Preliminary Analysis of Demersal Fish Assemblages in Malaysian Waters

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Abstract

Spatial and temporal variations of the demersal fisheries resources of Malaysia were studied using multivariate analysis of their abundance (biomass) from research trawl surveys in relation to geographical and environmental parameters. TWINSPAN results indicate that the demersal resources of Malaysia can be geographically divided into five major species assemblages. Two assemblages are in Peninsular Malaysia and three assemblages are in Sabah and Sarawak waters. In general the demersal resources can be grouped into three types: assemblages associated with coastal/mangrove communities, with the offshore (deepwater) ecosystem and an intermediate assemblage. The coastal assemblage is found in shallow coastal waters, less than 40 m depth, while the offshore assemblage is beyond the 90 m depth range. The intermediate assemblages occur between 40 to 90 m depth. Intermediate assemblages were observed in the entire peninsula of Malaysia. A coastal assemblage was also found on the West Coast of Peninsular Malaysia. The Sabah and Sarawak waters were characterized by all three types of demersal assemblages. Salinity and temperature were noted as the environmental parameters that influence the delineation of the species assemblages geographically. In terms of temporal variation, two periods in relation to the monsoon were recognized, the pre-monsoon period and the post-monsoon period, separated from each other in July.

Introduction

The marine waters of Malaysia are generally grouped into three areas, namely: (1) West Coast of Peninsular Malaysia (WCPM); (2) East Coast of Peninsular Malaysia (ECPM); and (3) Sabah and Sarawak Coast (Fig. 1). These areas include parts of the Straits of Malacca, South China Sea, Sulu Sea and Sulawesi Sea. In 1996, the total landings from marine capture fisheries of Malaysia were about 1.1 million t, with a value of RM 3.6 billion *(US$1.431 billion) (Department of Fisheries (DOF) 1969 - 96). The WCPM contributed about half the landings, while the ECPM and the Sabah and Sarawak Coast each contributed about a quarter of landings. The trawl is considered the most important fishing gear, contributing about 55% of the total marine landings. About 65% of the demersal fish landings are trawl-caught.

The fisheries resources of Malaysia show area variations that are not yet fully understood. This is despite the number of demersal research (trawl) surveys in the three areas since the 1930s. The trawl

* 1 US$ = RM2.51596 (1996)

survey data are under-utilized, and knowledge of demersal assemblages is lacking.

This paper represents a first attempt to explore the distribution of demersal fish assemblages in the three areas surrounding Malaysia using classification techniques. The analysis utilizing extant trawl survey data aims to provide explanations and insights into the spatial and temporal variation of demersal species assemblages, as well as the potential factors that explain the causes of such variations.

Materials and Methods

Trawl Survey Data

Trawl surveys conducted in 1972, 1981, 1987, 1991 and 1997 from the three marine areas (Fig. 1) were used for this study. Demersal trawl surveys in Malaysia consist of coastal and offshore surveys. The coastal waters are subdivided into three zones based on distance from the coastline, namely: Zone A (0 - 5 nm), Zone B (5 - 12 nm), and Zone C (12 - 30 nm). The offshore waters (Zone D) are those beyond 30 nm up to the Exclusive Economic Zone (EEZ) boundary (see Fig. 1). The trawl surveys in 1972, 1981, and 1991 were coastal surveys while those conducted in 1987 and 1997 were offshore/EEZ surveys.

Two different sampling designs were employed during the surveys (i.e. grid sampling for the coastal surveys, and random stratified sampling for the offshore/EEZ surveys). In the grid sampling, the position of the trawl sampling station was normally at the center of a small grid (usually 10 x 10 nm). The survey area was divided into grids without any stratification and practically all the grids were visited. In the offshore surveys, the study area was first geographically divided into sub-areas, which were then further divided into depth strata. A three-depth strata system was normally applied (20 - 60 m, 60 - 100 m and 100 - 200 m) following the methodology outlined by Mackett 1973. The offshore surveys involved grid sizes of 15 x 15 nm.

The surveys were carried out using a bottom trawl. Each trawl haul lasted one hour at a constant trawling speed of 5.4 $km \cdot hr^{-1}$ and 7.2 $km \cdot hr^{-1}$ for the coastal and offshore surveys respectively. The catch from each haul was sorted and identified to Species Level (when possible), weighed and recorded. Identification to Species Level was done only for the more recent surveys (i.e. 1987, 1991 and 1997). In earlier surveys, taxonomic identification were done to the Family Level.

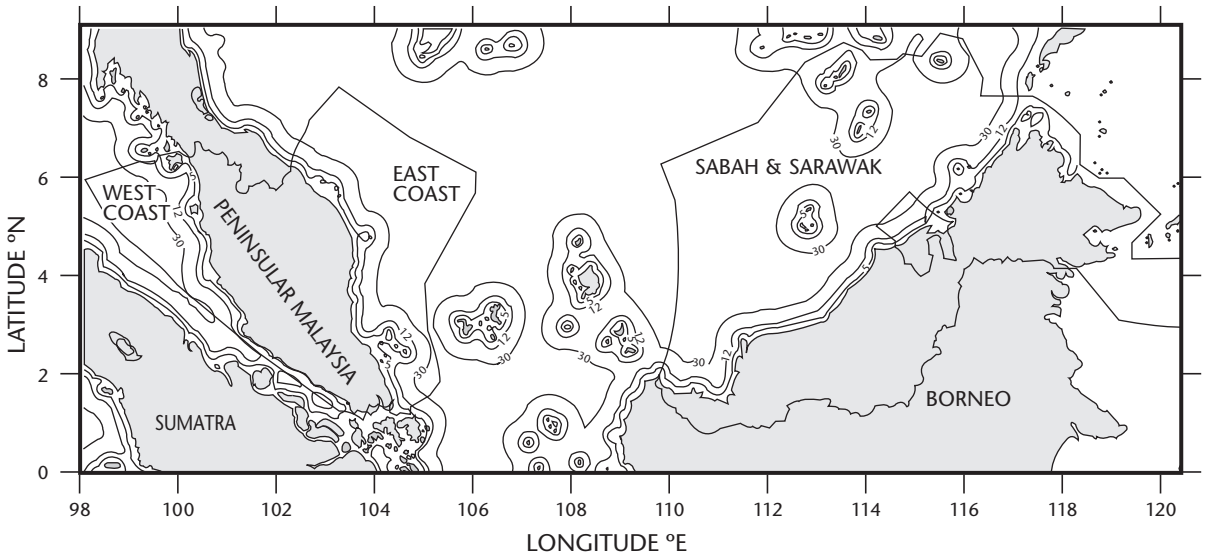

Fig. 1. Geographical boundaries of the three major coastal marine areas of Malaysia. Spatial and legal boundaries of Malaysia. Delineation of fishing area by distance from the coastline. (Zone A: 0 - 5 nm; Zone B: 5 - 12 nm; Zone C: 12 - 30 nm; Zone D: > 30 nm).

The research vessel K.K. Jehanak (85 GRT, 325 HP and 23 m LOA) and similar boats (Penyeledik I and II) were used for the coastal surveys in 1972, 1981 and 1991. For the offshore/EEZ surveys, R.V. Rastrelliger (390 GRT, 1320 HP and 46 m LOA) was used in 1987, and K.K. Manchong (150 GRT, 900 HP and 27 m LOA) in 1997. The locations of the trawl sampling stations during the surveys are illustrated in Appendix 1.

For the coastal surveys, a nylon trawl net with 40 mm cod-end mesh size and a head-rope length of 22.4 m was used. The head-rope length was increased to 34.8 m in the 1991 survey. The effective trawl net opening used in calculation of stock density was half the head-rope length. For the offshore survey in 1987, the trawl net used was made of nylon with a cod-end mesh size of 50 mm and a head-rope length of 79.5 m. Using sonar equipment, the effective trawl opening was calculated to be 26 m. For the 1997 offshore survey, the trawl net was made of polyethylene with a cod-end mesh size of 38 mm and ahead-rope length of 47.1 m. Using sonar, the trawl opening was calculated to be 19 m. For standardization purposes, the stock density for all surveys (coastal and offshore) were corrected to 40 mm mesh size and a value of 0.6 was used as a catchability factor.

Data Analyses

The **T**wo-**W**ay **IN**dicator **S**pecies **AN**alysis (TWINSPAN) software (Hill 1979) was used for classification analysis using the trawl survey data. To analyze the trawl survey data in a single run, a data compression method based on grid area was applied. Species were grouped to Family Level due to inconsistency in species identification over all five surveys. Using this method, station data belonging to the same grid area in one survey period were averaged for each family. This procedure resulted in a reduction in the number of samples (stations) from 1598 stations to 251 stations for a single run analysis using the TWINSPAN software. In addition, the species density values were transformed from $kg{\cdot}nm^{-2}$ to $kg{\cdot}nm^{-2}$ ($x\ 10^2$) to make the data suitable for analysis. Using the compressed data, the following analysis steps were then undertaken to obtain the spatial assemblages in the study areas:

1. Overall analysis - TWINSPAN run using the compressed data matrix consisting of 251 stations (20 x 20 nm grids square), resulting in two main groups (coastal and offshore).
2. Sub-group analysis - separate TWINSPAN runs for the coastal group and offshore group, resulting in five distinct assemblages. For each sub-group analysis, the grid square size was reduced to 10 x 10 nm to achieve higher resolution.
3. Mapping of clustered stations and validation of groups based on environmental parameters (salinity, depth).
4. Final delineation of assemblages.

To explore seasonal variations in the fish assemblages, two assemblages with a comprehensive coverage of months in a year were used (i.e. Assemblage 2 - the ECPM waters, and Assemblage 4 - Sabah/Sarawak area). The data used for this analysis was also analyzed using TWINSPAN and the same data was utilized for sub-group analysis.

Results and Discussion

Spatial Analysis

In the overall analysis of the 251 grids (stations) two distinct groups were found, coastal and offshore assemblages. The sub-group analysis for coastal assemblages yielded two groups, Peninsular and Sabah/Sarawak. In comparison, the analysis of the offshore assemblages separated the groups into west coast, east coast and Sabah/Sarawak area. Overall, the TWINSPAN results indicate that the demersal fish resources of Malaysia can be geographically divided into five major assemblages (see Fig. 2). The delineation was based on salinity and temperature or at the depth contour of 40 m (the WCPM and Sabah-Sarawak areas) and 90 m (Sabah-Sarawak). With salinity and temperature as the main factor, the demersal resources can be grouped into three assemblage types: assemblages associated with coastal / mangrove communities, offshore (deepwater) ecosystem assemblages, and intermediate assemblages. The coastal assemblage is found in shallow coastal waters less than 40 m deep, while the offshore assemblage is beyond the 90 m depth range. The intermediate assemblages are observed between 40 to 90 m.

Fig. 3 shows the sub-group mapping analysis and delineation of the clustered stations for assemblages 1 and 2. The clustered stations from the TWINSPAN analysis of the coastal data of Peninsular Malaysia are overlaid on the clustered stations

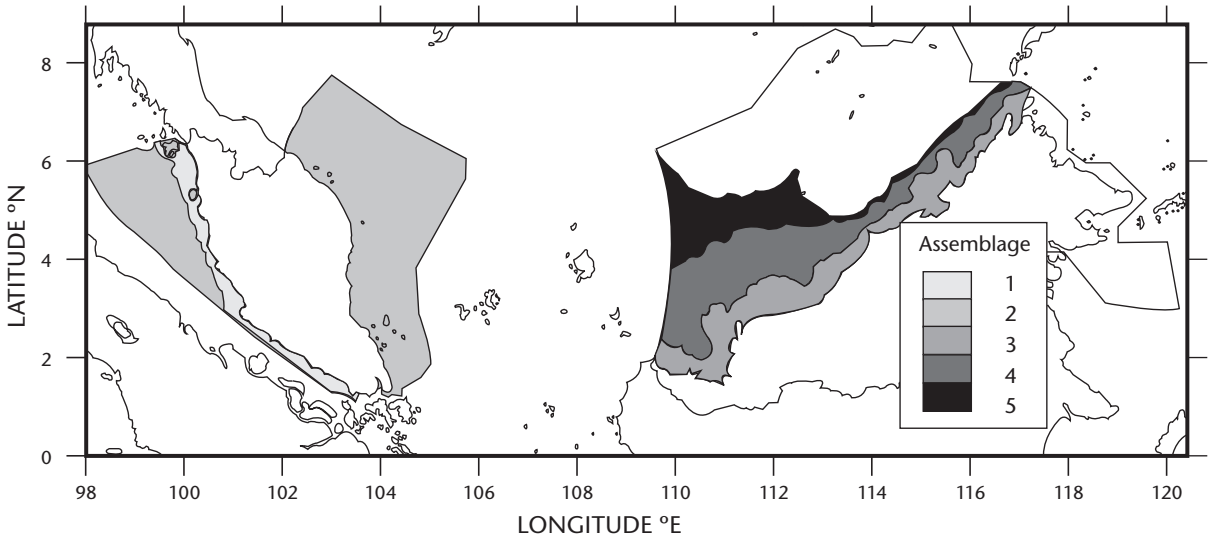

Fig. 2. Geographical delineation of major fish assemblages in Malaysia.

obtained from the analysis of the offshore data of Peninsular Malaysia. The map shows that the assemblages obtained from the coastal and offshore data on the ECPM are actually only one assemblage (Assemblage 2). On the other hand, the analysis on the WCPM showed two distinct assemblages that were delineated at a depth of about 40 m. Overall, two assemblages (Assemblage 1 and Assemblage 2) can be recognized in Peninsular Malaysian waters.

Similarly, Sabah and Sarawak waters can be divided into three distinct assemblages (Fig. 4). Assemblage 3 is situated close to the shore and is delineated from Assemblage 4 at about the 40 m depth contour. Assemblage 5 is located offshore and delineated from the Assemblage 4 at about 90 m depth. Assemblage 4 is the intermediate assemblage and is situated between 40 to 90 m depth.

Table 1 presents the species composition of the assemblages. It is evident that miscellaneous fish, mostly small-sized or trash fish and Leiognathids (slipmouths), are predominant in the coastal areas (i.e. Assemblages 1, 2a, 3 and 4), while Monacanthids (filefishes) are dominant in the offshore areas and along the East Coast of Malaysia.

The generalized fish assemblage structure covering the demersal resources in Malaysia based on the TWINSPAN results are summarized in Fig. 6. The assemblages are geographically (spatially) delineated by depth. Shallow coastal waters, less than 40 m depth, where the coastal assemblages are found, the offshore assemblages are beyond 90 m depth range, and intermediate assemblages are observed between 40 to 90 m depth. Salinity and temperature are also perceived to influence the distribution of fish communities. However, further research and data analyses is needed to confirm their specific effects on the fish assemblages.

Table 1. Percentage of abundance and species composition of the five major assemblages of demersal resources in Malaysia.

Assemblage 1		Assemblage 2a		Assemblage 2b		Assemblage 3		Assemblage 4		Assemblage 5	
Taxa	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**	**Taxa**	**%**
Miscellaneous	10.98	Leiognathidae	9.73	*Monocanthus* spp.	8.83	Miscellaneous	32.17	Miscellaneous	31.60	*Thamnaconus hypargyreus*	62.68
Leiognathidae	9.73	Miscellaneous	8.70	Miscellaneous	8.65	Mullidae	9.40	Mullidae	8.23	Miscellaneous	7.81
Rastrelliger kanagurta	9.39	Mullidae	5.93	*Nemipterus* spp.	8.07	Leiognathidae	7.72	*Nemipterus* spp.	5.88	*Saurida* spp.	3.40
Loliginidae	8.82	*Priacanthus* spp.	4.78	Sciaenidae	7.45	Carangidae	4.36	Dasyatidae (rays)	4.82	*Priacanthus* spp.	3.08
Leiognathus splendens	4.10	Nemipteridae	4.26	Leiognathidae	5.98	Dasyatidae (rays)	4.18	Synodontidae	3.50	*Priacanthus macracanthus*	2.25
Mullidae	3.72	*Nemipterus* spp.	3.71	*Priacanthus* spp.	4.48	*Nemipterus* spp.	3.10	Clupeidae	3.47	*Decapterus kurroides*	2.05
Carangidae	3.54	Gerreidae	3.14	*Paramonacanthus* spp.	4.32	Ariidae	3.09	Ariidae	3.40	*Nemipterus* spp.	1.70
Dussumieria hasselti	3.38	Loliginidae	3.02	Mullidae	3.62	Clupeidae	2.66	Carangidae	2.12	*Saurida tumbil*	1.55
Anodontostoma chacunda	3.06	*Trichiurus haulmela*	2.75	Loliginidae	2.92	*Anodontostoma chacunda*	2.61	*Abalistes stellatus*	1.73	*Neocentropogon aeglefinis*	1.44
Trichiurus spp.	2.46	*Lutjanus argentimaculatus*	2.51	*Pentaprion* spp.	2.77	Sciaenidae	2.38	Sharks	1.51	*Nemipterus bathybius*	1.38
Secutor insidiator	2.34	*Loligo* spp.	2.43	Carangidae	2.43	Sharks	2.31	*Pomadasys* spp.	1.43	*Diodon* spp.	1.00
Pampus argenteus	2.01	Synodontidae	2.17	*Scolopsis* spp.	1.72	*Pomadasys* spp.	2.30	Lutjanidae	1.26		
Sciaenidae	1.97	Carangidae	2.13	Dasyatidae (rays)	1.68	Gerreidae	2.15	*Pentaprion longimanus*	1.26		
Triacanthus brevirostris	1.75	*Leiognathus* spp.	2.06	Ariidae	1.63	Synodontidae	2.02	Loliginidae	1.24		
Pennahia macropthalmus	1.68	*Pentaprion longimanus*	1.97	*Selaroides leptolepis*	1.51	Lutjanidae	1.87	Leiognathidae	1.12		
Synodontidae	1.61	*Saurida undosquamis*	1.84	Synodontidae	1.47	Pomadasyidae	1.22				
Chirocentrus dorab	1.53	*Abalistes stellatus*	1.43	*Pentapodus* spp.	1.39	Loliginidae	1.07				
Triacanthus spp.	1.43	*Lagocephalus* spp.	1.36	*Loligo* spp.	1.32						
Clupeidae	1.41	Dasyatidae (rays)	1.32	*Lagocephalus* spp.	1.17						
Nemipterus spp.	1.41	*Pentaprion* spp.	1.22	*Terapon* spp.	1.00						
Ariidae	1.19	*Saurida* spp.	1.17								
Pomadasys spp.	1.12	*Atule mate*	1.10								
Loligo spp.	1.02	*Upeneus sulphureus*	1.01								
Priacanthus spp.	1.00										

Note: 1 - West Coast (coastal), 2a - West Coast (offshore), 2b - East Coast (whole area), 3 - Sabah/Sarawak (coastal), 4 - Sabah/Sarawak (shallow-offshore), 5 - Sabah/Sarawak (deep-offshore).

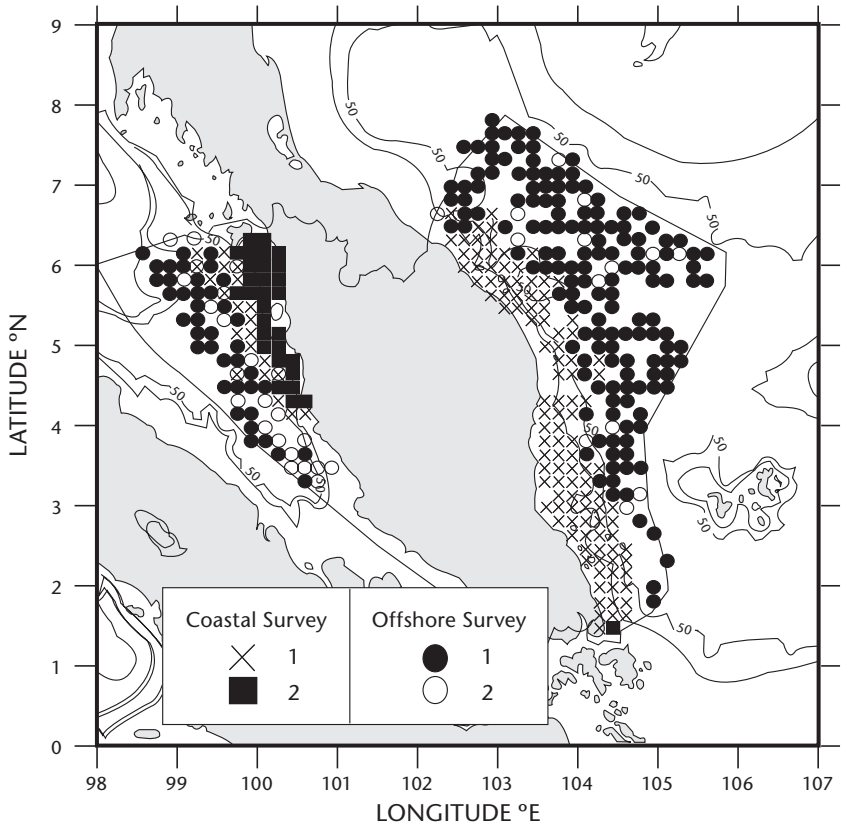

Fig. 3. Delineation of fish assemblages 1 and 2 off the west and east coasts of Peninsular Malaysia.

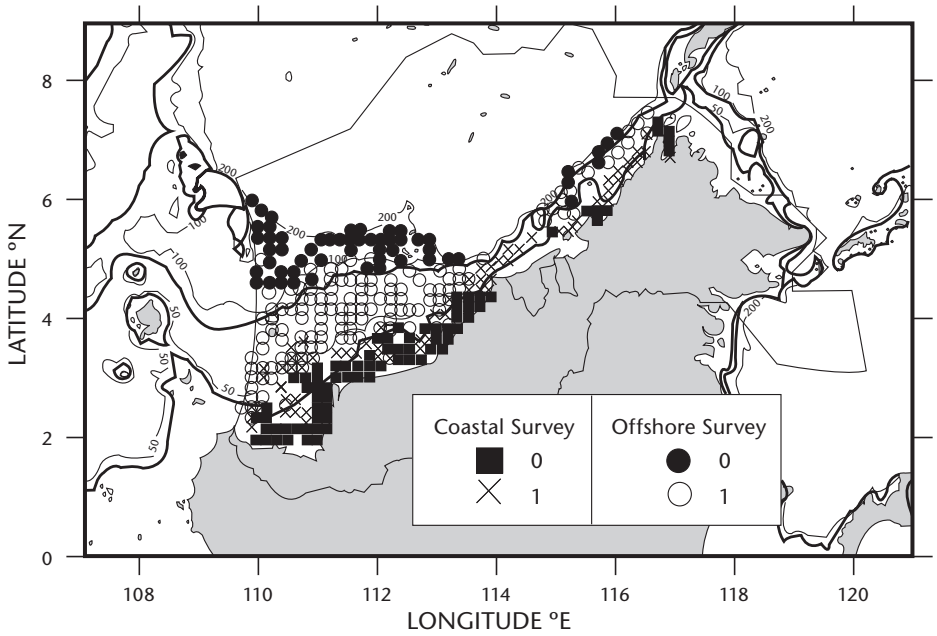

Fig. 4. Delineation of fish assemblages 3, 4 and 5 in Sabah and Sarawak waters, Malaysia.

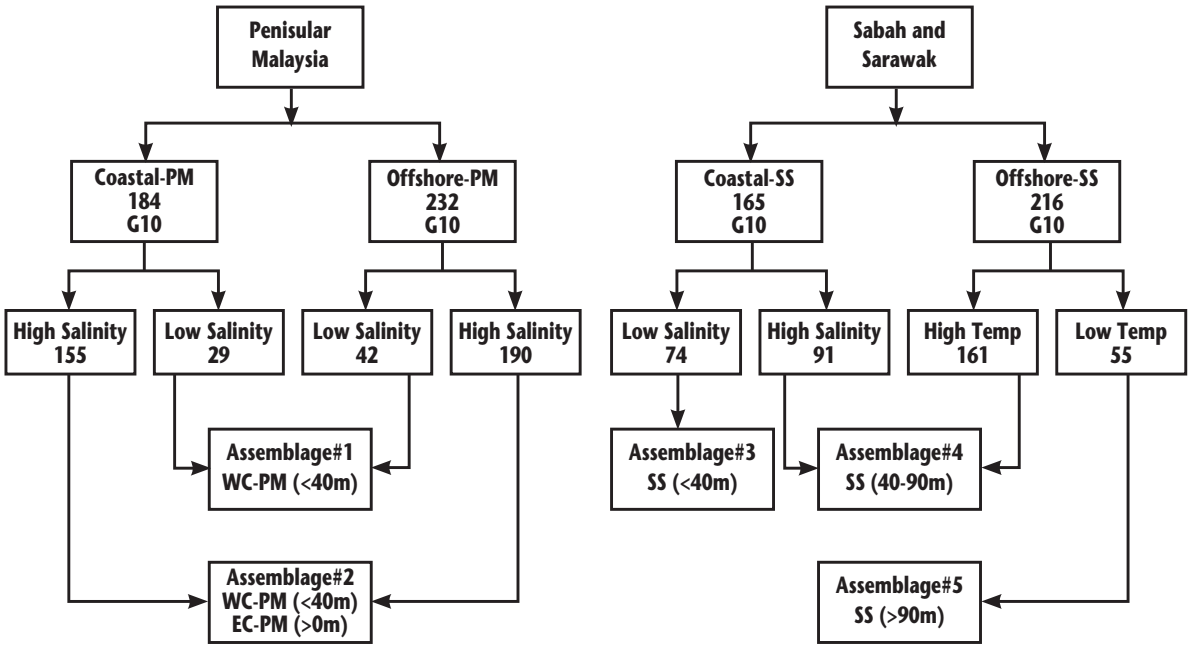

Fig. 5. Generalized classifications of the major fish assemblages in Malaysia.

Exploratory Temporal Analysis

Seasonal variations on the fish abundance were examined using Assemblage 2 (the east coast waters) and Assemblage 4 (Sabah/Sarawak area). In general, two seasonal periods were apparent. Both assemblages showed that the fish communities were differentiated by two temporal phases, the pre-monsoon season (June to November) and the post-monsoon season (March to June). Table 2 gives a summary of species/taxa that are abundant during the pre-monsoon and post-monsoon seasons.

Figs. 6 and 7 show the seasonal variations in terms of average fish density from the coastal and the offshore surveys respectively. The offshore surveys indicate that the ECPM has a relatively higher density of demersal fish during the pre-monsoon season as compared to the post-monsoon. Unlike on the ECPM, seasonal variation has little effect on the abundance and distribution of the demersal resources in Sabah-Sarawak waters. Moreover, consistent with general ecological principles, higher fish densities were obtained in coastal areas as compared to the offshore areas.

Table 2. List of abundant taxa during the post- and pre-monsoon seasons for the ECPM and Sabah/Sarawak waters.

East Coast		Sabah/Sarawak	
Post-monsoon	**Pre-monsoon**	**Post-monsoon**	**Pre-monsoon**
Tricanthidae	Lobsters	Sphyraenidae	Serranidae
Theraponidae	Lethrinidae	Lactariidae	Scombridae
Engraulidae	Balistidae	Labridae	Menidae
Tetraodontidae	Monacanthidae	Crustaceans	Lobsters
Sparidae	Lutjanidae	Soleidae	Lethrinidae
Pomacentridae	Sphyraenidae	Leiognathidae	Balistidae
Platicidae	Nemipteridae	Gerreidae	Trash fish
Megalopidae	Mmullidae	Siganidae	Psettodidae
Istiophoridae	Trichiuridae	Platycephalidae	Nemipteridae
Soleidae	Synodonthidae	Bivalves	Cephalopoda
Psettodidae	Serranidae	Shrimps	Carangidae
Pomadasyidae	Gerreidae	Rays	Plotosidae
Menidae	Plotosidae	Muraenesocidae	Ephipiidae
Caesionidae	Carangidae	Cynoglossidae	Clupeidae
Sharks	Sillaginidae	Bothidae	Chaetodontidae
Leiognathidae	Cephalopoda	Tricanthidae	Priacanthidae
Ariidae	Bothidae	Crabs	Centrolophidae
Muraenesocidae	Crustaceans	Caesionidae	Sciaenidae
Ariommidae	Crabs	Mullidae	Engraulidae
	Siganidae	Ariommidae	Theraponidae
	Platycephalidae		Chirocentridae
	Scombridae		Ariidae
	Rays		Tetraodontidae
	Trashfish		Sharks
	Shrimps		Drepanidae
	Achycentridae		Sparidae
	Labridae		Rachycentridae
	Bivalves		Pomacentridae
	Polynemidae		Lutjanidae
	Cynoglossidae		Stromateidae
	Sciaenidae		Batrachoididae
	Clupeidae		Sillaginidae
	Batrachoididae		Pomadasyidae
			Platacidae

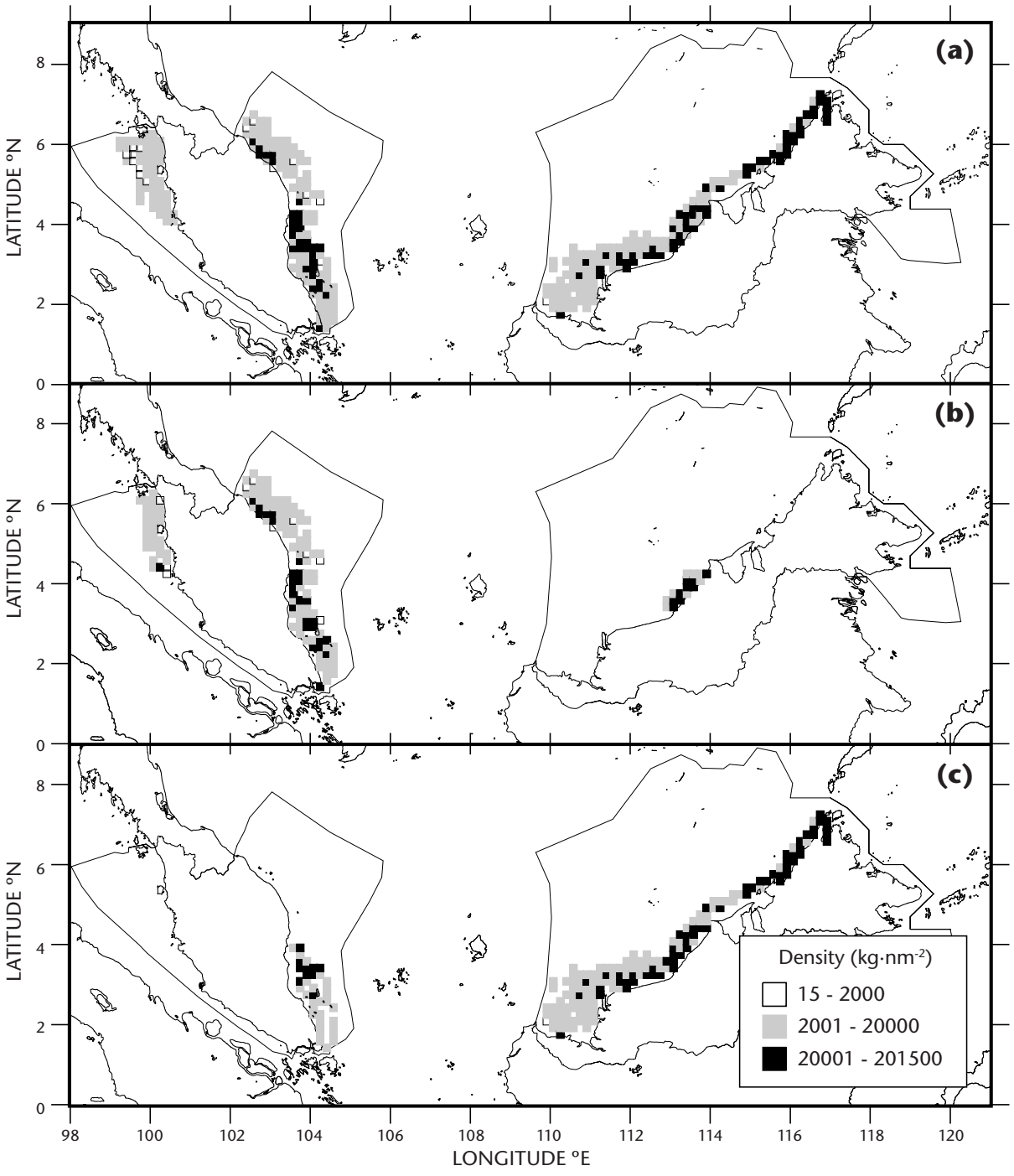

Fig. 6. Seasonal variation on the average fish density from the coastal surveys in Malaysia (a - average; b - pre-monsoon; c - post monsoon).

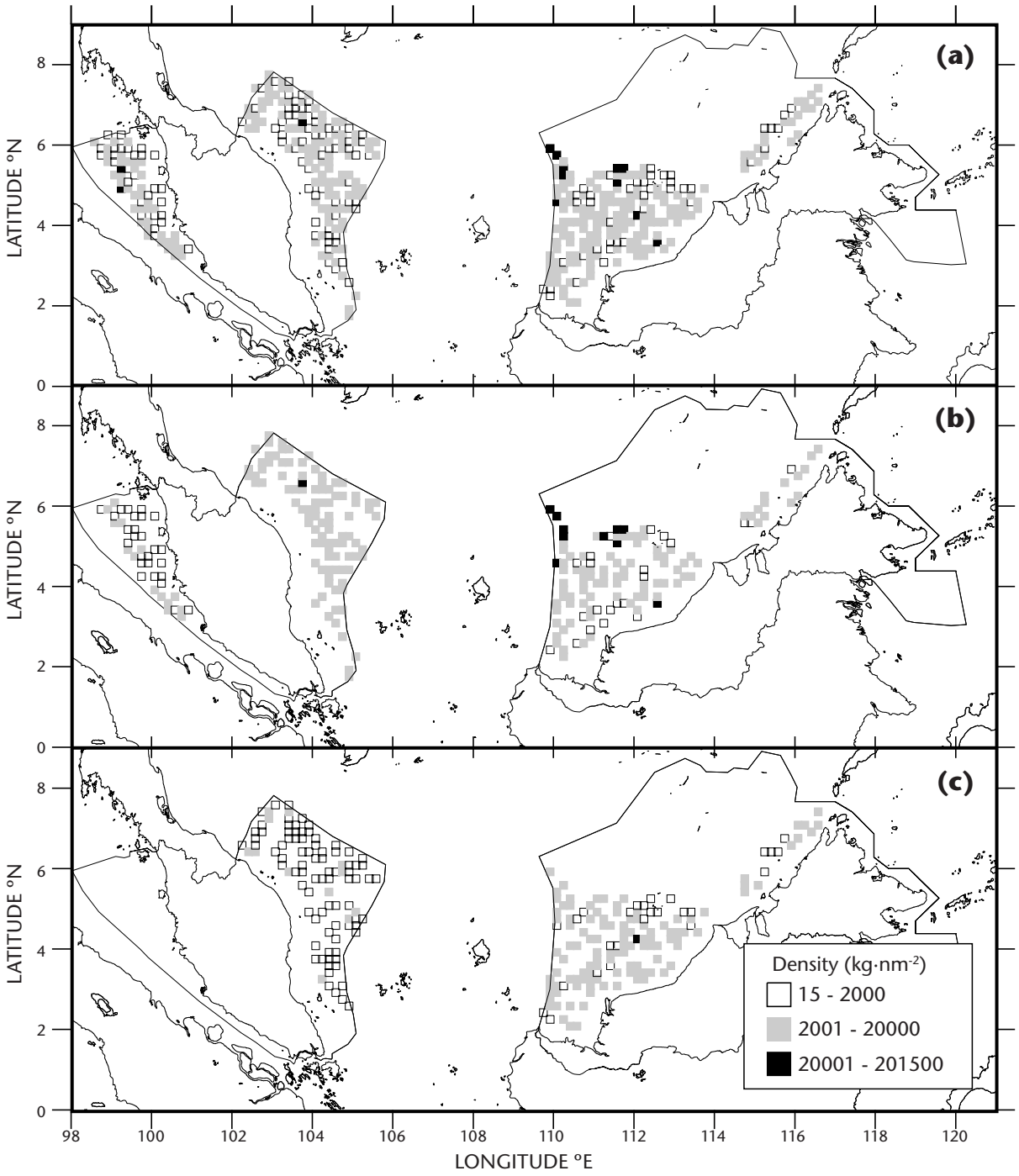

Fig. 7. Seasonal variation in average fish density from offshore surveys in Malaysia (a - average; b - pre-monsoon; c - post-monsoon).

Summary and Conclusion

Stock Boundary Delineation and Species Composition

The coastal assemblages off the WCPM and Sabah-Sarawak waters were similar. The coastal assemblages were separated at a depth of about 40 m. The main species were prawn and other mangrove-related fish species, caught mostly by prawn trawlers. The coastal assemblages have a relation to the mangrove areas, suggested by the fact that there was no such assemblage on the ECPM. On the east coast there are high salinity waters starting from the coastline. Mangroves are not present on the ECPM except in the southern part.

The offshore assemblage was separated into two; the shallower assemblage (between 40 – 90 m), and the deeper assemblage (> 90 m). The ECPM has the shallow offshore assemblage. For the WCPM and the Sabah and Sarawak waters, this assemblage is found immediately next to the coastal assemblage. The main component of this assemblage is the commercial demersal fish species, caught mostly by the fish trawlers. The deeper offshore assemblage can only be found in the Sabah and Sarawak waters, and is delineated at depths beyond 90 m. The main component of this fish assemblage is the low-value demersal fish species.

Implication on Research and Management

At present, the management of the fisheries rsources using various gear in Malaysia is based on the zoning system, that is, on the distance from the coastline (Fig. 2). This legally-binding zoning system allocates Zone A (0 – 5 nm) to traditional fisheries. Zones B, C and D are allocated to commercial fisheries. Zone B (5 – 12 nm) is for commercial fisheries with boats not larger than 40 GRT, Zone C (12 – 30 nm) is for commercial boats with 40 to 70 GRT, and Zone D is for boats greater than 70 GRT. With better information on fish assemblages, the management could be further improved. For example, mangrove communities in waters less than 40 m, on the west coast and in Sabah/Sarawak waters, need a special management strategy. These should be treated differently from the non-mangrove coastal communities found on the ECPM.

A more detailed analysis of the trawl survey data should be carried out to determine the spatial and temporal distribution of the demersal fish assemblages in the country. The results of the detailed analysis will be very useful for the review and possible revision of the zoning system.

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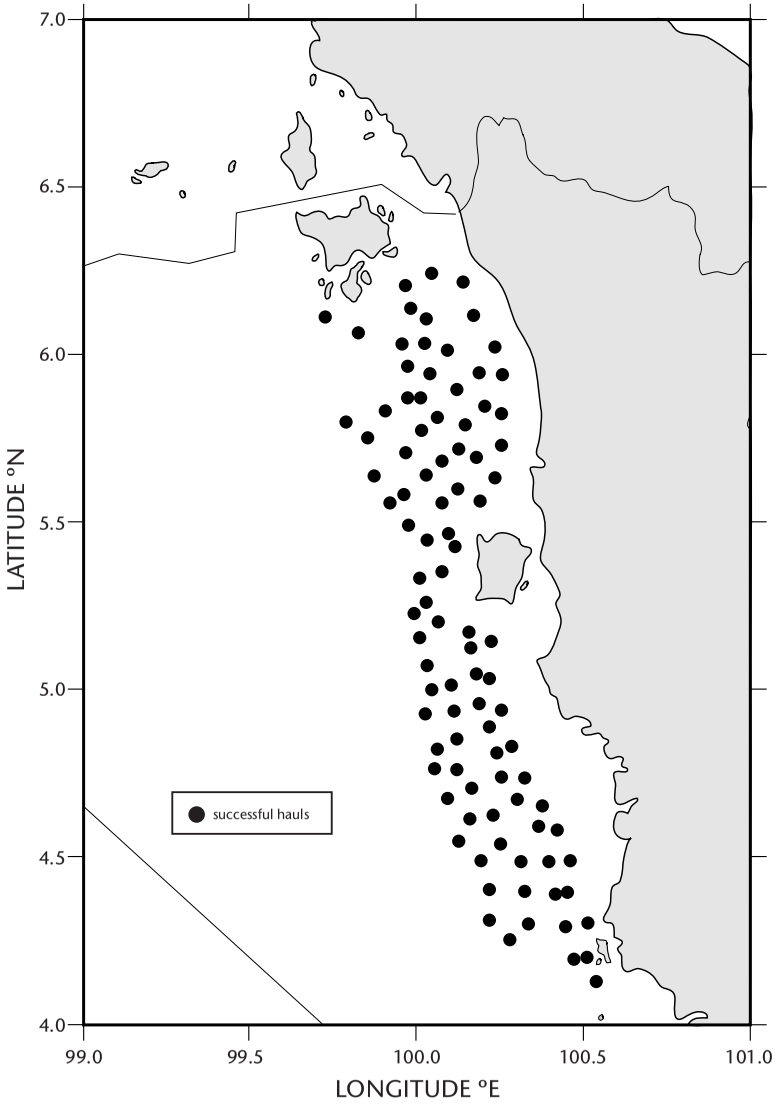
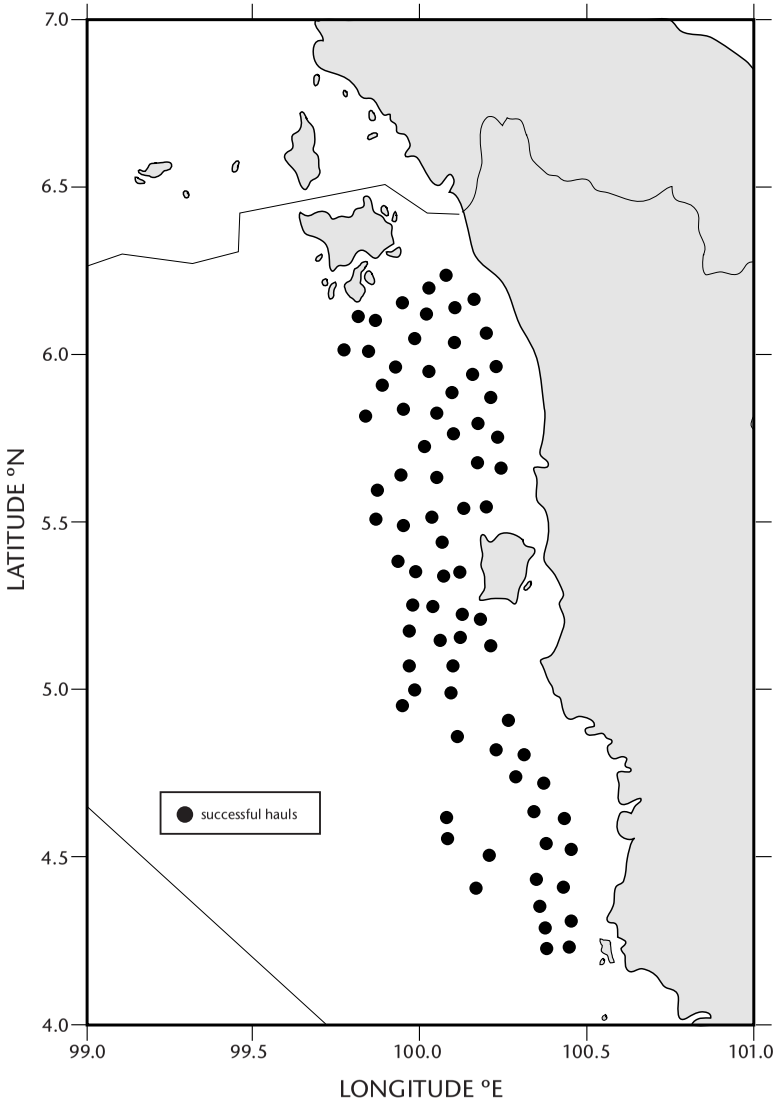
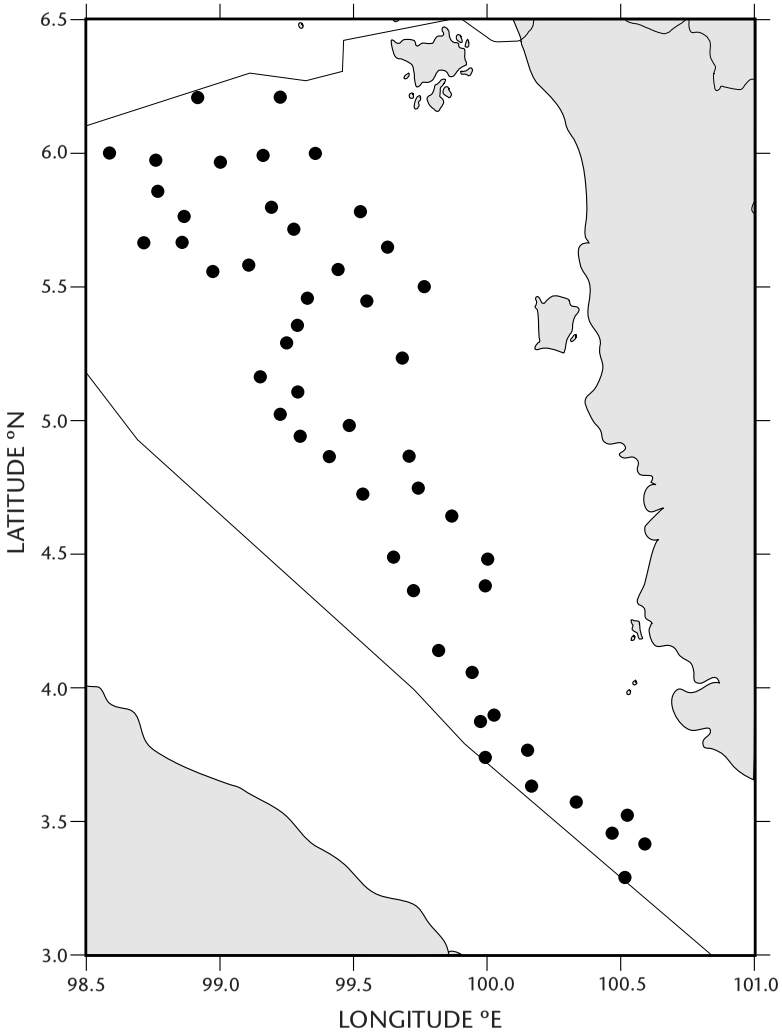


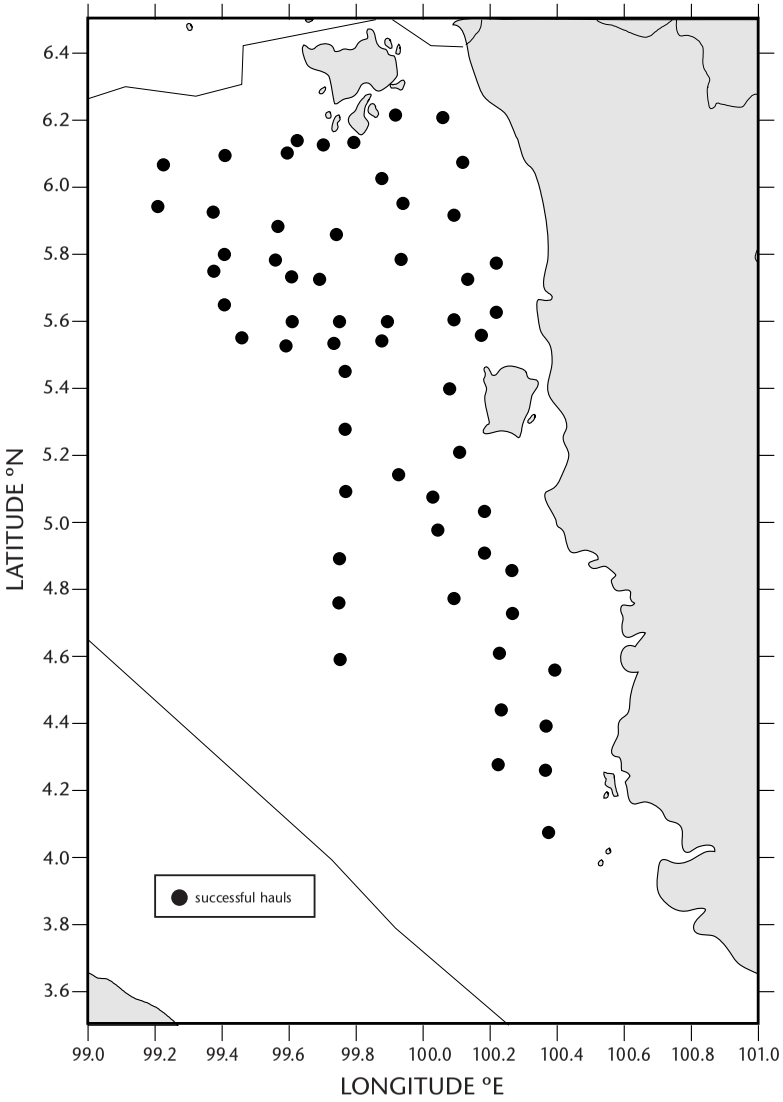
Appendix Fig. 1. Trawl sampling stations during the coastal survey on the WCPM in 1972.



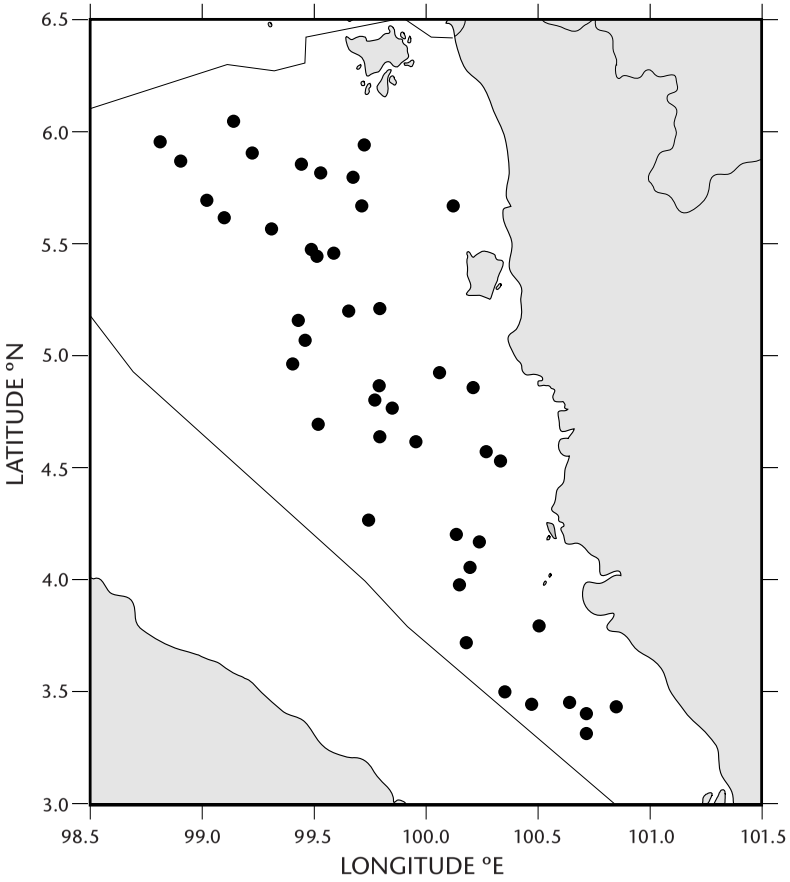
Appendix Fig. 2. Trawl sampling stations during the coastal survey on the WCPM in 1981.



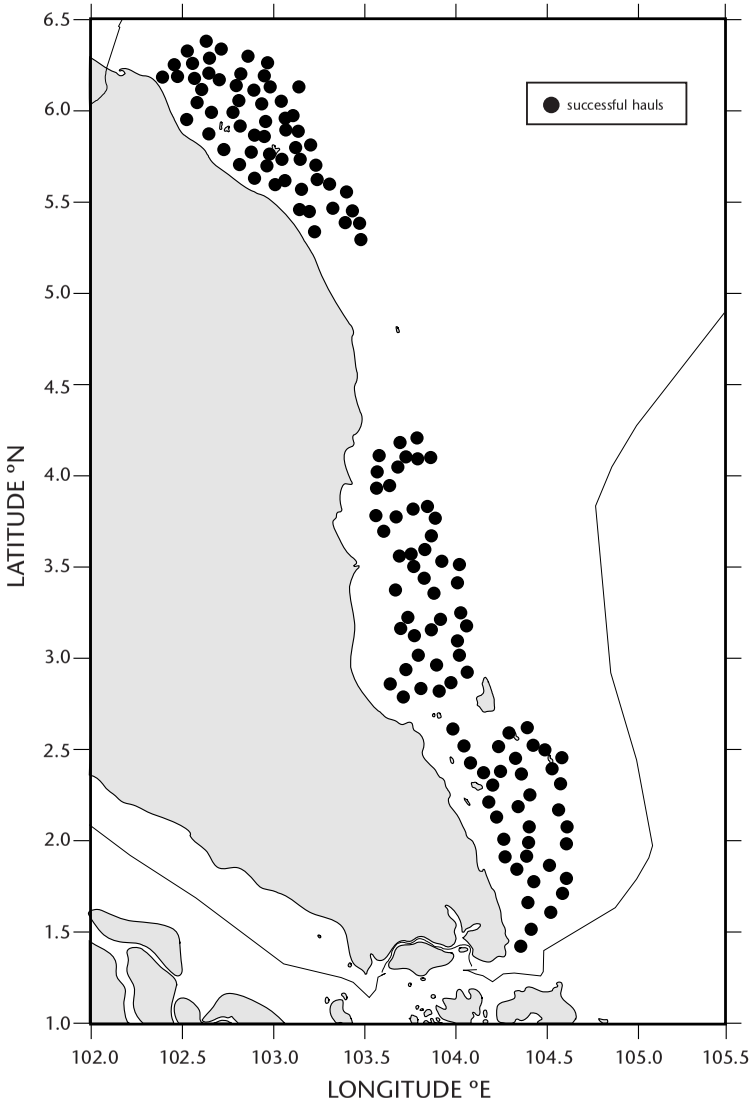
Appendix Fig. 3. Trawl sampling stations during the offshore/EEZ survey on the WCPM in 1987.



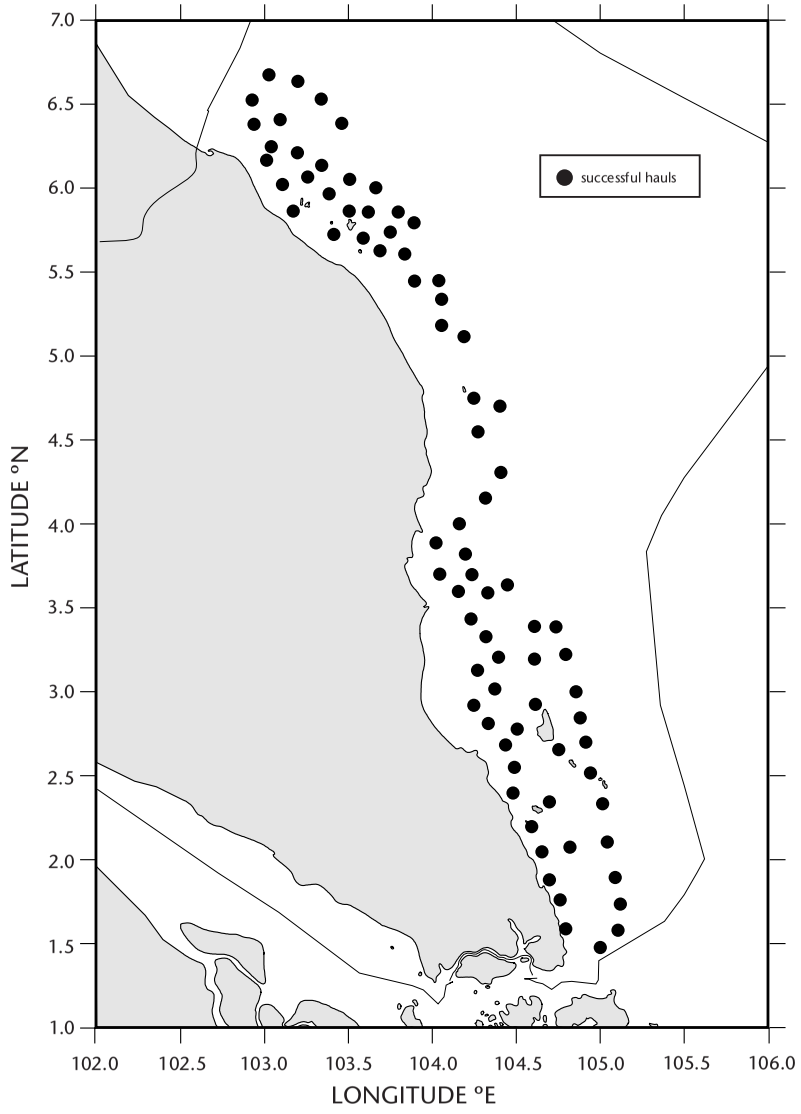
Appendix Fig. 4. Trawl sampling stations during the coastal survey on the WCPM in 1991.



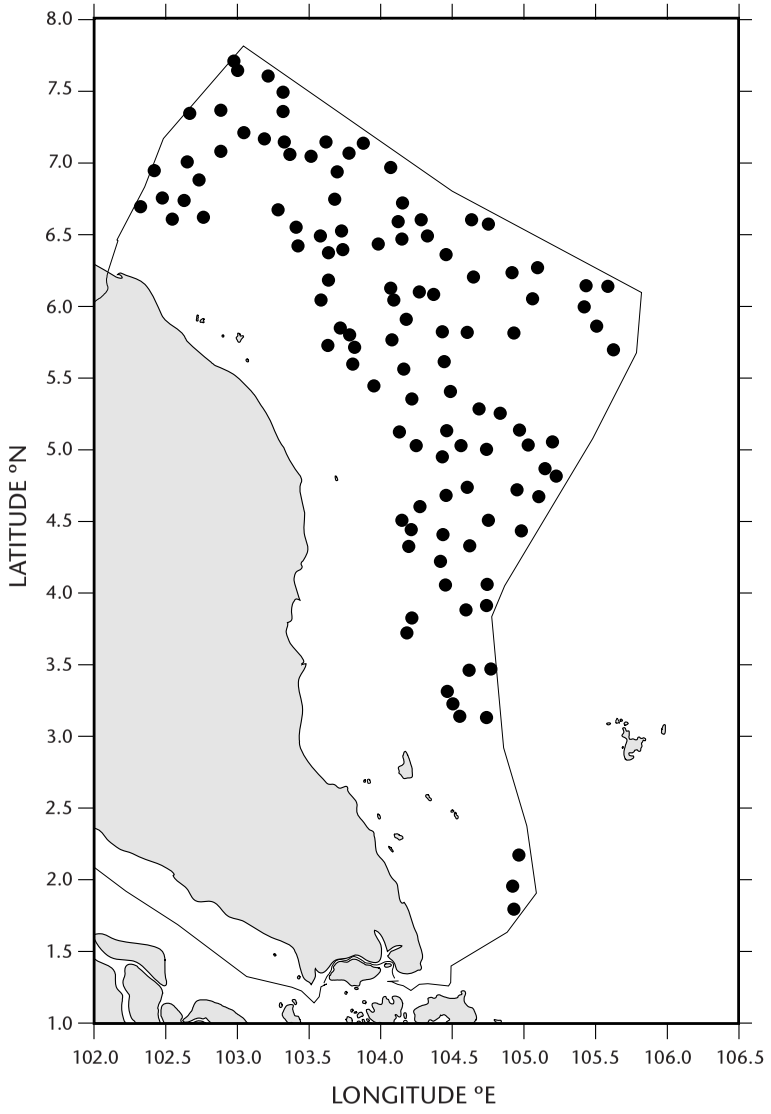
Appendix Fig. 5. Trawl sampling stations during the offshore/EEZ survey on the WCPM in 1997.



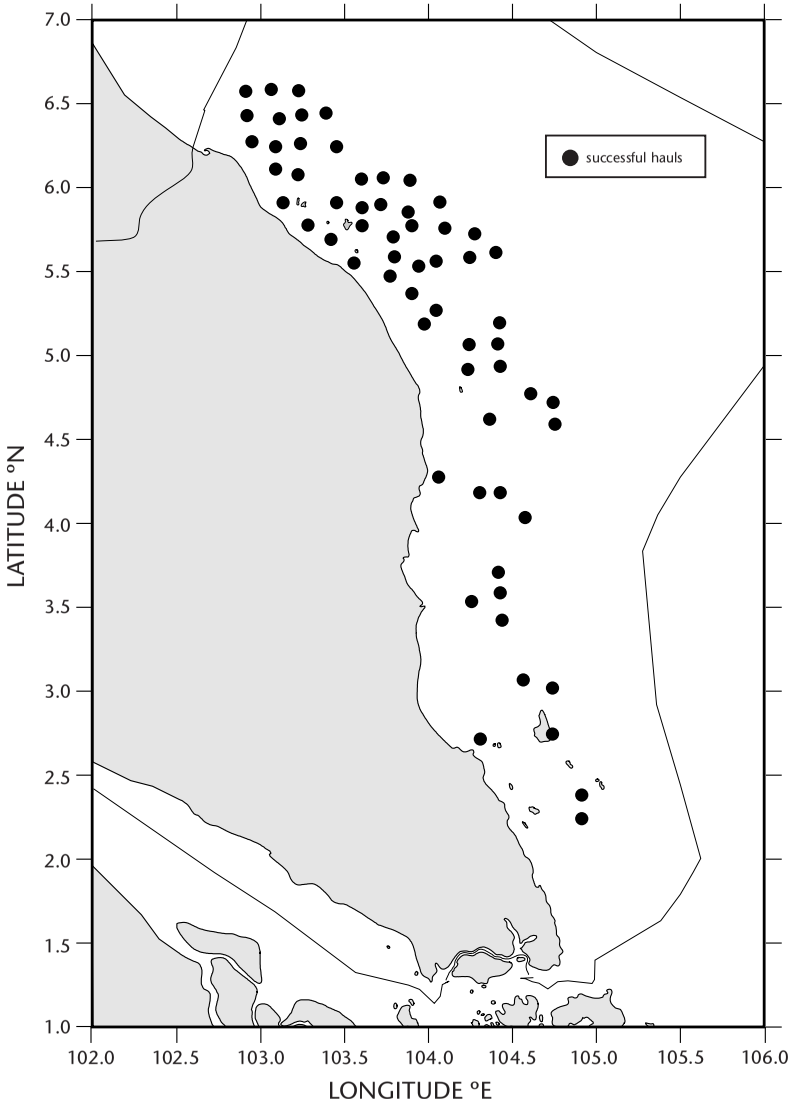
Appendix Fig. 6. Trawl sampling stations during the coastal survey on the ECPM in 1972.



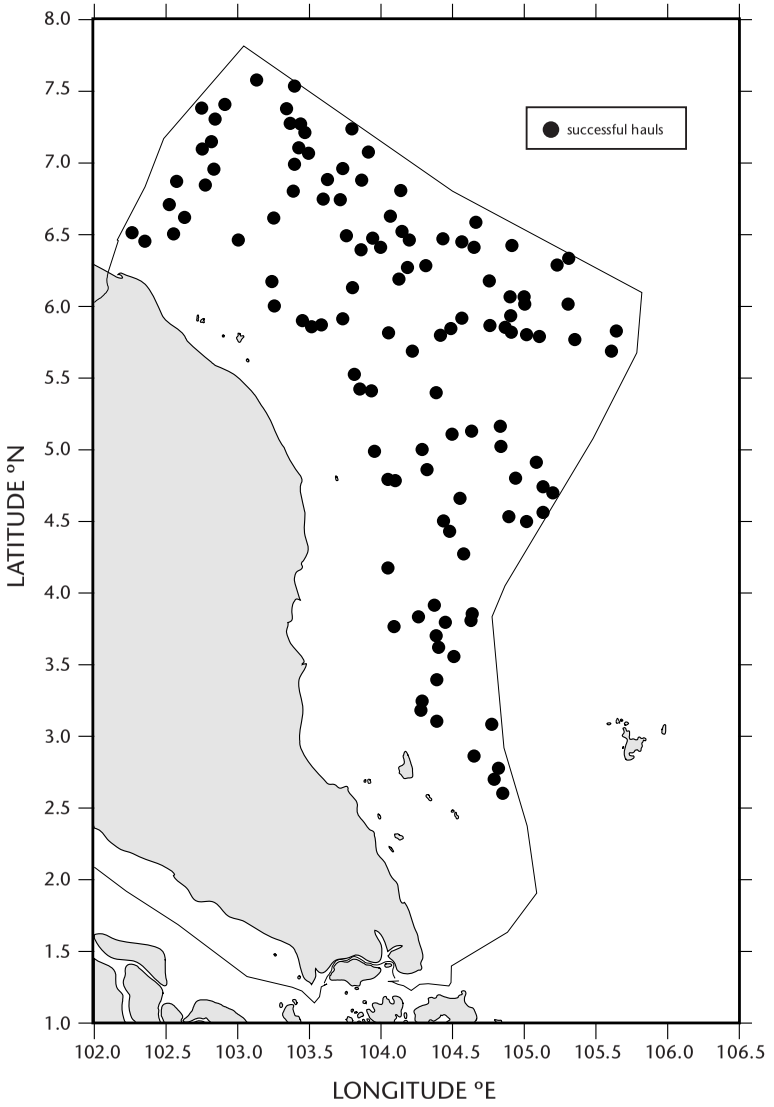
Appendix Fig. 7. Trawl sampling stations during the coastal survey on the ECPM in 1981.



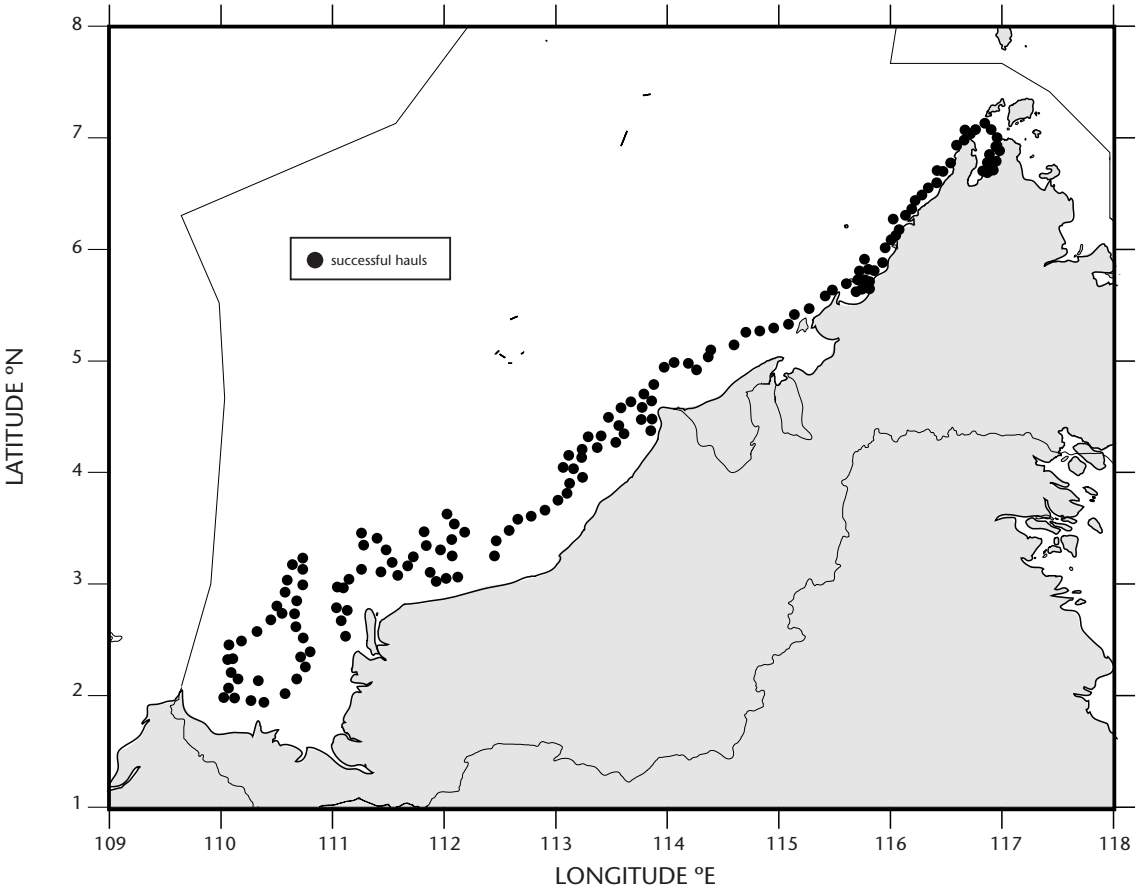
Appendix Fig. 8. Trawl sampling stations during the offshore/EEZ survey on the ECPM in 1987.



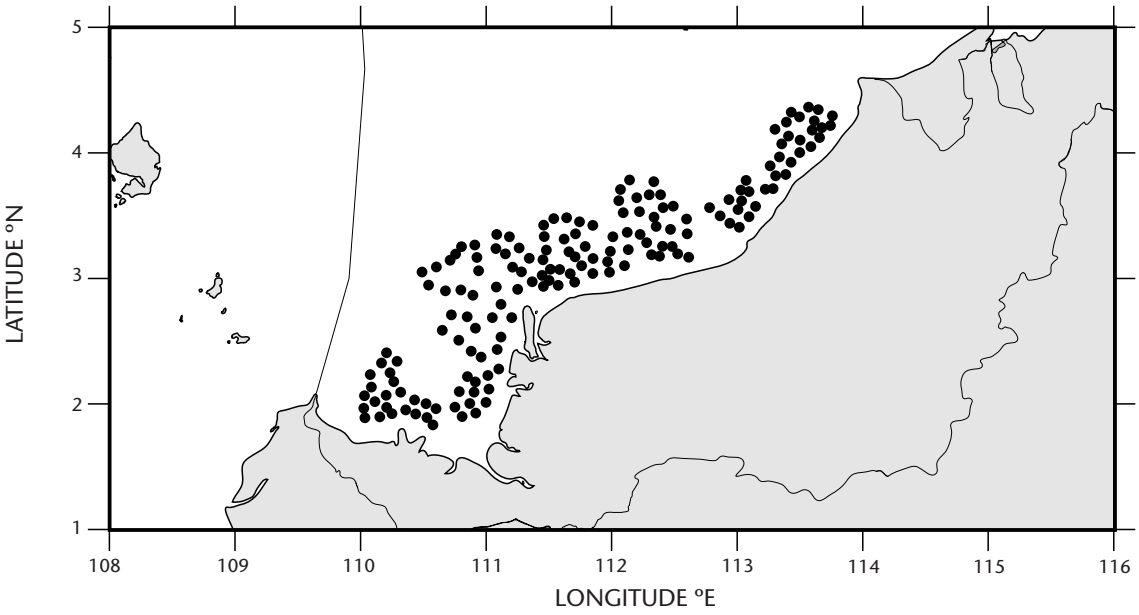
Appendix Fig. 9. Trawl sampling stations during the coastal survey on the ECPM in 1991.



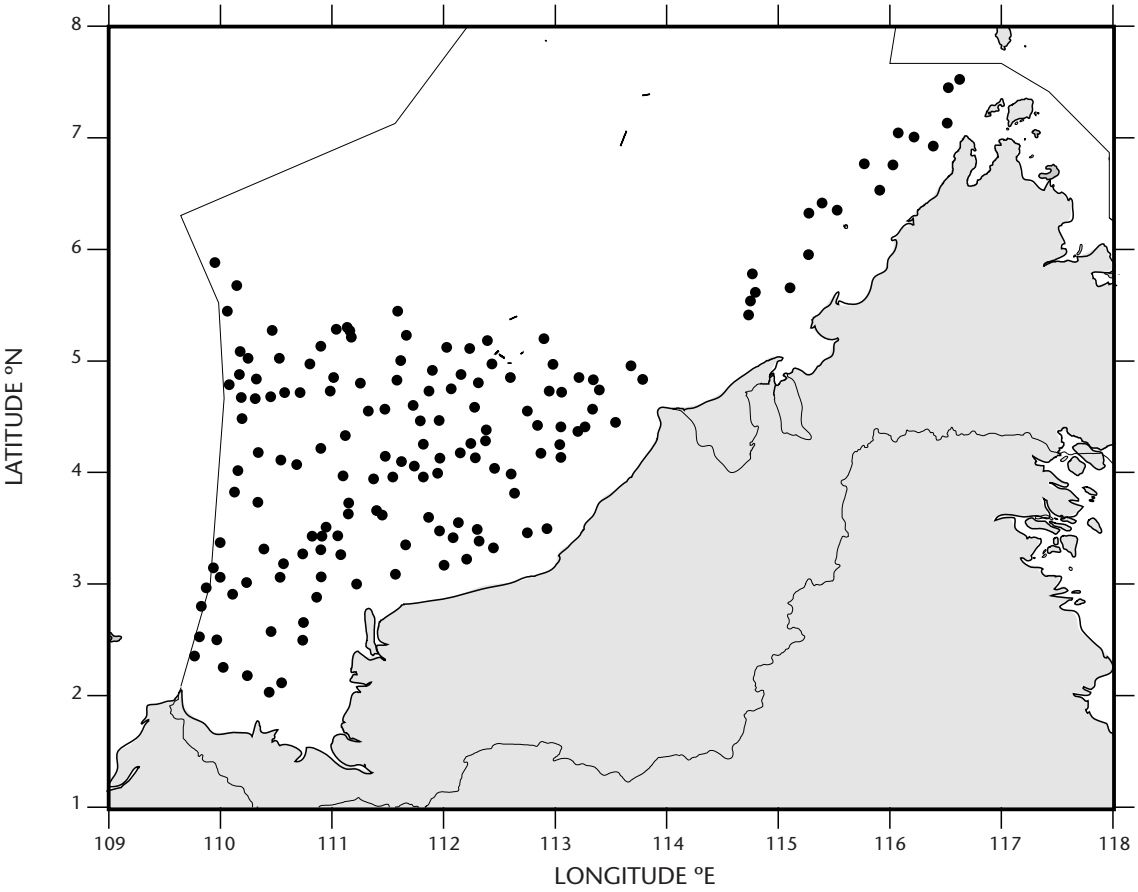
Appendix Fig. 10. Trawl sampling stations during the offshore/EEZ survey on the ECPM in 1997.



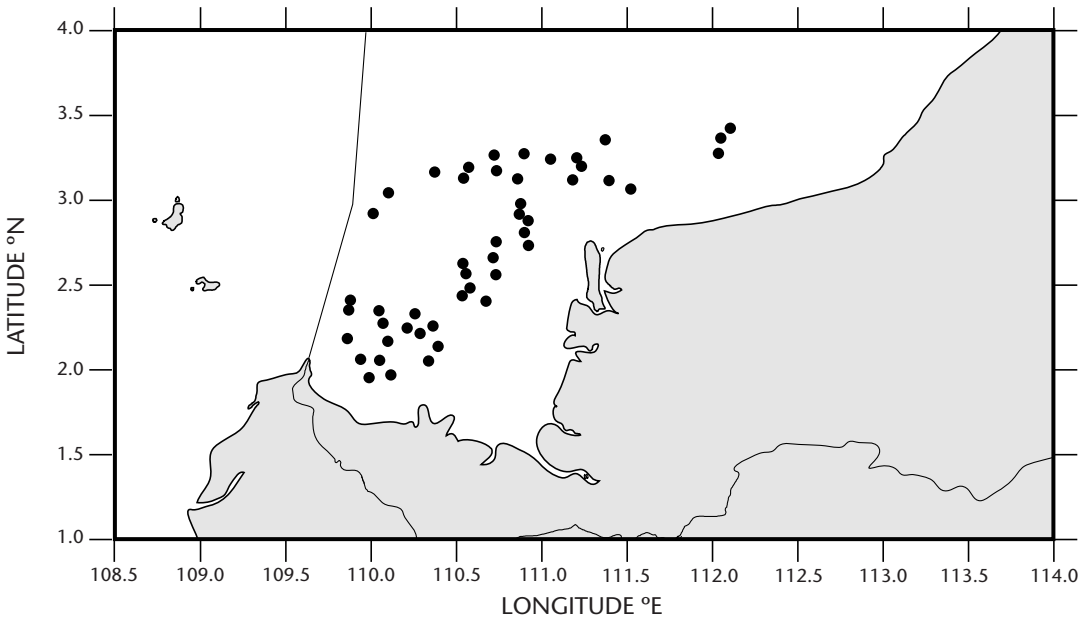
Appendix Fig. 11. Trawl sampling stations during the Sabah-Sarawak coastal survey in 1972.



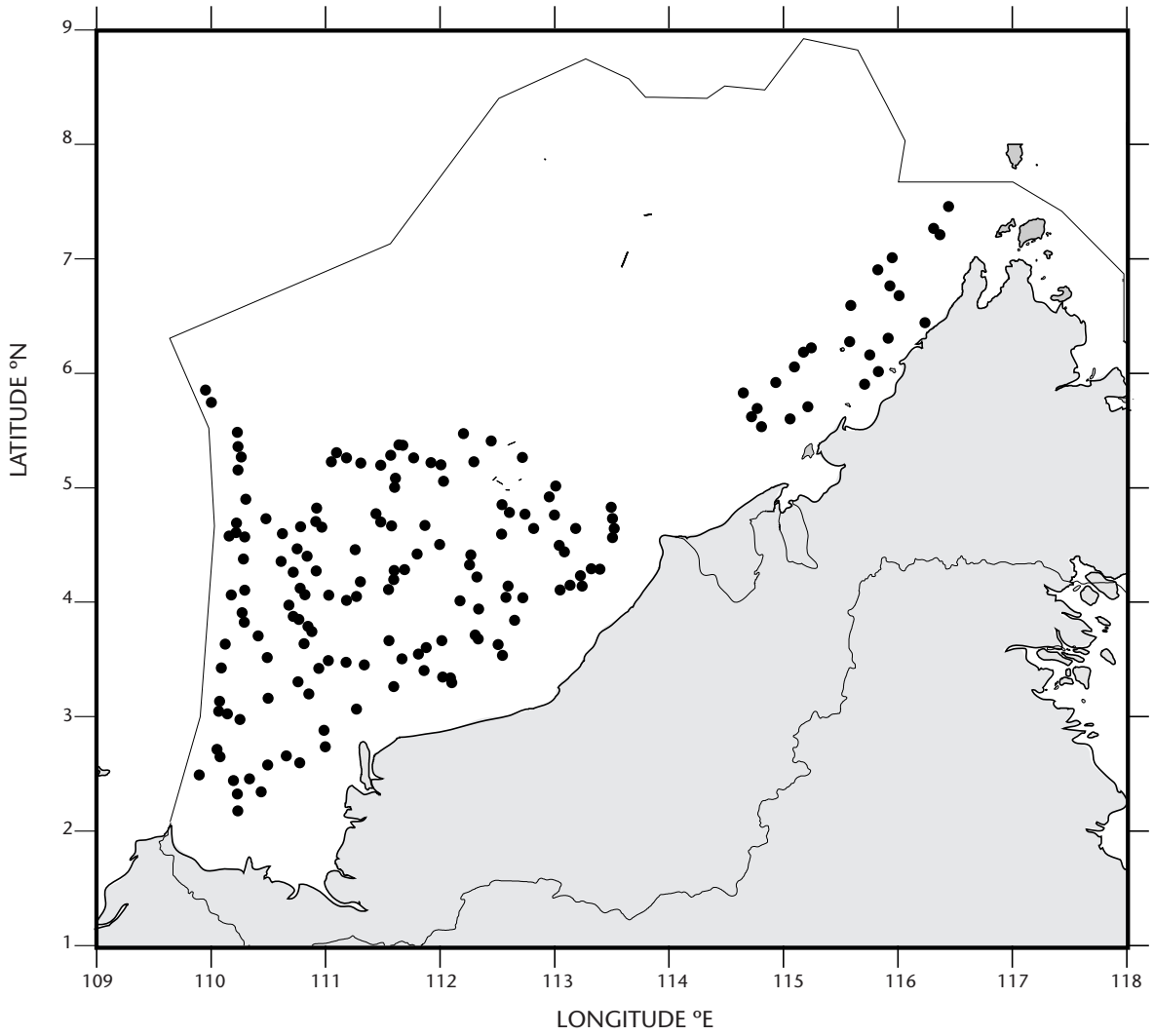
Appendix Fig. 12. Trawl sampling stations during the Sabah-Sarawak coastal survey in 1981.



Appendix Fig. 13. Trawl sampling stations during the Sabah-Sarawak offshore/EEZ survey in 1987.



Appendix Fig. 14. Trawl sampling stations during the Sabah-Sarawak coastal survey in 1991.



Appendix Fig. 15. Trawl sampling stations during the Sabah-Sarawak offshore/EEZ survey in 1997.