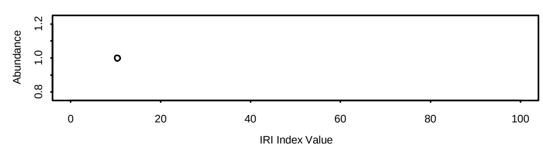
32. Leucilla nuttingi - i P=7.9 30-120 m



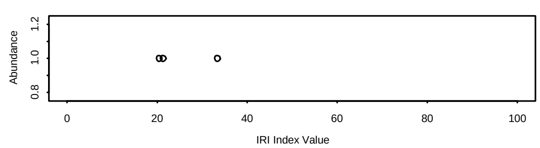
33. Leptopecten latiauratus - i   P=8 30-120 m



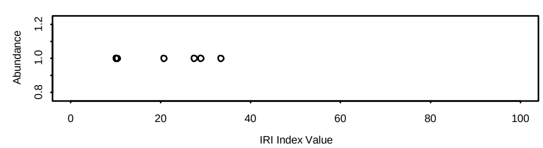
34. Platydoris macfarlandi - i   P=8.9 30-120 m



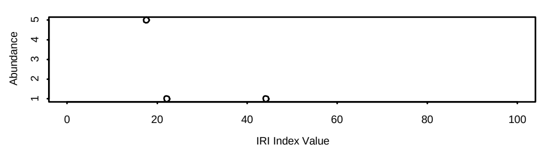
35. Doriopsilla albopunctata - i   P=9.2 30-120 m



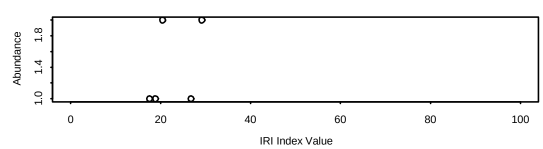
36. Paracyathus stearnsii - i   P=9.3 30-120 m



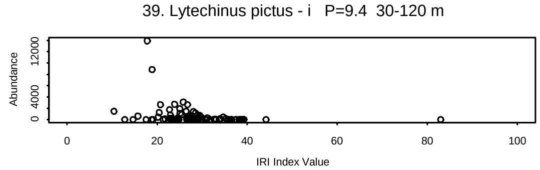
37. Cancer jordani - i   P=9.3 30-120 m



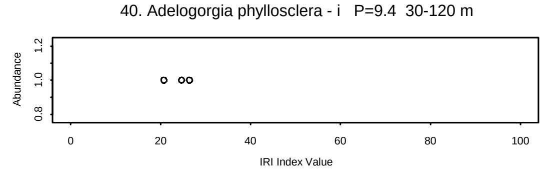
38. Kelletia kelletii (=kelletti) - i   P=9.4 30-120 m



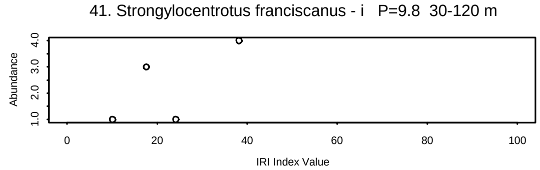
39. Lytechinus pictus - i   P=9.4 30-120 m



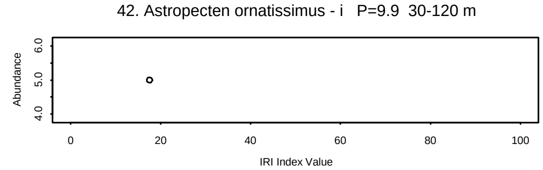
40. Adelogorgia phyllosclera - i   P=9.4 30-120 m



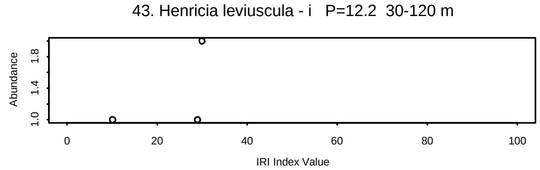
41. Strongylocentrotus franciscanus - i   P=9.8 30-120 m



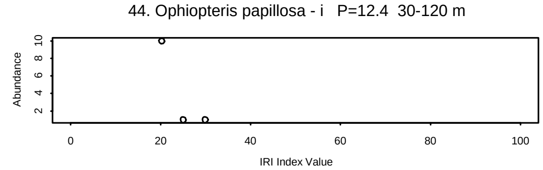
42. Astropecten ornatissimus - i   P=9.9 30-120 m



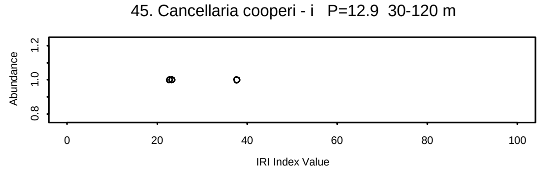
43. Henricia leviuscula - i   P=12.2 30-120 m



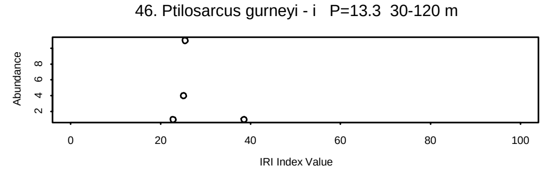
44. Ophiopteris papillosa - i   P=12.4 30-120 m



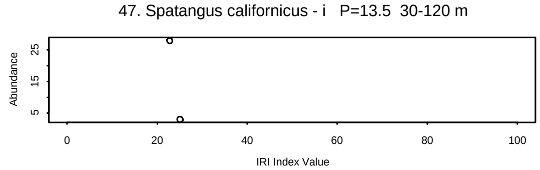
45. Cancellaria cooperi - i   P=12.9 30-120 m



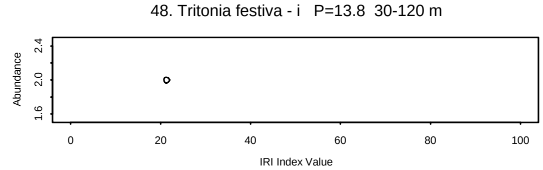
46. Ptilosarcus gurneyi - i   P=13.3 30-120 m



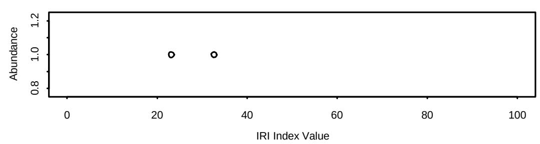
47. Spatangus californicus - i   P=13.5 30-120 m



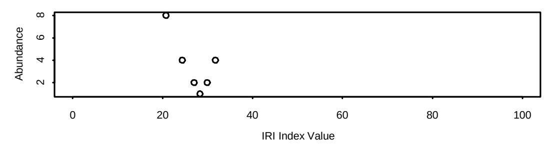
48. Tritonia festiva - i   P=13.8 30-120 m



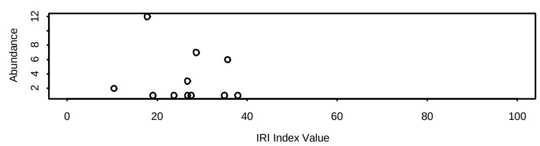
49. Ciona intestinalis - i   P=14.5 30-120 m



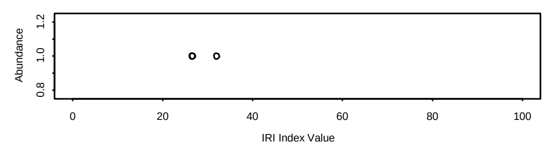
50. Podochela lobifrons - i   P=14.9 30-120 m



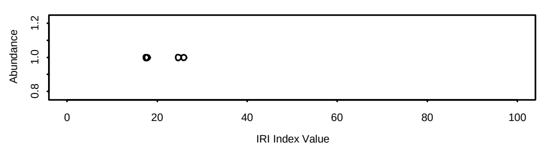
51. Luidia asthenosoma - i   P=15.7 30-120 m



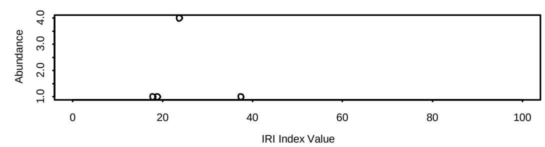
52. Heterogorgia tortuosa - i   P=16 30-120 m



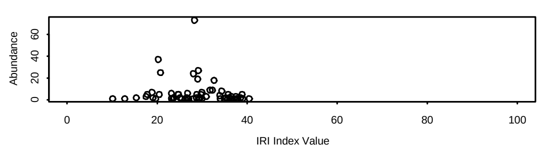
53. Paguristes turgidus - i   P=16.1 30-120 m



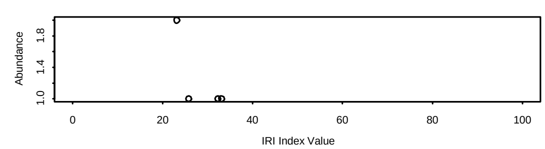
54. Stylasterias forreri - i   P=16.9 30-120 m



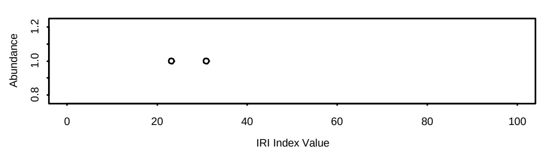
55. Ophiothrix spiculata - i   P=17.2 30-120 m



56. Lamellaria diegoensis - i   P=17.6 30-120 m

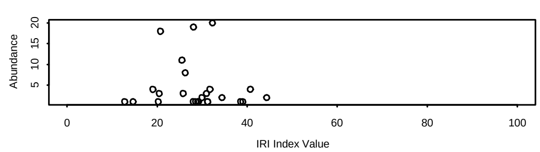


57. Neosabellaria cementarium - i   P=18 30-120 m

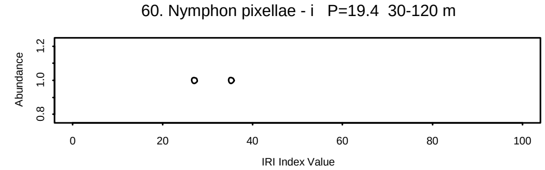


58. Calliostoma tricolor - i   P=18.3 30-120 m

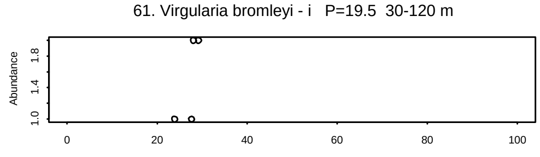
59. Luidia armata - i   P=18.8 30-120 m



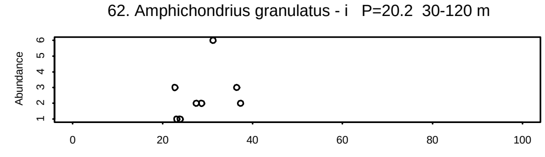
60. Nymphon pixellae - i   P=19.4 30-120 m



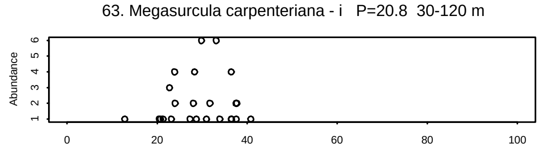
61. Virgularia bromleyi - i   P=19.5 30-120 m



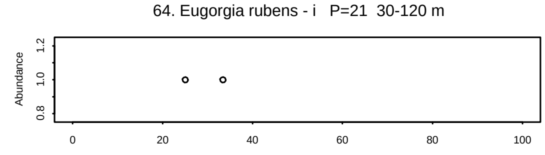
62. Amphichondrius granulatus - i   P=20.2 30-120 m



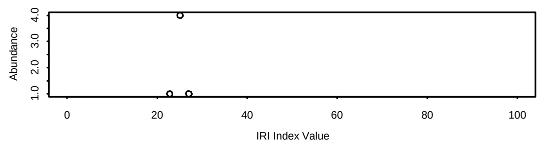
63. Megasurcula carpenteriana - i   P=20.8 30-120 m



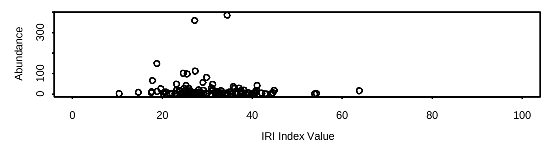
64. Eugorgia rubens - i   P=21 30-120 m



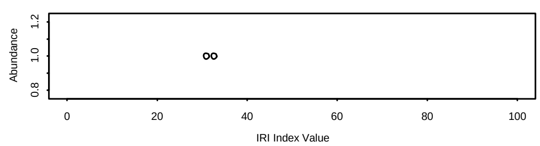
65. Brisaster latifrons - i   P=21.3 30-120 m



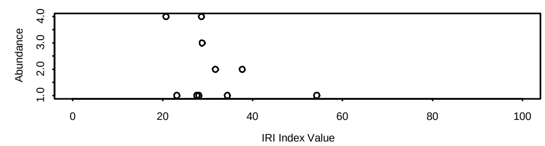
66. Astropecten verrilli - i   P=21.8 30-120 m



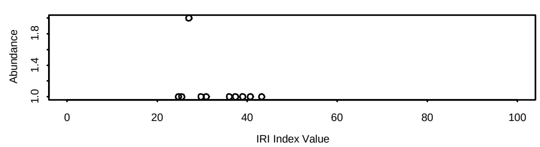
67. Havelockia benti - i   P=21.8 30-120 m



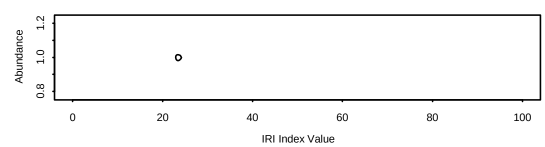
68. Styela gibbsii - i   P=21.9 30-120 m



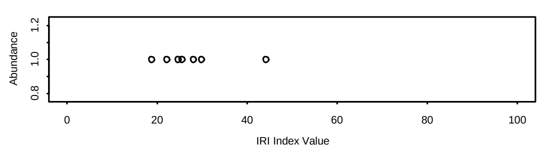
69. Calliostoma turbinum - i   P=21.9 30-120 m



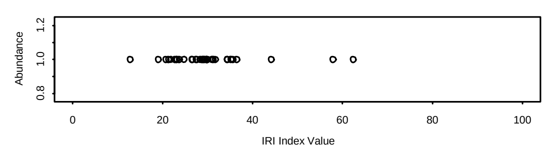
70. Livoneca californica - i   P=21.9 30-120 m



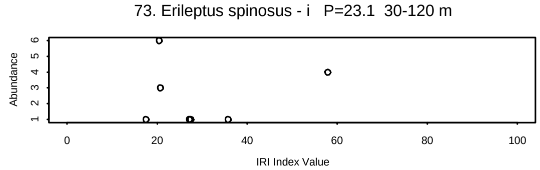
71. Balanus pacificus - i   P=22.1 30-120 m



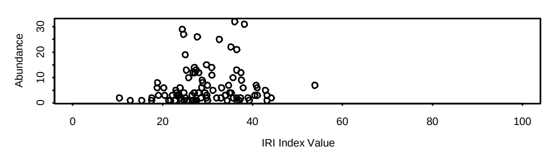
72. Hamatoscapellum californicum - i   P=22.9 30-120 m



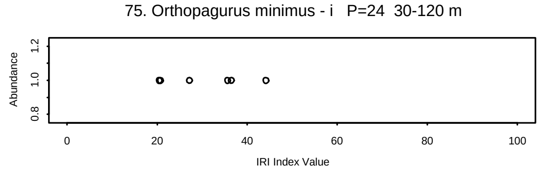
73. Erileptus spinosus - i   P=23.1 30-120 m



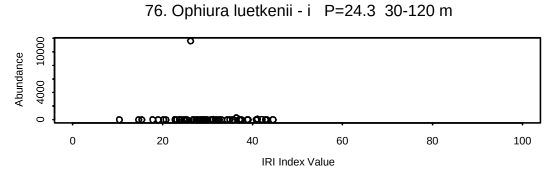
74. Luidia foliolata - i   P=24 30-120 m



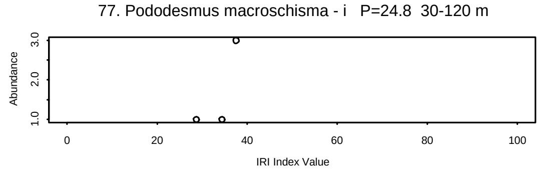
75. Orthopagurus minimus - i   P=24 30-120 m



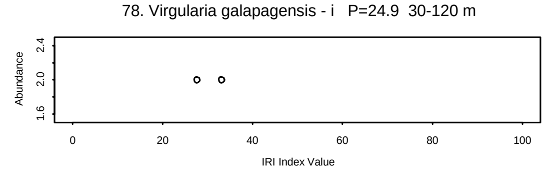
76. Ophiura luetkenii - i   P=24.3 30-120 m



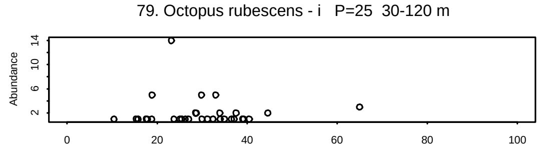
77. Pododesmus macroschisma - i   P=24.8 30-120 m



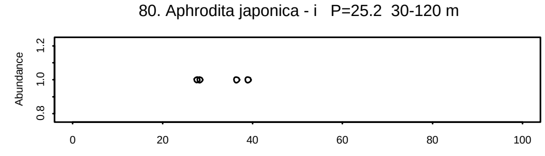
78. Virgularia galapagensis - i   P=24.9 30-120 m



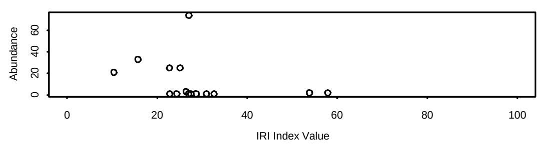
79. Octopus rubescens - i   P=25 30-120 m



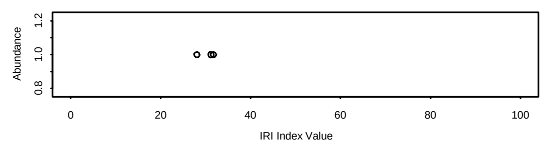
80. Aphrodita japonica - i   P=25.2 30-120 m



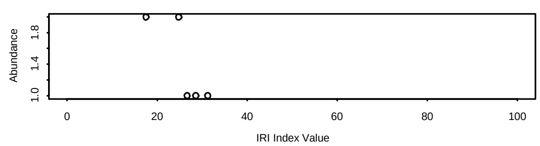
81. Allocentrotus fragilis - i   P=25.3 30-120 m



82. Amphiodia urtica - i   P=25.4 30-120 m

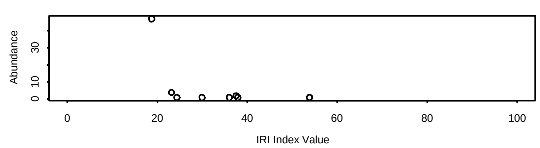


83. Pisaster brevispinus - i   P=25.6 30-120 m

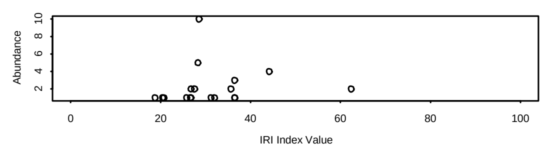


84. Pycnopodia helianthoides - i   P=26.5 30-120 m

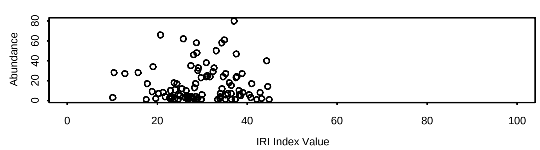
85. Strongylocentrotus purpuratus - i   P=27.2 30-120 m



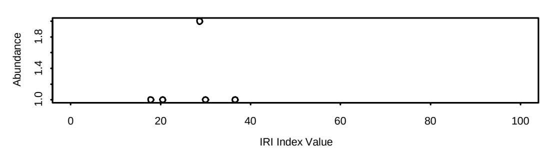
86. Pyromaia tuberculata - i   P=27.4 30-120 m



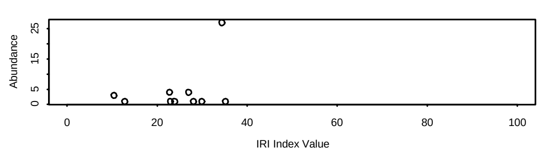
87. Parastichopus californicus - i   P=27.6 30-120 m



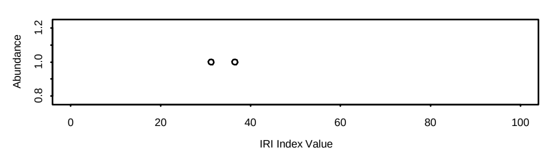
88. Podochela hemphillii - i   P=28.2 30-120 m



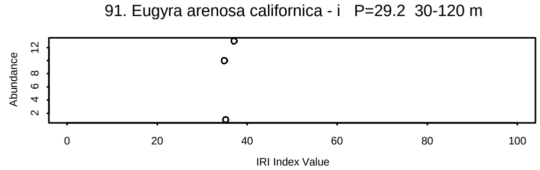
89. Metridium senile - i   P=28.5 30-120 m



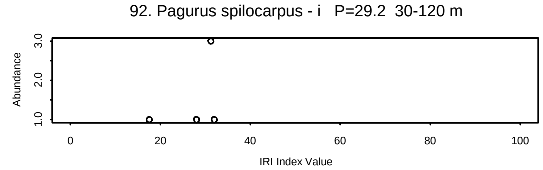
90. Flabellina iodinea - i   P=29 30-120 m



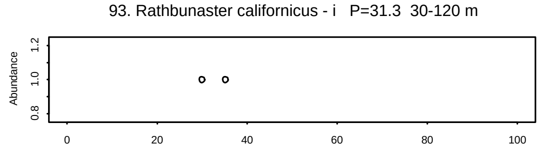
91. Eugyra arenosa californica - i   P=29.2 30-120 m



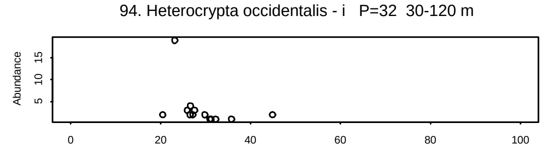
92. Pagurus spilocarpus - i   P=29.2 30-120 m



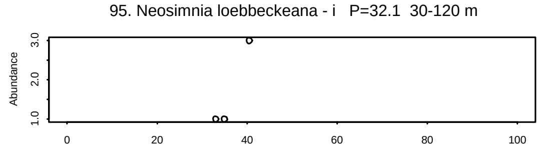
93. Rathbunaster californicus - i   P=31.3 30-120 m



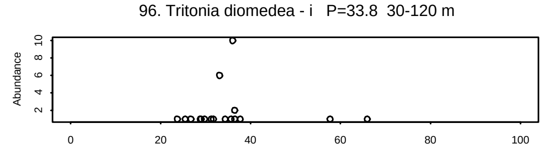
94. Heterocrypta occidentalis - i   P=32 30-120 m



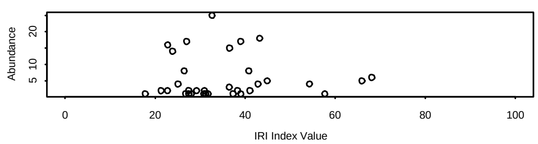
95. Neosimnia loebbeckeana - i   P=32.1 30-120 m



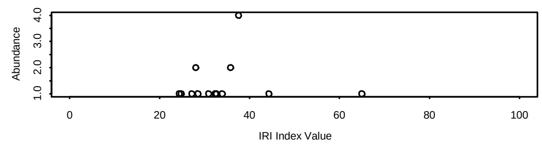
96. Tritonia diomedea - i   P=33.8 30-120 m



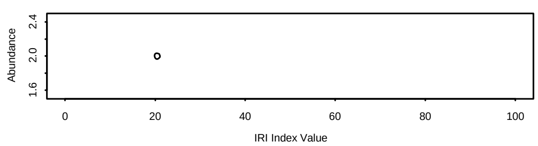
97. Loligo opalescens - i P=34 30-120 m



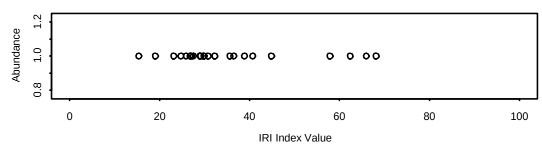
98. Loxorhynchus grandis - i P=35.8 30-120 m



99. Renilla koellikeri - i P=36.6 30-120 m

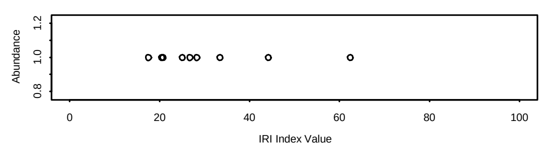


100. Livoneca vulgaris - i P=36.6 30-120 m

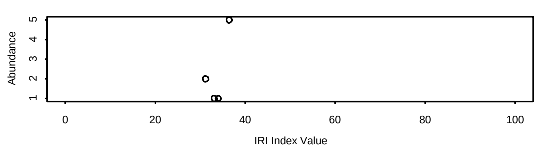


101. Heptacarpus stimpsoni - i P=36.7 30-120 m

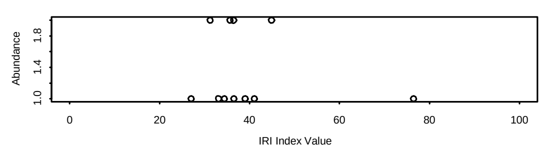
102. Lophogorgia chilensis - i P=38.4 30-120 m



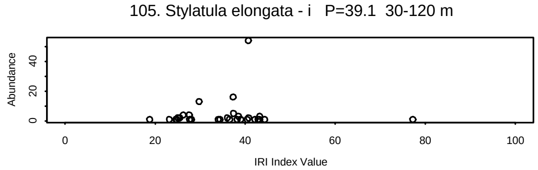
103. Metacrangon spinosissima - i P=38.6 30-120 m



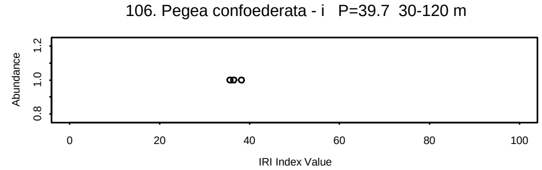
104. Armina californica - i P=38.7 30-120 m



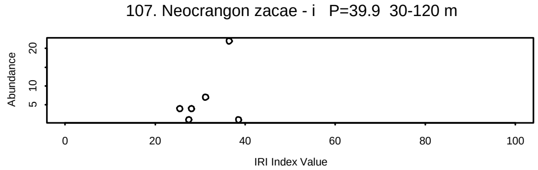
105. Stylatula elongata - i P=39.1 30-120 m



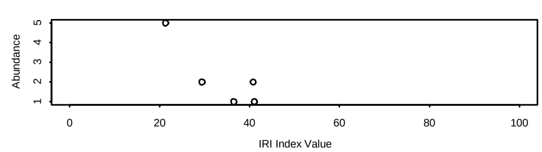
106. Pegea confoederata - i P=39.7 30-120 m



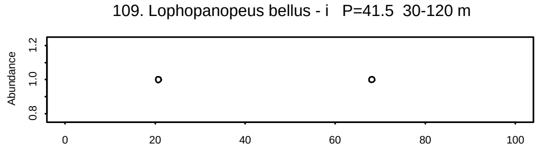
107. Neocrangon zacae - i P=39.9 30-120 m



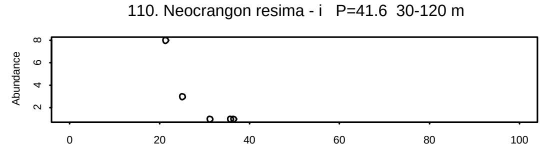
108. Randallia ornata - i P=39.9 30-120 m



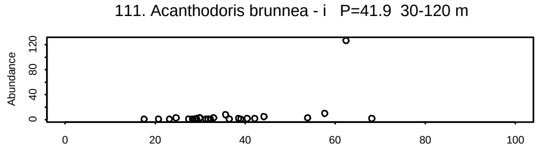
109. Lophopanopeus bellus - i P=41.5 30-120 m



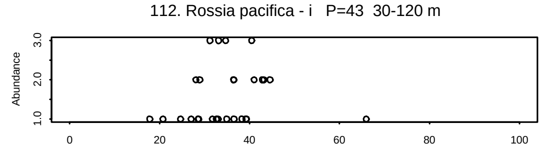
110. Neocrangon resima - i P=41.6 30-120 m



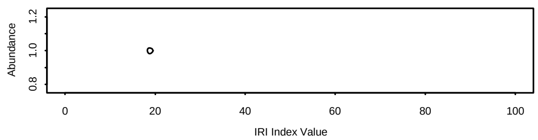
111. Acanthodoris brunnea - i P=41.9 30-120 m



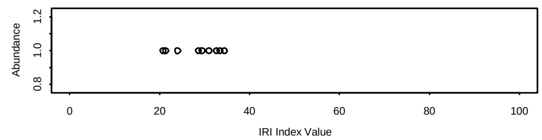
112. Rossia pacifica - i P=43 30-120 m



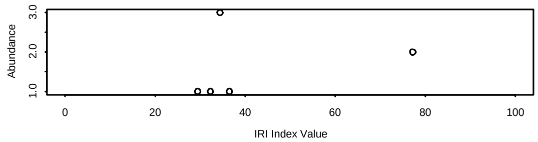
113. Schmittius politus - i   P=44 30-120 m



114. Corynactis californica - i   P=45.3 30-120 m

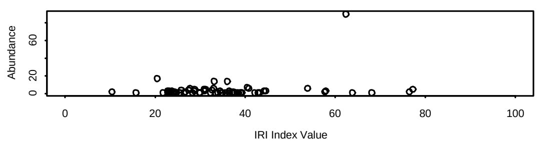


115. Neverita reclusiana - i   P=49.6 30-120 m

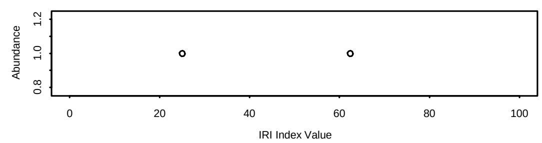


116. Cancellaria crawfordiana - i   P=52.4 30-120 m

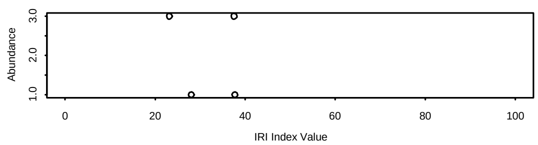
117. Pleurobranchaea californica - i   P=53 30-120 m



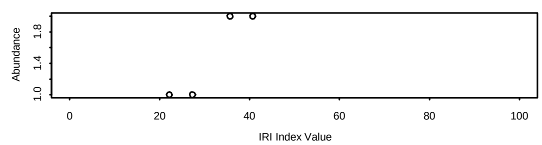
118. Pandalus danae - i   P=54.6 30-120 m



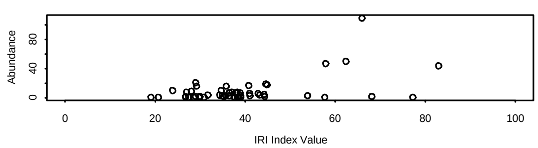
119. Pandalus platyceros - i   P=54.6 30-120 m



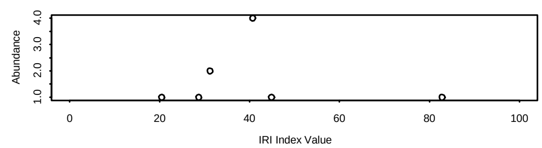
120. Nassarius perpinguis - i   P=55.1 30-120 m



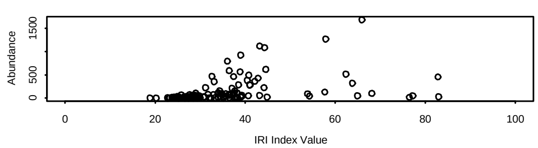
121. Crangon alaskensis - i   P=55.5 30-120 m



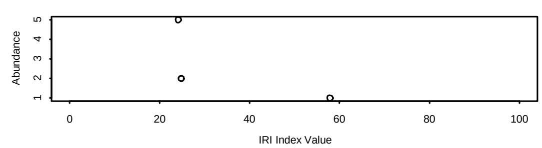
122. Cancer gracilis - i   P=56.1 30-120 m



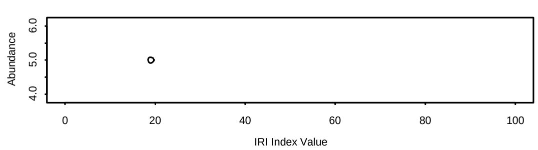
123. Sicyonia ingentis - i   P=61.7 30-120 m



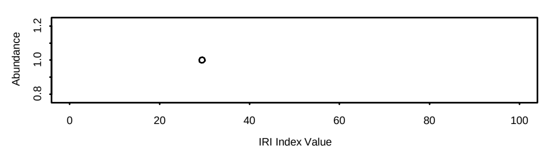
124. Asterina miniata - i   P=64.7 30-120 m



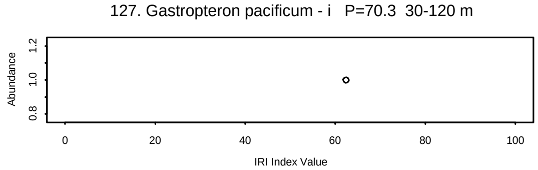
125. Astropecten armatus - i   P=65.6 30-120 m



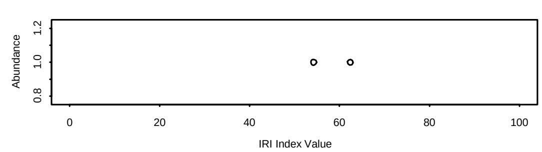
126. Portunus xantusii - i   P=69.9 30-120 m



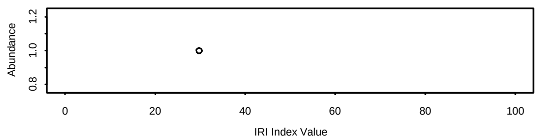
127. Gastropteron pacificum - i   P=70.3 30-120 m



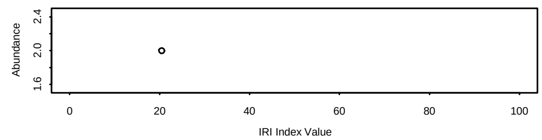
128. Polinices draconis - i   P=72.5 30-120 m



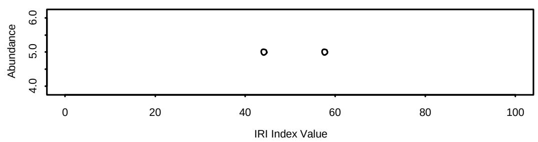
129. Lysmata californica - i   P=80.3 30-120 m



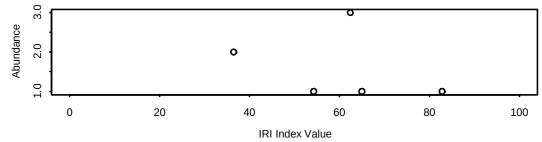
130. Pteropurpura vokesae - i   P=84.3 30-120 m



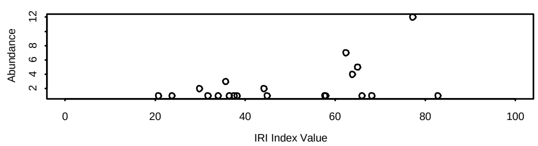
131. Nassarius insculptus - i   P=84.6 30-120 m



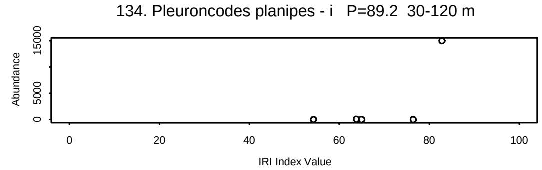
132. Calinaticina oldroydii - i   P=86.2 30-120 m



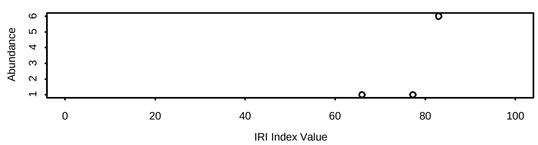
133. Platymera gaudichaudii - i   P=87.1 30-120 m



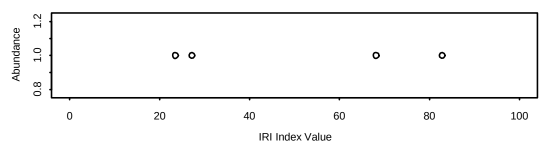
134. Pleuroncodes planipes - i   P=89.2 30-120 m



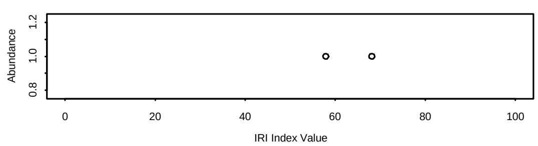
135. Crangon nigromaculata - i   P=98.8 30-120 m



136. Cancer productus - i   P=99.7 30-120 m

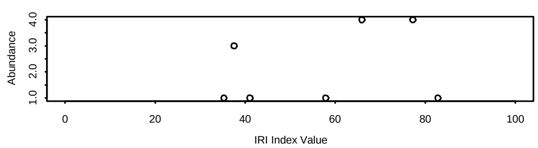


137. Nerocila acuminata - i   P=102 30-120 m



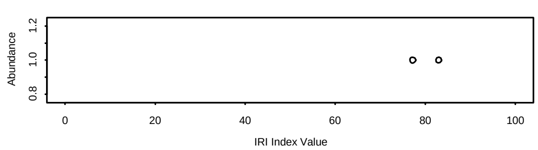
138. Cancer antennarius - i   P=107.9 30-120 m

139. Cancer anthonyi - i   P=112.2 30-120 m

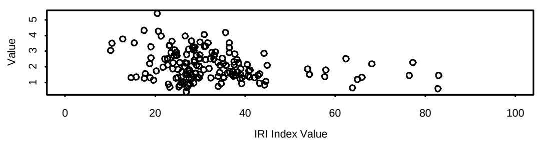


140. Nassarius mendicus - i   P=127.9 30-120 m

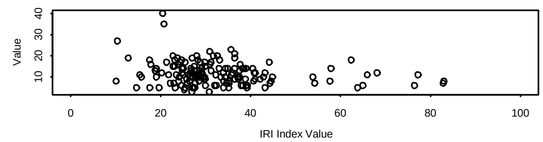
141. Muricea californica - i   P=158.1 30-120 m



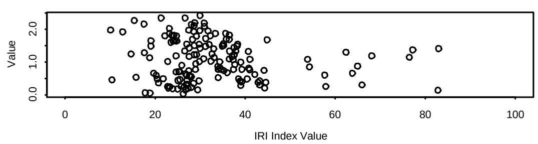
1. GLEASON RICHNESS DIVERSITY - invert 30-120 m



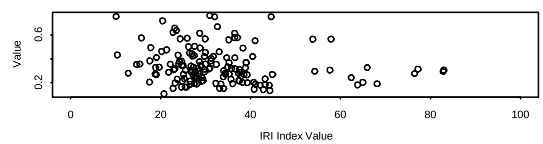
2. NO. OF SPECIES - invert 30-120 m



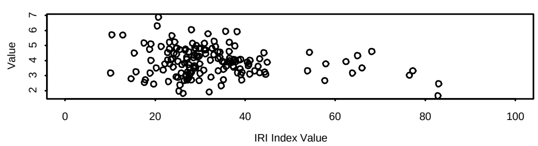
3. SHANNON-WIENER DIVERSITY - invert 30-120 m



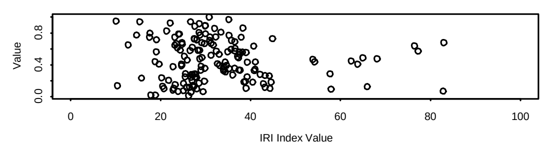
4. SIMPSON DOMINANCE INDEX - fish 30-120 m



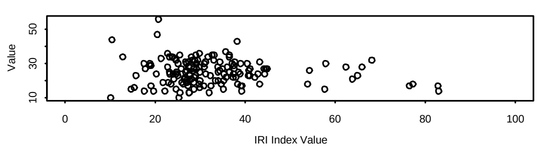
5. GLEASON RICHNESS DIVERSITY - fish + inv 30-120 m



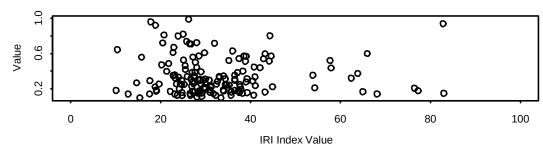
6. EVENNESS - invert 30-120 m



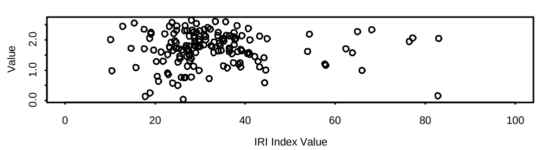
7. NO. OF SPECIES - fish + inv 30-120 m



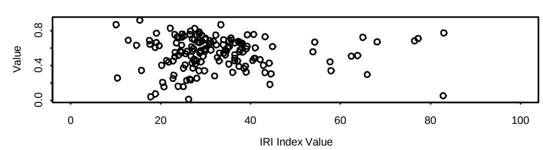
8. SIMPSON DOMINANCE INDEX - fish + inv 30-120 m



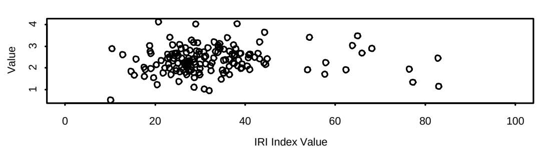
9. SHANNON-WIENER DIVERSITY - fish + inv 30-120 m



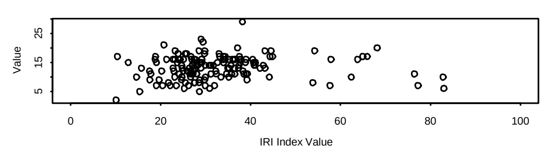
10. EVENNESS - fish + inv 30-120 m



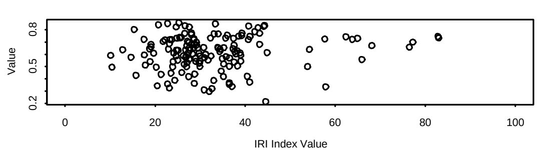
11. GLEASON RICHNESS DIVERSITY - fish 30-120 m



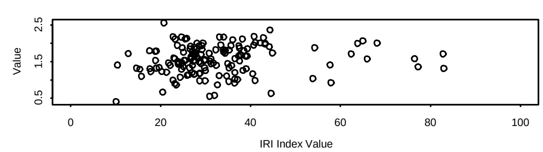
12. NO. OF SPECIES - fish 30-120 m



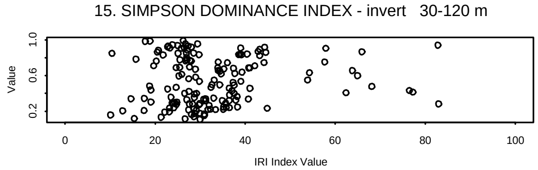
13. EVENNESS - fish 30-120 m



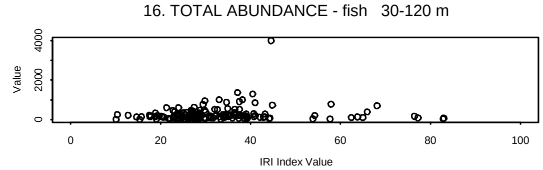
14. SHANNON-WIENER DIVERSITY - fish 30-120 m



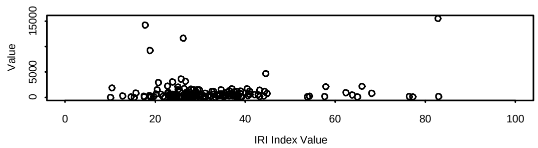
15. SIMPSON DOMINANCE INDEX - invert 30-120 m



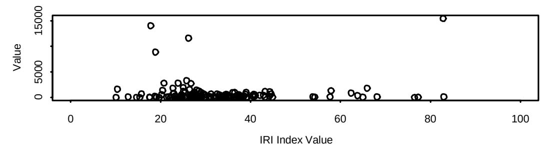
16. TOTAL ABUNDANCE - fish 30-120 m



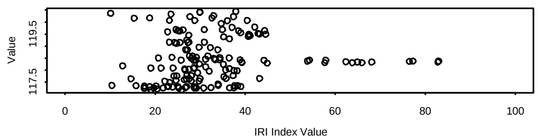
17. TOTAL ABUNDANCE - fish + inv 30-120 m



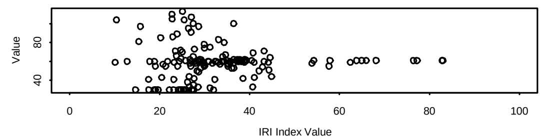
18. TOTAL ABUNDANCE - invert 30-120 m



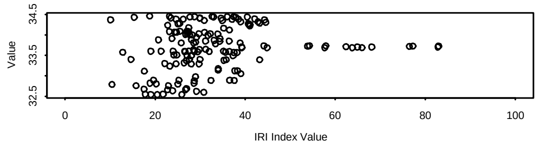
1. LONG 30-120 m



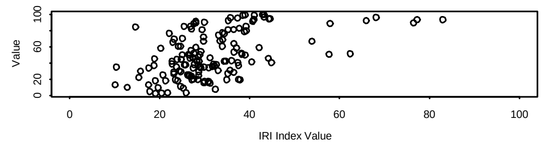
2. DEPTH 30-120 m



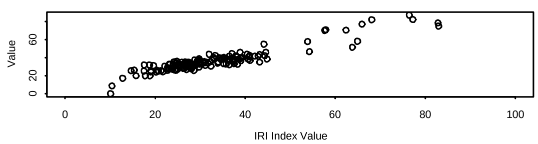
3. LAT 30-120 m



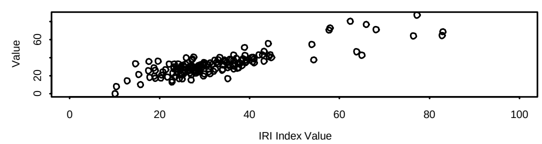
4. FINES 30-120 m



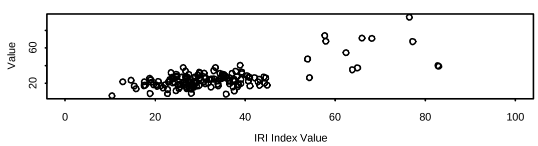
5. TRI 30-120 m



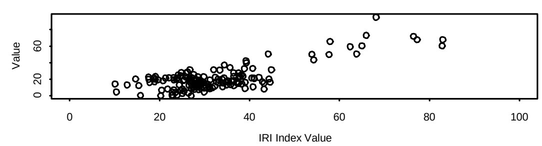
6. ORDINATION VECTOR 30-120 m



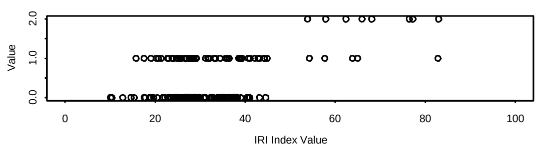
7. FRI 30-120 m



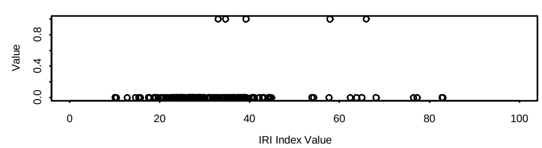
8. BRI 30-120 m



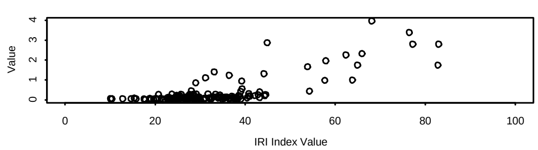
9. IMPACT 30-120 m



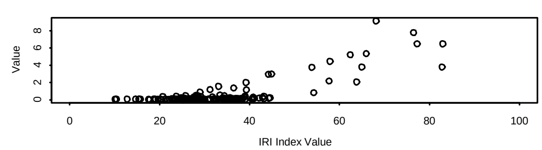
10. TUMOR 30-120 m



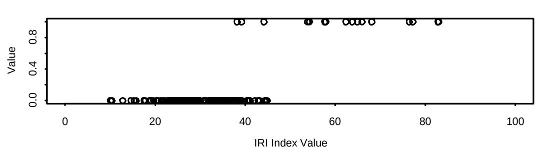
11. ERMQ 30-120 m



12. PELQ 30-120 m

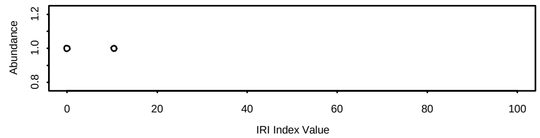


13. FINEROS 30-120 m

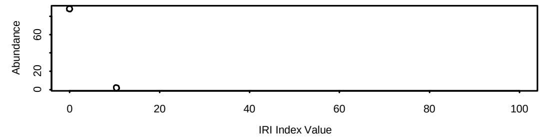


Outer Shelf (100-215 m)

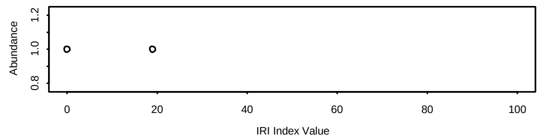
1. Cidarina cidaris - i   P=-23.5 100-215 m



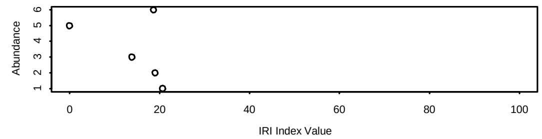
2. Laqueus californianus - i   P=-23.5 100-215 m



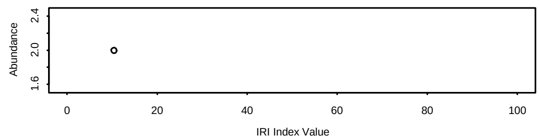
3. Ophionereis eurybrachiplax - i   P=-19.7 100-215 m



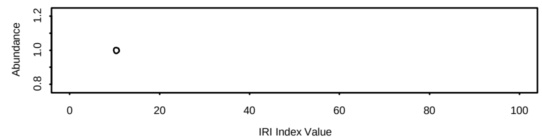
4. Gorgonocephalus eucnemis - i   P=-14.9 100-215 m



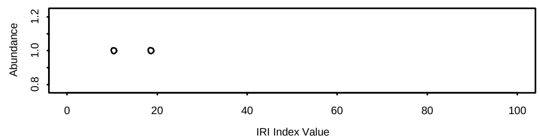
5. Terebratalia occidentalis - i   P=-8.8 100-215 m



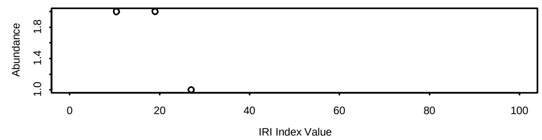
6. Protula superba - i   P=-6.3 100-215 m



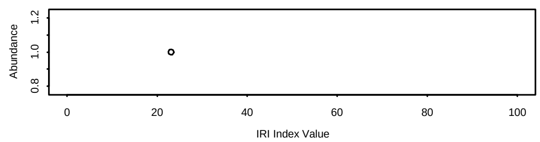
7. Fusinus barbarensis - i   P=-4.4 100-215 m



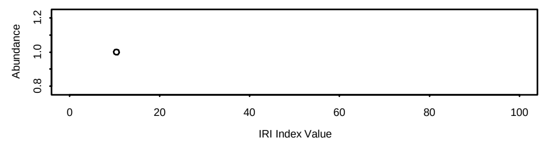
8. Florometra serratissima - i   P=-3 100-215 m



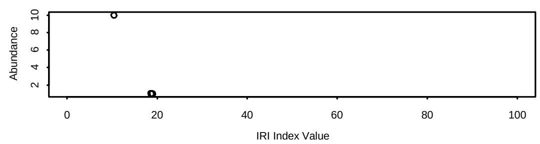
9. Balanus nubilus - i   P=-2.7 100-215 m



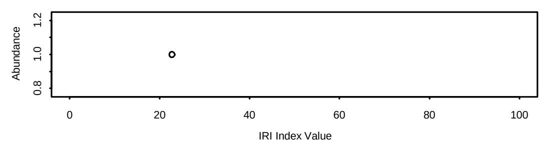
10. Leptasterias hexactis - i   P=-2.6 100-215 m



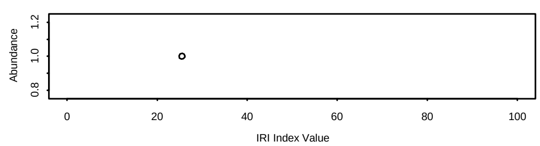
11. Philine alba - i   P=-2.1 100-215 m



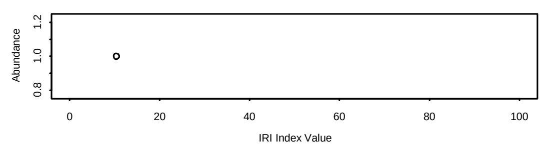
12. Amphiura arcystata - i   P=-1.4 100-215 m



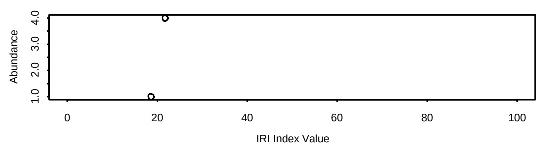
13. Lovenia cordiformis - i   P=0.2 100-215 m



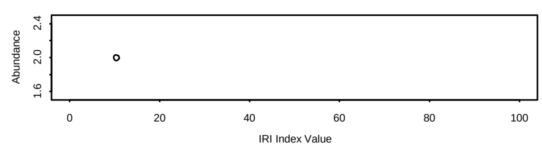
14. Pteropurpura macroptera - i   P=0.9 100-215 m



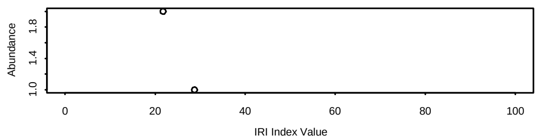
15. Parapagurodes laurentae - i   P=2.4 100-215 m



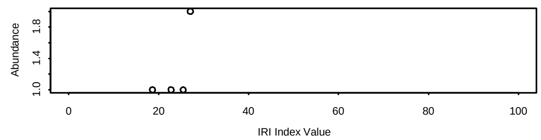
16. Loxorhynchus crispatus - i   P=3.4 100-215 m



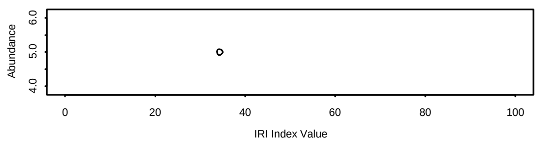
17. Parapagurodes makarovi - i   P=4.5 100-215 m



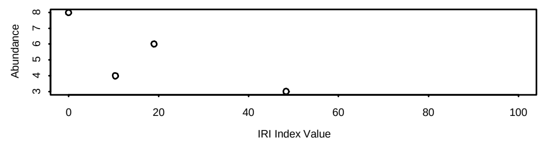
18. Neosimnia aequalis - i   P=5.6 100-215 m



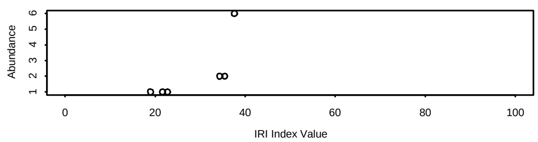
19. Phimochirus californiensis - i   P=5.9 100-215 m



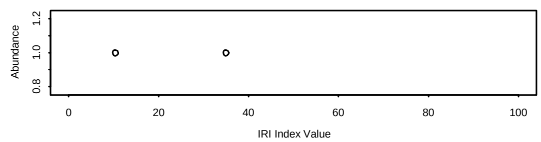
20. Ophiopholis bakeri - i   P=6.1 100-215 m



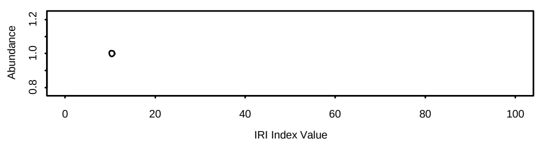
21. Mediaster aequalis - i   P=7.1 100-215 m



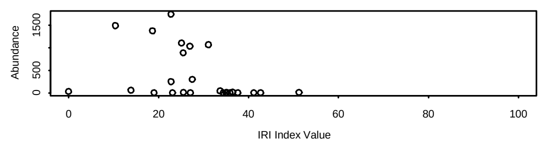
22. Platydoris macfarlandi - i   P=8.9 100-215 m



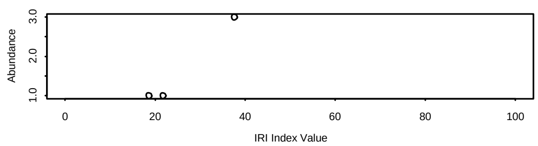
23. Paracyathus stearnsii - i   P=9.3 100-215 m



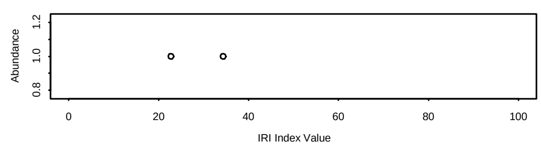
24. Lytechinus pictus - i   P=9.4 100-215 m



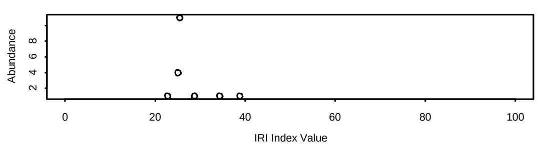
25. Astropecten ornatissimus - i   P=9.9 100-215 m



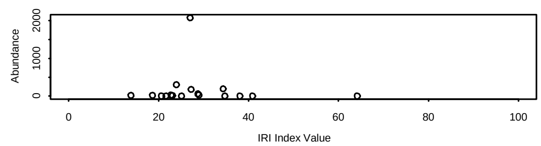
26. Cancellaria cooperi - i   P=12.9 100-215 m



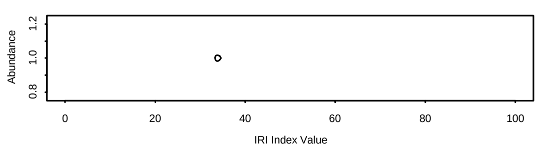
27. Ptilosarcus gurneyi - i   P=13.3 100-215 m



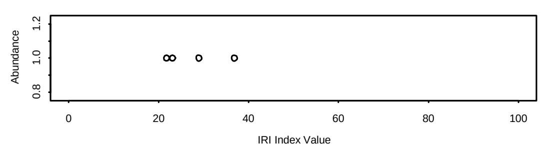
28. Spatangus californicus - i   P=13.5 100-215 m



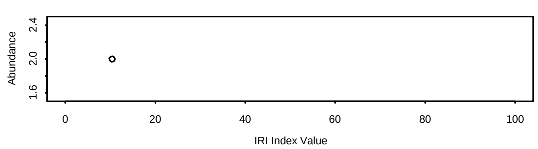
29. Tritonia festiva - i   P=13.8 100-215 m



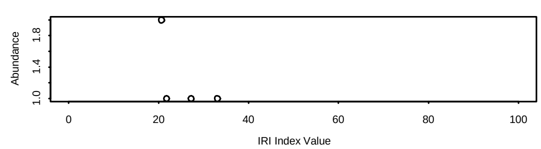
30. Neptunea tabulata - i   P=15.4 100-215 m



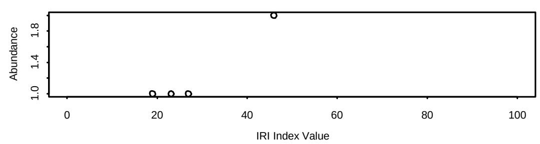
31. Luidia asthenosoma - i   P=15.7 100-215 m



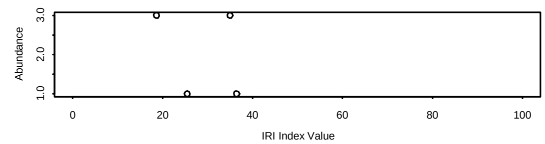
32. Paguristes turgidus - i   P=16.1 100-215 m



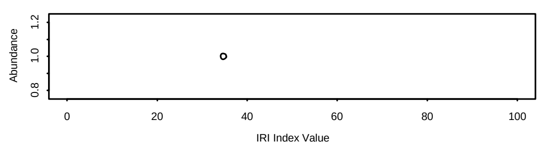
33. Stylasterias forreri - i   P=16.9 100-215 m



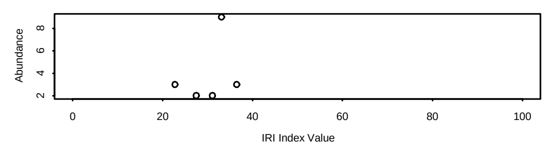
34. Ophiothrix spiculata - i   P=17.2 100-215 m



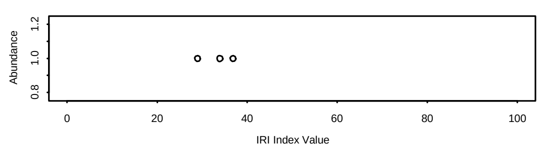
35. Neosabellaria cementarium - i   P=18 100-215 m



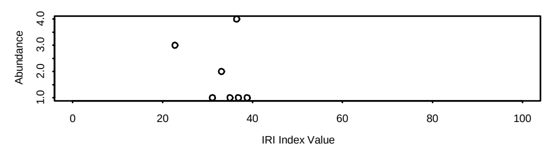
36. Amphichondrius granulatus - i   P=20.2 100-215 m



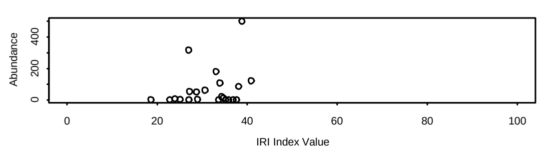
37. Paralithodes californiensis - i   P=20.6 100-215 m



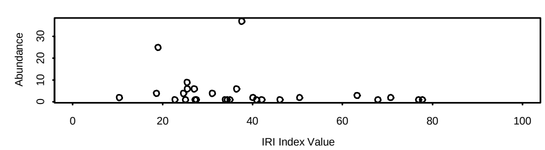
38. Megasurcula carpenteriana - i   P=20.8 100-215 m



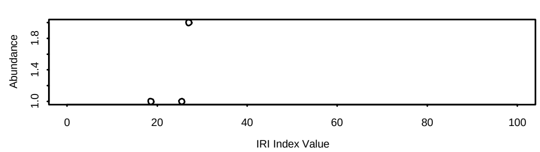
39. Brisaster latifrons - i   P=21.3 100-215 m



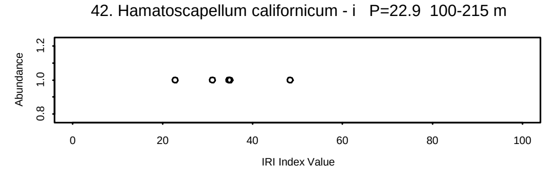
40. Astropecten verrilli - i   P=21.8 100-215 m



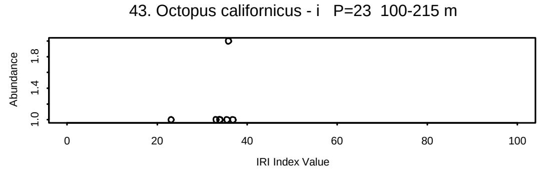
41. Calliostoma turbinum - i   P=21.9 100-215 m



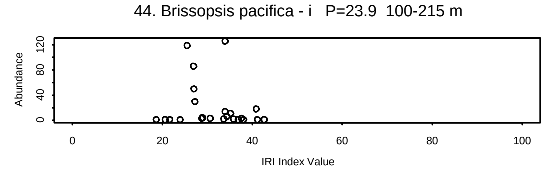
42. Hamatoscapellum californicum - i   P=22.9 100-215 m



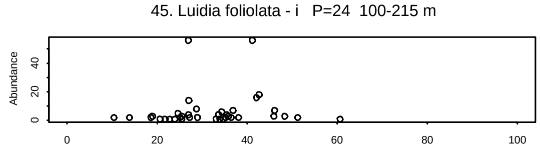
43. Octopus californicus - i   P=23 100-215 m



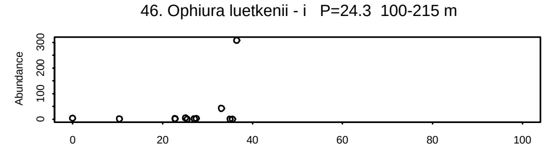
44. Brissopsis pacifica - i   P=23.9 100-215 m



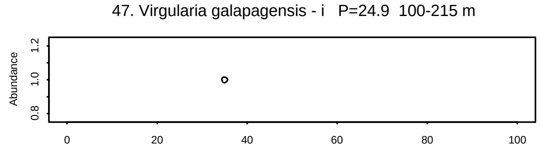
45. Luidia foliolata - i   P=24 100-215 m



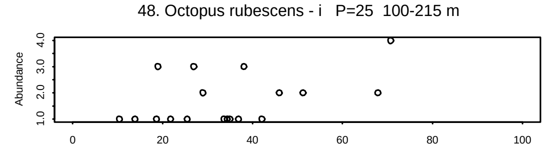
46. Ophiura luetkenii - i   P=24.3 100-215 m



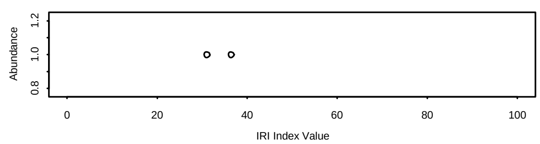
47. Virgularia galapagensis - i   P=24.9 100-215 m



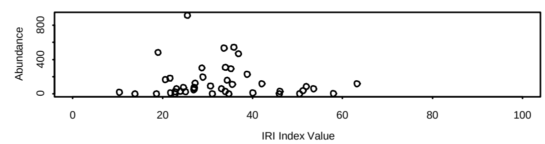
48. Octopus rubescens - i   P=25 100-215 m



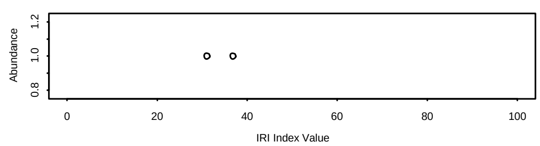
49. Aphrodita japonica - i P=25.2 100-215 m



50. Allocentrotus fragilis - i P=25.3 100-215 m

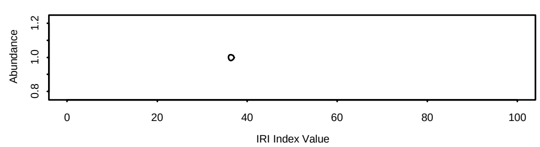


51. Octopus veligero - i P=26.5 100-215 m

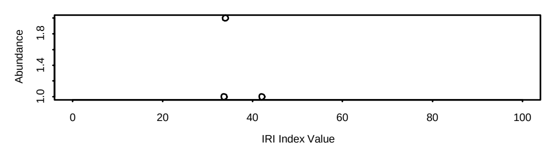


52. Strongylocentrotus purpuratus - i P=27.2 100-215 m

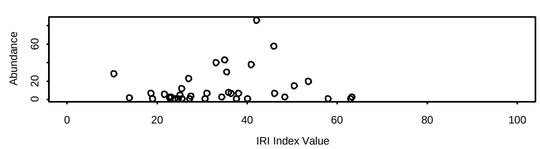
53. Pyromaia tuberculata - i P=27.4 100-215 m



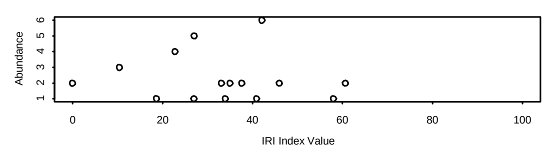
54. Paralithodes rathbuni - i P=27.5 100-215 m



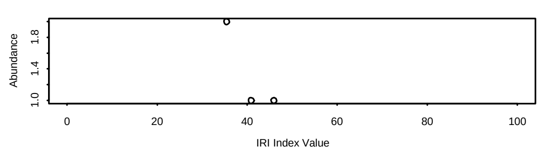
55. Parastichopus californicus - i P=27.6 100-215 m



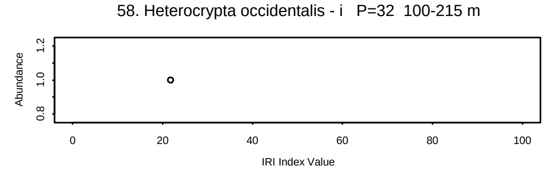
56. Metridium senile - i P=28.5 100-215 m



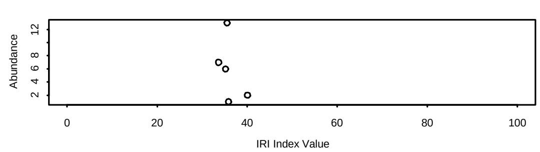
57. Rathbunaster californicus - i P=31.3 100-215 m



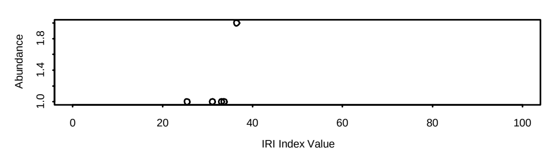
58. Heterocrypta occidentalis - i P=32 100-215 m



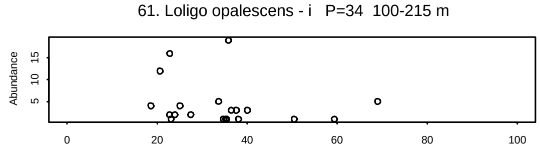
59. Dromalia alexandri - i P=32.7 100-215 m



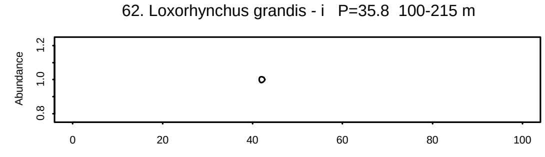
60. Tritonia diomedea - i P=33.8 100-215 m



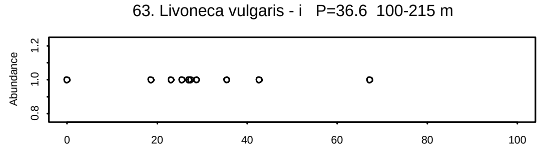
61. Loligo opalescens - i P=34 100-215 m



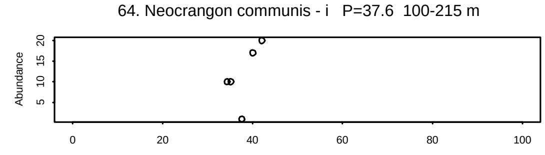
62. Loxorhynchus grandis - i P=35.8 100-215 m



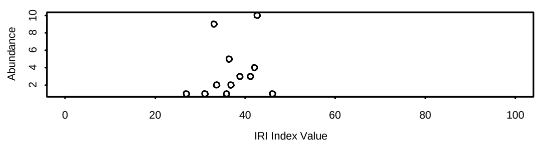
63. Livoneca vulgaris - i P=36.6 100-215 m



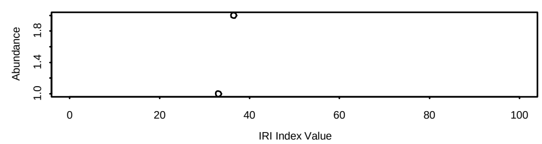
64. Neocrangon communis - i P=37.6 100-215 m



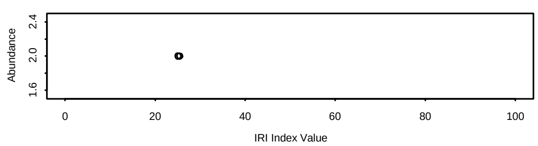
65. Metacrangon spinosissima - i P=38.6 100-215 m



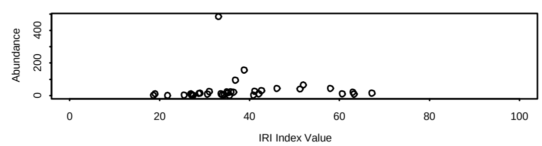
66. Armina californica - i P=38.7 100-215 m



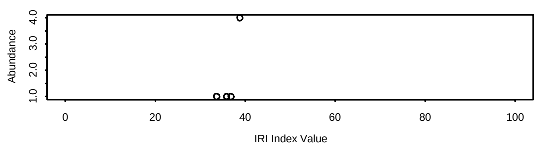
67. Stylatula elongata - i P=39.1 100-215 m



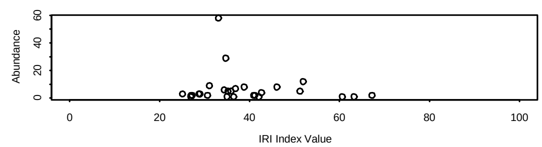
68. Neocrangon zacae - i P=39.9 100-215 m



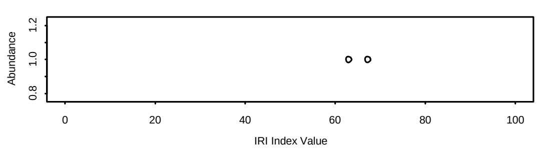
69. Antiplanes catalinae - i P=39.9 100-215 m



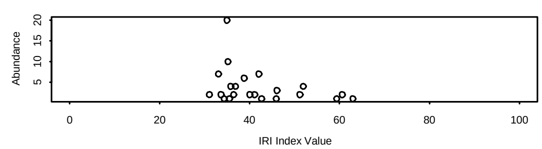
70. Neocrangon resima - i P=41.6 100-215 m



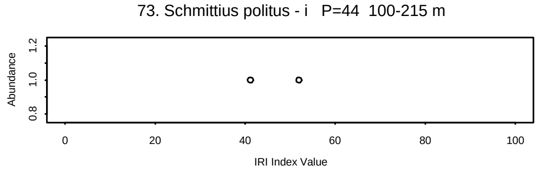
71. Acanthodoris brunnea - i P=41.9 100-215 m



72. Rossia pacifica - i P=43 100-215 m

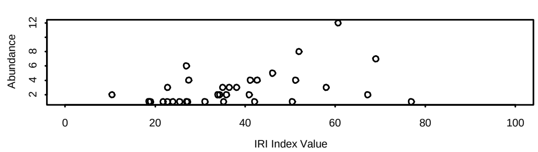


73. Schmittius politus - i P=44 100-215 m

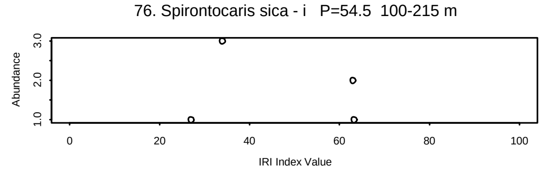


74. Cancellaria crawfordiana - i P=52.4 100-215 m

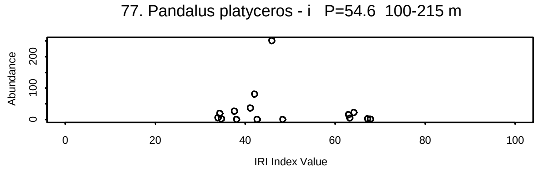
75. Pleurobranchaea californica - i P=53 100-215 m



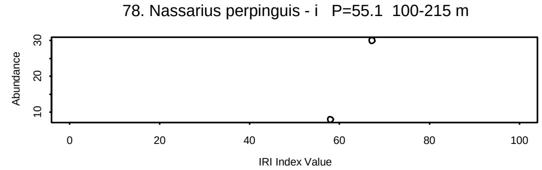
76. Spirontocaris sica - i P=54.5 100-215 m



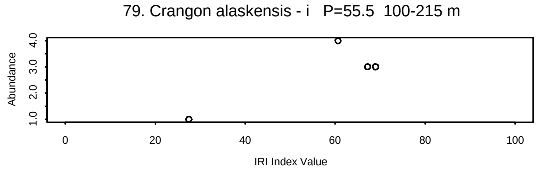
77. Pandalus platyceros - i P=54.6 100-215 m



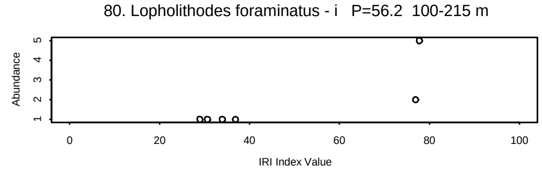
78. Nassarius perpinguis - i P=55.1 100-215 m



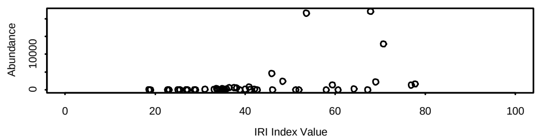
79. Crangon alaskensis - i P=55.5 100-215 m



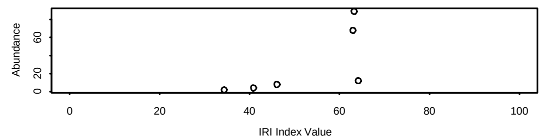
80. Lopholithodes foraminatus - i P=56.2 100-215 m



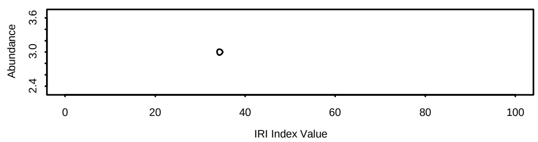
81. Sicyonia ingentis - i P=61.7 100-215 m



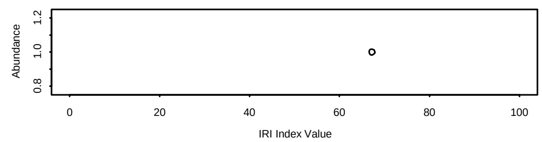
82. Pandalus jordani - i P=65.9 100-215 m



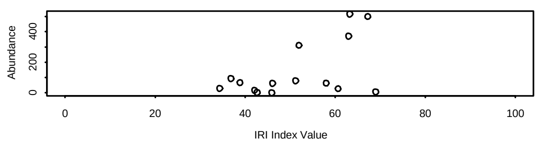
83. Gastropteron pacificum - i P=70.3 100-215 m



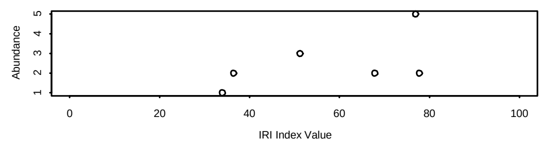
84. Lysmata californica - i P=80.3 100-215 m



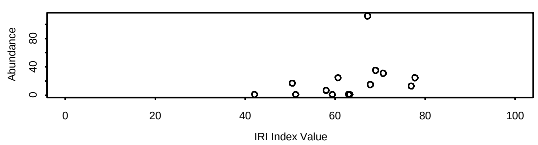
85. Spirontocaris holmesi - i P=83.6 100-215 m



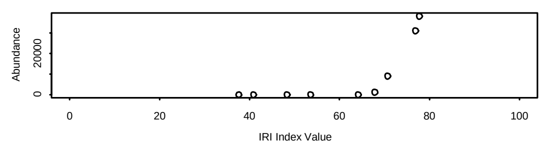
86. Calinaticina oldroydii - i P=86.2 100-215 m



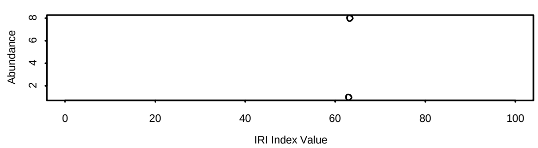
87. Platymera gaudichaudii - i P=87.1 100-215 m



88. Pleuroncodes planipes - i P=89.2 100-215 m

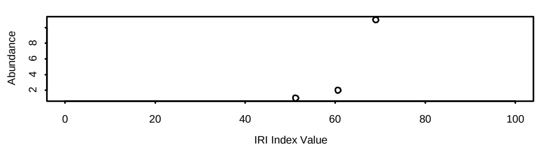


89. Heptacarpus tenuissimus - i P=92.6 100-215 m

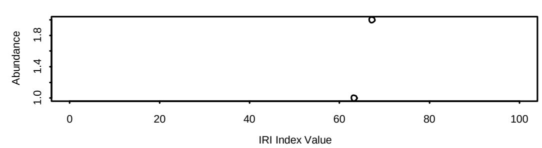


90. Crangon nigromaculata - i P=98.8 100-215 m

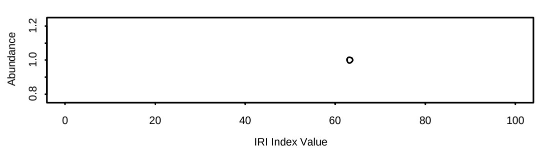
91. Cancer anthonyi - i P=112.2 100-215 m



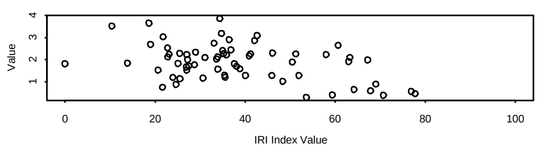
92. Nassarius mendicus - i P=127.9 100-215 m



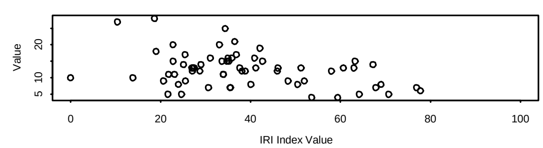
93. Crepidula onyx - i P=130.4 100-215 m



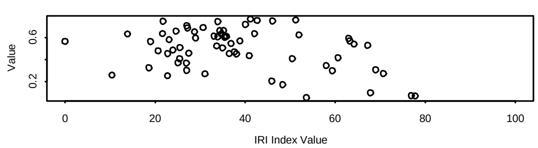
1. GLEASON RICHNESS DIVERSITY - invert 100-215 m



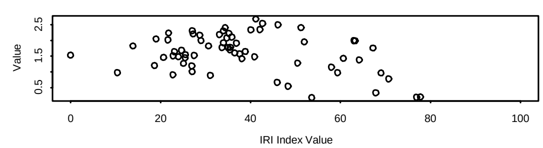
2. NO. OF SPECIES - invert 100-215 m



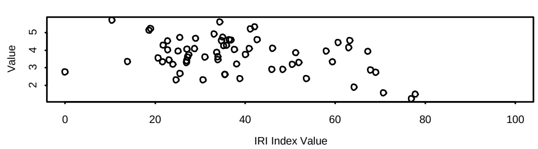
3. EVENNESS - fish + inv 100-215 m



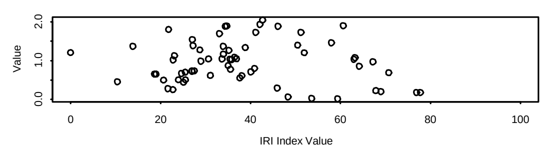
4. SHANNON-WIENER DIVERSITY - fish + inv 100-215 m



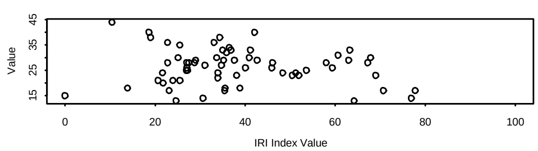
5. GLEASON RICHNESS DIVERSITY - fish + inv 100-215 m



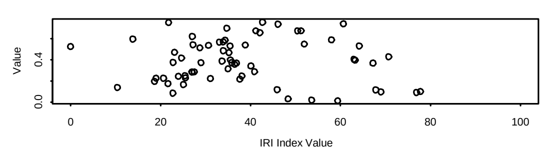
6. SHANNON-WIENER DIVERSITY - invert 100-215 m



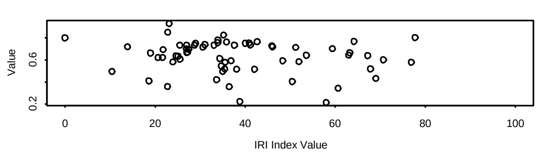
7. NO. OF SPECIES - fish + inv 100-215 m



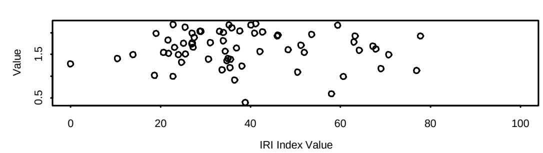
8. EVENNESS - invert 100-215 m



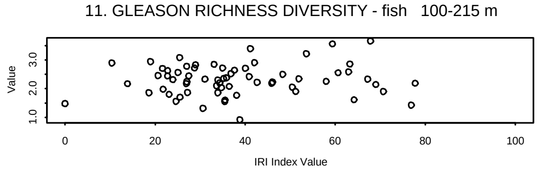
9. EVENNESS - fish 100-215 m



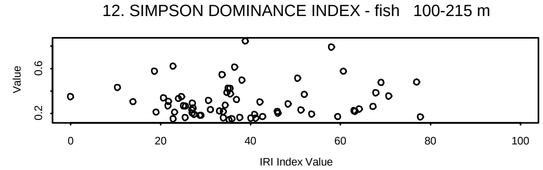
10. SHANNON-WIENER DIVERSITY - fish 100-215 m



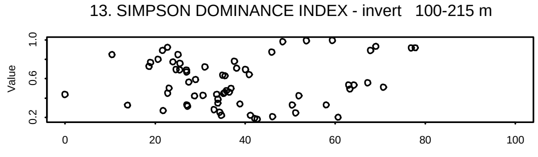
11. GLEASON RICHNESS DIVERSITY - fish 100-215 m



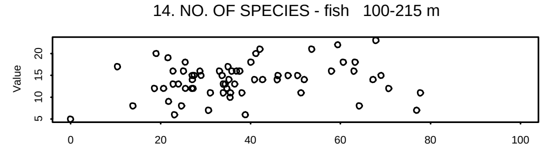
12. SIMPSON DOMINANCE INDEX - fish 100-215 m



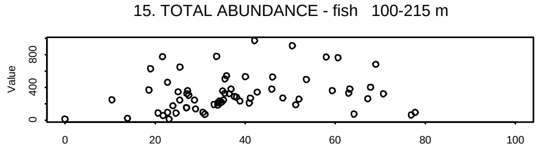
13. SIMPSON DOMINANCE INDEX - invert 100-215 m



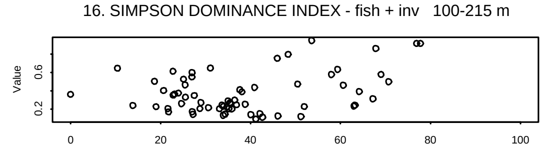
14. NO. OF SPECIES - fish 100-215 m



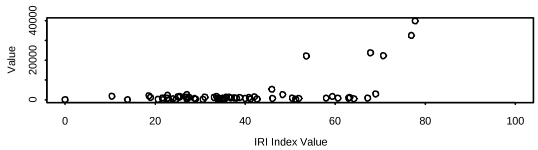
15. TOTAL ABUNDANCE - fish 100-215 m



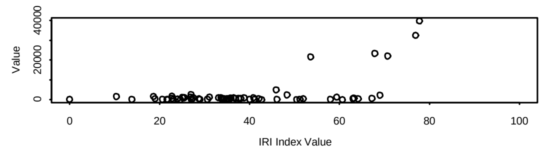
16. SIMPSON DOMINANCE INDEX - fish + inv 100-215 m

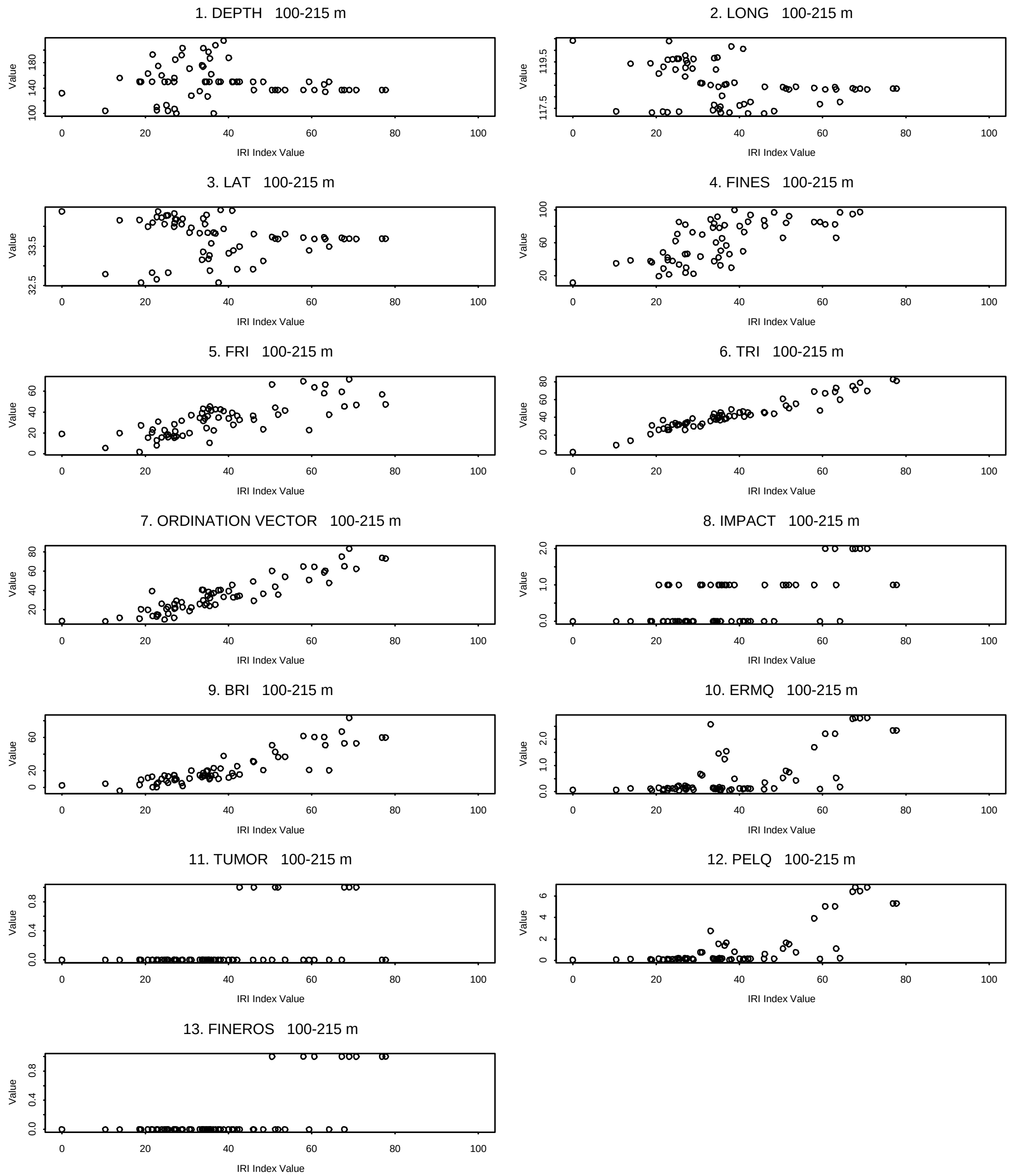


17. TOTAL ABUNDANCE - fish + inv   100-215 m



18. TOTAL ABUNDANCE - invert   100-215 m



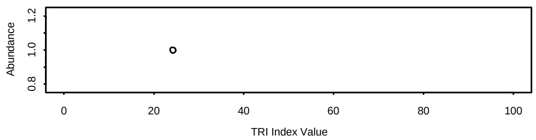

1. DEPTH 100-215 m
2. LONG 100-215 m
3. LAT 100-215 m
4. FINES 100-215 m
5. FRI 100-215 m
6. TRI 100-215 m
7. ORDINATION VECTOR 100-215 m
8. IMPACT 100-215 m
9. BRI 100-215 m
10. ERMQ 100-215 m
11. TUMOR 100-215 m
12. PELQ 100-215 m
13. FINEROS 100-215 m
Value
IRI Index Value

Appendix B8. Patterns of selected variables along the pollution gradient in calibration data base as defined by Trawl Response Index (TRI) values for southern California demersal fish and megabenthic invertebrate species and other ecological variables.

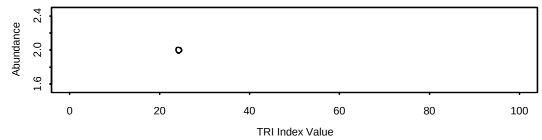
The nature of the gradient defined by the Trawl Response Index (TRI) values is shown by plotting pertinent variables vs. the index values for the calibration observations. The variables plotted include community parameters, environmental variables, BRI, and the projections onto the pollution vector in the ordination space (ORDINATION VECTOR). The FINES parameter is the percent of silt plus clay in the sediment. In addition, the abundance of each species is plotted in the order of the p_i values, which shown are shown above each graph. Fish and invertebrate species are plotted. No p_i value was computed for species occurring only once in the calibration data at the depth range in question. Data for each depth range (inner shelf, 9-40 m; middle shelf, 30-120 m; and 100-215 m) is plotted separately.

Inner Shelf (9-40 m)

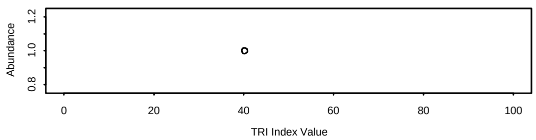
1. Brosmophycis marginata - f P=-31 9-40 m



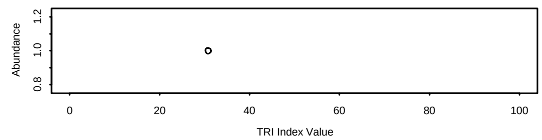
2. Eualus herdmani - i P=-15.9 9-40 m



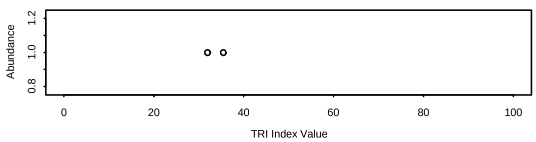
3. Syngnathus exilis - f P=-14 9-40 m



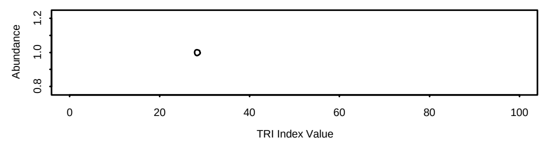
4. Hemisquilla ensigera californiensis - i P=-5.7 9-40 m



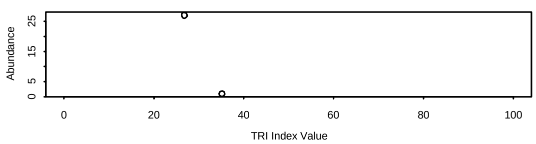
5. Amphiura arcystata - i P=-3.1 9-40 m



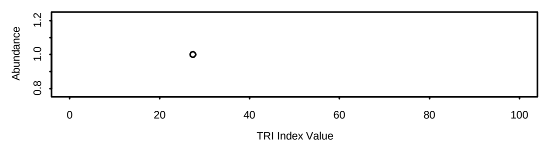
6. Sebastes constellatus - f P=-2.5 9-40 m



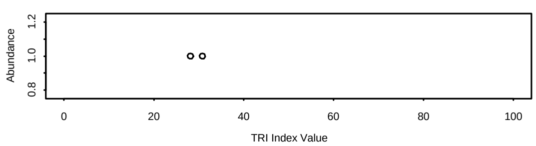
7. Paguristes turgidus - i P=-0.1 9-40 m



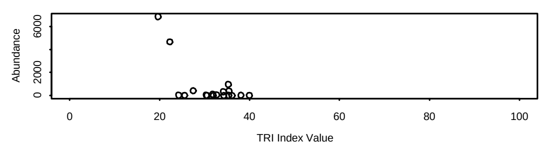
8. Terebra pedroana - i P=0.6 9-40 m



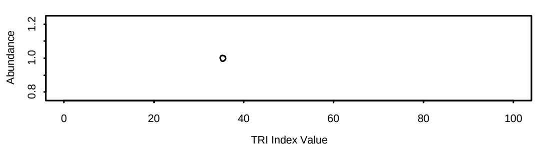
9. Neosimnia aequalis - i P=1.4 9-40 m



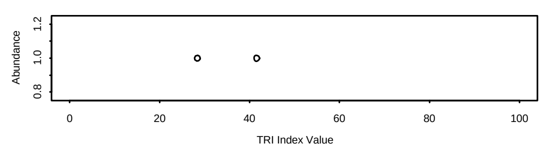
10. Lytechinus pictus - i P=1.9 9-40 m



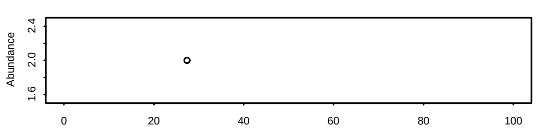
11. Loxorhynchus crispatus - i P=3.6 9-40 m



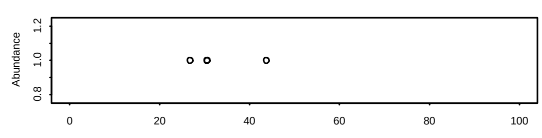
12. Livoneca californica - i P=4 9-40 m



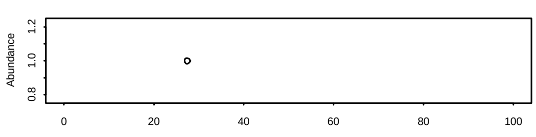
13. Podochela lobifrons - i P=4.2 9-40 m



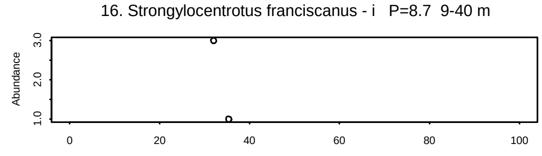
14. Heterogorgia tortuosa - i P=5.4 9-40 m



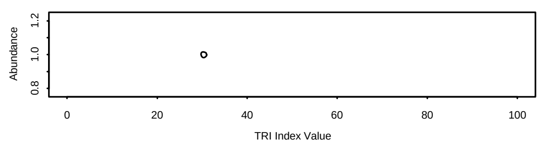
15. Phimochirus californiensis - i P=8.2 9-40 m



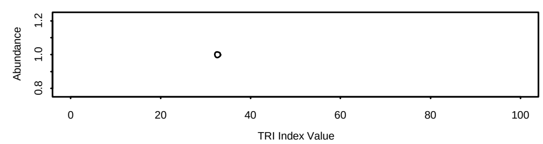
16. Strongylocentrotus franciscanus - i P=8.7 9-40 m



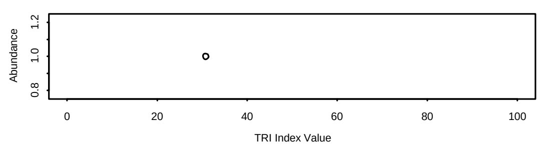
17. Luidia asthenosoma - i   P=9.9 9-40 m



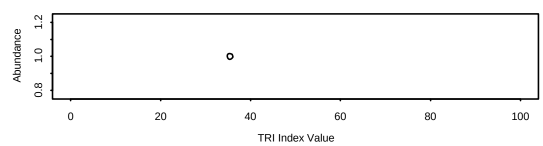
18. Neosabellaria cementarium - i   P=13.6 9-40 m



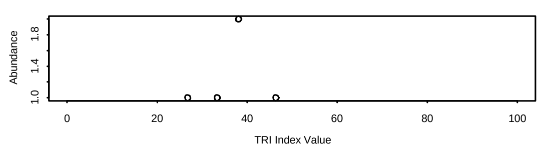
19. Virgularia bromleyi - i   P=14.1 9-40 m



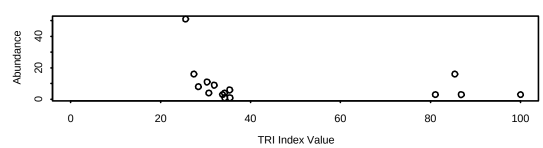
20. Euvola diegensis - i   P=14.8 9-40 m



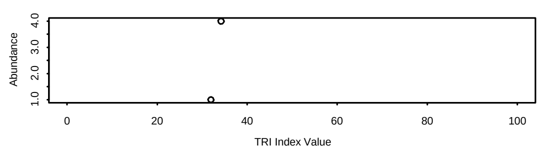
21. Renilla koellikeri - i   P=15.1 9-40 m



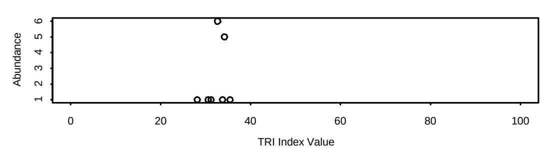
22. Citharichthys sordidus - f   P=15.6 9-40 m



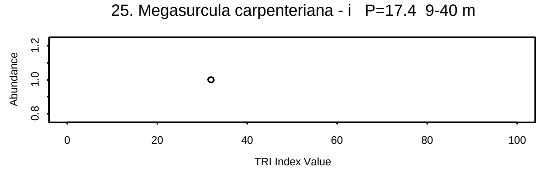
23. Isocheles pilosus - i   P=16.9 9-40 m



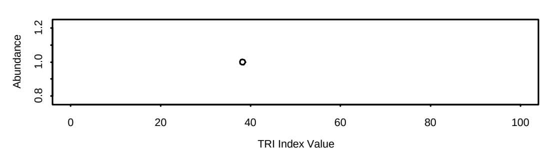
24. Ophiothrix spiculata - i   P=17.4 9-40 m



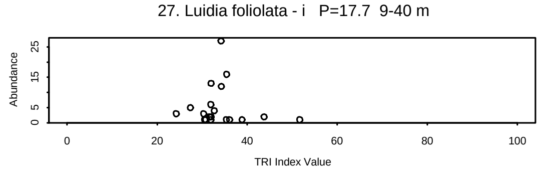
25. Megasurcula carpenteriana - i   P=17.4 9-40 m



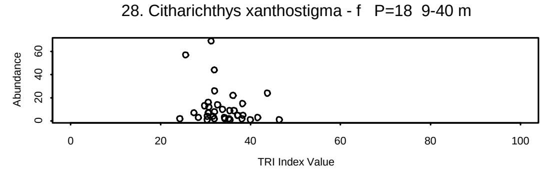
26. Calliostoma turbinum - i   P=17.6 9-40 m



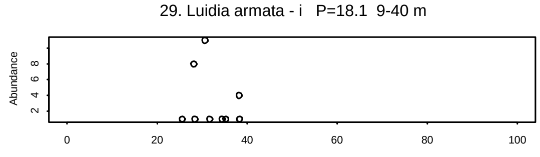
27. Luidia foliolata - i   P=17.7 9-40 m



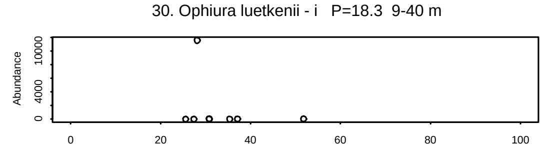
28. Citharichthys xanthostigma - f   P=18 9-40 m



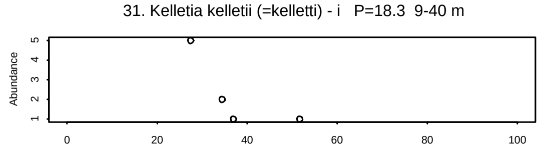
29. Luidia armata - i   P=18.1 9-40 m



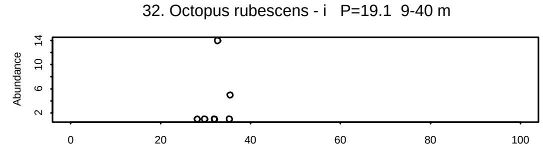
30. Ophiura luetkenii - i   P=18.3 9-40 m



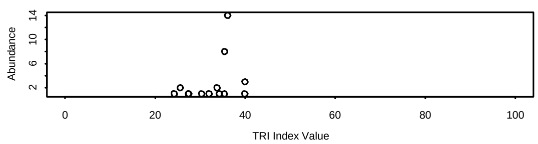
31. Kelletia kelletii (=kelletti) - i   P=18.3 9-40 m



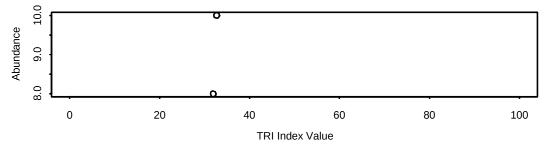
32. Octopus rubescens - i   P=19.1 9-40 m



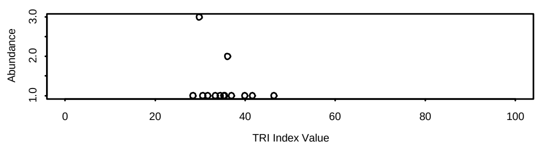
33. Lovenia cordiformis - i   P=19.7 9-40 m



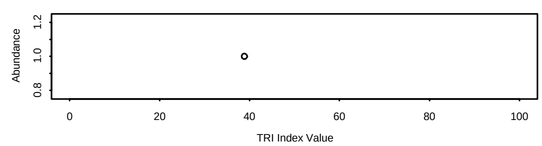
34. Triopha maculata - i   P=20.7 9-40 m



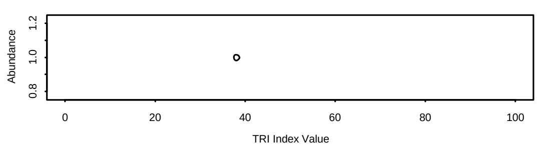
35. Pisaster brevispinus - i   P=21 9-40 m



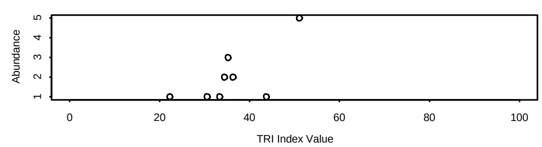
36. Virgularia galapagensis - i   P=21.8 9-40 m



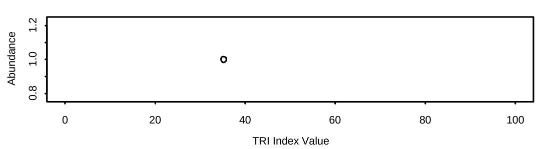
37. Diaulula sandiegensis - i   P=22 9-40 m



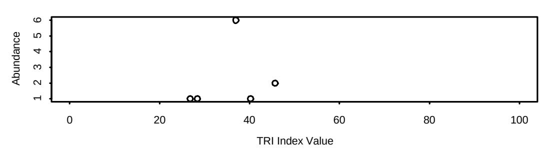
38. Pagurus spilocarpus - i   P=23.5 9-40 m



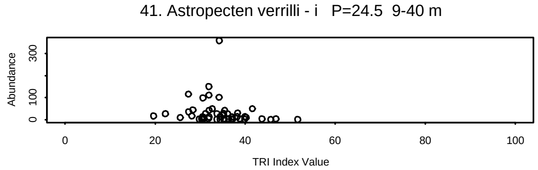
39. Flabellina iodinea - i   P=24.4 9-40 m



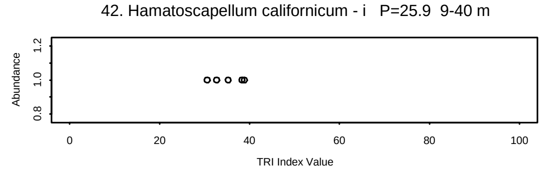
40. Randallia ornata - i   P=24.5 9-40 m



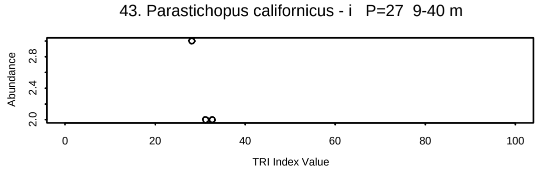
41. Astropecten verrilli - i   P=24.5 9-40 m



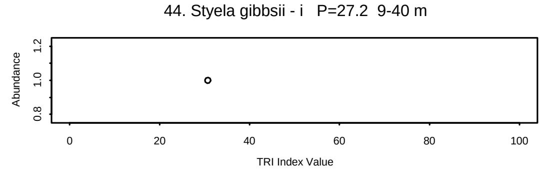
42. Hamatoscapellum californicum - i   P=25.9 9-40 m



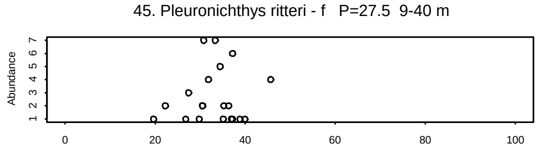
43. Parastichopus californicus - i   P=27 9-40 m



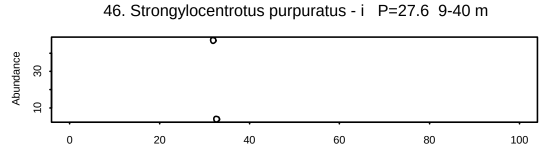
44. Styela gibbsii - i   P=27.2 9-40 m



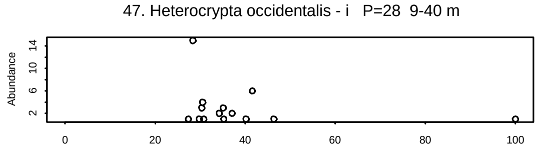
45. Pleuronichthys ritteri - f   P=27.5 9-40 m



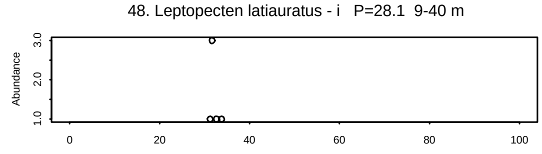
46. Strongylocentrotus purpuratus - i   P=27.6 9-40 m



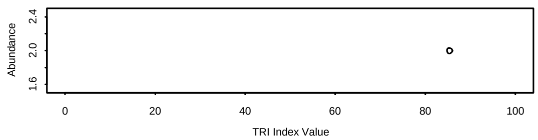
47. Heterocrypta occidentalis - i   P=28 9-40 m



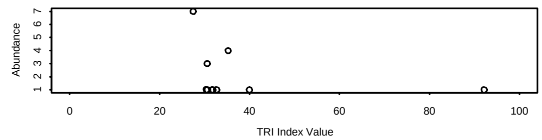
48. Leptopecten latiauratus - i   P=28.1 9-40 m



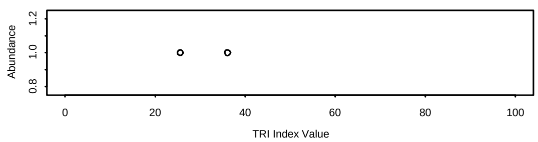
49. Odontopyxis trispinosa - f   P=28.1 9-40 m



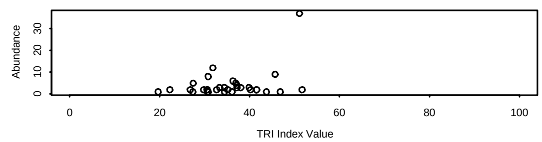
50. Chitonotus pugetensis - f   P=28.5 9-40 m



51. Raja binoculata - f   P=28.5 9-40 m

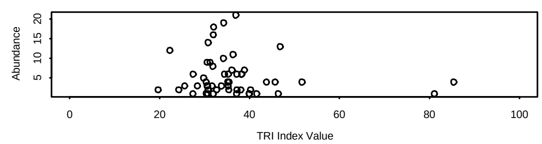


52. Paralichthys californicus - f   P=28.5 9-40 m

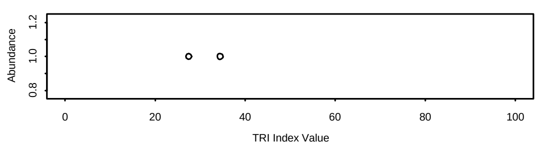


53. Ciona intestinalis - i   P=28.8 9-40 m

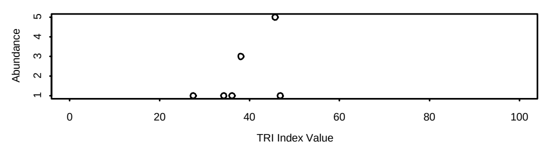
54. Pleuronichthys verticalis - f   P=28.8 9-40 m



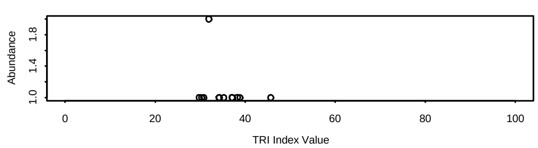
55. Paguristes ulreyi - i   P=29 9-40 m



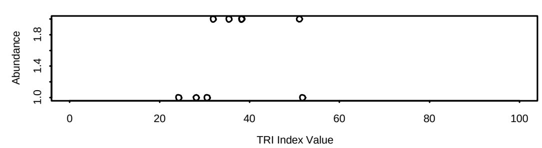
56. Loxorhynchus grandis - i   P=29.2 9-40 m



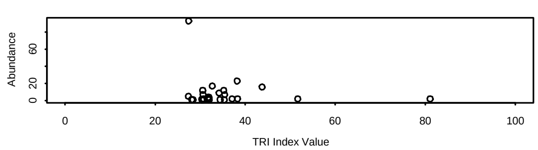
57. Raja inornata - f   P=30 9-40 m



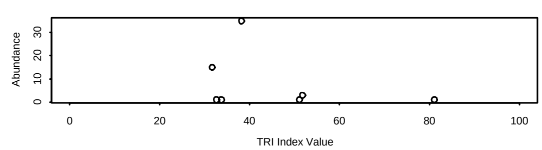
58. Porichthys myriaster - f   P=30.1 9-40 m



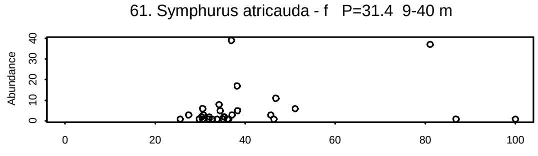
59. Icelinus quadriseriatus - f   P=30.1 9-40 m



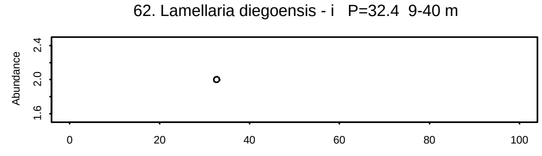
60. Lepidogobius lepidus - f   P=30.5 9-40 m



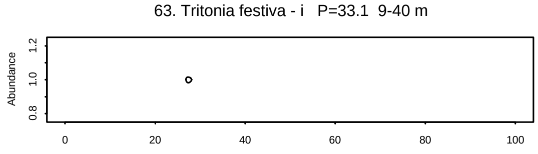
61. Symphurus atricauda - f   P=31.4 9-40 m



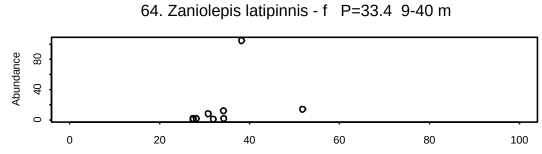
62. Lamellaria diegoensis - i   P=32.4 9-40 m



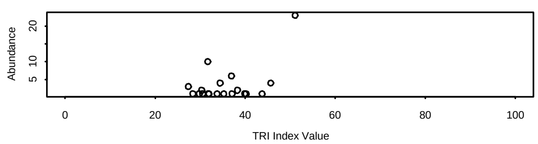
63. Tritonia festiva - i   P=33.1 9-40 m



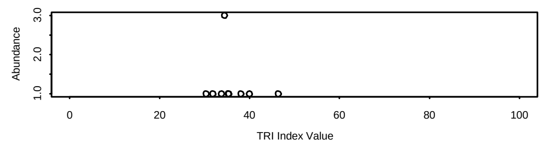
64. Zaniolepis latipinnis - f   P=33.4 9-40 m



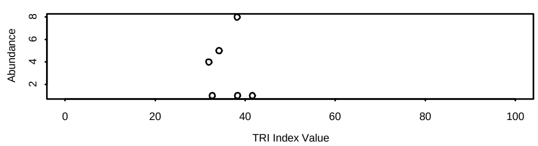
65. Pyromaia tuberculata - i   P=34.2 9-40 m



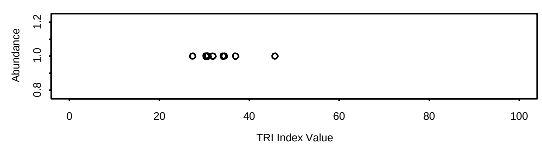
66. Paralabrax nebulifer - f   P=34.5 9-40 m



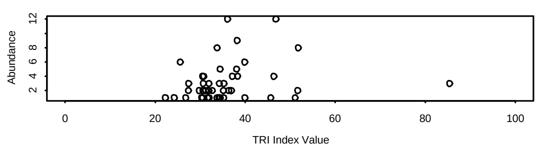
67. Porichthys notatus - f   P=34.9 9-40 m



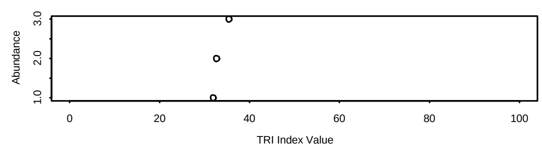
68. Balanus pacificus - i   P=35.5 9-40 m



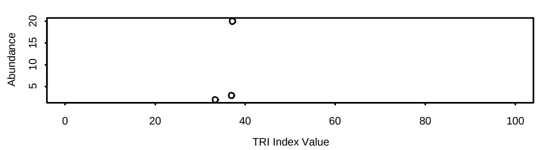
69. Synodus lucioceps - f   P=36.4 9-40 m



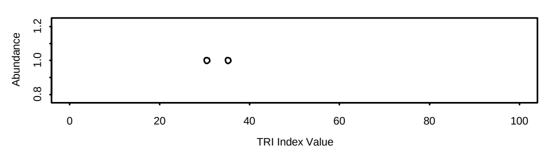
70. Sebastes dallii - f   P=36.5 9-40 m



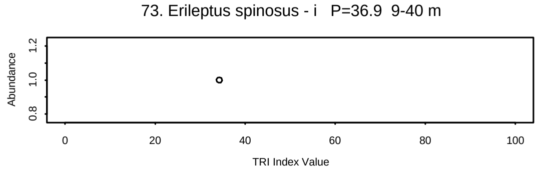
71. Engraulis mordax - f   P=36.6 9-40 m



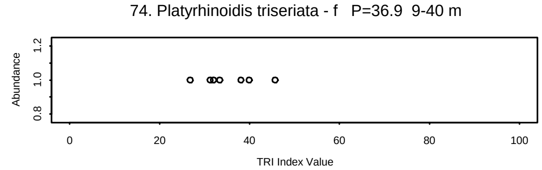
72. Loligo opalescens - i   P=36.9 9-40 m



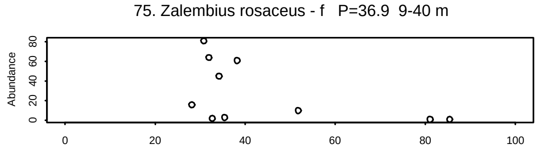
73. Erileptus spinosus - i   P=36.9 9-40 m



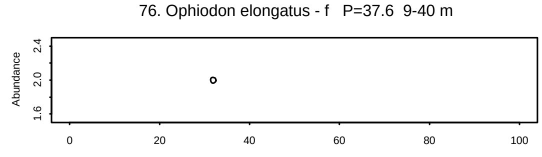
74. Platyrhinoidis triseriata - f   P=36.9 9-40 m



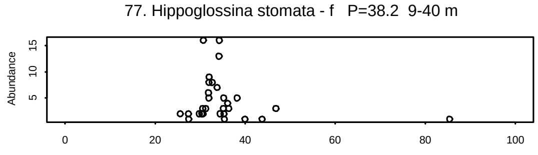
75. Zalembius rosaceus - f   P=36.9 9-40 m



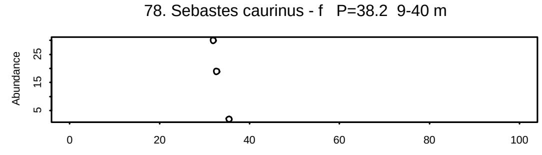
76. Ophiodon elongatus - f   P=37.6 9-40 m



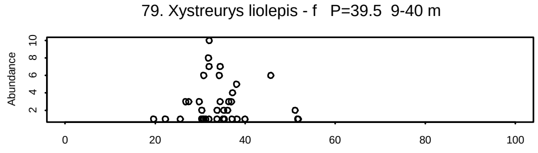
77. Hippoglossina stomata - f   P=38.2 9-40 m



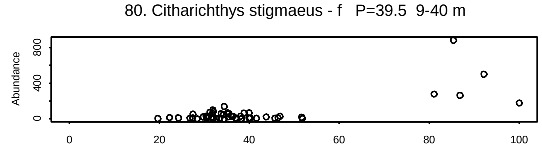
78. Sebastes caurinus - f   P=38.2 9-40 m



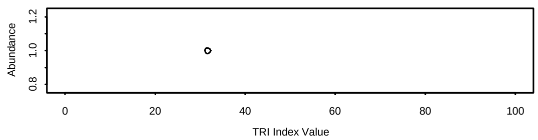
79. Xystreurys liolepis - f   P=39.5 9-40 m



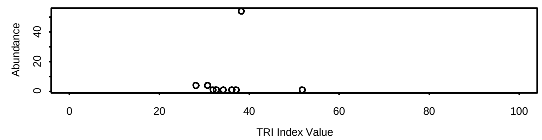
80. Citharichthys stigmaeus - f   P=39.5 9-40 m



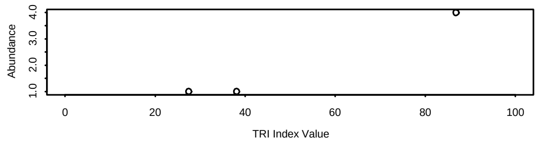
81. Rossia pacifica - i   P=39.8 9-40 m



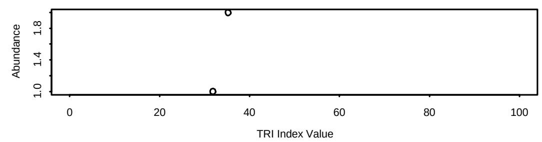
82. Stylatula elongata - i   P=39.9 9-40 m



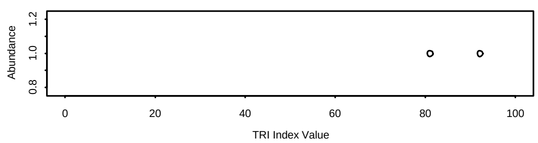
83. Podochela hemphillii - i   P=39.9 9-40 m



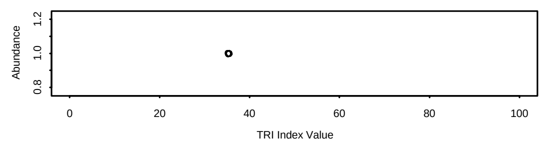
84. Armina californica - i   P=41.2 9-40 m



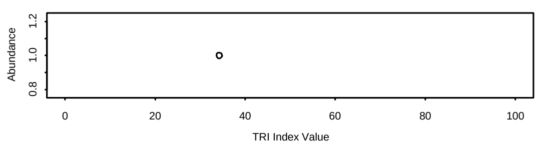
85. Chilara taylori - f   P=41.3 9-40 m



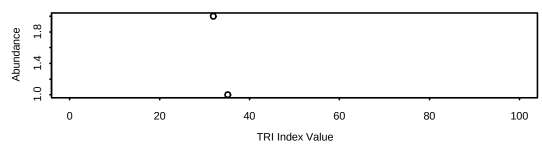
86. Tritonia diomedea - i   P=42.8 9-40 m



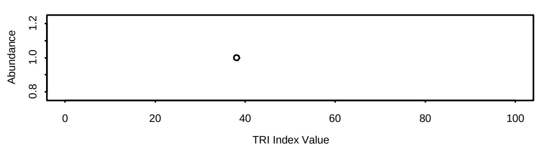
87. Orthopagurus minimus - i   P=44.1 9-40 m



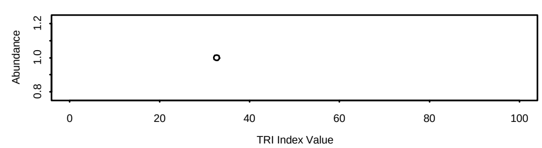
88. Sebastes auriculatus - f   P=44.4 9-40 m



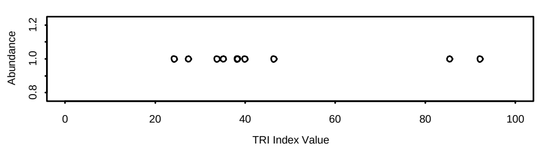
89. Peprilus simillimus - f   P=44.7 9-40 m



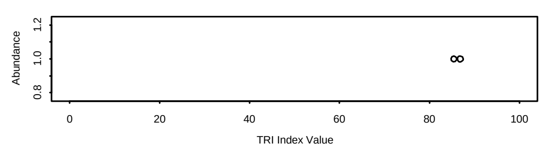
90. Cephaloscyllium ventriosum - f   P=45.5 9-40 m



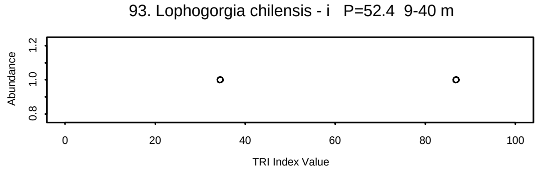
91. Livoneca vulgaris - i   P=50.7 9-40 m



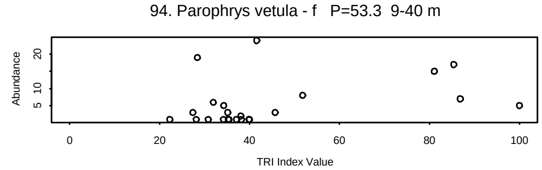
92. Corynactis californica - i   P=51.9 9-40 m



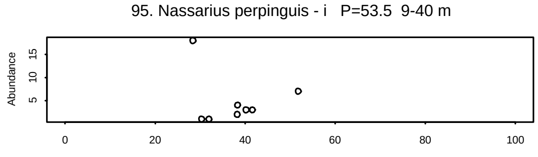
93. Lophogorgia chilensis - i   P=52.4 9-40 m



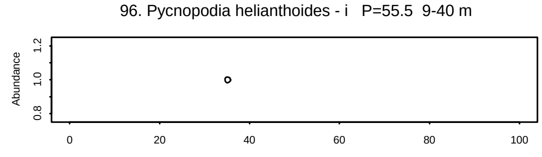
94. Parophrys vetula - f   P=53.3 9-40 m



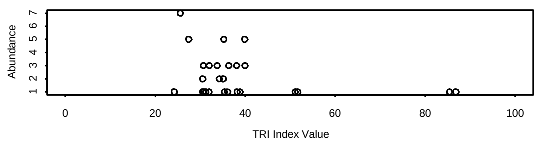
95. Nassarius perpinguis - i   P=53.5 9-40 m



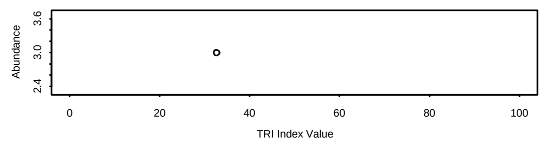
96. Pycnopodia helianthoides - i   P=55.5 9-40 m



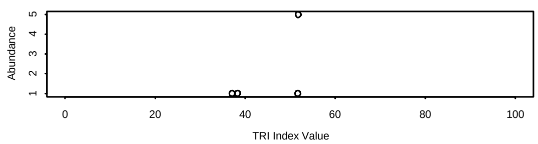
97. Scorpaena guttata - f   P=57.5 9-40 m



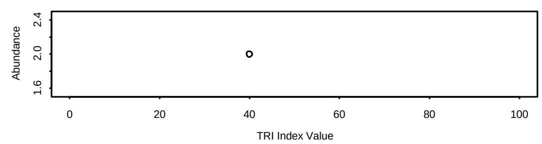
98. Pandalus platyceros - i   P=58.2 9-40 m



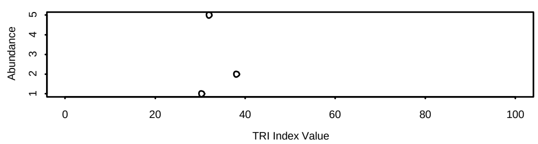
99. Neverita reclusiana - i   P=58.8 9-40 m



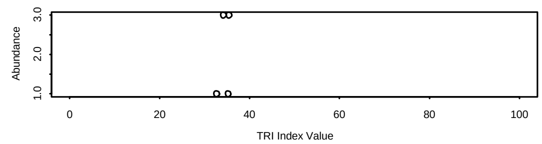
100. Heptacarpus stimpsoni - i   P=59.1 9-40 m



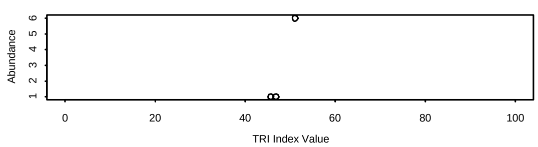
101. Cancer jordani - i   P=59.4 9-40 m



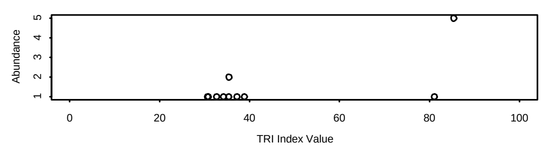
102. Acanthodoris brunnea - i   P=60.6 9-40 m



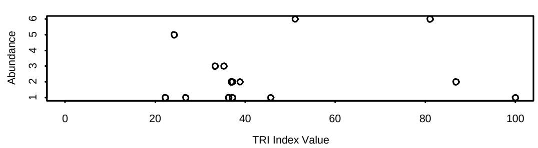
103. Seriphus politus - f   P=60.9 9-40 m



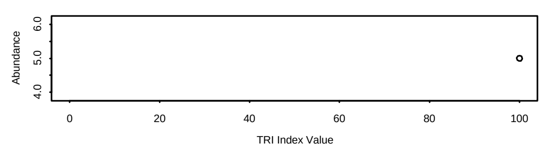
104. Pleurobranchaea californica - i   P=61.1 9-40 m



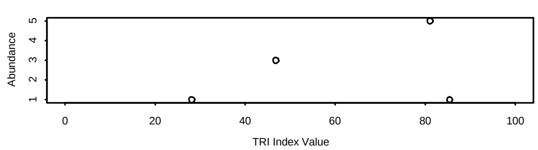
105. Astropecten armatus - i   P=62.3 9-40 m



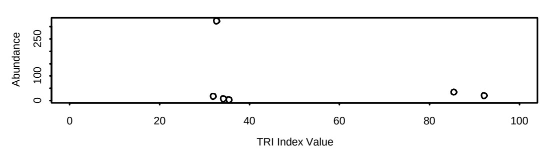
106. Crangon alaskensis - i   P=63.5 9-40 m



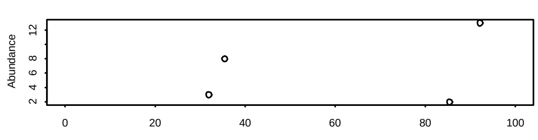
107. Microstomus pacificus - f   P=64.8 9-40 m



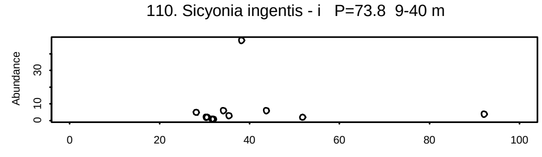
108. Sebastes saxicola - f   P=66.1 9-40 m



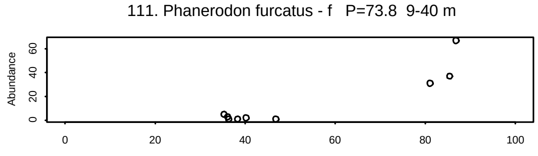
109. Sebastes miniatus - f   P=68.8 9-40 m



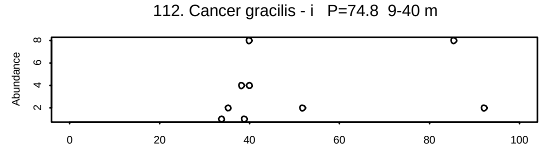
110. Sicyonia ingentis - i   P=73.8 9-40 m



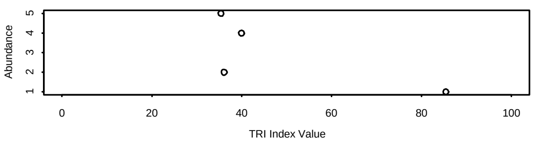
111. Phanerodon furcatus - f   P=73.8 9-40 m



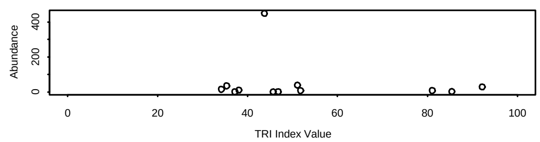
112. Cancer gracilis - i   P=74.8 9-40 m



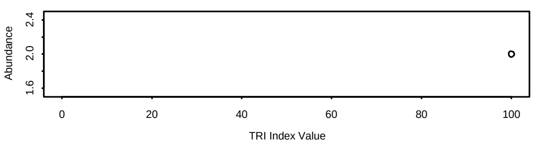
113. Asterina miniata - i   P=89.9 9-40 m



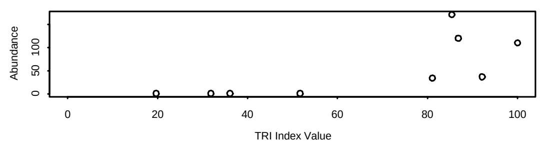
114. Genyonemus lineatus - f   P=90 9-40 m



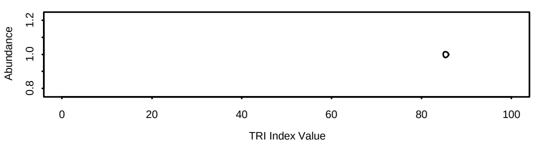
115. Spirontocaris holmesi - i   P=93.5 9-40 m



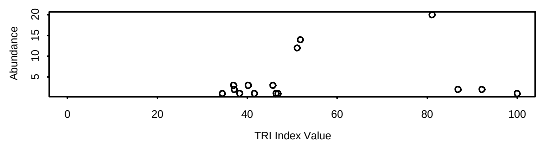
116. Pleuronichthys decurrens - f   P=94.7 9-40 m



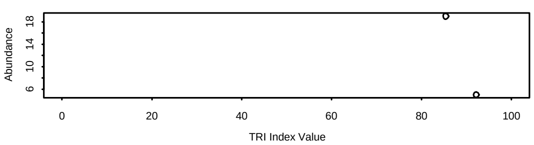
117. Sebastes paucispinis - f   P=95.5 9-40 m



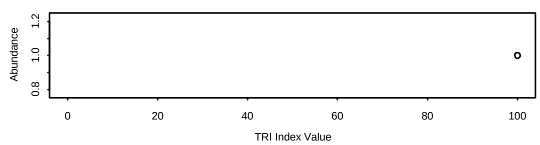
118. Crangon nigromaculata - i   P=106 9-40 m



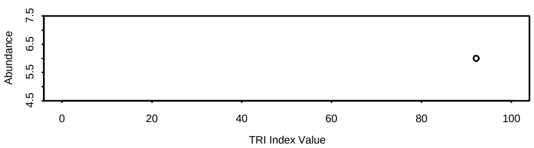
119. Platymera gaudichaudii - i   P=114.8 9-40 m



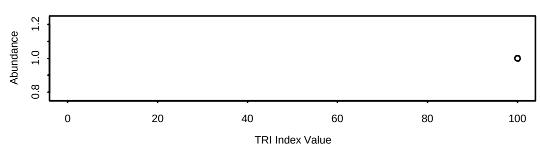
120. Pteropurpura vokesae - i   P=119.1 9-40 m



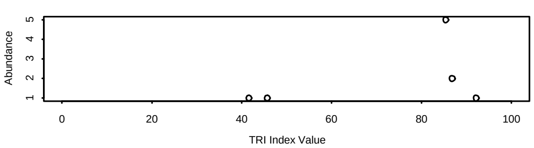
121. Sebastes jordani - f   P=119.3 9-40 m



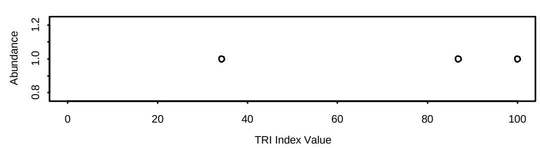
122. Torpedo californica - f   P=120.9 9-40 m



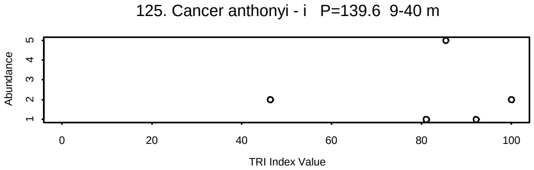
123. Cancer antennarius - i   P=129.9 9-40 m



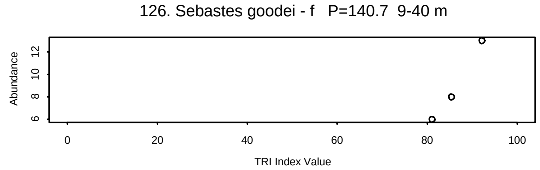
124. Cancer productus - i   P=130.6 9-40 m



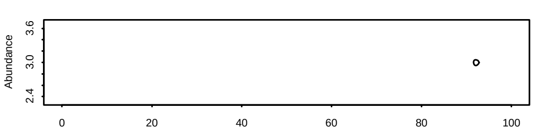
125. Cancer anthonyi - i   P=139.6 9-40 m



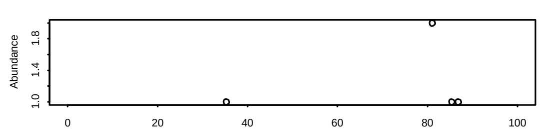
126. Sebastes goodei - f   P=140.7 9-40 m



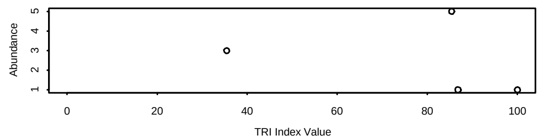
127. Portunus xantusii - i   P=141.9 9-40 m



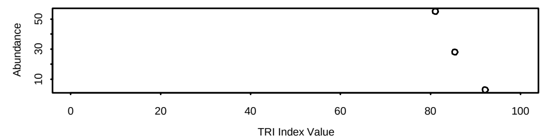
128. Rhacochilus vacca - f   P=142 9-40 m



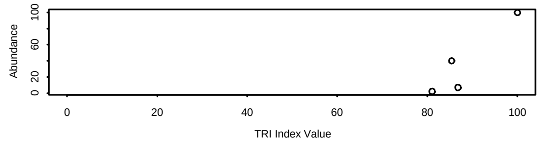
129. Conus californicus - i   P=158.7 9-40 m



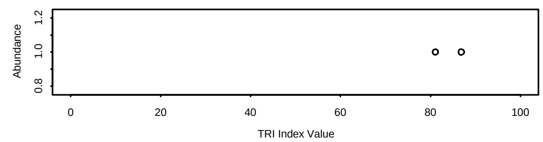
130. Cymatogaster aggregata - f   P=167.5 9-40 m



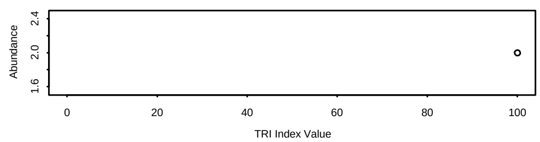
131. Nassarius mendicus - i   P=170.8 9-40 m



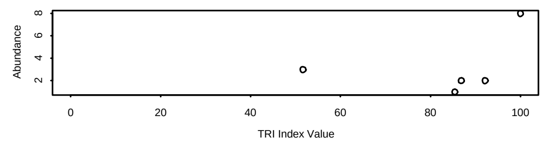
132. Muricea californica - i   P=184.3 9-40 m



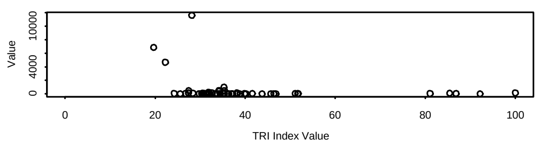
133. Crepidula onyx - i   P=188 9-40 m



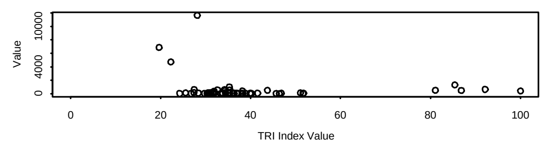
134. Pleuronichthys coenosus - f   P=188.6 9-40 m



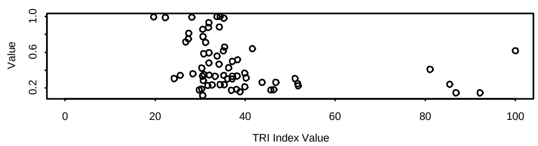
1. TOTAL ABUNDANCE - invert   9-40 m



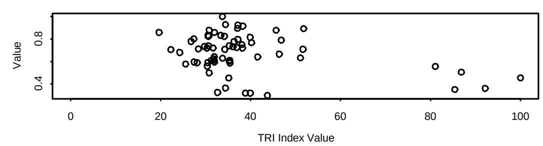
2. TOTAL ABUNDANCE - fish + inv   9-40 m



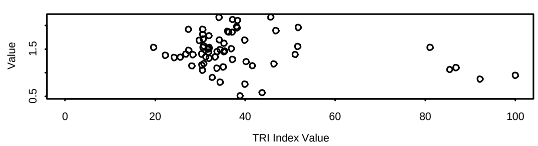
3. SIMPSON DOMINANCE INDEX - invert   9-40 m



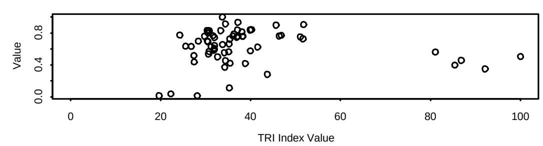
4. EVENNESS - fish   9-40 m



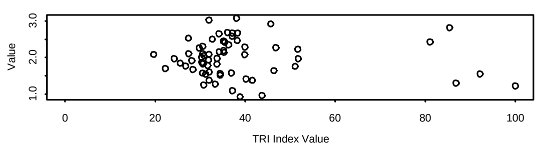
5. SHANNON-WIENER DIVERSITY - fish   9-40 m



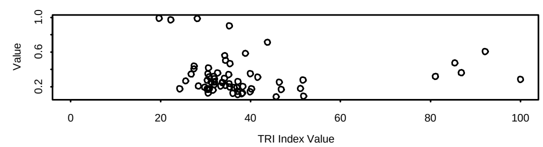
6. EVENNESS - fish + inv   9-40 m



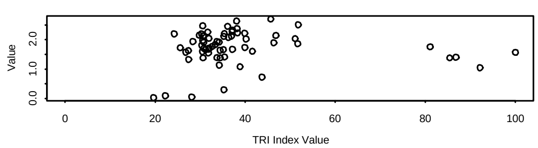
7. GLEASON RICHNESS DIVERSITY - fish   9-40 m



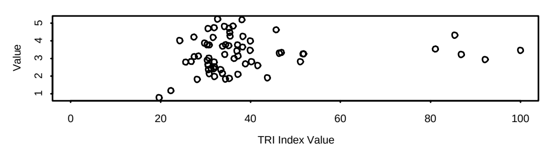
8. SIMPSON DOMINANCE INDEX - fish + inv   9-40 m



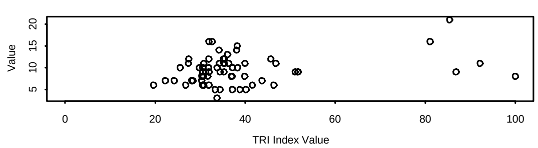
9. SHANNON-WIENER DIVERSITY - fish + inv   9-40 m



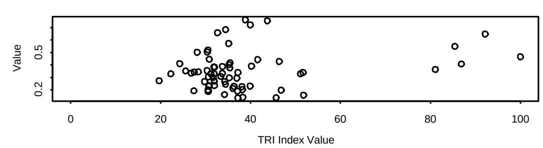
10. GLEASON RICHNESS DIVERSITY - fish + inv   9-40 m



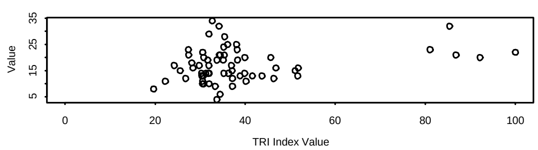
11. NO. OF SPECIES - fish   9-40 m



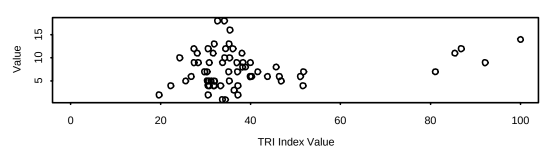
12. SIMPSON DOMINANCE INDEX - fish   9-40 m



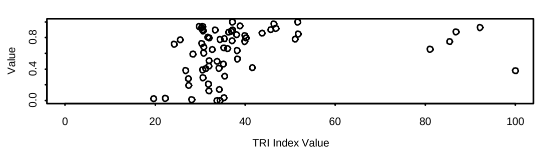
13. NO. OF SPECIES - fish + inv   9-40 m



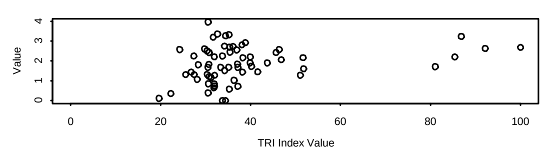
14. NO. OF SPECIES - invert   9-40 m



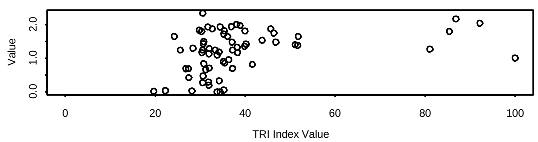
15. EVENNESS - invert   9-40 m



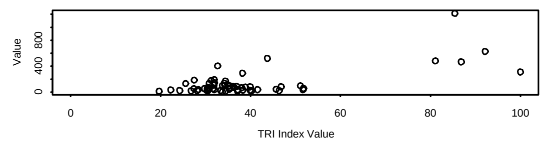
16. GLEASON RICHNESS DIVERSITY - invert   9-40 m



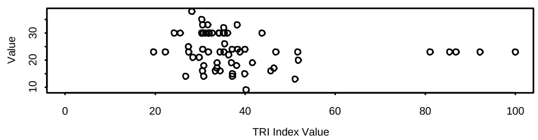
17. SHANNON-WIENER DIVERSITY - invert   9-40 m



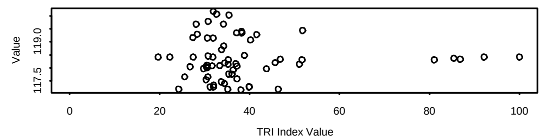
18. TOTAL ABUNDANCE - fish   9-40 m



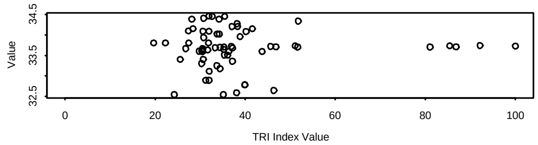
1. DEPTH   9-40 m



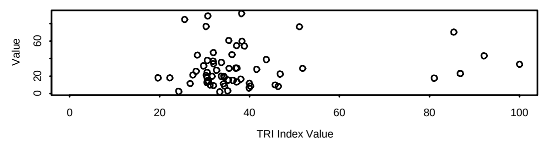
2. LONG   9-40 m



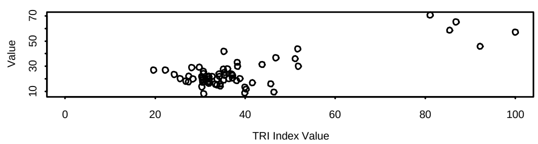
3. LAT   9-40 m



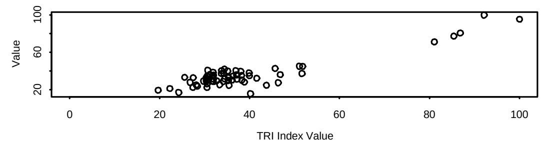
4. FINES   9-40 m



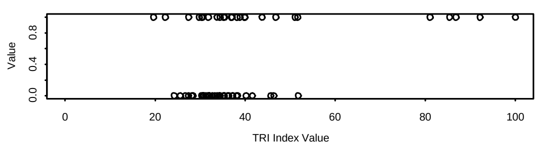
5. BRI   9-40 m



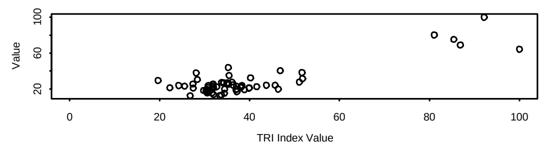
6. ORDINATION VECTOR   9-40 m



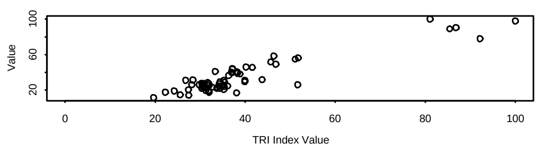
7. IMPACT   9-40 m



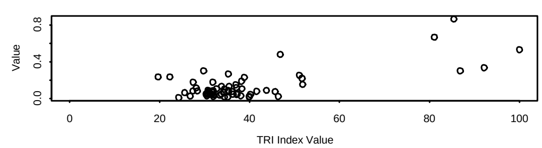
8. FRI   9-40 m



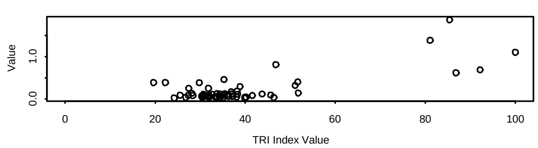
9. IRI   9-40 m



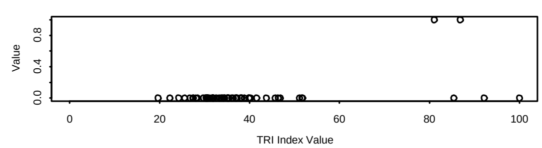
10. ERMQ   9-40 m



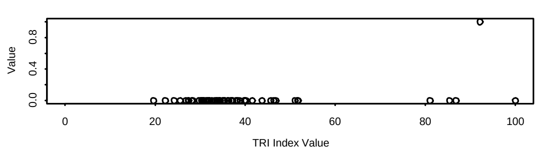
11. PELQ   9-40 m



12. FINEROS   9-40 m

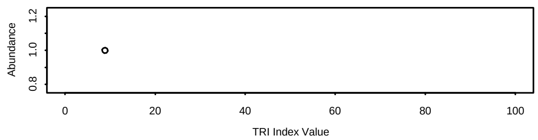


13. TUMOR   9-40 m

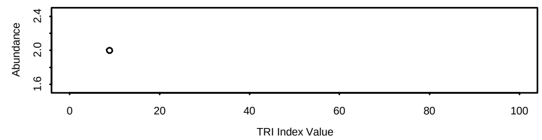


Middle Shelf (30-120 m)

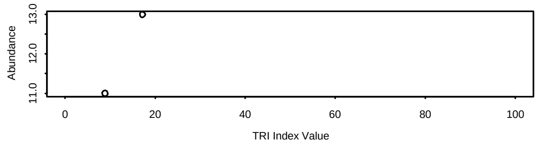
1. Cidarina cidaris - i   P=-54.8 30-120 m



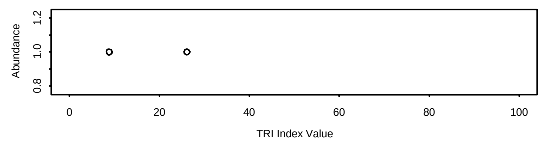
2. Laqueus californianus - i   P=-54.8 30-120 m



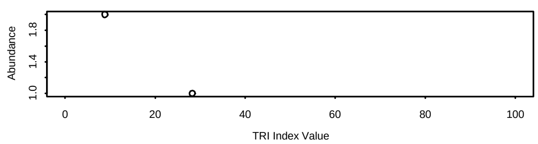
3. Icelinus tenuis - f   P=-43.7 30-120 m



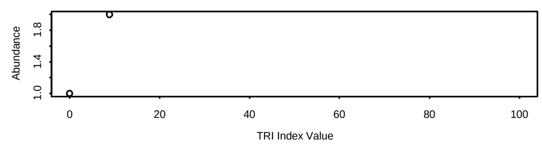
4. Pteropurpura macroptera - i   P=-39.9 30-120 m



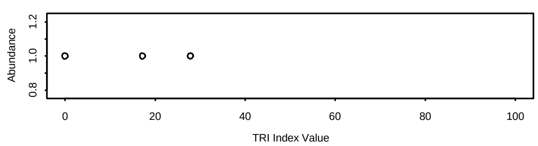
5. Terebratalia occidentalis - i   P=-36.3 30-120 m



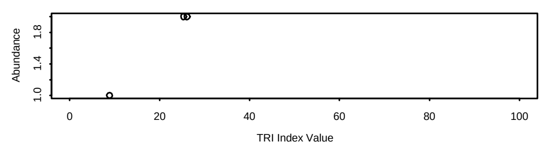
6. Florometra serratissima - i   P=-35.9 30-120 m



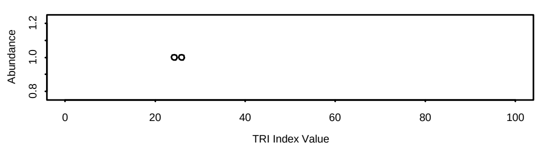
7. Sclerasterias heteropaes - i   P=-34.3 30-120 m



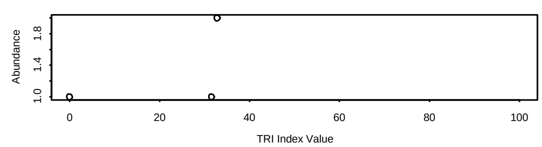
8. Fusinus barbarensis - i   P=-31.1 30-120 m



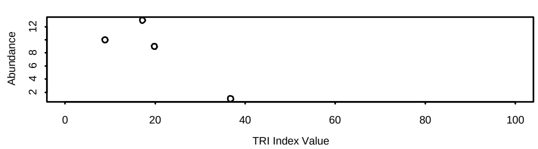
9. Brosmophycis marginata - f   P=-31 30-120 m



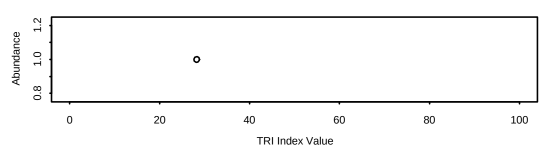
10. Henricia leviuscula - i   P=-28.4 30-120 m



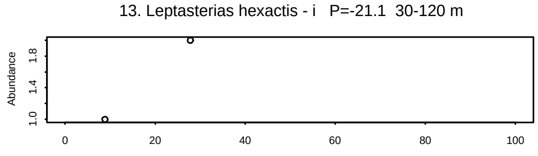
11. Philine alba - i   P=-26.2 30-120 m



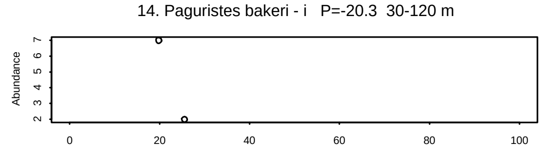
12. Balanus nubilus - i   P=-24.4 30-120 m



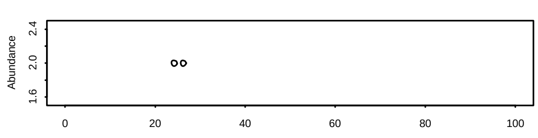
13. Leptasterias hexactis - i   P=-21.1 30-120 m



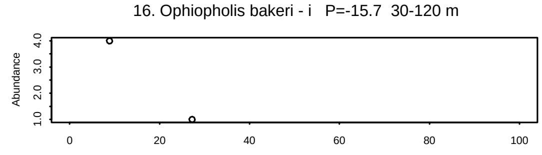
14. Paguristes bakeri - i   P=-20.3 30-120 m



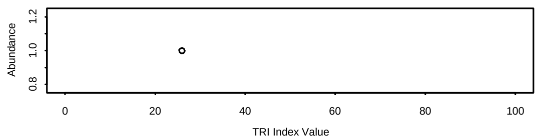
15. Eualus herdmani - i   P=-15.9 30-120 m



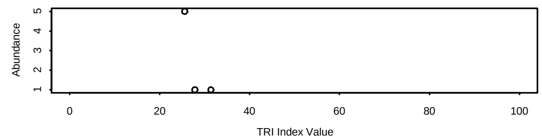
16. Ophiopholis bakeri - i   P=-15.7 30-120 m



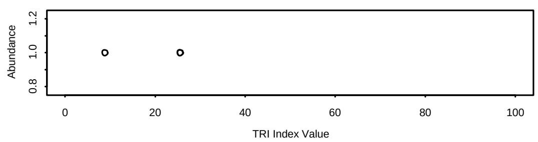
17. Syngnathus exilis - f   P=-14 30-120 m



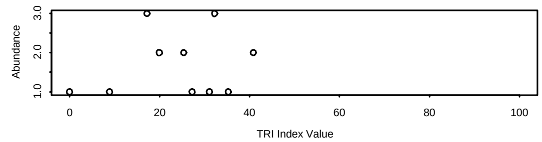
18. Parapagurodes laurentae - i   P=-13.5 30-120 m



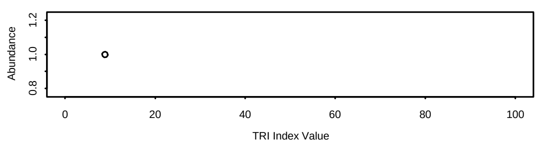
19. Protula superba - i   P=-13 30-120 m



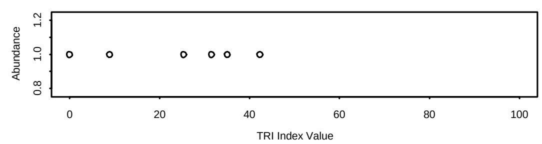
20. Rathbunella hypoplecta - f   P=-10.9 30-120 m



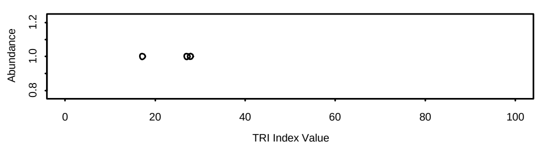
21. Platydoris macfarlandi - i   P=-9.4 30-120 m



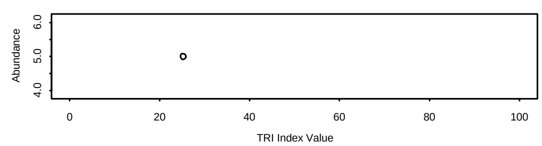
22. Paracyathus stearnsii - i   P=-9.3 30-120 m



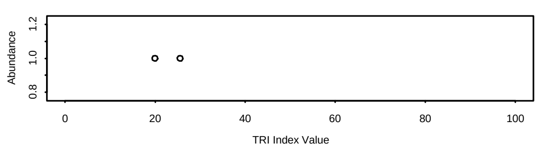
23. Hemisquilla ensigera californiensis - i   P=-5.7 30-120 m



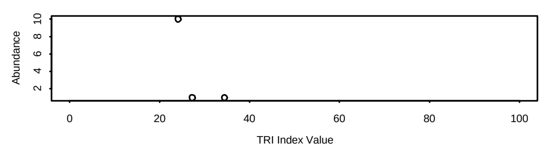
24. Astropecten ornatissimus - i   P=-4.7 30-120 m



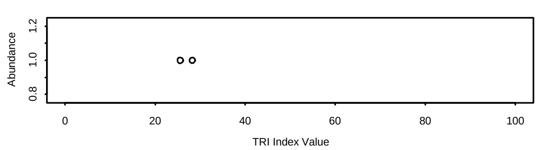
25. Heptacarpus tenuissiumus - i   P=-3.8 30-120 m



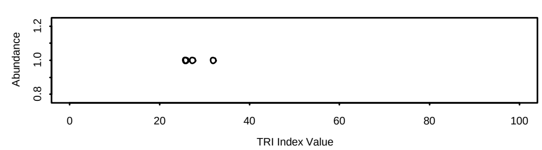
26. Ophiopteris papillosa - i   P=-3.6 30-120 m



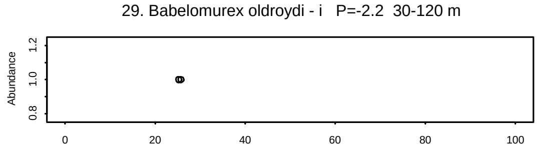
27. Sebastes pinniger - f   P=-3.5 30-120 m



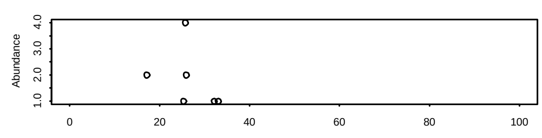
28. Amphiura arcystata - i   P=-3.1 30-120 m



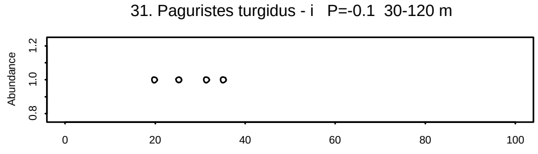
29. Babelomurex oldroydi - i   P=-2.2 30-120 m



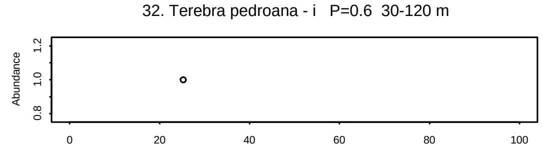
30. Crossata californica - i   P=-0.7 30-120 m



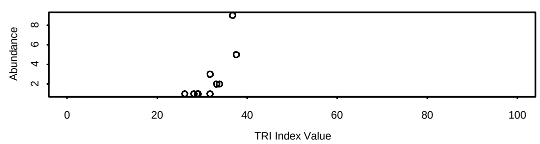
31. Paguristes turgidus - i   P=-0.1 30-120 m



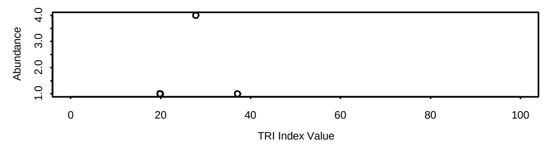
32. Terebra pedroana - i   P=0.6 30-120 m



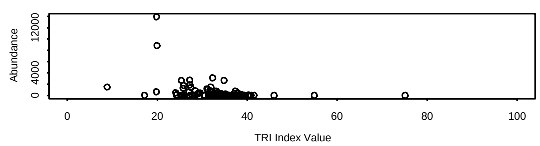
33. Neosimnia aequalis - i   P=1.4 30-120 m



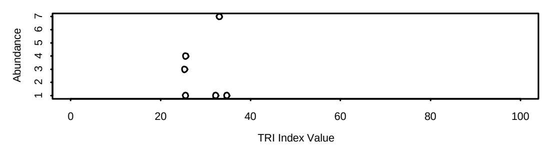
34. Stylasterias forreri - i   P=1.8 30-120 m



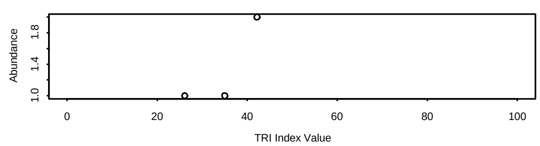
35. Lytechinus pictus - i   P=1.9 30-120 m



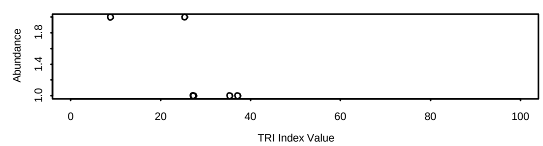
36. Sebastes rubrivinctus - f   P=2.2 30-120 m



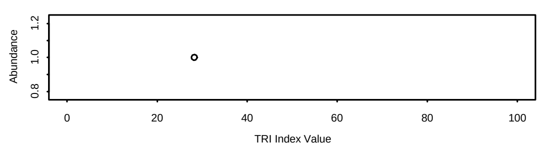
37. Eopsetta jordani - f   P=2.9 30-120 m



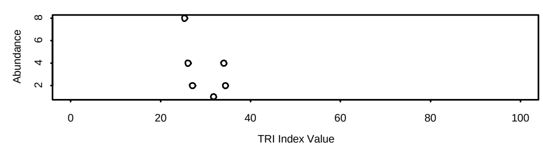
38. Loxorhynchus crispatus - i   P=3.6 30-120 m



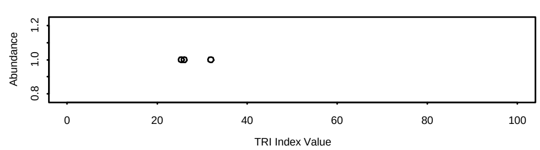
39. Livoneca californica - i   P=4 30-120 m



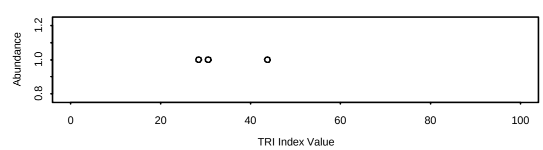
40. Podochela lobifrons - i   P=4.2 30-120 m



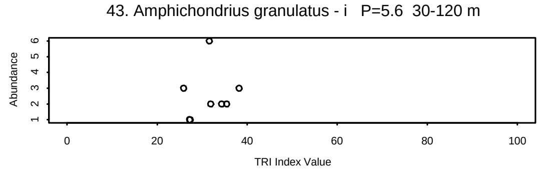
41. Adelogorgia phyllosclera - i   P=4.8 30-120 m



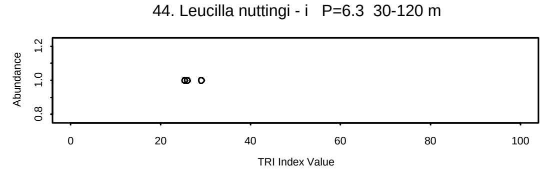
42. Heterogorgia tortuosa - i   P=5.4 30-120 m



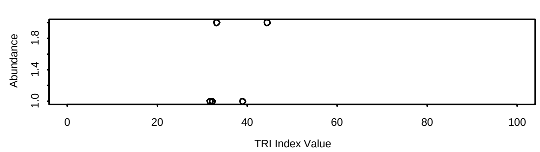
43. Amphichondrius granulatus - i   P=5.6 30-120 m



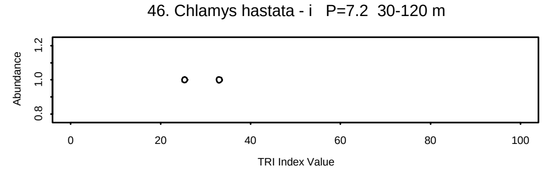
44. Leucilla nuttingi - i   P=6.3 30-120 m



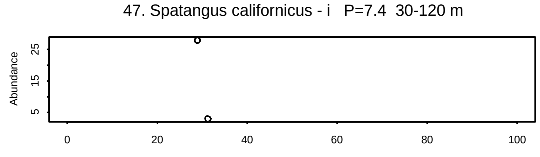
45. Xeneretmus triacanthus - f   P=6.7 30-120 m



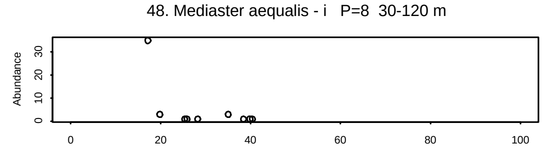
46. Chlamys hastata - i   P=7.2 30-120 m



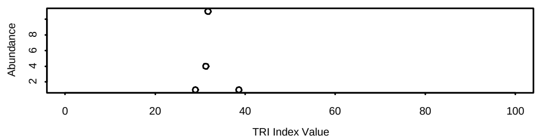
47. Spatangus californicus - i   P=7.4 30-120 m



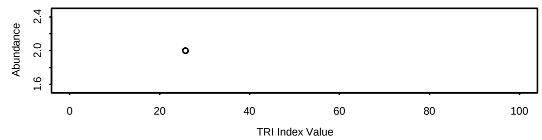
48. Mediaster aequalis - i   P=8 30-120 m



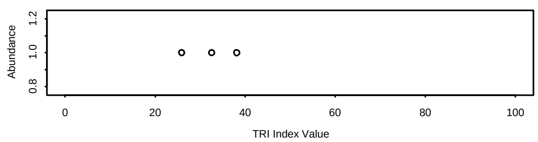
49. Ptilosarcus gurneyi - i   P=8.2 30-120 m



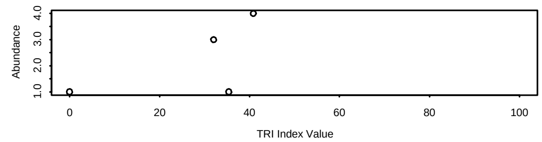
50. Phimochirus californiensis - i   P=8.2 30-120 m



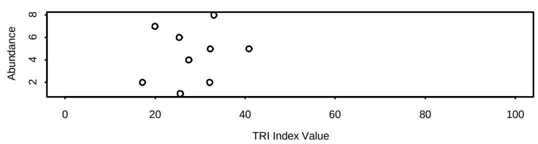
51. Cancellaria cooperi - i   P=8.5 30-120 m



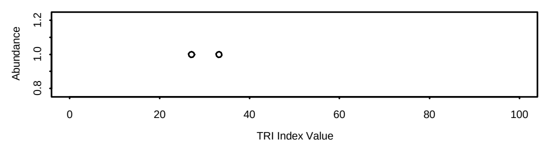
52. Strongylocentrotus franciscanus - i   P=8.7 30-120 m



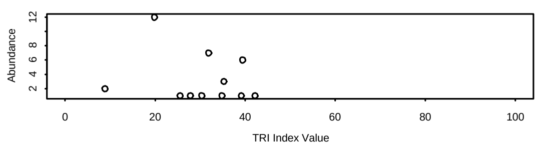
53. Coryphopterus nicholsii - f   P=9.3 30-120 m



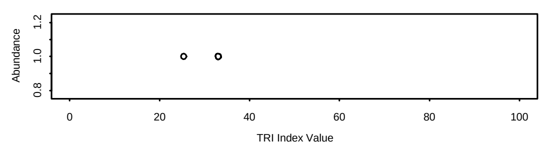
54. Sebastes eos - f   P=9.4 30-120 m



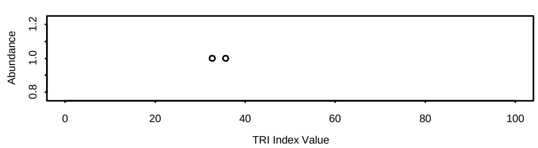
55. Luidia asthenosoma - i   P=9.9 30-120 m



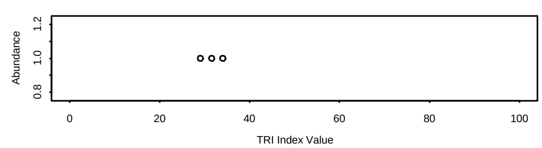
56. Sebastes rosaceus - f   P=12.3 30-120 m



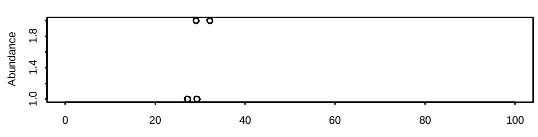
57. Neosabellaria cementarium - i   P=13.6 30-120 m



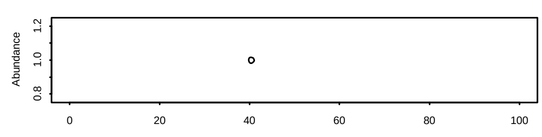
58. Amphiodia urtica - i   P=13.9 30-120 m



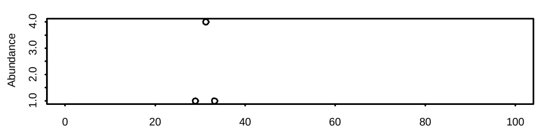
59. Virgularia bromleyi - i   P=14.1 30-120 m



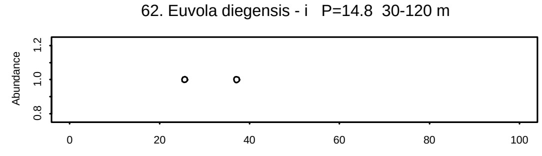
60. Lyconema barbatum - f   P=14.3 30-120 m



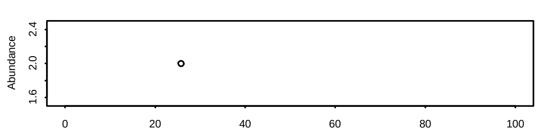
61. Brisaster latifrons - i   P=14.6 30-120 m



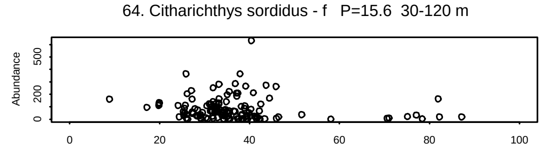
62. Euvola diegensis - i   P=14.8 30-120 m



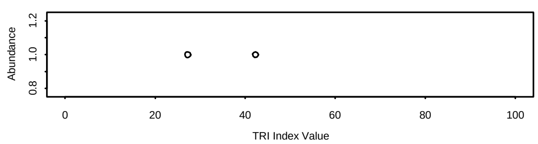
63. Renilla koellikeri - i   P=15.1 30-120 m



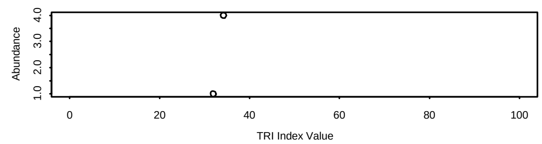
64. Citharichthys sordidus - f   P=15.6 30-120 m



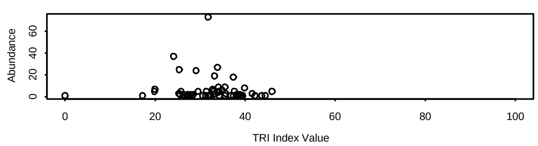
65. Eugorgia rubens - i P=15.6 30-120 m



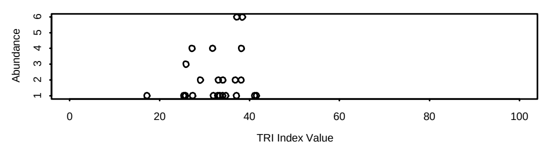
66. Isocheles pilosus - i P=16.9 30-120 m



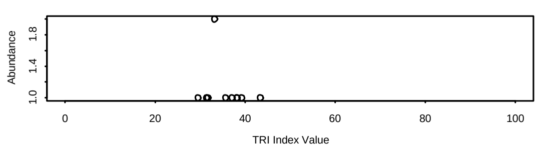
67. Ophiothrix spiculata - i P=17.4 30-120 m



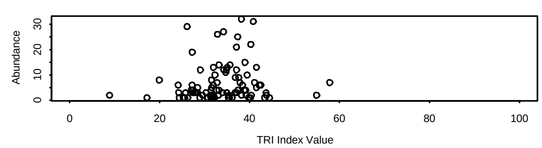
68. Megasurcula carpenteriana - i P=17.4 30-120 m



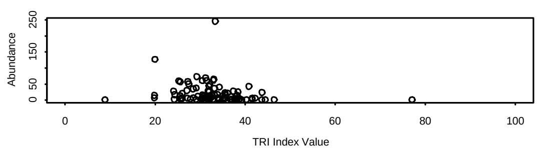
69. Calliostoma turbinum - i P=17.6 30-120 m



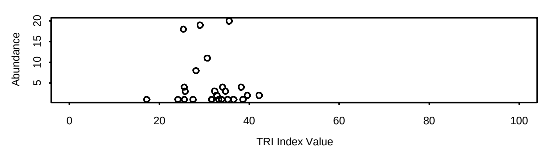
70. Luidia foliolata - i P=17.7 30-120 m



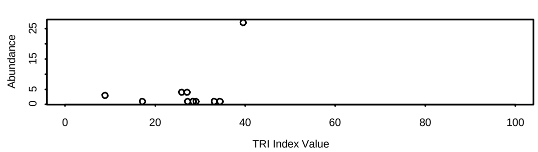
71. Citharichthys xanthostigma - f P=18 30-120 m



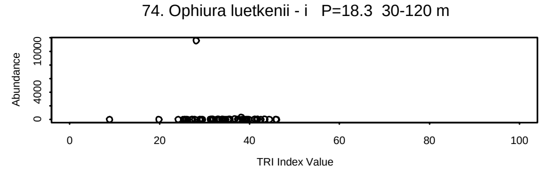
72. Luidia armata - i P=18.1 30-120 m



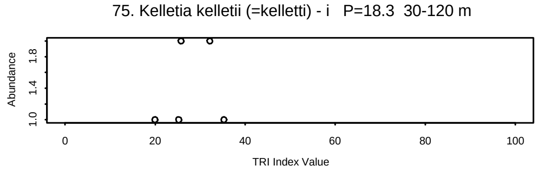
73. Metridium senile - i P=18.3 30-120 m



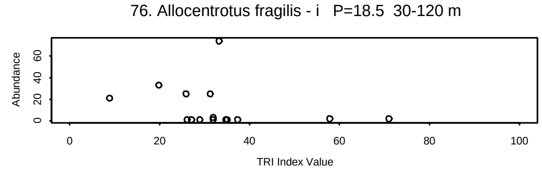
74. Ophiura luetkenii - i P=18.3 30-120 m



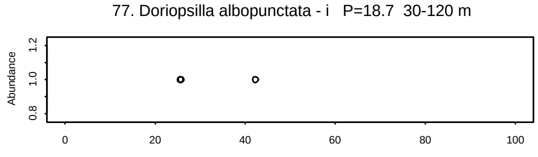
75. Kelletia kelletii (=kelletti) - i P=18.3 30-120 m



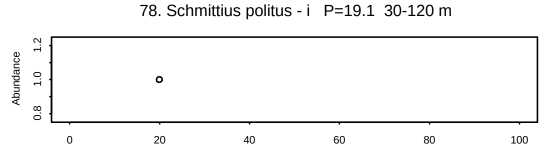
76. Allocentrotus fragilis - i P=18.5 30-120 m



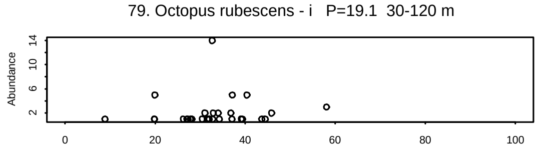
77. Doriopsilla albopunctata - i P=18.7 30-120 m



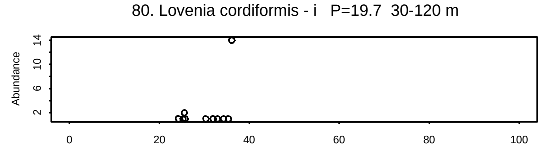
78. Schmittius politus - i P=19.1 30-120 m



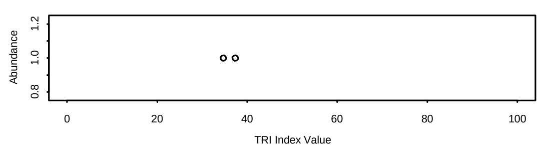
79. Octopus rubescens - i P=19.1 30-120 m



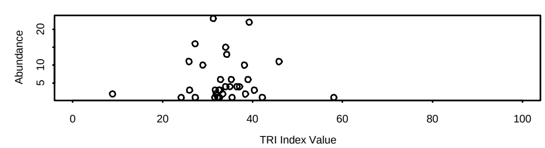
80. Lovenia cordiformis - i P=19.7 30-120 m



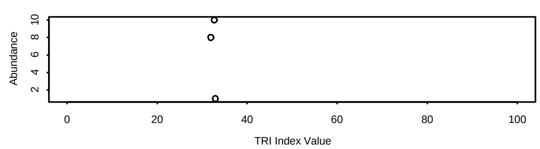
81. Havelockia benti - i   P=19.8 30-120 m



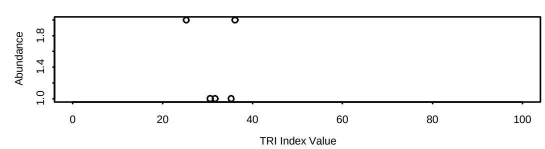
82. Argentina sialis - f   P=20.6 30-120 m



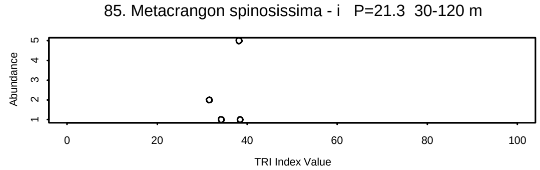
83. Triopha maculata - i   P=20.7 30-120 m



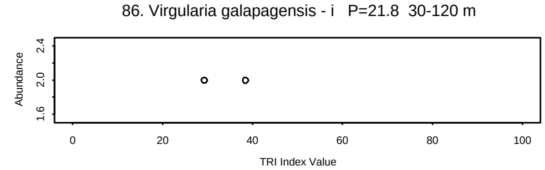
84. Pisaster brevispinus - i   P=21 30-120 m



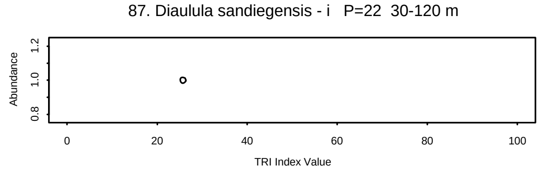
85. Metacrangon spinosissima - i   P=21.3 30-120 m



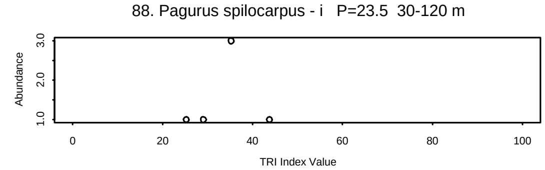
86. Virgularia galapagensis - i   P=21.8 30-120 m



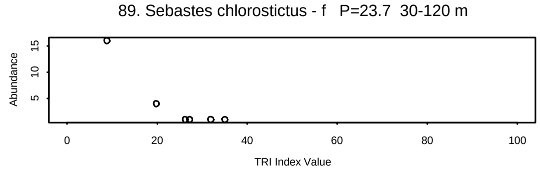
87. Diaulula sandiegensis - i   P=22 30-120 m



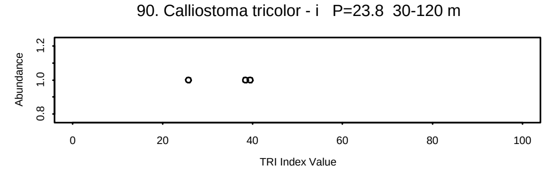
88. Pagurus spilocarpus - i   P=23.5 30-120 m



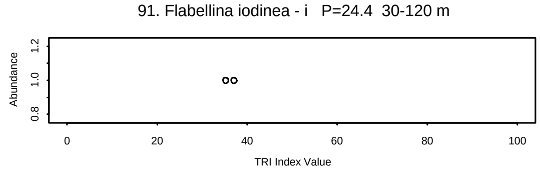
89. Sebastes chlorostictus - f   P=23.7 30-120 m



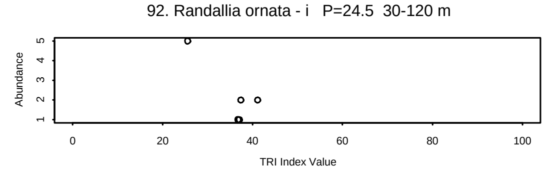
90. Calliostoma tricolor - i   P=23.8 30-120 m



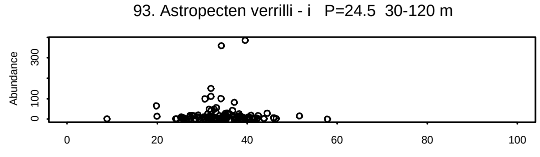
91. Flabellina iodinea - i   P=24.4 30-120 m



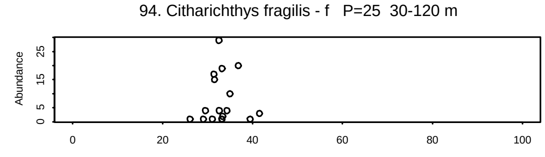
92. Randallia ornata - i   P=24.5 30-120 m



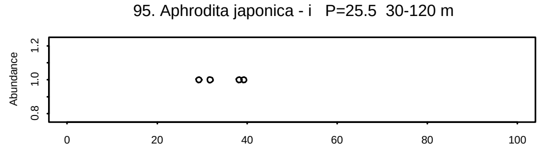
93. Astropecten verrilli - i   P=24.5 30-120 m



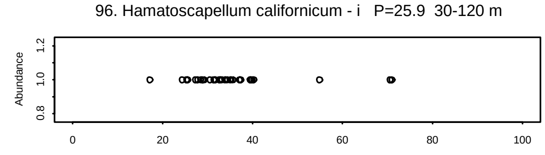
94. Citharichthys fragilis - f   P=25 30-120 m



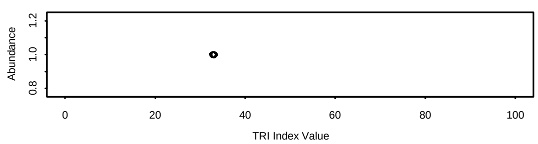
95. Aphrodita japonica - i   P=25.5 30-120 m



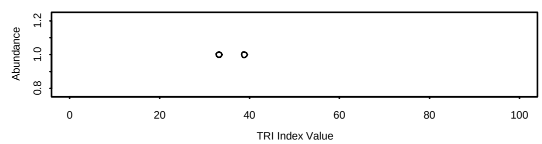
96. Hamatoscapellum californicum - i   P=25.9 30-120 m



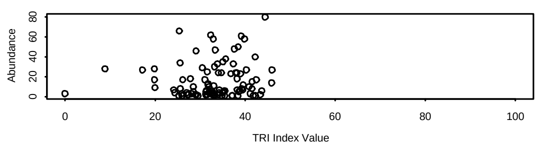
97. Rathbunaster californicus - i   P=26.5 30-120 m



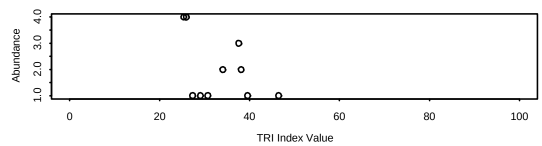
98. Nymphon pixellae - i   P=26.8 30-120 m



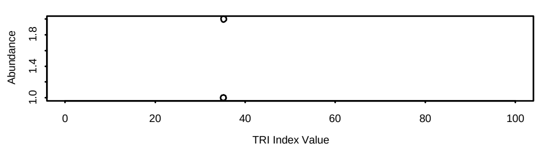
99. Parastichopus californicus - i   P=27 30-120 m



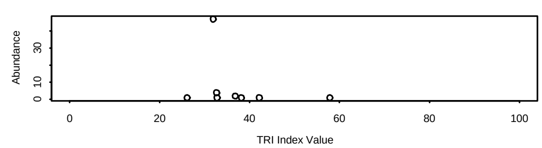
100. Styela gibbsii - i   P=27.2 30-120 m



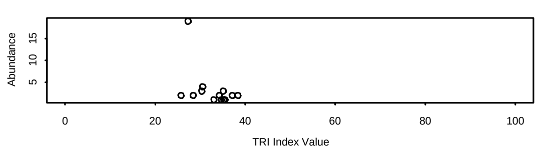
101. Pleuronichthys ritteri - f   P=27.5 30-120 m



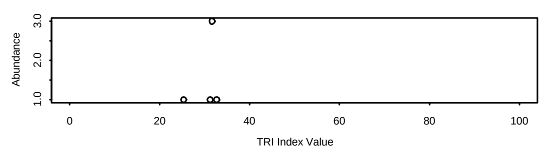
102. Strongylocentrotus purpuratus - i   P=27.6 30-120 m



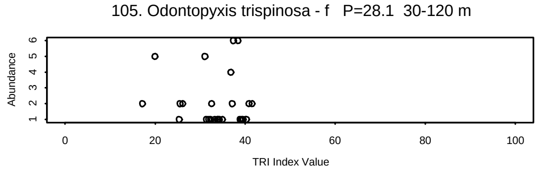
103. Heterocrypta occidentalis - i   P=28 30-120 m



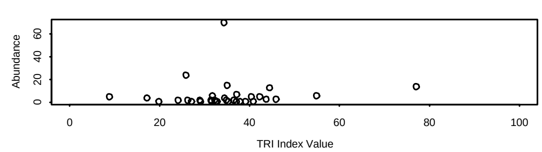
104. Leptopecten latiauratus - i   P=28.1 30-120 m



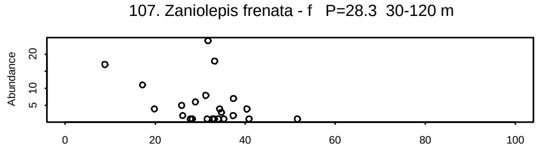
105. Odontopyxis trispinosa - f   P=28.1 30-120 m



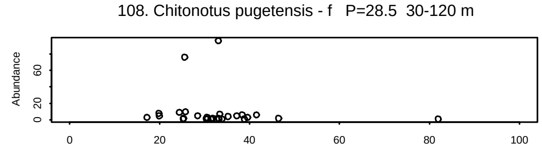
106. Sebastes semicinctus - f   P=28.2 30-120 m



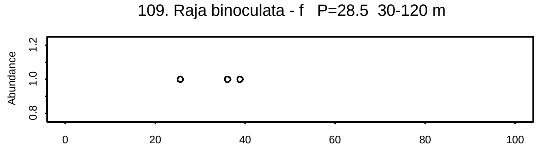
107. Zaniolepis frenata - f   P=28.3 30-120 m



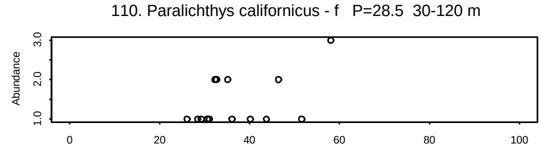
108. Chitonotus pugetensis - f   P=28.5 30-120 m



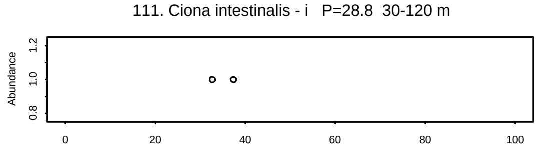
109. Raja binoculata - f   P=28.5 30-120 m



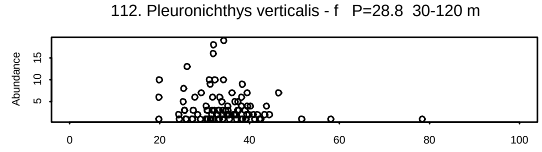
110. Paralichthys californicus - f   P=28.5 30-120 m



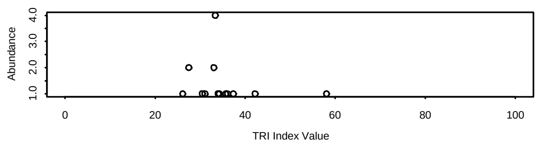
111. Ciona intestinalis - i   P=28.8 30-120 m



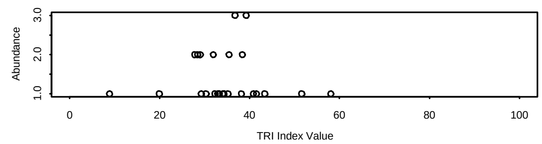
112. Pleuronichthys verticalis - f   P=28.8 30-120 m



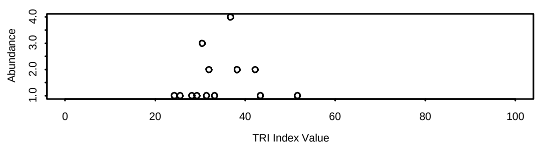
113. Loxorhynchus grandis - i   P=29.2 30-120 m



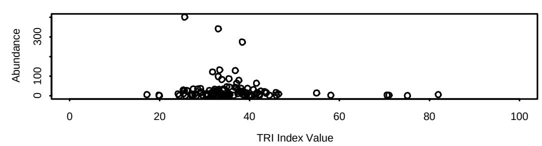
114. Raja inornata - f   P=30 30-120 m



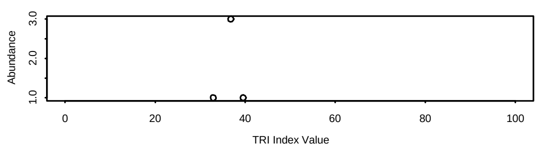
115. Porichthys myriaster - f   P=30.1 30-120 m



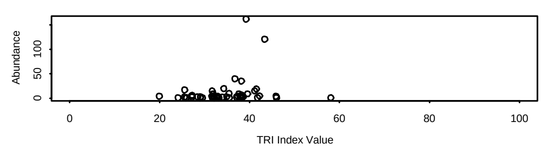
116. Icelinus quadriseriatus - f   P=30.1 30-120 m



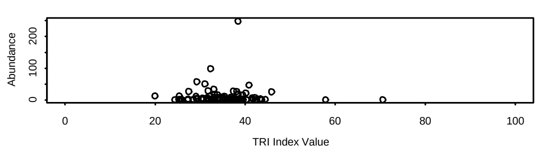
117. Pododesmus macroschisma - i   P=30.3 30-120 m



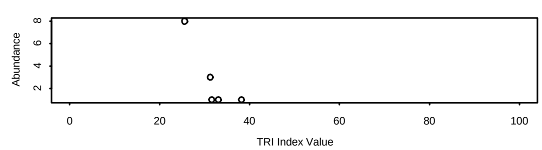
118. Lepidogobius lepidus - f   P=30.5 30-120 m



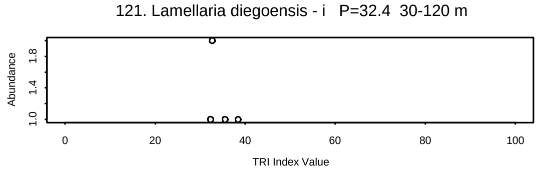
119. Symphurus atricauda - f   P=31.4 30-120 m



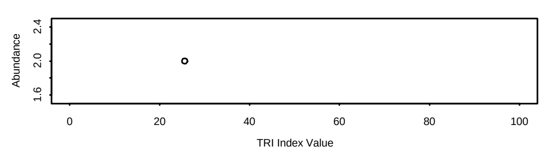
120. Neocrangon resima - i   P=31.5 30-120 m



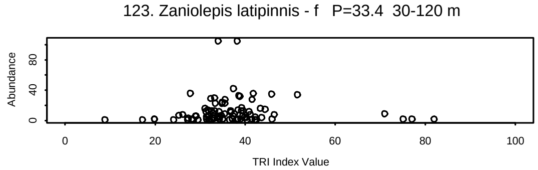
121. Lamellaria diegoensis - i   P=32.4 30-120 m



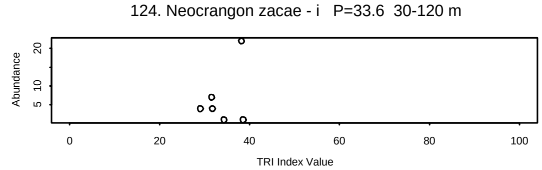
122. Tritonia festiva - i   P=33.1 30-120 m



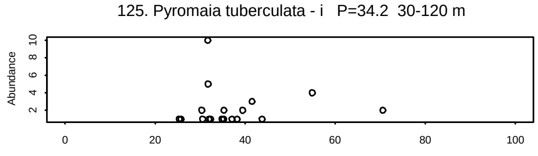
123. Zaniolepis latipinnis - f   P=33.4 30-120 m



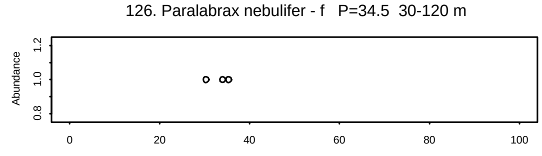
124. Neocrangon zacae - i   P=33.6 30-120 m



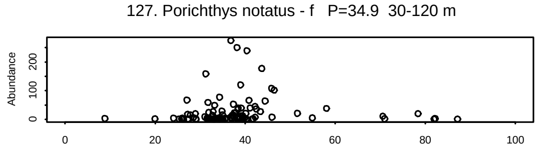
125. Pyromaia tuberculata - i   P=34.2 30-120 m



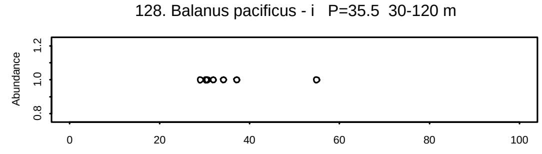
126. Paralabrax nebulifer - f   P=34.5 30-120 m



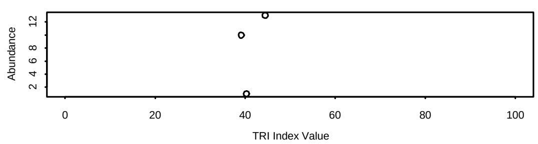
127. Porichthys notatus - f   P=34.9 30-120 m



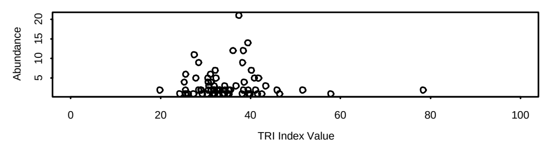
128. Balanus pacificus - i   P=35.5 30-120 m



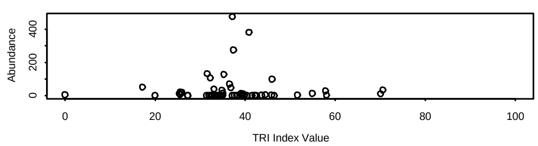
129. Eugyra arenosa californica - i   P=35.9 30-120 m



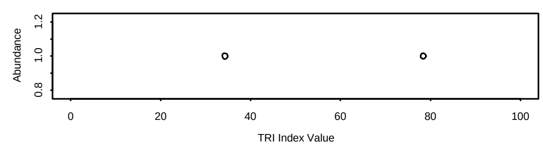
130. Synodus lucioceps - f   P=36.4 30-120 m



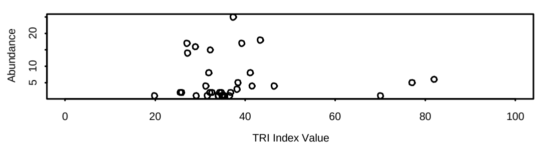
131. Sebastes dallii - f   P=36.5 30-120 m



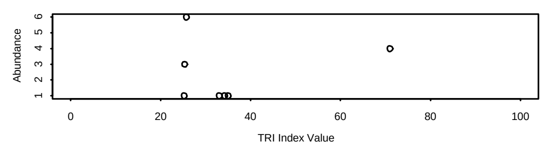
132. Engraulis mordax - f   P=36.6 30-120 m



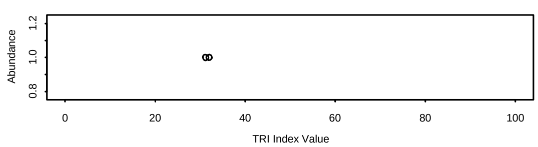
133. Loligo opalescens - i   P=36.9 30-120 m



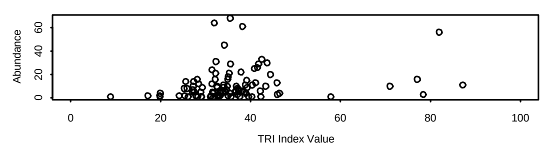
134. Erileptus spinosus - i   P=36.9 30-120 m



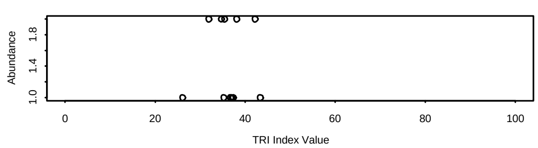
135. Platyrhinoidis triseriata - f   P=36.9 30-120 m



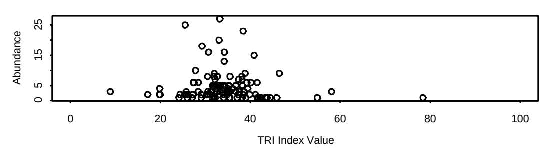
136. Zalembius rosaceus - f   P=36.9 30-120 m



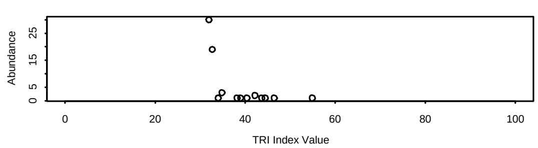
137. Ophiodon elongatus - f   P=37.6 30-120 m



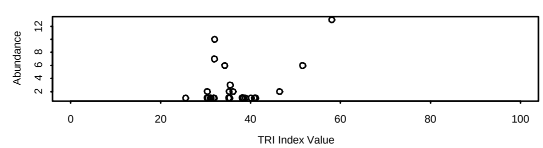
138. Hippoglossina stomata - f   P=38.2 30-120 m



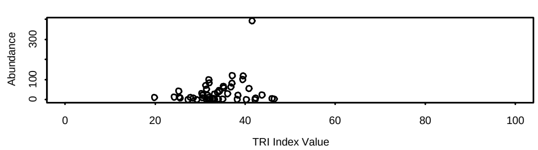
139. Sebastes caurinus - f   P=38.2 30-120 m



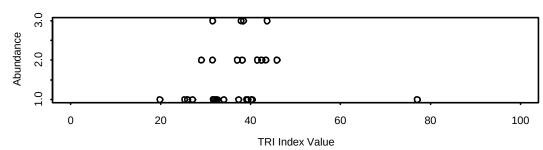
140. Xystreurys liolepis - f   P=39.5 30-120 m



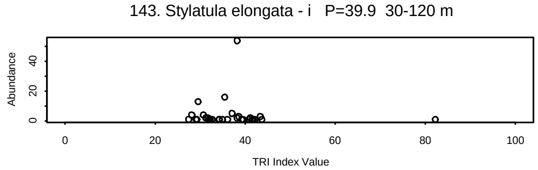
141. Citharichthys stigmaeus - f   P=39.5 30-120 m



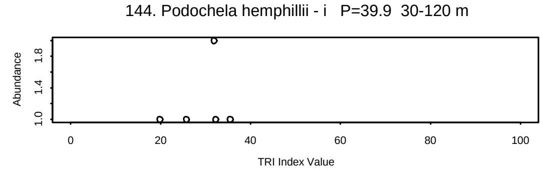
142. Rossia pacifica - i   P=39.8 30-120 m



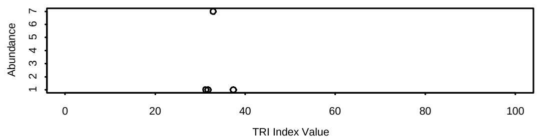
143. Stylatula elongata - i   P=39.9 30-120 m



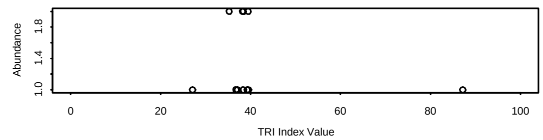
144. Podochela hemphillii - i   P=39.9 30-120 m



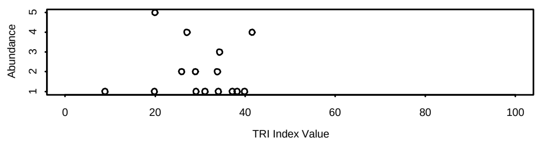
145. Errex zachirus - f   P=40.5 30-120 m



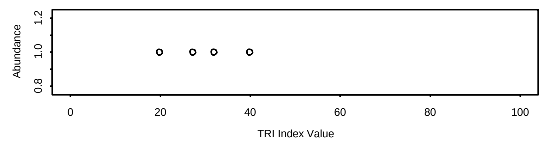
146. Armina californica - i   P=41.2 30-120 m



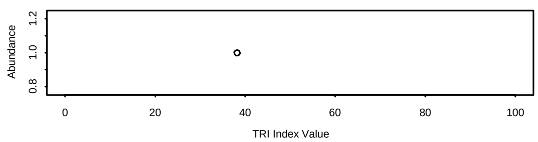
147. Chilara taylori - f   P=41.3 30-120 m



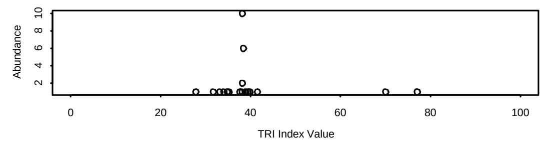
148. Sebastes elongatus - f   P=41.4 30-120 m



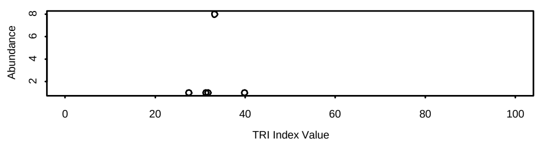
149. Cancellaria crawfordiana - i   P=41.6 30-120 m



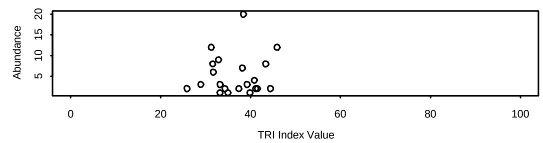
150. Tritonia diomedea - i   P=42.8 30-120 m



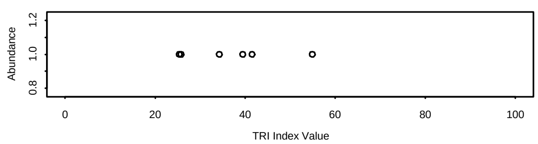
151. Xeneretmus latifrons - f   P=43.3 30-120 m



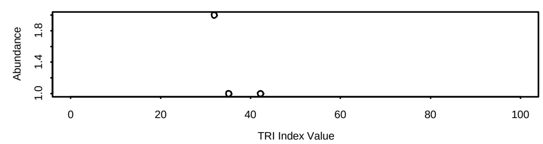
152. Lyopsetta exilis - f   P=43.4 30-120 m



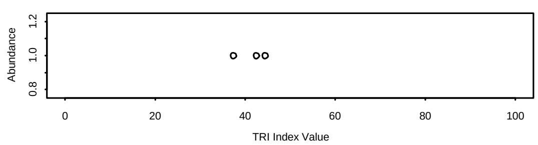
153. Orthopagurus minimus - i   P=44.1 30-120 m



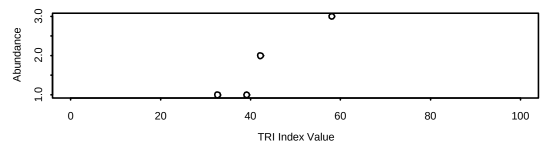
154. Sebastes auriculatus - f   P=44.4 30-120 m



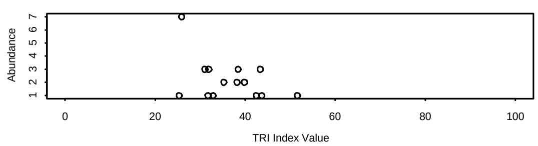
155. Peprilus simillimus - f   P=44.7 30-120 m



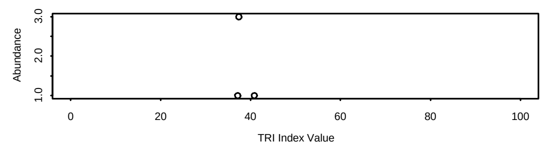
156. Cephaloscyllium ventriosum - f   P=45.5 30-120 m



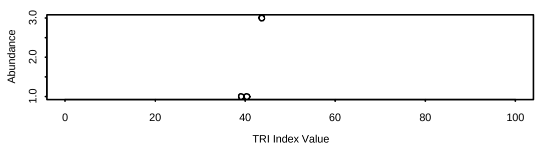
157. Sebastes rosenblatti - f   P=46.6 30-120 m



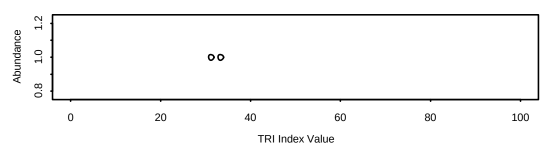
158. Sebastolobus alascanus - f   P=46.8 30-120 m



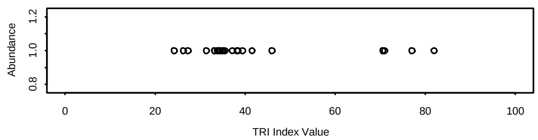
159. Neosimnia loebbeckeana - i   P=47.3 30-120 m



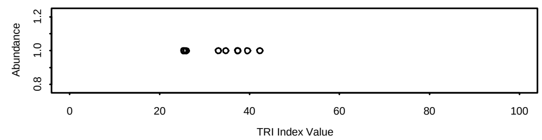
160. Merluccius productus - f   P=50.6 30-120 m



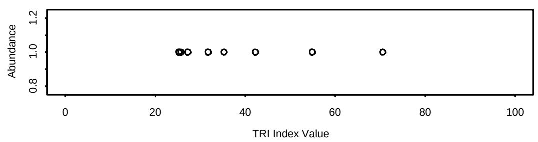
161. Livoneca vulgaris - i   P=50.7 30-120 m



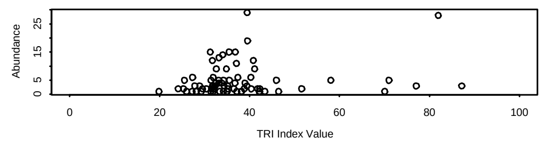
162. Corynactis californica - i   P=51.9 30-120 m



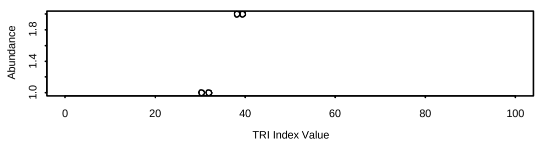
163. Lophogorgia chilensis - i   P=52.4 30-120 m



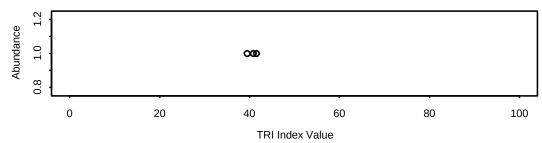
164. Parophrys vetula - f   P=53.3 30-120 m



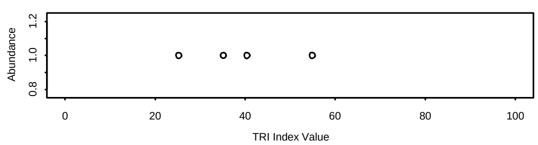
165. Nassarius perpinguis - i   P=53.5 30-120 m



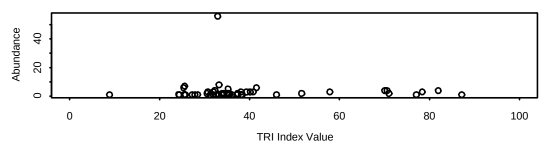
166. Pegea confoederata - i   P=53.7 30-120 m



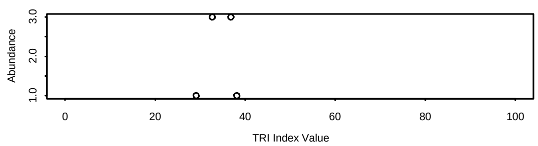
167. Pycnopodia helianthoides - i   P=55.5 30-120 m



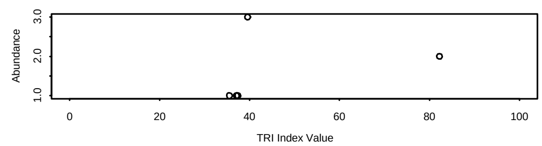
168. Scorpaena guttata - f   P=57.5 30-120 m



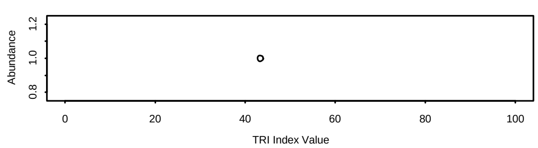
169. Pandalus platyceros - i   P=58.2 30-120 m



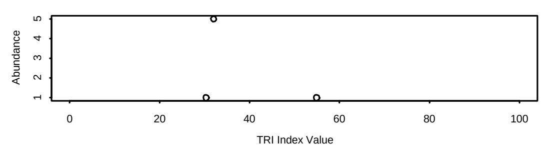
170. Neverita reclusiana - i   P=58.8 30-120 m



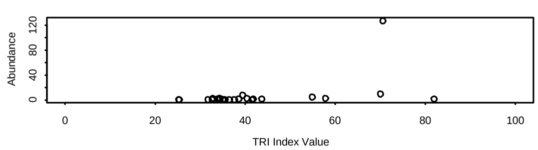
171. Heptacarpus stimpsoni - i   P=59.1 30-120 m



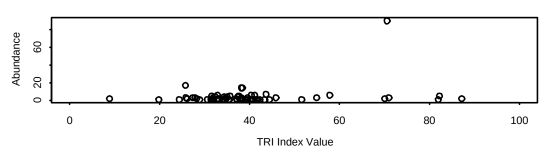
172. Cancer jordani - i   P=59.4 30-120 m



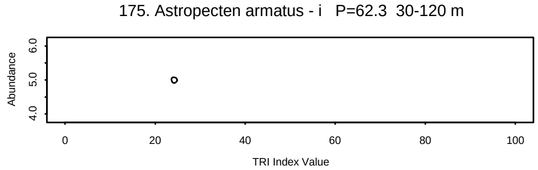
173. Acanthodoris brunnea - i   P=60.6 30-120 m



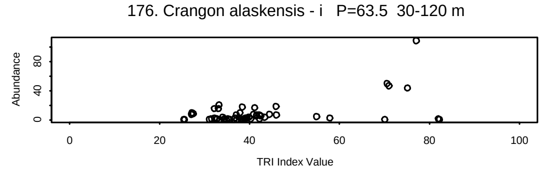
174. Pleurobranchaea californica - i   P=61.1 30-120 m



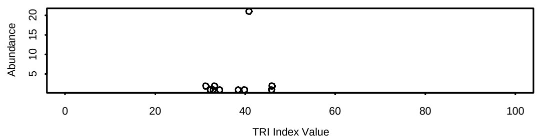
175. Astropecten armatus - i   P=62.3 30-120 m



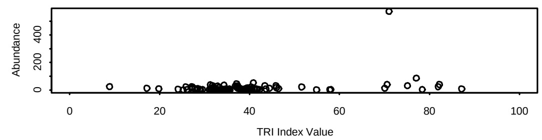
176. Crangon alaskensis - i   P=63.5 30-120 m



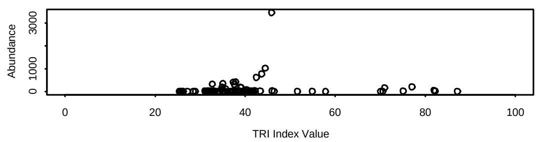
177. Lycodopsis pacifica - f P=63.7 30-120 m



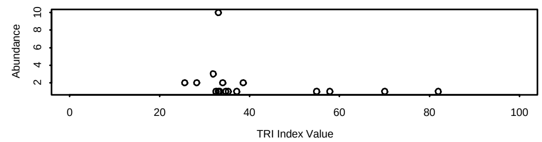
178. Microstomus pacificus - f P=64.8 30-120 m



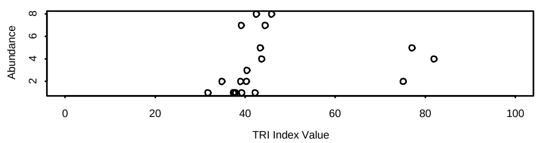
179. Sebastes saxicola - f P=66.1 30-120 m



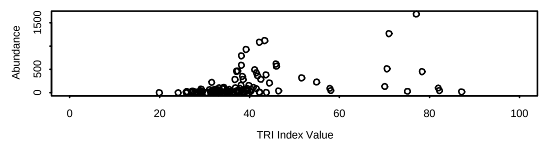
180. Sebastes miniatus - f P=68.8 30-120 m



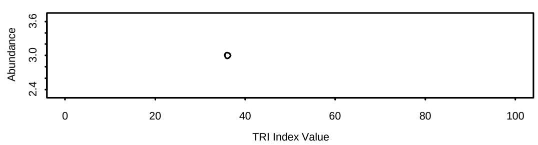
181. Sebastes levis - f P=72 30-120 m



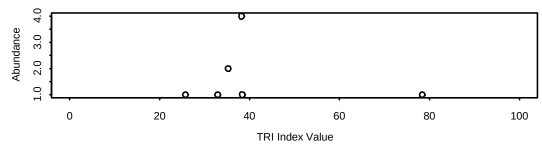
182. Sicyonia ingentis - i P=73.8 30-120 m



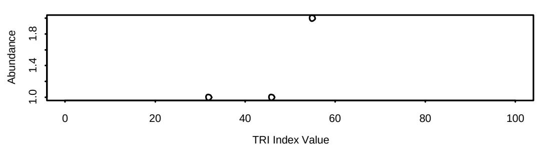
183. Phanerodon furcatus - f P=73.8 30-120 m



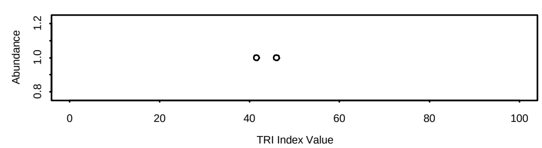
184. Cancer gracilis - i P=74.8 30-120 m



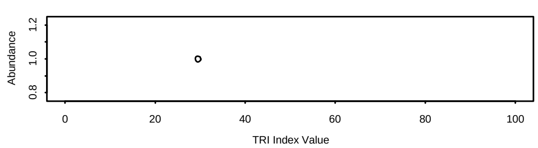
185. Sebastes diploproa - f P=80 30-120 m



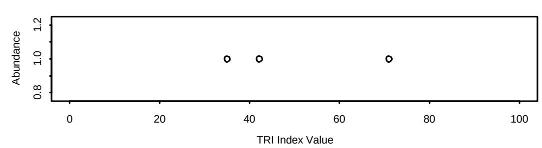
186. Sebastes serranoides - f P=80.7 30-120 m



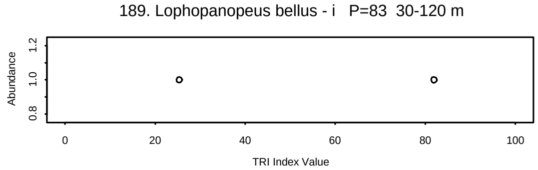
187. Lysmata californica - i P=81.8 30-120 m



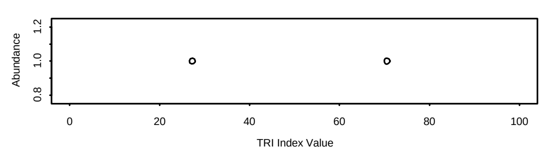
188. Sebastes mystinus - f P=82.8 30-120 m



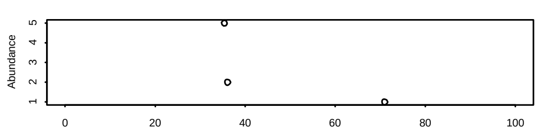
189. Lophopanopeus bellus - i P=83 30-120 m



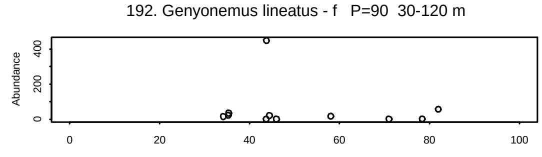
190. Pandalus danae - i P=85.5 30-120 m



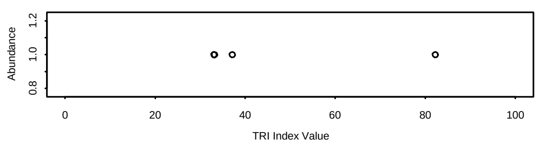
191. Asterina miniata - i P=89.9 30-120 m



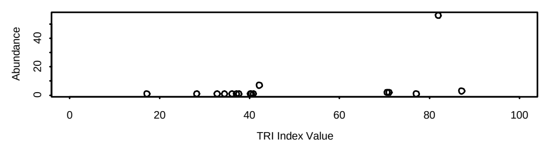
192. Genyonemus lineatus - f P=90 30-120 m



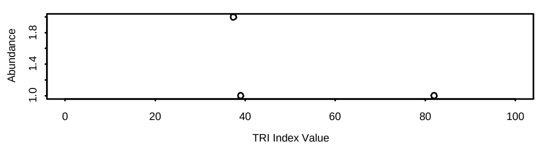
193. Sebastes hopkinsi - f   P=93 30-120 m



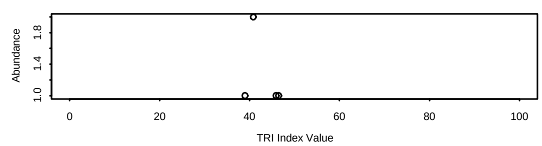
194. Pleuronichthys decurrens - f   P=94.7 30-120 m



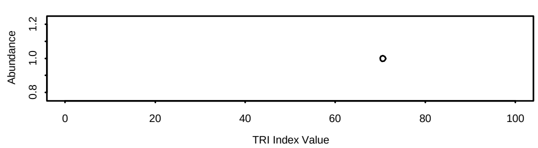
195. Hydrolagus colliei - f   P=95.3 30-120 m



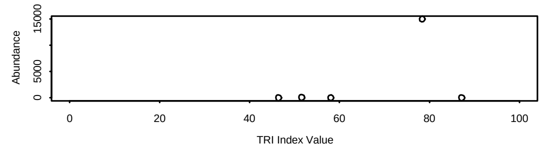
196. Sebastes paucispinis - f   P=95.5 30-120 m



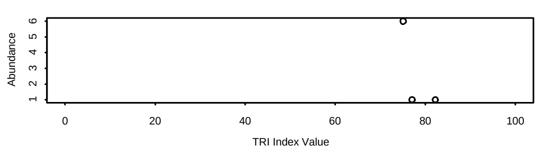
197. Gastropteron pacificum - i   P=100.5 30-120 m



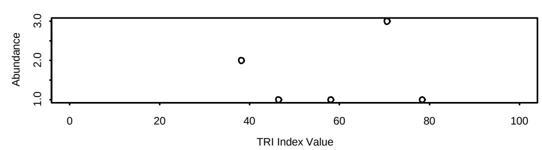
198. Pleuroncodes planipes - i   P=104.4 30-120 m



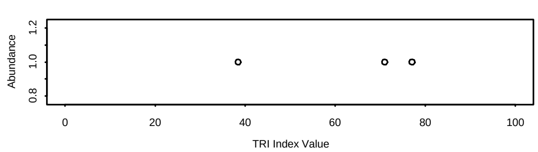
199. Crangon nigromaculata - i   P=106 30-120 m



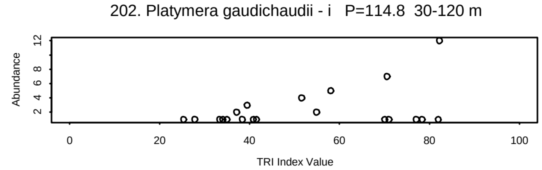
200. Calinaticina oldroydii - i   P=107.4 30-120 m



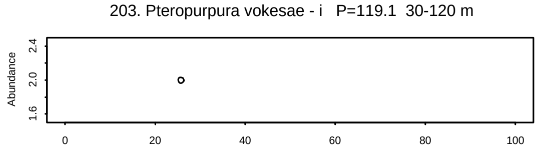
201. Kathetostoma averruncus - f   P=109.6 30-120 m



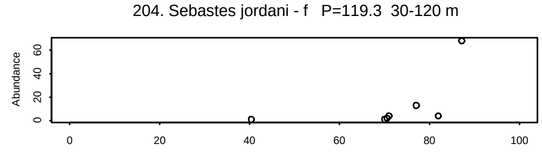
202. Platymera gaudichaudii - i   P=114.8 30-120 m



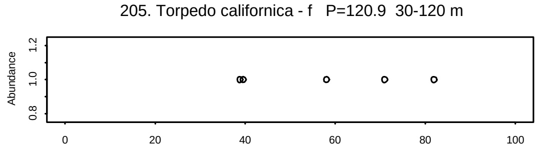
203. Pteropurpura vokesae - i   P=119.1 30-120 m



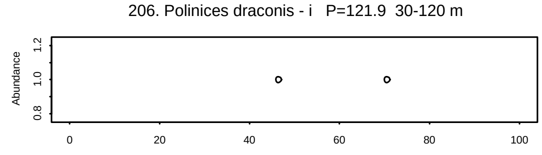
204. Sebastes jordani - f   P=119.3 30-120 m



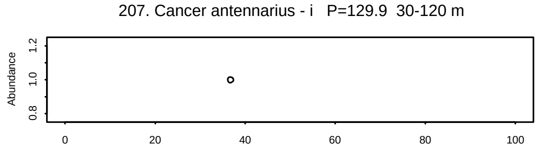
205. Torpedo californica - f   P=120.9 30-120 m



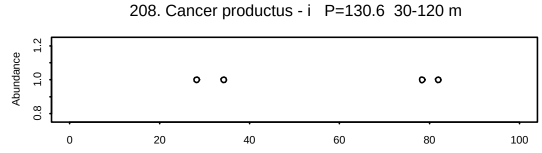
206. Polinices draconis - i   P=121.9 30-120 m



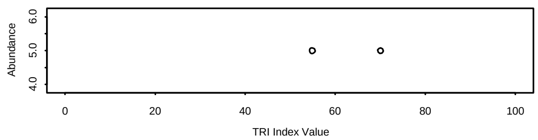
207. Cancer antennarius - i   P=129.9 30-120 m



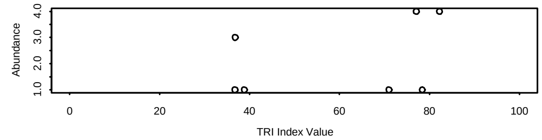
208. Cancer productus - i   P=130.6 30-120 m



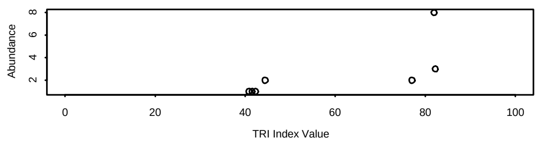
209. Nassarius insculptus - i   P=136.7 30-120 m



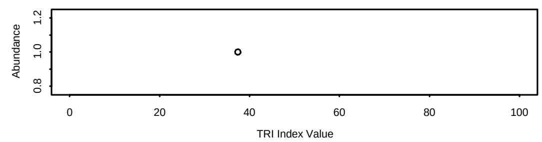
210. Cancer anthonyi - i   P=139.6 30-120 m



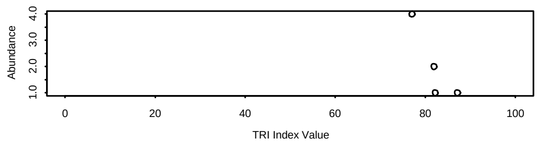
211. Sebastes goodei - f   P=140.7 30-120 m



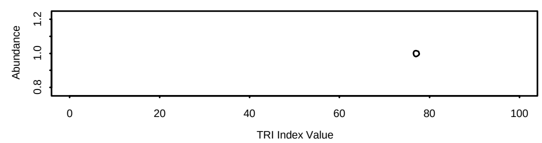
212. Portunus xantusii - i   P=141.9 30-120 m



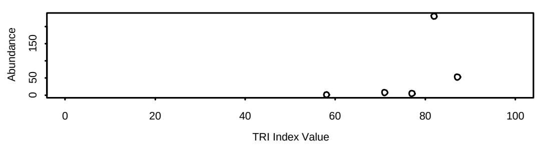
213. Sebastes crameri - f   P=149.2 30-120 m



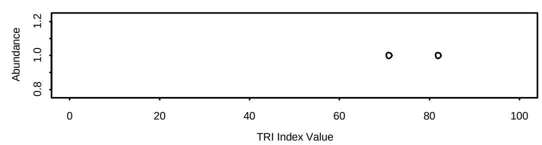
214. Anoplopoma fimbria - f   P=159.4 30-120 m



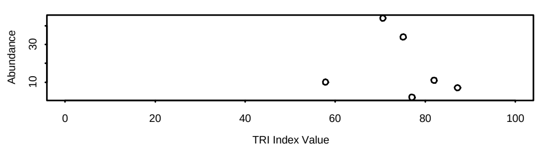
215. Cymatogaster aggregata - f   P=167.5 30-120 m



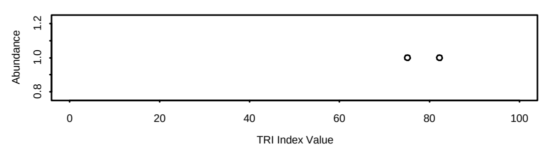
216. Nerocila acuminata - i   P=168 30-120 m



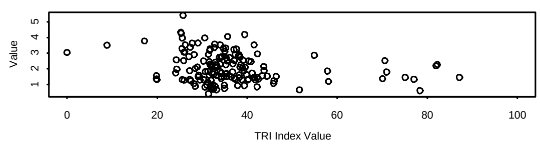
217. Nassarius mendicus - i   P=170.8 30-120 m



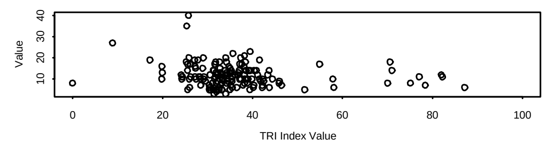
218. Muricea californica - i   P=184.3 30-120 m



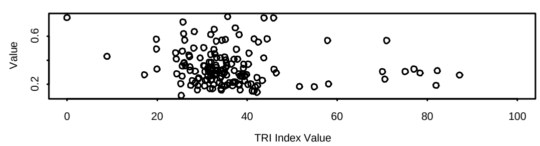
1. GLEASON RICHNESS DIVERSITY - invert 30-120 m



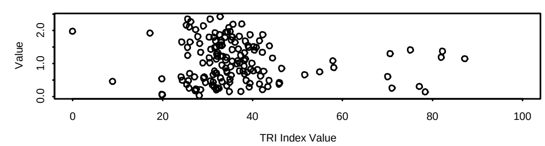
2. NO. OF SPECIES - invert 30-120 m



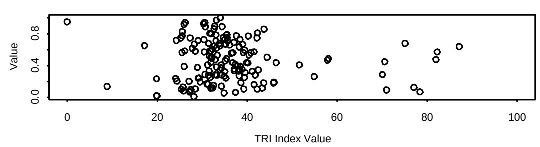
3. SIMPSON DOMINANCE INDEX - fish 30-120 m



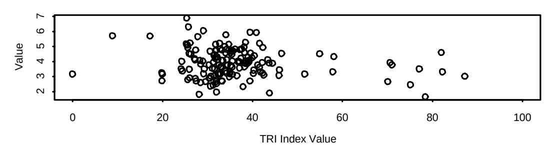
4. SHANNON-WIENER DIVERSITY - invert 30-120 m



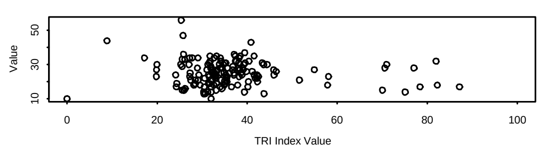
5. EVENNESS - invert 30-120 m



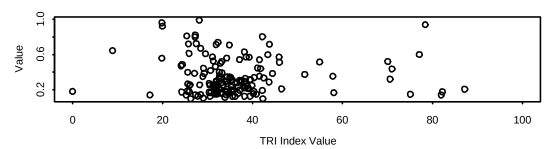
6. GLEASON RICHNESS DIVERSITY - fish + inv 30-120 m



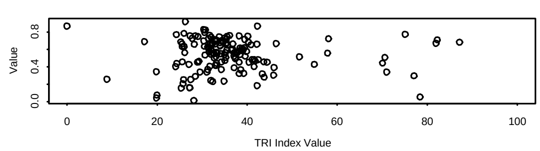
7. NO. OF SPECIES - fish + inv 30-120 m



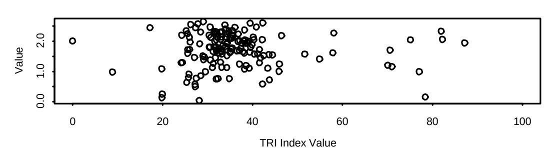
8. SIMPSON DOMINANCE INDEX - fish + inv 30-120 m



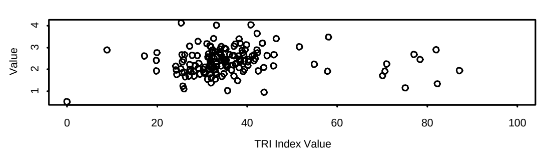
9. EVENNESS - fish + inv 30-120 m



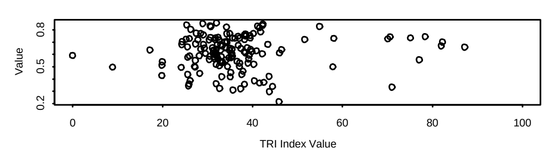
10. SHANNON-WIENER DIVERSITY - fish + inv 30-120 m



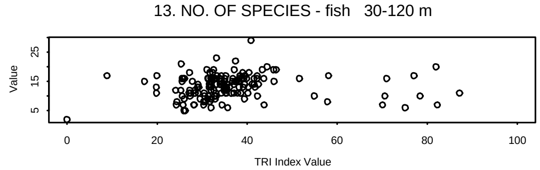
11. GLEASON RICHNESS DIVERSITY - fish 30-120 m



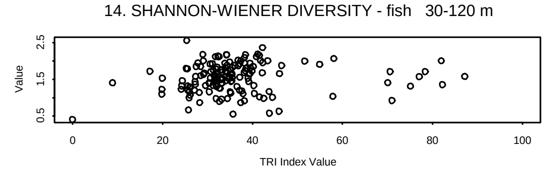
12. EVENNESS - fish 30-120 m



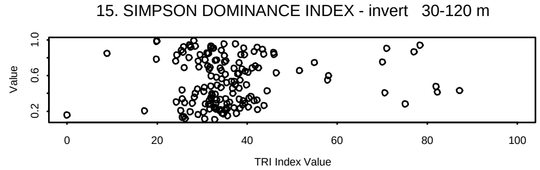
13. NO. OF SPECIES - fish 30-120 m



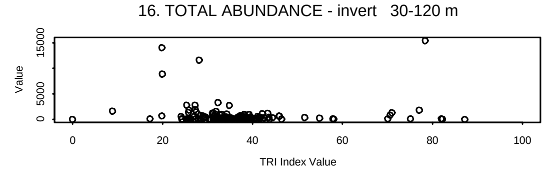
14. SHANNON-WIENER DIVERSITY - fish 30-120 m



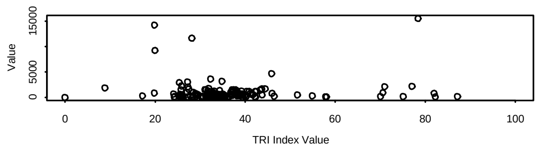
15. SIMPSON DOMINANCE INDEX - invert 30-120 m



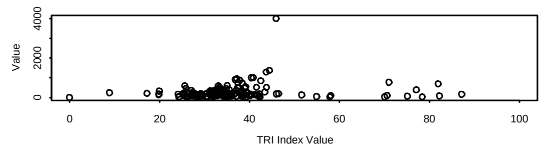
16. TOTAL ABUNDANCE - invert 30-120 m

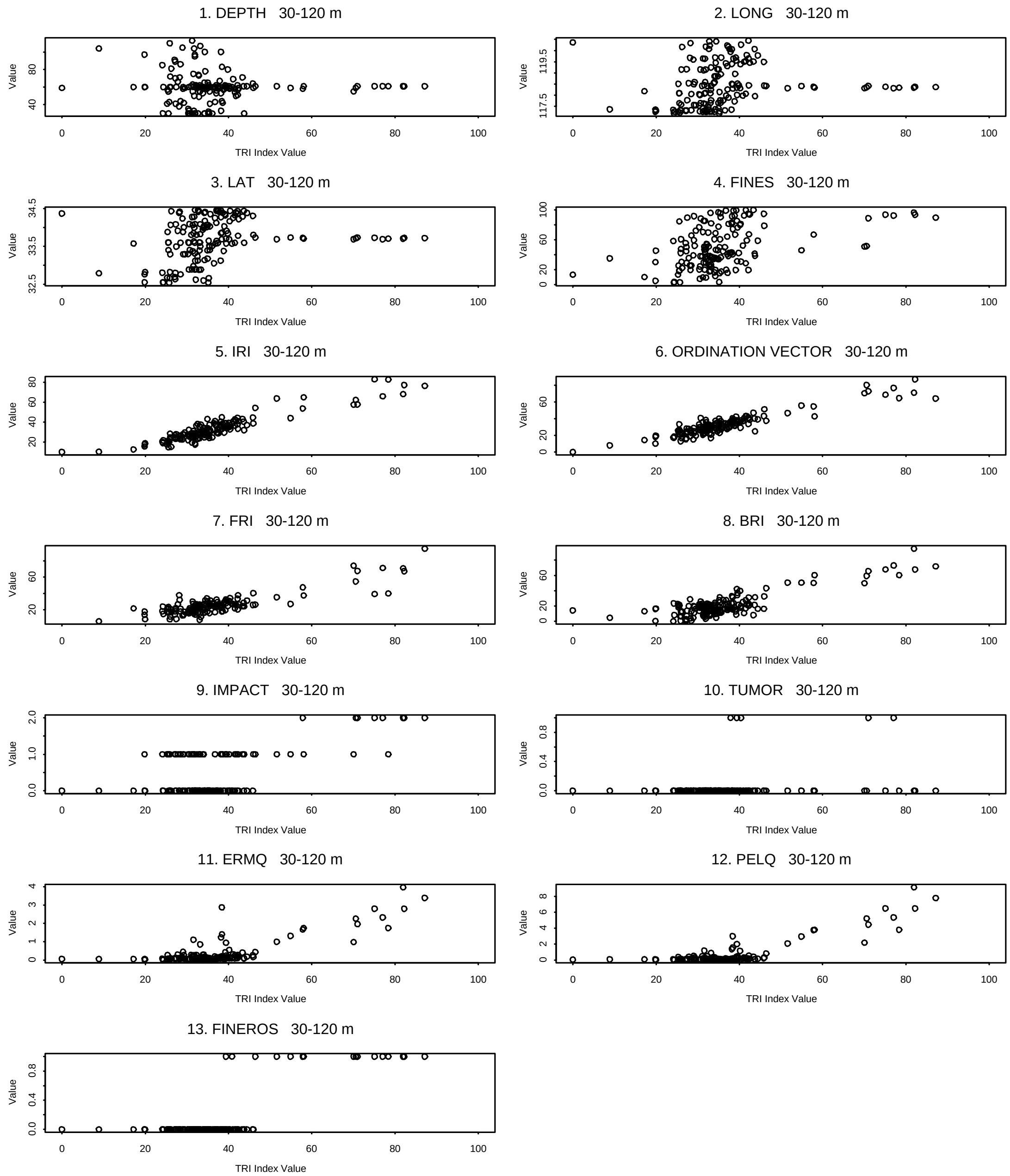


17. TOTAL ABUNDANCE - fish + inv   30-120 m



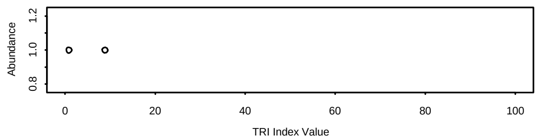
18. TOTAL ABUNDANCE - fish   30-120 m



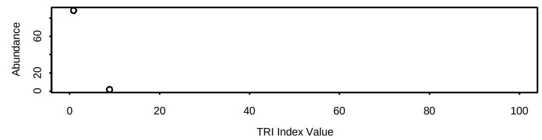

1. DEPTH 30-120 m
2. LONG 30-120 m
3. LAT 30-120 m
4. FINES 30-120 m
5. IRI 30-120 m
6. ORDINATION VECTOR 30-120 m
7. FRI 30-120 m
8. BRI 30-120 m
9. IMPACT 30-120 m
10. TUMOR 30-120 m
11. ERMQ 30-120 m
12. PELQ 30-120 m
13. FINEROS 30-120 m
Value
TRI Index Value

Outer Shelf (100-215 m)

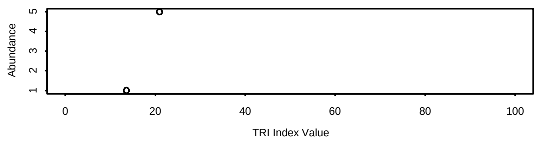
1. Cidarina cidaris - i   P=-54.8 100-215 m



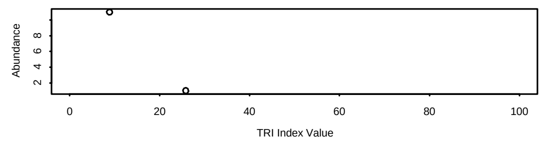
2. Laqueus californianus - i   P=-54.8 100-215 m



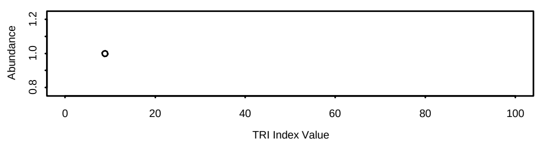
3. Sardinops sagax - f   P=-44.3 100-215 m



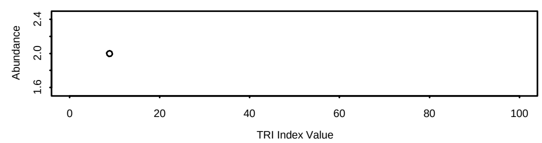
4. Icelinus tenuis - f   P=-43.7 100-215 m



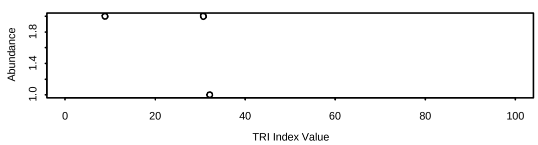
5. Pteropurpura macroptera - i   P=-39.9 100-215 m



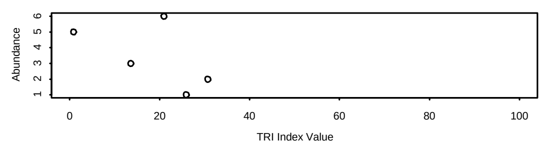
6. Terebratalia occidentalis - i   P=-36.3 100-215 m



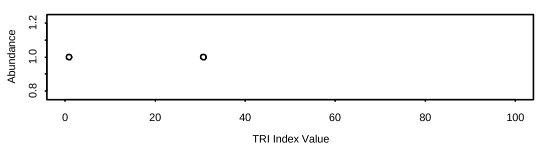
7. Florometra serratissima - i   P=-35.9 100-215 m



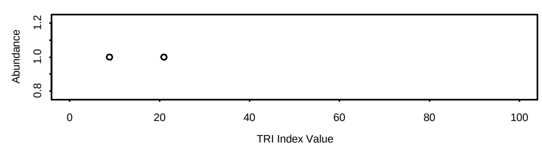
8. Gorgonocephalus eucnemis - i   P=-33.6 100-215 m



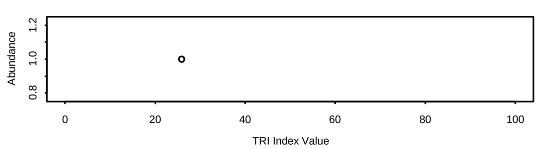
9. Ophionereis eurybrachiplax - i   P=-32.9 100-215 m



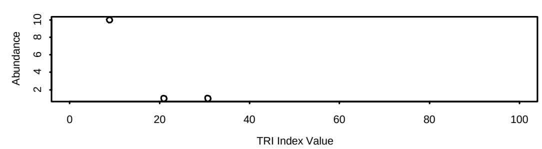
10. Fusinus barbarensis - i   P=-31.1 100-215 m



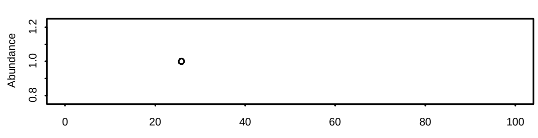
11. Brosmophycis marginata - f   P=-31 100-215 m



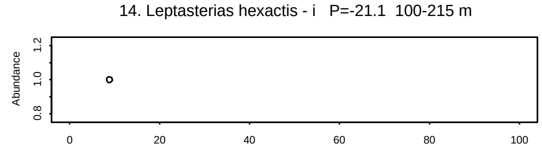
12. Philine alba - i   P=-26.2 100-215 m



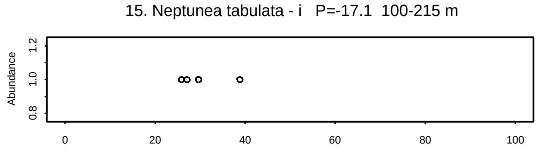
13. Balanus nubilus - i   P=-24.4 100-215 m



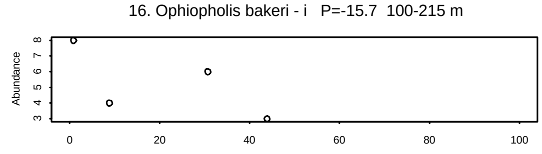
14. Leptasterias hexactis - i   P=-21.1 100-215 m



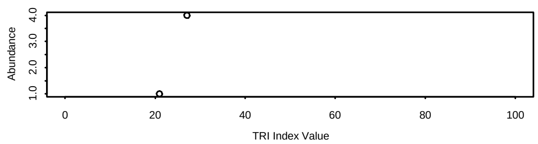
15. Neptunea tabulata - i   P=-17.1 100-215 m



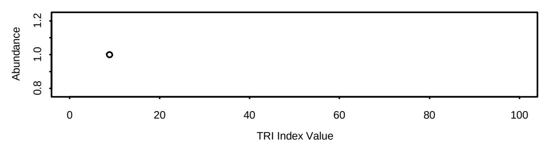
16. Ophiopholis bakeri - i   P=-15.7 100-215 m



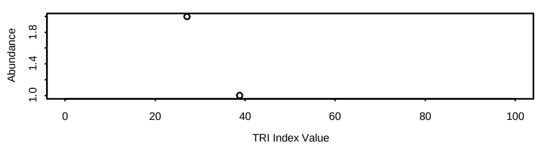
17. Parapagurodes laurentae - i   P=-13.5 100-215 m



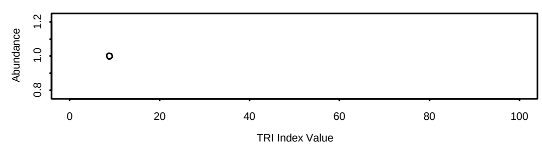
18. Protula superba - i   P=-13 100-215 m



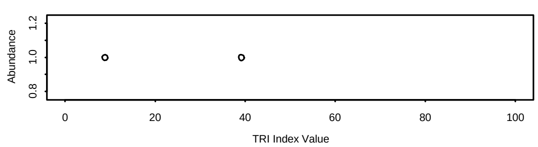
19. Parapagurodes makarovi - i   P=-11.5 100-215 m



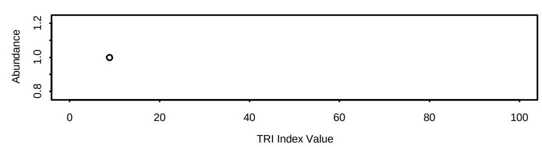
20. Rathbunella hypoplecta - f   P=-10.9 100-215 m



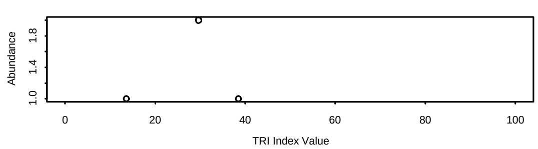
21. Platydoris macfarlandi - i   P=-9.4 100-215 m



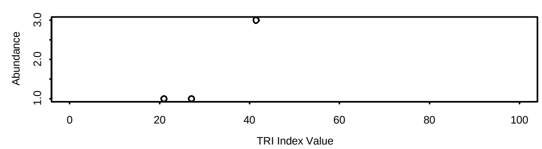
22. Paracyathus stearnsii - i   P=-9.3 100-215 m



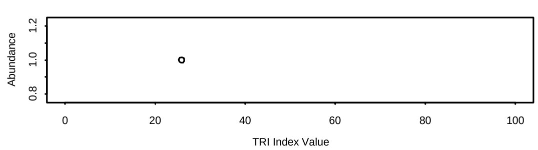
23. Icelinus filamentosus - f   P=-9.1 100-215 m



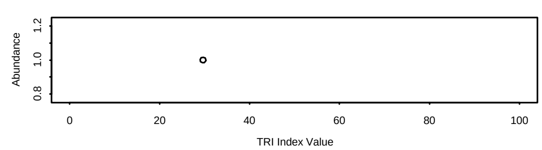
24. Astropecten ornatissimus - i   P=-4.7 100-215 m



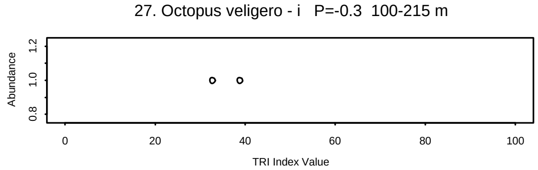
25. Amphiura arcystata - i   P=-3.1 100-215 m



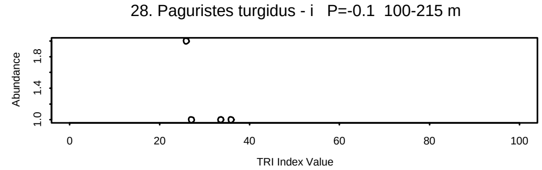
26. Sebastes constellatus - f   P=-2.5 100-215 m



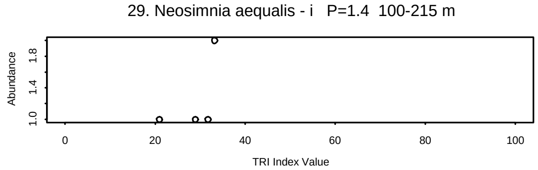
27. Octopus veligero - i   P=-0.3 100-215 m



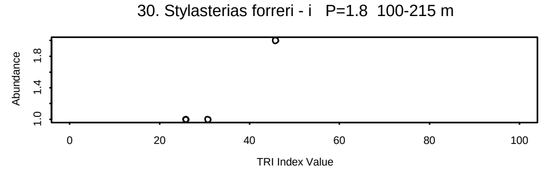
28. Paguristes turgidus - i   P=-0.1 100-215 m



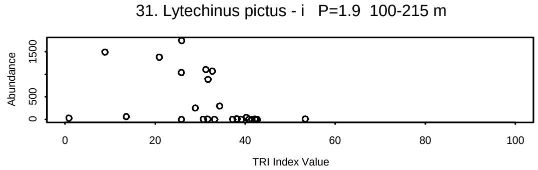
29. Neosimnia aequalis - i   P=1.4 100-215 m



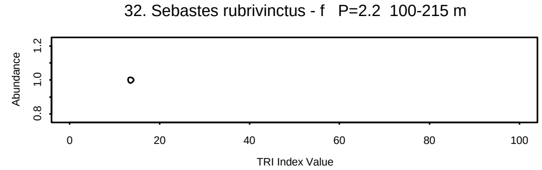
30. Stylasterias forreri - i   P=1.8 100-215 m



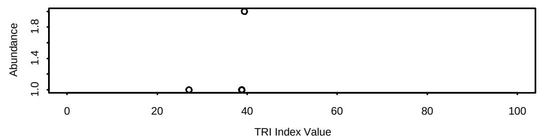
31. Lytechinus pictus - i   P=1.9 100-215 m



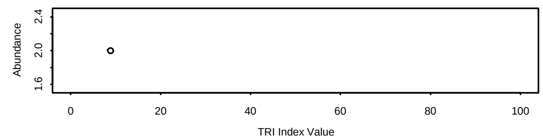
32. Sebastes rubrivinctus - f   P=2.2 100-215 m



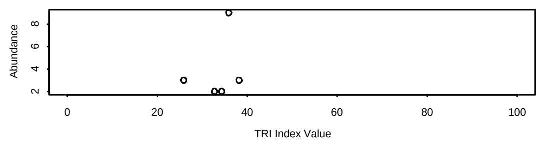
33. Eopsetta jordani - f   P=2.9 100-215 m



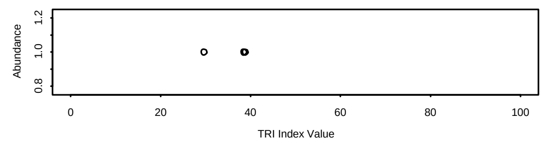
34. Loxorhynchus crispatus - i   P=3.6 100-215 m



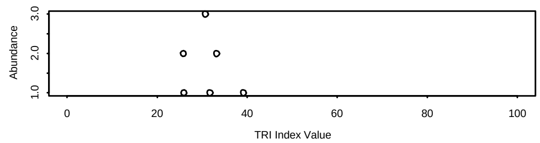
35. Amphichondrius granulatus - i   P=5.6 100-215 m



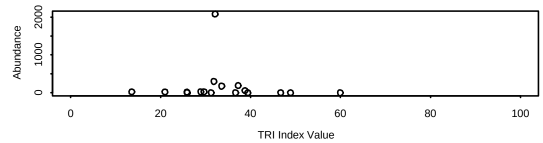
36. Paralithodes californiensis - i   P=6.7 100-215 m



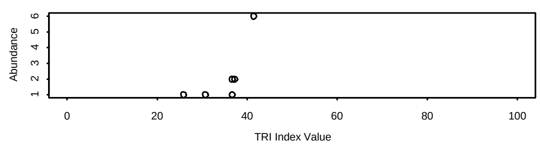
37. Xeneretmus triacanthus - f   P=6.7 100-215 m



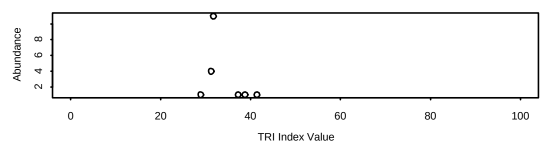
38. Spatangus californicus - i   P=7.4 100-215 m



39. Mediaster aequalis - i   P=8 100-215 m

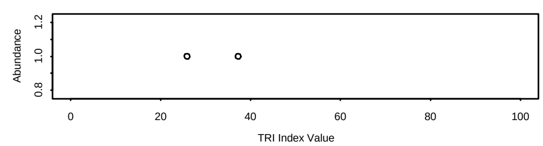


40. Ptilosarcus gurneyi - i   P=8.2 100-215 m

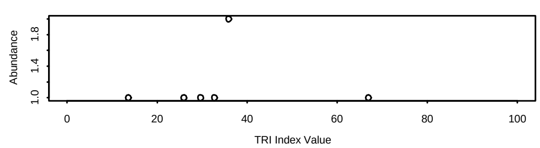


41. Phimochirus californiensis - i   P=8.2 100-215 m

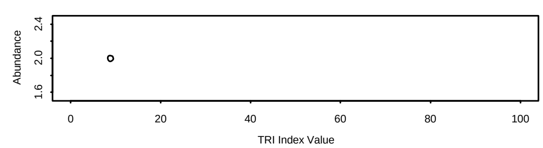
42. Cancellaria cooperi - i   P=8.5 100-215 m



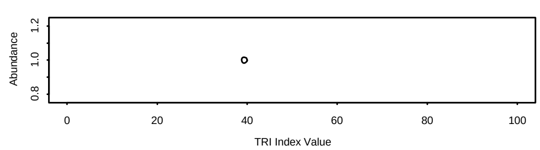
43. Sebastes eos - f   P=9.4 100-215 m



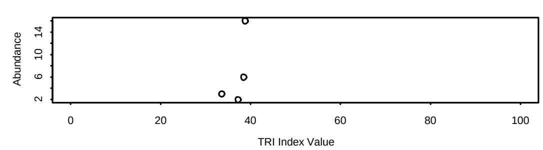
44. Luidia asthenosoma - i   P=9.9 100-215 m



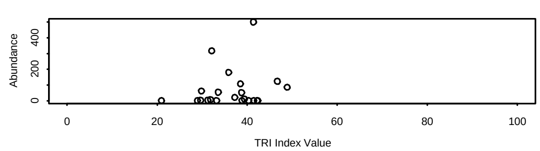
45. Neosabellaria cementarium - i   P=13.6 100-215 m



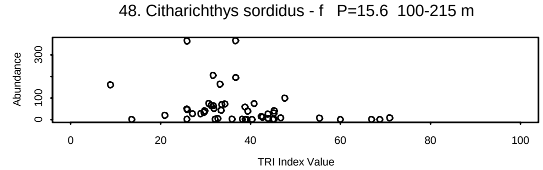
46. Lyconema barbatum - f   P=14.3 100-215 m



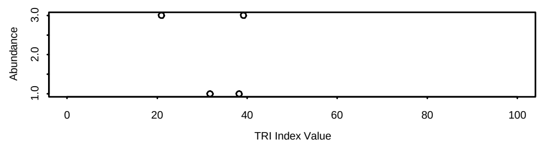
47. Brisaster latifrons - i   P=14.6 100-215 m



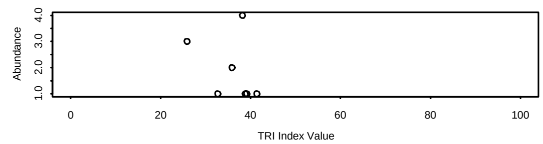
48. Citharichthys sordidus - f   P=15.6 100-215 m



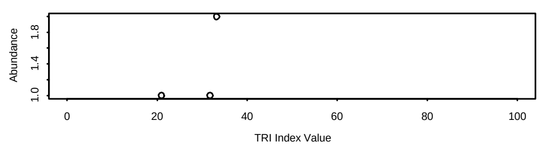
49. Ophiothrix spiculata - i   P=17.4 100-215 m



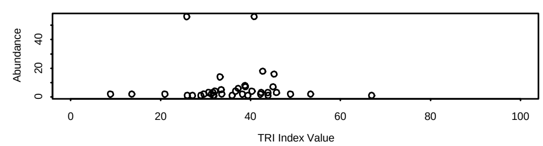
50. Megasurcula carpenteriana - i   P=17.4 100-215 m



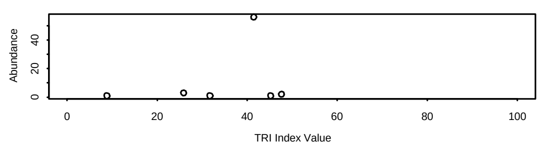
51. Calliostoma turbinum - i   P=17.6 100-215 m



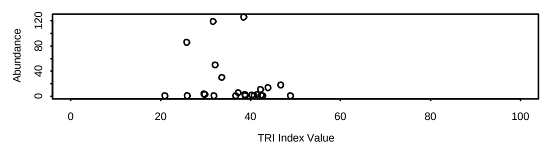
52. Luidia foliolata - i   P=17.7 100-215 m



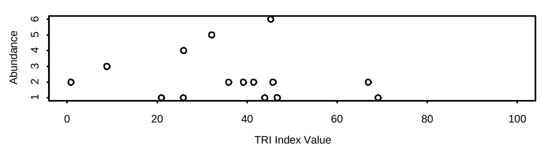
53. Citharichthys xanthostigma - f   P=18 100-215 m



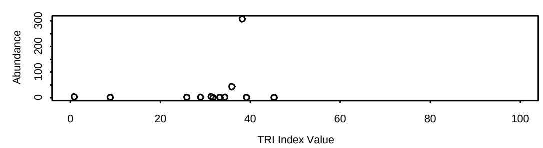
54. Brissopsis pacifica - i   P=18.3 100-215 m



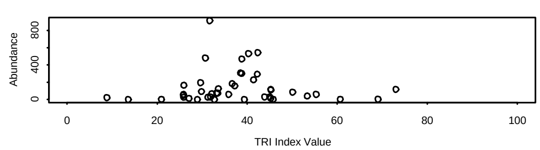
55. Metridium senile - i   P=18.3 100-215 m



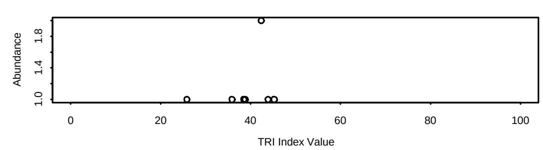
56. Ophiura luetkenii - i   P=18.3 100-215 m



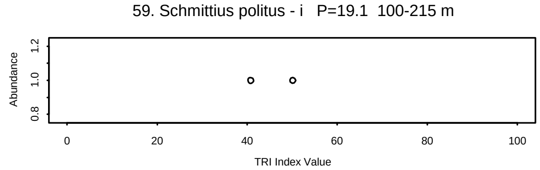
57. Allocentrotus fragilis - i   P=18.5 100-215 m



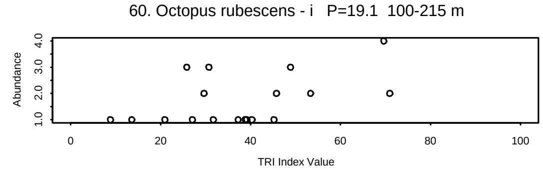
58. Octopus californicus - i   P=18.6 100-215 m



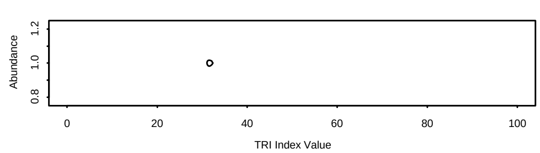
59. Schmittius politus - i   P=19.1 100-215 m



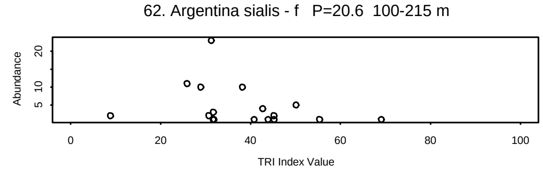
60. Octopus rubescens - i   P=19.1 100-215 m



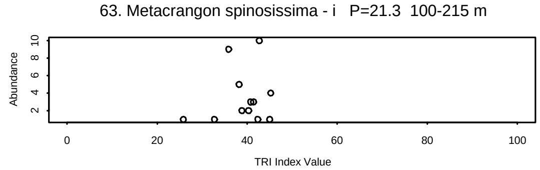
61. Lovenia cordiformis - i   P=19.7 100-215 m



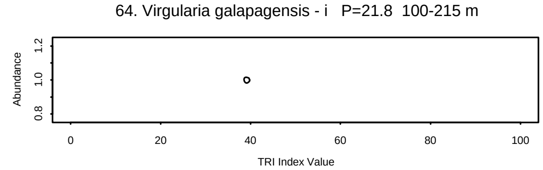
62. Argentina sialis - f   P=20.6 100-215 m



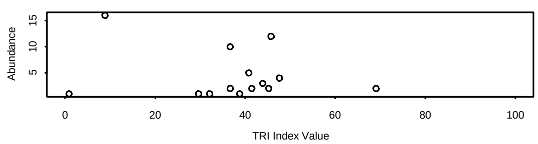
63. Metacrangon spinosissima - i   P=21.3 100-215 m



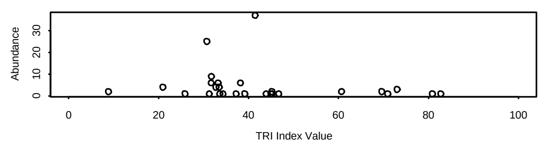
64. Virgularia galapagensis - i   P=21.8 100-215 m



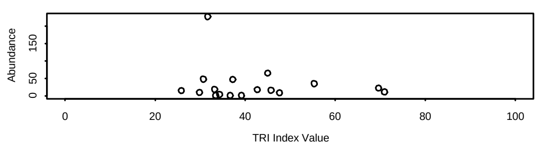
65. Sebastes chlorostictus - f   P=23.7 100-215 m



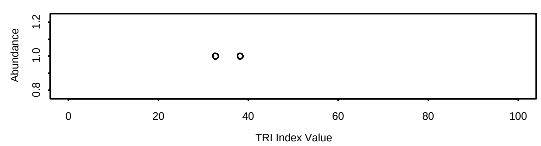
66. Astropecten verrilli - i   P=24.5 100-215 m



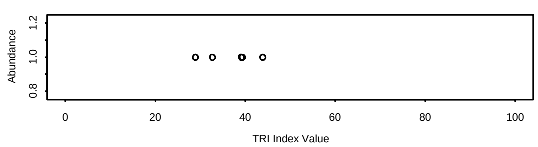
67. Citharichthys fragilis - f   P=25 100-215 m



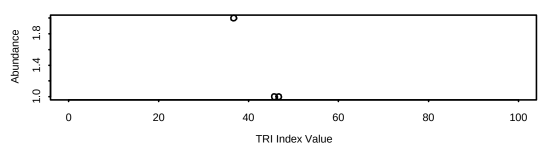
68. Aphrodita japonica - i   P=25.5 100-215 m



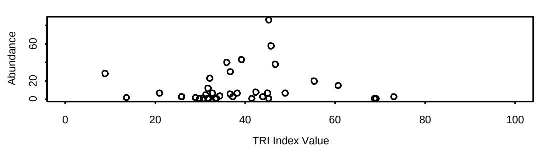
69. Hamatoscapellum californicum - i   P=25.9 100-215 m



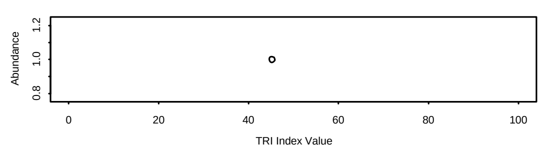
70. Rathbunaster californicus - i   P=26.5 100-215 m



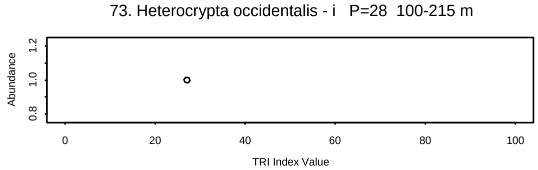
71. Parastichopus californicus - i   P=27 100-215 m



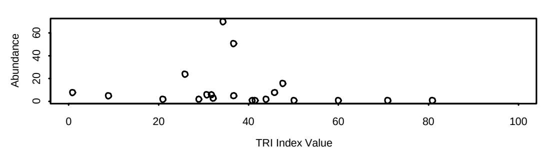
72. Strongylocentrotus purpuratus - i   P=27.6 100-215 m



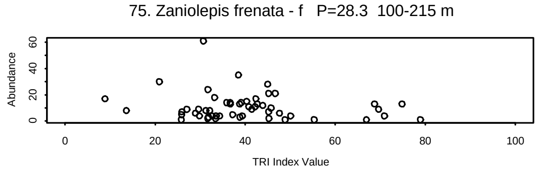
73. Heterocrypta occidentalis - i   P=28 100-215 m



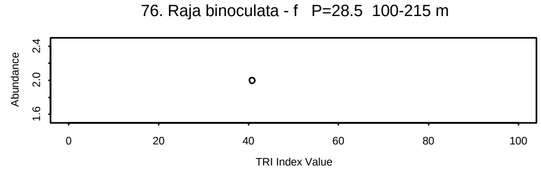
74. Sebastes semicinctus - f   P=28.2 100-215 m



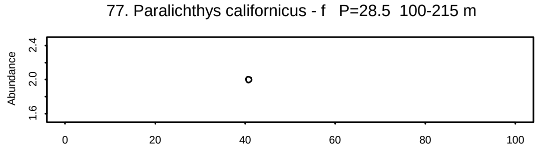
75. Zaniolepis frenata - f   P=28.3 100-215 m



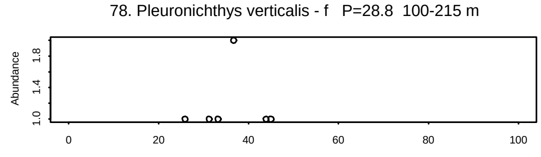
76. Raja binoculata - f   P=28.5 100-215 m



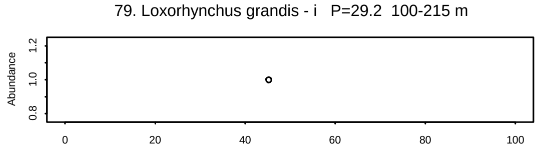
77. Paralichthys californicus - f   P=28.5 100-215 m



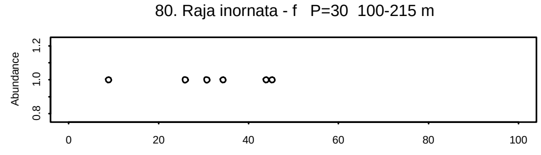
78. Pleuronichthys verticalis - f   P=28.8 100-215 m



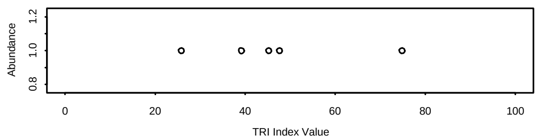
79. Loxorhynchus grandis - i   P=29.2 100-215 m



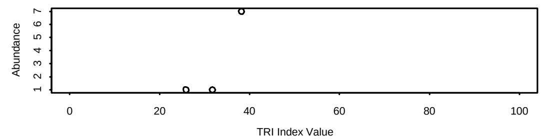
80. Raja inornata - f   P=30 100-215 m



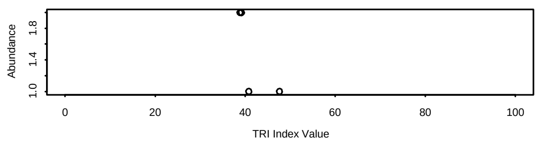
81. Icelinus quadriseriatus - f   P=30.1 100-215 m



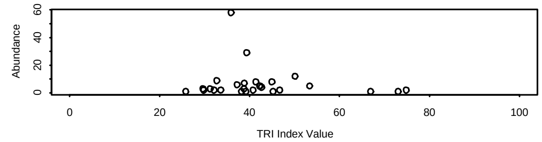
82. Lepidogobius lepidus - f   P=30.5 100-215 m



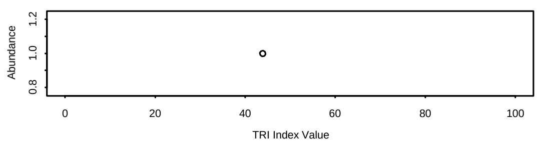
83. Symphurus atricauda - f   P=31.4 100-215 m



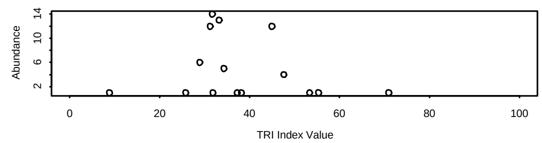
84. Neocrangon resima - i   P=31.5 100-215 m



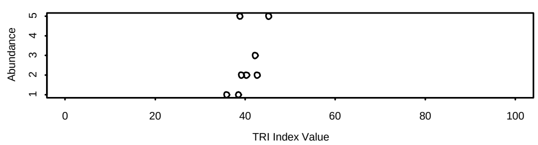
85. Tritonia festiva - i   P=33.1 100-215 m



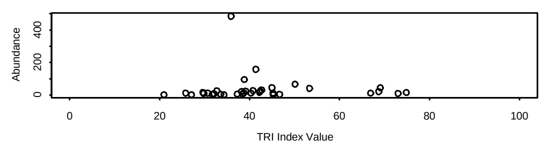
86. Zaniolepis latipinnis - f   P=33.4 100-215 m



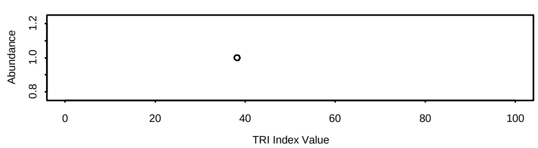
87. Plectobranchus evides - f   P=33.6 100-215 m



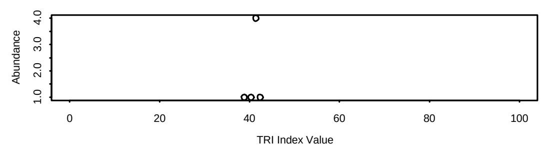
88. Neocrangon zacae - i   P=33.6 100-215 m



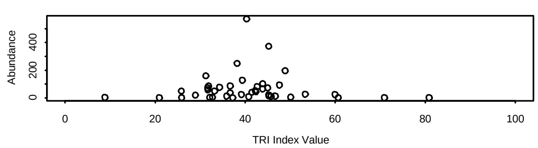
89. Pyromaia tuberculata - i   P=34.2 100-215 m



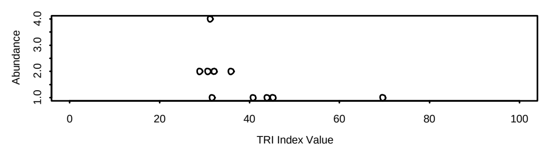
90. Antiplanes catalinae - i   P=34.5 100-215 m



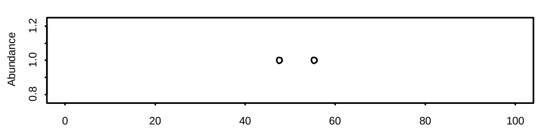
91. Porichthys notatus - f   P=34.9 100-215 m



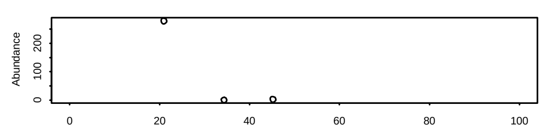
92. Synodus lucioceps - f   P=36.4 100-215 m



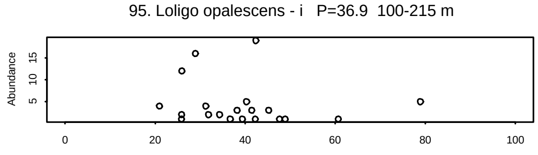
93. Sebastes dallii - f   P=36.5 100-215 m



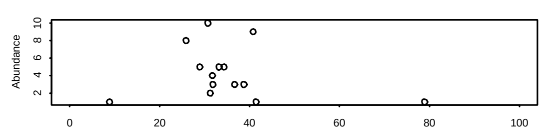
94. Engraulis mordax - f   P=36.6 100-215 m



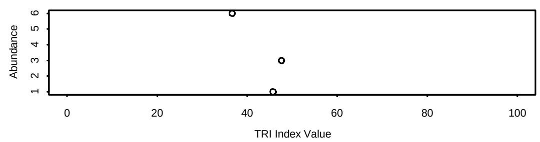
95. Loligo opalescens - i   P=36.9 100-215 m



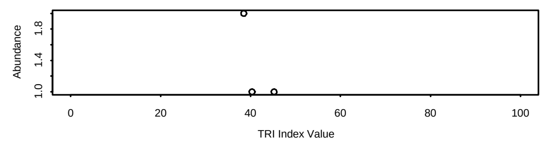
96. Zalembius rosaceus - f   P=36.9 100-215 m



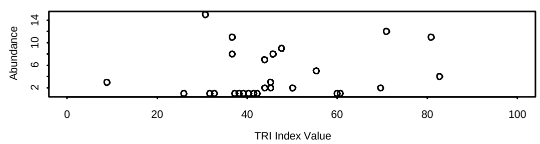
97. Ophiodon elongatus - f   P=37.6 100-215 m



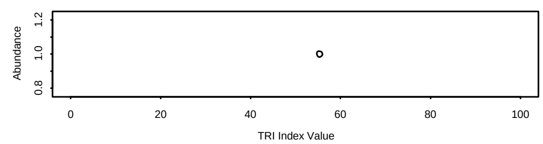
98. Paralithodes rathbuni - i   P=37.6 100-215 m



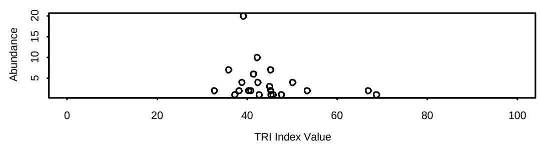
99. Hippoglossina stomata - f   P=38.2 100-215 m



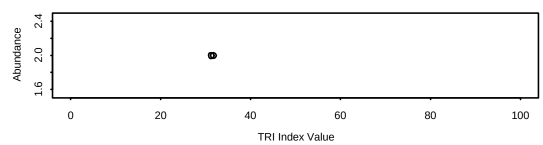
100. Xystreurys liolepis - f   P=39.5 100-215 m



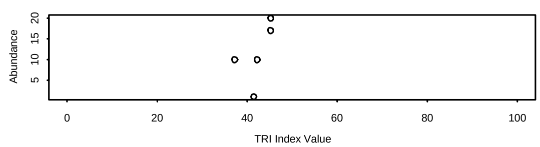
101. Rossia pacifica - i   P=39.8 100-215 m



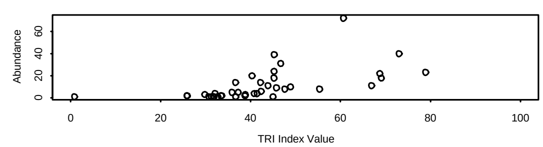
102. Stylatula elongata - i   P=39.9 100-215 m



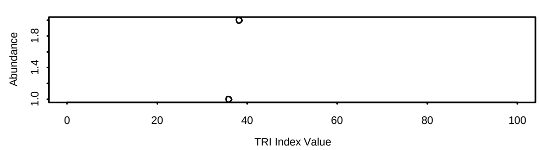
103. Neocrangon communis - i   P=40 100-215 m



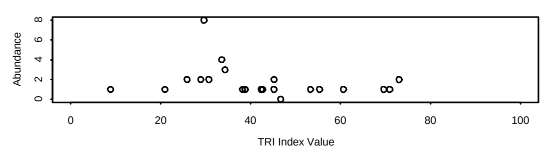
104. Errex zachirus - f   P=40.5 100-215 m



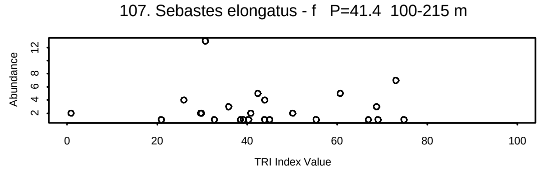
105. Armina californica - i   P=41.2 100-215 m



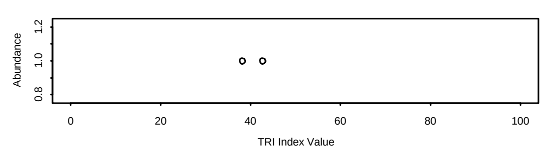
106. Chilara taylori - f   P=41.3 100-215 m



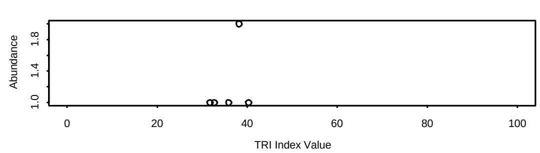
107. Sebastes elongatus - f   P=41.4 100-215 m



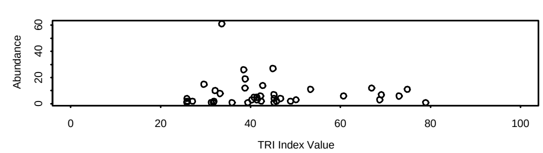
108. Cancellaria crawfordiana - i   P=41.6 100-215 m



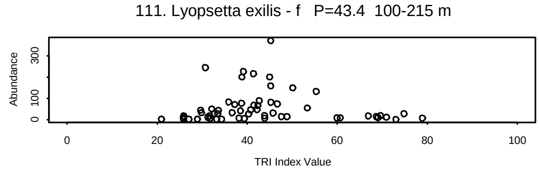
109. Tritonia diomedea - i   P=42.8 100-215 m



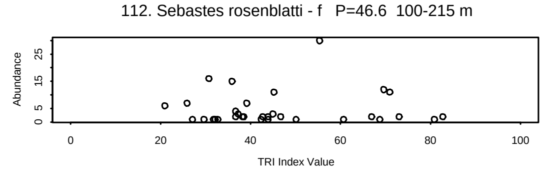
110. Xeneretmus latifrons - f   P=43.3 100-215 m



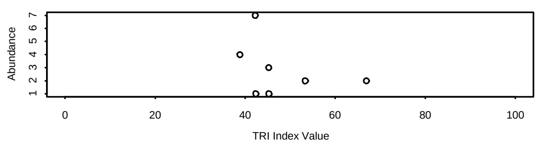
111. Lyopsetta exilis - f   P=43.4 100-215 m



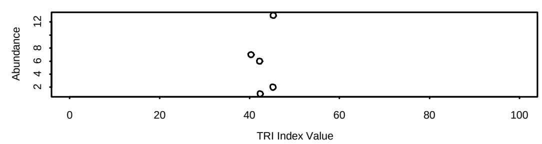
112. Sebastes rosenblatti - f   P=46.6 100-215 m



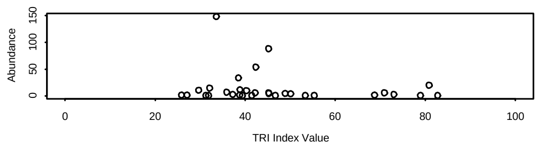
113. Sebastolobus alascanus - f   P=46.8 100-215 m



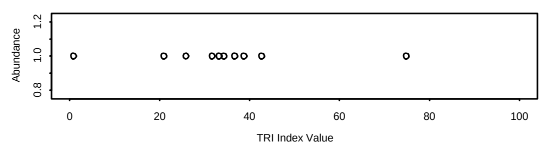
114. Dromalia alexandri - i   P=46.9 100-215 m



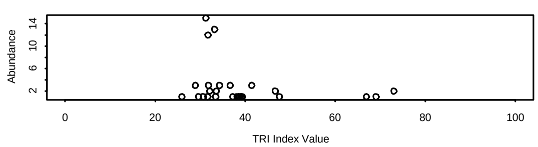
115. Merluccius productus - f   P=50.6 100-215 m



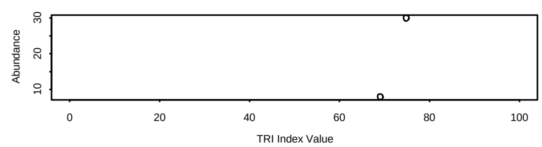
116. Livoneca vulgaris - i   P=50.7 100-215 m



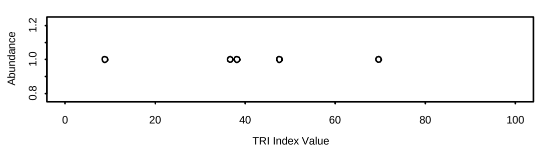
117. Parophrys vetula - f   P=53.3 100-215 m



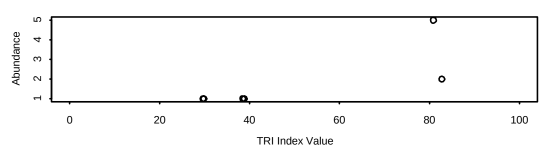
118. Nassarius perpinguis - i   P=53.5 100-215 m



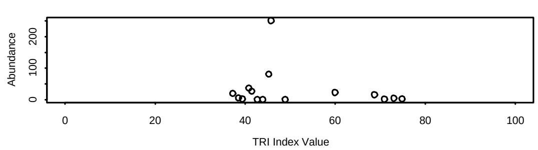
119. Scorpaena guttata - f   P=57.5 100-215 m



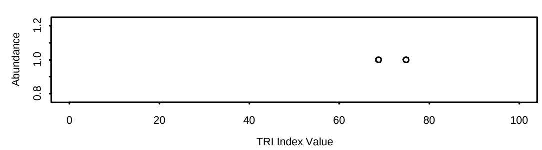
120. Lopholithodes foraminatus - i   P=57.6 100-215 m



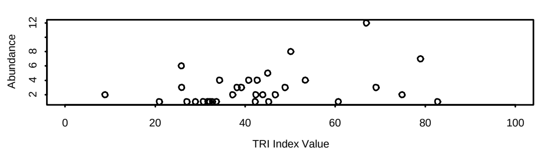
121. Pandalus platyceros - i   P=58.2 100-215 m



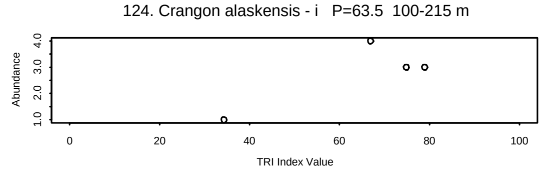
122. Acanthodoris brunnea - i   P=60.6 100-215 m



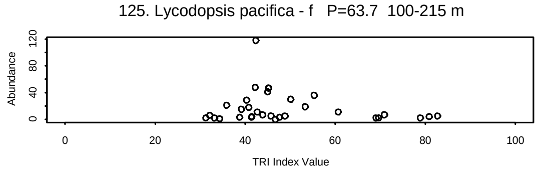
123. Pleurobranchaea californica - i   P=61.1 100-215 m



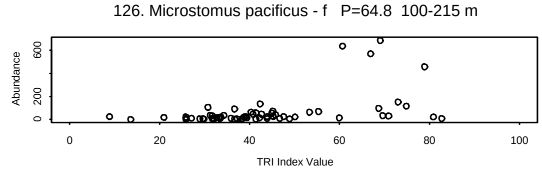
124. Crangon alaskensis - i   P=63.5 100-215 m



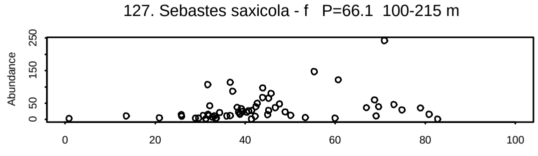
125. Lycodopsis pacifica - f   P=63.7 100-215 m



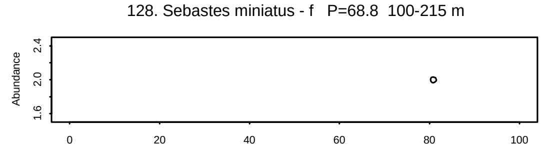
126. Microstomus pacificus - f   P=64.8 100-215 m



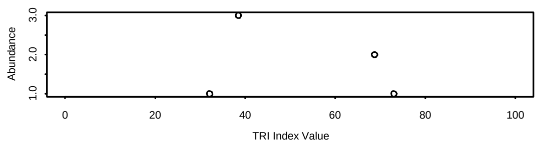
127. Sebastes saxicola - f   P=66.1 100-215 m



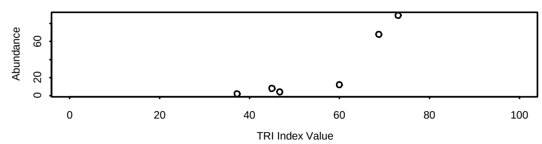
128. Sebastes miniatus - f   P=68.8 100-215 m



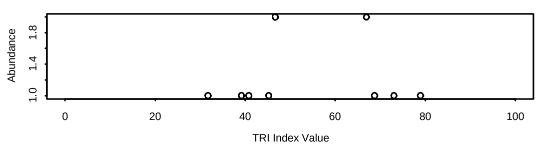
129. Spirontocaris sica - i P=68.9 100-215 m



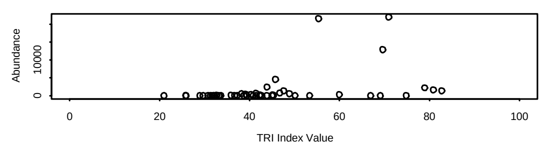
130. Pandalus jordani - i P=71.7 100-215 m



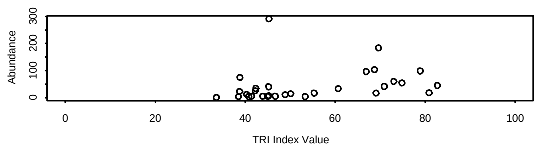
131. Sebastes levis - f P=72 100-215 m



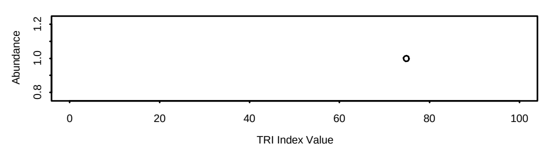
132. Sicyonia ingentis - i P=73.8 100-215 m



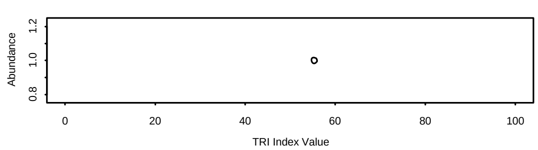
133. Sebastes diploproa - f P=80 100-215 m



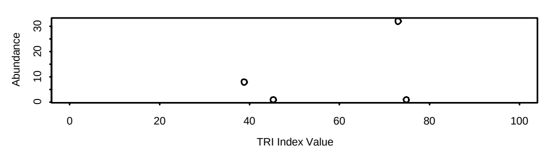
134. Lysmata californica - i P=81.8 100-215 m



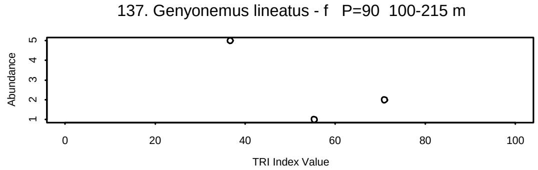
135. Sebastes mystinus - f P=82.8 100-215 m



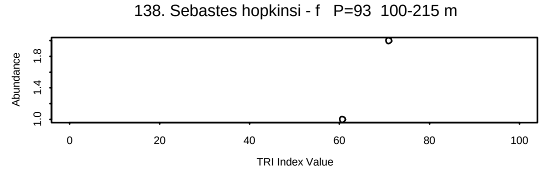
136. Lycodes cortezianus - f P=84.6 100-215 m



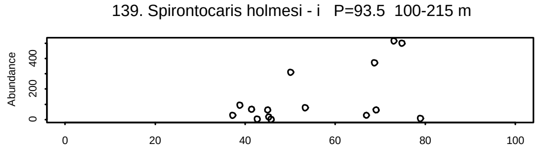
137. Genyonemus lineatus - f P=90 100-215 m



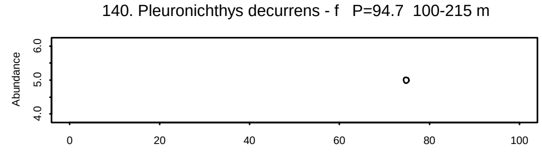
138. Sebastes hopkinsi - f P=93 100-215 m



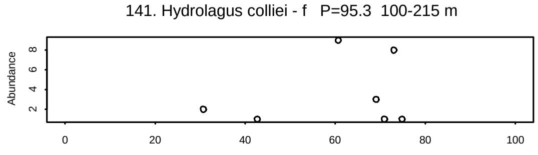
139. Spirontocaris holmesi - i P=93.5 100-215 m



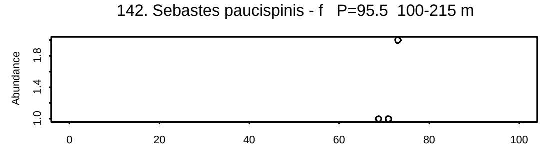
140. Pleuronichthys decurrens - f P=94.7 100-215 m



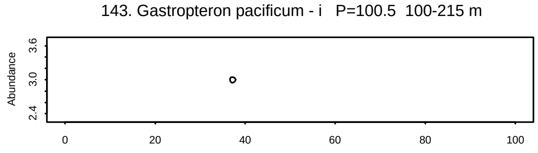
141. Hydrolagus colliei - f P=95.3 100-215 m



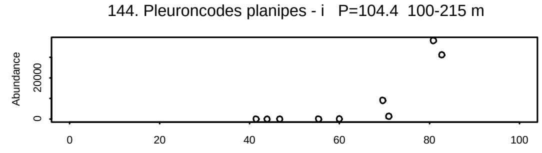
142. Sebastes paucispinis - f P=95.5 100-215 m



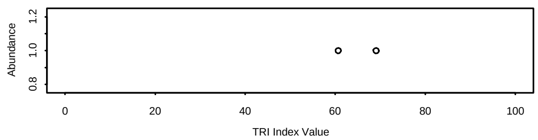
143. Gastropteron pacificum - i P=100.5 100-215 m



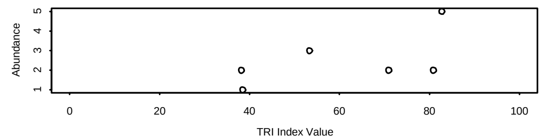
144. Pleuroncodes planipes - i P=104.4 100-215 m



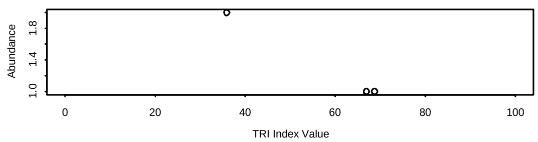
145. Crangon nigromaculata - i P=106 100-215 m



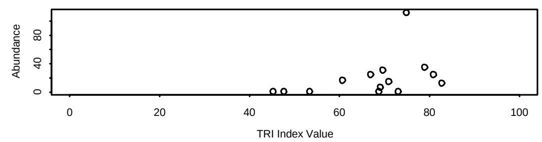
146. Calinaticina oldroydii - i P=107.4 100-215 m



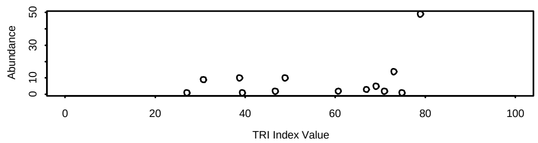
147. Kathetostoma averruncus - f P=109.6 100-215 m



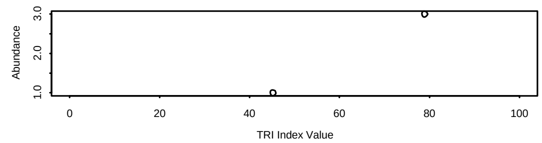
148. Platymera gaudichaudii - i P=114.8 100-215 m



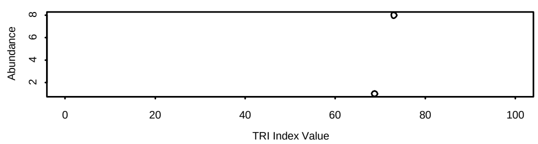
149. Sebastes jordani - f P=119.3 100-215 m



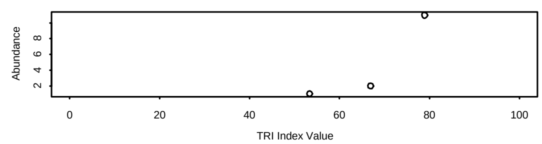
150. Physiculus rastrelliger - f P=120.7 100-215 m



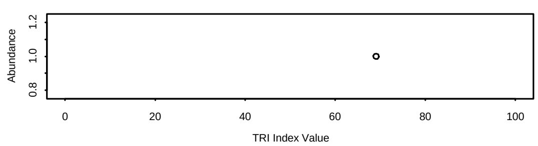
151. Heptacarpus tenuissimus - i P=124.1 100-215 m



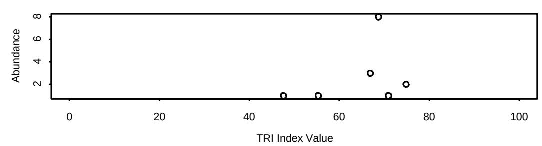
152. Cancer anthonyi - i P=139.6 100-215 m



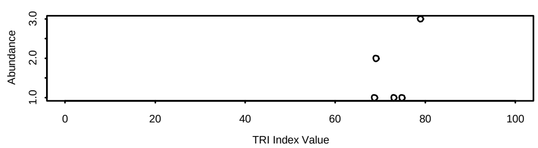
153. Sebastes goodei - f P=140.7 100-215 m



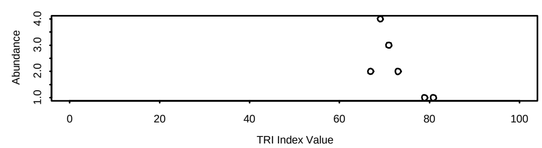
154. Sebastes crameri - f P=149.2 100-215 m



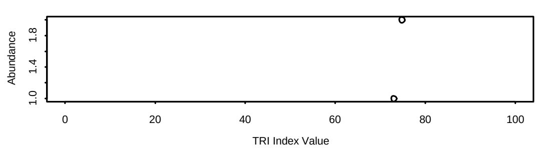
155. Sebastes macdonaldi - f P=155.2 100-215 m



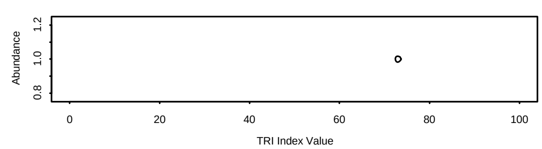
156. Anoplopoma fimbria - f P=159.4 100-215 m

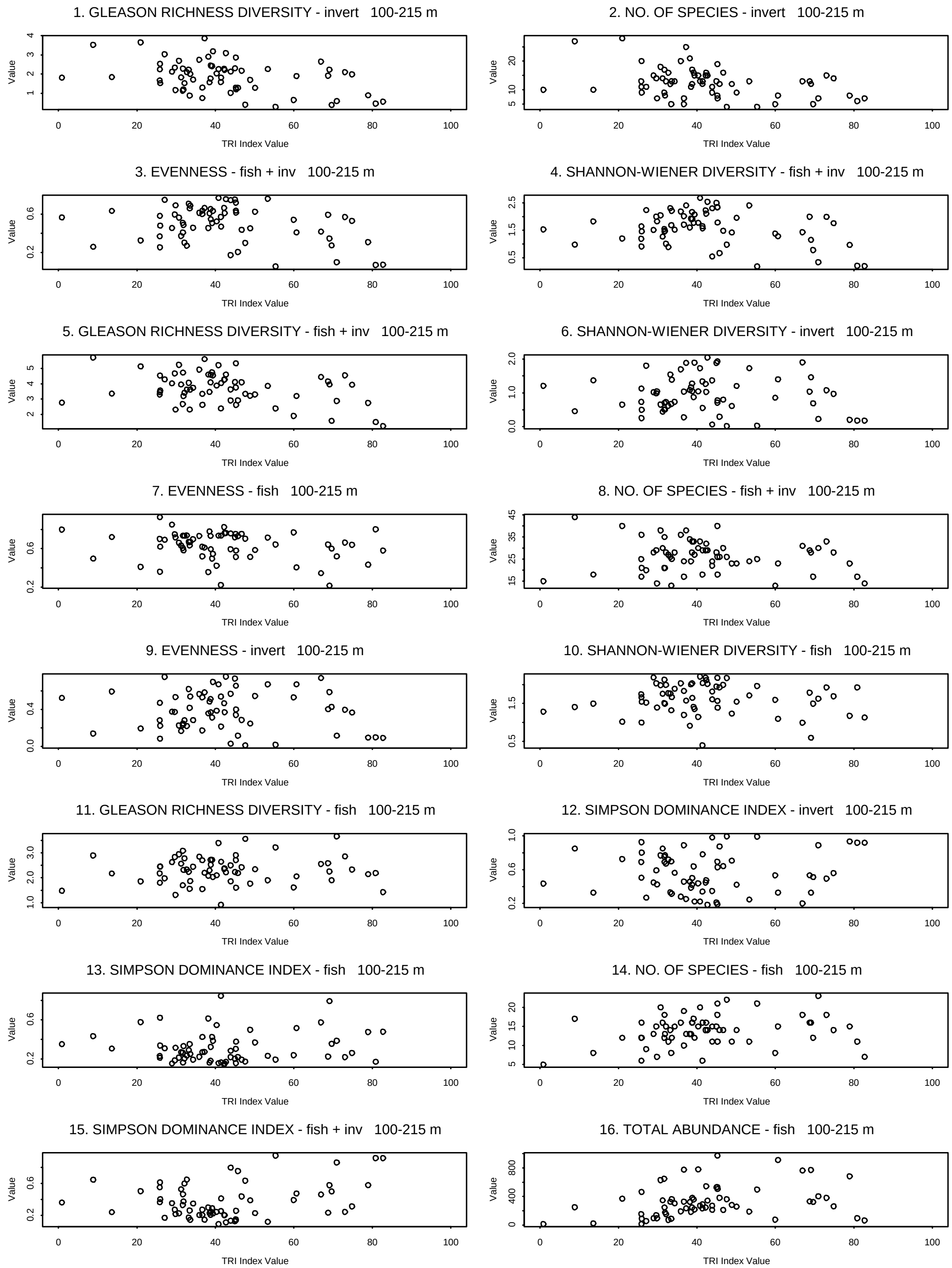


157. Nassarius mendicus - i P=170.8 100-215 m

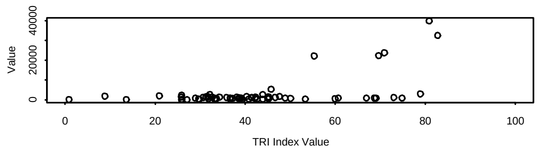


158. Crepidula onyx - i P=188 100-215 m

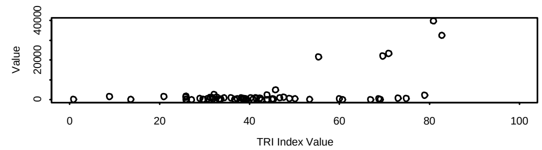



1. GLEASON RICHNESS DIVERSITY - invert 100-215 m
2. NO. OF SPECIES - invert 100-215 m
3. EVENNESS - fish + inv 100-215 m
4. SHANNON-WIENER DIVERSITY - fish + inv 100-215 m
5. GLEASON RICHNESS DIVERSITY - fish + inv 100-215 m
6. SHANNON-WIENER DIVERSITY - invert 100-215 m
7. EVENNESS - fish 100-215 m
8. NO. OF SPECIES - fish + inv 100-215 m
9. EVENNESS - invert 100-215 m
10. SHANNON-WIENER DIVERSITY - fish 100-215 m
11. GLEASON RICHNESS DIVERSITY - fish 100-215 m
12. SIMPSON DOMINANCE INDEX - invert 100-215 m
13. SIMPSON DOMINANCE INDEX - fish 100-215 m
14. NO. OF SPECIES - fish 100-215 m
15. SIMPSON DOMINANCE INDEX - fish + inv 100-215 m
16. TOTAL ABUNDANCE - fish 100-215 m
Value
TRI Index Value

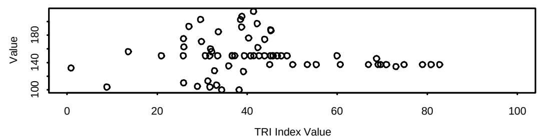
17. TOTAL ABUNDANCE - fish + inv   100-215 m



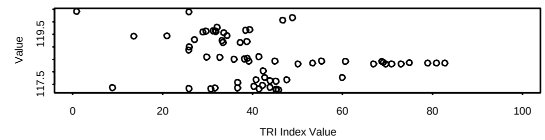
18. TOTAL ABUNDANCE - invert   100-215 m



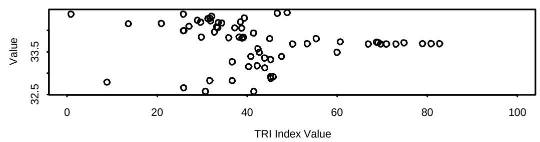
1. DEPTH   100-215 m



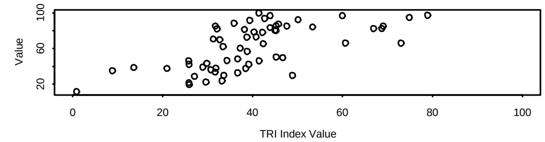
2. LONG   100-215 m



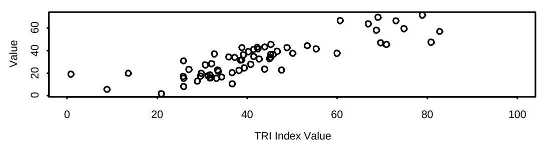
3. LAT   100-215 m



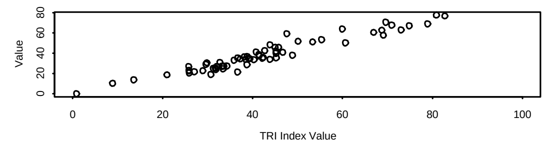
4. FINES   100-215 m



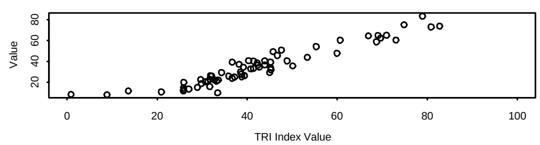
5. FRI   100-215 m



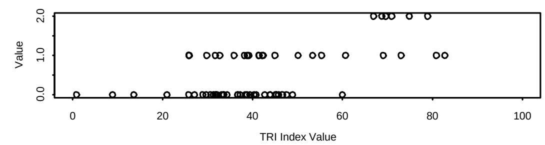
6. IRI   100-215 m



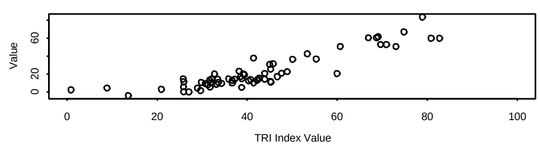
7. ORDINATION VECTOR   100-215 m



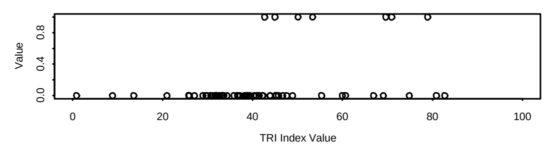
8. IMPACT   100-215 m



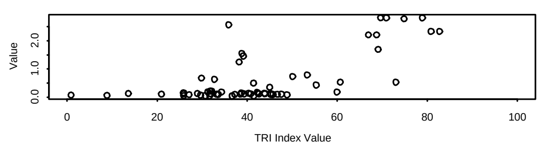
9. BRI   100-215 m



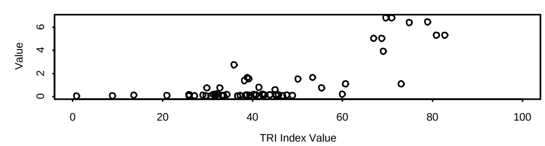
10. TUMOR   100-215 m



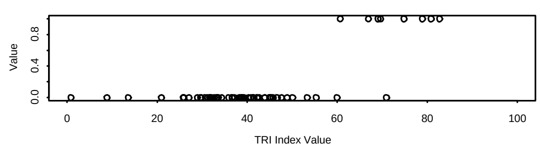
11. ERMQ   100-215 m



12. PELQ   100-215 m



13. FINEROS   100-215 m



Appendix C1. Median, percentiles, and Mann-Whitney summed ranks test results for catch parameters and guild abundance metrics tested for responses between reference and impacted conditions in southern California demersal fish biointegrity index study.

					Percentile				
Metric	**n**	**Range**	**%FO**	**Median**	**25%**	**75%**	**T**	**p**	**Significance**
Middle Shelf (30-120m)									
Catch Parameters									
Abundance							390.5	0.758	ns
Reference	95	4001	NA	188	97.7	341			
Impact	8	748	NA	140.5	82.5	543.5			
No. of Species							359.0	0.490	ns
Reference	95	27	NA	13	10.25	16			
Impact	8	14	NA	10.5	7.5	16.5			
Diversity (Shannon-Weiner)							395.0	0.801	ns
Reference	95	2.034	NA	1.496	1.237	1.731			
Impact	8	1.081	NA	1.471	1.178	1.647			
Pielou's Evenness							467.0	0.534	ns
Reference	95	0.642	NA	0.602	0.514	0.681			
Impact	8	0.41	NA	0.665	0.529	0.718			
Simpson's Dominance							382.0	0.68	ns
Reference	95	0.902	NA	0.322	0.265	0.426			
Impact	8	1.036	NA	0.301	0.255	0.439			
1A1							614.5	0.015	<0.05
Reference	95	24	32	0	0	1			
Impact	8	68	75	3.5	1	13.5			
1A2a							558	0.081	ns
Reference	95	3482	75	6	0	73.75			
Impact	8	220	100	36.5	22.5	107			
1A2b							364	0.526	ns
Refernce	95	275	66	1	0	14.75			
Impact	8	11	63	1.5	0	3			
1B1							606	0.019	<0.05
Reference	95	0	0	0	0	0			
Impact	8	231	50	2.5	0	30.5			
1B2							447.5	0.701	ns
Reference	95	1	4	0	0	0			
Impact	8	1	13	0	0	0			

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
1C1							429.5	0.873	ns
Reference	95	87	68	3	0	10.75			
Impact	8	56	63	5.5	0	13.5			
1C2							480.5	0.429	ns
Reference	95	36	8	0	0	0			
Impact	8	57	25	0	0	0.5			
1D							408	0.926	ns
Reference	95	5	14	0	0	0			
Impact	8	1	13	0	0	0			
2A							171	0.003	<0.01
Reference	95	28	78	3	1	6			
Impact	8	1	38	0	0	1			
2B							198.5	0.007	<0.05
Reference	95	633	98	77	30	161.5			
Impact	8	163	88	19	8.5	27.5			
2C2a							340	0.351	ns
Reference	95	6	20	0	0	0			
Impact	8	0	0	0	0	0			
2C2b							230	0.022	<0.05
Reference	95	132	83	4	1	18.5			
Impact	8	7	50	0.5	0	3.5			
2C2c							319	0.234	ns
Reference	95	10	36	0	0	1			
Impact	8	1	13	0	0	0			
2C2d							534	0.147	ns
Reference	95	56	46	0	0	2			
Impact	8	4	75	1.5	0.5	3.5			
2C1							259	0.054	ns
Reference	95	105	76	4	1	13			
Impact	8	9	50	1	0	2			
2D1a							692.5	<0.001	<0.001
Reference	95	57	93	4	2	10			
Impact	8	571	100	40.5	21	82.5			
2D1b							442	0.753	ns

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
Reference	95	33	51	1	0	3			
Impact	8	28	50	1.5	0	4			
2D2							214	0.013	<0.05
Reference	95	48	66	1	0	4.75			
Impact	8	1	25	0	0	0.5			
Outer Shelf (100-215m)									
Catch Parameters									
Abundance							177.0	0.088	ns
Reference	36	959	NA	270.5	166	367.5			
Impact	6	500	NA	367	325	684			
No. of Species							169.5	0.150	ns
Reference	36	17	NA	13.5	11.5	16			
Impact	6	11	NA	15.5	14	18			
Diversity (Shannon-Weiner)							89.0	0.156	ns
Reference	36	1.186	NA	1.704	1.451	1.995			
Impact	6	0.788	NA	1.561	1.173	1.689			
Pielou's Evenness							68.0	0.030	<0.05
Reference	36	0.441	NA	0.682	0.588	0.735			
Impact	6	0.299	NA	0.56	0.433	0.64			
Simpson's Dominance							179	0.075	ns
Reference	36	0.433	NA	0.265	0.189	0.317			
Impact	6	0.354	NA	0.368	0.258	0.476			
1A1							141.5	0.666	ns
Reference	36	284	72	2.5	0	11			
Impact	6	53	83	3.5	2	10			
1A2a							223.5	<0.001	<0.001
Reference	36	291	97	32.5	9.5	71			
Impact	6	202	100	157.5	135	223			
1A2b							53	0.007	<0.01
Reference	36	571	75	20.5	0.5	83.5			
Impact	6	1	17	0	0	0			
1B1							129	0.985	ns
Reference	36	0		0	0	0			
Impact	6	0		0	0	0			
1B2							180	0.067	ns
Reference	36	2	3	0	0	0			
Impact	6	3	50	0.5	0	2			

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
1C1							112.5	0.563	ns
Reference	36	10	28	0	0	1.5			
Impact	6	1	17	0	0	0			
1C2							159	0.285	ns
Reference	36	5	6	0	0	0			
Impact	6	3	33	0	0	2			
1D							143	0.626	ns
Reference	36	8	33	0	0	1			
Impact	6	2	50	0.5	0	1			
2A							138.5	0.746	ns
Reference	36	17	50	0.5	0	3			
Impact	6	12	67	1	0	3			
2B							55	0.008	<0.01
Reference	36	450	97	77.5	32	131			
Impact	6	34	100	23.5	15	30			
2C1							102.5	0.35	ns
Reference	36	61	92	10	4	16			
Impact	6	12	100	7	1	13			
2C2a							129	0.985	ns
Reference	36	0		0	0	0			
Impact	6	0		0	0	0			
2C2b							133.5	0.886	ns
Reference	36	61	64	2	0	6			
Impact	6	12	67	2	0	12			
2C2c							117	0.677	ns
Reference	36	2	11	0	0	0			
Impact	6	0	0	0	0	0			
2C2d							141	0.679	ns
Reference	36	17	64	2	0	4			
Impact	6	13	67	3	0	11			
2D1a							218	0.001	<0.01
Reference	36	106	17	16.5	7.5	32.5			
Impact	6	539	583	108	33	457			
2D1b							116.5	0.666	ns
Reference	36	47	75	2	0	6			
Impact	6	7	83	1.5	1	2			

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
2D2							133	0.9	ns
Reference	36	39	69	1.5	0	9			
Impact	6	23	50	5.5	0	22			
Entire Shelf (9-215m)									
Catch Parameters									
Abundance							1431.0	0.075	ns
Reference	147	4005	NA	178	68.25	358.25			
Impact	14	748	NA	328	111	684			
No. of Species							1311.5	0.288	ns
Reference	147	27	NA	12	9	15.75			
Impact	14	17	NA	14.5	10	17			
Diversity (Shannon-Weiner)							1021.0	0.500	ns
Reference	147	2.034	NA	1.513	1.266	1.82			
Impact	14	1.081	NA	1.536	1.173	1.689			
Pielou's Evenness							927.0	0.215	ns
Reference	147	0.785	NA	0.636	0.538	0.734			
Impact	14	0.41	NA	0.621	0.5	0.671			
Simpson's Dominance							1279.0	0.386	ns
Reference	147	0.762	NA	0.302	0.216	0.409			
Impact	14	0.386	NA	0.315	0.258	0.476			
1A1							1619.5	0.004	<0.01
Reference	147	284	39	0	0	2.75			
Impact	14	68	79	3.5	2	12			
1A2a							1702.5	<0.001	<0.001
Reference	147	3482	68	6	0	54.5			
Impact	14	286	100	111	31	176			
1A2b							843.5	0.082	ns
Reference	147	571	61	1	0	19			
Impact	14	11	43	0	0	2			
1B1							1428	0.077	ns
Reference	147	0	0	0	0	0			
Impact	14	231	29	0	0	5			
1B2							1364	0.168	ns
Reference	147	3	7	0	0	0			
Impact	14	3	29	0	0	1			

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
1C1							1060.5	0.661	ns
Reference	147	87	52	1	0	6			
Impact	14	56	43	0	0	10			
1C2							1331	0.237	ns
Reference	147	36	10	0	0	0			
Impact	14	57	29	0	0	1			
1D							1264.5	0.435	ns
Reference	147	8	15	0	0	0			
Impact	14	2	29	0	0	1			
2A							686.5	0.007	<0.01
Reference	147	28	74	3	0	6			
Impact	14	12	50	0.5	0	1			
2B							654	0.004	<0.01
Reference	147	633	97	66	20	145			
Impact	14	163	93	19	10	30			
2C1a							984.5	0.371	ns
Reference	147	105	70	3	0	12.75			
Impact	14	13	71	2	0	9			
2C2a							1001	0.426	ns
Reference	147	6	13	0	0	0			
Impact	14	0	0	0	0	0			
2C2b							906	0.172	ns
Reference	147	132	71	2	0	11			
Impact	14	12	57	1	0	4			
2C2c							859	0.099	ns
Reference	147	10	33	0	0	1			
Impact	14	1	7	0	0	0			
2C2d							1421.5	0.085	ns
Reference	147	56	49	0	0	2			
Impact	14	13	71	1.5	0	4			
2D1a							1948	<0.001	<0.001
Reference	147	106	92	6	2	13			
Impact	14	571	100	60	31	120			
2D1b							1229	0.571	ns
Reference	147	47	53	1	0	3.75			

Appendix C1 (continued)

Metric	n	Range	%FO	Median	Percentile 25%	Percentile 75%	T	p	Significance
Impact	14	28	64	1.5	0	3			
2D2							872	0.117	ns
Reference	147	48	65	1	0	5			
Impact	14	23	36	0	0	1			