Analysis of Demersal Fish Assemblages in Selected Philippine Fishing Grounds

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Abstract

This paper presents the results of analyses of demersal fish assemblages in various fishing grounds in the Philippines. Data from exploratory trawl surveys conducted in 1947 - 49 show that the 24 fishing grounds covered by the survey can be arranged along a gradient of substrate type (i.e. relative coral cover and sediment characteristics). These may be used to determine the species commonly caught in these grounds. A trend of increasing catch rates with decreasing water depth and increasing proportion of mud in the substrate was noted. Data from more recent systematic surveys in Samar Sea (1979 - 80), San Pedro Bay (1994 - 95) and Manila Bay (1992 - 93) were analyzed to examine spatio-temporal patterns in fish assemblages. In all 3 areas, the fish community was characterized by a large number of ubiquitous species, with Leiognathids comprising at least 28% of the total catch. In terms of habitat relations, depth was the primary factor in Samar Sea and San Pedro Bay, where transitions in fish assemblage composition were recognizable at certain depth ranges. In Manila Bay, however, species composition appears to be more related to location (inner versus outer portions of the bay).

Analysis of data from five locations (Manila Bay, Tayabas Bay, Sorsogon Bay, Samar Sea and San Pedro Bay) extending from the western to the eastern portions of the country showed similar seasonality, with fish assemblage composition varying slightly during the monsoon season.

Introduction

This paper summarizes analyses of data from selected trawl surveys conducted in the Philippines. The trawl data sources include (1) exploratory surveys (1947 - 49) in 24 fishing grounds around the country; (2) systematic trawl surveys in Samar Sea (1979 - 80), San Pedro Bay (1994 - 95) and Manila Bay (1992 - 93); and (3) quasi-systematic surveys for demersal biomass in Tayabas Bay (1994 - 95) and Sorsogon Bay (1994 - 95). Data were analyzed to: identify assemblages of trawl-caught organisms; examine how these are distributed in space and time within the surveyed areas; and determine if the different areas surveyed showed similar patterns. This information, in turn, can help in the delineation of assemblage boundaries and fishing zones applicable to various fishing grounds in the country.

Historical (1947 - 49) data were analyzed to examine the broad pattern of demersal fish assemblages in the country prior to the expansion of the trawl fishery in the mid-1970s. This provides insight into possible changes in the composition of demersal resources since that period, and whether such changes are indicative of ecosystem overfishing as reported in other heavily-fished areas.

Materials and Methods

The initial task of the study was to determine the distribution of demersal assemblages in space and time. Because the surveys had different objectives, there are differences in content and resolution of their information. For example, the exploratory surveys did very limited sampling in each fishing ground. The quasi-systematic surveys consisted of monthly sampling, but because fixed trawl stations were not used, this precluded spatial distribution analyses. Only the systematic surveys (with fixed sampling time intervals and trawl stations) allowed analyses across space and time. It was therefore not possible to employ a standard set of analyses for all the surveys. The general approach in data analyses is described in this section, while analytic details are given in separate sections dealing with the different data sets.

Data from the exploratory surveys were used to characterize the 24 fishing grounds with respect to species group composition and apparent habitat characteristics. Data from the systematic and quasi-systematic surveys were then analyzed to examine potential temporal patterns, and to see if similar patterns occur in different areas of the country. Lastly, data from the systematic trawl surveys were examined for extensive spatial analyses and for comparison between seasons.

Temporal Distribution

The objective here was to determine if any of the areas examined showed seasonality in species composition of the catch (e.g. seasonal differences in species caught in an area or relative abundance of the species). To do this, seasons or time slices (i.e. month groupings) within a year were determined by clustering months based on monthly species abundances (i.e. all stations combined). The resulting seasons then served as the time slices within which spatial distributions were further examined.

Spatial Distribution

The spatial distribution of demersal assemblages was examined at 2 levels: at the annual or within year level, and at the seasonal level. An annual characterization of species assemblages and habitats within each survey area was done by combining all monthly species abundance data for each station and then performing the cluster analysis. At the seasonal level, species abundance data for months in the time slice were combined for each station. The stations were then clustered to show the distribution of habitats within the area.

Internal Analysis

Cluster Analysis

All cluster analyses were executed using **T**wo-**W**ay **IN**dicator **SP**ecies **AN**alysis (TWINSPAN) (Hill, 1979), which produced two-way tables in which the row (species) arrangement corresponds to the species clusters (species assemblages) and the column (sample = station or month) arrangement corresponds to the sample clusters (i.e. stations form habitats, months form seasons). Dendrograms were constructed using the information contained in the output files of the software. These provide a visual presentation of the similarity or dissimilarity between the formed clusters. Ordinations were conducted as a way to verify the clusters formed (see below). Where necessary, a frequency of occurrence of 5 - 10% was used as criteria to limit the number of species included in the analysis. Because of apparent reading errors in the software, all data were first transformed (natural logarithms) and pseudospecies cut levels were then determined from a frequency table of the transformed data.

Ordination Analysis

Ordination of samples (stations or months) in "species space" and "sample space" was performed using Detrended Correspondence Analysis (DCA) in the CANOCO program (Ter Braak 1988). Ordination is a method of plotting samples on a coordinate system representing gradients in species abundance (species space) or plotting species along axes representing station (i.e. habitat) or month (i.e. season) preferences (sample space). These plots reveal how distinct (or indistinct) the TWINSPAN-generated clusters were from each other, or how effective the clustering method was.

External Analysis

External analysis refers to the technique of relating community data to habitat information that is normally not included, and thus external to, the typical samples-by-species data matrix. For the systematic and quasi-systematic trawl surveys, only depth could be extracted (when not recorded) as the habitat factor available for the various stations. It was only with the exploratory surveys that any useful habitat (fishing ground) information other than depth could be extracted, and thus sensibly subjected to external analyses.

Exploratory Trawl Surveys (1947 - 49)

Exploratory trawl fishing in different areas of the country was conducted as part of the Philippine Fishery Program from September 1947 to July 1949 (Warfel and Manacorp 1950). Twenty four areas were surveyed in an effort to explore potential trawling grounds in the country (Fig. 1). Generally, fishing grounds were surveyed only once during the two-year period (Table 1). Two vessels equipped with trawl nets that differed primarily in the length of head and foot ropes were used during the surveys. A total of 228 tows were attempted, 70% of which were successful. The rest were aborted because of underwater obstructions. In 16 of the 24 areas surveyed, at least 3 tows were made.

The semi-processed data are available in (Warfel and Manacorp 1950) as catch per hour of trawling (all tows in an area combined). Although the catch information in several fishing grounds reflects only 1 or 2 tows, all 24 fishing grounds were used in the analysis in an effort to maximize the use of the data. Catches were listed by families in $kg \cdot hr^{-1}$ units. In addition to catch data, information on total (surface) area, average depth, and general bottom characteristics were also reported (Table 1). Substrate information was based on observations recorded in the various fishing grounds during the surveys.

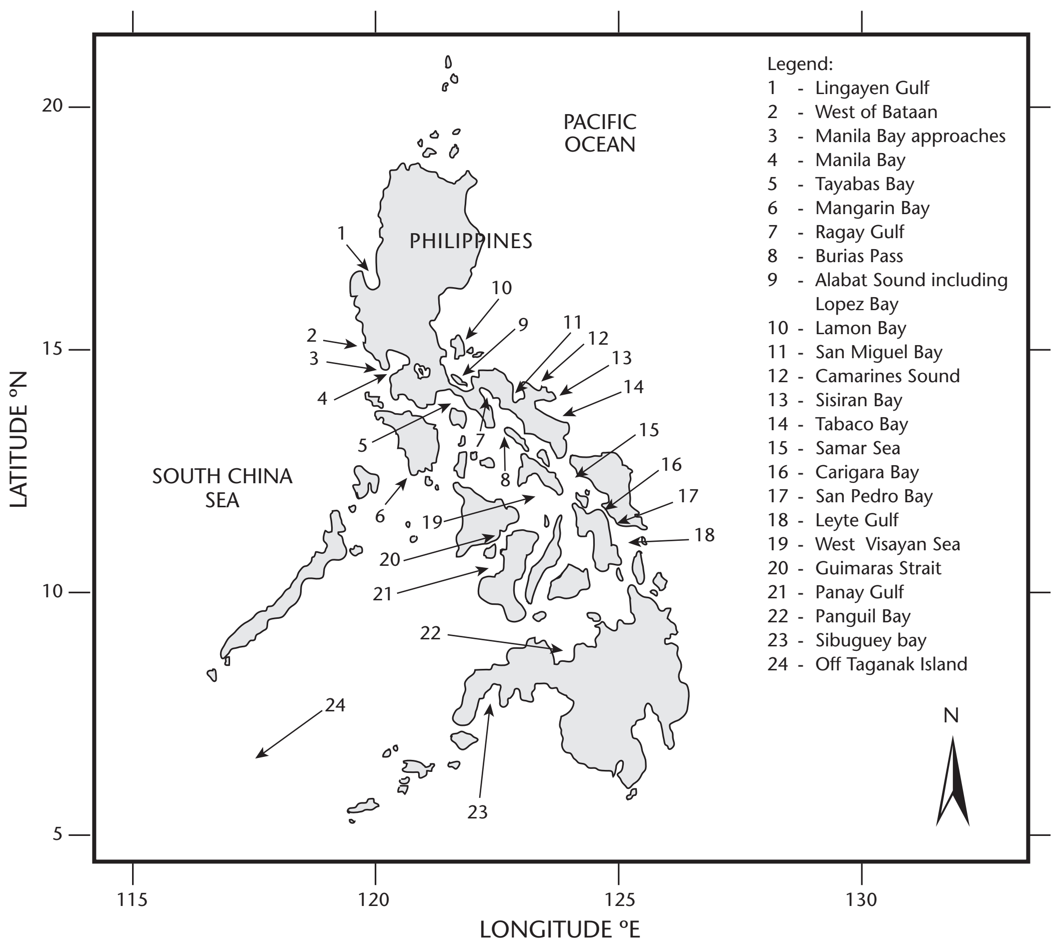


Fig. 1. Locations of the 24 fishing grounds covered during exploratory trawl surveys in 1947 - 49 (Warfel Manacop 1950).

Table 1. Catch and related data for the 24 fishing grounds covered during exploratory trawl surveys from 1947 to 1949 (Warfel and Manacorp 1950).

Area	Fishing ground	Survey dates	Surface area (km^2)	Average depth (m)	Mud & sand[a]	Coral cover[b]	CPUE ($kg \cdot hr^{-1}$)
1.	Lingayen Gulf	Feb - April 1949	1 482	45.8	2	1	67.7
2.	West of Bataan	Oct.1947, Oct. 1948	390	45.8	3	2	11.4
3.	Manila Bay approaches	Oct. to Nov. 1947	520	64.1	3	1	44.1
4.	Manila Bay	Sept. & Nov. 1947	1 352	27.5	2	4	33.6
5.	Tayabas Bay	Nov. 1948	910	64.1	1	5	59.5
6.	Mangarin Bay	Sept. 1948	26	366.0	2	4	40.5
7.	Ragay Gulf	Nov. 1948	1 820	164.7	2	1.5	66.4
8.	Burias Pass	Nov. 1948	520	82.4	1	4	80.0
9.	Lopez Bay	Jul. 1948	481	40.3	1	4	71.8
10.	Lamon Bay	Jul. 1948	2 080	69.5	1	5	136.4
11.	San Miguel Bay	Jul. 1948	520	12.8	1	0	289.1
12.	Camarines Sound	Jul. 1948	4 680	54.9	2	5	59.5
13.	Sisiran Bay	Jul. 1948	52	9.2	1	5	219.1
14.	Tabaco Bay	Jun. 1948	130	73.2	1	4	12.3
15.	Samar Sea	Aug. 1949	780	27.5	2	0	41.8
16.	Carigara Bay	Aug. 1949	520	45.8	2	0	177.3
17.	San Pedro Bay	Aug. 1949	286	14.6	2	4	67.3
18.	Leyte Gulf	Aug. 1949	27	69.5	2	1	27.7
19.	West Visayan Sea	Sept. 1948	650	27.5	1	5	279.5
20.	Guimaras Strait	Aug. and Dec.1948	2 080	18.3	1	4	236.4
21.	Panay Gulf	Jan. and Aug. 1948	520	32.9	1	4	198.5
22.	Panguil Bay	Jul. 1948	377	36.6	1	0	17.7
23.	Sibuguey Bay	Oct. 1949	1 560	32.9	2	4	50.0
24.	Off Taganak Island	Sept. 1949	5 200	36.6	2	5	19.1

Note: [a] Mud & sand scale: 1 = muddy, 2 = mud-sand, 3 = sand-mud, 4 = sand
[b] Coral cover scale: 1 = patchy heads, 2 = scattered corals, 3 = numerous heads, 4 = large coral heads, 5 = fringing reefs & numerous heads

Fishing grounds were first clustered based on catch abundance of 26 species groups (families) using TWINSPAN. The resulting clusters (species groups and fishing grounds) were then analyzed using Canonical Correspondence Analysis (CCA) in CANOCO and Discriminant Analysis (DA) in STATISTICA, in an attempt to examine habitat relations (external analysis).

Systematic & Quasi-systematic Surveys

These included data from surveys involving fixed stations sampled over regular time intervals (Samar Sea, Manila Bay and San Pedro Bay) and data from surveys involving only randomly-chosen trawling sites sampled monthly to determine stock biomass (Tayabas Bay and Sorsogan Bay). Information pertinent to the systematic trawl survey areas and their respective sampling schemes are shown in Table 2. The location of the surveyed areas are shown in Fig. 2.

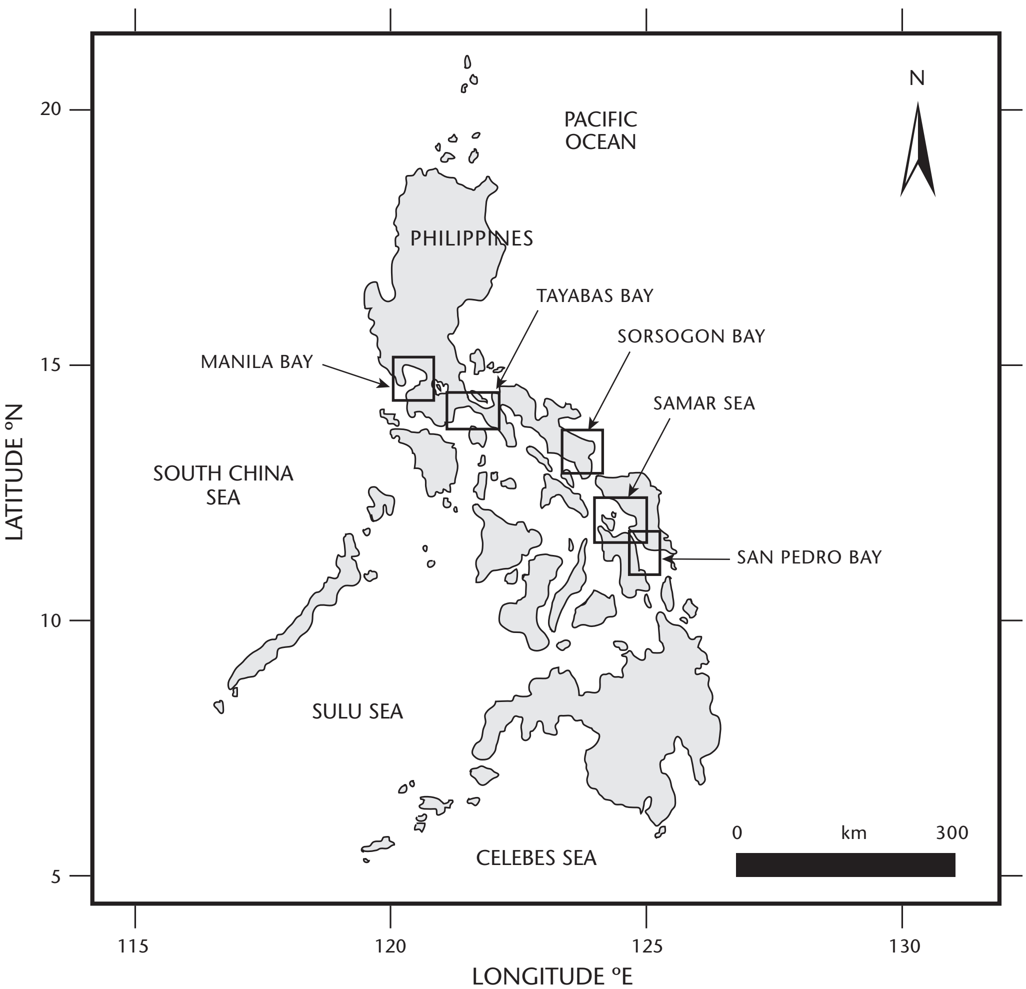


Fig. 2. Locations of areas covered by systematic and quasi-systematic trawl surveys used in the study.

Table 2. Information on systematic trawl survey areas and sampling schemes.

	Samar Sea	San Pedro Bay	Manila Bay	Sorsogon Bay	Tayabas Bay
Surface area (km²)	3 049	625	1 782	256	1 800[d]
Coordinates North Latitude East Longitude	 12º 00′ 00″ 124º 40′ 00″	 11º 05′ 30″ to 11º 17′ 30″ 125º 00′ 00″ to 125º 14′ 00″	 14º 15′ 00″ to 14º 50′ 00″ 120º 30′ 00″ to 121º 00″ 00′	 12º 51′ 00″ to 12º 58.5′ 00″ 123º 51′ 00″ to 124º 03′ 00″	 13º 15′ 00″ to 14º 00′ 00″ 121º 18′ 00″ to 122º 30′ 00″
Sampling period No. of Stations No. of Months	Mar 79 - May 80 28 11[a]	Jun 94 - May 95 13[b] 12	Nov 92 - Oct 93 16 6	Apr 94 - Jan 95 10[c] 10	Oct 94 - Jun 95 8 9
Fishing vessel	TRV Albacore	F/B Tristan Dos & F/B Roselle	Commercial fishing boat	Mini-trawler	Commercial fishing boat
Type	Steel Hull	With outriggers	With outriggers	With outriggers	With outriggers
Overall length (m)	31.60	15.20 / 17.80	13.50	6.0	–
Breadth (m)	7.00	1.50 / 1.82	1.20		–
Depth (m)	3.20	1.45 / 1.10	1.48	0.5	–
Engine	600 HP	185 HP / 145 HP	Fuzo 4DR5	16HP Gasoline	–
Sampling gear	High opening bottom trawl	Two-seamed net	Otter trawl	Two-seamed net	–
Head-rope (m)	48.80	28.00 / 26.00	15.40	6.0	14.0[e]
Ground-rope (m)	55.0		15.52	6.8	–
Cod-end mesh size (mm)	200	200 / 200	220	117	–
Reference	Armada et al. (1983)	Armada (1996)	MADECOR (Mandala Agricultural Development Corporation) and National Museum (1995)	Cinco and Perez (1996)	Resources Combines Incorporated (1997)

Note: [a] **Survey suspended from Oct 79 to Jan 80**
[b] **3 out of original 16 stations with incomplete data**
[c] **Not all stations were sampled regularly. In some months, hauls at some unspecified stations were unsuccessful.**
[d] **Surface area of the bay estimated from nautical chart and includes a large portion (~ 30%) with depths > 200m**
[e] **Head-rope estimated from raising factors used in deriving biomass estimates from CPUE ($kg \cdot h^{-1}$) estimates.**

For the systematic trawl surveys, both spatial and temporal distributions of species and samples were analyzed. For samples, station clusters reflect (spatial) habitats, while month clusters (temporal-annual) reflect seasons of the species clusters (species assemblages) formed. To examine seasonality in the distribution of species and habitats (temporal-seasonal), spatial analyses were also conducted within each time slice formed in the temporal annual analyses.

In the case of quasi-systematic surveys, only temporal analyses could be done, since sampling stations were randomly chosen in each sampling period. This allowed a comparison of seasons (i.e. formed by month clusters based on temporal species occurrences and abundances) among different areas of the country.

Results

Exploratory Trawl Survey (1947 - 49)

The two-way table formed by the resulting clusters of families and fishing grounds is shown in Fig. 3. The families formed 2 broad groups. One is uncommon or even absent in (the first 2 groups of) fishing grounds, where the substrate is a mixture of mud and sand, with low to moderate coral cover. The other broad group is relatively common in these grounds, and includes typical soft-bottom demersal families, such as Sciaenidae, Gerreidae, Synodontidae, Psettodidae and Nemipteridae. Species clusters 4 and 5 were most frequently recorded in fishing grounds with sandy substrate and coral cover ranging from low to high. These include common reef groups such as Sphyraenidae, Pomadasyidae, Serranidae and Lutjanidae.

Figure 4 shows the clustering of fishing grounds superimposed on a map of the country. Figs. 5a and b show the CCA plots of the fishing ground and species group clusters formed by the cluster analyses, while Fig. 5c shows the plot of environmental factors in the same ordination space. Figure 6 shows the 24 areas in environmental space, based on canonical roots resulting from discriminant analysis. The results of the latter, while not allowing direct correlations with habitat factors, are nevertheless consistent with those suggested by the clusters and by the CCA. It thus appears that the 24 areas can be arranged in gradients reflecting their substrate make-up (i.e. relative coral cover and sediment characteristics), which in turn somewhat determines the kind of species commonly caught in them. These characteristics however do not discount the importance of other factors such as water depth. Catch rate ($kg \cdot hr^{-1}$) was negatively correlated with both average water depth (-0.48, $p < 0.05$) and mud/sand substrate (-0.51, $p < 0.05$), and reflects an underlying trend of increasing catch rates in areas with shallower and more muddy bottoms. This is also consistent with the distribution of the more abundant families in the catches (e.g. Leiognathidae, Mullidae).

		1 11	1	22 112	1122	11	
		745909	1463	0123853	1624	827	
15	Menidae	------	-1--	331---1	----	---	0000
25	Polynemidae	------	1---	33-1---	-3--	---	0000
19	Pristidae	------	----	1-----4	442-	---	00010
2	Rhinobatidae	------	1---	-----1-	4---	---	00011
6	Drepanidae	1-1---	1---	4------	3---	---	00011
8	Drosomidae	------	122-	23---1-	3-3-	---	00011
13	Scombridae	------	-2--	3--1-1-	3---	---	00011
1	Sphyraenidae	3--2-4	12--	22131-2	3---	---	001
5	Trichiuridae	-----2	14-4	34-334-	1-3-	---	001
18	Pomadasyidae	--42-4	333-	4--2-22	4-2-	---	001
7	Myliobatidae	------	1---	-------	----	---	010
9	Serranidae	1-11-1	2223	2--2211	----	---	010
11	Lactariidae	---2--	21-4	1------	----	---	010
22	Leiognathidae	414444	4443	4333324	4343	2--	011
23	Lutjanidae	-23444	3314	4314211	----	-1-	011
4	Sciaenidae	413444	12-4	3433---	3---	12-	100
14	Gerreidae	3-3442	123-	2--1-11	----	1--	100
3	Carangidae	4121-2	22--	3333233	34-3	3--	101
12	Synodontidae	4243-3	4323	2222232	34--	12-	101
26	Psettodidae	3331--	2212	3-11133	-233	11-	101
21	Galeidae	---2--	----	2-12322	2---	-1-	110
10	Theraponidae	2-2323	---4	3---223	141-	--3	1110
16	Mullidae	43-4-4	12-4	44-4223	3---	-4-	1110
17	Nemipteridae	431--4	3322	1213-32	----	22-	1110
20	Ariidae	-----3	12-4	33-1-23	33-3	3--	1110
24	Dasyatidae	------	2--4	4--4424	-1--	444	1111
		000000	0000	0000000	0000	111	
		000000	0000	1111111	1111		
		000000	1111	0000000	1111		
		001111		0011111			
				00011			

Spp cluster 3

> Infrequent occurrences & in moderate abundances in sandy substrate

> Except for San Miguel bay, rare to absent around the Bicol Peninsula

Spp cluster 4

> Moderately abundances & frequent in mud/sand & coral substrate

Spp cluster 5

> Loose group including largely ubiquitous & abundant spp, & reef spp commonly absent in fishing ground clusters 1 & 2

Spp cluster 2

> Common in most grounds

> Most abundant in muddy substrate with some corals

Spp cluster 1

> Frequent in most grounds

> Most common in ground cluster 3

Fishing ground cluster 1

- Muddy to sand substrate with moderate coral cover
- On relatively wide shelf areas

Fishing ground cluster 2

- Mud/sand substrate with little or no coral

Fishing ground cluster 3

- Mostly sandy substrate with scattered corals
- Areas bordering deep open waters or in channels leading thereto

Fishing ground cluster 4

- Muddy to sandy substrate with moderate to high coral cover

Fishing ground cluster 5

- Primarily muddy bottom with moderate to high coral cover
- Vicinity of Bicol

Fig. 3. Two-way table of TWINSPAN results for data from 24 fishing grounds (26 species groups) around the Philippines.

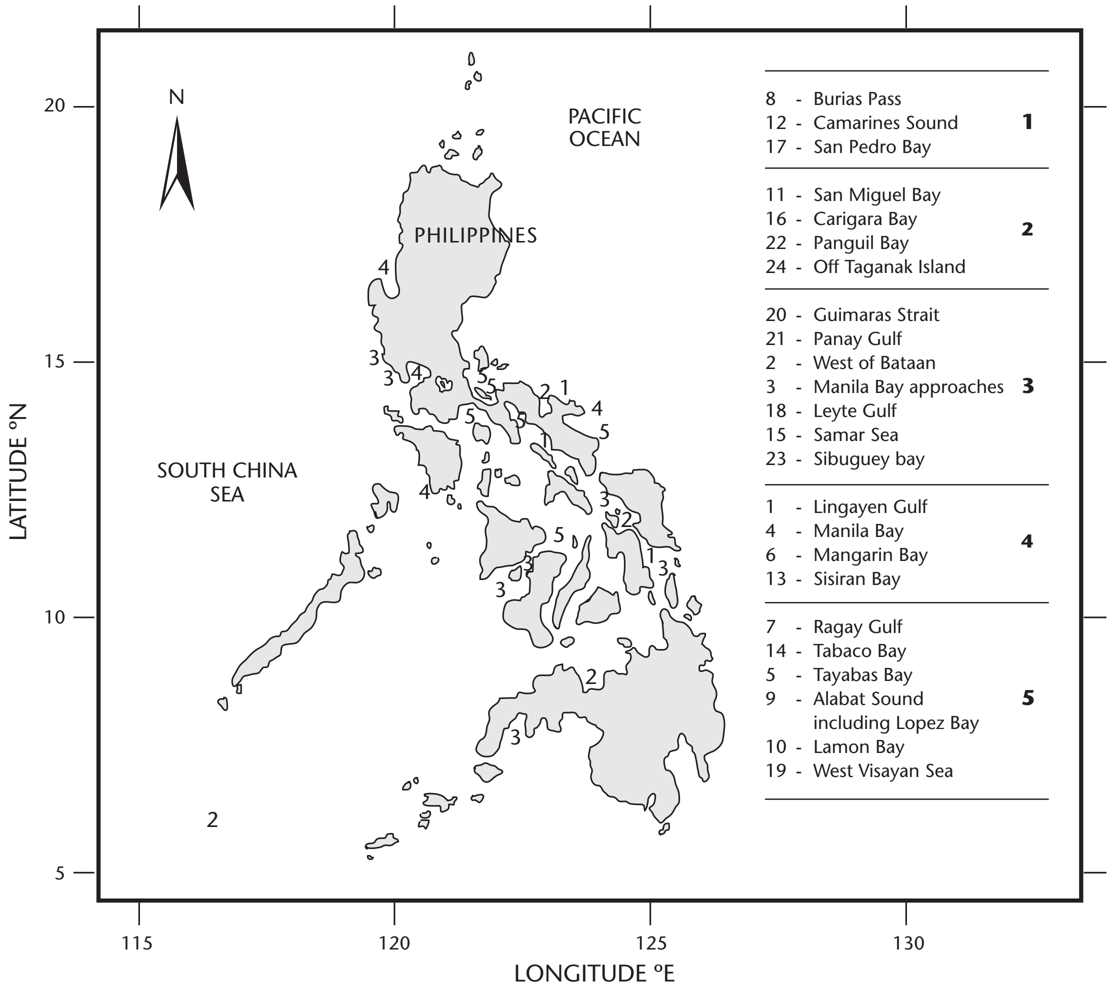


Fig. 4. Map showing the location of fishing ground clusters formed in the analyses of data from Warfel and Manacop (1950).

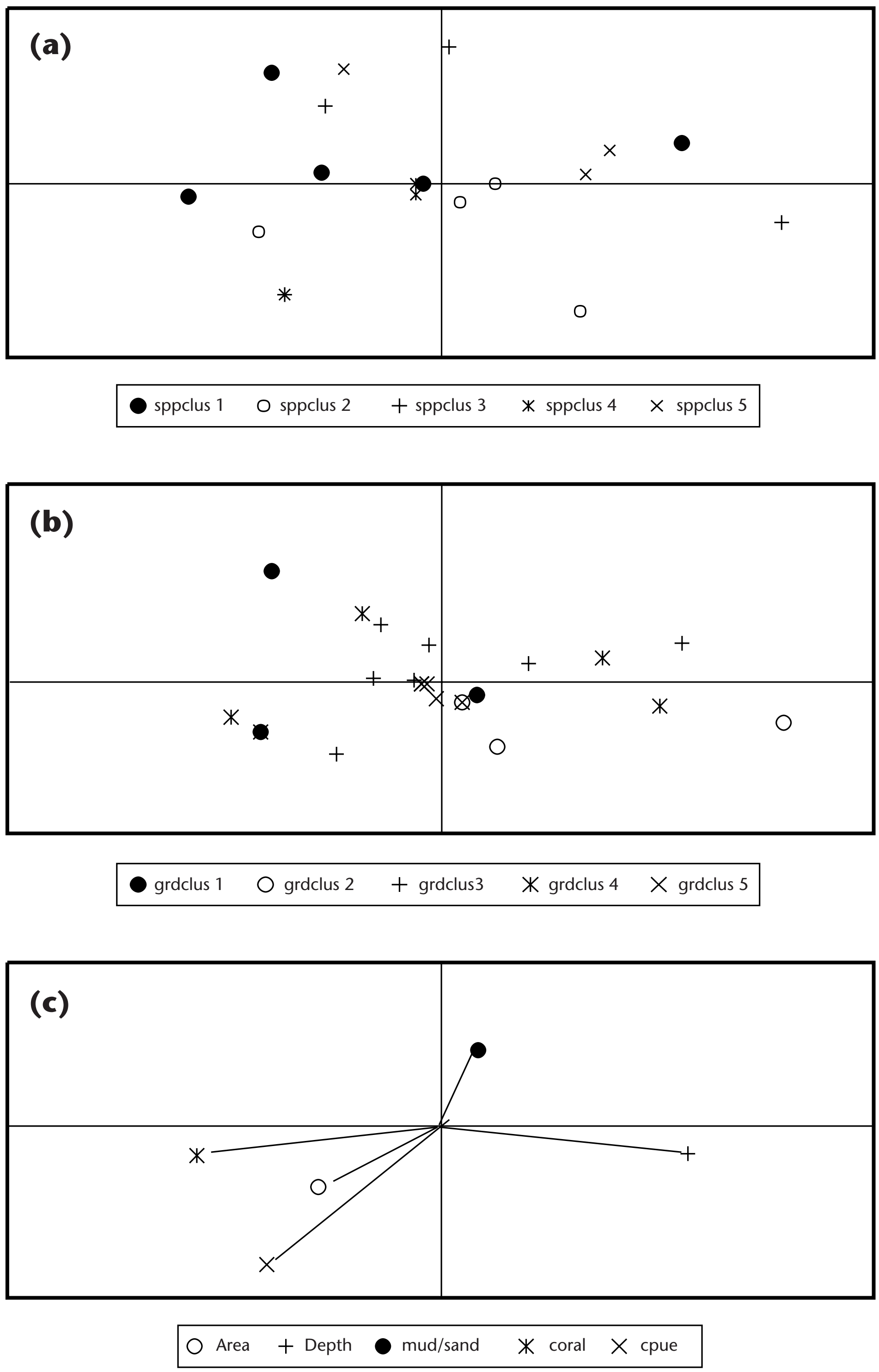


Fig. 5. (a) CCA plot of fishing ground clusters, (b) species group clusters, and (c) environmental factors for the 24 areas sampled during the exploratory surveys in 1947 - 49. The x and y axes are CCA Axes 1 and 2, respectively. In (a) and (b), the various symbols refer to the different species group or fishing ground clusters formed by the cluster analysis.

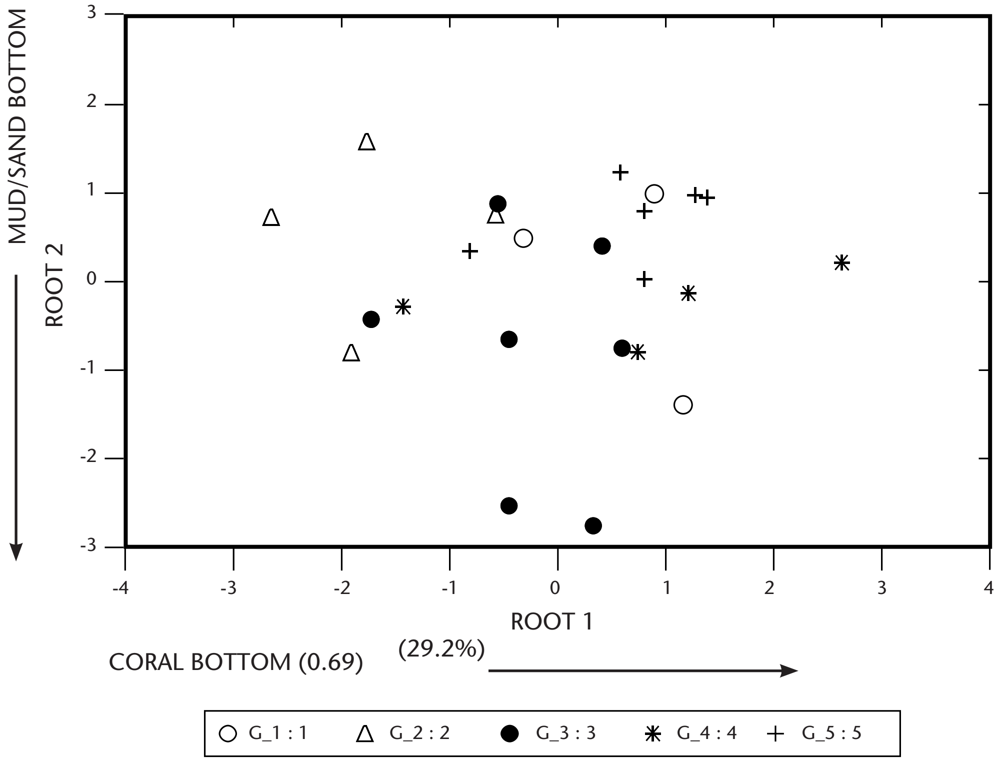


Fig. 6. Plot of 24 fishing grounds (cluster membership shown in legend at lower right of figure) in environmental space (i.e. canonical roots derived by discriminant analysis). Percentages refer to portion of total variation in the data accounted for by each root. Roots are defined by variables showing the highest correlations (in parentheses) with them.

Systematic and Quasi-systematic Trawl Surveys

Generally, the demersal resources in Manila Bay, San Pedro Bay and Samar Sea are characterized by a large number of ubiquitous species that occur in varying abundances across the different habitats in the areas surveyed. In all three areas leiognathids comprised at least 28% of the total trawl catches, and together with squid (*Loligo* spp) comprised up to 59% of the total catch (Tables 3 - 5).

In terms of habitat relations, depth appears to be the primary factor in San Pedro Bay and Samar Sea. In San Pedro Bay, catch species composition shows a transition at depths of 15 - 20 m (Figs. 7 & 8). This depth range transition is also consistent throughout the year. Temporal analysis of the data showed the following grouping of months: June - July, August - November, and December - May; roughly corresponding to the monsoon and inter-monsoon seasons. The spatial distributions of station clusters during the SW monsoon and inter-monsoon seasons show little variation from the overall annual pattern (Fig. 8), particularly the transition in species assemblage distribution at the 15 - 20 m depth range.

Similarly, demersal assemblage composition in Samar Sea shows a transition at the 30 - 40 m depth range, and again at the depths of 50 - 60 m, with further differences in composition between inner (southern) and outer (northern) stations in deeper areas (Figs. 9 & 10). As in San Pedro Bay, the results of the temporal analysis again closely paralleled the monsoon and inter-monsoon seasons; April - June, July - October, and February - June. Spatial analysis within each season showed close similarities with the overall annual pattern, with the depth range transition in species assemblages remaining constant all year round but also with some intensification of the inner-outer differences in station clustering towards and during the southwest monsoon season.

Manila Bay shows a different pattern, since changes in species composition appear to be more related to location (i.e. inner or outer portions) than to depth (Figs. 11 & 12). In both inner and outer portions there are also qualitative differences in species composition between the western and eastern halves of the bay (Fig. 12). Again, similar to the previous two areas, this general annual pattern is shown throughout the year, although some seasonal differences in the delimitation of inner and outer portions of the bay are evident. Whether such variations are the result of factors like local hydrography, bay topography, watershed characteristics or fishing effort distribution is not known, but it would be interesting to investigate further. The temporal pattern in Manila Bay shows a clear correspondence with the Northeast (November - March) and Southwest (May - September) monsoon seasons.

In all of the above three areas, seasonality or within-year differences in species distribution and composition reflect the monsoon and inter-monsoon systems. This is also shown in the results of the temporal analysis of data from Sorsogon Bay and Tayabas Bay (Figs. 13 & 14). In Sorsogon Bay, the grouping of months are April - July, August - November, and December - February. In Tayabas Bay, the transition months June, October and December grouped together, while the regular monsoons were formed by the remaining months. The question of possible differences in the effects of the monsoon systems on the distribution of demersal resources in different portions of the country (e.g. South China Sea coast, interisland waters and Pacific coast) still remains. This may be addressed when sufficient data for the different regions become available.

Table 3. Most abundant trawl-caught species in Samar Sea, 1979 - 80.

Species	% of total catch
Leiognathus bindus	25.30
Loligo sp.	5.93
Pentaprion longimanus	5.93
Saurida undosquamis	4.70
Saurida tumbil	3.60
Upeneus sulphureus	3.10
Nemipterus nematophorus	3.10
Leiognathus splendens	2.84
Rastrelliger brachysoma	2.74
Decapterus macrosoma	2.63
Apogon spp.	2.30
Sepia sp.	2.27
Leiognathus equulus	2.22
*Trichiurus haumela (T. lepturus)**	2.22
Rastrelliger kanagurta	2.01
*Sphoeroides lunaris (Lagocephalus lunaris)**	1.95
Priacanthus macracanthus	1.76
Priacanthus tayenus	1.73
Fistularia spp.	1.70
Stolephorus indicus	1.31

* Valid name in Fish Base

Table 4. Most abundant trawl-caught species in San Pedro Bay, 1994 - 95.

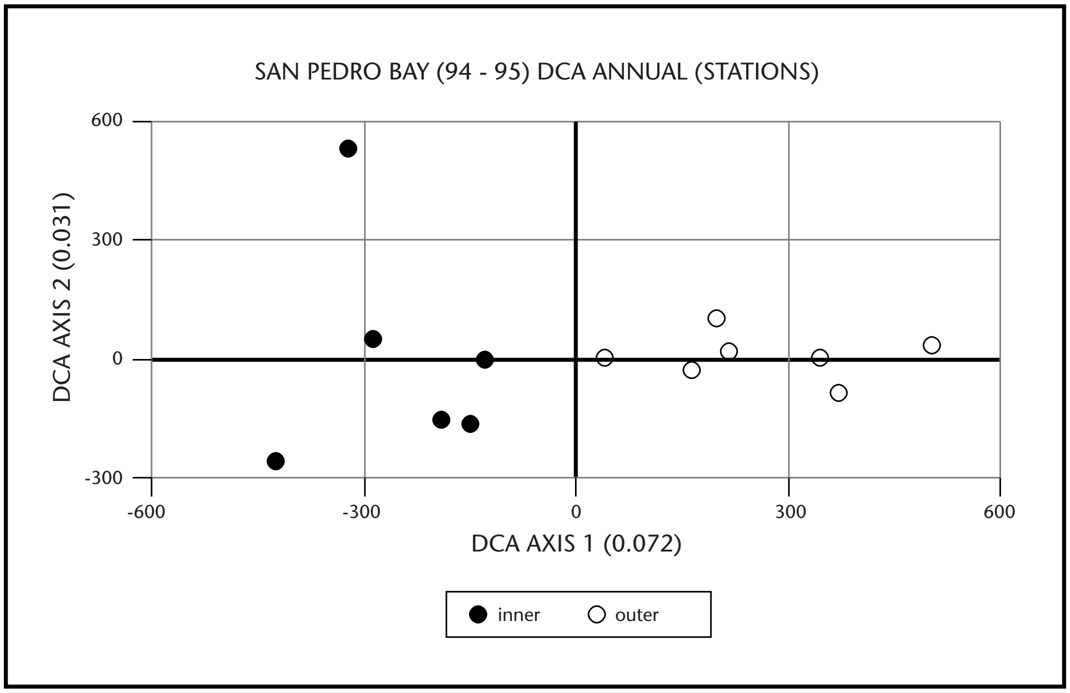
Species	% of total catch
Leiognathus splendens	26.18
Leiognathus bindus	17.43
Gazza minuta	6.54
Secutor ruconius	4.51
Leiognathus equulus	3.64
Dussumieria acuta	3.01
Loligo sp.	2.39
*Gerres abbreviatus (G. erythrourus)**	2.21
Nemipterus hexodon	2.18
Saurida tumbil	2.02
Leiognathus leuciscus	1.93
*Trichiurius haumela (T. lepturus)**	1.86
Apogonidae	1.58
Secutor insidiator	1.49
Selariodes leptolepis	1.30
*Stolephorus commersoni (S. commersonii)**	1.21
Holothuridae	0.99
Pentaprion longimanus	0.97
Sardinella gibbosa	0.78
Scolopsis taeniopterus	0.75

* Valid name in Fish Base

Table 5. Most abundant trawl-caught fishes in Manila Bay, 1992 - 93.

Species	% of total catch
Loligo sp.	22.70
Secutor insidiator	12.61
Leiognathus bindus	10.31
Gazza minuta	5.38
*Trichiurus haumela (T. lepturus)**	3.25
Thryssa setirostris	2.49
*Stolephorus bataviensis (S. waitei)**	2.37
Gerres filamentosus	2.29
Atule mate	2.24
Stolephorus indicus	2.06
Valamugil seheli	2.04
Apogon sp.	1.98
Pelates quadrilineatus	1.89
Upeneus tragula	1.65
Stolephorus commersonii	1.61
Stolephorus sp.	1.54
Sardinella fimbriata	1.51
*Caranx malabaricus (Carangoides malabaricus)**	1.41
*Pennahia macrophthalmus (P. anea)**	1.32
Arothron stellatus	1.22

* Valid name in Fish Base



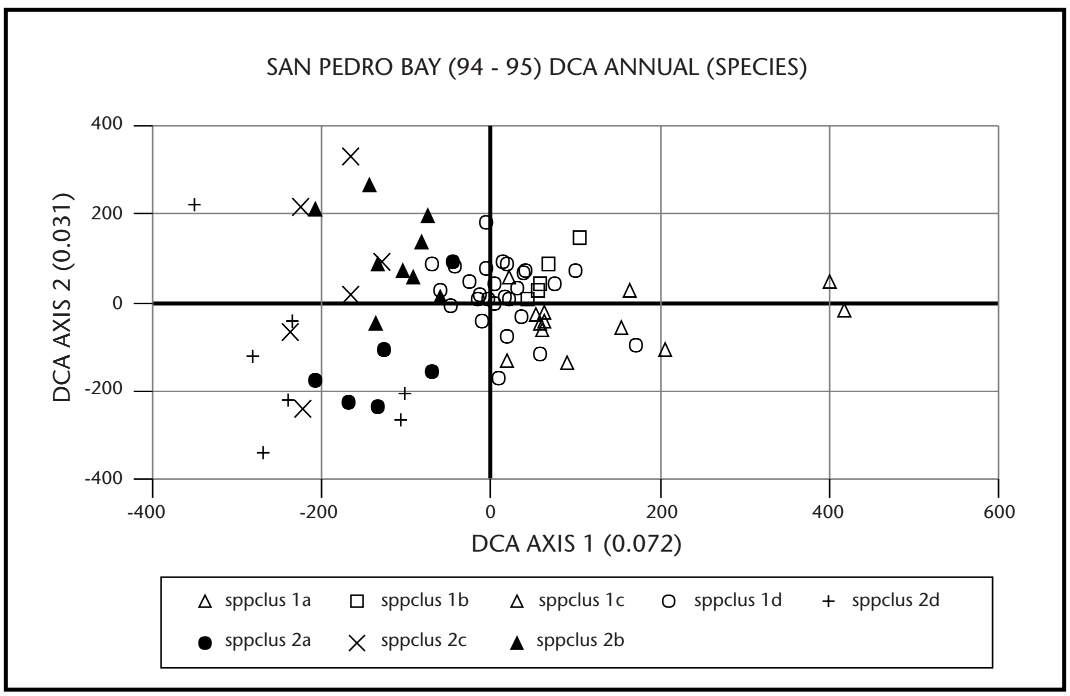


Fig. 7. Ordination of stations (above) and species (below) in the spatial analysis of San Pedro Bay data.

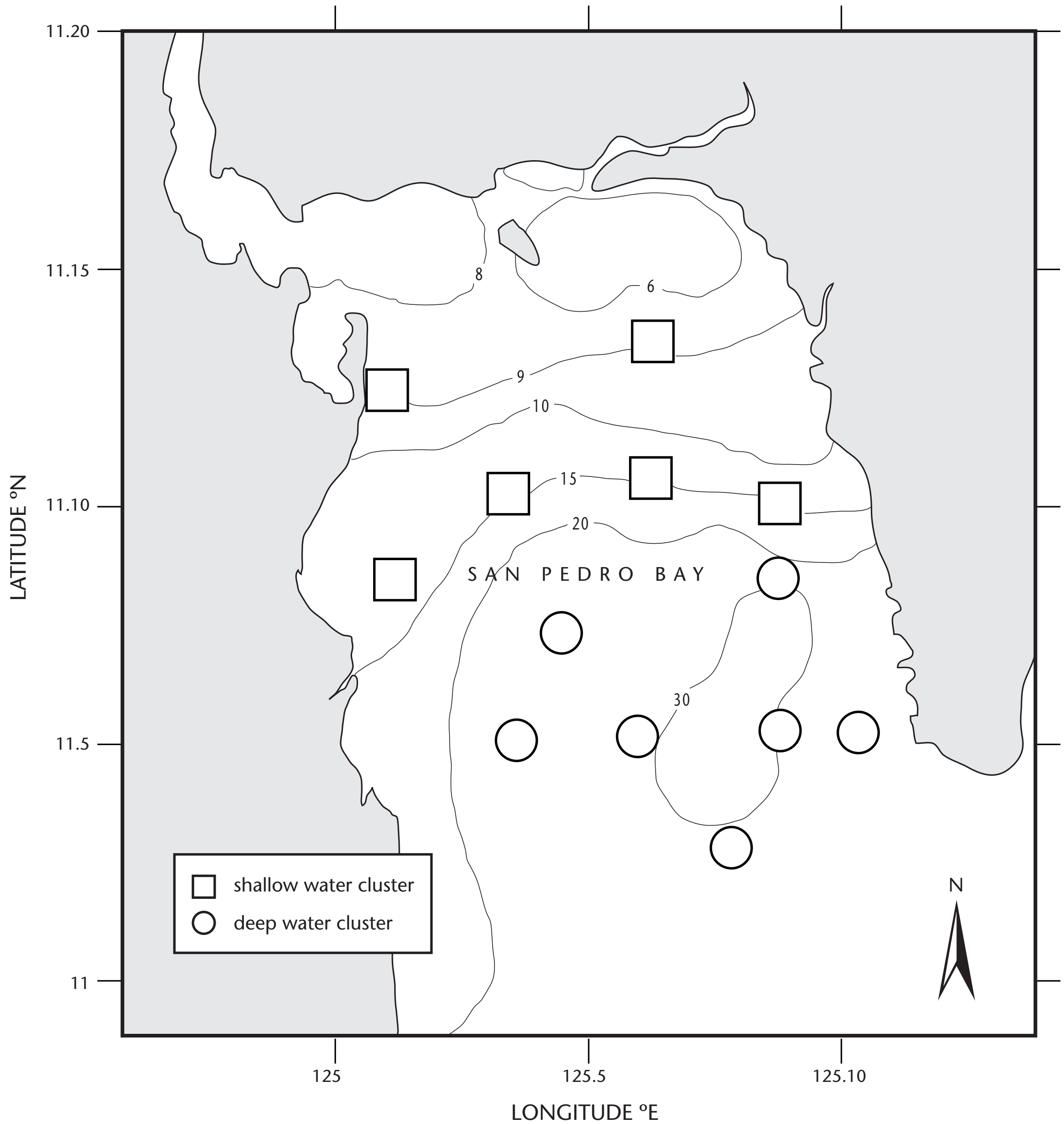


Fig. 8. Map of station cluster locations in San Pedro Bay based on the annual spatial analysis. Isobaths are in meters.

			Outer Deep	Inner Deep	Outer Shallow	Inner Shallow	
			11 1 112	122222	12 2	12 11	
			13890567490	281567	52344	283176	
4	Brac	spp	33332122322	322112	–1–1–	––––––	000
47	Trig		54111111344	442234	–1––1	––––––	000
22	Nemi	nem	55544445444	544244	23343	–22––1	001
25	Pria	mac	54443355444	442223	32–41	–1–––2	001
28	Pter	spp	2223–212232	332333	–1322	1–––2–	001
50	Urab	spp	33212222112	431223	3–111	11––––	001
2	Alut	mon	22–1221–122	333334	32113	–1––13	010
8	Deca	mac	53343222223	242444	21–32	133–25	01100
11	Fist	spp	44443444444	453344	33333	332–22	01100
10	Epin	sex	2223–333333	342334	31332	–22113	01101
23	Pent	lon	54554433444	554555	45445	333122	01101
34	Saur	und	45554455555	444334	44443	442333	01101
51	Uras	hel	2133–333222	332222	3233–	211–12	01101
9	Elat	spp	––1–3323122	13221	33232	111113	011100
26	Pria	tay	44333444444	344344	44444	224233	011100
35	Scol	tae	2–332224212	–22433	33334	123122	011100
43	Sphy	lan	31–43311–12	231122	12224	2121––	011100
3	Apog	spp	44443444444	444444	44443	443344	011101
7	Cham	spp	3232–222222	222122	23232	221221	011101
13	Leio	bin	65555555455	555655	45555	544343	011101
17	Loli	spp	54443444444	454544	54545	554555	011101
18	Natn	sp	21121111122	211122	11131	111222	011101
19	Nemi	bat	–133–222212	–33333	23222	3231–2	011101
21	Nemi	jap	43333333433	333223	43432	433444	011101
24	Plat	spp	33121222212	4–1121	12222	231332	011101
27	Pset	eru	322–22–1222	31332	––222	33212–	011101
29	Rast	bra	24334353344	344444	45444	335334	011101
30	Rast	kan	33423432545	2–1343	42453	443343	011101
32	Sard	sam	2231–232222	122333	23212	233343	011101
33	Saur	tum	45544445444	444444	44444	444444	011101
39	Sepi	spp	44442444444	444434	44453	444344	011101
40	Seri	nig	4234–323222	332312	13332	222311	011101
41	Spho	lun	44442444444	443333	43443	343444	011101
45	Stol	ind	32233434334	423344	44442	433344	011101
46	Tric	hau	34332333332	415225	54353	432443	011101
48	Upen	sul	444–2444444	544454	34444	444443	011101
5	Cara	mal	2122–312–21	332332	23323	121232	01111
31	Rept	3	3211–1–2333	31323	33113	132133	0111
36	Scom	com	–––2–313132	–13442	33333	343433	1000
37	Sela	mat	–4–––432222	–22432	33344	333132	1000
38	Sela	lep	–2–3–321333	133433	34434	444433	1000
49	Upen	sun	11–2–322232	343323	33233	233333	1000
20	Nemi	hex	11332122111	23–333	33323	333333	1001
42	Sphy	jel	32–1––––312	333–44	2–222	323333	1001
44	Sphy	obt	21––211221–	412223	23–34	223322	1001
1	Alep	dje	–––––23–112	1–3332	32452	234432	101
15	Leio	leu	431––2112––	3–1332	43434	432423	101
6	Cara	arm	11–––222211	–12221	22332	333332	11
12	Gerr	kap	–1–––1111–1	–1––––	32342	233434	11
14	Leio	equ	–––––––11–2	2222–2	44454	444544	11
16	Leio	spl	–––––––11––	–1––––	43553	354545	11
			00000000000	000000	11111	111111	
			00000000000	111111	00000	111111	
			00111111111	001111	00111	000001	
			000111111			00011	
			000111				

Fig. 9. Two-way table output for annual spatial analysis of Samar Sea data.

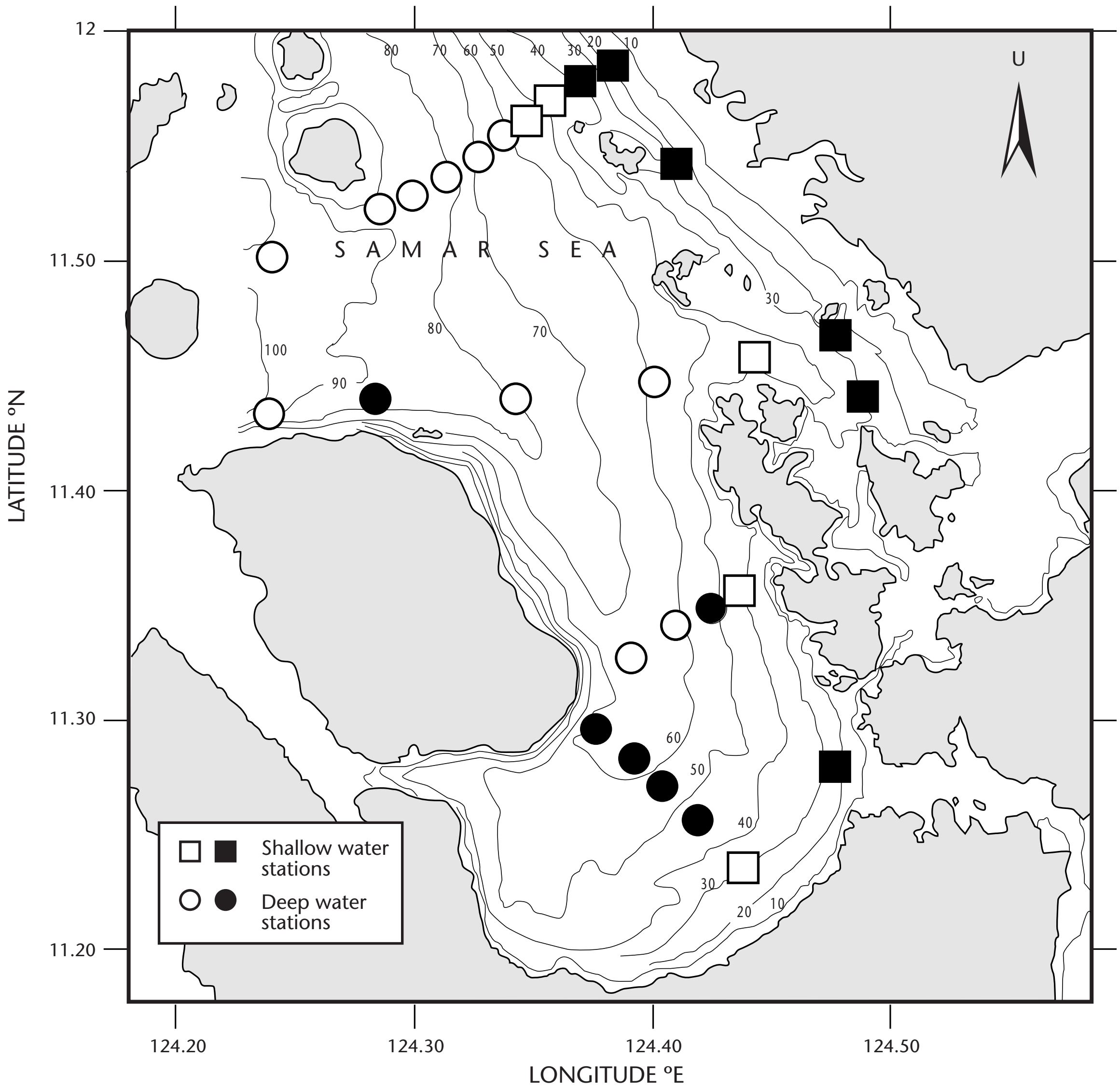


Fig. 10. Map of station cluster locations in Samar Sea for the entire study period, March 1979 - May 1980 (annual spatial analysis). Isobaths are in meters.

		Inner		Outer		
		111 012	578961	234	1111 3456	
3	Mugicep	244	–––––2	–––	–––1	000
14	Scomcom	––1	–12232	–––	1–––	000
16	Eleutet	334	–33211	–––	–––1	000
32	Stolbat	556	265537	–––	––––	000
27	Sciaenid	614	2–662–	–––	1–12	0010
28	Stoltri	444	66656–	––6	3–––	0010
37	Stolcom	677	544645	35–	2–––	00110
39	Pennmac	456	343442	–1–	2–44	00110
43	Sillsih	433	431343	131	–––2	00110
44	Thryset	654	464454	–46	1–1–	00110
23	Nemanas	445	–432––	–––	––32	00111
25	Valaseh	466	22–2–2	222	––––	00111
17	Stolepho	756	–––5–7	64–	––––	010
18	Therjar	122	––11–2	–21	–––1	010
22	Lagoine	333	2––213	–2–	–4–1	010
35	Leiospl	444	1–––33	344	–––2	010
34	Alepmel	222	–41232	322	–––2	01100
46	Sardfim	447	244324	343	–––4	01100
48	Atulmat	443	353451	–23	2144	01100
54	Gerrfil	655	454444	243	––44	01100
36	Pelaqua	231	222241	–21	–136	011010
50	Caramal	334	442343	244	134–	011010
51	Penaeus	444	343344	133	3–43	011010
2	Megacyp	–1–	–1–2––	–1–	––2–	011011
42	Nemijap	2––	232343	–13	2–34	011011
45	Upensul	122	13–353	332	––43	011011
55	Trichau	432	444645	255	4255	011011
56	Secinsi	644	476567	777	1464	011011
57	Loligos	655	666766	566	5466	011011
9	Rastkan	2––	331–––	–21	––1–	0111
11	Gobiidae	–12	22––3–	––1	1–2–	0111
12	Platycep	–11	–3111–	–––	–2–2	0111
6	Valamugi	–12	––––22	–22	––––	1000
7	Caraarm	–––	––2222	–42	––––	1000
26	Scatarg	–––	2–1–12	132	–––1	10010
38	Leioequ	11–	221–24	344	–––2	10010
10	Sphyfor	–1–	–––124	122	–4––	10011
20	Caradin	–––	–31211	–3–	–13–	10011
49	Gazzmin	244	442464	464	2434	10011
53	Apogons	233	543356	236	5655	10011
19	Sphyjel	––2	1112–2	–––	–234	1010
21	Alecind	2––	2–211–	–2–	2–32	1010
31	Squilla	––2	2–1–53	–22	2343	1010
8	Pomamac	–2–	––––21	–12	––12	1011
29	Sphybar	322	–221––	22–	–132	1011
47	Crabs	142	111111	111	3332	1011
33	Stolind	–––	–6–––6	254	––46	11000
40	Selalep	–––	–4–14–	453	2–42	11000
41	Leioleu	21–	232342	653	–334	11000
1	Aleccil	11–	1–––––	–3–	––2–	11001
24	Tetraodo	11–	–211–1	223	–2–2	11001
30	Saurtum	–1–	11–––2	332	––3–	11001
52	Leiobin	–2–	5–2342	–67	5776	1101
4	Pentlon	–––	––––––	––1	–424	111
5	Pomacent	–––	––––––	3––	–4––	111
13	Priatay	–––	–––––1	233	2–2–	111
15	Upentra	–––	––––––	21–	–62–	111
		000 000	000000 111111 000001 00001	111 000	1111 1111	

Spp cluster 1a

More common and abundant in inner stations

Spp cluster 1b

No clear spatial distribution pattern; Includes ubiquitous species

Spp cluster 2a

Low to moderately abudant species with slight preference for outer stations

Spp cluster 2b

Low to moderately abudant species with somewhat stronger preference for outer stations

Fig. 11 Two-way table output from TWINSPAN showing station and species clusters for the annual spatial analysis of Manila Bay trawl data (1992 - 93).

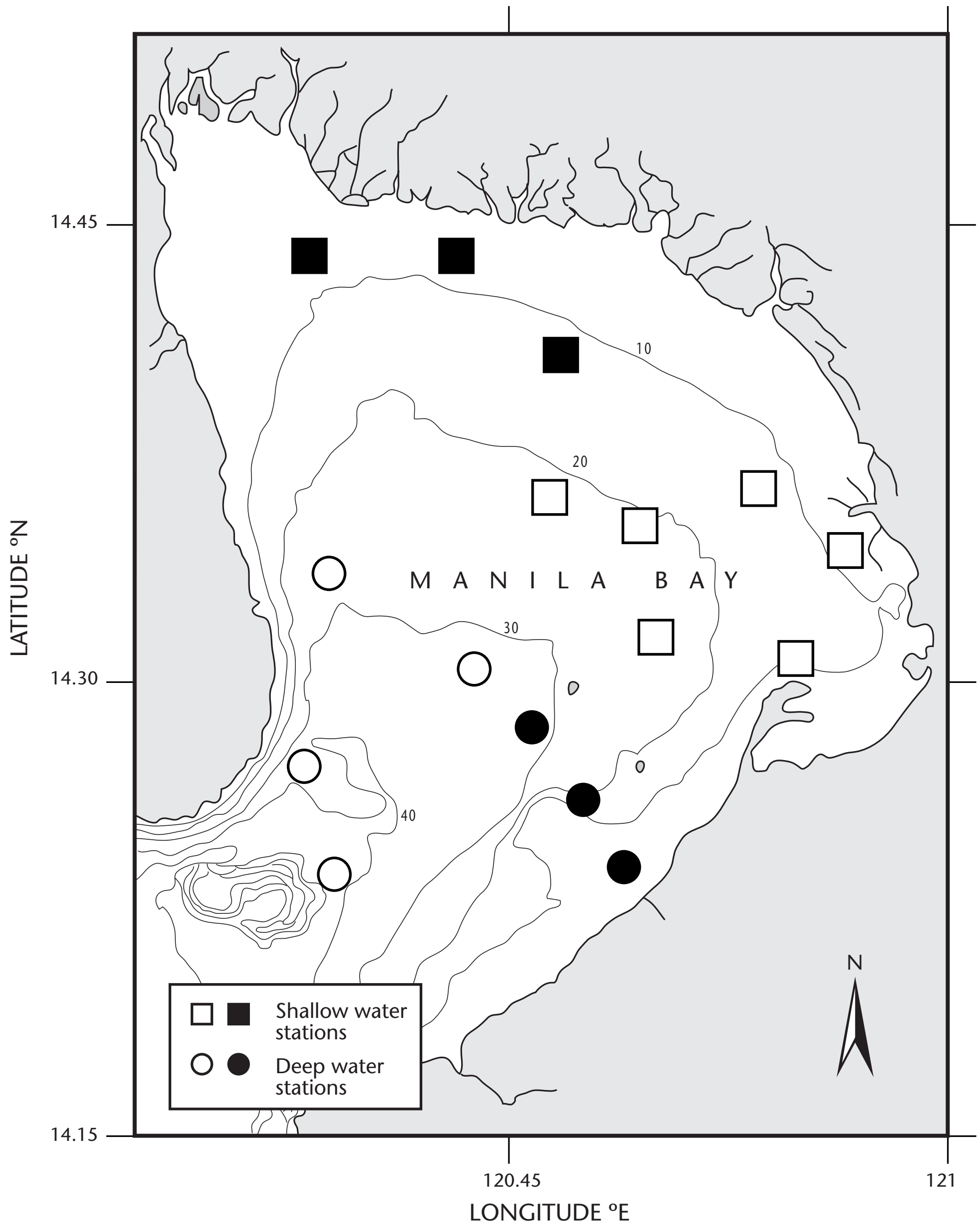


Fig. 12. Map showing location of station clusters formed in the annual spatial analysis of Manila Bay data (September 1992 to October 1993).

No.	Species	89 [Northeastern monsoon months]	4567 [Southwest monsoon months]	123 [Transition months (Apr - Jul)]	Code	Group
7	Crabs(s)	3 3	– – – –	– – –	0 0 0 0	Present only during Northeastern monsoon months
18	Shrimp	3 –	– – – –	– – –	0 0 0 0	
34	Cynoglos	2 –	– – – –	– – –	0 0 0 0	
40	Saurida	3 –	– – – 1	– – –	0 0 0 0	
53	Charybdi	– 3	– – – –	– – –	0 0 0 0	
38	Soleahu	– 2	– – – 1	– – –	0 0 0 1 0 0	Moderately abundant during both Northeastern & Southwest monsoon months, but with higher abundances
41	Octopus	2 –	1 – – –	– – –	0 0 0 1 0 0	
48	Therapon	– 2	– 1 – –	– – –	0 0 0 1 0 0	
17	Shrimp (	– 4	1 1 – 2	– – –	0 0 0 1 0 1	
21	Goby sp.	4 4	3 2 3 2	– – –	0 0 0 1 0 1	
26	Gerress	2 3	– – – 3	– – –	0 0 0 1 0 1	
12	Sillago	3 4	– – 2 –	– – 1	0 0 0 1 1	
15	Seasnake	– –	2 – – –	– – –	0 0 1 0	Absent during transition months (Apr - Jul), but no clear pattern for the rest of the year. Includes uncommon and ubiquitous apecies
19	Sphyraen	– –	– – 1 –	– – –	0 0 1 0	
22	Goby sp.	– –	1 – – –	– – –	0 0 1 0	
23	Goby sp.	– –	1 – – –	– – –	0 0 1 0	
32	Bukawil	– –	– 1 – –	– – –	0 0 1 0	
45	Lagoceph	– –	– – 2 –	– – –	0 0 1 0	
50	Therapon	– –	– – 2 –	– – –	0 0 1 0	
51	Upeneus	– –	1 – – –	– – –	0 0 1 0	
2	Apogonq	4 4	4 4 4 4	4 – –	0 0 1 1	
46	Leiognat	4 3	3 4 4 4	– 1 1	0 0 1 1	
20	Triacant	2 –	– – – 1	– – 1	0 1 0 0	
43	Platycep	3 3	– 1 1 –	1 1 –	0 1 0 0	
49	Therapon	3 –	– 1 – –	– 1 –	0 1 0 0	
13	Seacucu	– 4	3 – 3 –	– – 3	0 1 0 1 0	Species with moderate to high abundances and common throughout the year
28	Platycep	3 2	3 3 3 3	2 3 –	0 1 0 1 0	
11	Portunus	4 4	3 3 4 3	3 3 4	0 1 0 1 1 0	
16	Secutor	2 2	3 1 3 –	– 1 3	0 1 0 1 1 0	
31	Brachyrh	3 3	4 3 3 3	2 3 4	0 1 0 1 1 0	
39	Scorpaen	2 2	1 – 2 2	1 1 2	0 1 0 1 1 0	
8	Pseudorh	3 3	– – 1 3	3 1 –	0 1 0 1 1 1	
6	Tetraodo	– –	– 3 – 2	3 – –	0 1 1	Species with low abundances and present during the Southwest and trasition months
9	Pseudorh	– –	2 2 2 3	– 2 3	0 1 1	
25	Gerress	– –	– 2 2 –	– – 1	0 1 1	
37	Solea sp	– –	– – 2 2	1 – –	0 1 1	
14	Seas nake	3 2	2 – 2 –	– 3 2	1 0	Species rarely occurring during the Northeastern months and most common during transition months
36	Sepia sp	– 3	– 1 – 1	– 1 2	1 0	
5	Loligos	– –	3 2 2 –	4 3 3	1 1 0	
27	Platycep	– –	1 – – 1	– – 2	1 1 0	
30	Sillago	– –	1 2 – 2	2 2 –	1 1 0	
55	Cyno glos	– –	– – – 1	– 1 1	1 1 0	
1	Alectis	– –	– – – –	– – 1	1 1 1	Species present only during transition months
3	Apogonq	– –	– – – –	– 4 4	1 1 1	
4	Gobiidae	– –	– – – –	4 4 2	1 1 1	
10	Pseudorh	– –	– – – –	– 1 –	1 1 1	
24	Gobiidae	– –	– – – –	3 3 –	1 1 1	
29	Penaeus	– –	– – – –	2 3 2	1 1 1	
33	Cynoglos	– –	– – – –	2 – –	1 1 1	
35	Squilla	– –	– – – –	– – 2	1 1 1	
42	Platycep	– –	– – – –	1 – –	1 1 1	
44	Platycep	– –	– – – –	1 – –	1 1 1	
47	Leiognat	– –	– – – –	1 – –	1 1 1	
52	Penaeus	– –	– – – –	1 – –	1 1 1	
		0 0	0 0 0 0	1 1 1		
		0 0	1 1 1 1			

Northeastern monsoon months

Southwest monsoon months

Transition months (Apr - Jul)

Fig. 13. Two way table output for temporal analysis of Sorsogon trawl data. Sampling was monthly April (1) to January (9) (no sampling in May).

		8 4 5 6 2 7	1 3 9	
13	Red Snap	– 3 3 2 1 –	– – –	0 0 0
19	Thick-li	– 2 2 – 1 3	– – –	0 0 0
22	Trumpetf	– 1 – 1 – –	– – –	0 0 0
15	Redbull	– 3 2 3 1 2	1 1 –	0 0 1
20	Groupers	3 2 – – – –	– – 1	0 0 1
21	Blackpo	– 1 – 2 2 1	– 1 –	0 0 1
7	Lizardfi	3 4 3 3 2 3	1 2 –	0 1 0
11	Threadfi	3 2 3 2 4 3	1 1 1	0 1 0
17	Whitings	2 1 1 3 1 2	– 1 1	0 1 0
16	Imperial	1 2 3 2 – –	1 2 –	0 1 1 0 0
6	Barracud	– 4 1 3 1 3	3 3 1	0 1 1 0 1 0
1	Slipmout	4 4 4 4 4 4	4 4 4	0 1 1 0 1 1
2	Goatfish	4 4 4 4 4 4	3 4 4	0 1 1 0 1 1
3	Carangid	4 4 3 4 3 4	3 4 4	0 1 1 0 1 1
4	Mojarras	4 3 4 3 2 3	2 2 3	0 1 1 0 1 1
5	Anchovie	4 4 2 3 3 3	2 2 –	0 1 1 0 1 1
10	Monocle	2 3 3 3 – 3	2 1 3	0 1 1 0 1 1
12	Four-lin	2 3 2 2 2 2	1 2 2	0 1 1 0 1 1
26	Crabs	1 1 1 1 1 1	1 1 1	0 1 1 0 1 1
8	Hairtail	– 2 – 2 2 4	3 2 –	0 1 1 1
9	Sardines	3 2 2 2 3 2	3 – 2	0 1 1 1
14	Mackerel	2 2 – 1 2 3	1 – 2	0 1 1 1
23	Squids	3 3 3 3 3 3	3 4 4	1 0
29	Scallops	3 2 1 1 2 1	1 4 3	1 0
24	Cuttlefi	– 1 1 1 2 1	1 4 –	1 1 0
27	Mantiss	– – 1 – 1 1	– 4 1	1 1 0
18	Fusilier	– – – – – 1	2 – 3	1 1 1
25	Octopus	– – – – – –	– – 1	1 1 1
28	Penaeid	– – – – – –	– – 1	1 1 1
		0 0 0 0 0 0	1 1 1	
		0 1 1 1 1 1		
		0 0 0 1 1		

Species rare during transition months (Oct, Dec & Jun)

Species occurring all year round in comparable abundances. Includes species with high and low abundances

Species most abundant during transition months

Transition months

Northeastern monsoon months

Fig. 14. Two way table output for temporal analysis of Tayabas Bay data. Sampling was monthly from October (1) to June (9).

Conclusion

The 24 fishing grounds in the exploratory surveys in 1947 - 49 can be arranged in gradients reflecting their substrate make-up (i.e. relative coral cover and sediment characteristics). Catch rate ($kg \cdot hr^{-1}$) was negatively correlated with both average water depth (-0.48, $p < 0.05$) and mud/sand substrate (-0.51, $p < 0.05$), and reflects an underlying trend of increasing catch rates in areas with shallower and more muddy bottoms. This is also consistent with the distribution of the more abundant families in the catches (e.g. Leiognathidae, Mullidae).

Depth appears to be the primary factor that determines the station clusters in Samar Sea and San Pedro Bay. In San Pedro Bay, catch species composition shows a consistent transition at depths of 15 - 20 m throughout the year. Similarly, Samar Sea shows a transition at the 30 - 40 m depth range, and again at the depths of 50 - 60 m, with further differences in composition between inner (southern) and outer (northern) stations. Manila Bay shows a different pattern; changes in species composition appear to be more related to location (i.e. inner or outer portions) than to depth. Differences in demersal assemblages were observed throughout the year in both inner and outer portions, and between the western and eastern halves of the bay seasonality or within-year differences in species assemblages reflecting the monsoon systems were also evident in Sorsogon Bay and Tayabas Bay.

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