Pelagic Stock Assessment by Hydroacoustic Method in the South China Sea, Area IV: Vietnamese Waters

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ABSTRACT

A collaborative acoustic survey between the Research Institute of Marine Products (RIMP), Vietnam and the Marine Fishery Resources Development and Management Department (MFRDMD) of SEAFDEC, was carried out in Vietnam waters from April, 29 to May, 29 1999. Survey was conducted by using the scientific echo sounder, FQ70 installed on board of MV SEAFDEC. Survey transects were designed perpendicular to the coastline with standard length of 60 nautical miles. The vessel was cruised at 10 knot and stopped at each station for oceanographical sampling. During cruising, the back scattering strength, SV were collected and saved in multiple storage media. SV values were verified during data analyses by removing any noise and scattering layers. The back scattering values by area (SA) is calculated and the fish density by transects are produced. Using those parameters, the biomass of pelagic is estimated based on representative species from the sampling program and national fisheries statistics. Pelagic biomass in Vietnamese waters was estimated at 9.26×10^6 tonnes with the average density of 15.93 tonnes/km^2. This estimation is based on dominance species of *Decapterus maruadsi*.

Key words : Acoustic survey, SV, SA, representative species, biomass estimation

Introduction

Acoustic is a tool for fish stock assessment and becoming more important in the future. Its capability to cover wide area in short time duration may reduce the overall operation cost required for such assessment study. Hydroacoustic methods potentially provide a cost-effective assessment technique to obtain pelagic fishes abundance estimates within the South China Sea. Such methods are attractive since the estimates are independent of the fishery and it is feasible to obtain results rapidly. Furthermore, there are no alternative methods available with comparable pelagic fish sampling power.

SEAFDEC has ventured into this discipline of studies since 1995. The first survey in 1995 has covered the first area in the Gulf of Thailand and the East Coast of Peninsular Malaysia (Albert *et al*, 1998). The second survey confined in the area of Sarawak, Brunei and Sabah (Rosidi *et al*, 1998) , while the third survey was conducted in the western Philippines (Raja Bidin *et al*, 2000). Our recent survey in Vietnam waters was conducted in April/May 1999. These surveys were conducted using a scientific echo-sounder FQ-70 (FURUNO Company) to study the distribution and biomass estimation of multi species pelagic fish. It was an additional experience and information for SEAFDEC to develop a proper methodology for tropical multi species stock assessment by hydro-acoustic technology.

The fisheries industry plays the fourth most important role in Vietnam's international trade based economy. Furthermore, it supplies some 40 % of animal protein to the national diet (JICA, 1998).

Following these circumstances, fish stock assessment program becomes one of the most high priority projects to be carried out. With JICA cooperation in 1995, a marine resource study in Vietnam waters was conducted by the Research Institute of Marine Products (RIMP) using RV Bien Dong. The study has set their main objective to investigate relative stock abundance of pelagic fishery resources in the EEZ of Vietnam. Additional objective was to clarify coastal fishery condition through landing site survey at selected major fish landing sites (JICA, 1998). Previous survey revealed the abundance of pelagic fishes such as skipjack tuna, dolphin fishes and frigate mackerels were caught by the drift gillnets. However, results from the previous study (JICA, 1998) do not indicate the volume of fish stocks. Its only report the qualitative abundance of pelagic fish and their species composition. Therefore, the current study is very important to provide those lacking information.

In Vietnam, the principle fishing gears used are the trawl, gill net, purse seine, lift net, set net, casting net, long-line and hand line. The different gears used by fishers basically targetted for different species. Figure 1 indicates the trend of pelagic fish landings (all gear combined) in Vietnam which increasing annually at the average rate of 6.7 %. The highest landing recorded so far is 720,000 tonnes, given the average annual production of 636,004 tonnes (1995 to 1999). The positive trend shows that the surface fishery is very important for Vietnam peoples. (Fig.1)

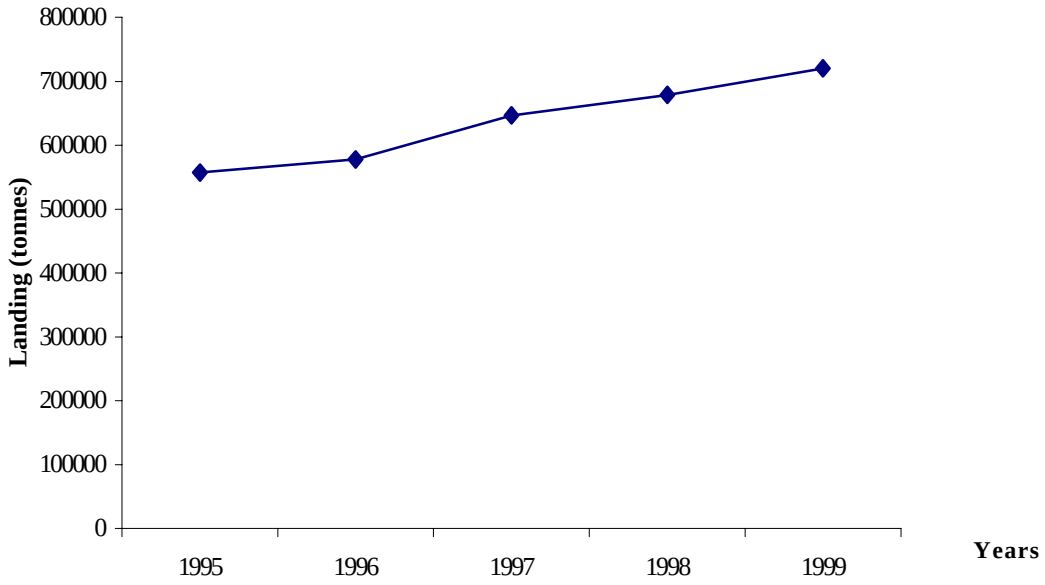

Fig. 1. Trend of pelagic landings in Vietnam.

The main objectives of the current study are to estimate the biomass and to study the distribution pattern of pelagic fishes in Vietnam waters.

Materials and Methods

Equipment Calibration

Calibration procedure is very important to ensure the collected raw data are reliable and meaningful. It is necessary to accurately estimate the resource volume. Calibration works for FQ-70 was conducted off Tonkin Bay, exactly located at Latitude 20° 36' N and Longitude 107° 15' E prior to survey cruise. Calibration was done for both transducers of 50 kHz and 200 kHz frequency. Output

parameters measured during calibration process were used for collection of SV data by FQ-70. These include the source level, receiving sensitivity and the gain of amplifier. Comparatively the low frequency transducer has produced higher receiving sensitivity as shown in Table 1.

Table 1. Parameters settings after calibration work of the scientific echo sounder.

Parameters	Frequency	
	50 kHz	**200 kHz**
Source Level (dB)	215.2	211.1
Pulse Duration (ms)	1.2	1.2
Beam Width (dB)	-14.5	-16.1
Absorption Coefficient (dB)	10.8	89.9
Receiving Sensitivity (dB)	-185.1	-201.3
Amplifier Gain (dB)	49.3	49.7

Survey area and transects

A total of 43 acoustic transects (33 transects of 60nm and 10 transects of 30nm) were conducted within the survey duration from 30th April to 29th May 1999. These transects were shown in Fig. 2. Using the ESSR technique, the total survey area was estimated at 581,146 km^2. The area is quite big as Vietnam has a long coast line extending 3,260 km.

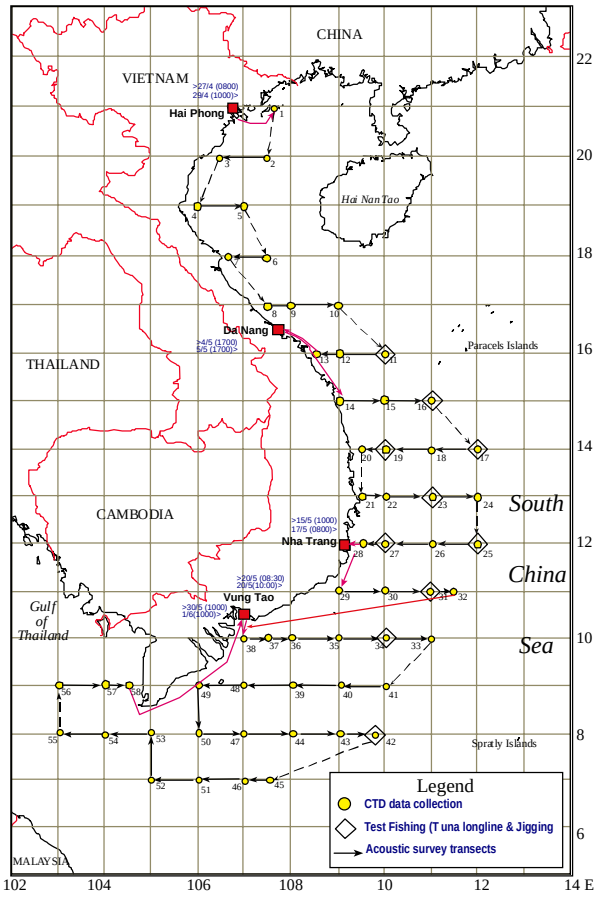

Fig. 2. Survey transects in Vietnamese waters.

The raw data of volume backscattering strength (SV) were recorded by FQ-70 for every integration interval of 0.1 nautical mile along the transects. At the same time, the vertical distribution curves (VDC) were recorded on recording paper and also displayed by the second steep integration.

Layer setting

Five types of layer setting are used for collection of SV data. Each layer setting is applied to a respective layer depth of each transects. It means each transect may use different layer setting depending on their depth condition. The maximum depth is set at 200m. While the upper layer is set at 10m below the transducer. Table 2 shows the different layer setting for respective maximum depth. Layer 9 and 10 were used for bottom layers.

Table 2. Five types of layer setting used for acoustic survey in Vietnam.

	Layer Setting 1	Layer Setting 2	Layer Setting 3	Layer Setting 4	Layer Setting 5
Max depth	**50m**	**60m**	**70m**	**100m**	**200m**
Layer No					
1	10 - 15	10 - 20	10 - 20	10 - 20	10 - 20
2	15 - 20	20 - 25	20 - 30	20 - 30	20 - 40
3	20 - 25	25 - 30	30 - 35	30 - 40	40 - 60
4	25 - 30	30 - 35	35 - 40	40 - 50	60 - 80
5	30 - 35	35 - 40	40 - 45	50 - 60	80 - 100
6	35 - 40	40 - 45	45 - 50	60 - 70	100 - 130
7	40 - 45	45 - 50	50 - 60	70 - 80	130 - 160
8	45 - 50	50 - 60	60 - 70	80 - 100	160 - 200
9	B 5 -10	B 5 -10	B 5 -10	B 5 -10	B 5 -10
10	B 5 - 1	B 5 - 1	B 5 - 1	B 5 - 1	B 5 - 1

Note : B 5-1 = One to five meter from bottom
B 5-10 = Five to ten meter from bottom

Data collection and recording media

Echogram and integrated raw SV data were collected by FQ-70 and stored into several storage media, including VHS video tape, magnetic optical disk (MO), floppy diskette, data catridge (DAT) and normal echo sounder recording paper. VHS and DAT tapes are capable to playback for a fine verification or secondary recording when required.

Species verification

Two approaches were adopted to verify the dominant pelagic species and its biological parameters. The first method is conducting fishing operations by using gillnet of different mesh sizes. Fishings were conducted by RV Bien Dong from 1st - 20th May 1999 at predetermined station. The second method is implementing landing place survey at major landing places in Vietnam from April 28 to May 19, 1999. However, both methods produced insufficient data for the species verification. Therefore, determination on dominant species was depended on statistical information provided by RIMP. It was decided that *Decapterus maruadsi* is the dominant pelagic species in Vietnam with the average standard length (SL) and body weight (W) of 15.4cm and 63g respectively.

Data Processing

A similar procedure used for Area II (Hadil *et al*, 1999) and Area III (Raja Bidin *et al*, 2000) were applied for data processing in Vietnam. The raw data is checked thoroughly to remove any mechanical noise and unlock bottom echoes. The processed data then run using macro program. Small modifications were made in macro program as compared to earlier procedure due to multiple layers setting used for integrated SV data collection. As the layer depth is not similar, so calculated SA values were used instead of SV for the calculation of pelagic fish density.

Target strength (TS)

Currently there are no target strength database was established for tropical fishes in this region. Therefore, the target strength of *Decapterus maruadsi* that selected as dominant species in this study was determined using the empirical formula derived by Furusawa (1990) as follows;

$TS = 20 \text{ Log}_{10} (SL) - 66$ where

TS = Target strength (dB)

SL = Average standard length (cm)

Using the biological information provided by RIMP, the calculated target strength based on given assumptions for *Decapterus maruadsi* was –42.25dB.

Fish density

The fish density is calculated based on assumptions that the SA values are free from noise and interferences. Calculated and corrected SA values were used later for pelagic fish density and biomass estimation. Calculation for the pelagic fish density was based on following formula:

$$\text{Density} = 10^{((SA-TS)/10)} * W$$

Where, SA = Average area backscattering (dB)

TS = Target strength (dB)

W = Average fish weight (g)

The pelagic fish density distibution in Vietnam water is shown in Fig. 4. It was plotted using the "Marine Explorer" program.

Biomass Estimation

The biomass estimation is calculated using the following formula;

Q = Average Density x Total Area , where

Q = Total Biomass in tonnes

Average Density in tonnes/km^2 was calculated based on Table 3

Total Area (using ESSR technique) in km^2

Results

Distribution Pattern of SA

Fig. 3 indicates the distribution of SA in Vietnam waters based on high frequency (200 kHz) transducer performance. Distribution of SA may also represent the density pattern of pelagic fish in the study area. As the low frequency transducer may record some reflection from bottom, which is very

difficult to remove, therefore the results presented here merely depended on high frequency transducer outputs. SA values in coastal waters of the North and South region were estimated higher than –45 dB/m^2. In deeper water more than 200m, SA values were recorded smaller than –45 dB/m^2. It was clearly shown that density of pelagic concentrated in coastal waters than the offshore areas. During the survey period, more pelagic fish was clearly distributed in the North and South of Vietnam, where the water depth is less than 50m. However, it was observed also that pelagic is quite abundance off Nha Trang in the water not exceeding 100m depth.

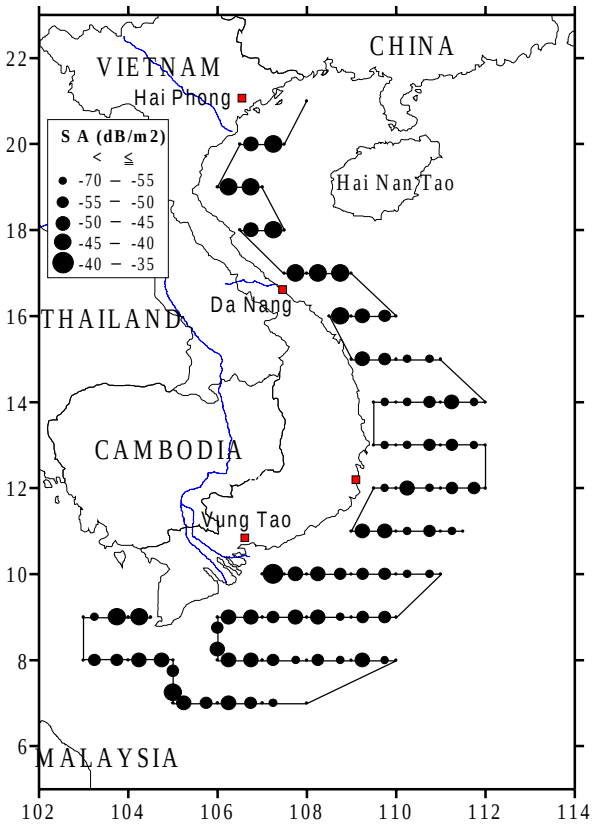

Fig. 3. Distribution pattern of SA (high frequency) in Vietnamese waters.

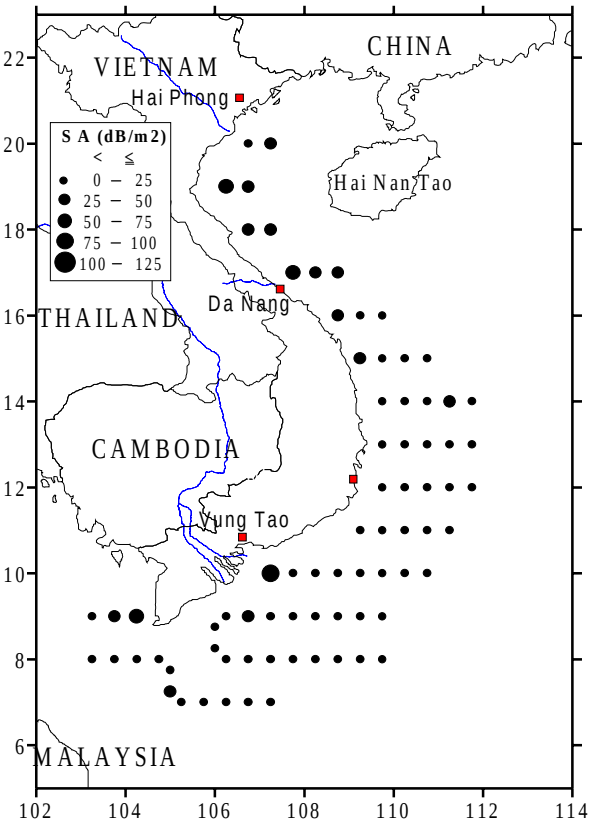

Fig. 4. Density ditribution of pelagic fish in Vietnamese waters.

Pelagic Fish Density

Table 3 and Fig. 4 indicate the distribution pattern of pelagic fish density in Vietnam waters based on high frequency transducer outputs as applied in the earlier surveys (Hadil *et al*, 1999 and Raja Bidin *et al*, 2000).

In general observation, about 27.6% of the survey area recorded relatively high density of pelagic exceed 20 tonnes/km^2. The maximum density recorded was 113.0 tonnes/km^2 while the minimum value was 0.1 tonnes/km^2. Using the high frequency band, the average density of pelagic was estimated at 15.93 tonnes/km^2. It was apparent also that a small addition in SA would change the average density significantly. This result is in consistent with the earlier report by Levy (1991).

Fig. 4 indicates the pelagic fish density concentrated in the North and South of Vietnam waters. Two transects located in these areas recorded the density larger than 90 tonnes/km^2. Whereas the other transects recorded not more than 25 tonnes/km^2.

Table 3. SA and density values by transect (high frequency).

Assumption parameters;

Average length (SL) 15.40 cm

Average weight 63 g

TS in dB -42.25

Based on dominant species *Decapterus maruadsi*

Date	Station			Avg. SA(H)	Density
	From		To	in dB unit	tonnes/km^2
30-Apr	2	-	3	-44.09	41.3
30-Apr	2	-	3	-46.77	22.2
1-May	4	-	5	-43.24	50.1
1-May	4	-	5	-43.97	42.4
1-May	6	-	7	-46.27	25
1-May	6	-	7	-40.59	92.4
2-May	8	-	9	-42.1	65.3
2-May	9	-	10	-44.65	36.2
2-May	9	-	10	-44.9	34.2
3-May	11	-	12	-54.7	3.6
3-May	11	-	12	-49.32	12.4
3-May	12	-	13	-44.11	41.1
6-May	14	-	15	-45.28	31.4
6-May	14	-	15	-53.72	4.5
6-May	15	-	16	-58.92	1.4
6-May	15	-	16	-56.72	2.3
8-May	17	-	18	-58	1.7
8-May	17	-	18	-45.77	28
8-May	18	-	19	-53.69	4.5
9-May	18	-	19	-58.09	1.6
10-May	19	-	20	-64.28	0.4
10-May	21	-	22	-63.51	0.5
10-May	22	-	23	-55.14	3.2
10-May	22	-	23	-51.95	6.7
12-May	23	-	24	-53.42	4.8
12-May	23	-	24	-67.43	0.2
13-May	25	-	26	-51.34	7.8
13-May	25	-	26	-50.71	9
13-May	26	-	27	-59.27	1.3
13-May	26	-	27	-49.69	11.4
14-May	27	-	28	-59.14	1.3
17-May	29	-	30	-49.11	13
17-May	29	-	30	-47	21.1
18-May	30	-	31	-66.11	0.3
18-May	30	-	31	-51.86	6.9
19-May	31	-	32	-55.34	3.1
20-May	38	-	37	-39.71	113
20-May	37	-	36	-47.44	19.1
20-May	36	-	35	-48.9	13.6
21-May	36	-	35	-53.53	4.7
21-May	35	-	34	-52.97	5.3
21-May	35	-	34	-52.83	5.5
22-May	34	-	33	-64.02	0.4
22-May	34	-	33	-68.54	0.1
22-May	41	-	40	-53.05	5.2
23-May	41	-	40	-51.45	7.6
23-May	40	-	39	-57.94	1.7
23-May	40	-	39	-46.76	22.3
23-May	39	-	48	-48.23	15.9
23-May	39	-	48	-52.94	5.4
23-May	48	-	49	-45.9	27.2
24-May	48	-	49	-49.82	11
24-May	49	-	50	-53.81	4.4
24-May	49	-	50	-47.99	16.8
24-May	50	-	47	-48.65	14.4
24-May	50	-	47	-48.65	14.4
24-May	47	-	44	-53.11	5.2
24-May	47	-	44	-57.3	2
25-May	44	-	43	-54.63	3.6
25-May	44	-	43	-62.74	0.6
25-May	43	-	42	-48.29	15.7
25-May	43	-	42	-63.57	0.5
26-May	45	-	46	-59.94	1.1
27-May	46	-	51	-51.05	8.3
27-May	46	-	51	-47.19	20.2
27-May	51	-	52	-51.85	6.9
27-May	51	-	52	-46.45	23.9
27-May	52	-	53	-43.87	43.4
27-May	52	-	53	-53.98	4.2
28-May	53	-	54	-47.49	18.8
28-May	53	-	54	-49.52	11.8
28-May	54	-	55	-54.54	3.7
28-May	54	-	55	-53.77	4.4
28-May	56	-	57	-56.56	2.3
28-May	56	-	57	-43.91	43
29-May	57	-	58	-43.2	50.6
Average					**15.93**

Estimated Biomass

Based on the recent survey and available informations, the biomass of pelagic fish in Vietnam waters was estimated at 9.26 million tonnes. However, precautionary approach should be adhering that the estimated biomass may include other marine organisms in addition to pelagic fish. The coastal zone which is a productive fishing ground only cover 24,000 km^2 (JICA, 1998). Using the average pelagic fish density from the current survey, estimated biomass for this area is about 420,000 tonnes. Therefore it was presumed that more than 8 million tonnes of pelagic fish biomass is available outside the coastal waters of Vietnam.

Discussion and Conclusion

The highest pelagic fish concentration was found in the coastal waters of the North and South regions. The average density for pelagic in Vietnamese waters was estimated at 15.93 tonnes/km^2, which is almost on the similar scale, compared to the western coast off Philippines (Raja Bidin *et al*, 2000). One consistent feature in the patterns of distribution observed during these surveys is that pelagic abundance is generally high in inshore of less 100m isobath. This was also reported during the Marine Resource Study in Vietnam in 1997 (JICA, 1998). However, further study is deem necessary to verify and confirm our results.

In acoustic, the echo verification is very important to determine the dominant species for each particular transects. Unfortunately, our recent study could not provide enough information to verify the species, therefore, it is not possible to derive biomass by single pelagic fish species. Therefore the biomass peresented is comprises of several pelagic fish species. A proper fish sampling methodology is deem necessary and strongly recommended for future survey. With those valuable informations, comprehensive biomass estimation would be produced. As the final result, it may reduce errors to the final outputs.

The success of hydroacoustic technique to evaluate fish stock depends on understanding the capacity of fish being investigated. The reflecting properties of both target strength and volume back scattering strength of the fish and how these properties change due to environment, behaviour and physiology have not been satisfactorily explored. The most critical source of error in abundance estimates derived from echo integration method is the lacking of appropriate knowledge on target strength characteristics of the fish being surveyed (Nainggolan, 1993). SEAFDEC needs further study in acoustic especially on target strength determination and species identification. Improvements on these requirements are vital for more meaningful results which basically important for pelagic fishery management. Concerning this urgent requirement, MFRDMD has started an intensive TS measurement study beginning in April 2000. The objectives are to develop TS measurement system and to measure TS for targeted pelagic species.

Acoustic approach is a potential method to assess the pelagic fish stock in the South China Sea area. However, many precautions need to be considered before and after conducting the acoustic research. The value of biomass is very much dependent on the target strength (TS) and SA values.

Acknowledgements

The authors would like to thank SEAFDEC for providing fund to implement this study in Vietnam waters. We are also grateful for the cooperation shown by the crew of MV SEAFDEC while collecting raw data. Thanks are also due to our colleagues from RIMP in Vietnam for providing us with the information on pelagic fishery.

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