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# DISTRIBUTION OF CORAL REEF FISH IN SINGAPORE

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## ABSTRACT

A total of 107 species of coral reef fish from 26 families were observed from two sets of surveys (1987-89 and 1991-92) at six sites in Singapore. The Pomacentridae contained the most number of species, while the Labridae was the next most diverse, followed by the Apogonidae and the Nemipteridae. The indicator and target fishes were poorly represented, with only 4% of total species number belonging to the Chaetodontidae, and 6% from the families Lutjanidae, Haemulidae and Serranidae. Correlation analysis of reef fish abundance with distance from the main island showed a significant positive correlation ($r = 0.481$).

## INTRODUCTION

The coral reefs of Singapore, consisting of fringing and patch reefs, are mostly situated to the south of the main island. Almost all these reefs suffer from heavy sedimentation, the result of extensive reclamation of Singapore's coastline. A number of the islands, like Pulau Hantu, were reclaimed to create a recreational island. No comprehensive studies were made of the reef fish communities in Singapore prior to such impact.

However, a few comprehensive surveys on the coral reef fish communities have been conducted since then (Tay & Khoo, 1984; Lim *et al.*, 1990; Lim & Chou, 1991a & 1991b). The composition and distribution of coral reef fish at Pulau Salu was studied by Tay & Khoo (1984). Sampling was done through a variety of methods, including 30m to 50m line transect visual census and collection of specimens by hook and line, rotenone and fish traps. Lim & Chou (1991a & 1991b) studied a total of 8 fringing and patch reefs, employing the visual census method described in Dartnall & Jones (1986).

Five of the sites studied by Lim & Chou (1991b) were resurveyed between 1991 and 1992, including an additional site, Lazarus Island. Data from these two surveys were used to establish possible spatial and temporal trends in the reef fish community.

## METHODOLOGY AND STUDY SITES

Studies on fish communities were conducted at two patch reefs (Cyrene Reefs and Hantu West) and four fringing reefs (Pulau Hantu, Pulau Semakau, Raffles Lighthouse and Lazarus Island) (Fig. 1). Two sites at each of these locations were surveyed along the 3 m and 10 m depths of the reef slope, using fish visual census (Dartnall & Jones, 1986). SCUBA divers swimming along a 150m transect tape recorded the number of fishes observed within 3m to the left, right and above the tape, equivalent to a volume of 2700m$^3$.

The fish observed were grouped into three categories: indicator species from the family Chaetodontidae, target species from the families Lethrinidae, Lutjanidae, Serranidae and Haemulidae, and species from the "major" families Pomacentridae, Labridae, Pomacanthidae, Caesionidae, and Carangidae.

The data were analysed by Pattern Analysis package, PATN (Belbin, 1987) using actual counts of all species were used for the analysis. In cases where only log4 abundance categories were available, the mid-points of that category were used.

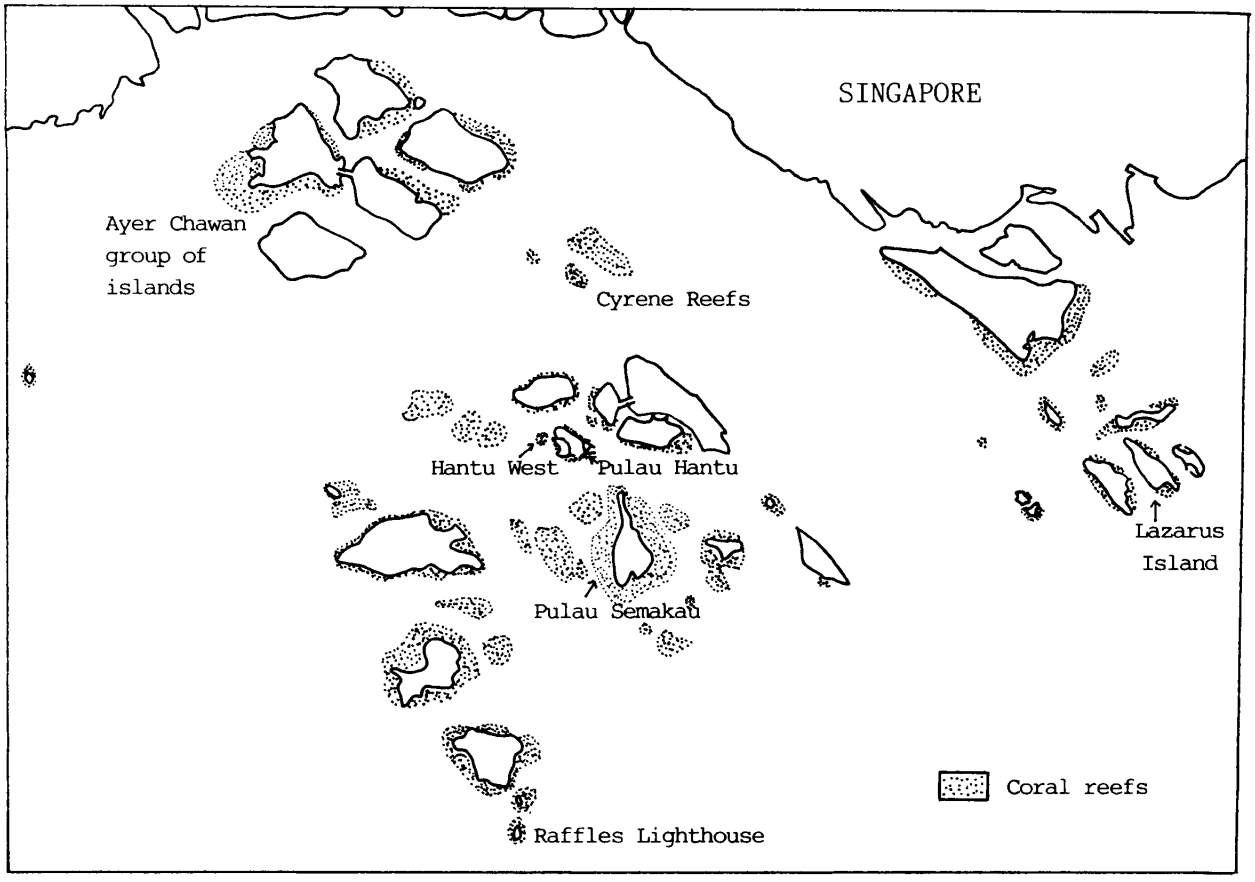



Fig. 1. Map showing the six reefs surveyed.

## RESULTS

A total of 107 species from 26 families were observed (Table 1). Thirty-one new species not observed before in Singapore are marked with an asterisk in Table 1. The dominant species in terms of abundance, and diversity were mainly from the "major" families. Species from the family Pomacentridae were the most common, being found in relatively large numbers on all the reefs, especially *Pomacentrus albimaculus*, *Pomacentrus littoralis*, *Neopomacentrus taeniurus*, *Neopomacentrus nemurus*. The next most common family was Labridae, with *Halichoeres dussumeri*, *Halichoeres hoeveni* and *Choerodon anchorago* being abundant. One species of Pomacanthidae (*Chaetodontoplus mesoleucus*) was common, as with Caesionidae (*Caesio teres*) and Grammistidae (*Diploprion bifasciatus*). The indicator and the target fish were poorly represented, with only 4 species from Chaetodontidae (*Chelmon rostratus* and *Chaetodon octofasciatus* being common), and 6 species from three target fish families, the commonest being *Cephalopholis pachycentron*.

The combined data set (ie. data for the first and second surveys) was analysed in PATN using the Bray-Curtis dissimilarity index. The dendrogram exhibited a "chaining effect". No definite pattern was discernable, and the dendrogram was therefore not included in this paper. However, there seemed to be a segregation of the first survey transects from the second survey transects.

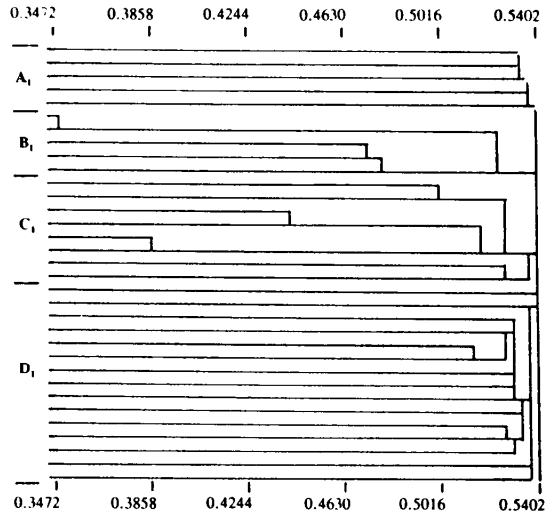
No strong pattern was seen for the first set of survey data (Fig. 2), although four groups may be recognised: the first consisting of transects from Cyrene Reefs, the second from Pulau Hantu, the third from Hantu West patch reef, and the last group consisting largely of transects from Raffles Lighthouse and Pulau Semakau. A better pattern was obtained with the second survey data set (Fig. 3). Of interest were: Pulau Semakau site 1 ($E_2$) and site 2 ($A_2$) being in different "blocks"; similarly for Cyrene Reefs site 1 ($D_2$) and site 2 ($G_2$); and Hantu West site 1 and 2 ($F_2$) with Pulau Hantu

**Table 1. List of Singapore fish species observed from all surveys (1987 to 1992) of the ASEAN-Australia Marine Science Project: Living Coastal Resources.**

| Family | No. of species | Species |
|---|---|---|
| Apogonidae | (8) | Apogon compressus |
| | | **Apogon cyanosoma* |
| | | **Apogon sealei (niger?)* |
| | | *Apogon trimaculatus* |
| | | *Apogon sp. 1 |
| | | *Cheilodipterus macrodon* |
| | | *Cheilodipterus quinquelineatus* |
| | | *Sphaeramia nematoptera* |
| Batrachoidae | (1) | *Halophryne diemensis* |
| Blennidae | (3) | *Meiacanthus grammistes* |
| | | Blenny sp1 (brown) |
| | | *Blenny sp2 (grey and yellow) |
| Caesionidae | (2) | *Caesio caerulaureus* |
| | | *Caesio teres* |
| Carangidae | (2) | *Selaroides leptolepis* |
| | | Carangid sp. |
| Centrisidae | (1) | *Aeoliscus strigatus* |
| Chaetodontidae | (4) | *Chelmon rostratus* |
| | | *Chaetodon octofasciatus* |
| | | *Parachaetodon ocellatus* |
| | | *Coradion chrysozonus* |
| Dasyatididae | (1) | *Taeniura (Dasyatis?) lymma* |
| Ephippidae | (2) | *Platax pinnatus* |
| | | **Platax tiera* |
| Gobiidae | (1) | Goby sp1 (big goby) |
| Grammistidae | (1) | *Diploprion bifasciatus* |
| Haemulidae | (1) | *Plectorhynchus chaetodontoides* |
| Holocentridae | (1) | **Holcentrus* sp. |
| Labridae | (16) | *Bodianus mesothorax* |
| | | *Cheilinus fasciatus* |
| | | *Choerodon anchorago* |
| | | *Choerodon schoelenii* |
| | | *Halichoeres chloropterus* |
| | | *Halichoeres dussumeri* |
| | | *Halichoeres hoeveni* |
| | | **Halichoeres hartzfeldii* |
| | | *Halichoeres melanochir* |
| | | *Halichoeres scapularis* |
| | | *Hemigymnus melapterus* |
| | | *Labroides dimidiatus* |
| | | **Pterogogus flagellifera* |
| | | **Pteragogus* sp. |
| | | *Thalassoma lunare* |
| | | **Halichoeres* sp. (green) |
| Leiognathidae | (1) | **Leiognathus equulus* |
| Lutjanidae | (3) | *Lutjanus carponotatus* |
| | | *Lutjanus johni* |
| | | *Lutjanus lutjanus* |
| Monacanthidae | (3) | *Monacanthus chinensis* |
| | | **Monacanthus macrurus* |
| | | **Monacanthus* sp. |
| Monodactylidae | (1) | *Monodactylus argenteus* |
| Mugiloididae | (1) | *Parapercis clathrata* |
| Mullidae | (1) | *Upeneus tragula* |
| Nemipteridae | (7) | *Pentapodus canius* |
| | | **Pentapodus setosus* |
| | | *Pentapodus* sp. |
| | | *Scolopsis bilineatus* |
| | | *Scolopsis ciliatus* |
| | | *Scolopsis dubiosus* |
| | | *Scolopsis vosmeri* |
| Ostraciidae | (1) | *Ostracion* sp. |
| Pempheridae | (2) | *Pempheris* sp. 1 |
| | | *Pempheris* sp. 2 |
| Pomacanthidae | (3) | *Chaetodonoplus mesoleucus* |
| | | **Pomacanthus annularis* |
| | | *Pomacanthus sexstriatus* |
| Pomacentridae | (28) | *Abudefduf bengalensis* |
| | | *Abudefduf coelestinus* |
| | | *Abudefduf notatus* |
| | | **Abudefduf saxatilis* |
| | | **Abudefduf septemfasciatus* |
| | | *Abudefduf vaigensis* |
| | | *Amblyglyphidodon curacao* |
| | | *Amblyglyphidodon leucogaster* |
| | | *Amphiprion clarkii* |
| | | *Amphiprion frenatus* |
| | | **Amphiprion melanopus* |
| | | *Amphiprion ocellaris* |
| | | *Chrysiptera unimaculata* |
| | | *Dascyllus trimaculatus* |
| | | *Dischistodes prosopotaenia* |
| | | *Hemiglyphidodon plagiometapon* |
| | | **Neopomacentrus nemurus* |
| | | *Neopomacentrus taeniurus (filamentosus?)* |
| | | **Neopomacentrus* sp. (white-spotted) |
| | | *Neoglyphidodon nigroris* |
| | | **Pomacentrus albimaculus* |
| | | *Pomacentrus alexanderae* |
| | | **Pomacentrus bankanensis* |
| | | *Pomacentrus brachialis* |
| | | **Pomacentrus littoralis* |
| | | *Pomacentrus moluccensis* |
| | | **Pomacentrus rhondonatus* |
| | | *Pomachromis richardsoni* |
| Scaridae | (2) | *Scarus ghobban* |
| | | *Scarus* sp. |
| Serranidae | (6) | **Cephalopholis argus* |
| | | *Cephalopholis boenack* |
| | | **Cephalopholis pachycentron* |
| | | *Epinephalus tauvina* |
| | | **Plectropomus maculatus* |
| | | *Plectropomus leopardus* |
| Siganidae | (3) | **Siganus guttatus* |
| | | **Siganus javus* |
| | | **Siganus virgatus* |
| Sphyraenidae | (1) | **Sphyraena flavicauda* |

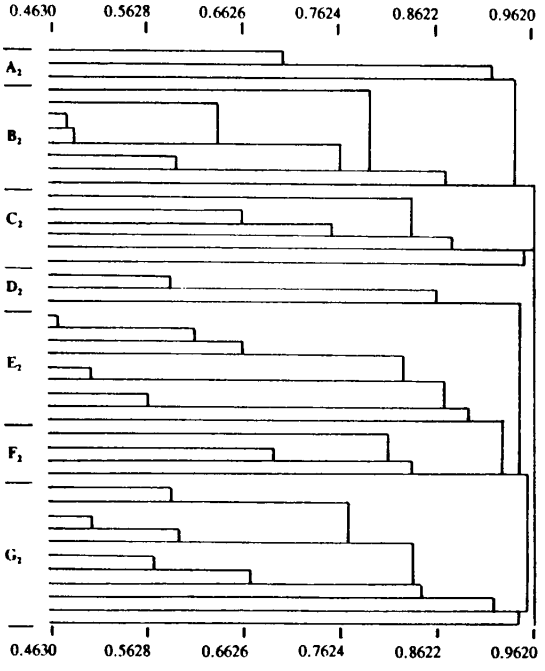
* New species encountered by authors in second set of surveys (1991 - 1992)

site 1 and 2 ($G_2$).




$A_1$: Cyrene Reefs, sites 1 and 2.
$B_1$: Pulau Hantu, sites 1 and 2.
$C_1$: Hantu West patch reef, sites 1 and 2.
$D_1$: Raffles Lighthouse, sites 1 and 2; Pulau Semakau, sites 1 and 2.

Fig.2. Dendrogram of fish abundance from surveys conducted between 1987 and 1989 by Lim & Chou (1991b).




$A_2$: Pulau Semakau, site 2.
$B_2$: Lazarus Island, site 1 and 2.
$C_2$: Raffles Lighthouse, sites 1 and 2.
$D_2$: Cyrene Reefs, site 1.
$E_2$: Pulau Semakau, site 1.
$F_2$: Hantu West patch reef, sites 1 and 2.
$G_2$: Pulau Hantu, sites 1 and 2; Cyrene Reefs site 2.

Fig. 3. Dendrogram of fish abundance distribution, from surveys conducted between 1991 and 1992.

An attempt at determining a correlation between fish abundance with distance from the main island (using Pearson's correlation matrix), produced a significant positive correlation at $r = 0.481$.

## DISCUSSION

The increase in the number of reef fish species between the two sets of surveys appears to indicate an overall improvement in the reef fish population over time. However, one must be wary when reporting "new" species. As no specimens were collected for verification, the possibility of misidentification must not be rule out. This "error" can be eliminated by proper training of the recorders and collection of specimens for identification. Furthermore, use of different sampling methods will yield different results, as was the case for the study by Tay & Khoo (1984) at Pulau Salu. They observed at least 31 species that were never encountered in our surveys. This was because they used more elaborate and time-consuming sampling methods, in addition to sampling the intertidal zone. While a discussion on the merits of different sampling methods is beyond the scope of this paper, it is important to highlight variation in results one may get either by (1) using different methods, (2) sampling in different zones on the reef, and (3) observer error. The merits of different methods of sampling can be found in Russell *et al.* (1978) and Russ (1985).

The "chaining effect" observed for the dendrogram on the combined data set was probably an artifact (Belbin, 1987) produced by observer variation. As the first and second surveys were recorded by different people, the segregation of a majority of the first set of survey transects from that of the second survey transects may be an indication of this. The dendrograms of the separated data set (Figs. 2 and 3) were more informative, showing that there was some degree of differentiation in the fish populations on the different reefs. The fish populations between Semakau site 1 and 2, as well as Cyrene site 1 and 2 showed differences. Semakau site 1 is adjacent to an extensive mangrove habitat, and has also been

affected by earth spoils dumping (Quek, 1989). Cyrene site 1 is next to a major shipping lane, and exposed to relatively strong wave action caused by shipping traffic. Hilomen & Gomez (1988) had shown association patterns for fish assemblages with areas of similar environmental conditions, and that areas with different wave exposure supported different fish assemblages.

The separation of Pulau Hantu from Hantu West patch reef in the dendrogram was probably due to disturbance by sport divers. Pulau Hantu is a popular weekend dive site, and although Hantu West patch reef is just adjacent to Pulau Hantu, it is much less visited. Raffles Lighthouse is not only the furthest from the main island, but access to it is also highly restricted. The site is also next to the open sea and has better flushing conditions. These factors would account for the high fish species richness.

The strong positive correlation of fish abundance to distance from the main island could be due to a combination of factors, among them the effects of sedimentation and the influence of divers and fishermen on the reef fish population. Decreased levels of sedimentation further from the mainland has been reported (Lane, 1991). Also, as some of the further reefs are also restricted areas or less frequented by divers and fishermen, the impact of man's activities on the reef fish are lessened. While this correlation is not be illusory (ie. nonsense correlation) (Sokal & Rohlf, 1973), distance from the mainland would definitely not be the sole contributing factor. Other factors, such as turbidity of the waters, the general lack of reef topographical features (Lim & Chou, 1991b), feeding habits, wave action (Gomez *et al.*, 1988; Hilomen & Gomez, 1988) and territoriality (Leng, 1990) would be contributory.

This study indicates the existance of some sort of spatial pattern in the distribution of Singapore reef fishes. Factors influencing the pattern however, are not clearly identified, although there are indications of it being distance related. Attempts at determining temporal patterns were not successful.

## ACKNOWLEDGEMENTS

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