conditions.

Although the species composition of trawl catch in this fishingg ground was remarkably different from those of most areas in the South China Sea, a high similarity in species composition was observed between the catch of the present surveys and that obtained from waters off Sarawak in November 1972. During the latter trip, CHANGI operated only in shallow waters (26–48 m), and about 50% of total catch was occupied by croaker, catfish, shad, golden snapper, and jacks and scad, although red snappers also showed high percentage of 12.9% (in preparation). It appears therefore that the depth and bottom topography are factors which may determine the differences or similarities in species compositions of the two areas.

The trawl surveys were restricted to the months of December and January, and therefore, it is difficult to determine if seasonal fluctuation affects the species composition. However, it may be noted that white pomfret was caught in substantial amounts in the four cruises in December 1972 but was negligible in January 1973.

The differences in catch per hour and species composition have been shown to be related to depth. It seems that the good fishing grounds are distributed in the shallow waters of not more than 40 metres deep. However even within the shallow waters, the catch per hour varied considerably, indicating a rather patchy distribution of good fishing localities. The deeper waters, especially those at a depth of 6–80 metres yielded comparatively poor catch. Nevertheless, the mean value for catch per hour (168 kg) in such waters were at the same level as those in the good fishing grounds in the South China Sea.

The formation of good fishing grounds in the shallow water may not be attributed to the depth itself. A rich supply of nutrient salts, less saline water masses, and muddy bottoms caused by the discharge of Irrawaddi and Sittang Rivers may be supporting the high productivity thereby creating suitable environments for coastal demersal fishes in this region.

The fishing ground in north Andaman Sea is promising and has economic potential. However, more surveys need to be carried out to study the fluctuation of catch and the distribution pattern of the fishing ground.

5. ACKNOWLEDGEMENTS

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SEAFDEC/SCS.73: S–15

Demersal Fish Resources in Untrawlable Waters, Viewed through Vertical-Line Fishing

by
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Abstract

Rocky reefs (80–120 m. in depth) along shoulders of steep continental slope in the South China Sea and the Andaman Sea often provide potentially good fishing grounds. Demersal fish resources in these reefs, having quite different species composition from those in trawl fishing grounds, have been scarcely exploited so far.

The results of the recent surveys by Japanese research vessels and by R/V CHANGI revealed that vertical line fishing is promising in such untrawlable fishing grounds. The daily catch often exceeded one ton and was composed mainly of white snapper, gold-lined sea bream, grouper, pigface, trevally and jobfish.

The catch and species composition in different areas did not vary much provided that the above mentioned bottom feature and oceanic environment were present. Daily catch may fluctuate considerably the above men-

tioned bottom features but tends to be equally poor during the period around the 4th day of a lunar month.

While the relatively inexpensive fishing gear and equipment for vertical line fishing are important, the skill of skipper and crew in searching for fish schools and in the manoeuvring of vessel and gears will affect the catch.

1. INTRODUCTION

Except for its south western part, the South China Sea has only a narrow band of continental shelf. The 500 m depth contour approaches so near to the east coast of Vietnam, the eastern half of north coast of Borneo and the Philippines that the continental slopes are very steep in these areas. Rocky reefs are usually found along the shoulders (80–120 m. in depth) of the steep continental slope, and schools of esteemed fishes are often located in these untrawlable areas. Such potential fishing grounds, which may also occur in some bank formations of the South China Sea and in the Andaman Sea of the region, have not been fully developed and exploited.

For the past decade, some Japanese fishing boats have been operating vertical line fishing ("taté-nawa") in the South China Sea for the purpose of exploiting demersal fish resources especially white snapper (*Pristipomoides* spp.), inhabiting these rocky reefs. In 1971/72 fiscal year, the Japanese Marine Fisheries Resources Exploitation Center (MFREC) chartered two boats for experimental "taté-nawa" operations in the Andaman Sea. For the sake of convenience the two Japanese vessels are designated as boat I (276.3 GT) and boat II (100.0 GT) in this paper. Although a Japanese fiscal year is from April through March of the following year, boat I operated from November 1971 to March 1972 while boat II operated from January to May 1972. The results obtained have been encouraging (Anon., 1972 a, b). For 1972/73 fiscal year MFREC sent another vessel (boat III) to the Andaman Sea.

With the aim of exploring and developing every possible fisheries resource in the region the Marine Fisheries Research Department of the Southeast Asian Fisheries Development Center (SEAFDEC) has been preparing for "taté-nawa". In February/March and April 1973 the 387 GT research vessel CHANGI conducted two preliminary vertical line operations, one to the Andaman Sea and another to the South China Sea respectively.

As there is an urgent need for intensive and concerted research on the abovementioned fisheries resources the present paper summarizes the results of experimental vertical line fishing obtained mainly by boats I and II.

2. DATA USED AND TREATMENT OF DATA

2.1 Main data

For the most part of this paper, the operation and catch records of boats I and II are utilized. The catches are given for each of the major species in terms of number of boxes (each containing 11 kg. of fish on average) plus individual number of surplus fish, and in the case of boat II in terms of total individual number. As is explained later in 3.2, daily operation was made at several locations. Boat II gives the catch record for each spot, while boat I gives the daily total catch. Before freezing, some of the fish species were dressed (viz. the head and viscera were cut off) and the catch record of these species represents headless fish. Average yield rate of dressed fish for each of these species is also shown in the report (Lit. Cit., 1972 a).

In this study the following treatment of the catch records of the two boats were made before any further calculation:

The catch of boat II at each spot was totalled to a daily catch.

The daily catch in kilograms was obtained by a) multiplying the number of boxes by 11 kg. and b) multiplying the individual number of surplus fish by average body weight of each species. The latter calculation was based on the total individual number caught, total number of boxes and total individual number of surplus fish obtained by boat II for the whole experimental period.

From the average yield rate of dressed fish the recorded catch of each of the dressed fish was converted into the catch of round fish. On analysis the logarithm-transformations were made on the catch record. Thus, in this paper, the means are geometric means.

2.2 Supplementary data

Since the data obtained by CHANGI during the 9-day operation in the Andaman Sea and 4-day operation in the South China Sea are limited they can only be used as supplementary data. Besides, with the exception of the second author, none of the crew had the experience in operating "taté-nawa." The exercise therefore provided the crew the opportunity to gain some experience in vertical line fishing rather than being only to collect data for the assessment of fish resources.

The boat III from MFREC conducted her first and second trips in the period from August to September 1972. Since no other record is available for these months which are in the south-west monsoon season, her catch record for the period is utilized as additional data.

3. BRIEF ACCOUNT OF FISHING GEAR AND FISHING METHOD

3.1 Fishing gear

The fishing gear used by CHANGI, not very different from those used by boats I and II, is composed of the following:

a) a lead line (nylon, 180 lbs., 300 m. long)
b) a main line (nylon, 130 lbs., 3 m. long) connected to a free end of lead line by means of swivel
c) four to five branch lines (nylon, 80 lbs., 50 cm. long) attached to a main line with swivels at intervals of 1.5 m.
d) a hook of 6 cm. long at an end of each branch line
e) a sinker, 1.0 to 2.0 kg, at a lower end of a main line
f) a reel (30 cm. in diameter) with a guide roller, stopper, clutch and winding handle for facilitating the paying-out and pulling-in of lead line.

Many varieties or modifications may be possible to improve the catching efficiency. A Japanese commercial boat, about 80 tons, operating on Vangurd Reef in the South China Sea as witnessed by CHANGI used sinkers which also served as containers for attractant bait.

3.2 Method of operation

Fish schools are located by means of the fish-finder. As schools of desirable fishes are distributed on rocky reefs along the shoulder of the steep, it is wise to sail in a zigzag fashion along the upper margin of the steep. As soon as a school of demersal fishes is found, a marker-buoy is set and the vessel is allowed either to drift or anchor while angling near the buoy.

Slices of fresh squid, small-sized fish either fresh or salted, etc. are used as bait giving almost no difference in result. Feeding activity of fish school may last for only 30 minutes or even a few hours. When the fish school stops feeding, the vessel shifts its position a little or begins a search for the next school. Daily operations are, therefore, made at several spots.

4. FISHING GROUNDS: WHERE TO SEEK FOR FISH SCHOOLS

4.1 Topography of sea bottom

Fig. 1 illustrates the areas where boats I, II and CHANGI conducted operations after fish schools were located. The fishing grounds were found only in narrow belts along the upper margins of continental slope or around islands and banks. The depth of the sea seems to be one of the important factors for forming good fishing grounds. While rocky reefs of depths of 80 to 120 m. found along the shoulders of the steep always provide good fishing grounds, desirable fish schools are seldom found or reefs of similar topography in shallow waters such as 30 to 40 m. deep.

4.2 Oceanographic conditions

In Fig. 1, the operated areas are grouped into 5 geographical areas, A–E, for convenience of explanation. Table I compared the mean catch per day by areas.

From the table, it is obvious that no good catch is expected in area E. The fact that the number of days operated in area E is few also means that promising fish schools were rarely recorded by the fish-finder inthis area.

The other four areas, A–D, were considered to be of the same value as fishing grounds. Their confidence limits of mean catch per day overlapped even at such a low level as 68%. Areas C and D were visited less often, since the catches were not much different from those in areas A and B while the distance from the base port in Penang is greater. Boat II spent 3 days in searching for fishing grounds in the northern Andaman Sea beyond 14° latitude, but without much success.

Table II shows the change in surface and bottom salinity from the Straits of Malacca to the Andaman Sea observed by CHANGI in February 1973.

Combining the geographic distribution of good fishing grounds and the oceanographic conditions, it seems that good fishing grounds for vertical line are formed only in areas of oceanic waters. Furthermore, prominent upwellings were often found to exist in areas of good fishing ground as determined by sea observation as well as by a fish-finder.

5. SPECIES COMPOSITION OF CATCH AND SIZE OF FISH

5.1 Main objectives of vertical line fishing

While snapper (*Pristipomoides*) is by far the most important species among the catch, usually occupying about 60% or more of total catch. Gold-lined sea bream (*Gnathodentex mossambicus*) comes next, constituting about 20% of the total catch. Groupers (*Epinephelis* and *Cephalopholis*), pigface (*Lethrinus*), trevally (*Caranx chrysophrys*) and jobfish (*Aphareus rutilans*) are also of some significance in the catch.

Table I. Geometric means of catch per day by area calculated for combined data of boats I and II for the whole period, Nov. 1971 to Apr. 1972

Area	A	B	C	D	E
Days operated	97	21	6	6	5
Mean catch per day (kg)	552	585	331	1044	24
Antilog. of standard deviation	2.32	2.61	2.44	1.79	3.22
68% confidence limits					
Upper limit (kg)	1290	1530	809	1890	79
Lower limit (kg)	238	224	136	586	8

Table II. Salinity of the sea along the west coast of Malay Peninsula by latitude, February 1973

Latitude	5°00'N	7°00'N	9°30'N	12°00'N	15°05'N
Depth of the sea (m)	82	78	160	2000	43
Salinity °/00					
Surface	31.58	32.18	32.76	32.04	30.59
Bottom	33.94	34.56	34.98	34.96	34.10

Pristipomoides typus and *P. filamentosus reseus* are two species of white snapper, of which the former outweighed the latter by about 1.5 times. There are 2 types of *P. typus* which show a rather remarkable difference in some features such as body colour and patterns on the head (in one type several yellow stripes run horizontally on the cheek some of which extend onto the body, while the other type is more reddish in colour without yellow stripes), suborbital depth, etc., although both have the same number of lateral line scales, 49–50. Important among several species of groupers caught are *Epinephelus chlorostigma*, *E. amblycephalus*, *E. areolatus* and *E. morrhua*. Pigface is composed of two species, *Lethrinus miniatus* and *L. choerorhynchus*.

5.2 Species composition by area

Table III showsthe species composition of the catch by boats Iand II for the whole period of operations. Species compositions of catch are not much different by areas, except for area E. According to information obtained from the Japanese commercial boat mentioned in 3.1, the catches in the South China Sea do not show much difference in species composition.

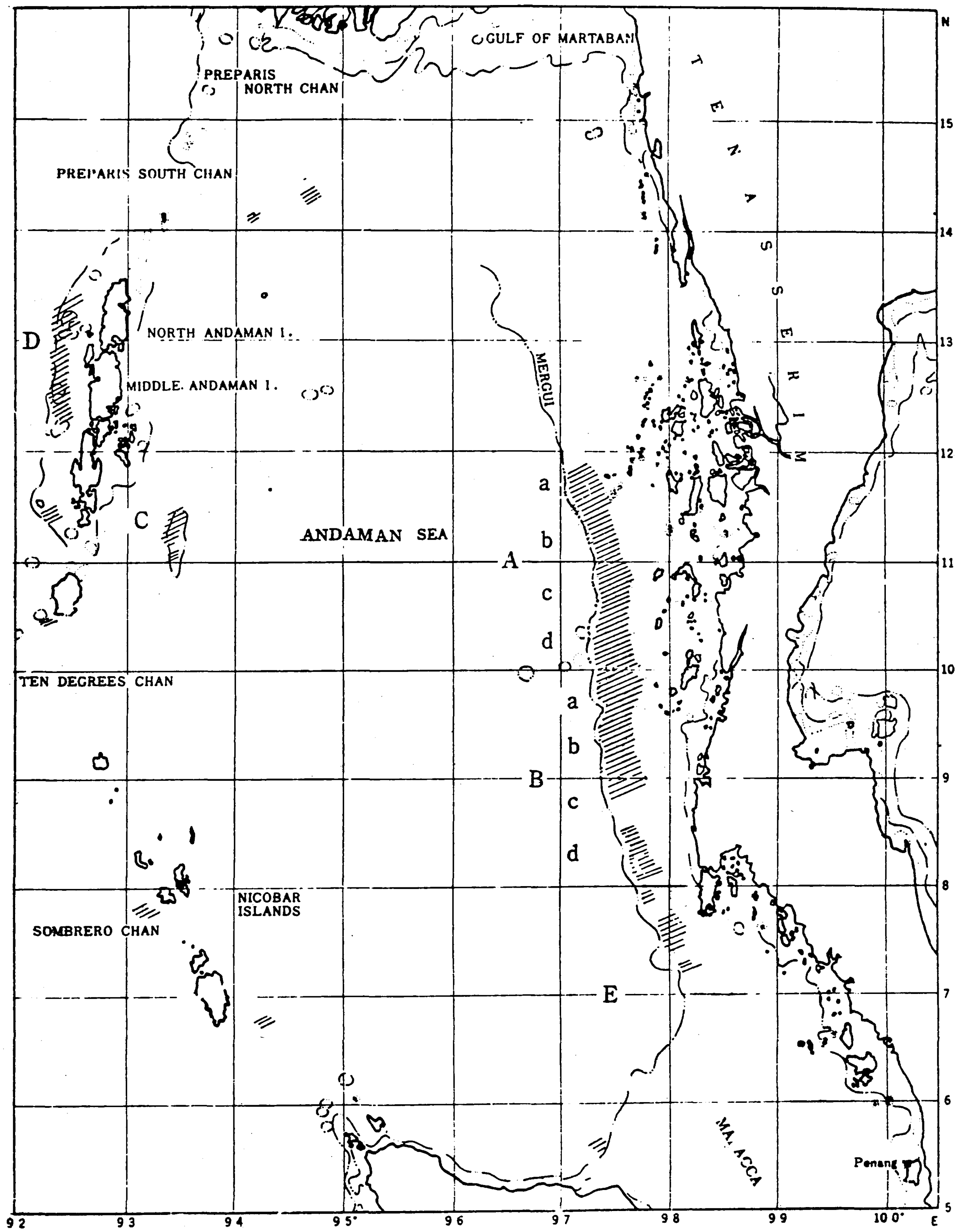

Fig. 1 A chart to show vertical line fishing ground (shaded areas) in the Andaman Sea operated by Japanese boats I and II and CHANGI.
A-E shows the division of operated fishing grouds into 5 areas, a-d showing subareas of areas A and B which correspond those in Figs. 2 and 3.

Table III. Species composition of the catch by area for combined data of boat I and II for the whole period, November 1971 to April 1972

Area	A	B	C	D	E
Total catch (ton)	74.5	21.2	2.6	7.0	0.2
	%	%	%	%	%
White snapper	58.0	70.9	50.8	72.7	65.7
Gold-lined sea bream	21.6	10.2	24.4	16.4	0.0
Grouper	8.6	4.4	6.9	1.0	11.9
Pigface	2.8	6.5	10.2	1.3	0.0
Trevally	5.4	5.5	1.3	0.9	0.0
Jobfish	0.8	0.6	0.0	5.2	0.0
Others	2.8	1.9	6.4	2.5	22.4

5.3 Size of fish in the catch

Figs. 2 and 3 show the length frequency distribution of two species of white snapper caught by boat II. The fork length which is about 10% longer than standard length was measured.

Fig. 2 indicates that most of *Pristipomoides typus* in the catch ranged from 50 to 62 cm. in fork length. According to measurements of both body length and body weight of the fish made on board CHANGI, the fish of the above mentioned size range weighed from 2 to 4.5 kg. From Fig. 3, it is seen that *P. filamentosus roseus* on average was slightly smaller than *P. typus*. In the catch and measurement record of boat II, the 2 types of *P. typus* are not separated (in boat I, the 2 species were collectively recorded as white snapper). Measurements made on board CHANGI (Fig. 4) showed that the reddish type of *P. typus* was smallerthan the yellow type.

For the other species, the frequent size ranges in the catch were as below:

Gold-lined sea bream, 30–46 cm. in fork length, 0.7–2.7 kg in body weight

Grouper

E. chlorositgma, 40–50 cm. in standard length, 1.5–312 kg

E. amblycephalus, 40–60 cm. in standard length, 1.7–5.0 kg

E. areolatus, 25–33 cm. in standard length, 0.5–0.8 kg

Pigface

L. Miniatus, 60–65 cm. in standard length, 4.0–5.5 kg

L. choerorhynchus, 45–54 cm. in standard length 2.0-3.5 kg

Trevally, 45–55 cm. in fork length, 1.6–3.0 kg

Jobfish, 50–75 cm. in fork length, 2–5 kg.

6. CATCH BY SEASON

6.1 Catch per day by season

Catch data in areas A and B are combined for further discussion, since the average catch per day and the species composition are not very different between the 2 areas (Table I and III). Data from areas C and D are omitted because of geographical isolation from areas A and B.

Table IV compares the means of catch per day by periods of operation. The data for each boat is treated seprately, since th difference in the skill of the crew in vertical line fishing between the boats would have affected the results. The data for August–September (south-west monsoon season) is supplemented by the catch record of boat III. Although the mean catch per day was higher in

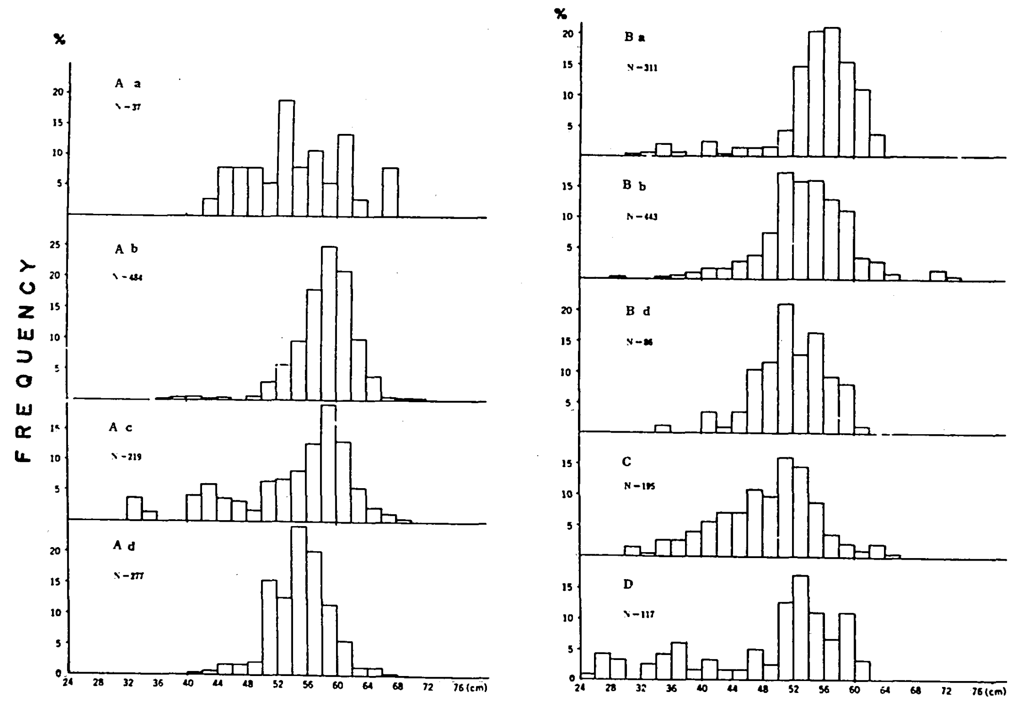

Fig. 2 Body length frequency histograms of white snapper, *Pristipomoides typus* caught by boat II, from different areas. Aa-D shows area/sub-areas, and N is number of fish measured. (after Anon. 1972a)

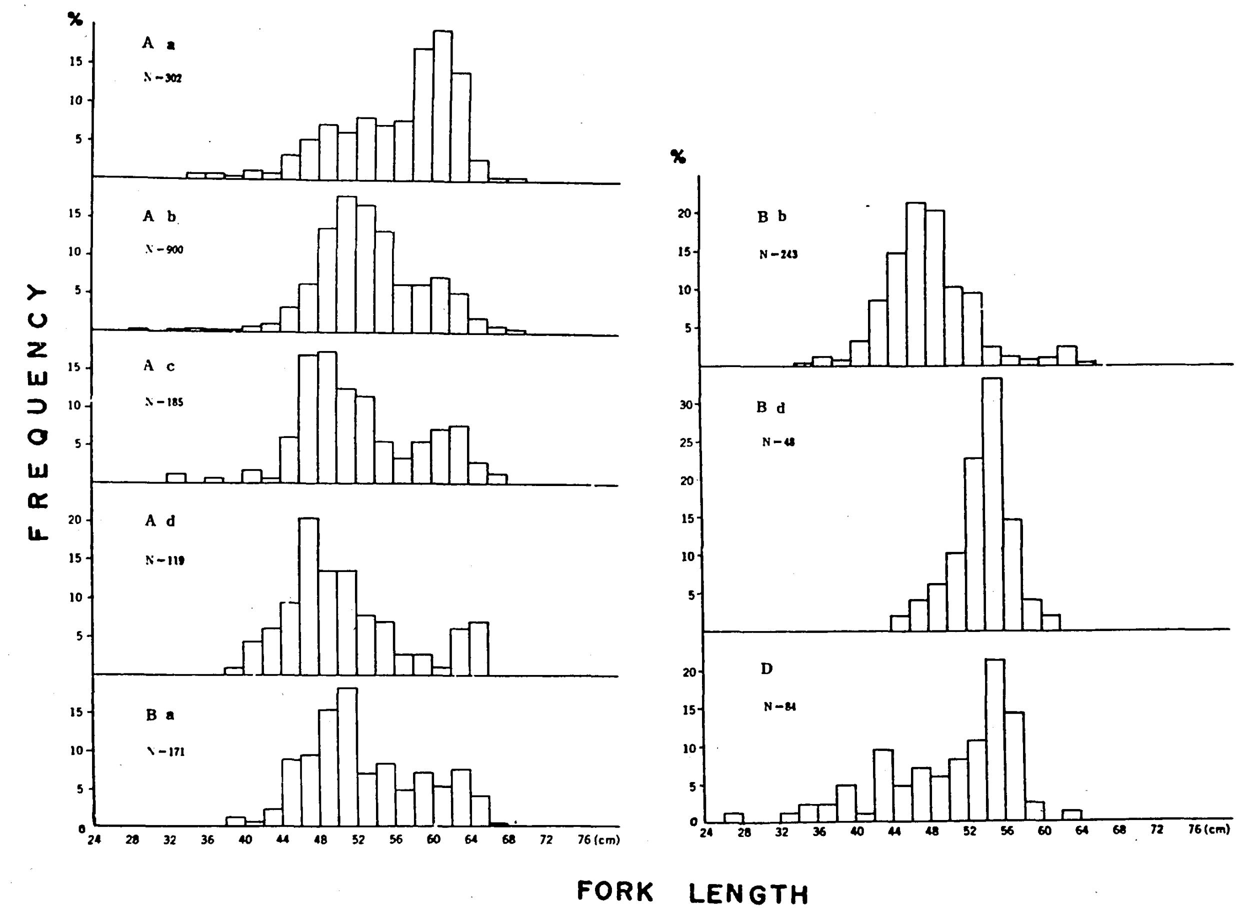

Fig. 3 Body length frequency histograms of white snapper, *Pristipomoides filamentosus roseus* caught by boat II from different areas. Aa-D shows area/sub-areas, and N is number of fish measured. (after Anon. 1972a)

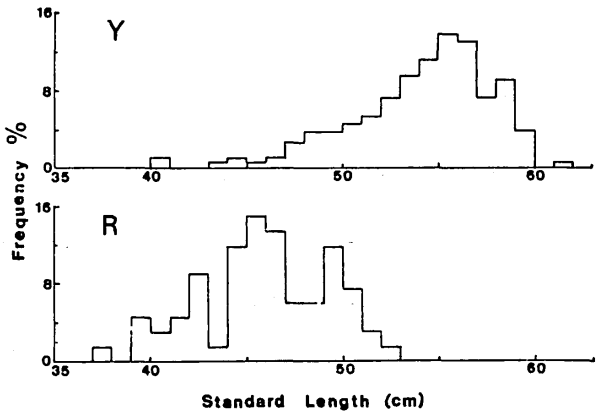

Fig. 4 Body length frequency histogram of two types of *Pristipomoides typus* caught in areas A and B by changi.
Y: yellow type with yellow stripes on cheek.
R: reddish type without yellow stripes on cheeks.

January–March period as shown in the table, the 68% confidence limits of the average for each period overlapped. It may be concluded that the fluctuation in fishing condititions for vertical line by season is small compared with the daily fluctuation.

6.2 Species composition by season

Table V shows the species composition by periods for the same data as in 6.1. A certain degree of difference in the species composition is seen, although white snapper and gold-lined sea bream always occupied the highest percentages. In November–December period low percentage of white snapper combined with high percentage of gold-lined sea bream and the absence of pigface and jobfish is characteristic. In April, grouper occupied a considerably higher percentage compared with other periods. August–September period showed a high percentage of white snapper and a rather low percentage of gold-lined sea bream. The species composition in January–March period was found to be in between those of the other periods.

7. EFFECT OF TIDAL CONDITION ON CATCH

7.1 Average catch by tides

It is often observed in angling that the fishing condition (i.e. the feeding activity of the fish) is better in spring tides than in neap tides. In order to examine whether this occurs also in the vertical line fishing, the catch records of boats I and II in areas A and B are grouped into four stages according to the tidal condition of the day of operation. The four stages employed here are:

a. first spring tide (S. 1): 27th-3rd day of Lunar month
b. first neap tide (N. 1): 4th-11th day of lunar month
c. second spring tide (S. 2): 12th-18th day of lunar month
d. second neap tide (N. 2): 19th-26th day of lunar month.

The geometric means of catch per day for boats I and II by the tidal stages (Table VI) indicate no obvious difference at 68% confidence limits.

7.2 **Daily catch against the day in lunar calendar**

For further examination of the effect of tidal condition on the fishing condition, the daily catch of boats I and II in areas A and B obtained in those trips when operation exceeded 14 days are plotted against the day of a month in the lunar calendar (Fig. 5).

Although the daily catch fluctuated within a total stage, there is a remarkable tendency for the fishing condition to be usually poor for several days around the 6th day of a lunar month. During spring tides and a few days after the seconéd spring tide the catch fluctuated remarkable from day to day.

Table IV. Geometric mean of catch per day by periods and by boats. The data for areas A and B combined

	Nov.–Dec. 1971	Jan.–Mar. 1972	April 1972	Aug.–Sept. 1972
Boat I				
Days operated	26	45	0	0
Mean catch/day (kg)	587	849		
Antilog. of standard deviation	2.26	2.36		
68% confidence limits				
Upper limit (kg)	1325	2000		
Lower limit (kg)	260	369		
Boat II				
Days operated	0	34	19	0
Mean catch/day (kg)		410	352	
Antilog. of standard deviation		2.29	2.04	
68% confidence limits				
Upper limit (kg)		938	719	
Lower limit (kg)		179	179	
Boat III				
Days operated	0	0	0	0
Mean catch/day (kg)				712
Antilog. of standard deviation				1.78
68% confidence limits				
Upper limit (kg)				1270
Lower limit (kg)				401

Table V. Species composition by periods based upon the data obtained in areas A and B by boats I, II and III

	Nov.–Dec.	Jan.–Mar.	April	Aug.–Sept.
Total catch (ton)	19.7	66.6	8.3	21.5
	%	%	%	%
White snapper	54.9	63.6	53.3	72.4
Gold-lined sea bream	28.4	16.2	19.8	10.5
Grouper	7.4	6.4	15.5	2.0
Pigface	0.0	4.4	6.2	2.1
Trevally	4.0	6.4	0.9	3.5
Jobfish	0.0	0.8	2.0	3.7
Others	5.3	1.8	2.3	5.8

Table VI. Geometric mean of catch per day by tides as calculated for the data of boats I and II in areas A and B

Tidal stage	S.1	N.1	S.2	N.2
Boat I				
Days operated	19	22	22	8
Mean catch/day (kg)	606	657	869	942
Antilog. of standard deviation	2.46	1.72	2.47	3.00
68% confidence limits				
Upper limit (kg)	1950	1130	2140	2826
Lower limit (kg)	247	382	351	314
Boat II				
Days operated	14	10	13	16
Mean catch/day (kg)	526	238	505	326
Antilog. of standard deviation	1.74	2.10	2.05	2.43
68% confidence limits				
Upper limit (kg)	918	500	1130	795
Lower limit (kg)	302	114	251	134

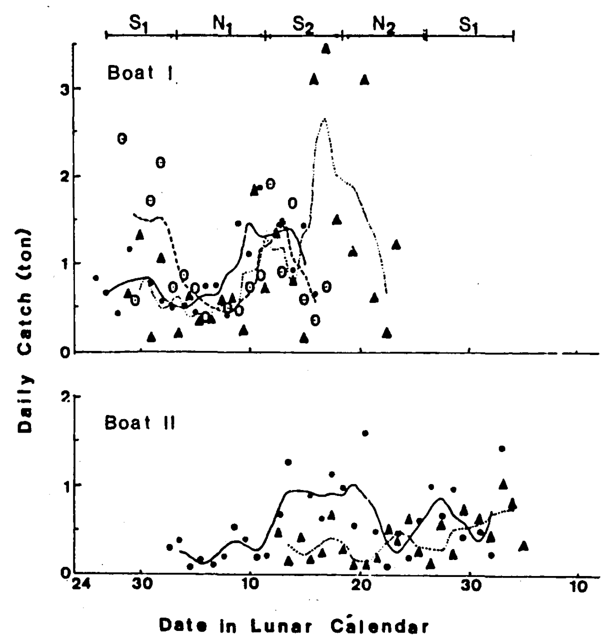

Fig. 5 Daily catches of boat I (top) and boat II (bottom) plotted against the date in lunar calendar. Marks show daily catches, and lines represent smoothed curve by way of arithmetic moving means for each 3 consecutive days.

I. Solid circles and solid line: trip Dec. 1971 – Jan. 1972

Triangles and dotted line: Jan. – Feb. 1972.

Double circles and broken line: Feb. – Mar. 1972.

II. Solid circles and solid line: trip in Jan. – Feb. 1972.

Triangles and dotted line: trip in Mar. – Apr. 1972.

S_1: first spring tide S_2: second spring tide

N_1: first neap tide N_2: second neap tide

8. CONCLUSION AND SUGGESTIONS

8.1 Prospects and merit of vertical line fishing

From the discussions in the previous chapters, it is clear that promising demersal fish resources exist and are not fully developed and exploited. Although the possible daily total catch may be less than that of trawl fishing, the catches of vertical line fishing are almost exclusively composed of fishes of high marketability. The fishing gear and equipment needed for this fishery are much less expensive than those for trawl fishery,and can be operated by boats of much smaller size.

The fish species caught by the vertical line fishing are also different from those for trawl fishing. Those species such as *P. filamentosus roseus*, gold-lined sea bream, *Epinephelus chlorostigma, E. amblycephalus, Lethrinus choerorhynchus*, jobfish and trevally which are main components of the vertical line catch seldom occur in the trawl catch. In other words, these two methods of fishing exploit two different groups of demersal fish resources.

One of the advantage of the vertical line fishing as compared with the bottom long-line is in its mobility. Ease in manipulating the fishing gear facilitates the manoeuvering of the boat in its operation.

The stock size of such demersal fish resources in the South China Sea and the Andaman Sea may be smaller than fish resources for trawl fishing, because the distribution of fish resources for the vertical line fishing is restricted in narrow bands along the upper margin of the continental steep. This makes the locations of fishing grounds much easier.

Apart from the boat itself, the only costly equipment is a fish-finder, which in relative terms is not expensive. In the early stage of developing vertical line fishing one fish-finder can serve a fleet of about 3 boats. On locating fish schools the boat equipped with the fish-finder sets a market buoy bearing the same number as one of the boats which can then commence vertical line operation.

8.2 Importance of skill

Improvement of skill through experience are essential for successful operation of vertical line fishing. Not only the skipper must be familiar with the location of potential fish reefs and the quick manoeuvre of his boat during operation the crew must also be skillful in the handling of fishing gear. Knowledge of the design and improvment of fishing gear is an added advantage especially in the use of some attractant device as mentioned in 3.1.

8.3 Future studies

As the accumulated data on vertical line fishery resources are limited, urgent and intensive studies are needed. With the presently available data fluctuation and difference in catch and species composition by areas and seasons can only be discussed superficially in this paper. Detailed studies on these as well as on the effect of tidal stages are needed. Tidal phases, viz. flow, stagnant and ebb, may also affect the feeding activity of fishes.

Ecological characteristics of each fish species and physiological aspects, especially seasonal change in gonadal condition, of each species are also important subjects to be studied.

9. ACKNOWLEDGEMENT

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