AN ABSTRACT OF THE DISSERTATION OF

Tomas Vergel C. Jamir for the degree of Doctor of Philosophy in Oceanography presented on June 30, 1998. Title: Distribution, Seasonal Variation and Community Structure of the Demersal Trawl Fauna of Ragay Gulf, Philippines.

Abstract approved: Redacted for privacy

William G. Pearcy

The demersal fish community structure of Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines (RABUTINOS) was studied from data obtained from the surveys carried out by RV Sardinella during the wet northeast monsoon, dry intermonsoon and wet southwest monsoon seasons. Also included were samples taken during the dry early maturity stages of the strong 1982-1983 El Niño-Southern Oscillation event.

Detrended Correspondence Analysis (DCA), Cluster Analysis, Two-Way Indicator Species Analysis (TWINSPAN) and correlation of DCA Axis 1 with depth, temperature, salinity and oxygen implemented by the PC-ORD and SAS programs revealed depth as the principal environmental gradient along which faunal changes occur. Fisher's Protected Least Significant Difference tests and multiple linear regression analysis associated the observed depth zonation pattern with species assemblages distributed above the thermocline (warm water fauna), within the thermocline (cool water fauna) and below the thermocline (cold water fauna). These corresponds to regions shallower than 90 m, between 90 to 150 m, and deeper than 150 m, respectively.

Within each of these major depth zones, the important determinants of fish assemblage structure include substrate characteristics (rocky-coralline, sandy, muddy); proximity to major rivers (salinity and/or turbidity gradient); depth (shallower or deeper than 35 m); biotic interactions (predation, competition, recruitment) and availability of

food. Seasonal ordination and classification based on species abundance and occurrences revealed eight gradually overlapping species site groups and five species groups separable by distinct demersal fish assemblages, depth ranges, substrate types and water mass characteristics.

Except for seasonal variability in distribution, the fish assemblages of RABUTINOS were relatively stable in terms of species composition, relative abundance and dominance. Two-thirds of the top 20 most abundant species/taxa remained as common components of the seasonal species assemblages. The main environmental perturbations associated with the 1982-'83 El Niño event included significant declines in precipitation, elevated salinity and temperature levels, and early spring-like conditions that resulted in the drastic reduction in mean seasonal catch rates and number of demersal fish assemblage groups by half. These remaining assemblages contained species/taxa that were well adapted to the harsh and shifting environmental conditions typical of their estuarine and thermocline habitats.

Distribution, Seasonal Variation and Community Structure of the Demersal Trawl Fauna of Ragay Gulf, Philippines

by

Tomas Vergel C. Jamir

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31 July '98

Tomas Vergel C. Jamir, Author

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INTRODUCTION

Over the last four decades, commercial exploitation of Southeast Asia's demersal fishery resources has been confined primarily to shallow coastal waters less than 50 m deep (Pauly, 1988). Recently, however, the depletion of nearshore stocks and advances in mechanized fishing technology have shifted commercial fishing interests towards the economic potential of deeper waters. The meteoric rise of the Gulf of Thailand demersal trawl fishery and the subsequent decline of its resource base (Pauly, 1988) is a classic example of the serious ecological, political and economic consequences of unfettered overcapitalization in the fishing industry.

Effective management of the fishery not only requires knowledge of the species composition of assemblages but also the interactions among species and their responses to the environment. Despite its recognized shortcomings the single-species stock model remains the basis for most of today's management decisions (Brander, 1988; Sainsbury, 1988). This is partly due to the marine scientist's need to know about the autecology and biology of single-species stocks (Pauly, 1982) and to the slow progress in the development of multispecies models that can be used as guides in the formulation of management strategies (Brander, 1988; Sainsbury, 1982).

A number of problems arise in the stock assessment and management of diverse temperate and tropical fisheries based on the single species approach. As the diversity of the species within the catch increases, the assessment of each individual's state of exploitation becomes more difficult and complicated. In this situation, the consequence of attempting to manage the fishery by regulating only a few of the main species become less predictable (Brander, 1988). Single species studies often ignore differences in yield and overall species composition of different areas (Brander, 1988). To a fisheries manager, however, these differences are important, as the value of the catch in most fisheries are strongly influenced by its species composition (Pauly and Mines, 1982; Sainsbury, 1988).

Few fisheries operate on a single species or stock, especially in the tropics, where multispecies fisheries are predominant (Russ, 1991). Fishing operation directly influences the community by the removal of individuals or indirectly through habitat modification (Sainsbury, 1988; Russ, 1991). It is now recognized that unmanaged growth in this industry not only causes the decline of target species but also leads to ecosystem overfishing (Pauly, 1979, 1988). This phenomenon is recognized worldwide from its trail of widespread alterations in the species composition of most exploited fish communities, e.g., the *Balistes* (Family: Balistidae) population explosion that displaced the sciaenid community from Senegal to Nigeria (Longhurst and Pauly, 1987) and the *Loligo* (Family: Loliginidae) population outburst that displaced the Leiognathidae population in the Gulf of Thailand (Tiews *et al.*, 1967; Pauly, 1979) and Manila Bay (Ganaden, 1990). Therefore, confident multispecies fisheries management requires an understanding of community structure and dynamics from which (1) the ecological and fishery implications of alternative exploitation strategies may be ascertained (Brander, 1988; Sainsbury, 1988) and (2) undesirable community changes in species composition may be prevented while encouraging desirable ones (Pauly and Murphy, 1982; Sainsbury, 1982; May, 1984; Rothschild, 1983; Sherman and Alexander, 1986).

Besides the extensive studies conducted in northern Australian continental shelves, relatively little is known about the complex structure of demersal fish communities in the tropical western Pacific Ocean (Longhurst and Pauly, 1987). To the author's knowledge, only a few studies of tropical demersal fish community structure by means of multivariate analysis (excluding coral reef areas and lagoons) have been carried out in Southeast Asia, e.g., the Samar Sea (McManus, 1985) and Ragay Gulf, Philippines

(Federizon, 1992), and Malaysia (Chan and Liew, 1986). This deficiency implies that work on the population dynamics of demersal fish stocks in the region is usually conducted blindly using data (e.g., catch/effort, species and size composition) that may come from different communities (Pauly, 1988).

In the tropics, different interacting factors have been attributed to the way demersal fish communities are structured. This includes depth and spatial factors (McManus, 1985; Harris and Poiner, 1990; Ramm *et al.,* 1990; Federizon, 1992), temperature and salinity (Rainer and Munro, 1982; Rainer, 1984; Longhurst and Pauly, 1987; Bianchi, 1991; Sheaves, 1998), substrate type (Rainer and Munro, 1982), proximity to rocky or coral reefs (Watson *et al.,* 1990; Federizon, 1992; Newman *et al.*, 1997), ontogenetic factors (Rainer and Munro, 1982; Weng, 1990; Morin *et al.,* 1992), sensory adaptation (Tejerina-Garro *et al.*, 1998), seasonal cycles (Watson *et al.*, 1990; Ansari *et al.*, 1995); food availability (Weng, 1990; Caddy and Bakun, 1995) and turbidity (Watson *et al.*, 1990; Cyrus and Blaber, 1992; Caddy and Bakun, 1995). The complexity in which fish communities are structured emphasizes the importance of conducting rigorous community analyses on demersal fishes as a prerequisite to ecologically sound resource management.

After comparing the distribution of demersal tropical fishes around the world, Longhurst and Pauly (1987) found relative stability in the fish fauna of the continental shelves, with many of the same families represented over similar substrates and depths. From these environmental factors, they also established four basic fish assemblage categories, i.e., fishes of (1) inshore and estuarine, muddy habitats and turbid waters, (2) sandy deposits and clear waters, (3) rocky reefs (both estuarine and offshore), and (4) coral reef outlier species.

The strong El Niño-Southern Oscillation event in 1982-'83 presented a major, albeit limited, opportunity to see whether Longhurst and Pauly's hypothesis holds true. In this study, the stability of the RABUTINOS demersal fish communities subjected to exogenous perturbations will be looked at in terms of the following criteria: (1) stability of relative abundance patterns, (2) stability of dominance, (3) stability of species composition, and (4) stability of spatial distribution (Krebs, 1978).

This study investigates the species composition and structure of demersal fish assemblages in Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea (=RABUTINOS) in relation to environmental variables, (wet and dry) seasons, a strong El Niño-Southern Oscillation event and geographic location. More specifically, the main objectives of this research are:

(1) to describe the abundance, structure and composition of demersal fish assemblages at RABUTINOS in relation to other Indo-Pacific forms,

(2) to determine the spatial distribution and temporal variation of fish assemblage patterns in relation to the regular Southeast Asian monsoon seasons and the local effects of the El Niño-Southern Oscillation,

(3) to identify possible key environmental gradients and/or biotic processes that may be responsible for the way the fish assemblages were distributed and structured, and

(4) to determine the stability of tropical fish communities in relation to the regional environmental perturbations brought about by the strong 1982-1983 El Niño-Southern Oscillation event.

This type of synecological study is a necessary step towards understanding multispecies stocks (Caddy and Sharp, 1986) and can be extended to descriptive community dynamics (McManus, 1985) in order to find general patterns of species compositions under given environmental conditions and fishing effort. Comparison of assemblages from similar ecosystems in different areas might also reveal general trends in the community dynamics of tropical shelves (Bianchi, 1990). In addition, this work could also be useful in fisheries management. For example, species composition of trawl catches from a given area may be roughly anticipated from assemblage maps derived from this analysis, or assemblage boundaries can be used to frame legislation aimed at reducing the impact of growing commercial trawl fisheries on the small-scale non-trawl fisheries (Pauly, 1988).

A. Review of Literature:

1. Community Structure of Tropical Demersal Fishes.

Longhurst and Pauly (1987) determined that the main environmental factors determining what species occur in a given area are the amount of organic mud in the substrate, presence of isolated patches of rocky or coral reefs, occurrence of brackish conditions associated with lagoons and river mouths, and the characteristics of the continental shelf's water mass. Under similar conditions in the tropics, they also asserted that the expected fish fauna is remarkably consistent, with more families being represented in the western Indo-Pacific than in the Atlantic. Essentially four basic categories of fish assemblages can be found in the tropics (Longhurst and Pauly, 1987).

a. *Fish of inshore and estuarine muddy habitats and turbid waters*. This assemblage is dominated by two forms of drums/croakers (fmily: Sciaenidae) -- fast swimming bentho-pelagic piscivores and the benthic forms with inferior mouth and sometimes with gular barbels. Sciaenid assemblages inhabit the shallow (<15 - 20 m), soft-bottom waters of Southeast Asia (Chong *et al.,* 1990), northern Australia (Blaber *et al.,* 1989; Blaber *et al.,* 1995), west coast of India (Ansari *et al.*, 1995) and western Africa (Fager and Longhurst, 1968). This bathymetric boundary could be deeper than 20 m depending on the extent of riverine influence and warm water mass, e.g., down to 60 m northwest off Guiana and Brazil where large volumes of freshwater are discharged into the sea by the Orinoco, Amazon and other major South American rivers (Richards, 1955; Lopez, 1964; Longhurst and Pauly, 1987).

b. *Sandy deposits and clear waters*. This assemblage are found farther offshore, where fishes of pink or silvery color with large eyes adapted to clear waters and lighted conditions and feed mostly on benthic epifauna and vagile benthos abound (Longhurst and Pauly, 1987). Included here are the grunts (family: Haemulidae), breams (family: Sparidae), mojarras (family: Gobiidae), large-eyes (family: Priacanthidae), goatfishes (family: Mullidae), threadfin breams (family: Nemipteridae) and slipmouths (amily: Leiognathidae) found throughout the tropics (Fager and Longhurst, 1968; Blaber *et al.,* 1994). The last two families, however, are common only in the Indo-Pacific region (Jones, 1985) and are the mainstay of Southeast Asian demersal fisheries (Tiews and Borja, 1965; McManus, 1985; Pauly, 1988). The sandy and cold water regions between 200 - 300 m deep are home to benthopelagic and benthic faunas like the greeneyes (family: Chlorophthalmidae), lizardfishes (family: Synodidae = Synodontidae) and jacks (family: Carangidae) in western Africa (Fager and Longhurst, 1968), northern Australia (Okera, 1982), and in Southeast Asia (Federizon, 1992).

c. *Rocky reefs (both estuarine and offshore).* There are three principal families that dominate this assemblage, i.e., groupers, snappers and emperors (Longhurst and Pauly, 1987). These families inhabit the windward reef slopes, lagoons and leeward back reefs of the Great Barrier Reef (Newman *et al.,* 1997). Snappers are also known to move upstreams in the tropical estuaries of Australia (Sheaves, 1996a, 1996b) and are abundant in the rocky coralline areas in the Philippines (Warfel and Manacop, 1950; Federizon, 1992), Caribbean (Russ, 1991), or sandy regions in East Africa (Morgan, 1964), Australia (Okera, 1982), and South China Sea (Longhurst and Pauly, 1987).

d. *Outlier species of coral reefs*. There is no single dominant family in this group composed mainly of triggerfishes (Balistidae), pufferfishes (Tetraodontidae) and boxfishes (Ostraciontidae). These families are abundant in areas close to coral reefs, e.g., Southeast Asia (Russ, 1991), Great Barrier Reef (Newman *et al.*, 1997), and Equatorial Pacific Islands (Thresher, 1991).

Warfel and Manacop (1950) conducted exploratory trawling surveys of different potential fishing grounds in the Philippines prior to the extensive mechanization of the fishery. Their findings indicated little variation in the biomass and dominance of fish families living within 75 fathoms (140 meters) of the muddy and sandy substrates throughout the country. The dominant species include slipmouths (family: Leiognathidae), lizardfishes (family: Synodidae) and mojaras (family: Gobiidae). Thirty years later, McManus (1985) found similar relative abundance and species/taxa composition in Samar Sea and Carigara Bay, validating Longhurst and Pauly's (1987) thesis regarding the general stability of tropical demersal fish communities.

2. Application of Multivariate Statistics in Community Ecology.

The application and power of multivariate statistical techniques in the analysis of complex, multispecies tropical fish stock has been well documented by researchers from Australia and elsewhere. For example, Bianchi (1991) employed two-way species indicator analysis (TWINSPAN) and detrended correspondence analysis (DECORANA) to identify demersal species groups in Mexico and Costa Rica. Ross and Doherty (1994) used principal components analysis (PCA) to examine the physicochemical properties and species abundance relationships in the Barrier Island, Gulf of Mexico. Canonical discriminant analysis (CDA) was used by Sheaves (1998) to investigate species distributions and abundances of fishes in tropical Queensland estuaries; hierarchical classification by Newman et al. (1997) for the Great Barrier Reef and by Rainer and Munro (1982) in northern Australia. Bray-Curtis Ordination (BCO) and principal coordinate analysis (PCO) were used by Long and Poiner (1994) and by Ramm *et al.*, (1990) to analyze fish communities in northern Australia, and by *Ansari et al.* (1995) on the west coast of India.

In the Philippines, multivariate analysis was conducted by McManus (1985) on the Samar Sea demersal trawl fishery using DECORANA and TWINSPAN. Federizon (1985) used a combination of DECORANA, TWINSPAN, Correspondence Analysis (CA), Non-Metric Multi-Dimensional Scaling (NMDS) and cluster analysis to analyze the fish community structure of Ragay Gulf.

B. Description of the Survey Area:

1. Marine Geography of RABUTINOS.

The waters of Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea form a narrow channel of water oriented along the northwest - southeast direction on Eastern Luzon, Philippines (Figure 1). This body of water is about 180 miles long and 10 to 25 miles wide. This is approximately half the width and the same length as Oregon's Central Willamette Valley. This narrow passageway serves as the primary connection between the strong Kurushio Current and the internal seas of Central Philippines (Wyrtki, 1961). Hence, any anomalous perturbation in the equatorial western Pacific Ocean readily reflects on the physico-chemical properties of RABUTINOS, making the Ragay Gulf system potentially useful as a barometer for detecting or monitoring possible ENSO impacts in the region.

Oriented in a northwest-southeast direction, RABUTINOS is bounded to the north by Viñas River (122°27'E, 13°55'N) and to the south by the 12°N latitude for the purpose of this research. To the east are the Cordillera Mountain range of Luzon and the island of Samar. Separating these two land masses is the narrow San Bernardino Strait, the gateway to the Pacific Ocean. North of San Bernardino Strait is the shallow Sorsogon Bay. The western boundaries include Bondoc Peninsula and the islands of Burias, Ticao and Masbate.

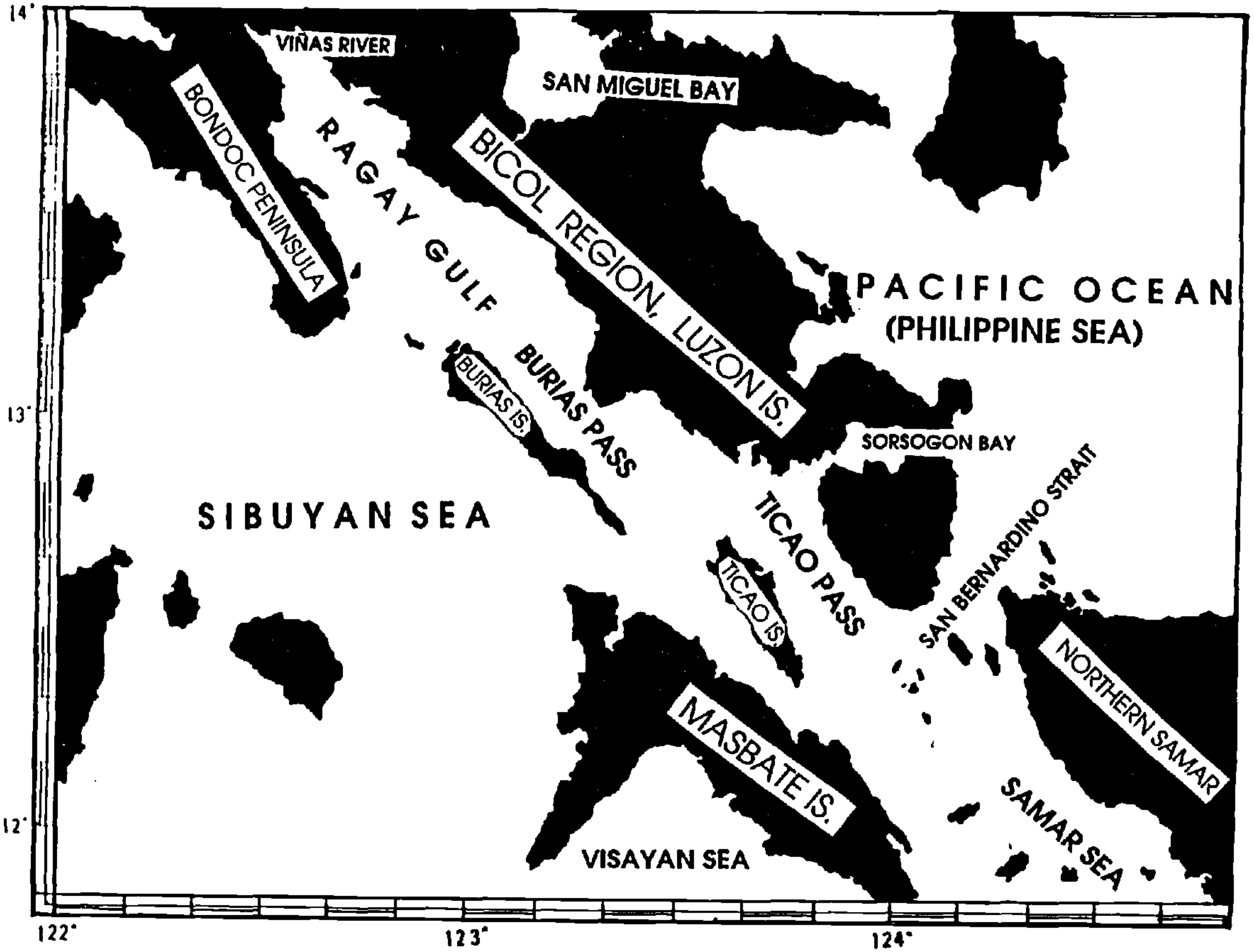


Figure 1. Geographic Map Showing the Location of Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines.

Ragay Gulf is a small protected basin approximately 600 m deep at its mid-section (Figure 2). It has two broad sills of about 100 - 130 m deep, with a western and southern opening to the larger Sibuyan Sea Basin. The waters of the western equatorial North Pacific Ocean directly interact with Sibuyan and Sulu Sea Basins through the narrow and deep channels of San Bernardino Strait, Burias Pass, Ticao Pass and western Samar Sea. The Ragay Basin is characterized by relatively wide insular shelf and steep insular slope. Terrigenous mud and riverine sands characterize the sea floor in the vicinity of Viñas River while sandy-silty ooze characterizes the bottom deposits of the deeper sections of the basin farther away from the rivers. Much of Northern Samar Sea is also made up of a wide, gradually sloping insular shelf overlain by riverine mud and sand deposits. This makes the two areas highly suitable for trawling operations.

Narrow shelves, sharp drop-offs and rocky-coralline substrates characterize the eastern coast of Ticao Pass. Complex underwater ridges, deep channels and hard, rocky to sandy substrates mark the seafloor west of San Bernardino Strait. These conditions severely limit the areas available for demersal trawl operation within these two sites.

2. The Southeast Asian Monsoon.

Much of Southeast Asian climate and oceanography are influenced by the regular seasonal patterns of the monsoons (Morgan and Fryer, 1985; Suryanaryana *et al.*, 1992). The strong northeast winds that sometimes exceed 39 kph characterize the northeast monsoon season. It is most fully developed in the months of January - February and is often associated with cool weather and torrential rains in RABUTINOS.

The dry, inter-monsoon transition period follows the northeast monsoon season. Around the months of July - August, the southwest monsoon season reaches its peak with

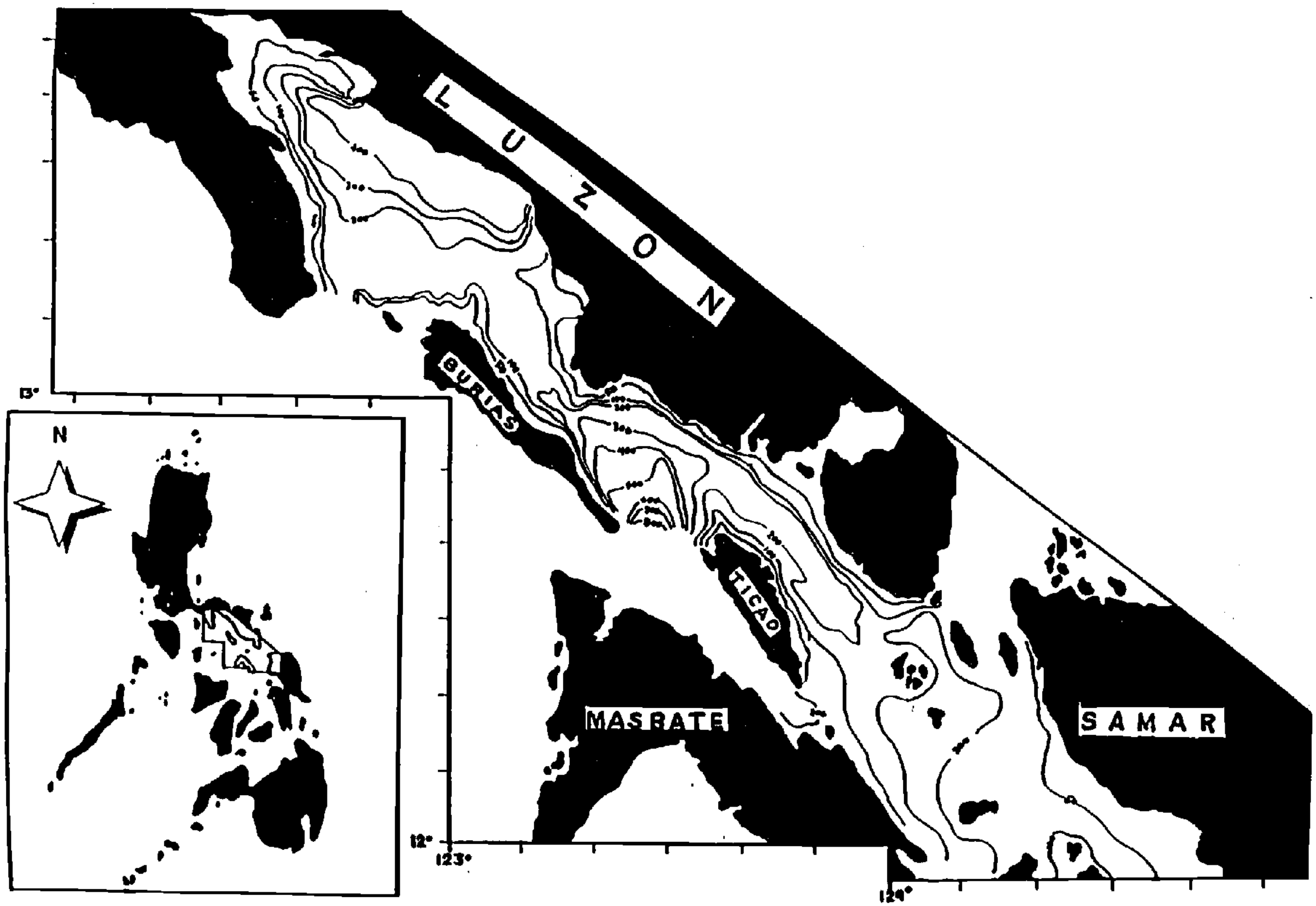


Figure 2. Bathymetric Map of Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines. Depths are given in meters.

winds reaching 20-29 kph (Kumagai and Bagarinao, 1983). Warm humid weather punctuated by occasional hurricanes and heavy rainfall typifies the southwest monsoon season.

The wind lulls typical of the inter-monsoon transition phase may have a significant influence on the recruitment of tropical fishes as indicated by the pervasive bi-modal recruitment pattern for most species (e.g., Pauly and Navaluna, 1983; Ingles and Pauly, 1984; Corpuz *et al.,* 1985; Robertson and Duke, 1990). Peak spawning seasons for many species have been found to occur at times of the year when prevailing wind and/or current is at their minimum velocities (Johannes, 1980), i.e., from March - May and October - November.

The 15 year average annual rainfall pattern for the Masbate Island Weather Station is shown in Figure 3. The lowest precipitation levels usually occur during the dry intermonsoon months of March and April. The average monthly precipitation starts to increase thereafter until it reaches a high plateau around the months of July to December. The increase in precipitation during the southwest monsoon months of June to August reflects the passage of typhoons and tropical storms as the Inter-Tropical Convergence Zone (ITCZ) moves into the region.

The high precipitation levels during the northeast monsoon months of September to December is typical on the eastern side of the Philippines and attributed to orographic effects. The sudden drop in precipitation levels around August before spiking up again a month later signals the change in the seasons as the winds shift from the southwest to the northeast. The variation in the mean monthly rainfall pattern in Masbate Island is large, especially during the rainy season.

The monthly average rainfall pattern from January 1979 to December 1984, which includes the period of this study, is shown in Figure 4. The abrupt drop in rainfall around the month of August was very pronounced in all years except in 1981. Precipitation levels

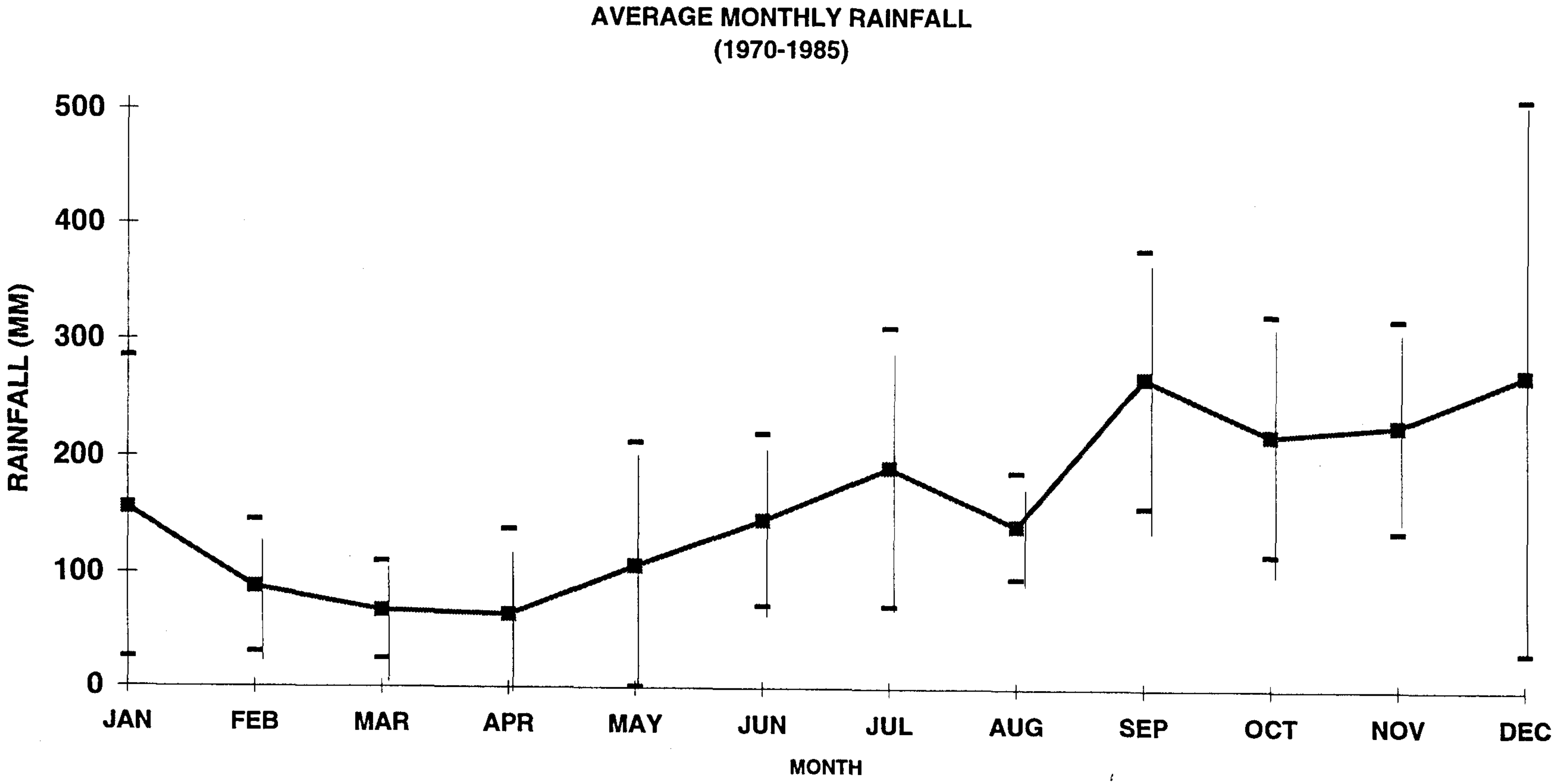


Figure 3. Average Monthly Rainfall Time Series Pattern for the Masbate Island Weather Station.

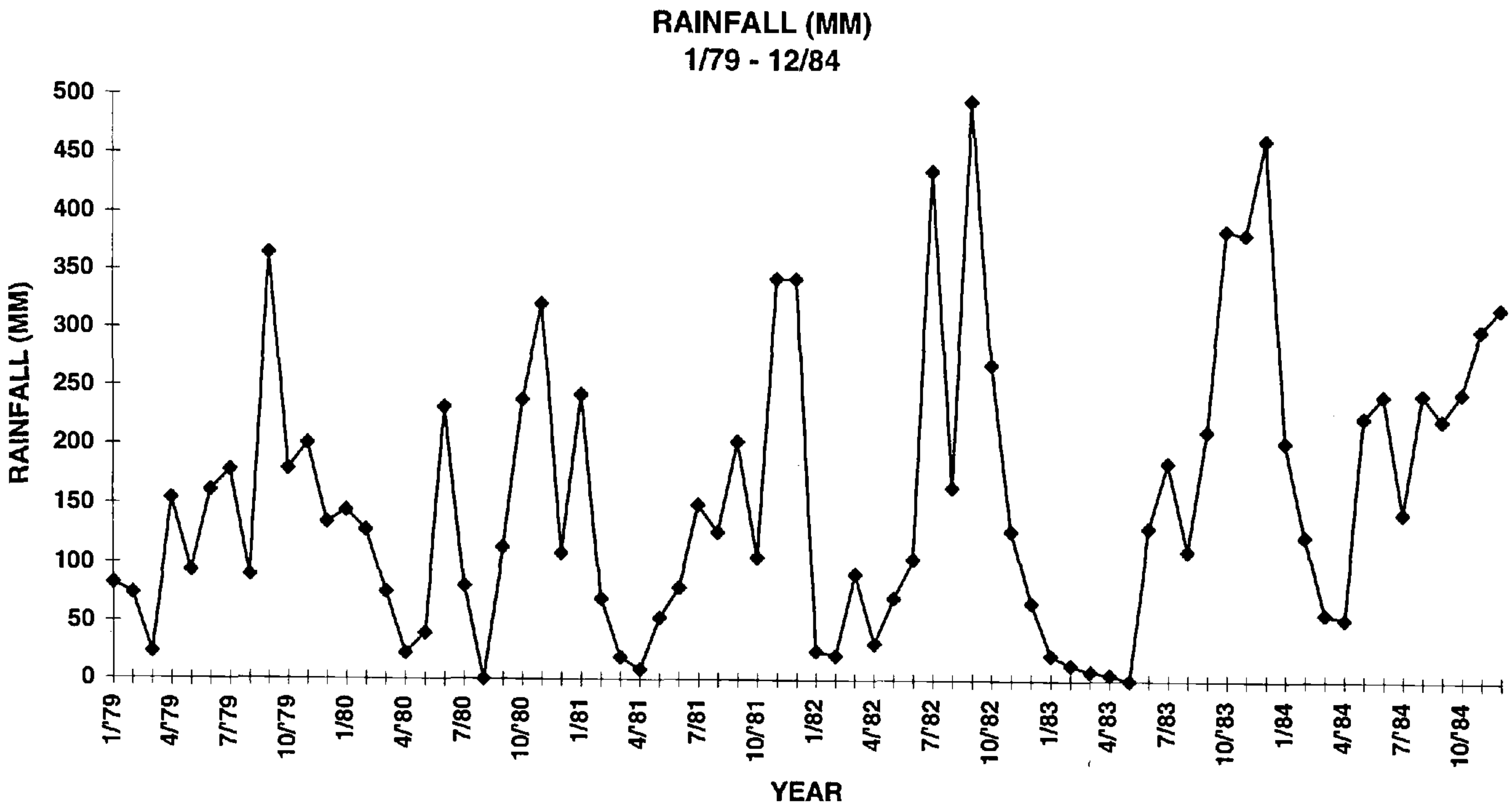


Figure 4. Monthly Rainfall Time Series Pattern from January 1979 to December 1984 for the Masbate Island Weather Station.

were also lowest around the month of April, except during the 1982-1983 ENSO when low precipitation levels were already recorded as early as January 1983 and remained low until May 1983.

Rainfall levels were high during the survey's first two cruises in November and December 1981, as well as in July and September 1982 followed by drought conditions thereafter. As the survey ended in January 1983, the normal northeast monsoon rains never came and the precipitation levels were already below normal values. This eventually developed into conditions that prevailed throughout Southeast Asia over the next five months.

3. Physical Oceanography.

The water masses of the Philippines is characterized by a thick (~50 - 100 m) thermocline located at 100 - 150 m depths (Megia and Villadolid, 1953; Megia and Sebastian, 1951; Wyrtki, 1961). This permanent thermal discontinuity is regarded as an effective barrier to the fertilization of the photic zone by the nutrient-rich bottom waters. Hence, fertilization of coastal waters is confined to nutrient inputs from rivers and terrestrial run-offs during the rainy southwest monsoon season and occasional localized upwellings during the northeast monsoon season (Megia and Sebastian, 1951; Megia and Villadolid, 1953; Jacinto, 1983; Suryanarayana *et al.*, 1992).

The oceanographic surveys conducted at the Gulf of Thailand and South China Sea (Wyrtki, 1961), Philippine territorial waters (Graham, 1952, 1953); Manila Bay (Megia, 1953), Lingayen Gulf (Sebastian *et al.*, 1959), Samar Sea and Carigara Bay (Labao, 1982), Visayan Sea (Aprieto, 1978), San Miguel Bay (Legasto *et al.*, 1975; Pauly and Mines, 1982), Sorsogon Bay (Ordonez *et al.*, 1975), shallow coastal lagoons of Batangas (Jacinto, 1983; San Diego, 1985); and Ragay Gulf (Mines *et al.*, 1984) all point to the pervasive influence of the seasonal monsoons in structuring the characteristics of the physical environment. The regular environmental cycle basically revolves around the "dry" and "wet" seasons which exert their influence on the distribution and physical characteristics (e.g., temperature, salinity, dissolved oxygen, nutrients) of the waters in the upper ocean.

During the wet southwest monsoon season, coastal bodies of water throughout the region become "estuarized" similar to the Gulf of Carpentaria in Northern Australia (Longhurst and Pauly, 1987); West Bay of Bengal (Suryanarayana *et al.,* 1992); Lingayen Gulf, Philippines (Sebastian *et al.,* 1959); Manila Bay (Megia, 1953); San Miguel Bay, Philippines (Pauly and Mines, 1982); and shallow coastal lagoons of Batangas, Philippines (Jacinto, 1983; San Diego, 1985). The extent of low salinity water layer varies from 30 - 35 m in the Gulf of Carpentaria and the shallow bays of the Philippines, to 50 m off the coast of India.

The relatively cool, dry, strong and persistent winds characteristic of the northeast monsoon tends to weaken thermal stratification as the low salinity layers disappear and the water column cools down and becomes mixed (Wyrtki, 1961; Suryanarayana et al., 1992). Occasional local inversions and "upwelling" (Rochford, 1991) events also take place during this season (Wyrtki, 1961; Megia, 1953; Mines *et al.*, 1984).

The fifteen year average monthly temperature pattern is shown in Figure 5. Cool temperatures characterized the northeast monsoon months from December to February. Air temperature warms up again during spring and continues to rise throughout the intermonsoon transition period. Peak temperatures occur during the month of May just before the southwest monsoon rains start to pour. The temperature cools down a little during the rainy months of June to July. Then if plateaus around 28°C during the northern hemisphere summer before starting to cool down again by autumn. The temperature variations from the mean monthly values are small and similar throughout the year.

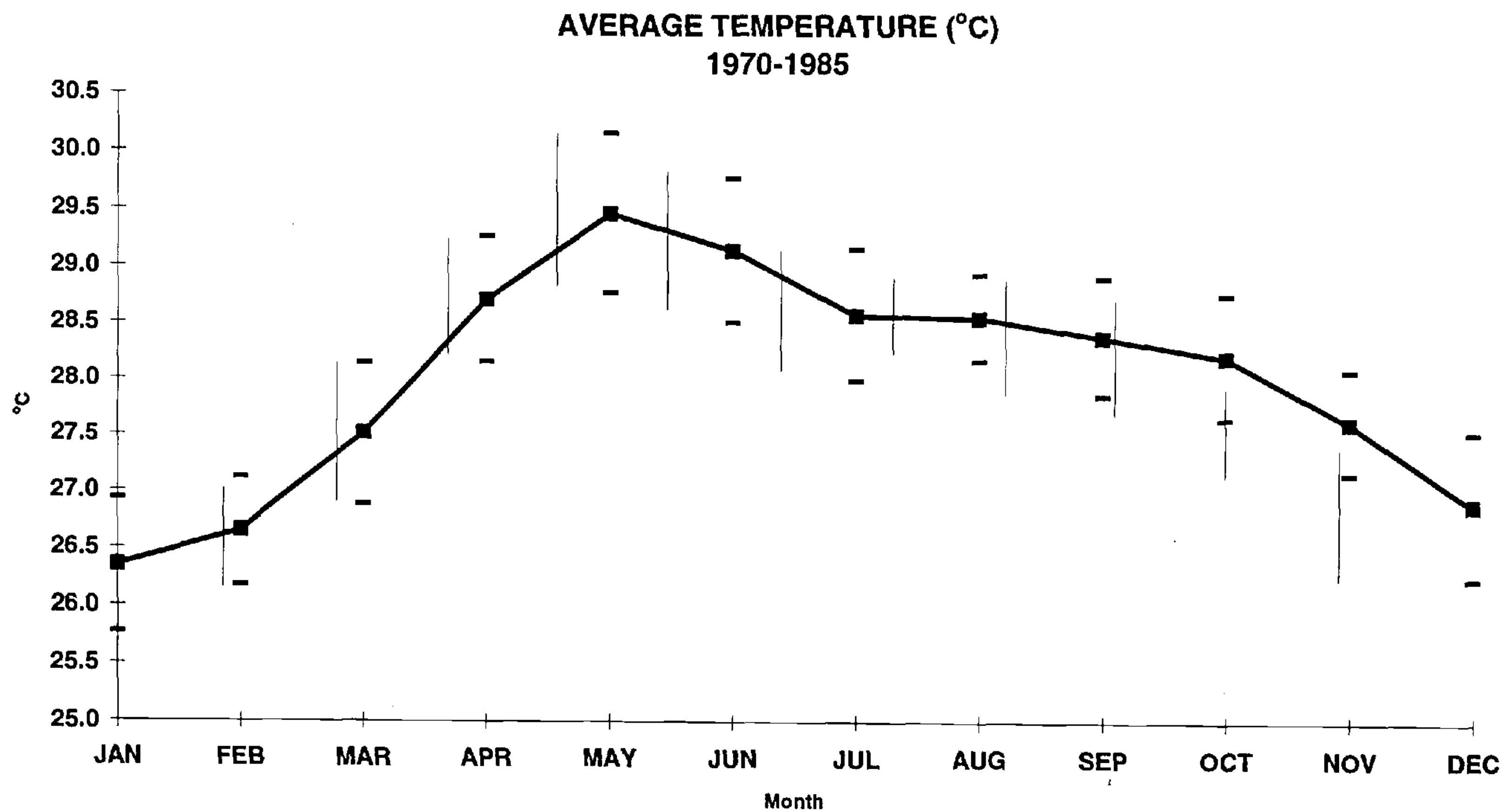


Figure 5. Average Monthly Air Temperature Time Series Pattern for the Masbate Island Weather Station.

The temporal variation in the average monthly air temperature at the Masbate Island Weather Station from January 1979 to December 1984 is shown in Figure 6. The regular seasonal temperature pattern described above was evident in this series, i.e., coolest temperatures in January and warmest in May, except during 1982-1983 and 1984 summer. Summer was relatively cooler and winter was warmer than normal at Masbate Island during the 1982-1983 ENSO event. Summer was also cooler than normal in 1984.

Figure 7 shows the variation in the average annual air temperature at the Masbate Island Weather Station from 1961 to 1996. This diagram shows that two to three years prior to a major ENSO event, (i.e., 1970-71, 1982-83 and 1997-98), the average annual temperature at Masbate Island rose above normal, with the annual average temperature immediately cooling after an ENSO event.

C. El Niño-Southern Oscillation

The relative stability and regular seasonal cycle of the monsoon system in Southeast Asia are periodically perturbed, at increasing regularity (Longhurst and Pauly, 1987), by the global climatic event called El Niño-Southern Oscillation. In the strictest sense, El Niño (EN) originally referred to the local, periodic mild warming of the Peruvian coastal waters around Christmastime, hence, El Niño or Spanish for "little boy" (Cane, 1983; Trenberth 1991; Enfield, 1992). The atmospheric counterpart of El Niño, the Southern Oscillation (SO) was coined by Sir Gilbert Walker for the sea-level pressure "see-saw" or standing wave that he observed between Darwin, Australia (12.4°S, 130.9°E) and Tahiti (17.5°S and 149.6°W) in the South Pacific (Trenberth, 1991; Diaz and Markgraf, 1992). Today, El Niño-Southern Oscillation (ENSO) refers to the large-scale anomalous warming of the Pacific Ocean due to the incursion of warm water from the Western Equatorial Pacific Ocean into Central and/or Eastern Equatorial Pacific Ocean in conjunction with the cessation of equatorial upwelling of cold waters there (Cane, 1983; Rasmusson and Wallace, 1983; Glantz, 1991; and Enfield, 1992).

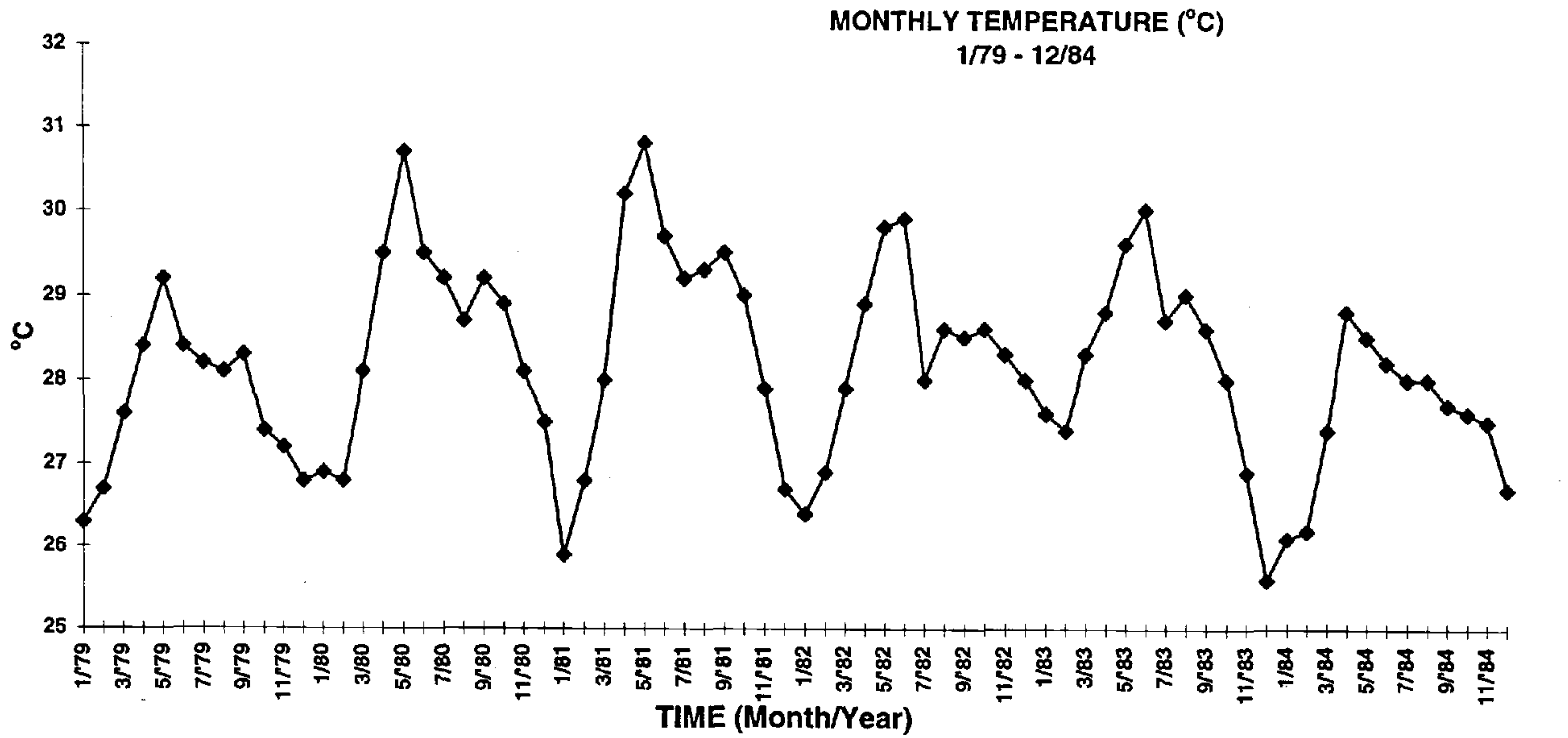


Figure 6. Monthly Air Temperature Time Series Pattern from January 1979 to December 1984 for the Masbate Island Weather Station.

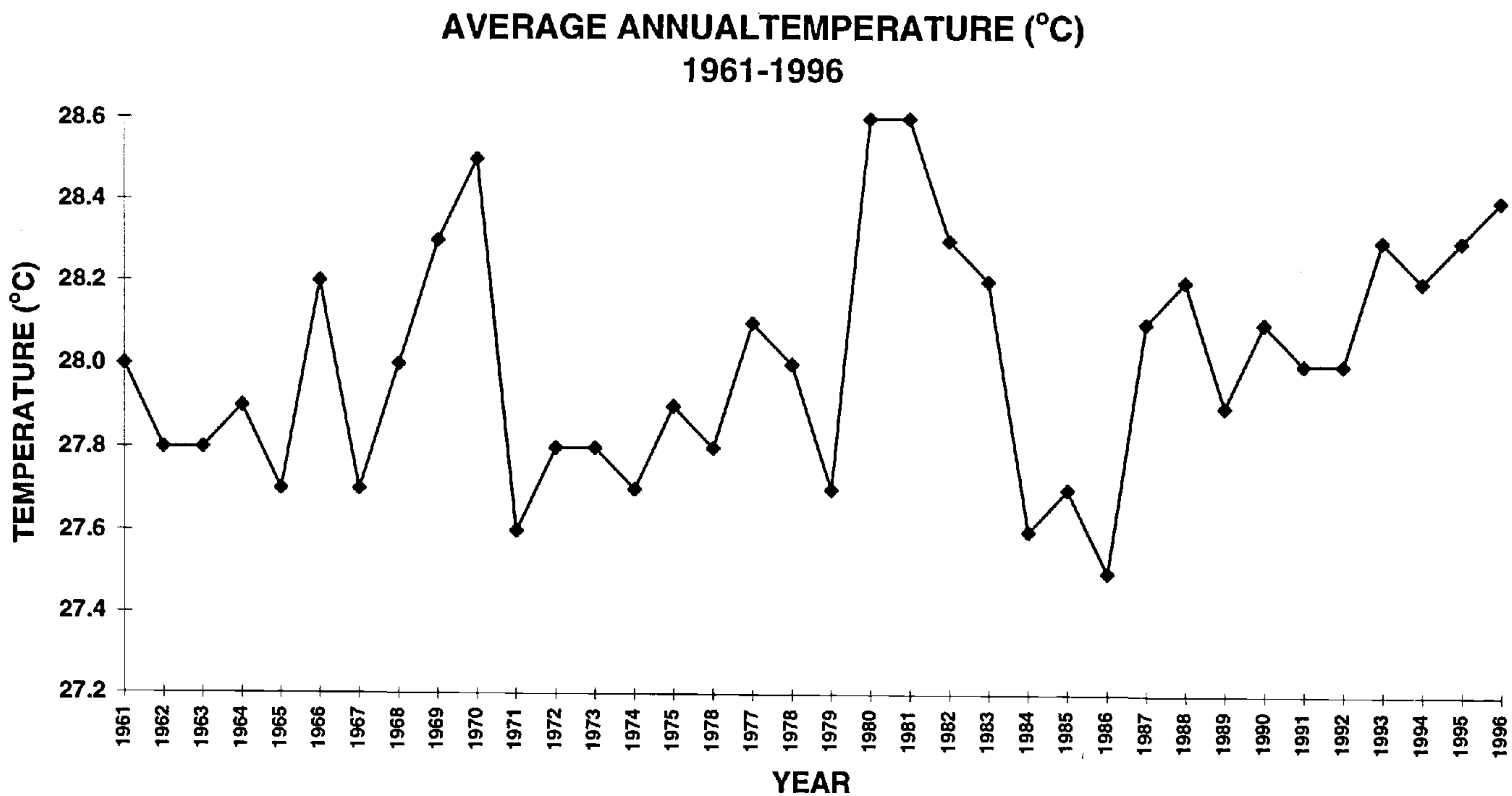


Figure 7. Average Annual Air Temperature Time Series Pattern from 1961 to 1996 for the Masbate Island Weather Station.

The life cycle of a canonical ENSO event can be subdivided into the prelude, onset, event and maturity stages (Cane, 1983; Trenberth, 1991). The start or end of a typical ENSO event occurs around the intermonsoon months of March to May. This period is characterized by the weakest wind and atmosphere-ocean coupling in the western Pacific Ocean (Trenberth, 1991). Following Cane's (1983) designation, the year prior to ENSO is designated as (-1), the ENSO event year as (0) and the year that follows as (+1).

The Prelude Stage, now referred to as La Niña" (Diaz and Kiladis, 1992), is characterized by stronger than average easterlies, higher sea levels, deeper than average thermoclines and anomalously warm sea surface temperature (SST) in the western equatorial Pacific Ocean. By Fall (-1), a significant reversal in the prevailing easterlies and an eastward shift in the Indo-Australian precipitation center marks the Onset Stage of ENSO (Trenberth, 1991; Enfield, 1992). An anomalous band of warm waters also appears in the Equatorial Pacific Ocean and extends across to the South Pacific between 15°S and 30°S (Trenberth, 1991) while the Intertropical Convergence Zone (ITCZ) and South Pacific Convergence Zone (SPCZ) shifts away from their normal positions (Trenberth, 1976).

As the trade winds weaken or reverse directions, waters piled on the western Pacific relaxes forming eastward moving Kelvin waves. Around March (0) to May (0), a tongue of anomalously warm water appears signifying the "peak phase" of the ENSO Event in the eastern Pacific. Later, this merges with the warm SST anomalies that develop in the central Pacific Ocean around August (0) to October (0). ENSO reaches Maturity around the months of December (0) to February (+1), ending the event around March (+1) to April (+1) as SST anomalies collapse and normal wind and ocean conditions prevail. Positive SST anomalies, however, could remain in the central and eastern Pacific through early part of the year before finally collapsing back to normal conditions around June (+1) or later.

The 1982-'83 ENSO event deviated from the canonical ENSO in a number of unique ways (Trenberth, 1991; Cane, 1983). The wind anomalies that occurred around Fall (1981) did not materialize until Spring (1982). By July (1982) to August (1982), the wind anomalies were already sufficiently strong and persistent. Around May (1982), SST anomalies were already noticeable and by August (1982), SST warming was already substantial in the eastern Pacific Ocean. Also, in a reversal of the normal ENSO pattern, mid-oceanic warming did not lag behind the major anomalies at the South American coasts (Trenberth, 1991). Instead, peak SST anomalies were already reached in the western Pacific Ocean sometime in November (1982) to December (1982) while along the South American coasts, they were attained only in January (1983) to February (1983).

Another dramatic swing in the SO around February (1983) to March (1983) signaled the return of the atmosphere to its normal conditions. In the central and eastern equatorial Pacific, however, positive SST anomalies lingered on throughout the early part of 1983, making the 1982-'83 ENSO event the strongest and longest recorded event of the century (Trenberth, 1991; Enfield, 1992).

In the monsoonal system of Asia, ENSO's impact is felt primarily in the alteration of the normal precipitation regime (Trenberth, 1991; Enfield, 1992). The correlation between rainfall, drought and ENSO events was examined by Quinn, *et al.* (1978) for Indonesia and by Allen (1989), Allen *et al.* (1989) and McGregor (1989) for New Guinea. During an ENSO event, the Inter-Tropical Convergence Zone (ITCZ) and the Southern Pacific Convergence Zone (SPCZ) merge together as the two systems shift equatorwards and to the east. This displaces the precipitation center thousands of miles to the southeast and away from the typical monsoon regions of Southeast Asia (Rasmusson and Wallace, 1983; Barnett, 1991; Lau and Shea, 1991). Therefore, instead of a normal "dry" season, year-long extreme drought conditions prevail in Indonesia, the Philippines and northern Australia while catastrophic flooding and strong tropical hurricanes hit the normally arid South Sea Islands to the east (Trenberth, 1991; Enfield, 1992).

The effects of El Niño-Southern Oscillation on fisheries can be substantial. For example, Staples (1983), Vance *et al.* (1985), and Love (1987) conducted extensive studies on the banana prawn fishery of the Gulf of Carpentaria and found the highest correlation between prawn catches and rainfall in the Karumba Region. Strong correlations were also found between the spring (especially November) Southern Oscillation Index (SOI) and total seasonal banana prawn catch in the Gulf of Carpentaria (Staples, 1983; Love, 1987). Longhurst and Pauly (1987) and Raja (1972, 1973) found possible correlation between juvenile *Sardinella longiceps* (Indian oil sardine, family: Clupeidae) abundance in the Kerala-Mysore section of the Indian coast and rainfall during the peak spawning period of the preceding season. Following a catastrophic failure of the monsoon rainfall and the strongest ENSO event since 1826, *S. longiceps* disappeared along the Indian coasts in 1941 and did not recover until 1949 (Longhurst and Pauly, 1987).

MATERIALS AND METHODS

A. Materials:

1. Demersal Fish Samples.

Nine research cruises were completed between November 1981 to January 1983 on board the 411 gross ton research vessel *RV Sardinella* of the College of Fisheries, University of the Philippine in the Visayas (Table 1). The first three cruises were conducted at monthly intervals while the rest were programmed every other month. The sampling period encompassed the two major Southeast Asian monsoon seasons, i.e., the northeast monsoon (winter), southwest monsoon (summer), and the dry intermonsoon period (spring). Also, the last two cruises (November 26 to December 4, 1982 and January 13-20, 1983) serendipitously coincided with the peak and early maturity phases of the 1982-1983 El Niño-Southern Oscillation (ENSO) event (Glynn, 1990; Diaz and Kiladis, 1992). Since ENSO teleconnections are most evident during the northern winter (i.e., at the end of year 0 and into year +1) in the extratropics (Diaz and Markgraf, 1992; Nichols, 1992), the last cruise may shed some information on the potential influence of this worldwide event on Southeast Asian fisheries.

All feasible trawling grounds inside the Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea areas (referred to as RABUTINOS for brevity) were subdivided into 50 m depth sampling strata where the location of the 23 fishing tracks or sampling units (SU) used throughout the survey were selected at random (Figure 8). More closely spaced fishing stations were allotted south of Viñas River inside Ragay Gulf and near the entrance to Sorsogon Bay to account for the expected environmental variability and spatial heterogeneity at the shallowest stratum (i.e., < 50m depth), especially near the major point sources of freshwater (Megia *et al.*, 1953; Sebastian *et al.*, 1959).

Table 1. Dates of the Oceanographic Cruises Conducted Aboard the Research Vessel, *RV Sardinella* at Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines.

CRUISE NO.	CRUISE DATE
CR 3	NOVEMBER 7 - 13, 1981
CR 4	DECEMBER 9 - 14, 1981
CR 5	JANUARY 21 - 27, 1982
CR 6	FEBRUARY 28 - MARCH 5, 1982
CR 8	MAY 14 - 28, 1982
CR 9	JULY 21 - 26, 1982
CR 10	SEPTEMBER 24 - 30, 1982
CR 12	NOVEMBER 26 - DECEMBER 4, 1982
CR 13	JANUARY 13 - 20, 1983

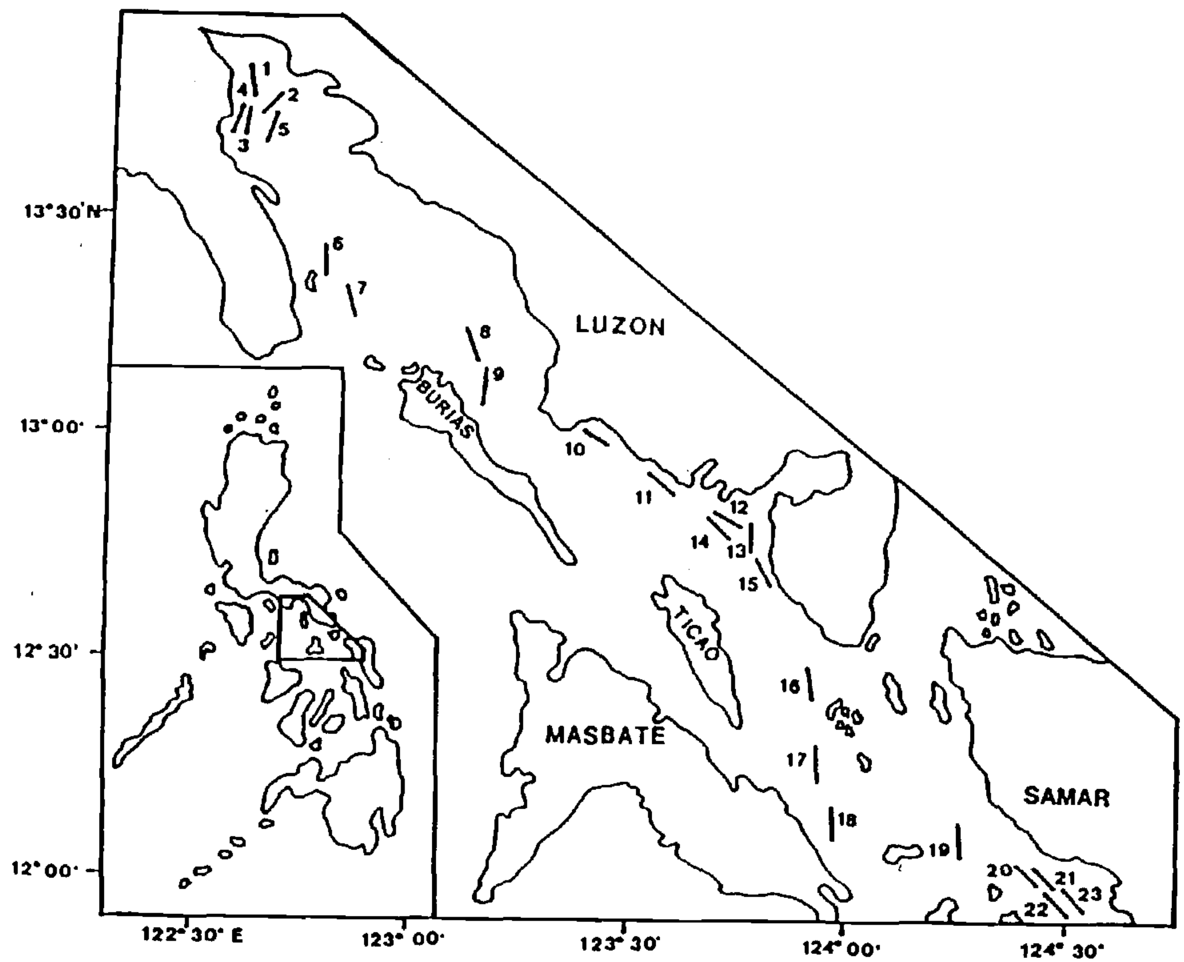


Figure 8. The Location of Fishing Stations (FS) at Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines.

Each of the 23 SU's was systematically sampled in every cruise. Due to budgetary constraints, however, fishing stations FS7, FS10, FS12 and FS18 were not sampled on the last cruise. Standard one hour trawl drag was completed at each SU using a German standard 2-seam Engel design otter trawl net with a cod-end stretched mesh size of 50 mm and a headrope length of 35.3 m. Based on earlier test fishing and instrument calibration cruise, the net sonde established the average horizontal and vertical opening of the trawl to be 21 and 5 m respectively when towed at normal speeds of 3.5 knots (6.3 km/h). This gives an average swept area of 0.1323 km^2 per tow.

All trawling tows were conducted during daylight hours following standard trawl sampling and catch-handling procedures, as in Pauly (1983) and Sparre (1985). Briefly, this involves randomly taking subsamples of the catch for sorting, weighing, and identification of fishes down to the species level if possible. Jellyfishes, sponges, corals and sea snakes were noted and discarded (Watson *et al.*, 1990). The total catches of each species was estimated from these subsamples using ratio and proportion. Catches less than 150 kg were counted directly. All catches were converted into catch per hour. The fish identification manuals of Jones and Rosa (1965), Rau and Rau (1980), FAO (1974), and Gjosaeter and Kawaguchi (1980) were used as key taxonomic references. Specimens that were difficult to identify were frozen for later analysis in the laboratory.

At the end of the research project, a total of 200 successful hauls was completed yielding a data set composed of 199 species/taxa from 19 to 23 sampling stations per cruise and 9 sampling periods (cruises). A detailed narrative of the Ragay Gulf survey is given in Sambilay *et al.* (1990).

2. Environmental Samples.

A total of 21 oceanographic stations was systematically sampled during each cruise (Figure 9). At each oceanographic station, *in situ* temperature was measured and

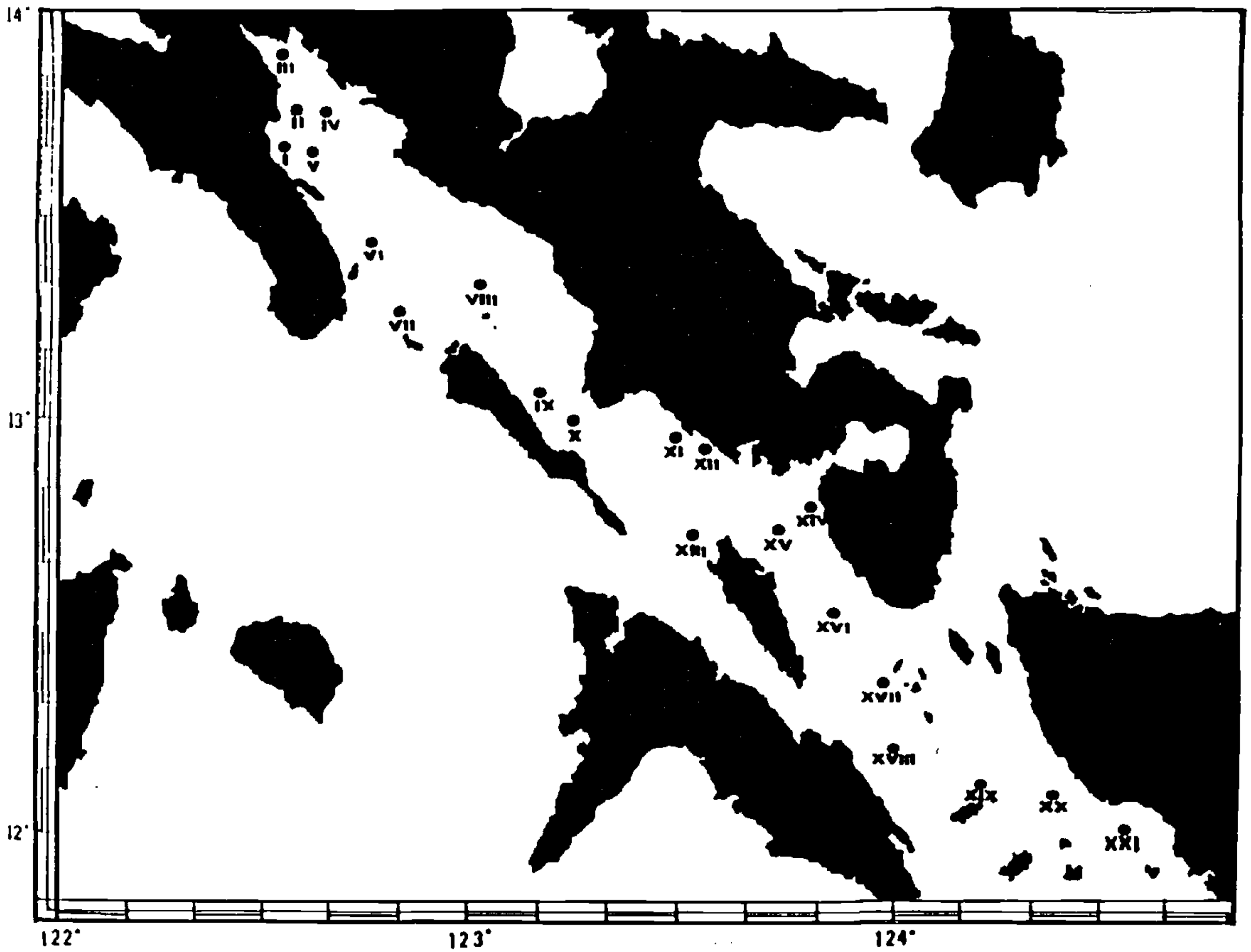


Figure 9. The Location of Oceanographic Stations (OS) at Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea, Philippines.

water samples taken at standard oceanographic depths, i.e., surface, 10, 20, 30, 50, 75, 100, 150, 200, 300, and 500 meters depending on the depth of the particular station. Whenever possible, additional measurements at approximately 1.5 m from the bottom were added to oceanographic stations near the start or end of each fishing track. Environmental characteristics of deep fishing stations were interpolated from the vertical profile(s) of the nearest oceanographic station(s) at similar depths (Bianchi, 1991). Sampling depths were recorded and monitored from the ship's Furuno scientific echosounder Model FE D824 at 1060 Hz and 28/200 Hz variable gain frequency. The ship's position was determined through radar triangulation and the ship's satellite navigation system.

Water temperatures were measured using reversing thermometers attached to Nansen bottles and corrected according to La Fond (1951) and Bialek (1966). Salinity was measured by a Tsurumi-Seiki salinometer periodically calibrated on standard sea water and the Mohr-Knudsen salinity titration procedure (Grashoff, 1976). Dissolved oxygen was determined using the modified Winkler titration method (Grashoff, 1976) and periodically checked with a Horiba water quality checker Model U-7.

All climatological data were derived from observations at the Masbate Island weather station furnished by the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). Substrate types were determined from hydrographic charts published by the Philippine Coast and Geodetic Survey for the area and checked once by taking sediment samples at each fishing stations using a van Veen grab.

B. Methods:

1. General Analytical Procedures.

The analytical strategy outlined by Field *et al.* (1982) for studying multispecies distribution patterns in the oceans was followed with some modifications. This approach separates the search for patterns among the biological variables from attempts to interpret them in terms of the environmental data. This allows the species to "tell their story" without the influence of any previous assumptions about the relationships between the biota and its environment (Day *et al.,* 1971). Each sampling group's environmental data was subjected to separate statistical tests and the ones that differ significantly were noted as being possible factors responsible for the biotic groups (Field, 1971; Field *et al.*, 1982). All standard multivariate analyses were done on PC-ORD version 2.0 (McCune and Mefford, 1995). Other statistical analyses were run on SAS Institute Statistical Programs (Ray, 1982; Cody and Smith, 1991).

Multivariate ordination and classification can be done on individual (i.e., monthly) cruises (e.g., Lasiak, 1984; McManus, 1985) or on data pooled over a period of two months (e.g., Bianchi, 1991; Blaber *et al.,* 1994), three months (Rainer and Munro, 1982) or more. For example, Ansari *et al.* (1995) subdivided the year into three seasons of four months each, i.e., pre-monsoon, monsoon, and post-monsoon and pooled his data accordingly, while over at the Gulf of Carpentaria in northern Australia, Sheaves (1998) subdivided the year into four seasons of three months each, i.e., pre-wet, wet, post-wet, and dry seasons. Pooling of similar sampling cruises was done to minimize redundancy, simplify analysis, even out noisy data and help reveal underlying ecological relationships without excessively smoothing out important community variations (Gauch, 1982; Digby and Kempton, 1987).

Taking into consideration that excessive agglomeration may smooth out important community variations, an objective approach was taken in deciding which cruises should be combined together. Since this work is about seasonal fish assemblage patterns, cruise data were pooled based on the classification and ordination of biotic variables rather than on physical climatic subdivisions. This approach was used effectively by Watson *et al.* (1990) and Ansari *et al.* (1995) to reveal cluster groups of cruises that demonstrated seasonal trends.

2. Normal or Q-Type Analysis.

a. *Raw Data.* Q-type analysis is the most common type of analysis in community ecology, where *n* samples (fishing stations) are grouped according to similarity in *s* species/taxa or biotic composition (Field *et al.*, 1982; Ludwig and Reynolds, 1988). Biomass (wet weight) was used as the unit of abundance since analysis based on fish weights is more ecologically appropriate (Field *et al.*, 1982; Bianchi, 1991) and relevant to fisheries management than analysis based on numbers (McManus, 1985; Bianchi, 1991; Federizon, 1992; McManus *et al.*, 1996).

A three dimensional primary data matrix of fishing stations (sites) x species x cruise (times) was analyzed in sets of two dimensional data as:

(1) Species (row) x cruise (column) data matrix where each cell contains species abundances averaged over all of the fishing stations that were sampled during each cruise.

(2) Species (row) x stations (column) data matrix where each cell contains the average abundance of each species caught at a given fishing station for all cruises that comprise the given seasonal cluster.

b. *Transformation and Standardization.* The original abundance data were log transformed using the formula:

$$Y_{ij} = \log(X_{ij} + 1),$$

were X_{ij} is the raw data score of the *i*th species in the *j*th sample and Y_{ij} is the corresponding transformed score. Field *et al.* (1982), Gauch (1982) and McManus (1985) consider the logarithmic transformation reasonable for this type of data. This transformation has the effect of compressing the upper end of the measurement scale to prevent swamping of other data by the dominance of very large species or large catches of smaller species (Digby and Kempton, 1987; Blaber *et al.*, 1994) and to facilitate comparison between trawl samples (Watson *et al.*, 1990). This transformation was not necessary in TWINSPAN analysis since the values were converted to a 1 to 5 scale based on the following lower class limits: 0, 2, 5, 10 and 20 kilograms.

c. *Ordination.* Since there is no one "correct" or ideal ordination or classification system, the most commonly used or highly recommended techniques available were empirically tested first to evaluate which would best represent the actual data set (Gauch, 1982; Krebs, 1989). The different ordination techniques tested and examples of their successful use in ecological research include: *Principal Components Analysis* (McCune, 1988; Ross and Doherty, 1994; Sheaves, 1996; Ponton and Copp, 1997), *Canonical Correlation Analysis* (ter Braak, 1986; Ponton and Copp, 1997), *Reciprocal Averaging* (Hill, 1973; Lasiak, 1984), *Detrended Correspondence Analysis* (Hill, 1979a; Hill and Gauch, 1980; Gauch, 1982; McManus, 1985; Bianchi, 1991; Metzeling, 1993; Marchant, *et al.*, 1994; McManus *et al.*, 1996; Miller and Death, 1997), *Non-Metric Multi-Dimensional Scaling* (Field *et al.*, 1982; Morin *et al.*, 1992; Connoly, 1994; Jones, *et al.*, 1996; Ohman, *et al.*, 1997) and *Bray-Curtis Ordination* (Beals, 1984; Watson, *et al.*, 1990). All analyses were tested using a variety of similarity measures available on the PC-ORD system and on log-transformed *versus* non-transformed data sets.

The different techniques were tested and ranked according to Gauch's (1982) basic performance evaluation criteria, i.e., effectiveness (summarizes the data well and aids understanding), robustness (ability to produce good results whether a data set involves long or short community gradients, one or more gradients, high or low noise, large or small number of species and samples, etc.), and practicality (computational feasibility, ease of data handling, and interpretability of results).

Principal Components Analysis (PCA) and Canonical Correlation Analysis (CCA) gave the worst results (i.e., points were often clumped around a single spot and produced varying degrees of "arch effect" or quadratic distortion of the first axis onto the second axis due to the ordination's inability to handle non-linear species response curve). Detrended Correspondence Analysis (DECORANA or DCA) and Reciprocal Averaging (RA) produced similar ordination groupings but RA suffered from extreme arch effect similar to PCA and CCA. Non-Metric Multi-Dimensional Scaling (NMDS) and Bray-Curtis Ordination (BCO) also produced similar patterns, but performance varied with the different seasonal data sets. Most of the ordination techniques were able to extract the major structure in the data and none performed perfectly all the time. After more than 300 test ordination runs on the PCORD program, DECORANA emerged to be the best technique for this particular data set, with BCO and NMDS ranked second.

DECORANA is a modification of Reciprocal Averaging (RA) developed to eliminate the "arch effect" through simple trend removal along successive axes, with optional rescaling of axes to remove compression of points and the distortion of relative distances at either end of the ordination (Digby and Kempton, 1987; Bianchi, 1991). Detrended Correspondence Analysis (DECORANA) is useful in ecological studies because it only assumes a simple unimodal species response curve (ter Braak and Prentice, 1988). Also, it does not assume linear relationships between species abundances and environmental variables like most other ordination techniques (Bianchi, 1991).

The DECORANA options on PC-ORD that were used in this study were:

Downweighting of Rare Species = yes

Rescale Axes = yes (default)

Rescaling Threshold = 0 (default)

Number of Segments = 26 (default)

DCA Output: List of Residuals, Eigenvalue, Scores, Graphs, Correlations

d. *Classification.* Evaluation procedures similar to the ordination techniques were also tested on two popular classification techniques in ecology: *Cluster Analysis* (Rainer and Munro, 1982; Lasiak, 1984; Ramm, *et al.*, 1990; Morin, *et al.*, 1992; Courtney *et al.*, 1995; Jones, *et al.*, 1996) and Two-Way INdicator SPecies ANalysis or *TWINSPAN* (Hill, 1973; Hill, 1979b; Gauch, 1982; Bianchi, 1991; Metzeling, 1993; McManus, 1985; McManus, *et al.*, 1996). Both techniques gave comparable results. Since cluster analysis was the preferred method for classifying smaller numbers of objects (Digby and Kempton, 1987), it was used to classify the nine cruises into their respective seasonal groupings.

Cluster analysis is a special kind of hierarchical classification system based on a similarity matrix that involves grouping objects into distinctive subsets (Jain and Dubes, 1988). The Relative Euclidean Dissimilarity measure (RED) was the similarity measure used as it corrects and maintains the metric qualities of the Euclidean measure (Ludwig and Reynolds, 1988). The Unweighted Pair-Group Method using Arithmetic Averages (UPGMA) was used to objectively determine the seasonal grouping of cruises. The UPGMA algorithm computes the average similarity or dissimilarity of a candidate sampling unit to an extant cluster by weighting each sampling unit in that cluster equally regardless of its structural subdivision. Monte Carlo simulation studies proved UPGMA at *par* with single-link clustering when the data were perturbed (Cunningham and Ogilvie,1972) and better than Ward's method on clusters of unequal sizes (Milligan and Isaac,1980).

The PCORD - CLUSTER options used were:

Cluster Distance Measure = Relative Euclidean

Group Linkage Method = 4 (i.e., Group Average or UPGMA)

Dendogram Options = Log Transform Dendogram Scale, Single space

TWINSPAN was adopted for the classification of SU's and species into their respective site and species groupings because of its compatibility with DECORANA ordination. Both DECORANA and TWINSPAN are based on correspondence analysis which makes it possible to compare directly the classification from TWINSPAN and the ordination along the first axis of DECORANA (Digby and Kempton, 1987; Bianchi, 1991). TWINSPAN also produces a sorted, two-way community table in which species and stations are arranged along the major gradients within the data (Belbin, 1991; Blaber, *et al.,* 1994). This makes the interpretation of the *r*-mode (species/taxa groupings based on their distribution and abundance on similar stations) and *q*-mode (station groupings based on similar species composition) dendograms easier. Furthermore, the selection of TWINSPAN and DECORANA as the main classification and ordination techniques allow the direct comparison of this work with those of Federizon (1992) for Ragay Gulf and McManus (1985) for Samar Sea.

TWINSPAN (Hill, 1979b) is a polythetic, divisive classification technique that begins with all samples together in a single cluster before being successively divided into a hierarchy of smaller and smaller clusters (Gauch, 1982). The basic procedure starts with an ordination of the samples by Reciprocal Averaging. Species that characterize the axis extremes (i.e., the most dissimilar species) are emphasized to polarize the samples before division of the principal axis near the middle. The process is repeated on the two sample subsets until each cluster has no more than a chosen minimum number of members. In TWINSPAN, importance values are not used directly but are converted to a scale based on lower class limits.

Each seasonally pooled data set was classified by TWINSPAN and the SU clusters for each season were initially assigned a temporary name, e.g., a1, a2, a3, etc. for season X; b1, b2, b3, etc. for season Y; etc. When the number of groups formed within each seasonal classification becomes large, however, it is not always obvious which pairs of groups from two or more classifications match. TWINSPAN and correspondence ordination of the seasonal SU clusters were implemented to classify, order and match each seasonal classification category into a common or "standardized" scale (Gauch, 1982; Digby and Kempton, 1987). Hence, if the same cluster was initially assigned two different temporary names based on its appearance on two different seasons, on the second round of classification, they will be grouped together under the same cluster because of their perfect similarity. Once all of the clusters were delineated in this manner, the temporary names initially given to each of the seasonal SU clusters were then changed into their new standardized group names.

The TWINSPAN options on PCORD used in this study were:

Pseudospecies Cut Levels = default
Maximum Number of Indicators per Division = 5 (default)
Maximum Level of Divisions = 6 (default)
Minimum Group Size for Division = 5 (default)
Maximum Number of Species in the Final Tabulation = 100 (default)

Instead of arbitrarily choosing a single similarity threshold to define cluster membership, more easily interpretable and ecologically reasonable clusters were obtained by "cutting joints" on the dendrogram (Helvey and Smith, 1985; Digby and Kempton, 1987; Dennis and Bright, 1988).

e. *Indicator Species.* After summarizing the fish assemblage patterns with the two complementary classification and ordination diagrams, the difference in species which caused the patterns were determined from the raw data (Field *et al.*, 1982). Since removing rare species has little effect on the results of community analysis (Stephenson and Cook, 1980; Long and Poiner, 1994), the top 20 most abundant species (60%-100% of the weight of all species/taxa in each group) were used as the basis for describing each group (Federizon, 1992; Cyrus and Blaber, 1992; Sheaves, 1998). More specifically, a group was qualitatively defined based on its five most dominant species/taxa or family, its overall species richness (i.e., total number of species), and its exclusive members in the top 20 most abundant species/taxa (Robertson and Blake, 1990; Prochazka, 1998). Here a species/taxa is considered "exclusive" to the group if it only occurs in that particular group's top 20 most abundant species/taxa list of 20 taxa. In all, a total of 90 species/taxa (45% of total) were included in the top 20 list for each season. The diversity of the communities is represented by species richness which is equivalent to the total number of species/taxa comprising the group.

3. Inverse or R-Type Analysis.

The transpose of the *q*-type data matrix was used in the complementary *r*-type analysis (i.e., grouping of species based on their abundance in similar stations). Similar procedures and techniques outlined above were applied. The analysis of species groups in relation to the environmental data is more complex in the *r*-type analysis and simple tests for significant differences between groups are not appropriate (Field *et al.*, 1982). Therefore, its use was limited primarily to the analysis of species grouping derived from the TWINSPAN two-way ordered table (Helvey and Smith, 1985; Dennis and Bright, 1988).

4. Relating Environmental Data to the Community Groups.

a. *Environmental Correlations.* The relationship between station groups and environmental variables was analyzed using the DECORANA joint plot option contained in the GRAPH menu of the PCORD program package. This also provides the option of correlating the ordination axes with environmental variables (depth and bottom temperature, salinity, and dissolved oxygen). Partial correlation and Pearson's rank correlation coefficients were calculated among the environmental variables and also between each variable and the scores of the ordination axis. A significance level of $\alpha \leq 0.05$ was selected as the cut-off level for analysis.

b. *Comparison of Group Means.* Following Field *et al.*'s (1982) procedure, all observations on each environmental variable (e.g., salinity) of one SU group were compared with the corresponding observations of other SU groups. The ones that differ significantly were noted as being possible factors responsible for the biotic groups. Multiple comparison of means was analyzed using Analysis of Variance (ANOVA) and Fisher's Protected Least Significant Difference (PLSD) technique (Ray, 1982; Cyrus and Blaber, 1992). Fisher's PLSD test takes into account the unequal variances of each treatment (Day and Quinn, 1989; Cyrus and Blaber, 1992) and also offers more protection against incorrect inference, *vis-à-vis,* the simple Least Significant Difference (LSD) method. This is achieved simply by adding the restriction that the F-test for equal means must be significant at the 5% level (Ray, 1982), which fixes the experimental error rate at approximately five percent.

c. *Multiple Regression of Fish Abundance on Environmental Variables.* In the absence of evidence to the contrary, (e.g., inter/intra-specific competition and predation, ontogenetic behavior, symbiosis), it is reasonable to assume that environmental factors determine, directly or indirectly, the level of fish abundance. In these circumstances the use of regression analysis is more appropriate than a simple correlation coefficient concerned only with degrees of interdependence (Quinn, 1980; Greig-Smith, 1983; Cyrus and Blaber, 1992; Blaber *et al.*, 1995). Forward Stepwise multiple linear regression (Ray, 1982; Tabachnick and Fidell, 1989) was used to determine the direction and degree of relationship between the properties of the overlying water mass at a given fishing station and the observed abundance of each species/taxon. Bottom temperature, salinity, dissolved oxygen concentration and depth were the variables used to estimate the y values, i.e., the seasonal abundance of fishes expressed as average catch (wet weight) per hour.

A variable was included in the model only if it increases R^2 by 10% or more, maintains an overall significance level of $\alpha \leq 0.05$ or better, and retains a fairly acceptable Mallow's Cp statistics. A value of $Cp > p$ is evidence of biased estimation of parameters due to dropping of variables from the complete model while values of $Cp < p$ results from strong collinearity among one or more of the environmental variables (Philippi, 1993). Here, p is the number of variables in the model including the intercept. Since the regression models are only designed to explore possible relationships and not for prediction purposes, the application of Mallow's Cp criteria and significance testing were more relaxed (Philippi, 1987). For Mallow's $Cp < p$, Studenmund and Cassidy (1987) suggested doing nothing if the multicollinearity has not decreased t-scores to the point of insignificance. If Mallow's $Cp > p$, additional variable(s) were considered, provided the resulting model retained an acceptable R^2 and significance level.

5. Sampling Errors and Limitations.

Shallow-water (< 20 m) communities were not sampled adequately due to the draft limitations of the research vessel and the constraints imposed by existing fisheries regulations. Demersal trawls are both size- and species-selective, however it was impossible to adjust for this type of selectivity without knowing the behavior of most species and/or the real age/size structure of populations (Bianchi, 1991). In shallow waters (20 - 40 m deep), many typically pelagic species were also caught. At this depth, it was difficult to differentiate the demersal fishes from the small pelagics that feed on the bottom and also inhabit this zone as both groups have a much closer relationship in these shallow waters than offshore (Watson *et al.*, 1990; Bianchi, 1991; Blaber *et al.*, 1994). Therefore, pelagic species were also included in the analysis whenever they occurred in the samples. The same applies to the mesopelagic fishes caught by the trawl while carrying out diurnal vertical migrations in the deeper part of the shelf and upper slope.

RESULTS

A. Grouping of Cruises:

The natural grouping of the different cruises are shown in Figure 10. The cruises were clustered based on the similarity of their component fish assemblages. This process revealed four distinct groups of sampling cruises corresponding to the Southeast Asian dry and wet monsoon seasons. The result indicates seasonality in the composition and abundances of the demersal trawl fauna of RABUTINOS.

Wet Northeast Monsoon Season. This group is composed of Cruises 3 (November 1981), 4 (December 1981) and 5 (January 1982) and corresponds to the northern hemisphere winter months. Cool and wet maritime airmass brought about by strong and persistent winds coming from the northeast characterize this Asiatic monsoon.

Dry Intermonsoon Period. Cruises 6 (February-March 1982), 8 (May 1982) and 9 (July 1982) comprise this group that coincides with the spring transition and northern hemisphere spring season. Light breeze, very warm temperatures and relatively dry climatic conditions are typical during this period.

Wet Southwest Monsoon Season. This group consists of Cruises 10 (September 1982) and 12 (November-December 1982) corresponding to the northern hemisphere summer and fall seasons. Warm and rainy weather conditions punctuated by the passage of typhoons characterize the climate during these months.

Dry ENSO Event composed of Cruise 13 (January 1983) represents the peak and early maturity stages of the strong 1982-1983 ENSO event. Instead of joining the Northeast monsoon cluster, both the TWINSPAN and Cluster Analysis separated Cruise 13 as totally different from the rest, indicating the uniqueness of the event.

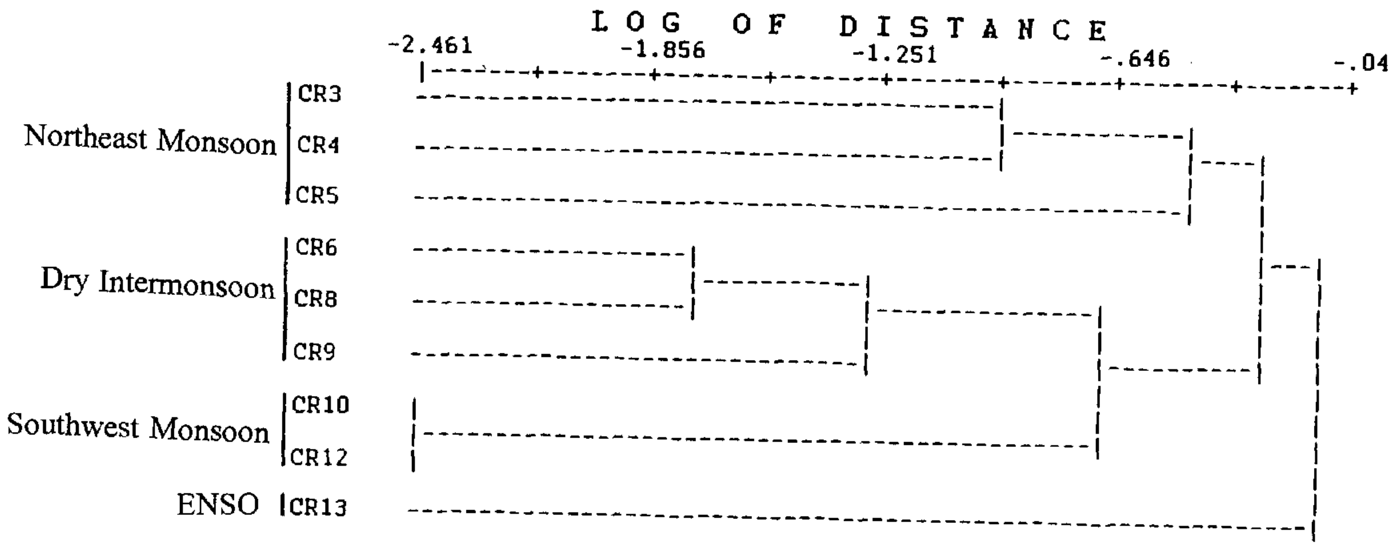


Figure 10. Seasonal Allocation of Cruises Based on Cluster Analysis of Ragay Gulf, Burias Pass, Ticao Pass and Northern Samar Sea Fish Abundance Data.

B. General Description of Trawl Catch:

This section presents the top 20 most abundant (by weight) species or taxa for the whole area and sampling cruises conducted at RABUTINOS. More than half of the 199 species/taxa is rare, each occurring in fewer than 20 of the 200 hauls. Despite the multispecies nature of tropical fisheries, about 60% to 100% of the catch is usually represented by just the top 10 or top 20 species which makes this list very valuable in describing and monitoring the development of any fishery. Both the overall aggregate species list and the seasonal trends in species abundances are included in this section for descriptive and comparative purposes. A list of the species arranged by families is provided in Appendix I.

1. Top 20 Most Abundant Species By Weight.

Table 2 lists the twenty most abundant (by wet weight) species or taxa caught by the sampling gear at RABUTINOS for the whole sampling period. Although this list represents only 11% of the total number of species/taxa (185) in the trawl samples, they account for approximately 3/4 (28 metric tons) of the all the samples caught (44 metric tons). Species dominance was not very pronounced. None of the species/taxa excessively dominated the top 20 most abundant species pool, with relative difference among adjacent species/taxa of 2% or less. Even the share of the top three species/taxa were comparable at 7% to 8%, although their combined abundances accounts for 22%.

At the family/group level, more than half of the catch came from the 18 families represented by the 20 most abundant species/taxa. They include: Tetraodontidae, Balistidae (*Abalistes stellaris*), Monacanthidae (*Alutera monoceros*), Diodontidae, Carangidae (*Carangoides speciousus, Decapterus muruadsi*), Centriscidae (*Aeliscus strigatus*), (Dasyatidae), Leiognathidae (*Leiognathus bindus, L. splendens*), Lethrinidae (*Lethrinus lentjan*), Mullidae (*Upeneus sulphureus*), Ariommidae (*Ariomma indica*),

Table 2. Top 20 Most Abundant (Wet Weight) Species/Taxa at RABUTINOS for all Cruises and Fishing Stations.

RANK	CODE	SPECIES	N	Total Weight (kgs)	%	Cumulative Frequency
1	ARIOMA	*Arioma indica*	207	3422.42	7.73%	7.73%
2	TRICHI	*Trichiurus haumela*	207	3202.82	7.23%	14.96%
3	LEOBIN	*Leiognathus bindus*	207	3201.80	7.23%	22.19%
4	DIODON	Diodontidae	207	2261.28	5.11%	27.30%
5	DASYAT	Dasyatidae	207	2035.21	4.60%	31.89%
6	CRXSPE	*Caranx speciousus*	184	1479.93	3.34%	35.23%
7	PRIAMA	*Priacanthus macracanthus*	207	1376.37	3.11%	38.34%
8	DECAMU	*Decapterus muruadsi*	207	1362.30	3.08%	41.42%
9	UPESUL	*Upeneus sulphureus*	207	1338.74	3.02%	44.44%
10	SAURUN	*Saurida undosquamis*	207	1209.98	2.73%	47.17%
11	TETRAO	Tetraodontidae	207	1163.43	2.63%	49.80%
12	LEOSPL	*Leiognathus splendens*	207	1083.46	2.45%	52.25%
13	ABALIS	*Abalistes stellaris*	207	839.15	1.89%	54.14%
14	LOLIGO	Loligo sp.	207	799.22	1.80%	55.95%
15	AELISC	*Aeliscus strigatus*	115	645.08	1.46%	57.40%
16	LTRILE	*Lethrinus lentjan*	184	603.04	1.36%	58.77%
17	ALUTMO	*Alutera monoceros*	207	560.77	1.27%	60.03%
18	SCOMME	*Scomberomorus commersonii*	207	498.25	1.13%	61.16%
19	LOPHII	Lophiidae	207	487.82	1.10%	62.26%
20	SHARKS	Sharks	207	484.08	1.09%	63.35%
		OTHERS				36.65%
		TOTAL (wt.)		44,286 kgs.		100.00%
		TOTAL (No. of Species)		185		

Trichiuridae (*Trichiurus haumela*), Lophiidae, Priacanthidae (*Priacanthus maculatus*), Synodontidae = Synodidae (*Saurida undosquamis*), sharks, Scombridae (*Scomberomorus commerson)*, and the squids, Loliginidae (*Loligo* spp.).

2. Seasonal Trends in Species Abundance.

In order to determine if the four temporal groups derived by cluster analysis were distinct, the top 20 most abundant species/taxa were compared in this section (Figure 11). A total of 40 species/taxa belonging to 28 families was included in the combined top 20 most abundant species/taxa list. The habitat (depth) designations were derived from the TWINSPAN table discussed in later sections.

a. *Northeast Monsoon Season (NE).* The top five species/taxa during the wet northeast monsoon season include: Dasyatidae and Mobulidae (rays), *Ariomma indica* (Indian drift fish, Family: Ariommidae), *Lutjanus bojar* (snapper, Family: Lutjanidae) and Tetraodontidae (pufferfish). Together, they account for 22% of the catch while the top 20 listed species/taxa comprise 54% of the catch. The relative percentage abundance of the species/taxa comprising the catch during this season was relatively even with 17 families represented in the top 20 list. There were five exclusive members in this list, i.e., Mobulidae (rays), *Lutjanus bojar* (Family: Lutjanidae), *Selar crumenophthalmus* (bigeye scads, Family: Carangidae), *Epinephelus guttatus* (grouper, Family: Serranidae), and Ostraciidae (boxfishes). If the ENSO repetition (EN) is not included, the number of exclusive species/taxa is seven, with the addition of *Lethrinus opercularis* (emperors, Family: Lethrinidae) and *Saurida tumbil* (common saury, Family: Synodidae).

b. *Intermonsoon Period (INT).* During the dry intermonsoon period, the top five species/taxa include *Leiognathus bindus* (orange ponyfish, Family: Leiognathidae), *Ariomma indica* (Indian driftfishes, Family: Ariommidae), Diodontidae (pufferfish), *Carangoides speciousus* (jack) and *Decapterus muruadsi* (round scad, Family:

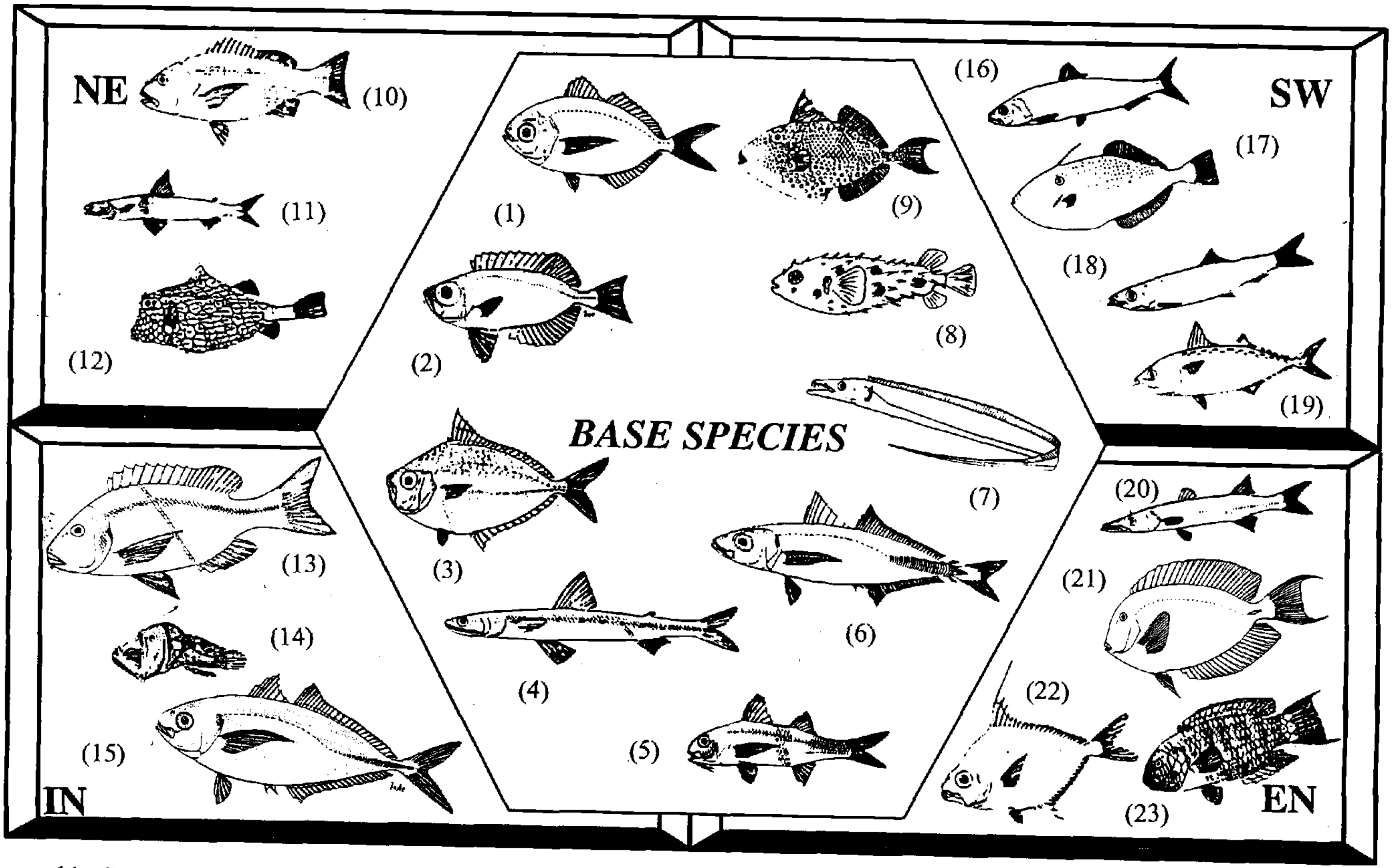


Figure 11. Seasonal Changes in the Top 20 Most Abundant Species/Taxa of RABUTINOS. (Numbers inside the parenthesis refer to the species' name in the index).

	SPECIES	Habitat	NE			INT			SW			EN		
			Mean	%	Rank	Mean	%	Rank	Mean	%	Rank	Mean	%	Rank
NE	*Dasyatidae*	D/U	12.52	5.21	1	7.64	2.84	9	6.39	2.97	8	19.81	10.72	2
	Mobulidae	D	10.87	4.52	2									
	Ariomma indica (1)	D	9.79	4.08	3	23.18	8.62	2	12.77	5.93	2	31.03	16.79	1
	Lutjanus bojar (10)	S	9.73	4.05	4									
	Tetraodontidae	S/C	8.74	3.64	5	6.82	2.54	11						
	Priacanthus macracanthus (2)	D	8.64	3.59	6	8.10	3.01	6	4.79	2.23	11			
	Leiognathus bindus (3)	S	8.20	3.41	7	31.52	11.72	1	10.34	4.8	4	2.70	1.46	15
	Saurida undosquamis (4)	D	6.92	2.88	8	7.80	2.9	8	3.77	1.75	13	2.89	1.56	13
	Upeneus sulphureus (5)	S	6.75	2.81	9	5.69	2.12	13	7.63	3.54	6	6.85	3.71	5
	Decapterus muruadsi (6)	D	6.28	2.61	10	9.20	3.42	5	5	2.32	10	3.47	1.88	12
	Trichiurus haumela (7)	D	5.85	2.43	11	6.58	2.45	12	46.97	21.8	1	7.89	4.27	4
	Diodontidae (8)	S	5.49	2.29	12	18.90	7.03	3	9.8	4.55	5	6.76	3.66	6
	Loligo sp.	D/U	5.19	2.16	13				1.82	0.84	20	6.73	3.64	7
	Lethrinus opercularis	S/C	4.04	1.68	14							3.79	2.05	10
	Selar crumenophthalmus	D/U	3.90	1.62	15									
	Epinephelus guttatus	S/C	3.65	1.52	16									
	Carangoides speciosus	S/C	3.62	1.51	17	10.73	3.99	4	12.01	5.57	3			
	Saurida tumbil (11)	D/U	3.61	1.50	18							3.63	1.97	11
	Abalistes stellaris (9)	S/C	3.57	1.49	19	4.30	1.6	16	5.76	2.67	9	1.97	1.07	20
	Ostraciidae (12)	S/C	3.37	1.40	20									
INT	*Aeliscus strigatus*	S/C				7.86	2.92	7						
	Leiognathus splendens	S				7.04	2.62	10	2.74	1.27	16	16.32	8.83	3
	Lethrinus lentjan	S/C				4.89	1.82	14						
	Seriola grandis	D				4.78	1.78	15						
	Lophiidae (14)	D				3.84	1.43	17						
	Selaroides leptolepis (15)	S				3.48	1.3	18						
	Rhinobatidae	D				3.26	1.21	19						
	Lutjanus lineolatus	S/C				3.20	1.19	20	7.02	3.26	7			
SW	*Sardinella longiceps* (16)	S							3.92	1.82	12			
	Alutera monoceros (17)	S/C							3.27	1.52	14			
	Dussumiera acuta (18)	S							2.83	1.31	15			
	Centriscus scutatus	S/C							2.63	1.22	17	2.32	1.25	17
	Rastrelliger brachysoma (19)	S							2.28	1.06	18			
	Alectis ciliaris	S							1.9	0.88	19			
EN	*Sphyraena obtusata* (20)	S										4.04	2.18	8
	Seriolina nigrofasciata	D/U										4.01	2.17	9
	Gymnocaesio gymnoptera	S										2.71	1.47	14
	Acanthurus sp. (21)	S/C										2.68	1.45	16
	Leiognathus leuciscus (22)	S										2.13	1.15	18
	Labridae (23)	S/C										2.00	1.08	19
	Weight (kg)		240.30			268.92			215.41			184.80		
	Total No. of Species		178			170			150			133		

Legend: S = Shallow D = Deep C = Coralline U = Ubiquitous
NE=Northeast Monsoon Season
INT = Intermonsoon period
SW = Southwest Monsoon Season
EN = ENSO Early Maturity Stage

Figure 11. Seasonal Changes in the Top 20 Most Abundant Species/Taxa of RABUTINOS - Index to Species (continued).

Carangidae). Together they comprise 35% of this season's catch while the top 20 listed species/taxa account for 64%. Although *Leiognathus bindus* had a higher percentage share in abundance (12%) than during the NE monsoon, the contribution of each species/taxa was still relatively even. There were six exclusive members to this group, i.e., *Aeliscus strigatus* (shrimpfish, Family: Centriscidae), *Lethrinus lentjan* (red spot emperor, Family: Lethrinidae), *Seriola grandis* (trevally, Family: Carangidae), Lophiidae (goosefish), *Selaroides leptolepis* (Family: Carangidae), and Rhinobatidae (guitarfish). A total of 16 families was represented in the top 20 species list.

c. *Southwest Monsoon Season (SW).* The rainy southwest monsoon season had *Trichiurus haumela* (hairtails, family: Trichiuridae), *Ariomma indica* (Indian driftfish, family: Ariommidae), *Carangoides speciousus* (jack, family: Carangidae), *Leiognathus bindus* (orange ponyfish, family: Leiognathidae) and Diodontidae in the top 20 most abundant species/taxa list. All five made up 43% of the total catch during this season while the top 20 species/taxa on the list comprise 71%. A total of 16 families were represented by the top 20 species/taxa with *Trichiurus haumela* (family: Trichiuridae) dominating the catch (22%), followed by other taxa with relatively even percentage abundances. Five species were exclusive to this season, i.e., two sardine species, *Sardinella longiceps* (Indian oil sardine) and *Dussumiera acuta* (rainbow sardine, family: Clupeidae); *Alutera monoceros* (unicorn filefish, family: Balistidae); *Rastrelliger brachysoma* (short-bodied mackerel, family: Scombridae); and *Alectis ciliaris* (pennantfish, family: Carangidae). *Centriscus scutatus* (shrimpfish, family: Centriscidae) of the ENSO group is not included in this category.

d. *ENSO Early Maturity Stage (EN).* The dry ENSO early maturity period has the following species/taxa in the top 5 most abundant list: *Ariomma indica* (Indian driftfish, family: Ariommidae), Dasyatidae (ray), *Leiognathus splendens* (black-tipped ponyfish, family: Leiognathidae), *Trichiurus haumela* (hairtail, family: Trichiuridae) and *Upeneus sulphureus* (yellow goatfish, family: Mullidae). Together they accounted for 44% of the period's catch, while the top 20 species/taxa contributed 71%. *Ariomma indica* dominated the catch but not as much as *Trichiurus haumela* during the previous season. A total of 16 families was represented in the top 20 species/taxa list. There were six exclusive species/taxa during this season, i.e., *Sphyraena obtusata* (obtuse barracuda, family: Sphyraenidae), *Seriolina nigrofasciata* (black-banded trevally, family: Carangidae), *Gymnocaesio gymnoptera* (snappers, family: Lutjanidae), *Acanthurus* spp. (unicornfishes, family: Balistidae), *Leiognathus leuciscus* and Labridae (wrasses).

e. *Summary of Abundance Patterns.* The overall sequence of the seasonal variation in the species composition of RABUTINOS shows a number of recurring patterns. For example, the total number of families represented in the top 20 species/taxa list is constant at about 16 families. This is primarily brought about by two factors: (1) the total number of exclusive members added to the top 20 list in each season varied between 5 to 6 new entrant species and (2) the commonly occurring species (i.e., present in all seasons) were also stable at 9 to 11 species. These fishes include: Dasyatidae (ray), *Ariomma indica* (Indian driftfish, family: Ariommidae), *Leiognathus bindus* (orange ponyfish, family: Leiognathidae), *Saurida undusquamis* (brushtooh lizardfish, family: Synodidae), *Upeneus sulphureus* (yellow goatfish, family: Mullidae), *Decapterus muruadsi* (round scad, family: Carangidae), *Trichiurus haumela* (hairtail, family: Trichiuridae), Diodontidae (pufferfish), *Carangoides speciousus* (jack, family: Carangidae), *Abalistes stellaris* (starry triggerfish, family: Balistidae) and *Priacanthus macracanthus* (red bigeye, family: Priacanthidae). Many of these common species/taxa were also included in the top 5 most dominant species list, compared to the new entrants that usually ranked 10th or lower in abundance.

In summary, the majority (2/3) of the species included in the top 20 fishes remained common throughout the year, including during the ENSO period. About 1/3 of the top 20 most abundant species/taxa occurred during one season only. This seasonal species/taxa turn-over resulted in compositionally distinct species assemblages. The geographic areas most affected by this seasonal fluctuation will be covered in the next section.

C. Results of Ordination and Classification:

This section presents the results of the ordination and classification of the trawl samples aimed at unraveling the species/taxa assemblage and station groupings that comprise the demersal fish communities of RABUTINOS. The seven major, seasonally standardized SU and species groups (see methods section for details of the standardization procedures) are presented and described first in order to provide the necessary biological context to the succeeding discussions. The seasonal species/taxa composition, geographical distribution and environmental correlation of the different groups are presented thereafter.

The TWINSPAN dendogram, DECORANA ordination diagram, and table of correlation between the different environmental variables and the ordination axes were combined in one figure to show their interrelationships better. In the TWINSPAN dendogram, the small letter-number combinations inside the parentheses refer to the temporary seasonal group designations assigned to each SU cluster prior to standardization. The large numbers/letters in bold font refer to the final group designations after standardization. Table 3 summarizes the relationships among fishing stations, temporary seasonal clusters and the final standard cluster designation for each season (or group of sampling cruises). Appendix II lists some of the habitat characteristics of the fishing stations.

In the case of DECORANA ordination diagrams, (e.g., Figure 12), numbers refer to the fishing stations while diamonds mark their positions in the ordination space. The relationship between environmental variables and species ordination scores are shown as radiating lines coming from the ordination centroid of the "joint plot." The angle and length of the line indicate the direction and relative strength of the relationship. Only environmental variables having an $r^2 \geq 0.2$ with the scores on either axis were plotted.

Axis scaling using PC-ORD's 'minimum to maximum' option was used to maximize the spread of points on the graph and provide better visual resolution of the gradients. The second axis is stretched more relative to the first due to differences in their eigenvalues.

1. Standardized SU Groups and Their Fish Assemblages.

a. *Standardization of Classes.* Seven major standard groups and two sub-groups were identified by TWINSPAN based on the classification of all seasonal by derived clusters (Figure 12, upper diagram). Table 3 contains more detailed information on the temporary seasonal cluster designations. The first dichotomy separated the deep station (i.e., Groups 1 to 3) from the shallow fishing stations. The shallow fishing stations were further subdivided into the coralline station clusters (i.e., Group 7) near the Sorsogon Bay entrance and those further north (i.e., Group 5), including the riverine stations of Ragay Gulf and Northern Samar Sea (Groups 4A and 4B). The seasonal shifting of member species/taxa at the boundaries of Group 5 and Group 7 were captured by the transition Group 6. The major TWINSPAN classes formed relatively distinct and easily separable groupings either on the first or second DCA axis (Figure 12, lower diagram). The eigenvalues of the first three DCA axes were 0.75, 0.33 and 0.23 respectively.

b. *Characteristic Species/Taxa of the Major Site Groups.* A description of the different species assemblages comprising the seven major SU groupings are presented next. Figure 13 graphically illustrates and summarizes the corresponding habitat characteristics and principal families and species that make up the major SU groups. Appendix I lists the fish species/taxa arranged by families while Appendix III gives a complete list of all the fish species/taxa included in each major site group. The fishes shown in the upper section of the figure represent the most dominant species/taxa and/or the indicator species for the given community. The assemblage provides a visual approximation of what the trawl catch looks like on the deck of the trawler ship prior to sorting, boxing and storage.

Table 3. Standardized Group Designation and Equivalent Preliminary Seasonal Group Designation of Sampling Units with their Component Fishing Stations.

TWINSPAN GROUPING Standard	Preliminary	CRUISE	FISHING STATIONS
• ***DEEP FISHING AREAS:***			
1	a3	3, 4 & 5	FS6
2	b3	6, 8 & 9	FS6, FS7, FS17, FS18
	c4	10 & 12	FS17, FS18
3	a4	3, 4 & 5	FS7, FS8, FS9, FS16, FS17, FS18, FS19
	b4	6, 8 & 9	FS8, FS9, FS16, FS19
	c3	10 & 12	FS6, FS7, FS9, FS16, FS19
	d2	13	FS6, FS7, FS8, FS9, FS16, FS17, FS18, FS19
• ***SHALLOW RIVERINE/ESTUARINE FISHING AREAS:***			
4A	a2	3, 4 & 5	FS1, FS2, FS3, FS4, FS21, FS22, FS23
	b2	6, 8 & 9	FS1, FS2, FS3, FS4, FS21, FS22, FS23
	c2	10 & 12	FS1, FS2, FS3, FS4, FS5, FS21, FS22, FS23
	d1	13	FS1, FS2, FS3, FS4, FS5, FS20, FS21, FS22, FS23
4B	a1	3, 4 & 5	FS5, FS20
	b1	6, 8 & 9	FS5, FS20
	c1	10 & 12	FS8, FS20
5	b6	6, 8 & 9	FS10, FS11
	c6	10 & 12	FS10, FS11
• ***SHALLOW CORALLINE FISHING AREAS:***			
6	a6	3, 4 & 5	FS10, FS11, FS12
	b5	6, 8 & 9	FS12, FS13, FS14, FS15
	d3	13	FS11, FS13, FS14, FS15
7	a5	3, 4 & 5	FS13, FS14, FS15
	c5	10 & 12	FS12, FS13, FS14, FS15

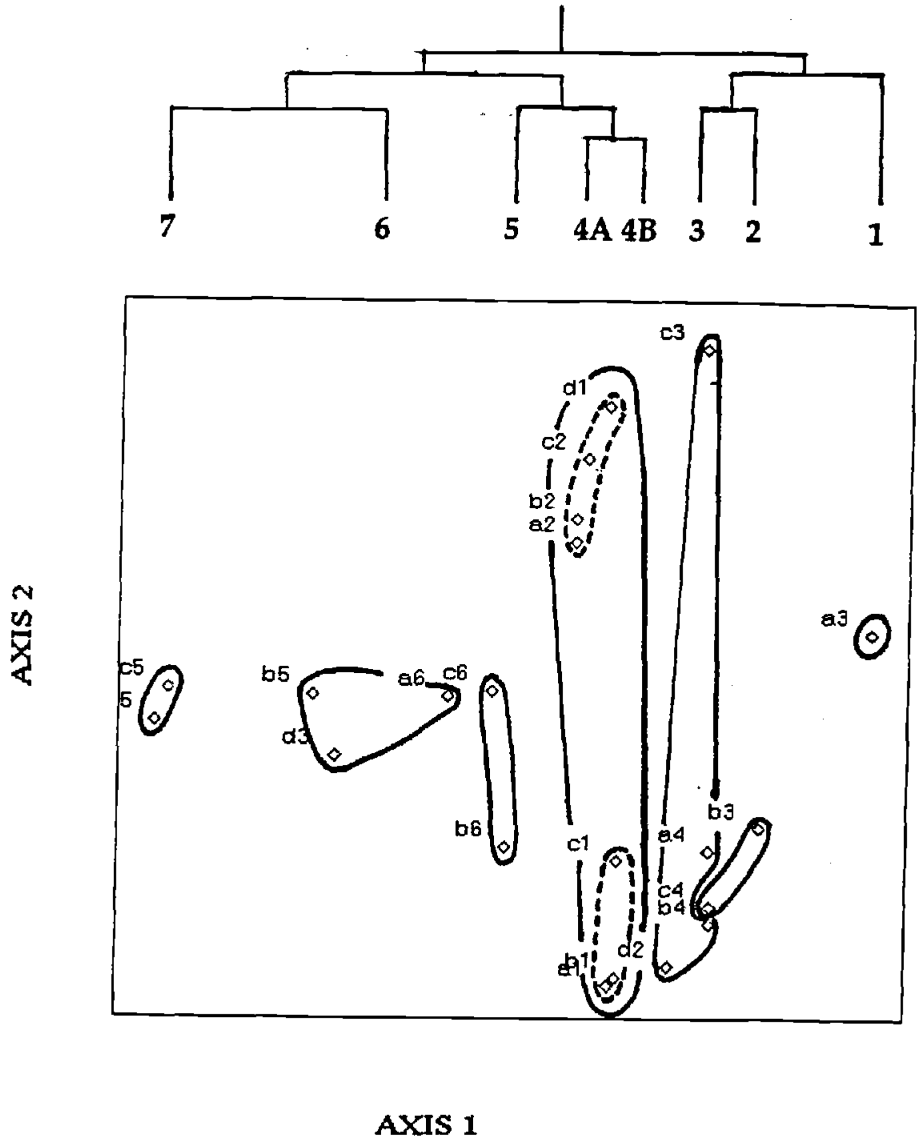


Figure 12. Results of the Q-Type Classification and Ordination Analyses on the Preliminary Seasonal Clusters. Upper diagram: TWINSPAN dendogram showing the "Standardized Group Designation." Lower diagram: DECORANA ordination plot showing the clustering of preliminary seasonal groups into standardized groups.

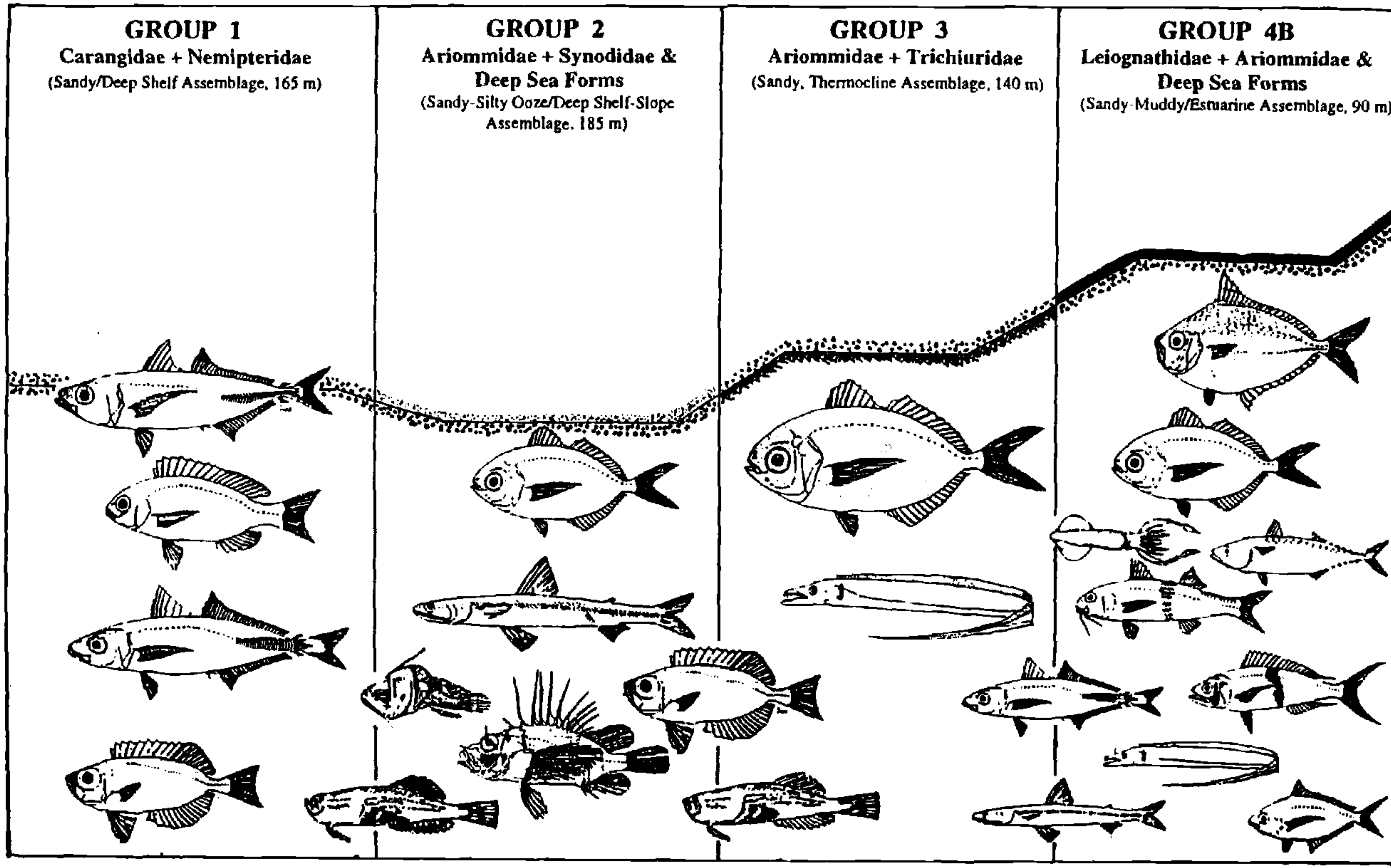


Figure 13. Schematic Representation of the Typical Species Composition and Habitat Characteristics of the Different Fish Assemblages found in RABUTINOS.

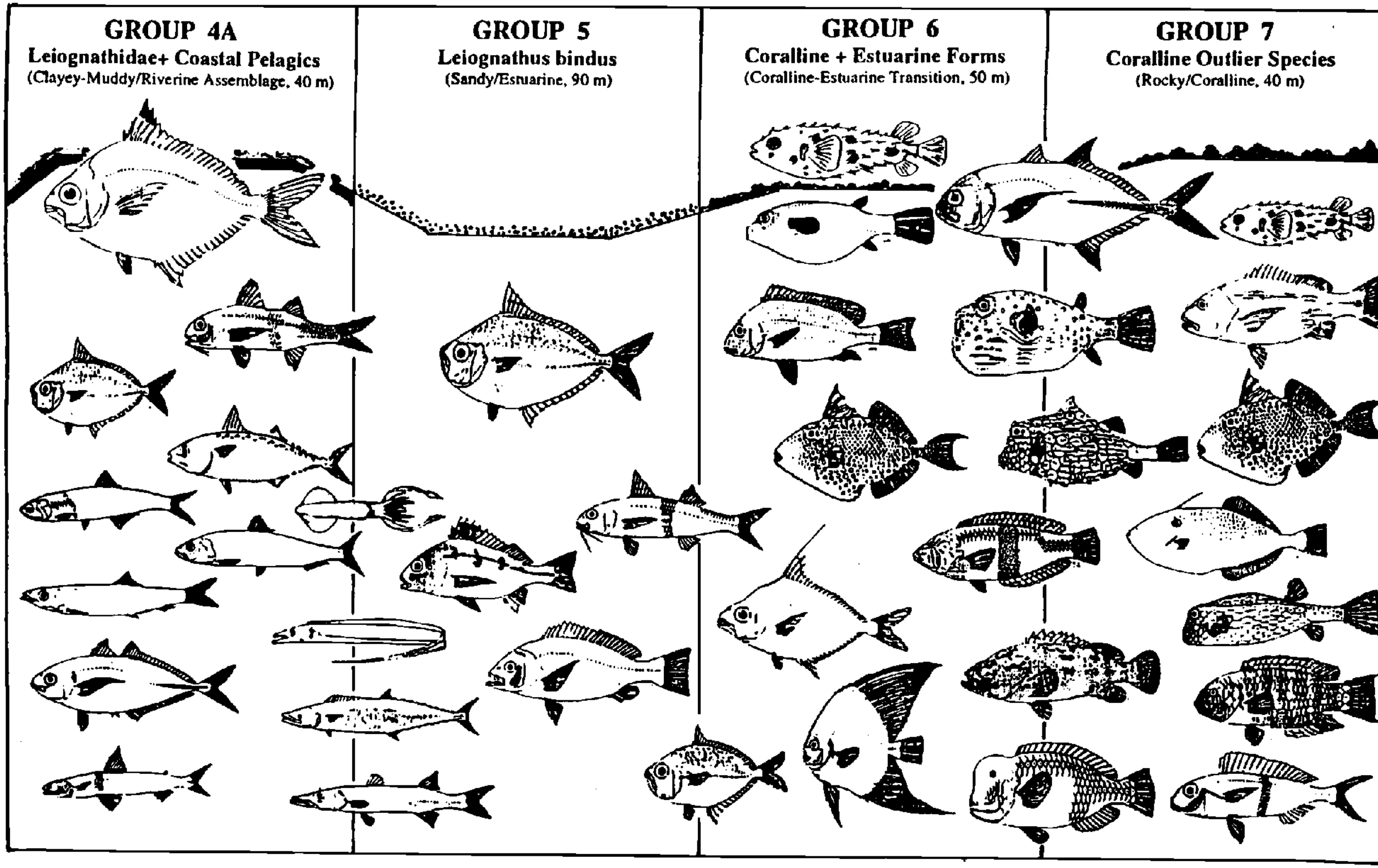


Figure 13 continued. Schematic Representation of the Typical Species Composition and Habitat Characteristics of the Different Fish Assemblages found in RABUTINOS.

Figure 13. (continued). Index to Species and Habitat Characteristics of the Fish Assemblage Groups.

GROUP 1

Primary Species:
Decapterus kurroides
Nemipteridae
Decapterus muruadsi

Associated Species:
Priacanthus macracanthus
Lophiidae
Uranoscopidae

Habitat Characteristics:
Substrate: Sandy
Mean Temp.: 18.17°C
Mean Salinity: 34.42‰
Mean DO: 1.80 ml/L
Mean Depth: 166 m
Others: Below Thermocline; Ragay Basin Sill; Wide Shelf
N = 18 sp. ; CPUE = 101 kg

GROUP 2

Primary Species:
Arioma indica
Saurida undosquamis

Associated Species:
Lophiidae
Priacanthus macracanthus
Scorpaenidae
Uranoscopidae

Habitat Characteristics:
Substrate: Sandy-Silty Ooze
Mean Temp.: 19.31°C
Mean Salinity: 34.46‰
Mean DO: 2.39 ml/L
Mean Depth: 185 m
Others: Below Thermocline; Sill or Ridge; Wide Shelf
N = 57 sp. ; CPUE = 236 kg

GROUP 3

Primary Species:
Arioma indica
Trichiurus haumela

Associated Species:
Priacanthus macracanthus
Decapterus muruadsi
Uranoscopidae
Saurida undusquamis

Habitat Characteristics:
Substrate: Sandy-Hard Surface
Mean Temp.: 21.98°C
Mean Salinity: 34.46‰
Mean DO: 3.68 ml/L
Mean Depth: 139 m
Others: Within Thermocline; Sill or Ridge; Wide Shelf
N = 87 sp. ; CPUE = 229 kg

GROUP 4B

Primary Species:
Leiognathus bindus
Arioma indica
Loligo sp.

Indicator Species:
Rastrelliger kanagurta

Associated Species:
Upeneus mollucensis
Decapterus muruadsi
Aphareus rutilans
Trichiurus haumela
Saurida undusquamis
Pentaprion longimanus

Habitat Characteristics:
Substrate: Sandy-Muddy
Mean Temp.: 26.07°C
Mean Salinity: 34.32
Mean DO: 5.18 ml/L
Mean Depth: 88 m
Others: Close to River; Near Shelf Break
N 104 sp. ; CPUE = 148 kg

Figure 13. (continued). Index to Species and Habitat Characteristics of the Fish Assemblage Groups.

GROUP 4A

Primary Species:
Leiognathus splendens
Upeneus sulphureus
Leiognathus bindus

Indicator Species:
Rastrelliger brachysoma

Associated Species:
Engraulidae (*Stolephorus indica*)
Clupeidae (*Sardinella longiceps*)
Loligo sp.
Clupeidae (*Dussumiera acuta*)
Trichiurus haumela
Scomberomorus commersonii
Saurida tumbil
Sphyraenidae (*S. barracuda*)

Habitat Characteristics:
Substrate: Clayish-Muddy
Mean Temp.: 25.94°C
Mean Salinity: 34.26‰
Mean DO: 5.58 ml/L
Mean Depth: 46 m
Others: Riverine/Estuarine
N = 120 sp. ; CPUE = 142 kg

GROUP 5

Primary Species:
Leiognathus bindus

Associated Species:
Upeneus mollucensis
Loligo sp.
Pomadasys maculatus
Trichiurus haumela
Lutjanus malabaricus
Scomberomorus commersonii
Sphyraena barracuda
Gazza minuta

Habitat Characteristics:
Substrate: Sandy
Mean Temp.: 25.74°C
Mean Salinity: 34.39‰
Mean DO: 5.18 ml/L
Mean Depth: 80 m
Others:Intermittent River Influence; Narrow shelf
N = 105 sp. ; CPUE = 355 kg

GROUP 6

Primary Species:
Diodontidae
Caranx speciousus
Triodontidae
Plectorhincus pictus
Triodontidae
Abalistes stellaris
Ostraciidae
Upeneus mollucensis
Labridae
Leiognathus fasciatus
Serranidae
Platax orbicularis
Leiognathidae (*Gazza minuta*)
Scaridae

Habitat Characteristics:
Substrate: Rocky-Coralline
Mean Temp.: 25.42°C
Mean Salinity: 34.32‰
Mean DO: 5.47 ml/L
Mean Depth: 47 m
Others: Near Entrance to Sorsogon Bay/Coral Reefs;
N = 183 sp. ; CPUE = 339 kg

GROUP 7

Primary Species:
Caranx speciousus
Diodontidae
Triodontidae
Lutjanus bohar
Triodontidae
Abalistes stellaris
Ostraciidae
Labridae
Alutera monoceros
Ostraciidae
Serranidae
Labridae
Scaridae
Nemipterus peronii

Habitat Characteristics:
Substrate: Rocky-Coralline
Mean Temp.: 26.35°C
Mean Salinity: 34.27‰
Mean DO: 4.98 ml/L
Mean Depth: 40 m
Others: Near Entrance to Sorsogon Bay/Coral Reefs; Narrow Shelf
N = 120 sp. ; CPUE = 489 kg

- **DEEP SEA STATIONS:**

GROUP 1

Key Species/Taxa: Carangidae and Nemipteridae

The main distinguishing features of this group are its very low species richness and the dominance of two fish families that account for 77% of the group's catch: Carangidae (*Decapterus kurroides, D. muruadsi*) and Nemipteridae (*Scolopsis inermis, Nemipterus marginatus, N. bathybius*). This may be a highly seasonal group.

Type of Substrate: Sandy to Silty Sand.

Average Depth: 165 meters

Average CPUE; Biomass: 101 kg/h; 8 kg/ha (0.76 mt/km^2)

This group contains only 18 species/taxa (Table 4), the least among the seven groups. The five most abundant species (by wet weight) accounted for almost all of the catch (87%). These were: *Decapterus kurroides,* family: Carangidae (28%); *Scolopsis inermis*, family: Nemipteridae (24%); *Decapterus muruadsi*, family: Carangidae (18%); *Priacanthus macracanthus,* family: Priacanthidae (10%) and *Nemipterus marginatus,* family: Carangidae (8%). The exclusive species among this assemblage are the greeneyes (*Chloropthalmus albatrosis*, family: Chlorophthalmidae), deepwater shrimps and crabs, grouper (*Epinephelus sp.*, family: Serranidae), and threadfin bream (*Nemipterus marginatus,* family: Nemipteridae).

GROUP 2

Key Species/Taxa: Ariommidae + Mixture of Deep Sea Forms

The main distinguishing characteristic of this group is the dominance of *Ariomma indica*, family: Ariommidae, comprising 19% of the group's catch, stingrays (13%) and a mix of

Table 4. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 1.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Decapterus kurroides*	DECAKU	28.18	27.81%	27.81%
2	*Scolopsis inermis*	SCOLIN	23.83	23.51%	51.32%
3	*Decapterus muruadsi*	DECAMU	18.19	17.95%	69.27%
4	*Priacanthus macracanthus*	PRIAMA	9.77	9.64%	78.91%
5	*Nemipterus marginatus*	NEMIMA	8.50	8.39%	87.30%
6	*Saurida undosquamis*	SAURUN	4.27	4.21%	91.51%
7	Epinephelus spp.	EPISPP	4.00	3.95%	95.46%
8	*Chloropthalmus albatrosis*	CHLORO	1.87	1.85%	97.31%
9	*Saurida tumbil*	SAURTU	1.67	1.65%	98.95%
10	Champsodontidae	CHAMPO	0.37	0.37%	99.32%
11	Shrimps	SHRIMP	0.19	0.19%	99.51%
12	Crabs	CRABSS	0.14	0.14%	99.64%
13	*Nemipterus bathybius*	NEMIBA	0.11	0.11%	99.75%
14	Rhinobatidae	RHINOB	0.07	0.07%	99.82%
15	Bothus spp.	BOTHUS	0.06	0.06%	99.88%
16	*Rexea solandri*	REXEAS	0.06	0.06%	99.94%
17	Uranoscopidae	URANOS	0.04	0.04%	99.98%
18	*Fistularia petimba*	FISTUL	0.02	0.02%	100.00%

deep sea demersal forms, i.e., big-eyes (family: Priacanthidae), rockfishes (family: Triglidae), stargazers (family: Champsodontidae), anglerfishes (Lophiidae), Scorpaenidae (lionfishes), and lizardfishes (Synodidae) (47%) (Table 5). Together, they comprised 79% of this group.

Type of Substrate: Sandy/Silty Ooze (at Central Ragay Gulf) to Hard-Sandy Bottom (west of San Bernardino Strait).

Average Depth: 185 meters.

Average CPUE; Biomass: 236 kg/h; 18 kg/ha (1.78 mt/km^2)

This group was represented by a total of 57 species/taxa and was second lowest in species richness among the seven groups (Appendix III). Group 2 is dominated by deep water fauna composed of *Ariomma indica,* family: Ariommidae (20% of the group's catch), *Saurida undusquamis*, family: Synodidae (12%), *Priacanthus macracanthus,* family: Priacanthidae (10%), Lophiidae (8%) and Dasyatidae (7%). These taxa comprise more than half (57%) of the fish landed in this group. The fish fauna that were exclusive to this group included members of the family Lophiidae (goosefish akin to anglerfish), Scorpaenidae (lionfish), *Decapterus russelli* (round scad, family: Carangidae), Triglidae (searobin related to scorpionfish) and Chimaeridae (ratfish).

GROUP 3

Key Species/Taxa: *Ariomma indica* + *Trichiurus haumela*

The key distinguishing feature of this group is that half of the catch is composed mainly of hairtails and Indian driftfishes (Table 6).

Type of Substrate: Sandy/Silty Ooze

Average Depth: 140 meters.

Average CPUE; Biomass: 229 kg/h; 17 kg/ha (1.73 mt/km^2)

This group is dominated by only two species: *Ariomma indica*, family: Ariommidae (27%) and *Trichiurus haumela*, Trichiuridae (23%). Each of the remaining

Table 5. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 2.

Rank	***SPECIES***	**Species Code**	**Mean**	**%**	**Cumulative Frequency**
1	*Arioma indica*	ARIOMA	46.00	19.51%	19.51%
2	*Saurida undosquamis*	SAURUN	29.51	12.51%	32.02%
3	*Priacanthus macracanthus*	PRIAMA	23.43	9.94%	41.96%
4	Lophiidae	LOPHII	18.70	7.93%	49.89%
5	Dasyatidae	DASYAT	16.80	7.12%	57.01%
6	*Decapterus muruadsi*	DECAMU	15.66	6.64%	63.65%
7	Rhinobatidae	RHINOB	14.25	6.04%	69.69%
8	*Trichiurus haumela*	TRICHI	9.14	3.88%	73.57%
9	Uranoscopidae	URANOS	6.93	2.94%	76.50%
10	*Nemipterus bathybius*	NEMIBA	5.66	2.40%	78.91%
11	*Champsodontidae*	CHAMPO	5.48	2.32%	81.23%
12	Scorpaenidae	SCORPI	4.90	2.08%	83.31%
13	*Decapterus russeli*	DECARU	4.81	2.04%	85.35%
14	Bothus spp.	BOTHUS	4.06	1.72%	87.07%
15	Triglidae	TRIGLI	3.88	1.64%	88.71%
16	Sharks	SHARKS	3.42	1.45%	90.16%
17	*Decapterus kurroides*	DECAKU	1.85	0.78%	90.94%
18	*Scolopsis inermis*	SCOLIN	1.84	0.78%	91.72%
19	*Rexea solandri*	REXEAS	1.76	0.75%	92.47%
20	Chimaeridae	CHIMAE	1.64	0.69%	93.17%

Table 6. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 3.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Arioma indica*	ARIOMA	61.36	26.81%	26.81%
2	*Trichiurus haumela*	TRICHI	53.32	23.29%	50.10%
3	*Priacanthus macracanthus*	PRIAMA	14.91	6.51%	56.61%
4	Dasyatidae	DASYAT	13.28	5.80%	62.42%
5	*Decapterus muruadsi*	DECAMU	10.40	4.55%	66.96%
6	*Saurida undosquamis*	SAURUN	9.04	3.95%	70.91%
7	Epinephelus spp.	EPISPP	8.15	3.56%	74.47%
8	*Seriola nigrofasciata*	SERION	6.88	3.00%	77.48%
9	Sharks	SHARKS	6.62	2.89%	80.37%
10	Loligo spp.	LOLIGO	5.49	2.40%	82.77%
11	Peristidiinae	PERIST	3.73	1.63%	84.40%
12	Lophiidae	LOPHII	3.15	1.38%	85.78%
13	Uranoscopidae	URANOS	2.63	1.15%	86.92%
14	*Upeneus vittatus*	UPEVIT	2.00	0.87%	87.80%
15	*Decapterus macrosoma*	DECAMA	1.95	0.85%	88.65%
16	*Nemipterus bathybius*	NEMIBA	1.85	0.81%	89.46%
17	Champsodontidae	CHAMPO	1.83	0.80%	90.26%
18	Tetraodontidae	TETRAO	1.53	0.67%	90.92%
19	*Selar crumenophthalmus*	SELACR	1.49	0.65%	91.57%
20	*Saurida tumbil*	SAURTU	1.27	0.56%	92.13%

85 species/taxa (Appendix III) comprise only small fractions of the total catch (Table 6). The top 20 most abundant species accounts for 92% of the group's total catch in this category. Exclusive to this list are *Seriolina nigrofasciata* (black-barred amberjack, family: Carangidae), Peristidiinae (lizardfish, family: Synodidae), Lophiidae (anglerfish), *Upeneus vittatus* (goatfish, family: Mullidae) and *Decapterus macrosoma* (roundscad, family: Carangidae).

- **SHALLOW RIVERINE/ESTUARINE STATIONS:**

GROUP 4A

Key Species/Taxa: Leiognathidae + Coastal Pelagics; neritic scombrid, *Rastrelliger brachysoma* (family: Scombridae) as indicator species.

The main distinguishing feature of this group is the dominance of Leiognathidae that accounts for 27% of the group's catch, Mullidae (10%) and coastal pelagics composed of Carangidae, Scombridae, Engraulidae and Clupeidae (25%) (Table 7). Together, they comprised 62% of the group's catch. The neritic species, *Rastrelliger brachysoma* are known to prefer shallow waters with muddy or clayish bottom (Jones and Rosa, 1965) and can be used as an indicator species for this group.

Type of Substrate: River Mud to Sandy Muddy.

Average Depth: 45 meters.

Average CPUE; Biomass: 142 kg/h; 11 kg/ha (1.07 mt/km^2)

This shallow, riverine sub-group contains 120 species/taxa (Appendix III) in which the top 20 most abundant species account for 81% of the group's catch (Table 7). The predominant species in this category include: *Leiognathus splendens* and *L. bindus* (ponyfish, family: Leiognathidae), *Upeneus sulphureus* (goatfish, family: Mullidae), *Trichiurus haumela* (hairtails, family: Trichiuridae), and *Selaroides leptolepis* (yellow-

Table 7. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 4a.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Leiognathus splendens*	LEOSPL	18.25	12.85%	12.85%
2	*Upeneus sulphureus*	UPESUL	15.60	10.99%	23.84%
3	*Leiognathus bindus*	LEOBIN	14.43	10.16%	34.00%
4	*Trichiurus haumela*	TRICHI	11.86	8.35%	42.36%
5	*Selaroides leptolepis*	SELARO	5.96	4.20%	46.55%
6	*Rastrelliger brachysoma*	RASTBR	5.38	3.79%	50.34%
7	*Sardinella longiceps*	SARDLO	4.70	3.31%	53.65%
8	*Leiognathus leuciscus*	LEOLEU	4.57	3.22%	56.87%
9	Loligo spp.	LOLIGO	4.41	3.10%	59.97%
10	*Dussumiera acuta*	DUSSUM	4.24	2.98%	62.96%
11	*Sphyraena obtusata*	SPHYOB	3.86	2.72%	65.68%
12	*Decapterus muruadsi*	DECAMU	3.39	2.38%	68.06%
13	*Selar crumenophthalmus*	SELACR	3.19	2.25%	70.31%
14	*Scomberomorus commersoni*	SCOMME	3.14	2.21%	72.52%
15	*Saurida tumbil*	SAURTU	2.65	1.87%	74.39%
16	*Stolephorus tri*	STOLTR	2.13	1.50%	75.89%
17	*Uraspis helvolus*	URASPI	1.90	1.34%	77.22%
18	*Leiognathus equulus*	LEOEQU	1.81	1.27%	78.50%
19	*Saurida undosquamis*	SAURUN	1.77	1.25%	79.74%
20	Tetraodontidae	TETRAO	1.72	1.21%	80.95%

striped crevalle, family: Carangidae). Together, they represented almost half (46%) of this group's total catch.

Exclusive to this group are *Leiognathus splendens* (black-tipped ponyfish), *L. leuciscus* (whipfin ponyfish) and *L. equulus* (common ponyfish), family: Leiognathidae; *Selaroides leptolepis*, (yellow-striped trevally, family: Carangidae); *Rastrelliger brachysoma* (short-bodied mackerel, family: Scombridae); *Sardinella longiceps* (Indian oil sardine, family: Clupeidae); *Sphyraena obtusata* (obtuse barracuda, family: Sphyraenidae); *Stolephorus tri* (anchovy, family: Engraulididae) and *Uraspis helvolus* (black ulua, family: Carangidae).

GROUP 4B

Key Species/Taxa: Leiognathidae + Ariommidae and other Deep Shelf Forms; oceanic scombrid, *Rastrelliger kanagurta* (family: Scombridae) as indicator species.

The main distinguishing feature of this group is the dominance of Leiognathidae that comprise 25% of this group's catch and deep sea forms like Ariommidae (11%), Loliginidae (8%), Mullidae (9%). The oceanic species, *Rastrelliger kanagurta*, known to prefer clear waters with salinities ≥ 34‰ (Jones and Rosa, 1965) and can be used as an indicator species to separate this group from Group 4A.

Type of Substrate: Muddy to Sandy Muddy.

Average Depth: 88 meters.

Average CPUE; Biomass: 148 kg/h; 11 kg/ha (1.12 mt/km^2)

This sub-group, composed of 104 species/taxa (Appendix III), represents the transition between the deep shelf and the shallow, riverine assemblages. The top 20 most abundant species/taxa account for 90% of the group's catch, while the top 5 species comprise more than half (54%) (Table 8). The predominant species include: *Leiognathus bindus* (slipmouth/ponyfish, family: Leiognathidae), *Ariomma indica* (Indian driftfish,

Table 8. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 4b.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Leiognathus bindus*	LEOBIN	34.69	23.36%	23.36%
2	*Arioma indica*	ARIOMA	16.36	11.02%	34.39%
3	Loligo spp.	LOLIGO	11.88	8.00%	42.39%
4	*Upeneus mollucensis*	UPEMOL	9.32	6.28%	48.66%
5	*Aphareus rutilans*	APHARE	8.26	5.56%	54.22%
6	*Decapterus muruadsi*	DECAMU	7.99	5.38%	59.60%
7	*Eupleurogrammus nuticus*	EUPLEU	7.09	4.78%	64.38%
8	*Saurida undosquamis*	SAURUN	6.57	4.43%	68.81%
9	*Fistularia petimba*	FISTUL	4.85	3.27%	72.08%
10	*Saurida tumbil*	SAURTU	4.83	3.25%	75.33%
11	*Dussumiera acuta*	DUSSUM	3.29	2.22%	77.55%
12	*Pentaprion longimanus*	PENTAP	3.26	2.20%	79.75%
13	*Rastrelliger kanagurta*	RASTKA	2.62	1.76%	81.51%
14	*Trichiurus haumela*	TRICHI	2.21	1.49%	83.00%
15	*Gymnocaesio gymnoptera*	GYMNOS	2.15	1.45%	84.45%
16	*Upeneus sulphureus*	UPESUL	2.08	1.40%	85.85%
17	*Leiognathus elongatus*	LEOELO	1.56	1.05%	86.90%
18	Upeneus spp.	UPESPP	1.37	0.93%	87.82%
19	Tetraodontidae	TETRAO	1.35	0.91%	88.73%
20	Rhinobatidae	RHINOB	1.33	0.90%	89.63%

family: Ariommidae), *Loligo* spp. (squid, family: Loliginidae), *Upeneus mollucensis* (goatfish, family: Mullidae) and *Aphareus rutilans* (small-tooth jobfish, family: Lutjanidae).

Exclusive members of this sub-group were: *Aphareus rutilans* (small-tooth jobfish, family: Lutjanidae), *Eupleurogrammus nuticus* (Malayan hairtail, family: Trichiuridae), *Pentaprion longimanus* (longfin mojarra, family: Gobiidae), *Rastrelliger kanagurta* (Indian mackerel, family: Scombridae), *Gymnocaesio gymnoptera* (family: Lutjanidae) and *Upeneus* spp. (goatfish, family: Mullidae).

GROUP 5

Key Species/Taxa: Leiognathidae, primarily *Leiognathus bindus*.
This group represents the main fishing ground for Leiognathidae where it comprises about 40% of the catch.
Type of Substrate: Sandy.
Average Depth: 80 meters.
Average CPUE; Biomass: 355 kg/h; 27 kg/ha (2.68 mt/km^2)

This group contains 105 species (Appendix III), with the top 20 most abundant species/taxa accounting for 80% of the group's catch (Table 9). It is dominated largely by the family Leiognathidae with the orange pony, *Leiognathus bindus,* comprising the bulk of the catch (34%). Other associated species/taxa include: *Upeneus sulphureus* (yellow goatfish) and *Upeneus mollucensis* (gold band goatfish, family: Mullidae); *Pomadasys maculatus* (blotched grunt, family: Pomadasydae = Haemulidae); and Dasyatidae (stingray), together comprising 53% of the group's catch.

The exclusive species comprising this group include: *Pomadasys maculatus* (blotched grunt) family: Haemulidae; *Alectis ciliaris* (pennantfish), *Carangoides dinema* (shadow kingfish) and *C. ciliaris* (longfin cavalla), family: Carangidae; *Formio niger*

Table 9. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 5.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Leiognathus bindus*	LEOBIN	119.19	33.60%	33.60%
2	*Upeneus sulphureus*	UPESUL	22.43	6.32%	39.93%
3	*Pomadasys maculatus*	POMAMA	19.70	5.55%	45.48%
4	Dasyatidae	DASYAT	14.16	3.99%	49.47%
5	*Upeneus mollucensis*	UPEMOL	11.28	3.18%	52.65%
6	*Lutjanus malabaricus*	LUTMAL	10.57	2.98%	55.63%
7	*Trichiurus haumela*	TRICHI	10.36	2.92%	58.55%
8	*Fistularia petimba*	FISTUL	8.83	2.49%	61.04%
9	*Gazza minuta*	GAZAMI	7.63	2.15%	63.19%
10	*Caranx ciliaris*	CRXCIL	7.07	1.99%	65.19%
11	*Alectis ciliaris*	ALECIL	6.95	1.96%	67.14%
12	*Leiognathus fasciatus*	LEOFAS	6.57	1.85%	69.00%
13	*Formio niger*	FORMIO	6.31	1.78%	70.77%
14	*Sphyraena forsteri*	SPHYFO	6.21	1.75%	72.53%
15	*Scomberomorus commersoni*	SCOMME	5.78	1.63%	74.15%
16	*Leiognathus elongatus*	LEOELO	4.67	1.32%	75.47%
17	*Lutjanus bojar*	LUTBOJ	4.35	1.23%	76.70%
18	Diodontidae	DIODON	4.24	1.19%	77.89%
19	*Carangoides dinema*	CRXDIN	3.66	1.03%	78.92%
20	*Epinephelus tauvina*	EPITAV	3.63	1.02%	79.95%

(black pomfret, family: Formionidae); *Sphyraena forsterii* (Forster's barracuda, family: Sphyraenidae); and *Epinephelus tauvina* (greasy grouper, family: Serranidae).

- **SHALLOW CORALLINE STATIONS:**

GROUP 6

Key Species/Taxa: Coralline Outliers + Leiognathidae and Haemulidae.
This group is characterized by a large number of coralline and estuarine species that are evenly distributed in the catch.
Type of Substrate: Sandy to Rocky/Coralline Rubble Mix.
Average Depth: 50 meters.
Average CPUE; Biomass: 339 kg/h; 69 kg/ha (2.56 mt/km^2)

A total of 183 species/taxa comprised this group (Appendix III). The top 20 most dominant species amounts to 62% of the group's catch, while the top 5 species/taxa, consisting mainly of Dasyatidae (stingray), Diodontidae (porcupinefish), *Carangoides speciousus* (crevalla, family: Carangidae), Tetraodontidae (pufferfish), and *Aeliscus strigatus* (shrimpfish, family: Centriscidae), account for 36% (Table 10).

Two members were exclusive to this group, i.e., *Plectorhincus pictus* (painted sweetlip, family: Haemulidae) and *Platax orbicularis* (batfish, family: Platacidae). Basically, Group 6 is a transition group containing a mixture of coralline and estuarine (Group 5) assemblages.

GROUP 7

Key Species/Taxa: Coralline Outliers; < 1% Leiognathidae, Pomadasydae, Mullidae.

Table 10. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 6.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	Diodontidae	DIODON	40.64	11.99%	11.99%
2	Dasyatidae	DASYAT	25.76	7.60%	19.59%
3	*Carangoides speciousus*	CRXSPE	22.93	6.76%	26.35%
4	*Aeliscus strigatus*	AELISC	16.35	4.82%	31.17%
5	Tetraodontidae	TETRAO	15.87	4.68%	35.86%
6	*Leiognathus bindus*	LEOBIN	8.91	2.63%	38.48%
7	*Plectorhincus pictus*	PLECIN	8.50	2.51%	40.99%
8	*Abalistes stellaris*	ABALIS	7.93	2.34%	43.33%
9	*Lutjanus lineolatus*	LUTLIN	7.64	2.26%	45.59%
10	*Lethrinus opercularis*	LTRIOP	7.00	2.07%	47.65%
11	*Gazza minuta*	GAZAMI	6.28	1.85%	49.50%
12	Ostraciidae	OSTRAC	6.21	1.83%	51.34%
13	*Alutera monoceros*	ALUTMO	6.00	1.77%	53.11%
14	*Upeneus mollucensis*	UPEMOL	5.50	1.62%	54.73%
15	Labridae	LABRID	4.73	1.39%	56.12%
16	Centriscidae	CENTRI	4.60	1.36%	57.48%
17	*Platax orbicularis*	PLATAX	4.58	1.35%	58.83%
18	*Leiognathus fasciatus*	LEOFAS	4.53	1.34%	60.17%
19	Acanthurus spp.	ACANSP	4.25	1.25%	61.42%
20	*Acanthurus bleekeri*	ACANBL	4.08	1.20%	62.62%

This group is distinguishable by the absence or rarity of Leiognathidae (slipmouths or ponyfishes), Haemulidae (grunts) and Mullidae (goatfishes).

Type of Substrate: Rocky/Coralline Mix.

Average Depth: 40 meters.

Average CPUE; Biomass: 489 kg/h; 37 kg/ha (3.69 mt/km^2)

Group 7 consisted of 120 coralline outlier species (Appendix III). The top 20 most abundant species/taxa accounted for 76% of the group's catch, while the top 5 percent in the list contributed 40% of the catch (Table 11). There is no dominant family. Exclusive members of this group included: *Lethrinus lentjan* (red spot emperor, family: Lethrinidae), *Naso* spp. (surgeonfish/unicornfish, family: Acanthuridae), *Epinephelus guttatus* (grouper, family: Serranidae), *Macolor macolor* (snapper, family: Lutjanidae), Scaridae (parrotfish), and *Nemipterus peronii* (Peron's butterfly bream, family: Nemipteridae).

In general, the above assemblage groupings were well separated by the two numerical techniques. What is more important is that the resulting group also made biological sense, i.e., using the categories described and illustrated in this section, visual discrimination and classification of trawl catches can easily be made based only on their distinct faunal composition and relative abundance (see Appendix V).

2. Species Clusters.

The resemblance among species based on the similarity of their station/habitat characteristics (r-type analysis) is shown as a TWINSPAN two-way ordered classification table (Figure 14). Due to the graphics limitation of the PC-ORD program, this diagram was abbreviated and shows only the 100 most important species/taxa. The site classification portion, i.e., q-type analysis, basically shows the seven major cluster groupings described in Figure 12 that represent the three basic assemblage/habitat types, i.e., deep marine, shallow riverine/estuarine, and shallow coralline SU groups.

Table 11. Top 20 Most Abundant (Net Weight) Species/Taxa Characteristic of Standardized Group 7.

Rank	*SPECIES*	Species Code	Mean	%	Cumulative Frequency
1	*Carangoides speciousus*	CRXSPE	47.55	9.73%	9.73%
2	Diodontidae	DIODON	47.25	9.67%	19.40%
3	*Lutjanus bojar*	LUTBOJ	37.29	7.63%	27.04%
4	Dasyatidae	DASYAT	34.94	7.15%	34.19%
5	*Abalistes stellaris*	ABALIS	25.98	5.32%	39.51%
6	Tetraodontidae	TETRAO	22.02	4.51%	44.02%
7	*Alutera monoceros*	ALUTMO	18.58	3.80%	47.82%
8	*Lethrinus lentjan*	LTRILE	14.82	3.03%	50.85%
9	*Lethrinus opercularis*	LTRIOP	14.69	3.01%	53.86%
10	Ostraciidae	OSTRAC	14.46	2.96%	56.82%
11	*Epinephelus guttatus*	EPIGUT	14.00	2.87%	59.69%
12	Labridae	LABRID	12.38	2.53%	62.22%
13	Naso spp.	NASOSP	10.36	2.12%	64.34%
14	Acanthurus spp.	ACANSP	9.45	1.94%	66.28%
15	*Macolor macolor*	MACOLO	9.33	1.91%	68.19%
16	*Lutjanus lineolatus*	LUTLIN	8.89	1.82%	70.01%
17	Centriscidae	CENTRI	8.76	1.79%	71.80%
18	Scaridae	SCARID	7.76	1.59%	73.39%
19	*Aeliscus strigatus*	AELISC	6.88	1.41%	74.79%
20	*Nemipterus peronii*	NEMIPE	6.74	1.38%	76.17%

Group	No.	Species	1 1211 11 1 112 1 576112828491734050963	Classification
CORALLINE SPECIES	1	ABALIS	5523322111-1111---1--	00000
	9	ALUTMO	54133221111111111----	00000
	53	DIODON	5525531----11--1--1--	00000
	108	OSTRAC	52133111---1---1-----	00000
	125	PSETOD	--212311---11-----1--	00001
	149	SCOMME	32221323211-2-111----	00001
	2	ACANBL	2114-1---------------	000100
	4	AELISC	4-25-----------------	000100
	20	CENTRI	24-24----------------	000100
	22	CHAEOC	22-21---11-----------	000100
	37	CRXFUL	411321--11-----------	000100
	38	CRXIGN	1223211--------------	000100
	39	CRXLIN	21221--1--1----------	000100
	43	CRXSPE	551531---------------	000100
	86	LTRILE	52-4--1-1------------	000100
	88	LTRIOP	5-114----------------	000100
	111	PARUHE	2112311--------------	000100
	140	SCARID	43223-1--------------	000100
	55	DREPAN	-223-11-1------------	000101
	91	LUTLIN	411432-1--1----------	000101
	6	ALECIN	231132111111---------	000110
	35	CRXDIN	2212222111--1--------	000110
	74	LABRID	43123--11111---------	000110
	130	RACHYS	12-131-11-1----------	000110
	165	SPHYBA	-21132-11------------	000110
	13	ARGYRO	1211111111-11--------	000111
	32	CRXCIL	2211142-1---1--------	000111
SOFT BOTTOM SPECIES	5	ALECIL	11221141121--1-------	001000
	31	CRXARM	112111-1111--1-------	001000
	40	CRXMAL	2111212111111--------	001000
	42	CRXPLU	-2-1122--11-1--------	001000
	80	LEOFAS	--41114-1-111--------	001000
	96	MEGALA	1-311121111-1--------	001000
	119	POMAMA	1--1245--------------	001000
	151	SECUIN	-121111121-----------	001000
	157	SELAMT	11111211111-11-------	001000
	79	LEOEQU	--31-2212221---------	001001
	81	LEOLEU	-31111132221---------	001001
	132	RASTFA	11-1-1-111111--------	001001
	147	SCOLTA	1111111111111--------	001001
	167	SPHYJE	1-111-111111---------	001001
	169	SPHYOB	--112111223----------	001001
	170	STOLIN	-111111111111--------	001001
	68	GAZAMI	--4113311111---1-----	001010
	76	LEOBIN	12413554531555111----	001010
	114	PENTAP	11211111111321-1-----	001010
	182	UPEMOL	1-313431111432121----	001010
	168	SPHYLA	11111-111111---1-----	001011
	158	SELARO	-1111--24321-1-------	001101
	67	FORMIO	--11-23111111--------	001110
	97	MENEMA	---1-111111111-------	001110
	184	UPESUL	--211454444131-------	001110
	56	DUSSUM	---1---233123--------	001111
	82	LEOSPL	---1-1-3535----------	001111
	131	RASTBR	---1---233211--------	001111
UBIQUITOUS SPECIES	66	FISTUL	11-21341111232111---1	010000
	160	SEPIAT	-111-1111111-11-1----	010000
	133	RASTKA	11111111111122-111---	010001
	137	SARDLO	-1-1-1-2241-1--1-1---	010001
	65	EUPLEU	---1-1--11151111-1---	01001
	103	NEMIJA	---11--11111--11--1--	010100
	83	LOLIGO	2111221232352222141--	010101
	105	NEMINE	--111--11112111111---	010101
	123	PRIATA	1-1111-11111111-1----	010101
	181	UPEBEN	1-1112-11-111-1111---	010101
	30	CRABSS	1111-1-11111111-1-1-1	010110
	78	LEOELO	11111231-1--121111---	010110
	138	SAURTU	1-21222321133121111-1	010110
	154	SELACR	1111-21411111-122----	010110
	189	URASPI	1-11121121211111111--	010110
	159	SEPIAS	321121211111111111-11-	010111
	174	TETRAO	53552211311211121111--	0110
	176	TRIACA	111111111--11-11--1--	0110
	120	PRIABO	3111111-----111--1---	01111

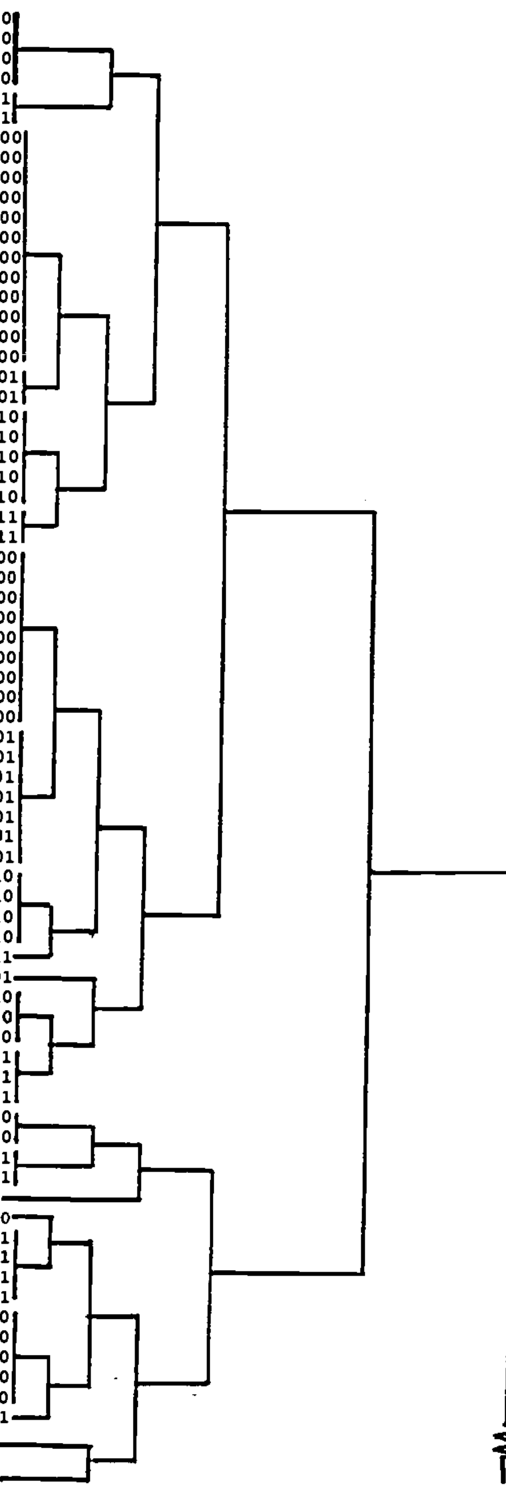


Figure 14. TWINSPAN 2-Way Indicator Species Table for RABUTINOS.

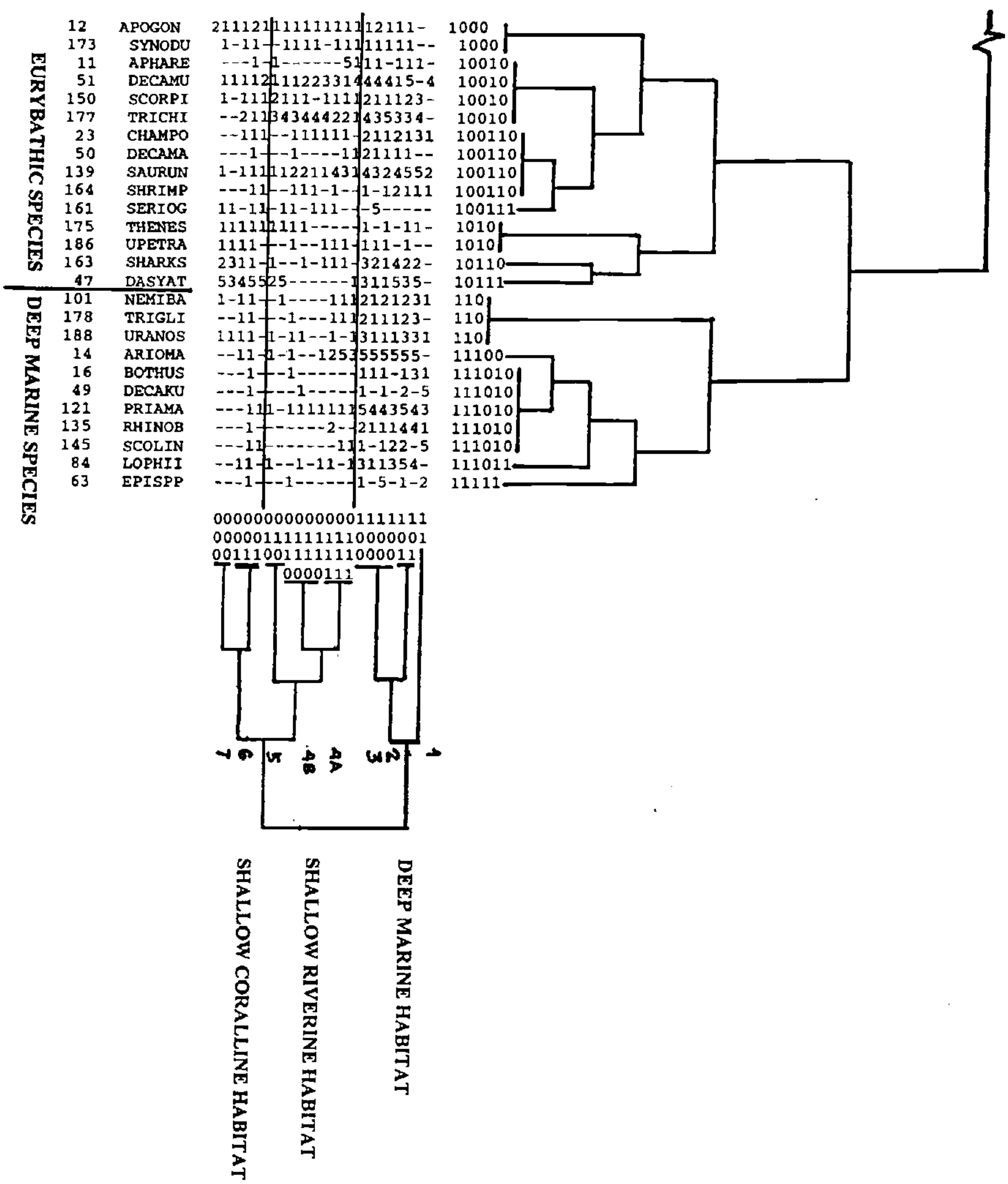


Figure 14. TWINSPAN 2-Way Indicator Species Table for RABUTINOS (continued).

Based on the species characteristics and location among the different fishing stations, the first dichotomy separated the deep sea from the shallow water fish assemblage. The deep sea group were further subdivided into the truly deep marine assemblage (i.e., species/taxa whose primary habitat is the deep sea, e.g., Myctophidae, lanternfish) and the eurybathic assemblage (i.e., deep preferential species/taxa found mostly in deeper regions but may also be present in shallower areas).

Based on the substrate characteristics of the fishing stations, the shallow water assemblages were subdivided into three general habitat categories: (1) rocky/coralline assemblage; (2) shallow soft bottom (muddy-sandy) assemblages of the inner shelf; and (3) ubiquitous assemblage that live primarily in shallow regions but also has the ability to traverse a wide range of depths. The coralline assemblages were separated further into two categories, i.e., the ubiquitous coralline species assemblage (belonging mainly to Group 6 or 7 SU assemblage) and those confined primarily to the shallow coralline areas (mostly of Group 7 SU assemblage). The vertical range of distribution of the shallow coralline and soft bottom fish assemblages was more defined compared to the deep sea species. The ubiquitous species belonging to this category are spread over a wide range of depths although concentrated more on shallow water areas.

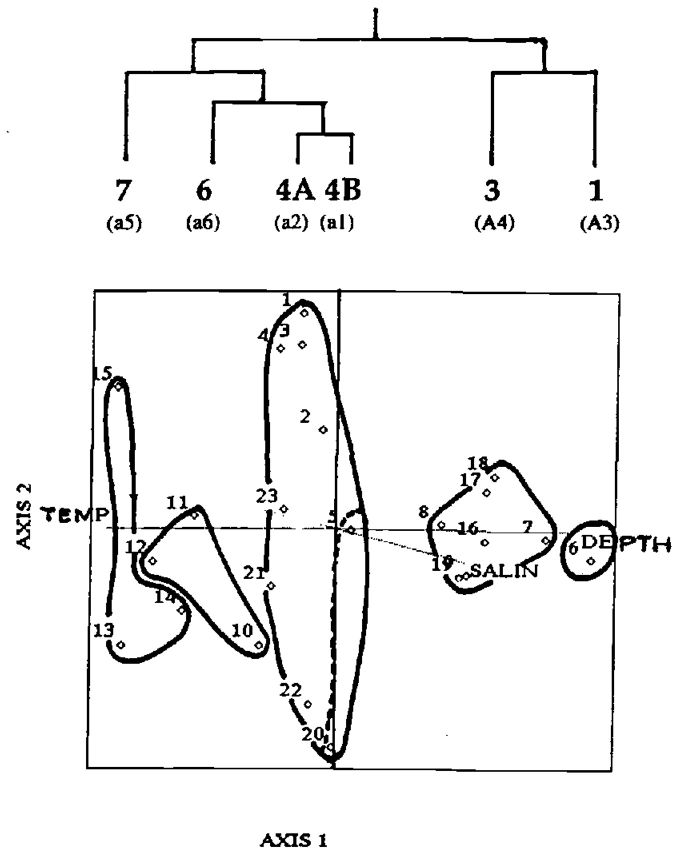
The key points derived from the TWINSPAN species grouping are: (1) the range of species distribution varies from eurybathic/ubiquitous to narrow habitat zones and (2) the distribution of species shows gradual overlaps, not sharp boundaries.

3. <u>Seasonality and Geographic Distribution of the SU Groups</u>.

The SU groups that comprised the demersal fish communities of RABUTINOS during the different seasons, including their species composition and geographic distribution, are presented in this section. Some of the possible environmental gradients that correlate with this distribution were also explored. The seasonal as well as equivalent standard group designations are included in the dendograms. Refer to Table 3 for a complete list of the standard group designations, their seasonal equivalent, inclusive fishing stations and the specific cruises where they occurred.

a. *Northeast Monsoon Season.* The upper diagram in Figure 15 shows the combined results of TWINSPAN classification and DECORANA ordination of the northeast monsoon samples based on the similarities between each station's fish occurrences and abundances. The first dichotomy in the dendogram separated the shallow (Groups 4A, 4B, 6 and 7) from the deep (Groups 1 and 3) fishing station clusters. During this season, the deep fishing stations were further subdivided into Group 1 (composed of FS6) and Group 3 (composed of FS7, FS8, FS9, FS16, FS17, FS18 and FS19). FS6 is the fishing station at the Ragay Gulf Basin sill nearest to Viñas River while FS7, FS8 and FS9 are those further away. FS16 to FS19 are fishing stations located at the deep sea ridge west of San Bernardino Strait.

The shallow fishing station clusters were also subdivided into the coralline stations, i.e., Group 7 (composed of FS13 to FS15), and the coastal riverine stations, i.e., Group 4B (composed of FS5, FS20), Group 4A (composed of FS1 to FS4, FS21 to FS23), and Group 6 (composed of FS10 to FS12). Since demersal trawls cannot operate on coral reefs, the term "coralline" refers to the similarity of the characteristic fauna to coral reef fish assemblages. "Estuarine" or "Riverine" refers to stations located near major river systems with soft, muddy to sandy-muddy substrates of terrigenous origins shallow depths and low salinities during the rainy season. The riverine stations were further subdivided into fishing stations near major sources of freshwater and over wide insular shelves, i.e., Group 4B (composed of FS1 to FS 5) and Group 4A (composed of FS20 to FS23), versus those with narrow shelves and further away from major rivers, i.e., Group 6 (composed of FS10 and FS11). Finer but minor distinctions were made between Group 4B (relatively deeper) and Group 4A (relatively shallower) fishing station groups.



PEARSON AND KENDALL CORRELATIONS WITH ORDINATION AXES N= 23

AXIS:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
DEPTH	.879	.772	.715	-.100	.010	-.008	.087	.008	.231
DOXY	-.861	.741	-.766	.037	.001	.004	-.154	.024	-.200
SALIN	.644	.415	.490	-.339	.115	-.164	.108	.012	.196
TEMP	-.808	.653	-.684	.038	.001	.040	-.111	.012	-.119

Figure 15. Results of the Q-Type Classification and Ordination Analyses on Fish Abundance Data During the Northeast Monsoon Season. Upper diagram: TWINSPAN dendogram of the seasonal fish assemblage grouping. Middle diagram: DECORANA ordination plots of the seasonal fish assemblage grouping. Bottom table: correlation between environmental variables and SU scores on the first three DCA axes.

The clusters derived from TWINSPAN were used to show the groups of fishing stations in the DCA ordination diagram (Figure 15, middle diagram). The eigenvalues for the first three DCA axes were 0.82, 0.42 and 0.25 respectively. The first DCA axis was sufficient enough to differentiate the TWINSPAN derived clusters. The seeming disparity between the possible group membership of FS12 and FS14 is just the result of the axis distortion mentioned above (see Methods section). The separation between the deep and shallow waters stations was very distinct as indicated by their cluster separation and distance.

Figure 15 (bottom table) shows the correlation between the first three DCA Axes and the four measured environmental variables. The highest correlations achieved were between the first DCA Axis and the environmental variables. Depth and salinity increases while DO and temperature decreased as one moves from left to right along the first DCA Axis, thereby separating the shallow water site clusters (i.e., Groups 7, 6, 4A and 4B) from the deep water site clusters (i.e., Groups 3 and 1).

The second DCA Axis hints of salinity influence, however, the generally low correlation between the second axis and the measured environmental variables indicate that some other important factors may be important in structuring the community. Given the ordination results (Figure 15; middle diagram), Groups 4A and 4B showed the widest ranges of salinity variations during the wet northeast monsoon season, followed by Group 7. The fishing stations near Viñas River (i.e., FS1, FS2, FS3, FS4, FS5) had the lowest salinity compared to the shallow fishing stations along the coast of northern Samar Sea (i.e., FS20, FS21, FS22, FS23). For Group 7, FS15 had the lowest salinity values compared to the rest. The fishing stations least affected by the northeast monsoon rains and corresponding drops in salinity were those from the deep water group (i.e., Groups 1 and 3) located within and below the halocline.

Although the correlation coefficients with the third DCA Axis were relatively higher than the second, the eigenvalues of the third DCA Axis was too low and basically gave the same information as the first DCA Axis. Hence, it was not included in the analysis.

The geographic boundaries of the six different site groups identified by TWINSPAN and DECORANA during this season are shown in Figure 16. Appendix II gives a list of the geographic characteristics of each Fishing Station. Starting at the mid-section of RABUTINOS, Group 5 composed of FS10 to FS12, hugs the narrow shelf of north of Sorsogon Bay and basically defined the main fishing area for *Leiognathus bindus*. Just outside the bay entrance and extending to the south along the narrow Ticao Pass shelf are the coralline stations (FS13 to FS15) belonging to Group 5.

The shallow, muddy shelf areas extending seawards from the coasts of Northern Samar Sea and south of Viñas River to about 50 m isobath defined the boundaries of sampling Group 4A. These were the locations of FS1 to FS4 and FS21 to FS23, and denoted the boundaries of Leiognathidae + coastal pelagic fish assemblages. Adjacent to this group and farther offshore were the areas that comprised Group 4B. The boundaries of this group were defined approximately by the 50 m and 100 m isobaths. This was the transition zone between the shallow and deep water stations and contained a fish assemblage dominated by Leiognathidae + Ariommidae and a variety of deep sea forms.

The deep water stations from the 100 m down to the 200 m isobaths defined the boundaries of Group 3 or the deep shelf stations dominated by Ariommidae + Trichiuridae. The stations included in this group were FS7 to FS9 for Ragay Gulf Basin and FS16 to FS19 for Northern Samar Sea. During this cruise, FS6 defined Group 1, the deep shelf/slope assemblage dominated by Nemipteridae and Carangidae.

b. *Dry Intermonsoon Period.* The deep fishing stations were separated from the shallow fishing stations by TWINSPAN in the first dichotomy (Figure 17, upper diagram), similar to the previous season's dendogram. The deep fishing stations were further subdivided into Group 2 (composed of FS6, FS7, FS17 and FS18) from Group 3

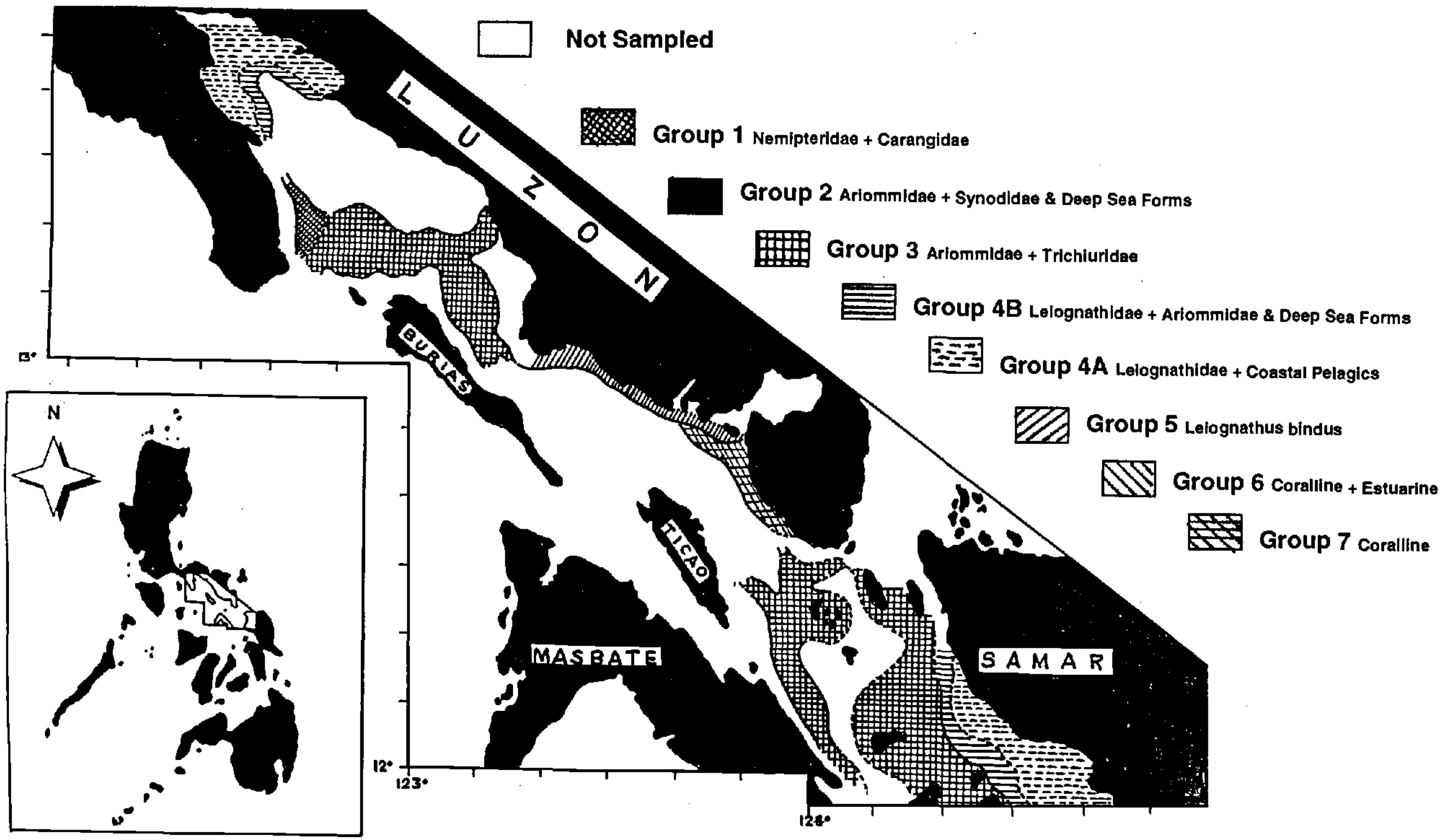


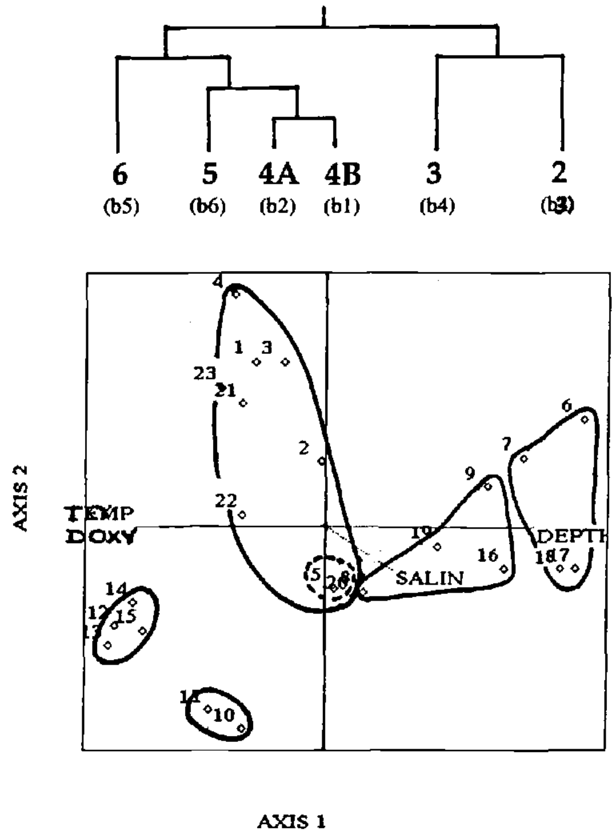
Figure 16. Geographic Location of the Different Fish Assemblage Groups at RABUTINOS During the Northeast Monsoon Season.

(composed of FS8, FS9, FS16 and FS19). The shallow fishing stations were also subdivided into the coralline station group, i.e., Group 6 (composed of FS12 to FS15) and the coastal riverine stations, i.e., Group 5 (composed of FS10, FS11), Group 4A (composed of FS1 to FS4 and FS21 to FS23) and Group 4B (composed of FS5, FS20). Further subdivisions on the coastal riverine group separated stations located on narrow insular shelves and relatively far from major freshwater influence, i.e., Group 5 from stations near major river systems emptying into wider insular shelves, i.e., Groups 4A and 4B.

The DECORANA ordination and TWINSPAN classification were both able to distinguish the different cluster groupings based on the first and second axis (Figure 17, middle diagram). The eigenvalues for the first three axes were 0.86, 0.43 and 0.36 respectively. Groups 4B and 4A were clearly separated from Group 5 by the second DCA axis while the rest were highly discernible from the first DCA axis alone. The compact clustering of stations within Group 6 and Group 5 and their distance of separation from the other clusters indicate stronger similarities among its members relative to the others.

The correlation between the DCA axes and environmental variables during the dry intermonsoon period is shown in Figure 17 (bottom table). The correlations were basically the same as the ones derived for the northeast monsoon season, except for the lower temperature correlation on the first DCA Axis. The distinct and compact clusters formed by Groups 5 and 6 (Figure 17; middle diagram) indicate strong similarities among their members and the conditions of their environment. Both groups were also in distinctively more saline habitats than the rest.

During this period, salinity differences among fishing stations located at similar depths were not discernible for stations located in northern Samar Sea and in the vicinity of Viñas River. However, the salinity difference was very pronounced between Group 4A and Group 4B. Also, the fishing stations comprising Group 4B and Group 3 were not as distant as the previous cruise.



PEARSON AND KENDALL CORRELATIONS WITH ORDINATION AXES N= 23

AXIS:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
DEPTH	.935	.875	.787	-.077	.006	.012	.249	.062	.197
DOXY	-.890	.793	-.679	.060	.004	.044	-.307	.094	-.165
SALIN	.523	.273	.585	-.448	.201	-.129	.156	.024	.126
TEMP	-.833	.694	-.521	.003	.000	.185	-.371	.138	-.167

Figure 17. Results of the Q-Type Classification and Ordination Analyses on Fish Abundance Data During the Dry Inter-Monsoon Season. Upper diagram: TWINSPAN dendogram of the seasonal fish assemblage grouping. Middle diagram: DECORANA ordination plots of the seasonal fish assemblage grouping. Bottom table: correlation between environmental variables and SU scores on the first three DCA axes.

During the dry months, the areal extent of Group 5 that defined the *Leiognathus bindus* fishing grounds, shrank to include just FS10 to FS11 located along the narrow shelf north of Sorsogon Bay shown in Figure 18. The southern half of this narrow shelf (FS12 to FS15) changed from Group 7, i.e., coralline fish assemblage, into transition Group 6 assemblage characterized by coralline + Leiognathidae and other estuarine species/taxa. The shift from Group 7 into Group 6 was brought about by substantial migration of slipmouths and grunts into areas occupied by the coralline fish assemblage during the dry inter-monsoon period.

For the riverine stations, the locations of Groups 4A (i.e., where Leiognathidae + coastal pelagic fishes abound) and 4B (i.e., where Leiognathidae + Ariommidae and other deep sea forms dominate), remained similar to the previous season. Some major changes occurred in the species assemblage of the deep sea fishing stations. In the Ragay Gulf Basin, areas formerly designated as Group 1 (Nemipteridae and Carangidae assemblage), were now occupied by Group 2 assemblage (characterized by Ariommidae + a wide variety of deep sea forms), which included FS6 and FS7. The deep fishing stations FS17 and FS18 in Northern Samar Sea were now also occupied by the Group 2 fish assemblage. This was brought about by outmigration of Trichiuridae and an immigration of deep sea forms into the area. The rest of the deep water stations remained as Group 3 where Ariommidae + Trichiuridae abound.

c. *Southwest Monsoon Season.* On the first dichotomy, the TWINSPAN dendogram separated the stations into the deep water group and the shallow water group (Figure 19, upper diagram). The deep water stations were further subdivided into Group 2 (composed of FS17, FS18) and Group 3 (composed of FS6, FS7, FS9, FS16, FS19). The shallow water group were subdivided into the coralline stations, i.e., Group 7 (composed of F12 to F15), and the riverine stations composed of two minor sub-groups, i.e., Group 4A (composed of FS1 to FS5 and FS21 to FS23) and Group 4B (composed of FS8 and FS20).

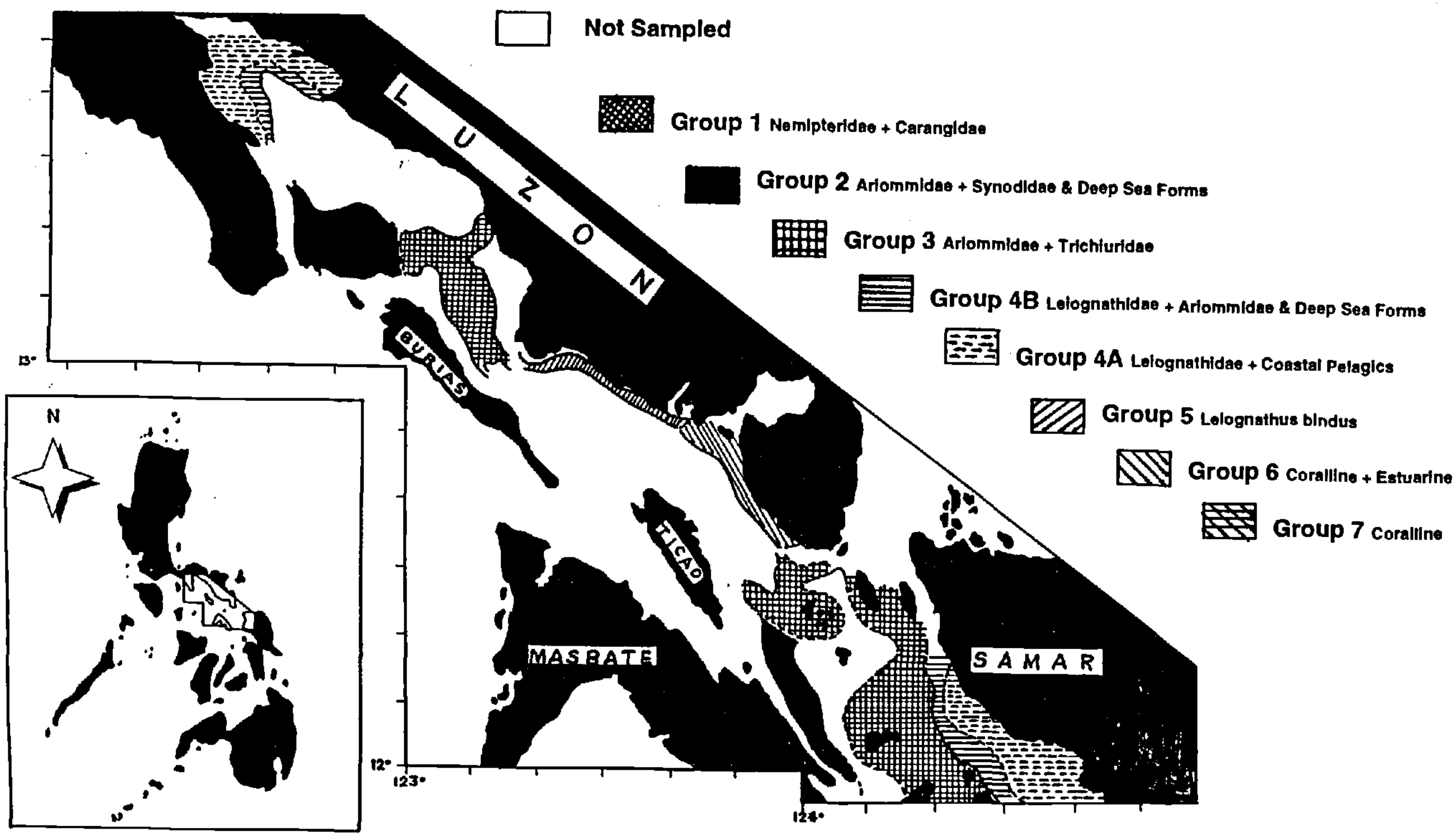
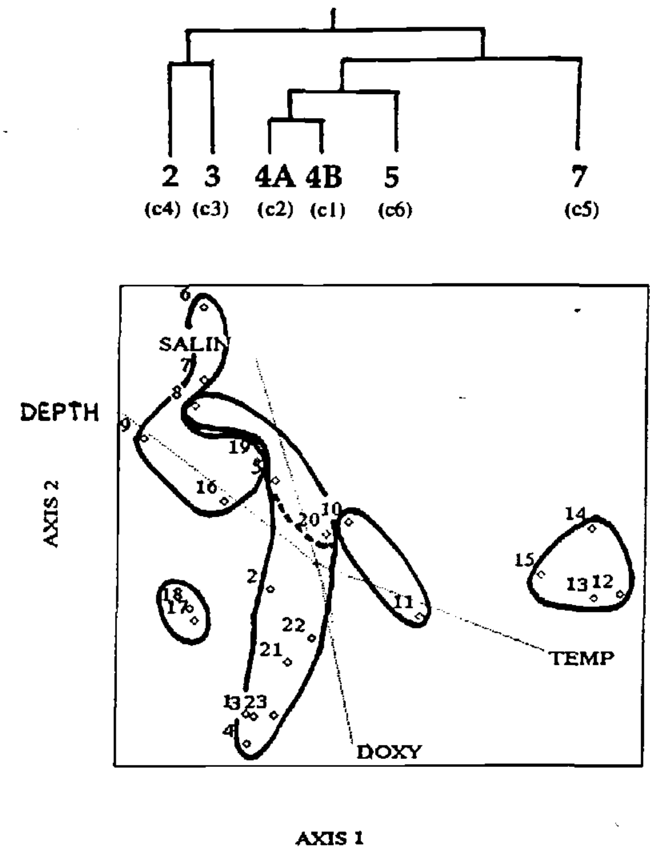


Figure 18. Geographic Location of the Different Fish Assemblage Groups at RABUTINOS During the Dry Inter-Monsoon Period.



PEARSON AND KENDALL CORRELATIONS WITH ORDINATION AXES N= 23

AXIS:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
DEPTH	-.561	.314	-.449	.525	.275	.512	-.365	.133	-.116
DOXY	.228	.052	.246	-.524	.274	-.404	.502	.252	.298
SALIN	-.294	.087	-.261	.559	.313	.348	-.330	.109	-.181
TEMP	.572	.327	.600	-.366	.134	-.319	.489	.239	.024

Figure 19. Results of the Q-Type Classification and Ordination Analyses on Fish Abundance Data During the Southwest Monsoon Season. Upper diagram: TWINSPAN dendogram of the seasonal fish assemblage grouping. Middle diagram: DECORANA ordination plots of the seasonal fish assemblage grouping. Bottom table: correlation between environmental variables and SU scores on the first three DCA axes.

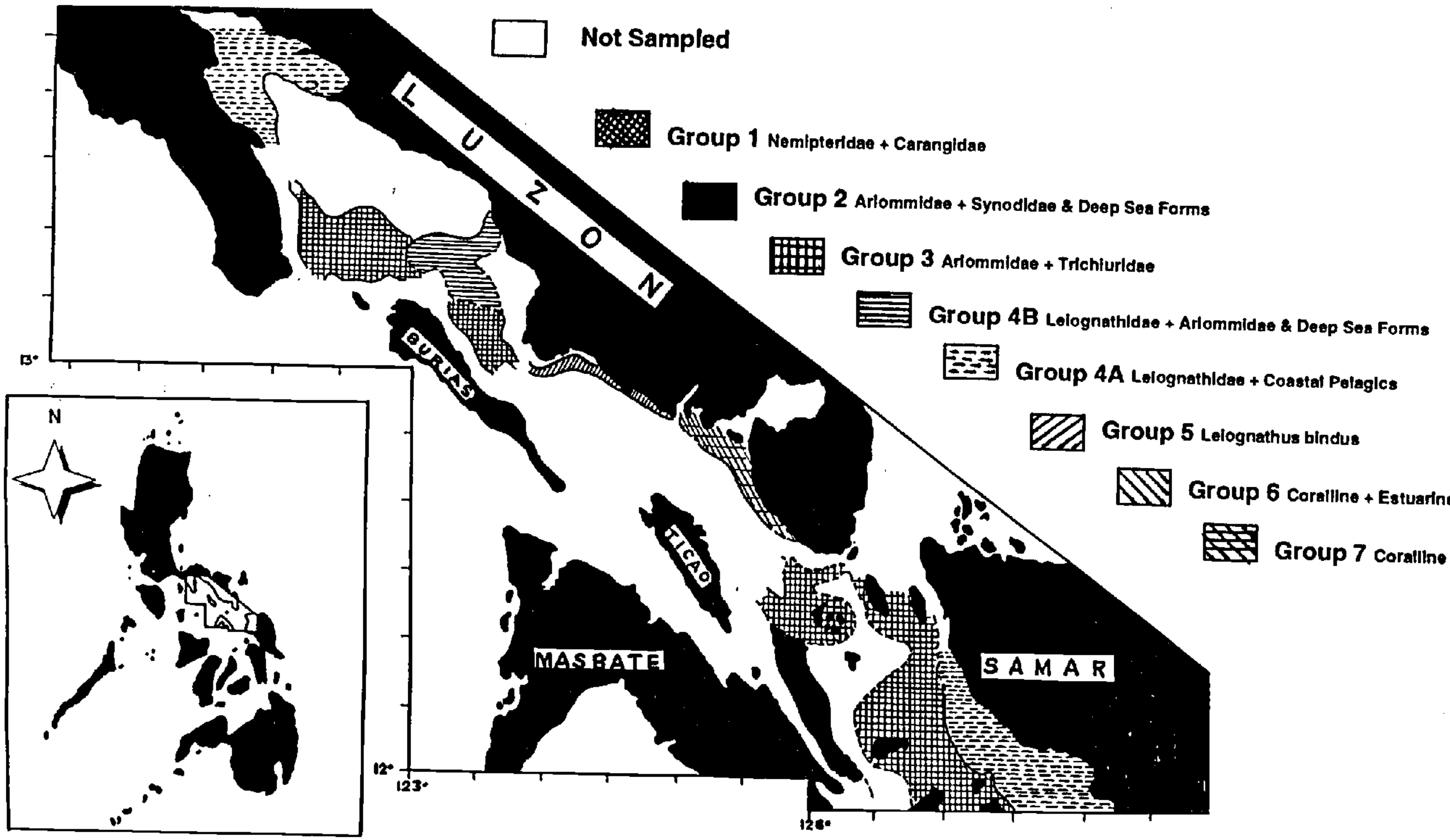


Figure 20. Geographic Location of the Different Fish Assemblage Groups at RABUTINOS During the Southwest Monsoon Season.

DCA ordination of the southwest monsoon data (Figure 19, middle diagram) distinctly separated the coralline Group 7 from the rest. During this season, Group 5 showed much closer affinity with Groups 4B and 4A compared to the previous season. The second DCA axis clearly separated the deepest stations, (i.e., Group 2), from the less deep adjacent stations, (i.e., Group 3). Apart from FS8, the coastal riverine stations formed a relatively distinct cluster. FS8 may have been misclassified as indicated by its greater affinity with Group 3 in the ordination diagram. The eigenvalues of the first three DCA axes were 0.86, 0.43 and 0.31 respectively.

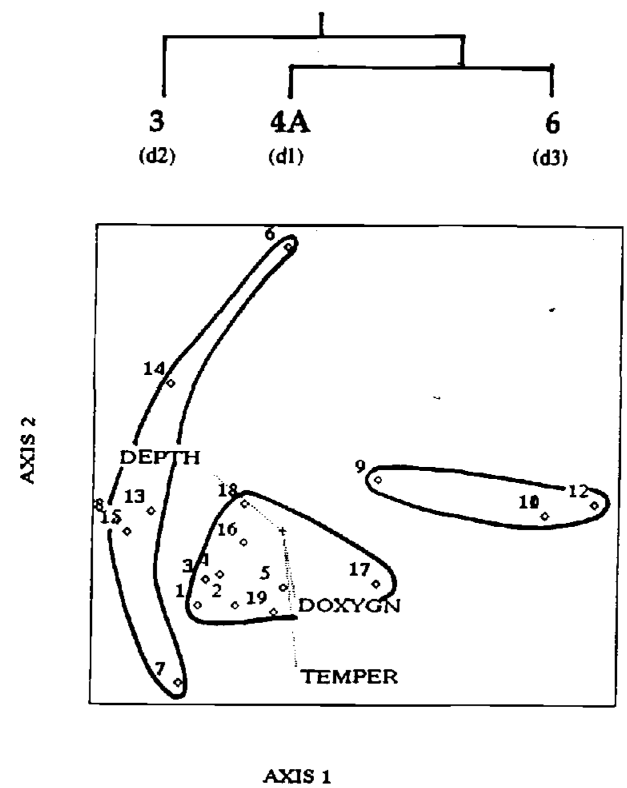
The rainy southwest monsoon season reduced the correlation between the first DCA Axis and the environmental variables (Figure 19; bottom table). The first DCA Axis is adequately represented by both temperature and depth gradients, i.e., depth decreases and temperature increased as one moved from left to right along the first DCA Axis (Figure 19; middle diagram). The second DCA Axis represented a complex gradient involving all of the environmental variables, i.e., salinity and depth decrease while temperature and DO concentration increase as one moved from top to bottom of the diagram. The fishing stations comprising Group 7 were distinctly separated from the rest due to its relatively high water temperature and medium salinity and DO values. The shallow water stations (Group 4A) were easily distinguishable from the deeper stations, e.g., Group 4B and Group 3 due to its high DO concentration. However, the separation between Groups 4B and 3 were not as distinct.

The rainy season brought some changes in the station groupings at RABUTINOS (Figure 20). On the narrow shelf off Sorsogon Bay and vicinity, the areas formerly occupied by transition Group 6 assemblage (i.e., composed of a mixed bag of coralline + Leiognathidae and other estuarine species/taxa) reverted back to Group 7 (composed mainly of coralline fish assemblage), resulting from the outmigration of Leiognathidae and associated species/taxa from the coralline fish assemblage boundaries and a return to their own main habitats to the north. Once again, a clear separation existed between Group 5 (*Leiognathus bindus* assemblage) and Group 7 (coralline assemblage).

On the shallow inner shelves of northern Samar Sea and Ragay Gulf, Group 4A (composed of Leiognathidae + other coastal pelagics) now extended all the way offshore into areas formerly occupied by Group 4B fish assemblage (i.e., Leiognathidae + Ariommidae and other deep sea forms). This was due to the outmigration of deep sea forms and the extension of the range of coastal/riverine pelagic species into these areas.

Except for FS8, most of the deep shelf areas in the central Ragay Gulf Basin were re-occupied by Group 3 assemblages composed of Ariommidae + Trichiuridae. FS8 was classified by TWINSPAN as belonging to Group 4B but was closer to Group 3 in the DECORANA ordination. Group 4B represented the transition zone between the shallow, riverine group (Group 4A) and the deep preferential species (Group 3) and was differentiated mainly by the relative abundances of Trichiuridae, Ariommidae and Leiognathidae. Since this period corresponds to the rainy southwest monsoon season, FS8 was assigned to Group 4B.

d. *Dry ENSO Early Maturity Phase.* The ENSO period showed radical structural and compositional departures from the previous seasonal dendograms (Figure 21, upper diagram). Only three major clusters were discerned by TWINSPAN, i.e., the deep water stations within the Southwestern region (Group 3), and the shallow water stations composed of coralline-estuarine mixture (Group 6) and riverine (Group 4A) clusters. The DCA ordination pattern (Figure 21, middle diagram) also indicated the same grouping. The eigenvalues of the first three DCA axes were 0.86, 0.49 and 0.40 respectively. (Note: Since four fishing stations were not sampled during this cruise, the sequential arrangement of numbers was not the same as the fishing station codes; see Table 3 for details).



PEARSON AND KENDALL CORRELATIONS WITH ORDINATION AXES N= 19

AXIS:	1			2			3		
	r	r-sq	tau	r	r-sq	tau	r	r-sq	tau
TEMPER	.251	.063	.144	-.793	.630	-.406	.099	.010	.154
SALINI	-.433	.187	-.314	.062	.004	.264	-.481	.231	-.165
DOXYGN	.224	.050	.135	-.553	.305	-.306	.256	.065	.207
DEPTH	-.553	.306	-.429	.519	.269	.261	-.311	.097	-.295

Figure 21. Results of the Q-Type Classification and Ordination Analyses on Fish Abundance Data During the ENSO Early Maturity Stage. Upper diagram: TWINSPAN dendogram of the seasonal fish assemblage grouping. Middle diagram: DECORANA ordination plots of the seasonal fish assemblage grouping. Bottom table: correlation between environmental variables and SU scores on the first three DCA axes.

The correlation between the first DCA Axis and the environmental variables were weakest during the Early Maturity Stage of ENSO (Figure 21; bottom table). Depth was the primary gradient along the first DCA Axis while temperature and DO concentration were the gradients along the second DCA Axis (Figure 21; middle diagram). Instead of producing noisy ordination and classification output, this group produced three very distinct clusters representing shallow-riverine (Group 4A), coralline/estuarine transition (Group 6), and deep thermocline water transition (Group 3) assemblages.

During this period (Figure 22), there was no change in the species assemblages of the estuarine areas as indicated by the same geographic extent of Group 4A. However, both the *Leiognathus bindus* (Family: Leiognathidae) assemblage north of Sorsogon Bay (Group 5) and the coralline assemblage (Group 7) were now replaced by Group 6 (coralline + Leiognathidae and other estuarine assemblage) indicating cross-mixing among species belonging to both groups along the whole length of the narrow Ticao Pass shelf. All the deep sea stations, i.e., from approximately 50 m to 200 m depth, exhibited a homogenous fish assemblage composed mainly of Ariommidae + Trichiuridae (Group 3).

e. *Summary of Seasonal Patterns.* In general, the primary dichotomy clearly identified by the ordination and classification analyses were along the bathymetric gradient. The depth of separation between the shallow and deep water communities was around the 90 m isobath. Secondary gradients were most pronounced in the shallow areas (<90 m depth). These were related mainly to geographical features, i.e., (1) proximity to riverine sources and associated physical attributes like varying levels of salinity; or (2) proximity to rocky or coral reefs characterized by high habitat complexity and rugosity.

Table 12 outlines the seasonal and spatial variation in the cluster membership of the different SU's. Contrary to expectations, the shallow coastal stations near major rivers and freshwater run-offs did not show any change in group membership with the season, even with ENSO-induced drought conditions. Instead of changing from Group 4A to Group 4B as freshwater discharge from rivers declined, the shallow water stations stayed the same during the dry ENSO early maturity period. This resulted in the enlargement of

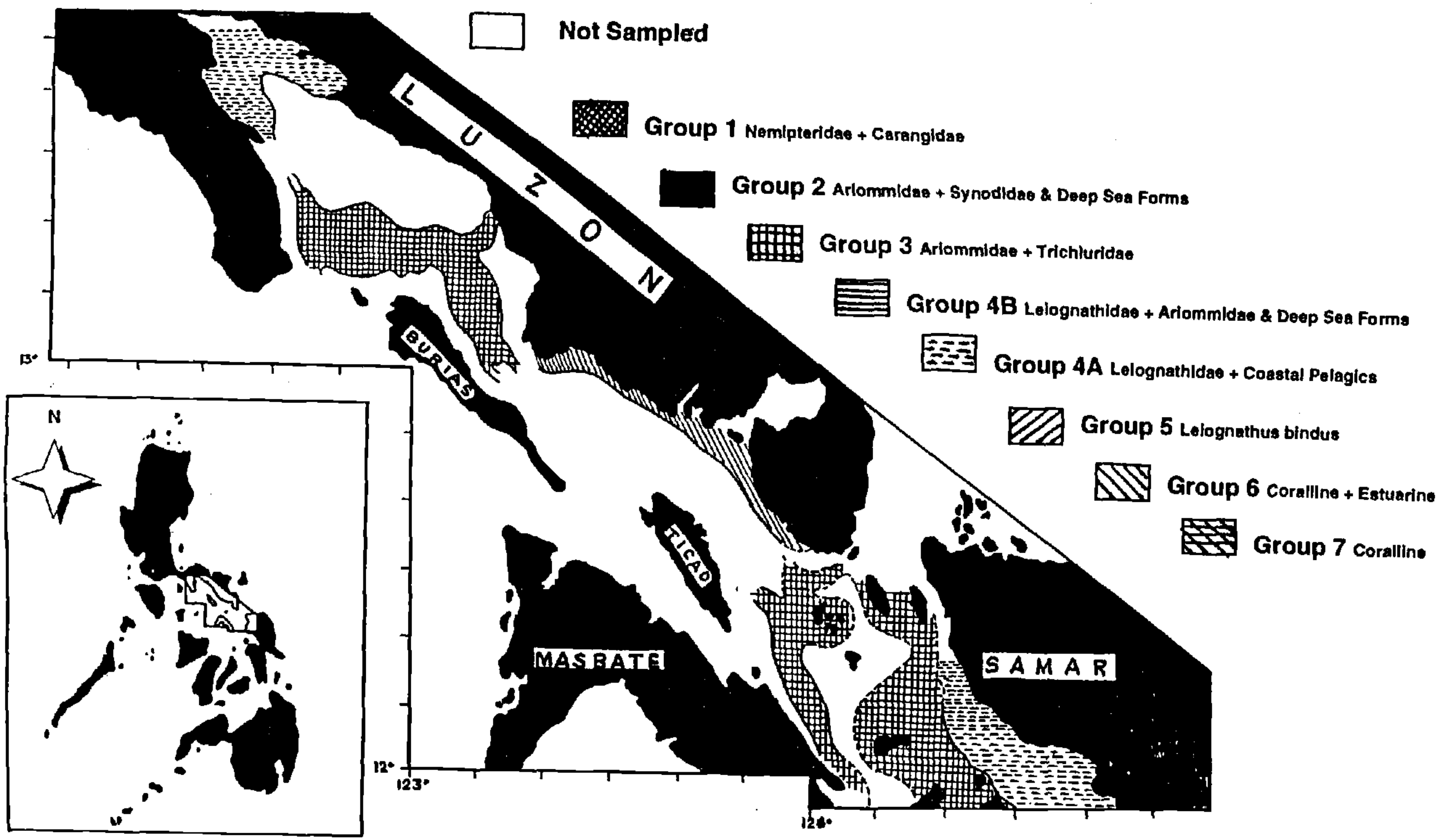


Figure 22. Geographic Location of the Different Fish Assemblage Groups at RABUTINOS During the ENSO Early Maturity Stage.

Table 12. Seasonal and Spatial Variation in the Station Cluster Membership. Standard group designations were derived from ordination and classification. Shaded cells indicate stations that show ENSO variations in group membership.

SAMPLING UNITS (FISHING STATIONS)

	Riverine					Deep				Ticao Pass/Coralline						Deep				Riverine			
SEASON	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Wet NE Monsoon	4A	4A	4A	4A	4B	1	3	3	3	6	6	6	7	7	7	3	3	3	3	4B	4A	4A	4A
Dry Intermonsoon	4A	4A	4A	4A	4B	2	2	3	3	5	5	6	6	6	6	3	2	3	3	4B	4A	4A	4A
Wet SW Monsoon	4A	4A	4A	4A	4A	3	3	4B	3	5	5	7	7	7	7	3	2	3	3	4B	4A	4A	4A
ENSO Maturity	4A	4A	4A	4A	4A	3	3	3	3	6	6	(6)	6	6	6	3	3	3	3	4A	4A	4A	4A
Normal NE Group	4A	4A	4A	4A	4B	1	3	3	3	6	6	6	7	7	7	3	3	3	3	4B	4A	4A	4A
Enso Effect?	No	No	No	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No	Yes	No	No	No
Seasonality?	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No

Legend: (grey shading) **Possible ENSO-Induced Change**

(hatched shading) **Possible Regular Seasonal Variation Only** the area occupied by Group 4A. Most of the seasonal variations and ENSO impacts were confined to the locations of the coralline station clusters and the riverine-deep sea transition groups (i.e., FS5 and FS20; FS10 to FS15), including some deep sea stations (FS 6 to FS8 and FS17).

The coralline stations alternate from Group 7 (purely coralline) during the wet season and into Group 6 (coralline-estuarine transition) during the dry season. The northerly stations (FS10 and FS11) alternate from Group 6 during the wet season, to Group 5 (mainly *Leiognathus bindus* assembly) during the dry season indicating stronger horizontal rather than vertical migration and species interchange between these two station clusters.

The deep water stations (FS 17, FS6 and FS7) exhibited greater vertical interchange of species, involving mainly the thermocline associated fauna and the deeper zones during the dry season. This was indicated by the change from Group3 to Group 2 and *vice-versa* among those stations. The fish assemblage in FS8 was primarily of transition Group 3 except during the wet rainy season when it became the shallower Group 4B transition assemblage. It is not definite from the data whether ENSO conditions were responsible for the non-appearance of Group 1 during the averted 1982 northeast monsoon season.

f. *Seasonal Assemblage Contribution to Overall Fish Abundance.* The seasonal variation in the mean catches of each fish assemblage is shown in Figure 23. Significant decline in the total abundance and number of fish assemblages occurred during the ENSO period. The mean catch dropped from approximately 1.5 metric tons during the northeast, intermonsoon and southwest monsoon seasons to about one half of this value (0.7 metric tons) by the early maturity stages of ENSO. Furthermore, the number of fish assemblages contributing to the observed abundances decreased from six to just three groups during ENSO. The three remaining assemblages all came from relatively less stable or highly variable marine environments, i.e., Group 3 (thermocline SU assemblage), Group 4A

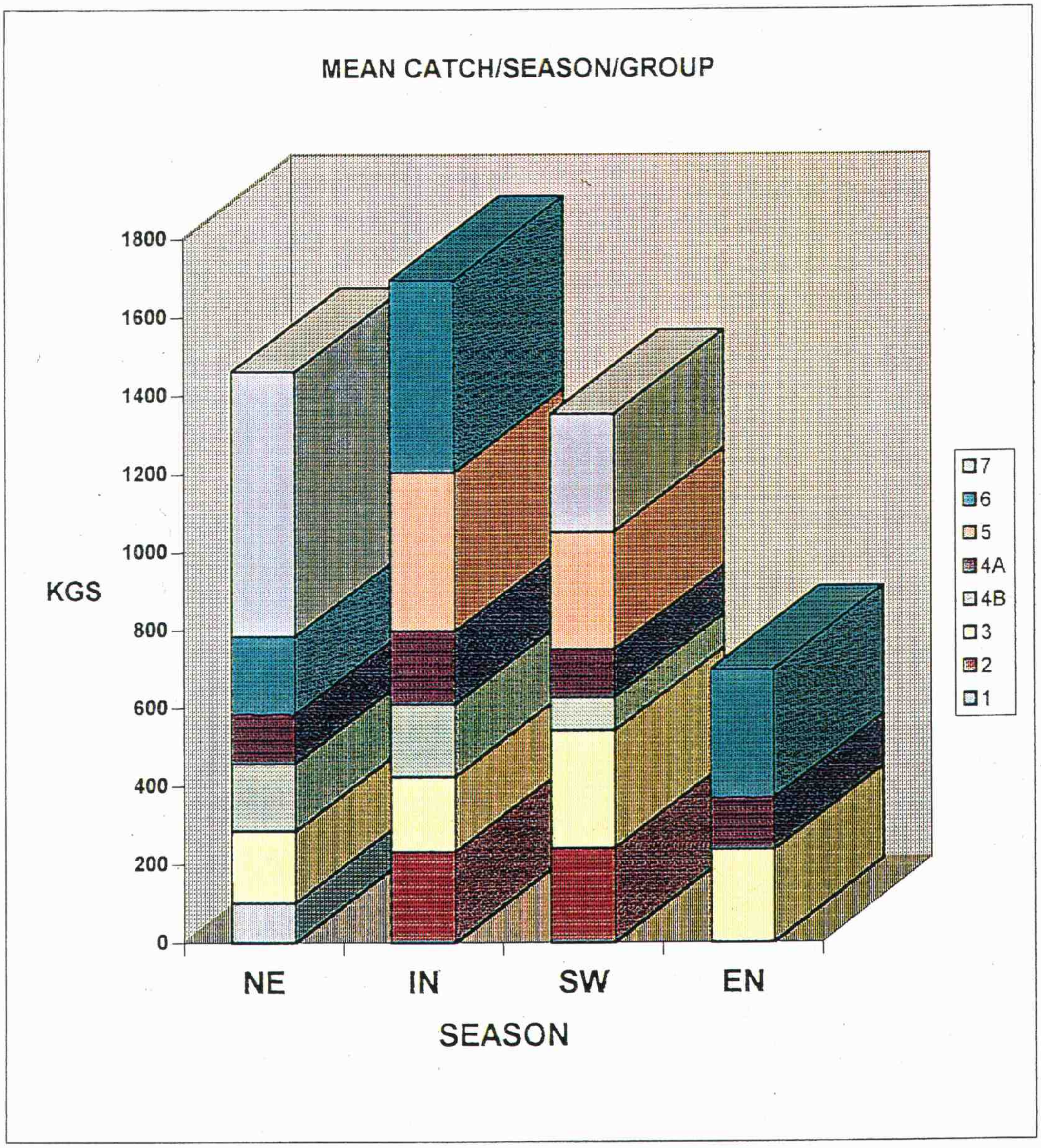


Figure 23. Seasonal Variation in Abundance of Demersal Trawl Fauna in Rabutinos

(shallow, riverine SU assemblage) and Group 6 (coralline-estuarine transition SU assemblage).

D. Environmental Association:

This section presents the results of the analyses done on the environmental characteristics of the different SU groups with the objective of identifying the principal gradient(s) that influence the observed fish assemblage structure at RABUTINOS. There were two basic environmental association methods employed and were presented as follows: (1) a comparative analysis of habitat characteristics aimed at statistically isolating significant differences between each SU groups and (2) multiple linear regression analysis for the simultaneous analysis of the direction and magnitude of each environmental variable's impact on the individual species comprising the community.

1. Seasonal Variation of Environmental Factors.

a. *Salinity*. The time series pattern of salinity distribution in the upper 100 m layer during the survey period is shown as a Tukey box plot in Figure 24. In general, the average salinity in the upper 100 m layer of water was low during the rainy months, (i.e., Cruise 3/ November '81, Cruise 4/December '81, Cruise 9/July '82 and Cruise 10/September '82), and high during the dry months, (i.e., Cruise 5/January '82, Cruise 6/March '82, Cruise 8/May '82, Cruise 12/November '82 and Cruise 13/January '83). Also, the average salinity during January '83 (Cruise 13), two months after the start of the ENSO-induced drought, was significantly higher than the previous January '82 (Cruise 5) based on the results of Fisher's Protected LSD test (Table 13). The dry months of December '81 (Cruise 4), July '82 (Cruise 9) and September '82 (Cruise 10) were also significantly more saline than the wet months of March '82 (Cruise 6), November '82 (Cruise 12) and January '83 (Cruise 13).

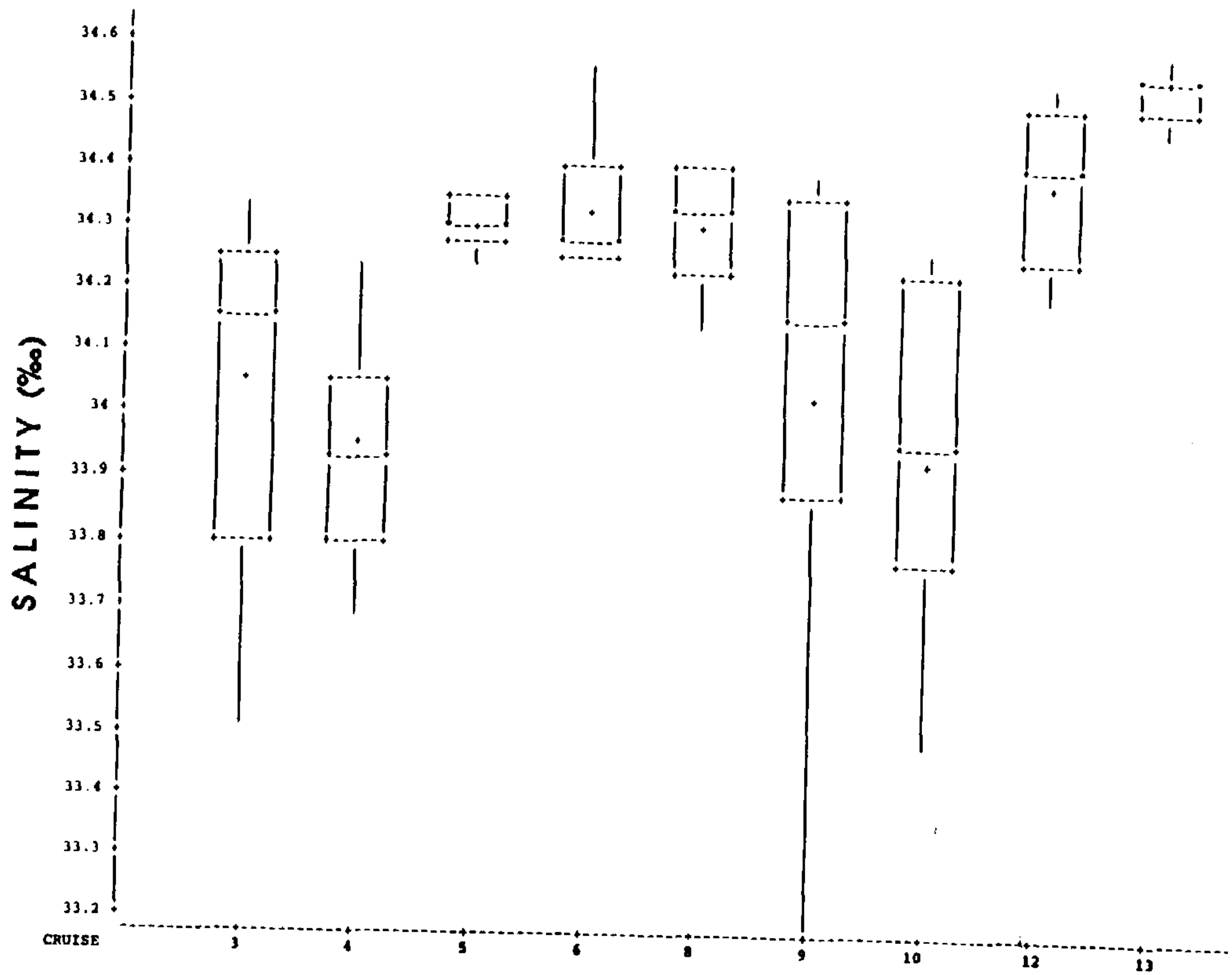


Figure 24. Time Series Plot of the Mean Salinity (Upper 100 m Layer) Variation at Ragay Gulf and Vicinity.

Table 13. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Salinity/Cruise in the Upper 100 m Layer of RABUTINOS.

T Grouping		Mean	Cruise
	A	34.54	13
B	A	34.39	12
B	A	34.33	6
B		34.31	5
B		34.31	8
B	C	34.04	3
	C	34.03	9
	C	33.94	4
	C	33.93	10
Alpha = 0.05		LSD=0.22	

Table 14. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Temperature/Cruise in the Upper 100 m Layer of RABUTINOS.

T Grouping			Mean	Cruise
	A		27.69	9
B	A		27.22	10
B	A		27.11	8
B	A	C	26.63	3
B	D	C	26.38	12
E	D	C	25.62	4
E	D		25.41	13
E			24.85	6
E			24.81	5
Alpha = 0.05			LSD=1.16	

The temporal variation in salinity, from the sea surface down to 300 m depth, is shown in Figure 25. The cross-hatched area in the diagram indicates seawater salinities ≤ 34.3‰ used as arbitrary reference point in the discussion. Low salinity waters extended down to 120 m depths during the 1981 and 1982 rainy southwest monsoon seasons, indicating the degree in which heavy rainfall affects the "estuarization" of the marine environment in tropics. Salinity stratification was accentuated during the rainy season as indicated by the number of salinity isopleths stacked on top of each other. The reverse happened during the dry season when most of the low salinity isopleths disappeared and the water column approached isohaline conditions. While it took more time to lower the salinity of the water column, once the heavy rains stopped, e.g., January - February '82 and November '82 onwards, it only took a short period of time for salinities at RABUTINOS to increase and for the water column to attain near isohaline conditions again.

b. *Water Temperature.* The temporal variation in seawater temperature during the survey period is given in Figure 26. Except for some phase delay, the diagram showed basic congruence in the pattern of variation between air temperature and the temperature of the water column. The local marine environment was coolest during the northeast monsoon months and warmest during the southwest monsoon season. Peak seawater temperature was reached around July, approximately one month after air temperature reached its maximum values. Fisher's Protected LSD procedure (Table 14), indicated that the mean seawater temperature in the upper 100 m water column during January '83 (Cruise 13) was not significantly higher than the average temperature of the previous year (January '82/Cruise 5).

The temporal variation in seawater temperature with depth is shown in Figure 27. The compactly spaced isotherms, i.e., the band of water between 18°C and 24°C, located at depths between 100 m to 150 m defined the typical location and vertical extent of the thermocline on this side of the equatorial Pacific Ocean. The cross-hatched portion in the

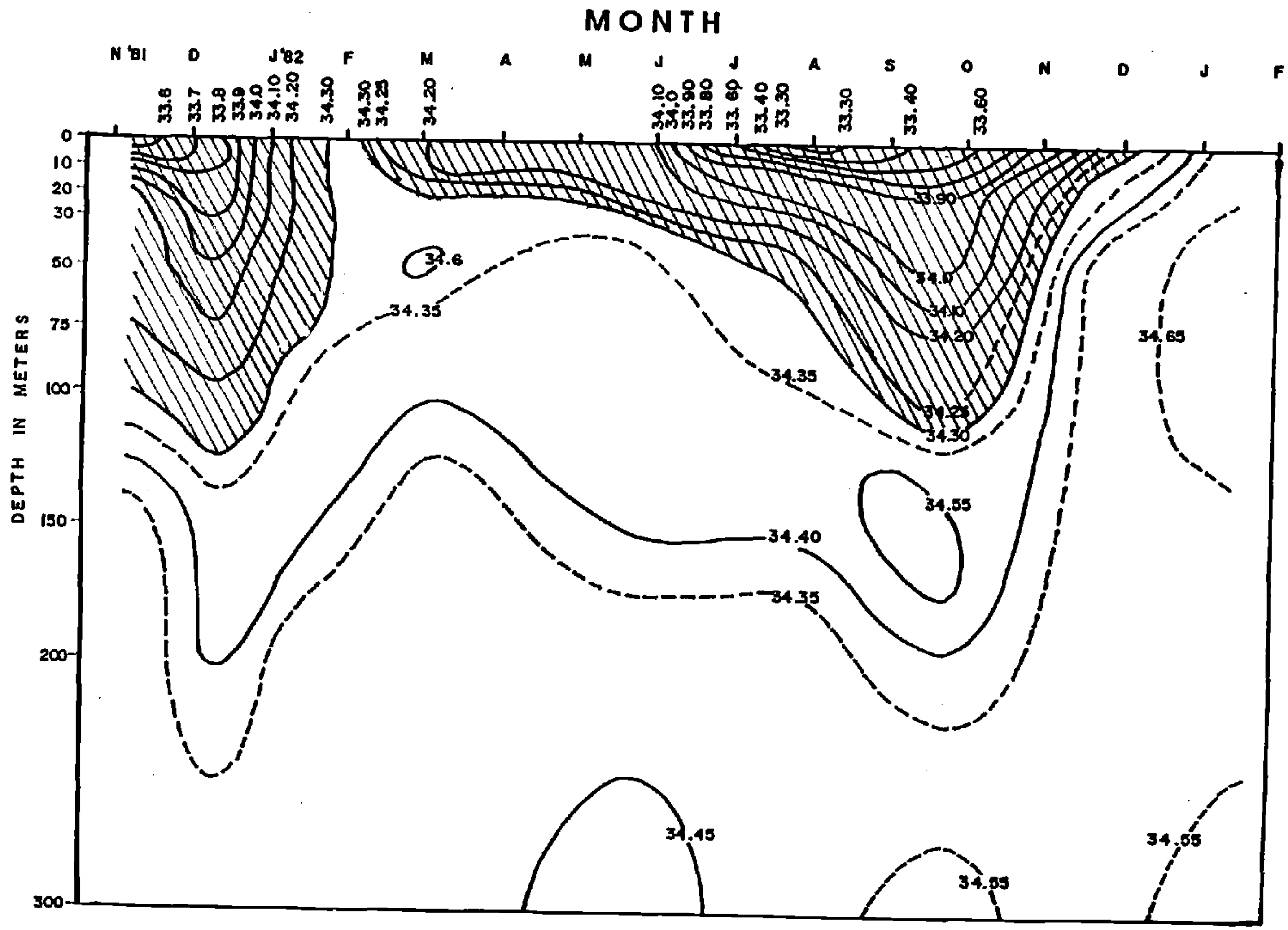


Figure 25. Isopleth Map of the Seasonal Variation in the Mean Salinities of Ragay Gulf and Vicinity.

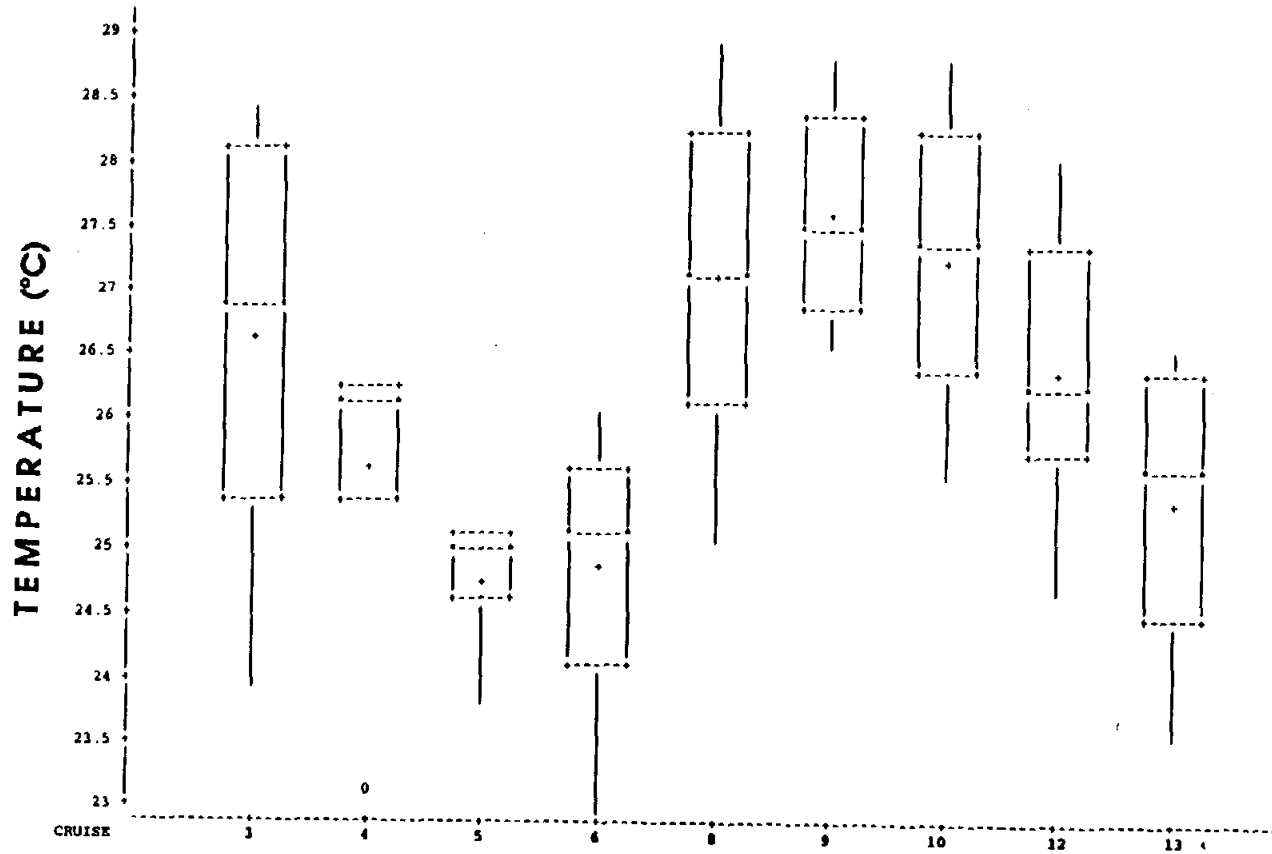


Figure 26. Time Series Plot of the Mean Sea Temperature (Upper 100 m Layer) Variation at Ragay Gulf and Vicinity.

diagram indicated waters warmer than 26°C. Much of the seasonal fluctuations in water temperature occurred above the thermocline (i.e., <100 m depth). This was manifested in the position of the 26°C isotherm as the seasonal warming and cooling process went on. Accentuated thermal stratification of the water column was also evident during the warm southwest monsoon season (Figure 27). The reverse was true during the cool northeast monsoon season as shown by water temperatures in the upper 100 m water column approaching the upper limits of the thermocline.

c. *Dissolved Oxygen.* The temporal variation in the dissolved oxygen (DO) content of sea water within the upper 100 m depth is shown in Figure 28. The time series pattern showed DO concentrations following a regular seasonal cycle. Low DO values were observed during the northeast monsoon while high values were typical during the southwest monsoon season. Comparing the pre-ENSO and ENSO cruises, Fisher's Protected LSD test (Table 15) indicated that the average dissolved oxygen concentration during January '82 (Cruise 5) was significantly higher compared to those observed in January '83 (Cruise 13).

The seasonal variation in DO concentration with depth is illustrated in Figure 29. The cross-hatched area delineated water layers with DO values > 6.0 ml/L and showed the extent in which the water column was oxygenated. High DO concentrations were prevalent throughout the surface layers but rapidly decreased with depth. An oxycline was present at around 75 m to 150 m depth during the dry intermonsoon period (February to May). This marked the boundary between the highly oxygenated surface layers from the oxygen deficient bottom waters. This layer mimicked the thermocline but exhibited wider vertical fluctuations. Tracing the 5.5 ml/L DO isopleth, the low oxygen boundary layer extended upwards near the sea surface during the northeast monsoon season and down to 40 m depth during the peak of the rainy southwest monsoon season.

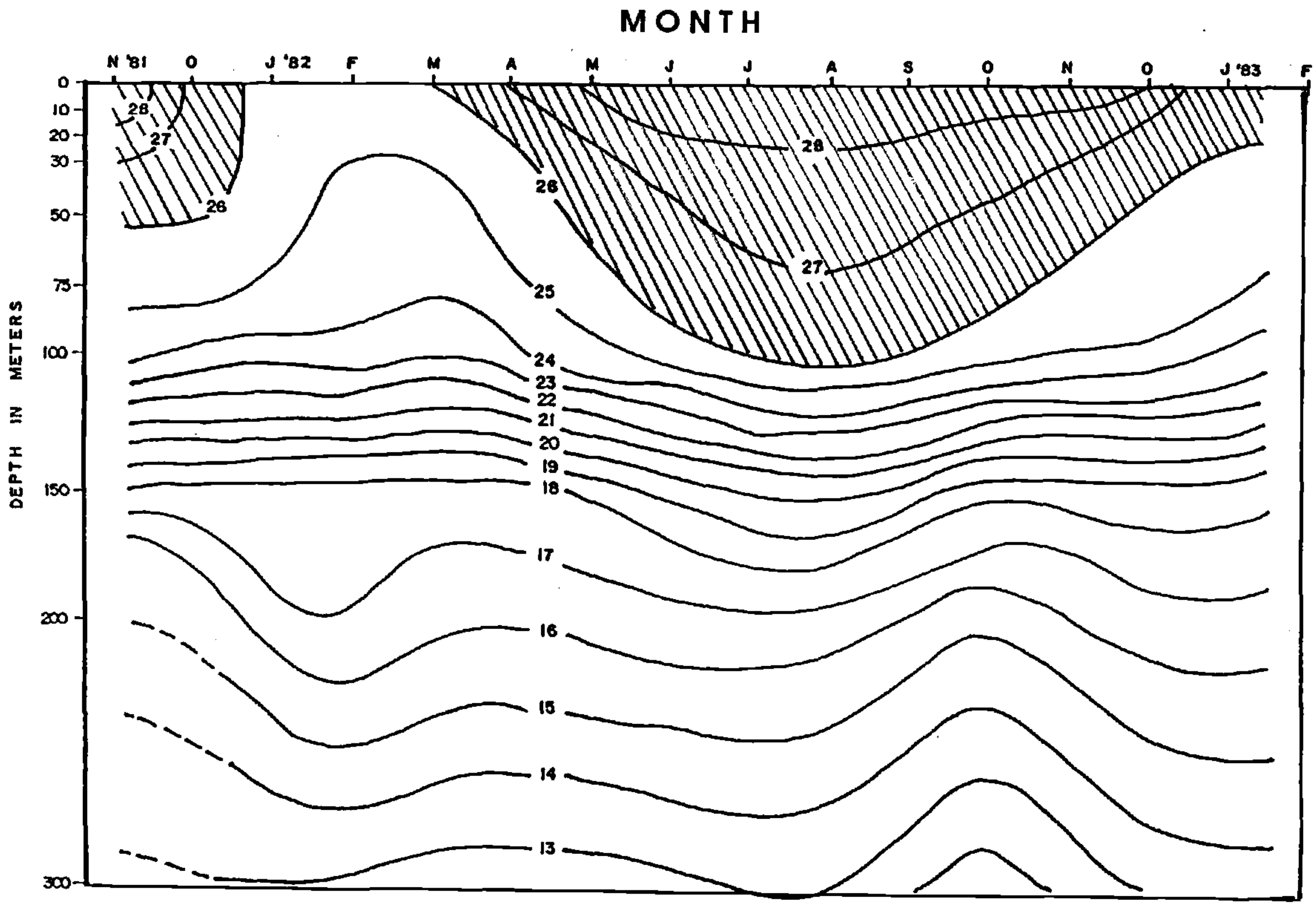


Figure 27. Isopleth Map of the Seasonal Variation in the Mean Temperature of Ragay Gulf and Vicinity.

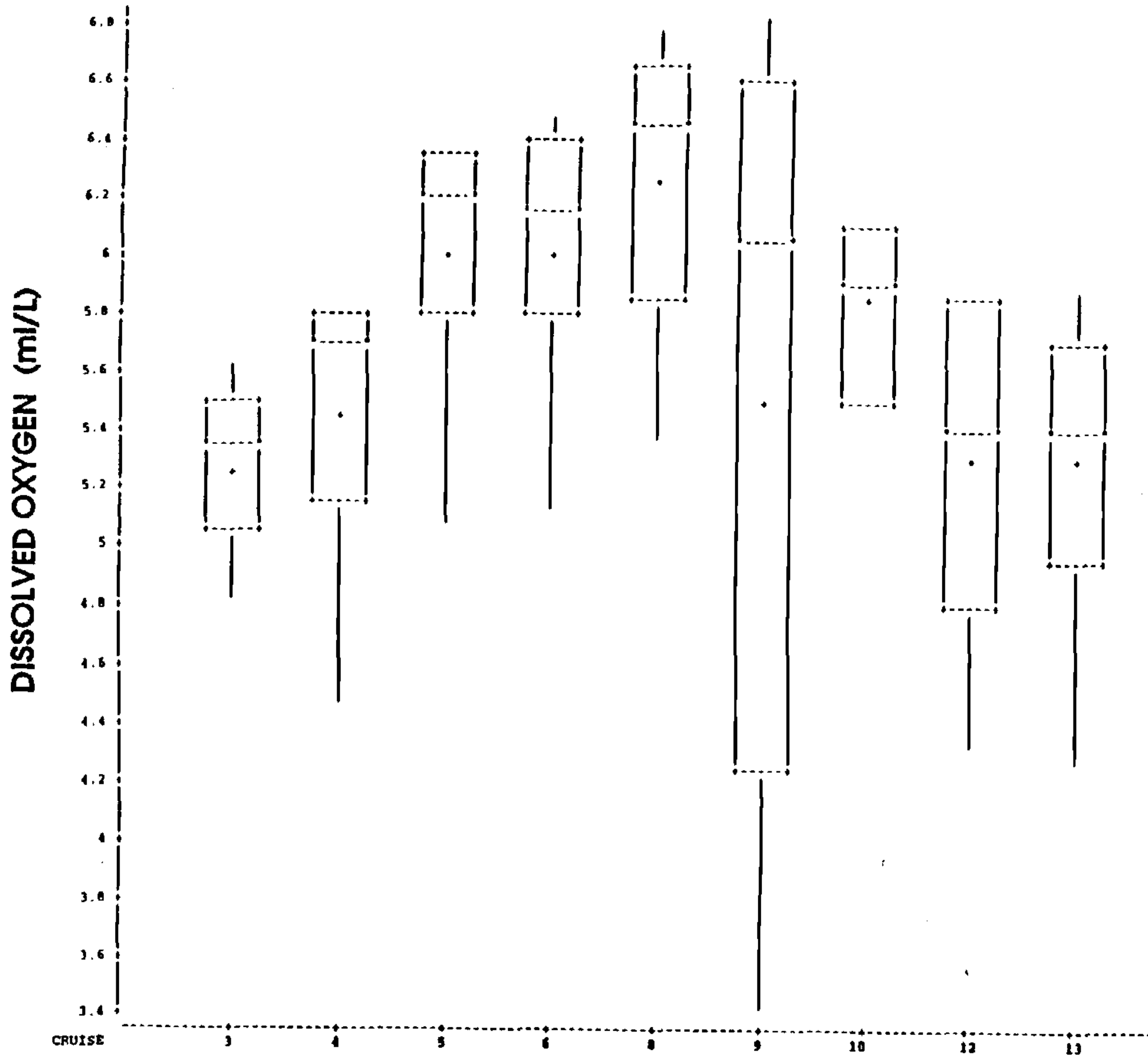


Figure 28. Time Series Plot of the Mean Dissolved Oxygen Concentration in the Upper 100 m Layers of Ragay Gulf and Vicinity.

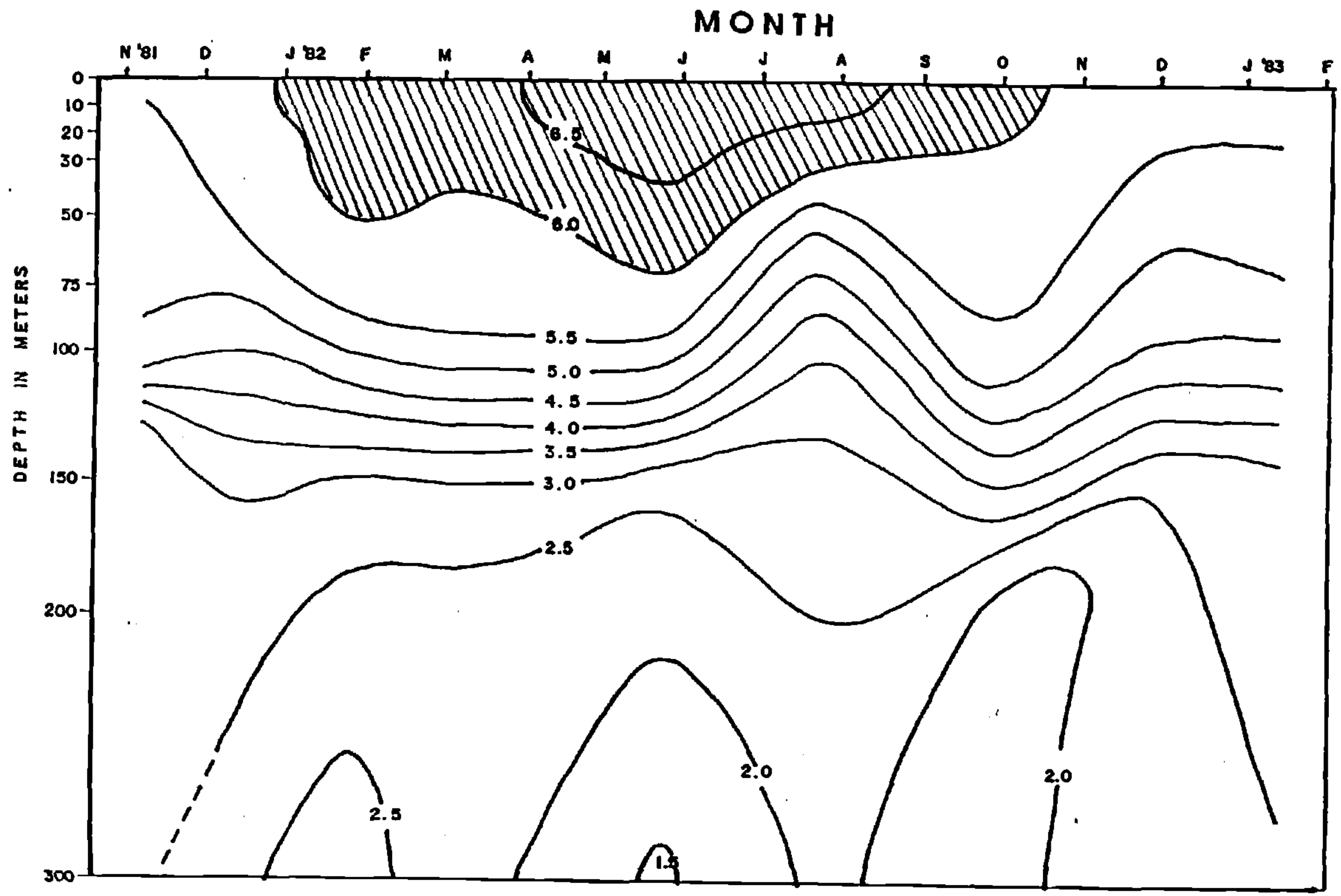


Figure 29. Isopleth Map of the Seasonal Variation in the Mean Dissolved Oxygen Concentration in Ragay Gulf and Vicinity.

Table 15. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Dissolved Oxygen/Cruise in the Upper 100 m Layer of RABUTINOS.

T Grouping			Mean	Cruise
	A		6.27	8
B	A		6.01	5
B	A		5.99	6
B	A	C	5.83	10
B		C	5.51	9
B		C	5.46	4
		C	5.29	13
		C	5.28	12
		C	5.26	3
Alpha = 0.05			LSD=0.64	

2. Relationship Between Biotic Groups and Environmental Factors.

a. *Environmental Characteristics of the Biotic Groups.* The results of Fisher's Protected LSD test among environmental variables are listed in Table 16. The shallow water group (i.e., Groups 4A, 4B, 5, 6 and 7) were significantly different from the deep water group (i.e., Groups 1, 2 and 3) in most of the environmental categories listed. Basically, the shallow water fishing stations were all above the thermocline while the deep water stations were either situated within or below the thermocline.

Within the deep water category, salinity was not a separating factor as most of the variability in salinity occurred near the sea surface and not at the bottom (Figure 23). What distinguished Group 3 (Ariommidae and Trichiuridae Assemblage) from Group 1 (Nemipteridae and Carangidae Assemblage) and Group 2 (Ariommidae + Deep Sea Forms) were temperature and DO concentration, i.e., Group 3 was significantly warmer and more oxygenated. At an average depth of 140 m, fishing stations belonging to Group 3 were located right at the thermocline and oxycline while fishing stations belonging to Group 1 (166 m) and Group 2 (185 m) were all located deeper. The vertical variations in temperature (Figure 27) and dissolved oxygen (Figure 29) below the thermocline were more gradual as shown by the widely spread isopleths below the thermocline/oxycline. None of the environmental factors measured in Group 1 and Group 2 were significantly different which implied that some other factors may have caused their separation.

Among the shallow water groups, the environmental conditions observed between fishing stations located above (i.e., Groups 4A, 6 and 7) and below (i.e., Groups 4B and 5) the 35 m isobath were significantly different from each other. Group 7 (Coralline Assemblage) was distinguishable from Group 6 (Coralline + Leiognathidae and Associated Estuarine Assemblage) and 4A (Leiognathidae + Coastal Pelagics) based on significantly lower DO concentration. Group 3 was warmer and had higher dissolved oxygen concentration than Groups 1 and 2 although it was not significantly shallower than Group 2.

Table 16. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Environmental Characteristics/Standardized Groups at RABUTINOS.

GROUP	TEMPERATURE* °C	SALINITY (ppt)	DISSOLVED OXYGEN* (ml/liter)	DEPTH* (meter)
1	18.17^{c}	34.42^{a}	1.80^{d}	165.67^{ab}
2	19.31^{c}	34.46^{a}	2.39^{d}	185.25^{a}
3	21.98^{b}	34.42^{a}	3.68^{c}	139.26^{b}
4A	25.94^{a}	34.26^{b}	5.58^{a}	45.75^{d}
4B	26.07^{a}	34.32^{b}	5.18^{ab}	88.20^{c}
5	25.74^{a}	34.39^{ab}	5.18^{ab}	79.90^{c}
6	25.42^{a}	34.32^{b}	5.47^{a}	47.24^{d}
7	26.35^{a}	34.27^{b}	4.98^{b}	40.00^{d}

**Means in the same column with different letters are significantly different ($p<0.05$)*
^{ns}Not significant ($p>0.05$)

Table 17. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Environmental Characteristics/Northeast Monsoon Seasonal Clusters at RABUTINOS.

GROUP	TEMPERATURE* °C	SALINITY^{NS} (ppt)	DISSOLVED OXYGEN* (ml/liter)	DEPTH* (meter)
NE1	18.17^{c}	34.42	1.80^{b}	165.67^{a}
NE3	21.73^{b}	34.37	3.75^{c}	147.40^{a}
NE4A	25.62^{a}	34.16	5.36^{a}	44.76^{c}
NE4B	27.14^{a}	34.21	5.00^{a}	85.00^{b}
NE6	25.61^{a}	34.22	5.46^{a}	56.75^{c}
NE7	25.88^{a}	34.23	5.51^{a}	42.78^{c}

**Means in the same column with different letters are significantly different ($p<0.05$)*
^{ns}Not significant ($p>0.05$)

b. *Seasonal Differences in the Environmental Characteristics of Biotic Groups.* The environmental characteristics of the different fishing stations corresponding to the SU fish assemblages are presented below according to the monsoon seasons:

(1) Northeast Monsoon Season. Six major biotic groups and sub-groups were present during the northeast monsoon season (Table 17), i.e., Groups 1, 3, 4A, 4B, 6 and 7. The "NE" prefix denotes that the groups being compared were from the northeast monsoon season. Salinity was not a significant environmental variable for discriminating the different groups. Fisher's Protected LSD test showed that the shallow water fishing stations (i.e., Groups NE4A, NE4B, NE6 and NE7) were significantly different from the deep water fishing stations (i.e., Groups NE1 and NE3) in all of the other environmental categories. While the depths of NE1 (Carangidae and Nemipteridae Assemblage) and NE3 (Ariommidae + Trichiuridae Assemblage) were not considerably different, NE3 stations located within the thermocline were substantially more oxygenated and warmer.

Among the shallow water groups, depth (i.e., above and below the 35 m isobath) was the only measured environmental variable that differentiated N4B (Leiognathidae + Ariommidae and Deep Sea Forms) from NE4A (Leiognathidae + Coastal Pelagics), NE6 (Coralline + Leiognathidae and Estuarine Assemblage) and NE7 (Coralline Assemblage).

(2) Dry Intermonsoon Period. Six major SU fish assemblage groups and sub-groups were represented during this period (Table 18). The prefix "IN" identifies the group to be compared as belonging to the intermonsoon period. Salinity was not very helpful in separating the different groups, but the rest of the measured environmental variables significantly discriminated the shallow water fishing stations (i.e., Groups IN4A, IN4b, IN5 and IN6) from the deep water fishing stations (i.e., Groups IN2 and IN3). Within the deep water group, all of the remaining environmental factors were also able to separate Group IN3 (stations within the thermocline) from Group IN2 (stations below the thermocline). For the shallow water stations, only depth was significantly better at separating the different biotic groups.

Table 18. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Environmental Characteristics/Dry Inter-Monsoon Period Clusters at RABUTINOS.

GROUP	TEMPERATURE* °C	SALINITY* (ppt)	DISSOLVED OXYGEN* (ml/liter)	DEPTH* (meter)
IN2	20.18^{c}	34.44^{a}	2.48^{d}	176.58^{a}
IN3	23.67^{b}	34.40^{a}	4.12^{c}	120.27^{b}
IN4a	26.54^{a}	34.22^{b}	5.99^{a}	48.52^{e}
IN4b	25.68^{a}	34.35^{ab}	5.35^{ab}	86.33^{c}
IN5	25.58^{ab}	34.40^{a}	5.25^{b}	74.67^{d}
IN6	25.58^{ab}	34.32^{ab}	5.69^{a}	42.38^{e}

**Means in the same column with different letters are significantly different ($p<0.05$)*

^{ns}Not significant ($p>0.05$)

Table 19. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Environmental Characteristics/Southwest Monsoon Seasonal Clusters at RABUTINOS.

GROUP	TEMPERATURE* °C	SALINITY^{NS} (ppt)	DISSOLVED OXYGEN* (ml/liter)	DEPTH* (meter)
SW2	16.70^{c}	34.52	2.15^{d}	211.25^{a}
SW3	20.92^{b}	34.46	3.12^{c}	143.60^{b}
SW4a	26.16^{a}	34.28	5.50^{a}	47.94^{d}
SW4b	25.33^{a}	34.42	5.15^{ab}	95.00^{c}
SW5	25.98^{a}	34.37	5.08^{ab}	87.75^{c}
SW7	26.88^{a}	34.31	4.38^{b}	36.88^{d}

**Means in the same column with different letters are significantly different ($p<0.05$)*

^{ns}Not significant ($p>0.05$)

(3) Southwest Monsoon Season. There was no discernible difference in the salinities of the six biotic groups during the Southwest monsoon season (Table 19). Apart from these, all other environmental variables were considerably different between the deep fishing stations (Groups SW2 and SW3) and the shallow ones (Groups SW4A, SW4B, SW5 and SW7). The "SW" prefix refers to southwest monsoon season. Among the deep water fishing stations temperature, DO concentration and depth were significantly different between Group SW2 (Ariommidae + Deep Sea Forms) and Group SW3 (Ariommidae + Trichiuridae Assemblage).

Temperature and salinity were not substantially different among the shallow water groups. The DO concentration of the fishing stations belonging to Group SW4B (Leiognathidae + Arioma and Deep Sea Forms) were significantly higher than those of Group SW7 (Coralline Assemblage). Depth was also comparably different between Groups SW4B and SW5.

(4) ENSO Early Maturity Phase. Only three biotic groups were discernible during this period (Table 20). Except salinity, all other environmental factors measured for group EN3 (i.e., temperature, DO concentration and depth), were considerably different from the rest based on Fisher's Protected LSD test. Only dissolved oxygen concentration significantly differentiated Group EN4A and Group EN6.

c. *Correlations Among Environmental Variables*. The degree of interdependence or simple correlation among the measured environmental variables is listed in Table 21. All of the indicated correlations were significant at the $\alpha \leq 0.05$ level. Depth was positively correlated with salinity and negatively correlated with dissolved oxygen and temperature. The strength and direction of the correlation were as expected and reflected the normal variation of the temperature, salinity and dissolved oxygen concentration with depth. Salinity had the lowest and most variable correlation with the other environmental

Table 20. Fisher's Protected Least Significant Difference (FPLSD) Test Comparing the Mean Environmental Characteristics of the 1982-'83 El Niño-Southern Oscillation's Early Maturity Stage Clusters at RABUTINOS.

GROUP	TEMPERATURE* °C	SALINITY^{NS} (ppt)	DISSOLVED OXYGEN* (ml/liter)	DEPTH* (meter)
EN3	21.48^{b}	34.57	3.57^{c}	139.67^{a}
EN4a	24.91^{a}	34.53	5.30^{a}	49.33^{b}
EN6	24.50^{a}	34.53	4.75^{b}	44.00^{b}

*Means in the same column with different letters are significantly different ($p<0.05$)

^{ns}Not significant ($p>0.05$)

factors due to the greater influence of exogenous factors, i.e., precipitation levels, in its distribution and concentration.

The correlations between salinity and the rest of the measured environmental variables were strongest during periods of heavy precipitation (i.e., during the "estuarization" of RABUTINOS) and weakest during drought situations (i.e., when the vertical salinity structure broke down and the water column approached isohaline conditions).

e. *Multiple Regression on Fish Abundance and Environmental Variables.* Tables 22 to 25 list the seasonal multiple regression coefficients of the models for the different species that met the acceptable significance level and minimum r^2 contribution criteria. A total of 45, 33, 25 and 31 species have significant regression models (i.e., $\alpha \leq 0.05$) in the northeast monsoon (Cruises 3, 4 and 5), intermonsoon period (Cruises 6, 8 and 9), southwest monsoon (Cruises 10 and 12) and ENSO early maturity phase (Cruise 13), respectively. This accounted for 13% to 23% of the total number of species/taxa that were affected and/or responded to changes in environmental conditions.

For the northeast monsoon season, depth and salinity were the variables that figured prominently in the models with 23 and 22 species associations respectively. During the intermonsoon period, depth was associated with 20 species followed by salinity with 10. Depth was associated with 13 species during the southwest monsoon season followed by salinity and temperature with 7 and 6 species associations each. None of the species included DO concentration level as a significant variable in the model. Salinity and temperature were the environmental variables included in most of the models during the ENSO early maturity phase with 14 and 13 species associations, respectively. Multicollinearity was evident in models with more than one independent variable as expected from the table of correlations among environmental factors. Most of the models

Table 22. Multiple Linear Regression Coefficients of the Environmental Variables Included in the Species/Taxa Models for the NE Monsoon Season.

SPECIES NAME	CODE	Intercept	TEMP	SALIN	DOXY	DEPTH	R^2		Cp
Ariomma indica	ARIOMA	-9.39				0.2200	0.28	2	3.3
Brotulinae	BROTUL	-0.03				0.0006	0.26	2	0.8
Carapidae	CARAPI	-295.73		8.645			0.27	2	-0.4
Champsodontidae	CHAMPO	-357.28		10.461			0.19	1	1.5
Chimaeridae	CHIMAE	-109.53		3.202			0.26	1	-0.4
Chlorophthalmus albat.	CHLORO	123.49		-3.497	-0.732		0.62	1	2.5
Chirocentrus dorab	CIROCE	27.97		-0.814			0.34	2	2.8
Congridae	CONGRI	-140.14		4.096			0.27	1	-0.3
Caranx chrysophrys	CRXCRY	-277.88		8.196		-0.0260	0.36	1	1.1
Caranx dinema	CRXDIN	1.82				-0.0130	0.17	1	1.3
Caranx malabaricus	CRXMAL	2.08				-0.0150	0.17	1	0.4
Cynoglossidae	CYNOGL	-522.85		15.284			0.27	1	-0.3
Decapterus kurroides	DECAKU	57.10			-9.329	-0.1350	0.65	2	1.4
Decapterus macrosoma	DECAMA	16.90	-0.655				0.18	1	1.5
Dussumiera acuta	DUSSUM	-19.14	1.326		-2.549		0.39	1	5.9
Epinephelus spp.	EPISPP	6.75			-1.114	-0.0150	0.49	1	1.2
Formio niger	FORMIO	110.49		-3.214			0.24	1	0
Leiognathus splendens	LEOSPL	849.85		-24.738			0.21	1	0.6
Loligo spp.	LOLIGO	-205.73	11.602		-17.867	0.1610	0.81	1	3.9
Lophiidae	LOPHII	-530.57		15.538			0.28	2	5.7
Myctophidae	MYCTOP	-23.71		0.693			0.26	1	-0.4
Nemipterus bathybius	NEMIBA	-0.60				0.0180	0.30	2	1.7
Nemipterus hexodon	NEMIHE	17.42		-0.507			0.18	1	0.1
Nemipterus marginatus	NEMIMA	16.70			-2.717	-0.0410	0.58	2	1.1
Priacanthus macracan.	PRIAMA	-9.55				0.2130	0.63	3	3.1
Promethichthys promet.	PROMET	-0.11				0.0020	0.35	2	0.3
Pseudorhombus eleva.	PSEUEL	-472.52		13.814			0.25	1	-0.5
Pseudorhombus spp.	PSEUSP	-908.21		26.549			0.26	1	-0.4
Rastrelliger brachysoma	RASTBR	241.11		-7.012			0.26	1	0.5
Sardinella longiceps	SARDLO	295.59		-8.605			0.22	1	0.7
Saurida undosquamis	SAURUN	-3.20				0.1100	0.67	1	5.1
Scolopsis inermis	SCOLIN	52.85				-0.1240	0.69	3	1.9
Scomberomorus comm.	SCOMME	4.79				-0.0300	0.24	2	-0.3
Secutor ruconius	SECURU	275.83	-0.232	-7.882			0.48	1	3
Selar boops	SELABO	39.61	-0.032	-1.133			0.65	2	3.9
Selar crumenophthalmus	SELACR	39.22		-1.140			0.27	2	0.1
Selar melanoptera	SELAME	85.37	-0.063	-2.444			0.50	1	1.5
Selaroides leptolepis	SELARO	343.15		-9.984			0.34	2	2.6
Seiola nigrofasciata	SERION	-6.66	0.456		-0.086		0.50	2	1.5
Sharks	SHARKS	-1.90				0.0580	0.27	2	2.4
Sphyraena langsar	SPHYLA	1.11				-0.0070	0.17	1	-0.8
Tetraodontidae	TETRAO	-12.88			2.022	0.0510	0.42	2	1.5
Trichiurus haumela	TRICHI	-2.73				0.0820	0.23	1	2
Upeneus mollucensis	UPEMOL	-61.01	2.255			0.0930	0.38	2	1.6
Uranoscopidae	URANOS	-5.20				0.0880	0.40	2	0

Legend: 1 = $p<0.05$ 2 = $p<0.01$ 3 = $p<0.001$

Table 23. Multiple Linear Regression Coefficients of the Environmental Variables Included in the Species/Taxa Models for the Dry Inter-Monsoon Period.

SPECIES NAME	CODE	Intercept	TEMP	SALIN	DOXY	DEPTH	R^2		Cp
Aluteres scriptus	ALUTSC	120.22		-3.493			0.23	1	0.4
Aphareus rutilans	APHARE	-0.02				0.000	0.20	1	1
Ariomma indica	ARIOMA	-15.61				0.333	0.24	1	0.3
Bothus spp.	BOTHUS	-1.25				0.022	0.22	1	0.4
Brotulinae	BROTUL	-0.48				0.009	0.24	1	0.2
Canthigaster compressus	CANTIG	-0.37				0.006	0.18	1	0.8
Chimaeridae	CHIMAE	-0.51				0.001	0.18	1	0.9
Chirocentrus dorab	CIROCE	-1.19			0.349		0.20	1	1
Congridae	CONGRI	-0.07				0.001	0.20	1	0.8
Cynoglossidae	CYNOGL	-0.06				0.001	0.18	1	0.8
Diodontidae	DIODON	261.62			-33.865	-1.008	0.37	1	3.7
Labridae	LABRID	34.85			-4.524	-0.134	0.35	1	3
Lactariidae	LACTAR	-0.03				0.001	0.18	1	0.8
Leiognathus splendens	LEOSPL	930.39		-27.017			0.17	1	0.1
Loligo spp.	LOLIGO	480.39		-13.944			0.57	3	0.5
Lophiidae	LOPHII	-1.86				0.045	0.19	1	2.2
Myctophidae	MYCTOP	-0.35				0.007	0.29	2	-0.2
Nemipterus bathybius	NEMIBA	6.58			-1.131		0.30	2	5.6
Priacanthus macracanth.	PRIAMA	80.42	-3.072				0.70	3	-0.2
Promethichthys promet.	PROMET	-0.17				0.003	0.19	1	0.9
Rastrelliger kanagurta	RASTKA	168.28		-4.881			0.21	1	-0.2
Rexea solandri	REXEAS	-14.44			2.052	0.060	0.29	1	1
Sardinella fimbriata	SARDFI	878.03		-25.628		0.029	0.84	3	4.6
Saurida undosquamis	SAURUN	-3.25				0.081	0.22	1	1.9
Scolopsis inermis	SCOLIN	1.04	-0.040				0.21	1	3.3
Scomberomorus comm.	SCOMME	421.11		-12.224			0.29	2	-0.7
Secutor insidiator	SECUIN	26.51		-0.770			0.19	1	4.9
Selar malam	SELAMA	47.22		-1.372			0.34	2	3.7
Selar mate	SELAMT	1.22				-0.008	0.18	1	-0.3
Selaroides leptolepis	SELARO	909.17		-26.432			0.60	3	1
Shrimp	SHRIMP	-0.60				0.011	0.26	1	0.2
Stolephorus tri	STOLTR	234.66		-6.815			0.44	3	-0.5
Upeneus vittatus	UPEVIT	15.72			-2.307	-0.048	0.32	1	2.1

Legend: 1 = $p<0.05$ 2 = $p<0.01$ 3 = $p<0.001$

Table 24. Multiple Linear Regression Coefficients of the Environmental Variables Included in the Species/Taxa Models for the Southwest Monsoon Season.

SPECIES NAME	CODE	Intercept	TEMP	SALIN	DOXY	DEPTH	R^2		Cp
Ariomma indica	ARIOMA	183.98	-6.537				0.18	1	0.9
Balistidae	BALIST	47.10		-1.370			1.00	3	11.5
Bothus spp.	BOTHUS	2.75	-0.102				0.30	2	2
Carapidae	CARAPI	-0.24				0.0040	0.39	3	0.5
Champsodontidae	CHAMPO	2.87	-0.106				0.26	1	1
Chelmon rostratum	CHELMO	0.02		-0.001			1.00	3	28
Chimaeridae	CHIMAE	-0.24				0.0040	0.35	2	0.3
Chlorophthalmus albatrosis	CHLORO	-0.20				0.0030	0.54	3	2.7
Cynoglossidae	CYNOGL	-0.01				0.0001	0.39	2	0.5
Dactylopteridae	DACTYL	1.15	-0.041				0.28	2	3.2
Decapterus kurroides	DECAKU	-1.79				0.0298	0.43	3	0.8
Decapterus muruadsi	DECAMU	-12.82				0.2650	0.41	3	-0.4
Decapterus russeli	DECARU	8.19		-0.342		0.0540	0.45	1	1.8
Formio niger	FORMIO	-3.54	0.171				0.23	1	1
Histiopterus indicus	HISTIN	4.49	-0.167				0.35	2	3.4
Lophiidae	LOPHII	-0.49				0.0310	0.19	1	2.4
Nemipterus hexodon	NEMIHE	3.05		-0.088			0.95	3	3.2
Priacanthus macracanthus	PRIAMA	-2.66				0.1020	0.36	2	0.5
Promethichthys prometheus	PROMET	-0.54				0.0090	0.41	3	0.3
Rhinobatidae	RHINOB	-6.95				0.1130	0.39	2	0.5
Saurida undosquamis	SAURUN	-1.43				0.0740	0.30	2	0.1
Shrimp	SHRIMP	13.13		-0.351			0.37	2	1.6
Triglidae	TRIGLI	30.34		-0.816			0.42	3	1.6
Upeneus vittatus	UPEVIT	-0.70				0.0120	0.44	3	0.9
Uranoscopidae	URANOS	27.73		-0.796			0.95	3	24

Legend: 1 = $p<0.05$ 2 = $p<0.01$ 3 = $p<0.001$

Table 25. Multiple Linear Regression Coefficients of the Environmental Variables Included in the Species/Taxa Models for the ENSO Early Maturity Stage

SPECIES NAME	CODE	Intercept	TEMP	SALIN	DOXY	DEPTH	R^2		Cp
Apogonidae	APOGON	1004.06		-29.048			0.27	1	-0.8
Brotulidae	BROTUL	0.86	-.034				0.25	1	3.7
Canthigaster compressus	CANTIG	658.70		-19.063			0.46	2	-0.1
Centricus scutatus	CENTRI	7325.39		-212.004			0.47	2	0.3
Champsodontidae	CHAMPO	38.00	-1.544				0.31	2	4.0
Chimaeridae	CHIMAE	7.57	-.031				0.31	2	4.0
Chlorophthalmus albatro.	CHLORO	0.76	-.031				0.53	3	2.5
Congridae	CONGRI	0.31	-.013				-0.31	2	4.0
Coradion altiveles	CORADI	31.37		-.907			0.22	1	3.9
Caranx chrysophrys	CRXCRY	2247.56		-65.047			0.47	2	0.3
Caranx malabaricus	CRXMAL	2501.73		-72.391			0.54	3	-0.7
Cynoglossidae	CYNOGL	0.62	-.025				0.31	2	4.0
Dasyatidae	DASYAT	344.68	-13.684				0.35	2	3.7
Diodontidae	DIODON	108.73			-16.006	-.362	0.41	1	4.5
Diploprion bifasciatus	DIPLOP	3.30		-.096			0.47	2	0.3
Labridae	LABRID	36.01			-5.335	-.121	0.42	1	3.0
Lactariidae	LACTAR	27.59	-1.121				0.31	1	3.9
Leiognathus elongatus	LEOELO	71.47		-2.068			0.29	1	1.9
Lutjanus lineolatus	LUTLIN	3394.14		-98.228			0.47	2	0.1
Myctophidae	MYCTOP	4.90	-.308		.569		0.37	1	2.1
Nemipterus nematophorus	NEMINE	-2.35	.251		-.732		0.62	3	17.7
Parupeneus indicus	PARUIN	298.83		-8.645			0.27	1	3.7
Plectorhincus pictus	PLECIN	94.85			-13.987	-.321	0.41	1	2.9
Priacanthus macracanthus	PRIAMA	-2.10				.046	0.22	1	0.3
Pseudorhombus oligodon	PSEUOL	3.38	-.184		.236		0.55	1	5.0
Saurida undosquamis	SAURUN	-32.73			5.252	.141	0.40	1	1.7
Scolopsis inermis	SCOLIN	1791.70	-1.524	-50.792			0.54	1	9.3
Scolopsis taeniopterus	SCOLTA	170.32		-4.926			0.22	1	3.5
Scorpaenidae	SCORPI	9.49	-.374				0.24	1	3.4
Secutor insidiator	SECUIN	2.66		-.077			0.47	2	0.3
Selar mate	SELAMT	579.12		-16.751			0.24	1	1.0

Legend: 1 = p<0.05 2 = p<0.01 3 = p<0.001

with Cp < p were the result of the trade-off between the high minimum r^2 incremental contribution required of a variable *versus* a better Cp index.

The seasonal regression coefficients of the environmental variables and their signs are summarized in Table 26. Within their normal range of distribution, the shallow (deep) water species generally had negative (positive) coefficients for depth. The signs were also consistent with the seasons except for *Decapterus kurroides* and *Upeneus vittatus*. The abundance of *D. kurroides* increased with decreasing depth during the northeast monsoon and the reversed during the southwest monsoon season. *U. vittatus* had a similar but reverse response.

The abundance of coastal species increased with decreasing salinity (negative salinity coefficients) while for the deep sea species, it increased with increasing depth. The relationship between salinity and abundance was more prevalent and strong among shallow, coastal dwellers during the dry season as indicated by the presence of strictly negative salinity coefficients in the models involving the intermonsoon period and ENSO early maturity phase. A reversal in sign from negative (northeast monsoon) to positive (southwest monsoon) was seen only in *Formio niger,* a riverine/estuarine species found in Group 4A/B and Group 6.

Most of the temperature coefficients were negative and associated with species that inhabited the deep seas. Temperature was important in predicting the abundance of only a few coastal species, e.g., *Dussumiera acuta, Loligo* spp., *Nemipterus nematophorus, Seriolina nigrofasciata* and *Upeneus mollucensis*. Except for two species, DO concentration levels factor in the regression model only in conjunction with another primary variable, mostly depth and temperature.

Table 26. Signs of the Multiple Linear Regression Coefficients Included Respective Species/Taxa Models for the Different Seasons at RABUTINOS.

		NE Monso				Intermonso				SW Monsoon				ENSO			
SPECIES NAME	**CODE**	**T**	**S**	**O**	**D**	**T**	**S**	**O**	**D**	**T**	**S**	**O**	**D**	**T**	**S**	**O**	**D**
Aluteres scriptus	ALUTSC						-										
Aphareus rutilans	APHARE								+								
Apogonidae	APOGON														-		
Arioma indica	ARIOMA				+				+	-							
Balistidae	BALIST										-						
Bothus spp.	BOTHUS								+	-							
Brotulinae	BROTUL				+				+					-			
Canthigaster compressus	CANTIG								+						-		
Carapidae	CARAPI		+										+				
Centriscus scutatus	CENTRI														-		
Champsodontidae	CHAMPO		+							-				-			
Chelmon rostratum	CHELMO										-						
Chimaeridae	CHIMAE		+						+				+	-			
Chloropthalmus albatrosis	CHLORO		-	-									+	-			
Chirocentrus dorab	CIROCE		-					+									
Congridae	CONGRI		+						+					-			
Coradion altiveles	CORADI														-		
Caranx chrysophrys	CRXCRY		+		-										-		
Caranx dinema	CRXDIN				-												
Caranx malabaricus	CRXMAL				-										-		
Cynoglossidae	CYNOGL		+						+				+	-			
Dactylopteridae	DACTYL									-							
Dasyatidae	DASYAT													-			
Decapterus kurroides	DECAKU			-	-								+				
Decapterus macrosoma	DECAMA	-															
Decapterus muruadsi	DECAMU												+				
Decapterus russeli	DECARU										-		+				
Diodontidae	DIODON							-	-							-	-
Diploprion bifasciatus	DIPLOP														-		
Dussumiera acuta	DUSSUM	+		-													
Epinephelus spp.	EPISPP			-	-												
Formio niger	FORMIO		-								+						
Histiopterus indicus	HISTIN									-							
Labridae	LABRID							-	-							-	-
Lactariidae	LACTAR								+					-			
Leiognathus elongatus	LEOELO														-		
Leiognathus splendens	LEOSPL		-				-										
Loligo spp.	LOLIGO	+		-	+		-										
Lophiidae	LOPHII		+						+				+				
Lutjanus lineolatus	LUTLIN														-		
Myctophidae	MYCTOP		+						+					-		+	
Nemipterus bathybius	NEMIBA				+			-									
Nemipterus hexodon	NEMIHE		-								-						
Nemipterus marginatus	NEMIMA			-	-												
Nemipterus nematophorus	NEMINE													+		-	
Parupeneus indicus	PARUIN														-		
Plectorhincus indicus	PLECIN															-	-
Priacanthus maculatus	PRIAMA				+	-							+				+
Promethichthys prometheus	PROMET				+				+				+				
Pseudorhombus elevatus	PSEUEL		+														
Pseudorhombus oligodon	PSEUOL													-		+	

Table 26. Signs of the Multiple Linear Regression Coefficients Included Respective Species/Taxa Models for the Different Seasons at RABUTINOS (continued).

Pseudorhombus spp.	PSEUSP		+														
Rastrelliger brachysoma	RASTBR		-														
Rastrelliger kanagurta	RASTKA						-										
Rexea solandri	REXEAS							+	+								
Rhinobatidae	RHINOB												+	.			
Sardinella fimbriata	SARDFI						-		+								
Sardinella longiceps	SARDLO		-														
Saurida undosquamis	SAURUN				+				+				+			+	+
Scolopsis inermis	SCOLIN				-	-								-	-		
Scolopsis taeniopterus	SCOLTA														-		
Scomberomorus commersonii	SCOMME				-		-										
Scorpaenidae	SCORPI													-			
Secutor insidiator	SECUIN						-								-		
Secutor ruconius	SECURU	-	-														
Selar boops	SELABO	-	-														
Selar crumenophthalmus	SELACR		-														
Selar malam	SELAMA						-										
Selar melanoptera	SELAME	-	-														
Selar mate	SELAMT														-		
Selaroides leptolepis	SELARO		-				-		-								
Seriola nigrofasciata	SERION	+		-													
Sharks	SHARKS				+												
Shrimps	SHRIMP								+		-						
Sphyraena langsar	SPHYLA				-												
Stolephorus tri	STOLTR						-										
Tetraodontidae	TETRAO			+	+												
Trichiurus haumela	TRICHI				+												
Triglidae	TRIGLI										-						
Upeneus mollucencis	UPEMOL	+			+												
Upeneus vittatus	UPEVIT							-	-				+				
Uranoscopidae	URANOS				+						-						

DISCUSSION

A. Community Structure:

This study demonstrated that the demersal fish assemblages of RABUTINOS display distinctive patterns of distribution and abundance. The sharpest changes in species composition occurred along the depth gradient corresponding to the three major oceanic zones similar to those established in the eastern tropical Pacific Ocean (Bianchi, 1991). These were the upper zone (down to about 90 - 100 m depth), the intermediate zone (between 100 - 150 m depth) and the deeper zone (>150 m). Each of these zones has their own distinct physico-chemical characteristics. The upper zone corresponds to the warm, low salinity, highly oxygenated wind-mixed layer. The intermediate zone is highly influenced by the thermocline and displays rapid changes in physico-chemical characteristics of the water masses while the deeper zone corresponds to the cold, poorly oxygenated and high salinity waters.

Fager and Longhurst (1968) found that separation boundary between different fish assemblages in the Gulf of Guinea was related to the thermocline as well as to sediment type, which also co-varies with depth (Bianchi, 1991). McManus (1985) found depth-dependent faunal distinction between 30 and 40 m in Samar Sea, independent of the season and substrate type. Federizon (1992) also found two important gradients in his ordination: the depth gradient and the coralline gradient. The dividing depth for Federizon's demersal fish assemblages was the 90 m isobath. The discrepancy between the separation depths of these two adjacent bodies of water and their resolution is discussed in the next section.

Hutchinson's (1957) view of a niche as an N-dimensional hypervolume combined with Fry's autecological paradigms on the responses of fishes to their environment can be used to relate depth to fish distribution (Magnuson et al., 1979; Kerr, 1980; Crowder and

Magnuson, 1983). For example, the thermal niche of a fish can be described as a range of preferred temperatures 4°C to 10°C wide. Using this concept, Magnuson et al. (1979) classified fishes into three thermal preference categories, i.e., coldwater fishes (10°C to 15°C), coolwater fishes (20°C to 25°C) and warmwater fishes (25°C to 30°C). This corresponds to the temperature of water within the deeper, intermediate and upper zones of the oceans, respectively, and provides a physiological basis for the way fish communities are structured.

Although depth, acting as a proxy variable, may be the principal determinant of fish distribution in RABUTINOS, the results of the correlation and linear regression analysis suggest other factors may also be important. This may include sediment type, turbidity and water mass characteristics. Turbidity is a primary factor affecting the distribution of estuarine and inshore fishes in the tropics (Cyrus and Blaber, 1987; Blaber et al., 1994) but has not been studied well with respect to tropical marine shelf assemblages. While temperature, salinity and DO concentration of water were adequately sampled, sediment type and turbidity were not. Refinements and quantification of these variables need to be carried out in the future. The approach followed in the northern Australian shelf (see Sainsbury, 1988) of taking continuous photographs of the sediment characteristics along the path of the trawl is a novel idea that may be worth trying.

Within each depth zone, secondary environmental gradients become more relevant in structuring demersal fish communities. At RABUTINOS these range from substrate characteristics (e.g., presence of rocky-coralline habitat or sandy to muddy bottom), geographic location (e.g., proximity to river mouths), and characteristics of the water masses (e.g., temperature, salinity, and DO concentration level) either alone or in tandem (Ramm *et al.,* 1990; Bianchi, 1991; Blaber *et al.*, 1994). Quinn (1980) postulated that salinity is the common feature between temperate and tropical ecosystem in the maintenance of community cycles.

My community analysis suggested that the fish fauna of RABUTINOS could be split into seven major groups. The primary separation found in the analysis is based on the 100 m isobath which separates the deep (cold water, sub-tropical fauna) from the shallow (warm, tropical faunal) assemblages. The deep assemblages can be subdivided further into Group 3 assemblage typical of the intermediate zone (or thermocline), Group 2 assemblage of the deep sea zone, and Group 1 assemblage composed primarily of scombrids and nemipterids characteristic of the cold, subtropical habitats (Longhurst and Pauly, 1987). Group 1's singular appearance, i.e., during the northeast monsoon season may reflect its seasonal nature, inadequacy of samples from the deeper regions, or both. Group 2 and Group 3 are essentially *Ariomma indica* and *Trichiurus haumela* dominated assemblages. Group 3 represented a community clearly dominated by these two species while Group 2 contained a mixture of deep sea forms like stargazers, angler fishes, bigeyes, and goosefishes.

The shallow water assemblages can be subdivided into two sub-groups: the coralline group or the Leiognathidae group. The coralline group includes Group 7 with its characteristic even distribution of species/taxa abundance and high similarity with coral reef species, and Group 6 -- a transition group composed of coralline fish assemblages mixed with the *Leiognatus bindus* assemblage. The Leiognathidae assemblage can be subdivided into those in close proximity of river mouths (Group 4A) and those relatively deeper (>50 m) and farther away in clear waters (Group 4B). Group 4A is basically composed of Leiognathidae family + coastal pelagic species while Group 4B is a combination of Leiognathidae family + Ariomma indica and other deep sea forms. Group 5 defined the *Leiognathus bindus* dominated assemblage inhabiting the relatively deeper (>50 m), sandy bottom areas intermittently flushed by distant rivers.

Aside from abiotic factors, biotic factors also contribute to the way communities are structured. For example, the spatial distributions of some congeneric species were partitioned along geographic or bathymetric gradients, or both (Ramm et al., 1990). Based on the analysis of each group's species composition, *Rastrelliger brachysoma* -- a neritic scombrid form, occurred predominantly in Group 4A assemblage while *R. kanagurta*, the oceanic form of the scombrid family, was associated more with Group 4B assemblage. These two scombrid forms are separated based on salinity preference, food habits, and avoidance or tolerance of highly turbid waters (Jones and Rosa, 1965; Collete and Nauen, 1983; Chullasorn and Martosubroto, 1986). The members of the family Leiognathidae were also separated according to depth (Villoso and Aprieto, 1983) as well as food (Jones, 1985; Chullasorn and Martosubroto, 1986).

Classic predator-prey interactions were also evident in the way Group 4A assemblage composition was structured. The principal species comprising Group 4A are prey species which include the Leiognathidae family (*Leiognathus splendens, L. bindus, L. leuciscus, L. equulus*), the coastal pelagics represented by the sardines (*Sardinella longiceps, Dussumiera acuta,* family: Clupeidae), anchovy (*Stolephorus tri,* family: Engraulididae), round scad (*Decapterus muruadsi,* family: Carangidae) and mackerel (*Rastrelliger brachysoma,* family: Scombridae). These species are attracted to shallow areas, especially near estuaries due to the abundance of their main food items (Hardenberg, 1955; Jones and Rosa, 1965; Tiews *et al.*, 1968; Tiews *et al.*, 1970a; Tiews *et al*, 1970b; Weng, 1990), i.e., mainly phytoplankton dominated microplankton, fish eggs and fish larvae (Manacop, 1956). In turn, the abundance of these prey species in a particular area attracts their main predators, e.g., mackerel (*Scomberomorus commerson,* family: Scombridae), hairtail (*Trichiurus haumela,* family: Scombridae), squid (*Loligo* spp., family: Loliginidae) and lizardfish (*Saurida tumbil,* family: Synodidae) to aggregate into the same area (Jones and Rosa, 1965; Tiews *et al.*, 1972; Chullasorn and Martosubroto, 1986; Robertson and Duke, 1990).

Some evidence of competition as a mechanism structuring tropical communities is evident from the abundances of *Rastrelliger kanagurta* and *Sardinella longiceps*. Both species have similar food and habitat preferences (mainly Group 4A and Group 4B fishing station locations) such that a high abundance of one group in a particular area, e.g., *S. longiceps* in Group 4A stations, corresponds with a low abundance of the other, i.e., *R. kanagurta*. This was similar to the descriptions of Jones and Rosa (1965), Chullasorn and Martosubroto (1986), and Longhurst and Pauly (1987).

B. Zoogeographic Affinities:

A number of authors (e.g., Rainer and Munro, 1982; McManus, 1985; Ramm *et al.,* 1990; Bianchi, 1991; Federizon, 1992; this study) have already established depth as a major gradient associated with the zonation of demersal fish communities (i.e., species composition changes with increasing depth). However, Ramm *et al.* (1990) and Federizon (1992) expressed caution when demarcating survey areas based on depth gradation alone as problems of spatial scales and seasonal factors (i.e., multiple gradients) may also be important in structuring fish communities. In most cases, depth is only a proxy variable representing the vertical distribution of some other environmental gradient that is physiologically of consequence (Magnuson, 1991; Jamir *et al.*, 1994).

The demarcation depth separating "shallow" and "deep" communities in Ragay Gulf and the adjacent Samar Sea highlights the limitations on the use of depth as the sole explanatory variable without searching for its environmental correlates. In partitioning the ordinated station points in Ragay Gulf, Federizon (1992) distinguished two subcommunities (i.e., "shallow" and "deep") separated by the 100 m isobath. In Samar Sea, McManus (1985) also came up with "shallow" and "deep" subcommunity designations separated by the 35 m isobath. In the absence of environmental data and detailed analysis of the ecological characteristics of the component species, Federizon attributed this discrepancy to possible bias induced by differences in the sample depth-frequency distribution. As a result, Federizon was not so sure whether either the 35 m or 100 m isobath really marked the boundaries of natural communities in Samar Sea and Ragay Gulf.

Similar disagreements existed in the findings of Rainer and Munro (1982) and Rainer (1984), vis-à-vis, Harris and Poiner (1990) and Ramm *et al.* (1990). The former asserted that seasonal variations in temperature and salinity were the main determinants of faunal distribution in the shallow, northern Australian continental shelves while the latter group believed that depth and spatial factors were more important. Ramm *et al.* (1990) suggested the possibility that sampling scale (both spatial and temporal) may be behind the differences in the observed results.

Ramm *et al.* (1990) were right in bringing sampling scale into the question. The maximum depth of Samar Sea is only 90 m, similar to the Gulf of Carpentaria (<80 m), with predominantly sandy and muddy substrates. RABUTINOS has a maximum sampling depth of 210 m covering a wide range of habitat types (e.g., riverine to deep marine, sandy to muddy substrates, soft bottom to rocky-coralline surface). Temporal scale is also important. In the case of Ramm *et al.* (1990), their sampling methodology prevented stratification by depth, season, fishing ground and time of day while Rainer and Munro's (1982) survey was limited to the post wet monsoon season months of March to May only. Although the data set used by Federizon and McManus spanned a period of 15 months, seasonal information was lost due to annual pooling and averaging the data.

Figure 30 compares the fish assemblage groupings derived by McManus (1985), Federizon (1992) and this study. In general, this study agrees with Federizon on the three major subcommunities, i.e., Coralline, Shallow and Deep. However, this study goes further by refining these subdivisions to include the possible effects of seasonal and other environmental factors in structuring the fish communities of RABUTINOS. The value of cluster standardization when doing comparative analysis of different author's work was also highlighted in this figure. It was clear that the two subcommunities identified by McManus were not the same as Federizon's "shallow" and "deep" categories. They were actually subsets of the latter's shallow water (<100 m) community. Combined with an analysis of the principal species comprising McManus's two subgroups, the shallow (<40 m, muddy substrate, dominated by Leiognathidae + coastal pelagics + *Rastrelliger*

COMPARISON OF SITE GROUP HABITAT & ASSEMBLAGE CHARATERISTICS

FEDERIZON	JAMIR	MCMANUS	Depth
			0 m
"Shallow"	**Shallow/Estuarine Assemblage:**		
	Group 4A (muddy deposit; rivcrine)	"Shallow"	
			35 m
	Group 4B (muddy deposit; clear water)	-	
	Group 5 (sandy deposit; clear water)	"Deep"	
			80 m
"Deep"	**Deep/Cold Water Assemblage:**		
	Lower Thermocline/Halocline:		
	Group 3 (sandy)	-	
			150 m
	Deep Shelf:		
	Group 1 (sandy)	-	
	Deep Shelf/Slope:		
	Group 2 (sandy/silty ooze)	-	
			200 m

OTHERS:			(< 90 m)
	Shallow Coralline Assemblage:		
	Group 6 (Coralline-Sandy/Estuarine Transition)	-	
"Coralline"	Group 7 (Coralline)	-	

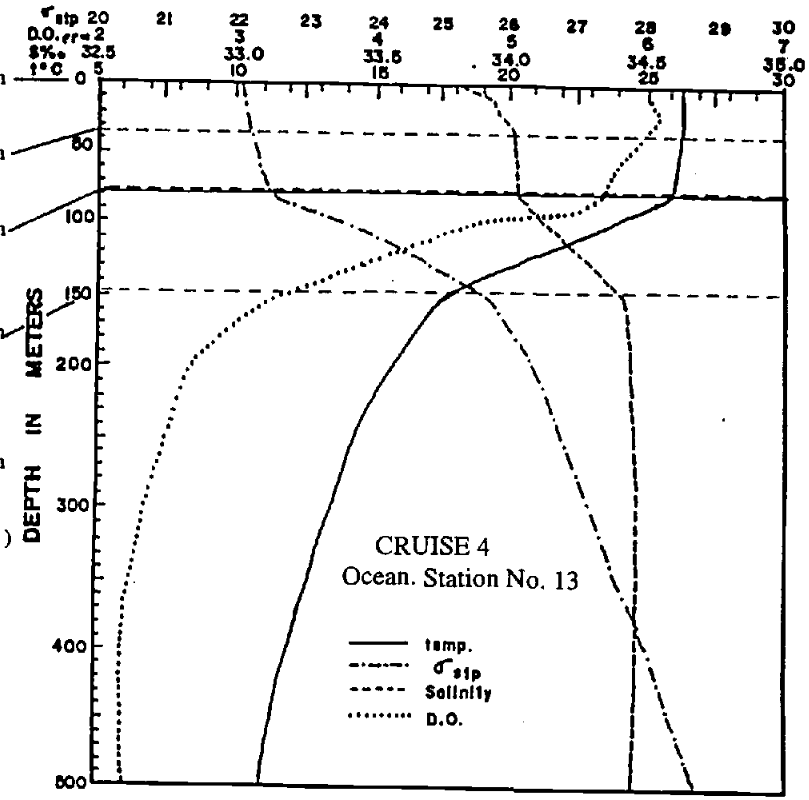


Figure 30. Comparison of McManus', Federizon's and Jamir's Site Group Categories In Relation to Habitat Characteristics.

brachysoma) community corresponded to Group 4A of this series, while the deep (>40 m, sandy substrate, dominated by *Leiognathus bindus*) community corresponded to Group 5.

The 35 - 40 m demarcation between the two communities most probably reflect the effects of riverine conditions on substrate characteristics, depth, salinity and productivity (Caddy and Bakun, 1995; Crivelli *et al.*, 1995; Halim *et al.*, 1995). This depth range roughly corresponds to water bodies subjected to freshwater dilution by rivers and other freshwater sources (Caddy and Bakun, 1995). For example, at the end of the rainy season, low salinity layers extending down to 30 m depth were commonly observed along the east coast of Sumatra (Wyrtki, 1961) and in Lingayen Gulf (Sebastian *et al.*, 1959), San Miguel Bay (Pauly and Mines, 1982), Samar Sea (Labao, 1980), Manila Bay, Philippines (Megia *et al.*, 1953), Central Ragay Gulf (Jamir, 1986) and this study. Surnarayana *et al.* (1992) showed that Indian monsoon rains mixes within the upper 50 m of the water column and spreads offshore to distances of up to 150 km as a lens of low-salinity water. Seasonal estuarization of the shallow Gulf of Carpentaria during the rainy season has also been reported (Longhurst and Pauly, 1987).

For the coastal and estuarine fish assemblages studied by Sheaves (1992, 1993, 1996, 1998), the physical environment (mainly related to salinity) and biological processes (supply of recruits) interact to control the distribution of individual species and determine locality-specific assemblage patterns. Besides these, Weng (1990) attributed the interaction between food availability, habitat preference and hydrological characteristics for the observed distribution of fish assemblages. The principal species in the shallow regions of Samar Sea included *Stolephorus indicus* (Family: Engraulididae) and *Rastrelliger brachysoma* (Family: Scombridae) while in waters deeper than 40 m, the dominant species were *Saurida undosquamis* (Family: Synodidae), *Decapterus macrosoma* (Family: Carangidae) and *Rastrelliger kanagurta* (Family: Scombridae) (McManus, 1985). The evolution of food partitioning among scombrids as a means of reducing competition (Collete and Nauen, 1983) limited the distribution of *Rastrelliger brachysoma* primarily within shallow, low salinity (<32‰), high turbidity coastal waters and estuaries rich in microplankton mix dominated by phytoplankton (Jones and Rosa, 1965). R. kanagurta, however, prefer salinities >32‰ and microplankton mix dominated by foraminiferans (Jones and Rosa, 1965; Chullasorn and Martosubroto, 1986). In the Southeast Asian waters, anchovies are usually confined within the nearshore and estuarine areas (Chullasorn and Martosubroto).

While all marine and most estuarine organisms can withstand full sea water, some cannot withstand lowered salinities (Gunter, 1961). *Decapterus macrosoma* (Family: Carangidae) and *Rastrelliger kanagurta* (Family: Scombridae) both avoid waters <30‰ and prefer depths greater than 40 m (Jones and Rosa, 1965; Chullasorn and Martosubroto, 1986). *D. macrosoma* (Family: Carangidae) does not enter Manila Bay (Tiews *et al*, 1970) as well as the bays of Jakarta (Soemarto, 1960) where they avoid zones of lower salinities. *Saurida undosquamis* (Family: Synodidae) can be found in depths ranging from 30 - 90 m but prefer deeper regions (Chullasorn and Martosubroto, 1986).

Environmental association also indicated that Federizon's "shallow" and "deep" fish assemblage categories actually correspond to natural ecological boundaries, i.e., corresponding to Magnuson *et al.*'s (1979) fishes living above the thermocline, within the thermocline and below the thermocline (Bianchi, 1990). The underlying physiological basis for such separation may be related to the characteristics of Magnuson *et al.*'s (1990) warm water, cool water and cold water fish. Understanding this principle facilitates regional comparison of research results. For example, given the oceanographic characteristics of western and eastern boundary regions (Pickard and Emery, 1982), it is easy to see that the 90m to 100 m demarcation depth separating the warm from the cold/cool water fishes in the western tropical Pacific is essentially the same as the 50 m demarcation depth found by Bianchi (1991) in the eastern tropical Pacific Ocean and by Longhurst and Pauly (1987) in the eastern tropical Atlantic Ocean.

The significance of the thermocline as a natural zone of separation between two physiologically distinct fish communities were recognized by Longhurst and Pauly

(1987) in their analysis of the Guinean Trawling Survey (GTS). The equatorial submergence through the Gulf of Guinea of the sparid-dominated fauna from the cooler regions to the north and south is a good example to illustrate this point. The western Pacific counterpart, composed mainly of a subtropical fauna dominated heavily by sea bream (Sparidae, Nemipteridae), large croaker (Sciaenidae) and lizardfish (Synodidae), replaced the shallow-water tropical fauna not far to the south of Hong Kong, and near Carnarvon in western Australia and Cooktown in Queensland (Longhurst and Pauly, 1987). These subtropical species corresponded to Group 2 of this study, but were caught mainly in the cold, deep waters below the thermocline at RABUTINOS.

Reasonable comparison of different demersal fish communities cannot be made without reference to the region's geographic and oceanographic characteristics. The Southeast Asian continental shelf consists of the Mainland, Sunda, Arafura and Sahul shelves (Morgan and Fryer, 1985). These areas are relatively shallow with maximum depths around the South China Sea ranging only from 40 - 100 m. Depths within the wide and gently sloping Gulf of Thailand are no greater than 80 m. The Arafura Shelf connecting Australia and New Guinea has depths ranging only from 30 m to 90 m while the Sahul Shelf extending along the northwest coast of Australia has depths of only 80 m to 100 m. It is not surprising that most of the demersal fishing activities in Southeast Asia are confined to depths <50 m (Pauly, 1988).

From an oceanographic point of view, this depth ranges basically define the extent of shallow, warm water habitats above the thermocline. Hence, the assemblage species expected from these areas would fall under Group 4A for predominantly shallow, muddy and riverine-influenced regions and Group 4B for similar but deeper areas (>30 m) and clear waters; Group 5 for coastal areas dominated by sandy substrates; Group 7 for shallow, rocky-coralline substrates; and Group 6 for the Group 7/Group 5 transition areas. In regions characterized by a complex array of marine environments, the resulting aggregate species assemblage will depend on the relative areal extent of each habitat/depth category.

These predictions parallel Okera's (1982) recurrent species groups derived from the shallow continental shelf of northern Australia. Okera's "Inner Shelf Assemblage" (muddy sands, 10m - 50 m) is similar to Group 4A of this study. The "Shelf Break Assemblage" (mixed deposits, 12-220 m) compares with Group 2 but not as clear due to the wide depth range included by Okera. The "Midshelf Assemblage" (mixed deposits, 60-110 m) as well as the "Offshore Sand Assemblage" (sand, 80-90 m) compared with Group 3 and Group 4B or Group 5 assemblage minus the leiognathids. The Leiognathidae family is most abundant in the catch of Southeast Asian trawlers but is only a minor component of the fishery in the northern Australia (Pauly, 1988) which explaine the relative absence of ponyfishes in Australia's Group 4B counterpart. Finally, Okera's "Hard Bottom Assemblage" (boulders and reefs, various depths) shows similarity to Group 7 assemblage.

The fit between Okera (1982) and this study's community groups were not as tight mainly because Okera used substrate type as the primary classification variable instead of depth. This was unfortunate since depth has been documented as the primary gradient structuring the demersal fish communities in this region (e.g., Rainer and Munro, 1982; Ramm, *et al.*, 1990; Watson *et al.*, 1990; Blaber *et al.*, 1994). As a result, there was an unnecessary agglomeration of species coming from different communities.

The average catch composition of the Gulf of Thailand prior to the squid population explosion (Pauly, 1988) was primarily dominated by Leiognathidae (24%); Carangidae (7%); *Nemipterus* spp., Family: Nemipteridae (6%); Sciaenidae (6%); Mullidae (5%); Rajidae (5%); Gerridae (4%); *Saurida* spp., Family: Synodidae (4%); *Scolopsis* spp., Family: Nemipteridae (3%); and Ariidae (3%). This corresponded well with Group 4A and Group 5 of this study, mixed with a sciaenid assemblage. This assemblage was as expected from the Gulf of Thailand composed primarily of muddy inshore and sandy offshore deposits. The sciaenid assemblage found in shallow (<15 m), muddy, riverine areas were not included in this study due to the depth limitation of the research vessel and existing fisheries management regulations in the survey areas.

Twenty years later, overfishing has significantly altered the catch composition of the Gulf of Thailand into a predominantly *Loligo* spp., Family: Loliginidae (20%); *Priacanthus* spp., Family: Priacanthidae (9%); *Nemipterus* spp., Family: Nemipteridae (9%); Leiognathidae (8%); *Saurida* spp., family: Synodidae (6%); *Sepia* spp., family: Loliginidae (3%); Carangidae (3%); Lutjanidae (2%); Ariidae (2%) and *Scolopsis* spp., family: Nemipteridae (1%) assemblage. These species are typical of the sciaenid assemblage mixed with Group 4B and Group 3 assemblages (excluding the leognathids) found in waters deeper than 50 m. This implies that as one community is decimated by overharvesting, the niche they vacate is immediately taken over by some species from the nearest assemblage capable of utilizing the available resources (Sainsbury, 1988). As mentioned earlier, demersal trawling in Southeast Asia is confined primarily to depths less than 50 m deep. This suggests that commercial fishing pressure in these waters have little influence on many of the species inhabiting the deeper communities (Pauly, 1988).

Within the normal depth range of most Southeast Asian trawl fishery, most of the demersal fish communities of the region were adequately represented in this study. Exceptions to this include the sciaenid community found in waters less than 15 m deep (Longhurst and Pauly, 1987) and the lutjanid community that prefers the rocky-coralline areas 60 - 120 m deep (Okera, 1982; Longhurst and Pauly, 1987; Sainsbury, 1988). Most of the lutjanids in this study were caught in the vicinity of Sorsogon Bay (FS 10 to FS15). The absence of deeper fishing stations in these locations may explain the relative absence of a distinct lutjanid assemblage in this study.

Consistent with the findings of Marten and Polovina (1982) and Pauly (1982), the highest biomass at RABUTINOS were from the shallow coralline fish assemblages (3.7 metric tons/km^2) and the lowest (0.8 metric tons/ km^2) were from the deep, sandy areas. The shallow, muddy/riverine areas gave a much lower biomass at about 1.1 tons/ km^2

while the deeper regions (i.e., >100 m) had a much higher biomass (1.7 tons/ km^2). This may be a reflection of the effects of intensive fishing operation within the shallow (<50 m depths) coastal shelves off Viñas River and northern Samar Sea.

In terms of magnitude, the biomass of the deep areas (>150 m) were comparable with the 1.8 tons/km^2 estimates of Yutuc and Trono (1977) for the Philippine shelves. The shallow, soft-bottom communities of RABUTINOS were much less productive compared to the estimated biomasses at the Gulf of Thailand (3.9 tons/ km^2) for depths of 0 - 50 m (SCS, 1978), north coast of Java (2.6 tons/ km^2) for 0 - 50 m (SCS, 1979), Sunda Shelf - South (2.3 tons/ km^2) for 0 - 50 m (SCS 1978), South China Sea (2.0 tons/ km^2) continental shelf (Aoyama, 1973), Sunda Shelf - NW Borneo (1.7 tons/ km^2) for 0 - 50 m (SCS, 1978). The limited extent of the shelf area (Marten and Polovina, 1982) and the intensity of fishing activities (Warfel and Manacop, 1950; Pauly, 1988) may explain the depauperate conditions of Ragay Gulf's fish stocks.

C. The Effects of El Niño-Southern Oscillation.

The main impact of the 1982-'83 ENSO event is best grasped by looking at how the normal seasonal pattern has been altered in the region. The normal sequence of the monsoon season at RABUTINOS is as follows:

(**WET**)NE ⇒ (**DRY**)INT ⇒ (**WET**)SW ⇒ (**WET**)NE ⇒ (**DRY**)INT ⇒ (**WET**)SW...
(Cool) **(Warm)** **(Warm)** **(Cool)** **(Warm)** **(Warm)**

During the strong 1982-1983 El Niño-Southern Oscillation event, this normal seasonal sequence was altered as follows:

(**WET**)NE ⇒ (**DRY**)INT ⇒ (**WET**)SW ⇒ (**DRY**)NE ⇒ (**DRY**)INT ⇒ (**WET**)SW...

(Cool) **(Warm)** **(Warm)** **(Warm)** **(Warm)** **(Warm)**

Main ENSO effects felt here

This pattern resulted in an early warm and dry season staring in November 1982 which basically mimicked the environmental conditions during the intermonsoon period (i.e., similar to spring conditions in the upper latitudes). Since the rains started to pick up only in July 1983 with the passage of a typhoon, the marine environment of RABUTINOS essentially experienced an extended "spring" condition which lasted for seven months instead of just three. The six months delay in the anomalous tradewind reversals associated with the 1982-1983 ENSO event tempered its impact on the fishery of the western Pacific Ocean by shortening the drought period from one full year to just half.

This anomalous condition was believed to be the cause of the extensive *Pyrodinium bahamense* red tide bloom that hit Samar Sea and Carigara Bay (Hermes *et al.,* 1985) in mid-1983. The above conditions may have also tricked some marine organisms to basically speed up their biological clocks. For example, in November and December of 1982, an anomalously high abundance of fish eggs were collected in the vicinity of Viñas River (i.e., located within the areas bounded by Groups 4A and 4B fish assemblages) which rivaled the regular peak egg-laying months of April to May recorded by Villoso *et al.* (1984) and Jamir (1986) for Ragay Gulf.

As mentioned in the introduction section, the ENSO-induced environmental perturbation offered an empirical test on the validity of Longhurst and Pauly's (1987) community stability hypothesis ("LPCS Hypothesis"). The performance of LPCS Hypothesis based on the stability criteria of Krebs' (1978) is as follows:

The constant 1:3 ratio in the number of seasonal entrants *versus* recurrent species appearing in the top 20 most abundant specie/taxa list attests to the relative stability of this community with respect to species composition. In terms dominance stability, if the LPCS Hypothesis is judged according to the continued dominance of a single species or family group, then it fails to satisfy this criterion since the demersal fish communities of RABUTINOS show distinct seasonal patterns of abundance and shifting species dominance. Taken as a group, however, the ability of the recurring species' membership to maintain the overall species dominance within their group regardless of the season attests to the dominance stability of the system. Also, the fact that most of the recurring group members never ranked lower than 10th place in relative abundance attests to the RABUTINOS community's stability with respect to this criterion.

The performance of the LPCS Hypothesis with respect to the last criteria, i.e., stability of spatial distribution, needs some qualification. There is no question that most of the geographic boundaries between the different demersal fish assemblages readily shift with the season. The changes are even more dramatic in the context of the early maturity phase of the ENSO event. Here, not only were the physical boundaries of the different assemblage groupings radically altered -- even the basic structure of the whole community was modified. The six assemblage groups typical of the previous seasons were reduced to just three assemblage groups by the time ENSO reached its early maturity stage.

While it is possible that the above may just be a sampling artifact, the distinctness of the groupings derived by the DCA ordination and TWINSPAN classification *vis-à-vis* other seasonal groupings indicate otherwise. What was more revealing and interesting from an ecological point of view were the characteristics of the three remaining groups. Group 6 is the transition group between the coralline assemblage (Group 7) and the estuarine/riverine assemblage (Group 5). Group 6 contains a mixture of fishes coming from both groups. Group 4A represents the estuarine/riverine assemblage -- the transition zone between the sea and the rivers. Finally, Group 3 represents the intermediate zone or thermocline assemblage which is the transition zone between the warm upper ocean layers and the deep, cold oceanic zone below. All three groups are located in relatively less stable or inhospitable environments and may be the reason why their component species persisted despite the environmental perturbations brought about by ENSO.

Theoretically, the more stable the environment, the more species will be present and the more stable is the resulting community (Krebs, 1978). According to this idea, areas with stable environments allow the evolution of finer specializations and adaptations than do areas with erratic, unpredictable environments. Therefore, species are expected to be more flexible in less stable habitat and more specialized in more stable environments. In the face of adverse environmental perturbations, communities coming from less stable habitat may be expected to survive and persist better than those coming from more stable environments. This was clearly demonstrated in Ragay Gulf during the early stages of ENSO.

Some of the hard, nagging questions that need at least partial resolution include the possible mistaken membership of FS8 during the rainy southwest monsoon season, the reasons why Group 4A remained stable despite ENSO drought conditions, and whether Group 1 was a true, seasonal group or just a sampling aberration (Table 12). Spikes in rainfall (see Figure 4) are common at RABUTINOS due to its location along the "typhoon belt." Typhoons or hurricanes passing right through RABUTINOS could easily dump several tens of inches of rain in just a few days (Hardjawinata, 1980) within the survey area. The semi-enclosed nature of the Ragay Gulf Basin makes it susceptible to extensive freshwater dilution from various point and non-point sources (Jamir, 1986) similar to the Gulf of Carpentaria (Longhurst and Pauly, 1987) or Bay of Bengal (Ansari et al., 1995). This may be the reason for the observed change in the group membership of FS 8 from Group 3 to Group 4B conditions.

Longhurst and Pauly (1987) have recorded carangids, scombrids and nemipterids as part of the regular catches coming from the deep tropical regions. These species are also known for their long migrations and seasonal occurrences in different fishing and spawning grounds (Jones and Rosa, 1965; Tiews *et al.*, 1970a; Ronquillo, 1975). In the

Philippines, for example, *Decapterus muruadsi*, family: Carangidae, are known to spawn and dominate the catch in Palawan during the months of December - March before migrating outside of Manila Bay two months later (Chullasorn and Martosubroto, 1986). The adults of the Scombridae family (e.g., the oceanic form, *Rastrelliger kanagurta*) are caught inside Ragay Gulf during the rainy months of May - December (Jones and Rosa, 1965; Chullasorn and Martosubroto, 1986). These months also correspond to one of their intense feeding periods (Manacop, 1961) associated with rapid gonadal development (Jones and Rosa, 1965) and the November - December spawning period inside the Ragay Gulf Basin (Mines, 1984). Therefore, it is highly likely that Group 1 assemblage is a regular, seasonal member of the Ragay Gulf demersal fish community and that the dry ENSO conditions may have aborted their November - December, 1982 spawning migration, much like the disappearance of *Sardinella longiceps* along the coast of India following an ENSO-induced recruitment failure (Raja, 1972, 1973; Longhurst and Pauly, 1987).

The most intense effects of nutrient runoff under open marine conditions have involved semi-enclosed systems (Caddy and Bakun, 1995), similar to the Ragay Gulf Basin. Concentration of floating debris, larval stages and food resources results from the convergence processes at the boundary of the river plume (Pauly, 1982; Pickard and Emery, 1982). This explains the year-round, high abundance of fish eggs and larvae in the vicinity of Viñas River (Villoso *et al.*, 1984; Jamir, 1986) and the corresponding accumulation of coastal pelagic fishes and associated predators which basically comprise the Group 4A assemblage. The spring-like conditions and high productivity associated with the dry intermonsoon period and also during the early maturity stages of ENSO explain the prevalence of Group 4A during the rest of the year.

As Gunter (1961) pointed out, most marine and estuarine organisms can withstand full sea water but some marine fishes cannot tolerate lowered salinities. The estuarization of the coastal areas explains the expansion of Group 4A habitats further offshore during the rainy southwest and northeast monsoon seasons as low salinity intolerant species migrate offshore. The relatively warm and dry ENSO conditions may have deterred some species from the deep, cold waters from venturing above the thermocline. Despite the shrinking low salinity lenses, the high productivity brought about by ENSO-induced "spring transition" conditions near major river systems act as oases that draw planktivores like leiognathids and coastal pelagics, as well as their associated predator assemblage, i.e., Group 4A, to agglomerate in the area. This may be the mechanism that enabled Group A assemblages to remain geographically stable or even expand their boundaries offshore during ENSO.

D. Implications for Fisheries Management and Research.

This study further confirms the existence of relatively stable demersal fish communities in such diverse habitats as Ragay Gulf, Burias Pass, Ticao Pass and northern Samar Sea. The primary separation of each demersal fish communities by depth (i.e., <35 m shallow/riverine assemblage, 35 - 90 m shallow/further offshore assemblage, 90 - 100 m thermocline assemblage, and >150 m cold, deep water assemblage) and further subdivisions according to substrate types have lots of implications for better fisheries management policies and practices in the Philippines and the Southeast Asian region.

Most of the commercial demersal trawl operations in the region are confined to waters less than 50 m deep. In the Philippines, the national government banned commercial trawling and purse seining operations in waters less than 7 fathoms (13 m) deep and/or within 3 nautical miles from the coast (see Presidentical Decree No. 704, Republic of the Philippines, 1975). Based on the findings of this research as well as by McManus (1985) and Federizon (1992), legislations aimed at reducing the impact of the growing commercial trawl fisheries on the municipal or sustenance fisheries by a physical separation should use 35 m (or 15 fathoms) as the dividing line rather than the current 7 fathom limit (Pauly, 1988).

Adoption of a deeper depth limit will practically close most of the country's overexploited traditional fishing grounds from commercial trawl operations. These include the shallow Lingayen Gulf, Manila Bay, San Miguel Bay, Samar Sea, Maqueda Bay, Villareal Bay, Visayan Sea and Panguil Bay (Smith et al., 1980; Ganaden, 1990). While this may be good for the fishes and the municipal fishery sector, the economic displacement that this will entail may not warrant the political risks involved unless alternate fishing grounds are explored and developed ahead of time. Again, the results of this research can be used to classify, map and project the catch composition and biomass potentials of new fishing grounds with more precision and less cost than the techniques currently available, e.g., Kvran (1971); Aoyama (1973); Menasveta *et al.* (1973); Marten and Polovina (1982); Silvestre (1986); Silvestre and Pauly (1986); and Silvestre *et al.* (1986).

The ENSO period covered in this study is limited to just the early maturity stages and drought conditions, however, a number of insights can be gained for more targetted studies in the future. The following are some recommendations on how to conduct this monitoring program. First, a re-examination of the present status of the fishery needs to be done to determine if significant alterations in the fish communities were evident. This will also serve as a benchmark for judging the short and long-term impacts of ENSO on the demersal fisheries of the area.

Second, knowing the location of fishing grounds that show signs of seasonal and ENSO related fish assemblage adjustments, the number of stations can be reduced by half and limited to just the Ragay Gulf Basin (close to Viñas River) and Ticao Pass. Given the progress in the early detection of an ENSO event, adequate preparation time is available between the commencement of an ENSO event, i.e., Fall (year -1), the time its impacts are felt throughout the Philippines, i.e., northeast monsoon (year 0), and the ocean's return to normal conditions sometime between February to June (year +1). Instead of monthly cruises, representative seasonal samples would significantly cut the cost of research and justify extension over a longer period of time, possibly at least one to two years after an ENSO event. The monitoring program should include plankton studies, physical oceanography and hydrology besides demersal trawl sampling.

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APPENDICES

Appendix I. List of Species and Families.

Acanthuridae:	
Acanthurus spp.	(Surgeonfish, Unicornfish)
Naso spp.	(Surgeonfish, Unicornfish)
Acanthurus bleekeri	(Bleeker's Surgeonfish)
Apogonidae:	(Cardinalfish)
Ariommidae:	
Ariomma indica	(Indian Driftfish)
Balistidae:	
Abalistes stellaris	(Starry Triggerfish)
Bothidae:	
Bothus spp.	(Left-eyed Flounder)
Carangidae:	
Alectis ciliaris	(Pennantfish, Threadfin Mirrorfish)
Carangoides chrysophrys	(Longnose Cavalla, Longnose Kingfish)
Carangoides ciliaris	(Longfin Cavalla)
Carangoides fulvoguttatus	(Goldspotted Trevally)
Carangoides dinema	(Shadow Kingfish)
Carangoides malabaricus	(Malabar Cavalla, Nakedshield Kingfish)
Caranx melampygus	(Bluefin Jack, Blue Kingfish, Blue Trevally)
Carangoides speciousus	(Jack)
Decapterus kurroides	(Scad)
Decapterus macrosoma	(Layang Scad, Cherootfish)
Decapterus muruadsi	(Round Scad)
Decapterus russelli	(Russel's Scad)
Selar crumenopthalmus	(Big-eye Scad, Purse-eye Scad)
Selaroides leptolepis	(Yellowstripe Trevally, Smooth-tailed Trevally)
Seriolina nigrofasciata	(Blackbanded Trevally, Butter Yellowtail)
Seriola grandis	(Trevally)
Uraspis helvolus	(Black Ulua)
Champsodontidae:	(Stargazer)
Chlorophthalmidae:	
Chlorophthalmus albatrosis	(Greeneyes)
Chimaeridae:	(Ratfish)
Centriscidae:	
Aeliscus strigatus	(Shrimpfish, Razorfish)
Centriscus scutatus	(Shrimpfish, Razorfish)
Clupeidae:	
Dussumiera acuta	(Rainbow Sardine)
Sardinella longiceps	(Indian Oil Sardine)
Dasyatidae:	(Ray)

Diodontidae:		(Two-Toothed Pufferfish)
Engraulididae:		
	Stolephorus tri	(Anchovy)
Fistulariidae:		
	Fistularia petimba	(Cornetfishes)
Formionidae:		
	Formio niger	(Black Pomfret)
Gobiidae:		
	Pentaprion longimanus	(Long-fin Mojarra)
Haemulidae (=Pomadasydae):		
	Plectorhinchus pictus	(Painted Sweetlip, Grunt)
	Pomadasys maculatus	(Blotched Grunt)
Labridae:		(Rainbowfish, Wrass, Tuskfish)
Leiognathidade:		
	Gazza minuta	(Toothed Ponyfish, Toothed Soapy)
	Leiognathus bindus	(Orange Ponyfish/Slipmouth)
	Leiognathus elongatus	(Slender Ponyfish, Elongate Slimy)
	Leiognathus equulus	(Slimy, Common Ponyfish)
	Leiognathus fasciatus	(Striped Ponyfish)
	Leiognathus leuciscus	(Whipfin Ponyfish/Slipmouth)
	Leiognathus splendens	(Splendid Ponyfish, Black-tipped Ponyfish)
Lethrinidae:		
	Lethrinus opercularis	(Emperor)
	Lethrinus lentjan	(Redspot Emperor)
Loliginidae:		
	Loligo spp.	(Squid)
Lophiidae:		(Goosefish, Anglerfish)
Lutjanidae:		
	Aphareus rutilans	(Small-tooth Jobfish)
	Lutjanus bojar	(Two Spot Red Snapper)
	Lutjanus lineolatus	(Bigeye Snapper, Yellow Snapper)
	Lutjanus malabaricus	(Malabar Red Snapper)
	Lutjanus vitta	(Brownstripe Red Snapper)
	Gymnocaesio gymnoptera	(Snapper)
	Macolor macolor	(Snapper)
Mobulidae:		(Ray)
Monacanthidae:		
	Alutera monoceros	(Unicorn Filefish, Unicorn Leatherjacket)
Mullidae:		
	Upeneus mollucensis	(Goldband Goatfish)
	Upeneus spp.	(Goatfish)

Upeneus sulphureus	(Yellow Goatfish)
Upeneus vittatus	(Yellowstriped Goatfish)
Nemipteridae:	
Nemipterus marginatus	(Threadfin Bream)
Nemipterus bathybius	(Yellowbelly Threadfin Bream)
Nemipterus peronii	(Peron's Butterfly Bream)
Scolopsis inermis	(Monocle Bream)
Ostraciidae:	(Boxfishes, Coffinfishes, Trunkfishes)
Platacidae:	
Platax orbicularis	(Batfish, Leaffish)
Priacanthidae:	
Priacanthus macracanthus	(Red Bigeye)
Rhinobatidae:	(Ray, Guitarfish)
Scaridae:	(Parrotfish)
Serranidae:	
Epinephelus fuscoguttatus	(Brown-marbled Grouper, Blotched Rockcod)
Epinephelus guttatus	(Grouper)
Epinephelus spp.	(Grouper)
Epinephelus tauvina	(Greasy Grouper)
Scombridae:	
Rastrelliger brachysoma	(Short-bodied Mackerel)
Rastrelliger kanagurta	(Long-jaw Mackerel, Indian Mackerel)
Scomberomorus commerson	(Narrow-barred Spanish Mackerel)
Scorpaenidae:	(Lionfish, Scorpionfish)
Sphyraenidae:	
Sphyraena obtusata	(Obtuse Barracuda)
Sphyraena forsterii	(Forster's Barracuda)
Synodidae (=Synodontidae):	
Saurida tumbil	(Common Saury)
Saurida undusquamis	(Brushtooth Lizardfish)
Peristidiinae	
Tetraodontidae:	(Pufferfish)
Trichiuridae:	
Trichiurus haumela	(Hairtail, Cutlass)
Eupleurogrammus muticus	(Malayan Hairtail)
Triglidae:	(Sea Robins)
Uranoscopidae:	(Stargazer)

Appendix II. Site Characteristics of the Different Sampling Units (Fishing Stations).

FISH. STN.	GEOGRAPHIC ATTRIBUTES						OTHER GEOGRAPHIC FEATURES
	SUBSTRA. TYPE	DEPTH (meters)	NO. RIVER TRIBUTARY	SLOPE (X1000)	SHR. DIST. (nau. mi.)	SHLF.WIDTH (nau. mi.)	
1	Clayey-Muddy	46	4	5	3	8	Near entrance of Vinas River
2	Clayey-Muddy	63	4	7	5	8	Near entrance of Vinas River
3	Clayey-Muddy	45	4	10	1	8	Near Vinas River
4	Clayey-Muddy	32	4	10	2	8	Near Vinas River
5	Clayey-Muddy	88	0	27	66	8	South of Vinas River/Deep Section of Shelf
6	Sandy	173	1	27	4	5	Near Coral Island & Intermittent River
7	Sandy	168	0	0	8	20	Basin Site
8	Sandy-Silty Ooze	119	0	0	8	20	Atop Basin Site
9	Sandy-Silty Ooze	132	0	0	4	20	Atop Basin Site
10	Sandy	85	0	13	2	4	
11	Sandy	72	1	27	1	2	Near Donsol River/Sorsogon Bay
12	Coralline	28	0	9	1	5	Off Sorsogon Bay
13	Coralline	29	0	13	1	3	At South Entrance of Sorsogon Bay
14	Coralline	59	0	9	3	4	Off Sorsogon Bay
15	Coralline	32	1	27	0.5	4	Off Sorsogon Bay
16	Hard-Sandy	141	0	0	7	4	Atop Ridge/Sn. Bernard Current Converg. Zone
17	Hard-Sandy	160	0	0	5	5	Atop Ridge/Sn. Bernard Current Converg. Zone
18	Hard-Sandy	216	0	0	3	4	Atop Ridge/Sn. Bernard Current Converg. Zone
19	Hard-Sandy	109	0	12	8	16	Atop Ridge/Sn. Bernard Current Converg. Zone
20	Muddy	77	1	9	4	20	Near Calbayog River
21	Muddy	39	2	5	4	20	Near Calbayog River
22	Muddy	57	1	5	7	20	Near Calbayog River
23	Muddy	25	2	4	6	20	Near Calbayog River

Appendix III. Complete List of All the Species/Taxa Belonging to the Different Fish Assemblages or Groups Found in RABUTINOS.

GROUP	Grp 1		Grp 2		Grp 3		Grp 4a		Grp 4b		Grp 5		Grp 6		Grp 7	
# SPECIES	n=18		n=57		n=87		n=120		n=104		n=105		n=183		n=120	
TOTAL WT.	wt=101.34		wt=235.80		wt=228.89		wt=141.97		wt=148.46		wt=354.67		wt=339.01		wt=488.51	
1	DECAKU	28.180	ARIOMA	46.003	ARIOMA	61.356	LEOSPL	18.248	LEOBIN	34.687	LEOBIN	119.186	DIODON	40.840	CRXSPE	47.546
2	SCOLIN	23.830	SAURUN	29.505	TRICHI	53.316	UPESUL	15.603	ARIOMA	16.382	UPESUL	22.428	DASYAT	25.757	DIODON	47.245
3	DECAMU	18.190	PRIAMA	23.428	PRIAMA	14.910	LEOBIN	14.425	LOLIGO	11.877	POMAMA	19.700	CRXSPE	22.933	LUTBOJ	37.292
4	PRIAMA	9.770	LOPHII	18.695	DASYAT	13.283	TRICHI	11.856	UPEMOL	9.317	DASYAT	14.158	AELISC	16.349	DASYAT	34.943
5	NEMIMA	8.500	DASYAT	16.795	DECAMU	10.405	SELARO	5.956	APHARE	8.258	UPEMOL	11.276	TETRAO	15.874	ABALIS	25.985
6	SAURUN	4.270	DECAMU	15.658	SAURUN	9.042	RASTBR	5.380	DECAMU	7.988	LUTMAL	10.566	LEOBIN	8.914	TETRAO	22.020
7	EPISPP	4.000	RHINOB	14.245	EPISPP	8.164	SARDLO	4.698	EUPLEU	7.093	TRICHI	10.383	PLECIN	8.500	ALUTMO	18.581
8	CHLORO	1.870	TRICHI	9.144	SERION	6.875	LEOLEU	4.572	SAURUN	6.573	FISTUL	8.825	ABALIS	7.928	LTRILE	14.818
9	SAURTU	1.670	URANOS	6.928	SHARKS	6.622	LOLIGO	4.406	FISTUL	4.853	GAZAMI	7.630	LUTLIN	7.846	LTRIOP	14.687
10	CHAMPO	0.370	NEMIBA	5.664	LOLIGO	5.486	DUSSUM	4.235	SAURTU	4.830	CRXCIL	7.088	LTRIOP	7.004	OSTRAC	14.480
11	SHRIMP	0.190	CHAMPO	5.479	PERIST	3.731	SPHYOB	3.860	DUSSUM	3.293	ALECIL	6.948	GAZAMI	6.280	EPIGUT	14.000
12	CRABSS	0.140	SCORPI	4.898	LOPHII	3.151	DECAMU	3.385	PENTAP	3.282	LEOFAS	6.568	OSTRAC	6.209	LABRID	12.375
13	NEMIBA	0.110	DECARU	4.810	URANOS	2.626	SELACR	3.189	RASTKA	2.620	FORMIO	6.305	ALUTMO	6.000	NASOSP	10.368
14	RHINOB	0.070	BOTHUS	4.056	UPEVIT	1.996	SCOMME	3.142	TRICHI	2.210	SPHYFO	6.210	UPEMOL	5.497	ACANSP	9.463
15	BOTHUS	0.060	TRIGLI	3.878	DECAMA	1.953	SAURTU	2.649	GYMNOS	2.150	SCOMME	5.775	LABRID	4.728	MACOLO	9.333
16	REXEAS	0.060	SHARKS	3.416	NEMIBA	1.850	STOLTR	2.133	UPESUL	2.077	LEOELO	4.673	CENTRI	4.601	LUTLIN	8.869
17	URANOS	0.040	DECAKU	1.850	CHAMPO	1.830	URASPI	1.896	LEOELO	1.555	LUTBOJ	4.350	PLATAX	4.583	CENTRI	8.756
18	FISTUL	0.020	SCOLIN	1.838	TETRAO	1.527	LEOEQU	1.806	UPESPP	1.373	DIODON	4.235	LEOFAS	4.528	SCARID	7.760
19			REXEAS	1.763	SELACR	1.487	SAURUN	1.768	TETRAO	1.350	CRXDIN	3.880	ACANSP	4.250	AELISC	6.875
20			CHIMAE	1.638	SAURTU	1.271	TETRAO	1.720	RHINOB	1.333	EPITAV	3.825	ACANBL	4.080	NEMIPE	6.737
21			BROTUL	1.534	SCOLIN	1.190	RASTKA	1.398	NEMINE	1.152	CRXMEL	3.558	CRXIGN	4.009	CRXFUL	6.565
22			HISTIN	1.483	PSEUSP	1.090	SEPIAT	1.170	SEPIAS	1.140	CRXPLU	3.418	SCARID	3.736	SCOMME	5.066
23			PROMET	1.433	RHINOB	1.087	UPEMOL	1.089	URASPI	1.082	PSETOD	3.325	LTRILE	3.556	LUTVIT	4.965
24			MYCTOP	1.209	SCORPI	0.983	MEGALA	0.943	ALUTMO	1.065	ABALIS	3.315	CRXFUL	3.179	SEPIAS	4.946
25			CARAPI	1.205	UPEMOL	0.968	ALEPDJ	0.918	SCOMME	0.833	LTRIMI	3.170	PARUHE	3.134	EPIFUS	4.272
26			UPEVIT	0.726	TRIGLI	0.867	SARDFI	0.917	ABALIS	0.817	LEOEQU	2.906	SCOLBI	3.133	SCOLPE	4.227
27			THENES	0.688	APOGON	0.774	CRXARM	0.891	LEOEQU	0.568	SAURTU	2.813	RACHYS	3.108	PRIABO	4.188
28			NEMIJA	0.683	LACTAR	0.758	SECUIN	0.875	DECAMA	0.525	CRXMAL	2.700	ALECIN	2.984	ALECIN	4.024
29			EPISPP	0.675	SHRIMP	0.696	DIPLOP	0.857	SERION	0.525	MEGALA	2.418	CRXCRY	2.850	SHARKS	3.868
30			APHARE	0.580	CYNOGL	0.661	FORMIO	0.834	PRIAMA	0.510	SEPIAS	2.415	DREPAN	2.849	CRXDIN	3.443
31			SERION	0.491	PSEUEL	0.583	SELAMT	0.824	SERION	0.446	EPIGUT	2.375	SPHYBA	2.811	CRXCIL	3.402
32			SHRIMP	0.490	URASPI	0.574	GAZAMI	0.794	PRIATA	0.418	TETRAO	2.308	GYMNOS	2.774	SYMPOR	3.022
33			TETRAO	0.451	SCOMME	0.504	CRXMAL	0.757	APOGON	0.392	ALUTMO	2.208	MYLIOB	2.667	CHAEOC	2.828
34			HISTYP	0.444	APHARE	0.410	CIROCE	0.736	ARGYRO	0.380	LOLIGO	1.970	MEGALA	2.631	LEOLEU	2.569
35			SEPIAS	0.409	CARAPI	0.361	FISTUL	0.734	UPETRA	0.342	SELABO	1.963	LEOEQU	2.449	PARUSP	2.512
36			CHLORO	0.375	DACTYL	0.359	SPHYLA	0.719	PSETOD	0.270	ALECIN	1.858	CRXDIN	2.370	LOLIGO	2.426
37			LOLIGO	0.368	CHIMAE	0.352	GYMNOS	0.678	SARDLO	0.260	URASPI	1.858	LTRIMI	2.250	CRXLIN	2.305
38			DECAMA	0.341	SYNODU	0.352	RASTFA	0.668	RASTFA	0.233	SCORPI	1.758	SAURTU	2.217	HENIOC	2.253
39			SCOMBE	0.298	FISTUL	0.344	SELAMA	0.659	SELACR	0.232	SELACR	1.595	SCOMME	2.208	ACANBL	2.035
40			APOGON	0.291	PRIATA	0.296	ALECIL	0.610	LOPHII	0.215	LUTLIN	1.398	CANTIG	2.189	SPHYBA	2.000
41			CYNOGL	0.239	HISTIN	0.286	SEPIAS	0.591	SEPIAT	0.212	SPHYBA	1.373	ALECIL	1.901	CRXCRY	1.977
42			CONGRI	0.233	ALUTMO	0.270	SERION	0.586	SCORPI	0.206	DREPAN	1.275	CRXCOM	1.851	PARUHE	1.967
43			TRIODO	0.183	THENES	0.251	SECURU	0.585	EPITAV	0.200	ARGYRO	1.265	UPESUL	1.789	DREPAN	1.938
44			LACTAR	0.179	PRIASP	0.250	SHARKS	0.546	TRIGLI	0.197	UPEBEN	1.250	SEPIAS	1.707	CRXMAL	1.935
45			URASPI	0.144	PSEUOL	0.215	SPHYBA	0.541	DASYAT	0.175	MENEMA	1.208	PSETOD	1.690	ARGYRO	1.890
46			DIODON	0.139	HISTYP	0.208	SPHYJE	0.471	FORMIO	0.165	SELAMT	1.085	CRXLIN	1.668	CRXCOM	1.728
47			MYLIOB	0.139	DECAKU	0.201	STOLIN	0.429	ALECIL	0.150	SEPIAT	0.996	SPHYOB	1.537	SPHYLA	1.686
48			DACTYL	0.135	CONGRI	0.198	PENTAP	0.386	CRXMAL	0.150	CIROCE	0.805	APOGON	1.512	LEOBIN	1.543
49			SAURTU	0.123	UPEBEN	0.198	SCOLTA	0.350	SCOLTA	0.138	CRXCOM	0.725	SCOLPE	1.469	APOGON	1.497
50			PARPER	0.103	LEOBIN	0.195	PRIATA	0.336	SHARKS	0.125	SCARID	0.725	CRXMAL	1.438	BALIST	1.333
51			CRABSS	0.100	RASTKA	0.180	SELAME	0.330	NEMIBA	0.123	SAURUN	0.623	CRXARM	1.427	CRXIGN	1.290
52			PSETOD	0.071	SEPIAS	0.177	APOGON	0.303	EPIBLI	0.117	PENTAP	0.578	POMAMA	1.417	EPITAV	1.250
53			TRIACA	0.053	PARPER	0.172	LEODAU	0.277	CHAMPO	0.108	SHARKS	0.578	FISTUL	1.370	CRXMEL	1.146
54			UPETRA	0.041	SCOMBE	0.171	MENEMA	0.264	SPHYLA	0.108	CRXEQU	0.575	PENTAP	1.343	SELAMT	1.134
55			TODARO	0.041	NEMINE	0.164	CRXDIN	0.243	CRABSS	0.105	CRXIGN	0.563	LUTGIB	1.333	CRXPLU	1.100
56			ABALIS	0.019	EUPLEU	0.144	EUPLEU	0.236	PRIABO	0.103	PRIATA	0.505	LUTMAC	1.333	RACHYS	1.098
57			SYNODU	0.010	CHLORO	0.142	ALUTMO	0.217	EPISEX	0.100	LTRILE	0.500	LOLIGO	1.303	ALUTSC	1.078
58					UPETRA	0.139	SERION	0.207	STOLIN	0.086	PRIAMA	0.420	CHAEOC	1.273	FISTUL	1.063
59					CRABSS	0.136	NEMINE	0.203	TRIACA	0.083	ARIOMA	0.415	DECAMU	1.130	SCOLDU	0.982
60					MYCTOP	0.132	CRXFUL	0.193	DACTYL	0.082	APOGON	0.405	PARUIN	1.082	SCOLBI	0.890
61					TRIODO	0.118	SCIENA	0.191	TRIODO	0.082	EPIMOR	0.400	CRXCIL	0.999	CORADI	0.880
62					NEMIJA	0.102	ALEPKA	0.153	URANOS	0.082	DECAMU	0.388	SECUIN	0.991	LTRIMI	0.855
63					PROMET	0.099	ALUTSC	0.149	LUTVIT	0.078	CRXTIL	0.375	TRICHI	0.971	NEMITO	0.832
64					EPITAV	0.088	UPESUN	0.142	DECARU	0.068	PRIABO	0.370	SELAMT	0.958	TRIODO	0.813
65					BALIST	0.075	ALECIN	0.134	SYNODU	0.068	ACANBL	0.333	LUTVIT	0.875	CHAELU	0.810
66					NEMIHE	0.068	NEMIJA	0.126	EPIMOR	0.060	LEOSPL	0.303	PRIABO	0.874	ALECIL	0.794
67					OSTRAC	0.065	EPISEX	0.120	SPHYJE	0.058	SPHYLA	0.288	ARGYRO	0.836	RASTKA	0.791
68					PRIABO	0.061	PRIAMA	0.118	CRXCIL	0.057	CRXARM	0.283	SPHYLA	0.829	CRXARM	0.709
69					BROTUL	0.042	ABALIS	0.116	LEOFAS	0.056	PARUHE	0.280	NASOSP	0.803	THENES	0.685
70					BOTHUS	0.042	CRABSS	0.104	RASTBR	0.048	PRIASP	0.280	CHAELU	0.790	SCOLTA	0.627
71					TODARO	0.041	NEMIHE	0.103	LEOLEU	0.047	OSTRAC	0.270	BALIST	0.783	POMAMA	0.550
72					TRIACA	0.039	EPIMOR	0.098	UPEBEN	0.047	CRXSPE	0.250	SELACR	0.771	CANTIG	0.540
73					SEPIAT	0.027	SELABO	0.097	LUTGIB	0.042	SECUIN	0.198	SPHYFO	0.758	EPIBLI	0.533
74					PSEUDU	0.025	ARIOMA	0.091	SCOLIN	0.038	GERESK	0.195	LEOELO	0.680	PSEUSP	0.532
75					EPIMOR	0.022	ARGYRO	0.088	MENEMA	0.037	APHARE	0.180	MACOLO	0.667	PARUIN	0.505
76					LEOELO	0.020	SCORPI	0.086	NEMIJA	0.037	SERION	0.163	PRIAMA	0.659	UPESUN	0.497
77					NEMITO	0.020	EPIFUS	0.056	STOLTR	0.033	EUPLEU	0.153	NEMITO	0.657	PARUCR	0.478
78					PENTAP	0.014	LOPHII	0.052	SELAMT	0.030	LOPHII	0.150	SCOLTA	0.609	UPETRA	0.467
79					SARDLO	0.013	PRIASP	0.049	DIODON	0.025	LEOLEU	0.120	THENES	0.551	SERION	0.460
80					ABALIS	0.013	CHAMPO	0.048	PSEUOL	0.023	SCOLTA	0.118	GERESK	0.540	LTRICO	0.425
81					DIODON	0.012	TRIODO	0.036	SCOMBE	0.023	PARUIN	0.113	SAURUN	0.536	ECHINE	0.359
82					UPESUN	0.007	RACHYS	0.036	NEMITO	0.020	STOLIN	0.103	PRIATA	0.524	PSEUDU	0.345
83					DECARU	0.007	PSEUOL	0.035	OSTRAC	0.020	CRXFUL	0.080	SCOLIN	0.508	URASPI	0.315
84					SPHYLA	0.004	TRIACA	0.032	NEMIPE	0.018	THENES	0.078	LEOLEU	0.493	SELACR	0.247
85					REXEAS	0.002	PSETOD	0.032	SELARO	0.018	EPISEX	0.070	CRXMEL	0.472	PENTAP	0.233
86					SCIENA	0.001	UPEBEN	0.031	CONGRI	0.015	URANOS	0.060	DAYAJE	0.462	SEPIAT	0.229
87					GAZAMI	0.001	GERESK	0.031	LABRID	0.015	SPHYOB	0.053	URASPI	0.452	UPEBEN	0.205
88							CRXPLU	0.028	SCOLBI	0.015	ECHINE	0.046	SCORPI	0.449	DAYAJE	0.200
89							CRXLIN	0.026	CRXPLU	0.013	RASTKA	0.043	NEMIPE	0.443	SPHYJE	0.200
90							LUTLIN	0.026	UPESUN	0.013	UPEVIT	0.043	TRIACA	0.432	SPHYFO	0.191
91							LUTMAL	0.025	ALECIN	0.012	TRIACA	0.038	PINJAL	0.417	DACTYL	0.188
92							CHAEOC	0.024	CRXARM	0.012	SPHYJE	0.035	SCOLDU	0.409	DIPLOP	0.183
93							URANOS	0.023	NEMIHE	0.012	CRABSS	0.020	PSEUDU	0.405	LEOELO	0.174
94							SYNODU	0.022	CRXCRY	0.010	DIPLOP	0.020	UPEBEN	0.387	RASTFA	0.159
95							LABRID	0.019	PARUCR	0.010	NEMIBA	0.015	CRXPLU	0.363	TRIACA	0.141
96							OSTRAC	0.019	MEGALA	0.005	RACHYS	0.015	HENIOC	0.349	URANOS	0.099
97							LEOFAS	0.018	SELAME	0.005	RASTFA	0.013	EPITAV	0.343	DECAMU	0.097
98							LUTVIT	0.017	SCIENA	0.003	SARDLO	0.008	NEMINE	0.343	SAURTU	0.093
99							EPIBLI	0.016	BROTUL	0.002	CANTIG	0.003	SPHYJE	0.329	MEGALA	0.078
100							DACTYL	0.014	CRXDIN	0.002	SYNODU	0.003	SELARO	0.325	UPEVIT	0.063
101							DECAMA	0.009	GAZAMI	0.002			STOLIN	0.323	CRXEQU	0.060
102							THENES	0.009	PARPER	0.002			FORMIO	0.322	CRABSS	0.052

Appendix III. Complete List of All the Species/Taxa Belonging to the Different Fish Assemblages or Groups Found in RABUTINOS.

	Grp 4a		Grp 4b		Grp 5	Grp 6		Grp 7	
103	UPETRA	0.009	SHRIMP	0.002		CORADI	0.309	GERESK	0.044
104	SPHYFO	0.008	ACANBL	0.000		SERION	0.308	SELARO	0.035
105	DREPAN	0.008				URANOS	0.292	PSEUOL	0.033
106	SHRIMP	0.007				NEMIBA	0.287	SELABO	0.030
107	TRIGLI	0.007				LOPHII	0.284	SCORPI	0.025
108	CRXCIL	0.006				ECHINE	0.273	PRIATA	0.020
109	BOTHUS	0.005				RASTKA	0.268	STOLIN	0.018
110	CHAELU	0.003				SERION	0.264	SAURUN	0.012
111	SCOMBE	0.003				EPIGUT	0.263	STOLTR	0.012
112	DECAKU	0.003				UPESPP	0.262	SYNODU	0.012
113	LTRILE	0.003				TRIGLI	0.256	SECUIN	0.010
114	DAYAJE	0.002				SYNODU	0.251	NEMIBA	0.005
115	NEMITO	0.002				SYMPOR	0.250	SARDLO	0.003
116	EPISPP	0.002				SHRIMP	0.248		
117	LEOELO	0.001				PSEUOL	0.242		
118	CRXEQU	0.001				RHINOB	0.238		
119	PARUSP	0.001				UPETRA	0.236		
120	PARUIN	0.001				DACTYL	0.234		
121						DIPLOP	0.233		
122						CRXEQU	0.213		
123						UPESUN	0.210		
124						SELAMA	0.206		
125						CHELMO	0.197		
126						SEPIAT	0.197		
127						STOLTR	0.193		
128						PARUSP	0.191		
129						CHAMPO	0.191		
130						NEMIHE	0.190		
131						CRABSS	0.189		
132						SHARKS	0.188		
133						BROTUL	0.186		
134						TRIODO	0.182		
135						NEMIJA	0.178		
136						EPISEX	0.176		
137						ALUTSC	0.171		
138						ARIOMA	0.169		
139						CONGRI	0.168		
140						ALEPDJ	0.167		
141						ALEPKA	0.167		
142						APHARE	0.167		
143						BOTHUS	0.167		
144						CARAPI	0.167		
145						CHIMAE	0.167		
146						CHLORO	0.167		
147						CIROCE	0.167		
148						CRXTIL	0.167		
149						CYNOGL	0.167		
150						DECAKU	0.167		
151						DECAMA	0.167		
152						DECARU	0.167		
153						DUSSUM	0.167		
154						EPIBLI	0.167		
155						EPIFUS	0.167		
156						EPISPP	0.167		
157						EUPLEU	0.167		
158						HISTIN	0.167		
159						HISTYP	0.167		
160						LACTAR	0.167		
161						LEODAU	0.167		
162						LEOSPL	0.167		
163						LTRICO	0.167		
164						LUTMAL	0.167		
165						MENEMA	0.167		
166						MYCTOP	0.167		
167						PARPER	0.167		
168						PRIASP	0.167		
169						PROMET	0.167		
170						RASTBR	0.167		
171						RASTFA	0.167		
172						REXEAS	0.167		
173						SARDFI	0.167		
174						SARDLO	0.167		
175						SCIENA	0.167		
176						SCOMBE	0.167		
177						SECURU	0.167		
178						SELABO	0.167		
179						SELAME	0.167		
180						UPEVIT	0.167		
181						PERIST	0.072		
182						PSEUSP	0.023		
183						PARUCR	0.017		

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Appendix IV. Complete List of the Names and Code Designations of All the Species or Taxa Included in the RABUTINOS Demersal Trawl Samples.

No.	CODE	SPECIES
1	ABALIS	Abalistes stellaris
2	ACANBL	Acanthurus bleekeri
3	ACANSP	Acanthurus sp.
4	AELISC	Aeliscus strigatus
5	ALECIL	Alectis ciliaris
6	ALECIN	Alectis indicus
7	ALEPDJ	Alepes djedaba
8	ALEPKA	Alepes kalla
9	ALUTMO	Alutera monoceros
10	ALUTSC	Aluteres scriptus
11	APHARE	Aphareus rutilans
12	APOGON	Apogonidae
13	ARGYRO	Argyrops spinifer
15	ARIOMA	Arioma indica
16	BALIST	Balistes sp.
17	BOTHUS	Bothus sp.
18	BROTUL	Brotulinae
19	CANTIG	Canthigaster compressus
20	CRXARM	Caranx armatus
21	CRXCRY	Caranx chrysophrys
22	CRXCIL	Caranx ciliaris
23	CRXCOM	Caranx compressus
24	CRXDIN	Caranx dinema
25	CRXEQU	Caranx equula
26	CRXFUL	Caranx fulvoguttatus
27	CRXIGN	Caranx ignobilis
28	CRXLIN	Caranx linear-fulvoguttatus
29	CRXMAL	Caranx malabaricus
30	CRXMEL	Caranx melampygus
31	CRXPLU	Caranx plumbeus
33	CRXSPE	Caranx speciousus
34	CRXTIL	Caranx tille
35	CARAPI	Carapidae
36	CENTRI	Centricus scutatus
37	CHAELU	Chaetodon lunula
38	CHAEOC	Chaetodon ocellatus
39	CHAMPO	Champsodontidae
40	CHELMO	Chelmon rostratum
41	CHIMAE	Chimaeridae
42	CIROCE	Chirocentrus dorab
43	CHLORO	Chloropthalmus albatrosis
44	CONGRI	Congridae
45	CORADI	Coradion altiveles
46	CRABSS	Crabs
47	CYNOGL	Cynoglossidae
48	DACTYL	Dactylopteridae
49	DASYAT	Dasyatidae
50	DAYAJE	Daya jerdoni
51	DECAKU	Decapterus kurroides
52	DECAMA	Decapterus macrosoma
53	DECAMU	Decapterus muruadsi
54	DECARU	Decapterus russeli
55	DIODON	Diodontidae
56	DIPLOP	Diploprion bifasciatus
57	DREPAN	Drepane punctata
58	DUSSUM	Dussumiera acuta
59	ECHINE	Echineis naucrates
60	EPIBLI	Epinephelus bleekeri
61	EPIFUS	Epinephelus fuscoguttatus
62	EPIGUT	Epinephelus guttatus
63	EPIMOR	Epinephelus morrhua
64	EPISEX	Epinephelus sexfaciatus
65	EPISPP	Epinephelus sp.
66	EPITAV	Epinephelus tauvina
67	EUPLEU	Eupleurogrammus nuticus
68	FISTUL	Fistularia petimba
69	FORMIO	Formio niger
70	GAZAMI	Gazza minuta
71	GERESK	Gerres kapas
72	GYMNOS	Gymnocaesio gymnoptera
73	HENIOC	Heniochus acuminatus
74	HISTIN	Histiopterus indicus
75	HISTYP	Histiopterus typus
76	LABRID	Labridae
77	LACTAR	Lactariidae
78	LEOBIN	Leiognathus bindus
79	LEODAU	Leiognathus daura
80	LEOELO	Leiognathus elongatus
81	LEOEQU	Leiognathus equulus
82	LEOFAS	Leiognathus fasciatus
83	LEOLEU	Leiognathus leuciscus
84	LEOSPL	Leiognathus splendens
85	LTRICO	Lethrinus choerorhincus
86	LTRILE	Lethrinus lentjan
87	LTRIMI	Lethrinus miniatus
88	LTRIOP	Lethrinus opercularis
89	LOLIGO	Loligo sp.
90	LOPHII	Lophiidae
91	LUTBOJ	Lutjanus bojar
92	LUTGIB	Lutjanus gibbus
93	LUTLIN	Lutjanus lineolatus
94	LUTMAC	Lutjanus macolor
95	LUTMAL	Lutjanus malabaricus
98	LUTVIT	Lutjanus vitta
99	MACOLO	Macolor macolor
100	MEGALA	Megalaspis cordyla
101	MENEMA	Mene maculata
102	MOBULI	Mobulidae
103	MYCTOP	Myctophidae
104	MYLIOB	Myliobatidae
105	NASOSP	Naso sp.
106	NEMIBA	Nemipterus bathybius
107	NEMIHE	Nemipterus hexodon
108	NEMIJA	Nemipterus japonicus
109	NEMIMA	Nemipterus marginatus
110	NEMINE	Nemipterus nematophorus
111	NEMIPE	Nemipterus peronii
112	NEMITO	Nemipterus tolu
113	OSTRAC	Ostraciidae
114	PARPER	Parapercidae
115	PARUCR	Parupemon chryserydros
116	PARUHE	Parupeneus heptacanthus
117	PARUIN	Parupeneus indicus
118	PARUSP	Parupeneus sp.
119	PENTAP	Pentaprion longimanus
120	PERIST	Peristidiinae
121	PINJAL	Pinjalo pinjalo
122	PLATAX	Platax orbicularis
123	PLATYC	Platycephalus indicus
124	PLECIN	Plectorhincus pictus
125	PLECLE	Plectropomus leopardus
126	PLECMA	Plectropomus maculatus
128	POMAHA	Pomadasys hasta
129	POMAMA	Pomadasys maculatus
130	PRIABO	Priacanthus boops
131	PRIAMA	Priacanthus macracanthus
132	PRIASP	Priacanthus sp.
133	PRIATA	Priacanthus tayenus
134	PROMET	Promethichthys prometheus
135	PSETOD	Psettodes erumei
136	PSEUDU	Pseudorhombus dupliciocellatus
137	PSEUEL	Pseudorhombus elevatus
138	PSEUOL	Pseudorhombus oligodon
139	PSEUSP	Pseudorhombus sp.
140	RACHYS	Rachycentron canadus
141	RASTBR	Rastrelliger brachysoma
142	RASTFA	Rastrelliger faughni
143	RASTKA	Rastrelliger kanagurta
144	REXEAS	Rexea solandri
145	RHINOB	Rhinobatidae
146	SARDFI	Sardinella fimbriata
147	SARDLO	Sardinella longiceps
148	SAURTU	Saurida tumbil
149	SAURUN	Saurida undosquamis
150	SCARID	Scaridae
151	SCIENA	Sciena dussumierii
152	SCOLBI	Scolopsis bimaculatus
153	SCOLDU	Scolopsis dubiosus
154	SCOLIN	Scolopsis inermis
155	SCOLPE	Scolopsis personatus
156	SCOLTA	Scolopsis taeniopterus
157	SCOMBE	Scomber australicus
159	SCOMME	Scomberomorus commersonii
160	SCORPI	Scorpaenidae
161	SECUIN	Secutor insidiator
162	SECURU	Secutor ruconius
163	SELABO	Selar boops
164	SELACR	Selar crumenophthalmus
165	SELAMA	Selar malam
166	SELAMT	Selar mate
167	SELAME	Selar melanoptera
168	SELARO	Selaroides leptolepis
169	SEPIAS	Sepia sp.
170	SEPIAT	Sepiatheutis
171	SERIOG	Seriola grandis
172	SERION	Seriola nigrofasciata
173	SHARKS	Sharks
174	SHRIMP	Shrimps
175	SPHYBA	Sphyraena barracuda
176	SPHYFO	Sphyraena forsteri
177	SPHYJE	Sphyraena jello
178	SPHYLA	Sphyraena langsar
179	SPHYOB	Sphyraena obtusata
180	STOLIN	Stolephorus indicus
182	STOLTR	Stolephorus tri
183	SYMPOR	Symphorus nematophorus
184	SYNODU	Synodus variegatus
185	TETRAO	Tetraodontidae
186	THENES	Thennes orientalis
187	TODARO	Todarodes pacificus
188	TRIACA	Triacanthidae
189	TRICHI	Trichiurus haumela
190	TRIGLI	Triglidae
191	TRIODO	Triodontidae
192	UPEBEN	Upeneus bensasi
193	UPEMOL	Upeneus mollucensis
194	UPESPP	Upeneus sp.
195	UPESUL	Upeneus sulphureus
196	UPESUN	Upeneus sundaicus
197	UPETRA	Upeneus tragula
198	UPEVIT	Upeneus vittatus
199	URANOS	Uranoscopidae
200	URASPI	Uraspis helvolus

Appendix V. Species/Taxa Composition of Standard SU Groups at RABUTINOS.

SPECIES NAME	G-1	G-2	G-3	G-4B	G-4A	G-5	G-6	G-7
Decapterus kurroides	28.2	1.9						
Scolopsis inermis	23.8	1.8						
Decapterus muruadsi	18.2	15.7	10.4	8.0	3.4			
Priacanthus macracanthus	9.8	23.4	14.9					
Nemipterus marginatus	8.5							
Saurida undosquamis	4.3	29.5	9.0	6.6	1.8			
Epinephelus spp.	4.0		8.2					
Chloropthalmus albatrosis	1.9							
Saurida tumbil	1.7			4.8				
Champsodontidae	0.4	5.5	1.8					
Shrimps	0.2							
Crabs	0.1							
Nemipterus bathybius	0.1	5.7	1.9					
Rhinobatidae	0.1	14.3		1.3				
Bothus spp.	0.1	4.1						
Rexea solandrii	0.1	1.8						
Uranoscopidae	0.0	6.9	2.6					
Fistularia petimba	0.0			4.9		8.8		
Ariomma indica		46.0	61.4	16.4				
Lophiidae		18.7	3.2					
Dasyatidae		16.8	13.3			14.2	25.8	34.9
Trichiurus haumela		9.1	53.3	2.2	11.9	10.4		
Scorpaenidae		4.9						
Decapterus russelli		4.8						
Triglidae		3.9						
Sharks		3.4	6.6					
Chimaeridae		1.6						
Seriola nigrofasciata			6.9					
Loligo spp.			5.5	11.9	4.4			
Peristidiinae			3.7					
Upeneus vittatus			2.0					
Decapterus macrosoma			2.0					
Tetraodontidae			1.5	1.4	1.7		15.9	22.0
Selar crumenophthalmus			1.5		3.2			
Saurida tumbil			1.3		2.7			
Leiognathus bindus				34.7	14.4	119.2	8.9	
Upeneus mollucensis				9.3		11.3	5.5	
Aphareus rutilans				8.3				
Eupleurorammus nuticus				7.1				
Dussumiera acuta				3.3	4.2			
Pentaprion longimanus				3.3				
Rastrelliger kanagurta				2.6				
Gymnocaesion gymnoptera				2.2				
Upeneus sulphureus				2.1	15.6	22.4		
Leiognathus elongatus				1.6		4.7		
Upeneus spp.				1.4				
Leiognathus splendens					18.3			
Selaroides leptolepis					6.0			

Appendix V. Species/Taxa Composition of Standard SU Groups at RABUTINOS (continued).

SPECIES NAME	G-1	G-2	G-3	G-4B	G-4A	G-5	G-6	G-7
Rastrelliger brachysoma					5.4			
Sardinella longiceps					4.7			
Leiognathus leuciscus					4.6			
Sphyraena obtusata					3.9			
Scomberomorus commerson					3.1	5.8		
Stolephorus tri					2.1			
Uraspis helvolus					1.9			
Leiognathus equulus					1.8			
Pomadasys maculatus						19.7		
Lutjanus malabaricus						10.6		
Gazza minuta						7.6	6.3	
Carangoides ciliaris						7.1		
Alectis ciliaris						7.0		
Leiognathus fasciatus						6.6	4.5	
Formio niger						6.3		
Sphyraena forsteri						6.2		
Lutjanus bohar						4.4		37.3
Diodontidae						4.2	40.6	47.3
Carangoides dinema						3.7		
Epinephelus tauvina						3.6		
Carangoides speciousus							22.9	47.6
Aeliscus strigatus							16.4	6.9
Plectorhincus pictus							8.5	
Abalistes stellaris							7.9	26.0
Lutjanus lineolatus							7.6	8.9
Lethrinus opercularis							7.0	14.7
Ostraciidae							6.2	14.5
Alutera monoceros							6.0	18.6
Labridae							4.7	
Centriscus scutatus							4.6	8.8
Platax orbicularis							4.6	
Acanthurus spp.							4.3	9.5
Acanthurus bleekeri							4.1	
Lethrinus lentjan								14.8
Epinephelus guttatus								14.0
Labridae								12.4
Naso spp.								10.4
Macolor macolor								9.3
Scaridae								7.8
Nemipterus peroni								6.7

Legend: [dark shaded box] = major distribution mode

[light shaded box] = minor distribution mode