Multi Species Stock Assessment by Acoustic Method in the South China Sea Area III: Western Philippines

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ABSTRACT

An acoustic resource survey off western Philippines waters from April 18 to May 07, 1998 was conducted by MFRDMD in collaboration with BFAR by using M/V SEAFDEC. A scientific echosounder FQ-70 developed by the Furuno Electric Co. of Japan was used to collect the SV data along the transects of 60 nautical miles apart. The raw data of backscattering strength (SV) collected from the 200 kHz transducer were carefully corrected and filtered to eliminate the influence of noises such as planktons. The corrected SV values were used to estimate the biomass of multi-species pelagic fish. *Decapterus macrosoma* was selected as representative species based on catch composition caught by M/V MAYA-MAYA during fishing operations. From the catch, the standard length (SL) and average weight of *Decapterus macrosoma* were obtained. Then the target strength (TS) of the representative species was calculated using formula, TS=20log (SL) - 66. The distribution of the SV values showed geographical difference. SV values were higher in the northern area and the southern waters of Manila. TS was estimated at -45.8 dB with the standard length of 10.2 cm. The estimated density and biomass of multi-species pelagics along the coastal waters were 18.9 tonnes/km^2 and 1.672 million tonnes respectively. Meanwhile the total area and depth layer used were 88,362 km^2 and 190 m resprectively.

Key words: acoustic survey, FQ70, SV value, biomass estimation, fish density

Introduction

South China Sea is one of the major fishing grounds in the Philippines from where the country depend, on fisheries for export , livelihood and other economic benefits. However, fishing activities off western Philippines are limited due to climatic conditions. During southwest and northeast monsoon seasons, only few large scale fishermen operate in offshore area while the artisanal fishermen concentrate along the coastal waters. Western Philippines, therefore is not considered as productive fishing grounds. However, it might be necessary to assess the potential of the fish resources before they are being exploited.

Fish stock assessment is a growing necessity in many countries in Southeast Asian countries. In the Philippines, stock assessment is only based on landed catch data. However, there is a need to adopt a new method in determining fish stocks i.e hydro-acoustic. As in other tropical regions, western coast of Philippines waters has a similar biological characteristics such as the distribution and abundance of multi-species and all year round spawning. The inherent characteristics of fisheries hinder the collection of reliable landing statistics throughout the area. Suitable fish stock assessment methods are not readily available in this region. SEAFDEC has been making efforts to develop appropriate methods using hydro-acoustics (Rosidi *et al*., 1998). Application of scientific hydro-acoustic equipments in assessing fish population seems to be a more appropriate means among others to meet overall goal of the rapid fish resources assessment, although the method does not give a complete answer for the tropical multi-species condition. But, it is an effective way to assess new fishing grounds where statistics are not sufficient and to provide baseline information for the fishery management.

In April-May 1998, the interdepartmental collaborative research program in the South China Sea (Area III) off western Philippines commenced through SEAFDEC/MFRDMD coordination. The study was conducted with the inclusion of ocenographic and other activities. This is the first ever acoustic survey done in Philippines waters. This report examines the distributions of volume backscattering strength (SV) collected by the scientific echosounder FQ-70 off western Philippines waters and presents the outputs for fish stock assessemnt including biomass estimation off Philippines.

Materials and Methods

The hydro-acoustic survey using the scientific echosounder FQ-70 (Furuno Electric Co.) was carried out simultaneously with oceanographic studies, tuna longline fishing and automatic squid jigging by M/V SEAFDEC off western coast of Philippines waters from April 18 – May 07, 1998.

Calibration of FQ-70 was done prior to survey cruise off Subic Bay (14 ^{o} 39.05’N, 120 ^{o} 15.98’E) before the vessel proceeded to oceanographic station no. 1 (20 ^{o} 20.02’N, 110 ^{o} 00.04’E) located off northwest of Philippines waters. The source level, receiving sensitivity, and the gain of amplifier were measured by means of a hydrophone. Parameter settings of the acoustic system based on the calibration results, were shown in Table 1.

The survey transect was set between the oceanographic stations. Both surveys were conducted along the same transect as shown in Figure 1. Innitially a total of 31 transects were planned, but the last transect between station 31-32 was cancelled due to bottom topographical condition. Each transect was approximately 60 nautical miles apart. The vessel cruised along the transect line at a speed of approximately 10 knots.

Data Collection

The hydro-acoustic system was set up to process echo and produce outputs of the volume backscattering strength (SV in dB/m^2) in real time from depth of 10m to 200m at horizontal intervals of 0.1 nautical mile. The depths were set into 10 layers as shown in Table 2. Layers 1 to 8 were set between 10m and 200m from the surface, while layers 9 and 10 were set between 1 and 10m from the bottom.

The SV values from the low frequency (50kHz) and the high frequency (200kHz) transducers were both recorded. However, only the values from the high frequency transducer were used in data processing and consequently in the fish biomass estimation. The data were recorded in multiple format media as follows:

Table 1. Parameters settings after calibration work of the scientific echo-sounder FQ-70 for the survey off the western coast of Philippines in April and May 1998.

Parameters	Frequency	
	50 khz	200 khz
Source Level (dB)	214.4	211.7
Pulse Duration(ms)	1.2	1.2
Beam Width(dB)	-14.5	-16.1
Absorption Coefficient(dB)	10.8	89.9
Receiving Sensitivity(dB)	-186.9	-200.8
Amplifier Gain(dB)	49.0	50.2

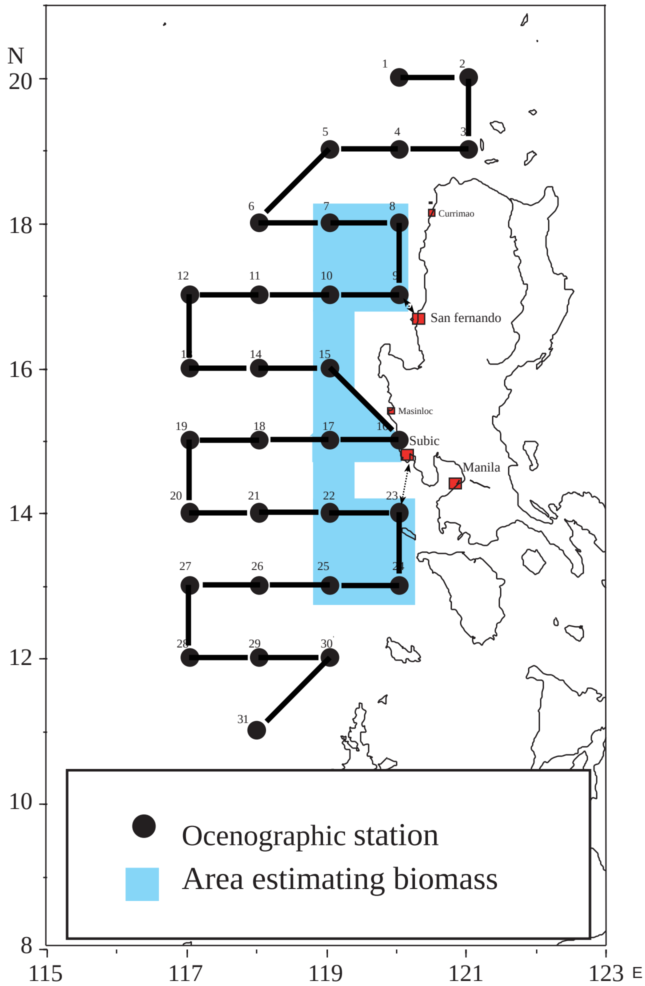

Fig. 1. Survey transects for the acoustic off the western coast of Philippines in April/May 1998. Numbers indicate the oceanographic survey stations.

1. Numeric data from integration results of echo signals were recorded in a floppy disk through data analyser FQ-770

2. Results of the echoes integration were also produced in print-out format (This output was also recorded simultaneously in a floppy disk).

3. Echo signals including echoes of the vertical distribution curve, were also produced on recording paper through the recorder unit FQ-706.

4. Analog and echo signals data including log data were recorded in VHS videotape.

However, during SV data processing only the numeric data in floppy disk and print out formats were used. The traced echo signals on recording papers were used only for verification of fish signals and planktons. Meanwhile the analog data in video tapes were not utilized due to the absence of the post data analyser.

SV correction

Noise produced from other electric devices and unlocked bottom echoes due to rough sea conditions might result in errors to the collected raw SV values. Besides noise and bottom unlocked echoes, plankton and other dense micronecton might also affect the raw SV values. Therefore, these raw SV values need to be corrected earlier before further analysis.

Graph of SV values against the integration numbers were plotted to detect the extreme values, which were probably produced, by fish, plankton layer or noise. The graph would indicate SV characteristic from layer 1 to 8 and bottom layers 9 to 10. By removing the extreme values due to the noise, the graph would automatically change accordingly, following trend similar to that of the data. These values were termed as the *Corrected SV* values.

The corrected SV values were further filtered to select the values produced by fish, using five-point moving average. These filtered SV values would be called the *Calculated SV* values.

The calculated SV values for each transect were averaged vertically from depth layer 1 to 8 for each integration number, and horizontally from the first integration number to the end. The calculated SV were sorted out into pelagic and demersal fish. Average SV values from layer 9 and 10 were considered as demersal fish. Pelagic fish was calculated from the remaining value of layer 2 to 8 after subtracting the SV values of layers 9 and 10. The overall averaged calculated SV values for all transects within the specified area were used for pelagic and demersal fish biomass estimation.

Biomass estimation

The pelagic particularly tuna and tuna like fishes as well as roundscad off western Philippines waters were estimated based on information available. Biomass for roundscads group in particular was based on limited area and information collected by M/V MAYA MAYA. The area considered for biomass estimation is shown in Figure 1. The following expression is used to estimate the fish biomass.

$$Q = (sv / ts).w.a.d \quad \text{.................... (1)}$$

where Q = Biomass

sv = $10^{(sv/10)}$: Backscattering strength

ts = $10^{(ts/10)}$: Target strength

w = average fish weight (g)

a = survey area (m^2)

d = layer depth (m)

Target strength (TS) was estimated using the Furusawa (1990) equation

$$TS = 20 \log SL - 66 \quad \text{............. (2)}$$

Where, TS = Target strength (dB)

SL = Fish Standard length (cm)

A single TS value from the representative species was used for biomass estimation in this report. The representative species for pelagic was determined based on the actual catch of M/V MAYA-MAYA (by purse seine). It was also compared with the catch statistics by major fishing gears operating along the area off western Philippines.

Maximum Sustainable Yield (MSY) Estimation Based on Biomass

MSY is one of the important indicators used for fishery management. MSY could be estimated from the catch and effort data, available from fishery statistics. One of the typical procedures is to use surplus production models devised by Schaefer (1954) or Fox (1970). In Philippines, historical statistics are not readily available to fit these models to estimate MSY. However, the Cadima's empirical equation (Troadec, 1977), modifed from Gulland's model (1971), may applicable to estimate MSY using biomass estimated from the hydro-acoustic method.

$$MSY = 0.5MB_o \quad \text{.....................(3)}$$

where M = Annual natural mortality

Bo = Biomass for unexploited fish stocks

M is estimated by using empirical equation developed by Pauly (1980)

$$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.463 \ln T \quad (4)$$

where M = Annual natural mortality

L_∞ = maximum length

K = Growth coefficient

T = Average annual temperature at the surface (°C).

The surface water temperatute in tropical waters are relatively constant at approximately 27-28°C (Chua and Charles, 1980; Sverdrup et al. 1947). In this analysis, T was set at 28 °C.

Results

Fish Echoes

Figure 2 shows an example of echogram with SV vertical distribution curves for both high and low frequency. Normally a large fish echo would appear on the echo-sounder screen and record a relatively higher SV value. In ideal situation, the same level of SV values are observed for high and low frequency echogram. However, the low frequency sometimes produce a continuous SV from -70 to –60 dB especially at the depth layer of 20 to 80m. Under such circumstances, SV values from high frequency only is used for further treatment and analysis.

SV Distribution

Distribution of the calculated SV values of pelagics is shown in Figures 3. These figures show that there are relatively higher SV values in depth layer between 100 and 200m on the continental shelf along the shore. There are significant differences for SV recorded along the coastal area with higher SV values appearing in the north and south of Manila.

Biomass Estimation

Fishing activities in the survey area are limited to the coastal waters up to 60 nm. It is difficult to obtain fishing information further off shore due to the capacity of the fishing boats. Fishing operation is pre determined to verify the echoes of dominant species. Then the biomass estimation is made based on representative species. In this study, roundscad of *Decapterus macrosoma* species was selected as representative species for biomass estimation. The parameter used for this species is indicated in Table 3. In this report, the biomass produced is only for coastal waters. Detailed results of biomass estimation for pelagic fish off the western coast of the Philippines bordering the South China Sea area is shown in Table 4. The estimated density and biomass of pelagic fish were 18.9 tonnes/km ^{2} and 1.672 million tonnes respectively.

MSY Estimation

Von Bertalanffy growth model was used to determine the annual natural mortality (M) for *Decapterus macrosoma* as obtained from Mohsin (1996). Other parameters were also derived, including L_{inf} and K at 33cm and 0.9 per year respectively. M was estimated at 1.62 for the surface temperature at 28 ^{o}C. Using the above parameters, MSY was estimated at 1.356 million tonnes (Gulland's equation) or 904,000 tonnes at 2/3 MSY (Table 5).

Discussion

This paper presents one of the approaches for multi-species stock assessment by hydro-acoustic method. This survey only collected SV values without proper echo identification as required for ideal biomass estimation. Future study should strongly emphasize on the echo identification by using appropriate fishing methods, such as the high-speed mid-water trawl, purse seine or vertical longline.

The present survey estimated the average pelagic fish density at 18.9 tonnes/km ^{2} based on roundscad fish as representative species. This figure is relatively higher in the region as

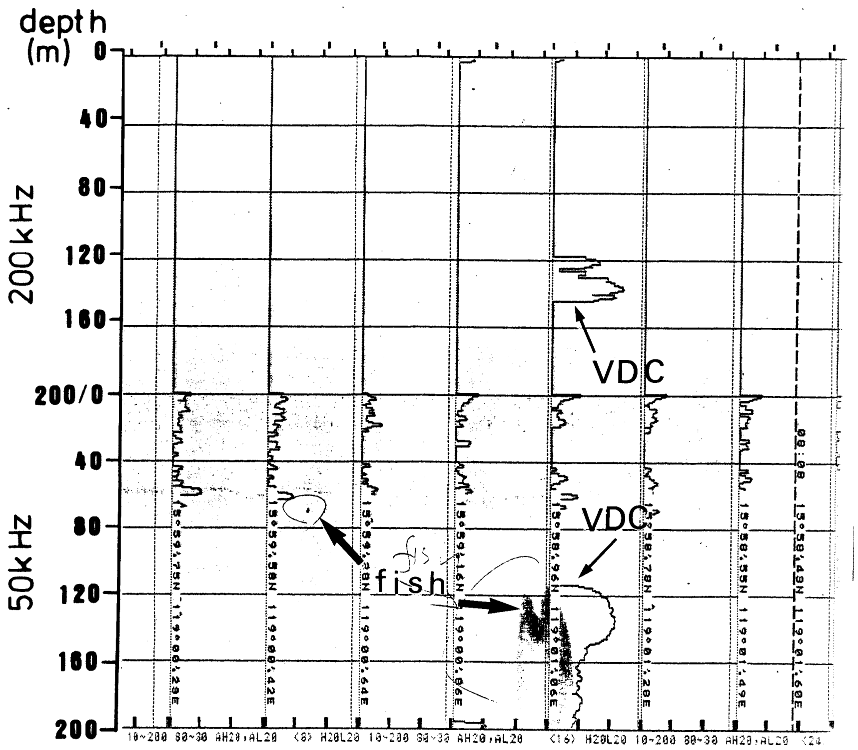

Fig. 2. An example of large fish school observed during the survey cruise at station no 15-16(1) in April 28, 1998.

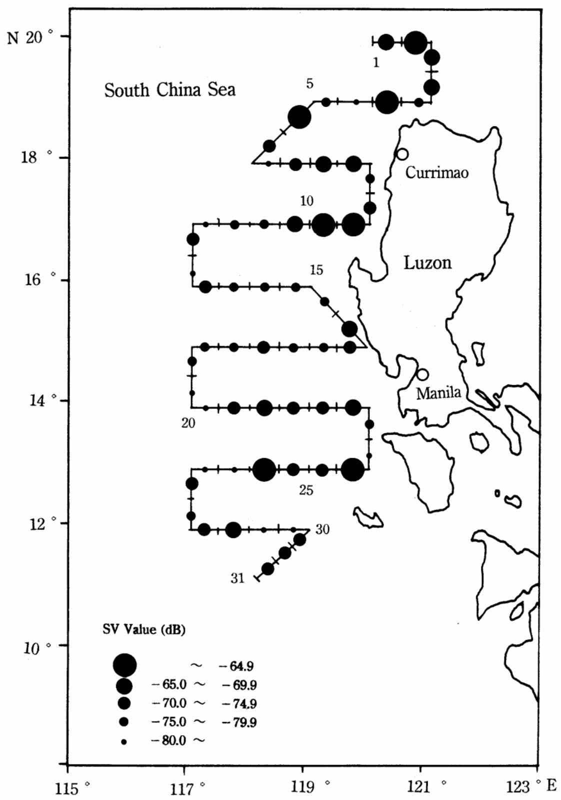

Fig. 3. Distribution pattern of SV along transect off western coast of Philippines in April/May, 1998. Numbers indicates the oceanographic survey stations.

Table 2. Depth layers and ranges for SV integration.

Depth Layer	Ranges (m)
1	10 - 20
2	20 - 40
3	40 - 60
4	60 - 80
5	80 - 100
6	100 - 130
7	130 - 160
8	160 - 200
9	10 – 5 (from Bottom)
10	5 – 1 (from Bottom)

Table 3. Average standard length (SL) and weight (w), and estimated TS (dB) for the representative species of pelagic fish off the western coast of Philippine waters, based on the catch by M/V Maya Maya.

Species	Standard length (cm)	TS (dB)	Weight (g)
Decapterus macrosoma	11.5	-44.8	19.1

Table 4. Estimated biomass for pelagic fish off the western coast of Philippines waters within Philippines EEZ , by using FQ-70.

	area (km^2)	Density ($tonnes/km^2$)	Biomass (tonnes)
Western Philippines	88,749	18.9	1,672,000

Table 5. Estimated MSY using Gulland's equation based on the biomass from the acoustic survey off the western Philippines waters in 1998.

Fish Group	Estimated Biomass (tonnes)	MSY (tonnes)	2/3MSY (tonnes)
Pelagic	1,672,000	1,356,000	904,000

Rosidi *et al* (1998) found the estimated fish density in Sabah/Sarawak is from 1.98 to 9.92 tonnes/km^2 during pre and post northeast monsoon season respectively.

Biomass and MSY estimation based on the limited area were 1.67 and 1.36 million tonnes respectively. The figures are quite high compared to the production records in the annual fishery statistics. Plankton and dynamics scattering layers (DSL) which are not 100% eliminated during analysis probably resulted in higher estimates. Better separation and reduction could be practiced if using Ei2nd software. However, the technology is not yet widely used due to limited experience and expertise. Perhaps it could be fully applied in the next survey excercises.

Figures 3 shows the distribution of SV values for pelagic fish with apparent differences by areas. However due to limited data, it is difficult to find a strong reason for the changes of SV distributions. These changes might be correlated to the oceanographic data available.

This report shows one of the approaches to estimate the fish biomass. Even though the report is also based on many assumptions, it is a step towards introducing the application of hydro-acoustic method in this region. Further efforts will be necessary to improve accuracy of multi-species biomass estimation. For example, the main target species need to be identified precisely for representative TS and weight applied for biomass. Further analyses could be done by Geostatistical Method (Pititgas, 1993) to infer the confidence interval of the fish biomass.

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