ABUNDANCE AND BIOMASS ESTIMATES OF COMMERCIAL FISH SPECIES USING HYDRO-ACOUSTIC METHOD IN JAKARTA BAY, INDONESIA

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ABSTRACT

The Jakarta Bay is known as a fishing ground area for several traditional types of fishing gears. The fishery has important role to provide nutrition, sustainable livelihoods, and poverty alleviation around the area. Abundance estimation of commercial fish species in the Jakarta Bay is essential particularly comparable of series data in order to evaluate the potential changes in distribution and abundance. The purpose of this study is to analise the distribution of commercial fish species in the Jakarta Bay and estimate their abundance and biomass. Fish assemblages were concentrated in the eastern and central part of bay. Apparently salinity and DO associated with rich density of phytoplankton and zooplankton may explain the spatial variability of short-bodied mackerel and pony fish, while assemblages pattern of spiny hairtail and croaker might be driven by the availability of small planktivorous fish as their diet. The most abundant commercial fish in the Jakarta Bay are Short-bodied mackerel (Rastrelliger brachysoma), Ponyfish (Leiognathus sp.), Croaker (Johnius sp.) dan Spiny hairtail (Lepturacanthus savala) respectively. Furthermore, biomass estimates for those species showed short-bodied mackerel has the highest biomass followed by spiny hairtail, croaker, and ponyfish.

KEYWORDS: Hydro-acoustics, fish abundance, spatial distribution, Jakarta Bay

INTRODUCTION

The Jakarta Bay located closely to Jakarta city has an important role in supporting economic activities of Jakarta. Various sectors of industry consist of mining, transportation, trade, fisheries and tourism rely to the bay's area. The area is about 514 km^2 consist of different ecosystems such as coral reef, seagrass, and mangrove (Wolanski, 2006). Therefore, Jakarta Bay has potential marine resources for human activities including marine capture, aquaculture, and tourism (Hartati *et al.*, 2014). Several traditional types of fishing gears exist in Jakarta Bay such as gillnet, liftnet, trap, and bottom danish seine. These fisheries provide fish for domestic market around the area.

In fisheries research, sampling methods are used to estimate characteristic of the stocks (Gulland, 1966). Hydro-acoustic method is the one of several sampling methods that can be used for estimating the fish abundance and its spatial distribution. The first attempt of fish abundance estimation using hydro-acoustic method was reported in 1950 (Simmonds & MacLennan, 2008). Recently, hydro-acoustic is being used widely and has been adopted by many research organizations to estimate fish populations in the sea and fresh waters (Appenzeller & Leggett, 1992; Simmonds & MacLennan, 2008). Echo integration and echo counting techniques allow for absolute abundance estimates and larger scale sampling volume compared to trawling methods (Conners & Schwger, 2002).

Abundance estimation and spatial distribution of fish in the Jakarta Bay is important particularly comparable of series data in order to evaluate the potential changes in distribution and abundance. In conjunction with the hydro-acoustic survey, fish catch data were obtained by port sampling method to aid the interpretation of hydro-acoustic data and to infer the taxa and size of target. Because the recent abundance and spatial distribution of commercial fish in the Jakarta Bay have not been well known, hence this study is aimed to analyze and investigate the latest distribution pattern, abundance, and biomass of these species.

MATERIALS AND METHODS

Survey area, sampling gears, and operational procedures

The study was conducted in the Jakarta Bay, Jakarta Indonesia (Figure 1) in 10-13 June 2014. The Jakarta Bay including the Seribu Islands are often referred as The Greater Jakarta Bay Ecosystem. The area is a large shallow bay approximately 514 km^2 located in the northern coast of Jakarta (Wolanski, 2006).

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Hydro-acoustic data was collected by the commercial fishing boat using SIMRAD EY60 scientific echo sounder with single frequency 120 kHz. There is 1 transducer deployment in an over-the-side mount and the transducer connected to 1-General Purpose Transceiver (GPT) attached onboard. Approximately 45.76 nmi^2 area of the Jakarta Bay was covered by the hydro-acoustic survey with total transect length 31.8 nmi. The survey design is systematic sampling with parallel transects line perpendicular to the coast.

Interpretation of hydro-acoustic data relied on port sampling data due to its limitation cannot directly imaging the targets. A port sampling data provides three things for hydro-acoustic abundance assessment: species identification, size distribution, and orientation distribution (Mackinson *et al*., 2004). Marine species cause the hydro-acoustic backscatter must be identified in order to estimate the proportion numerical abundance of all species that produce backscatters. Based on the size distribution and a

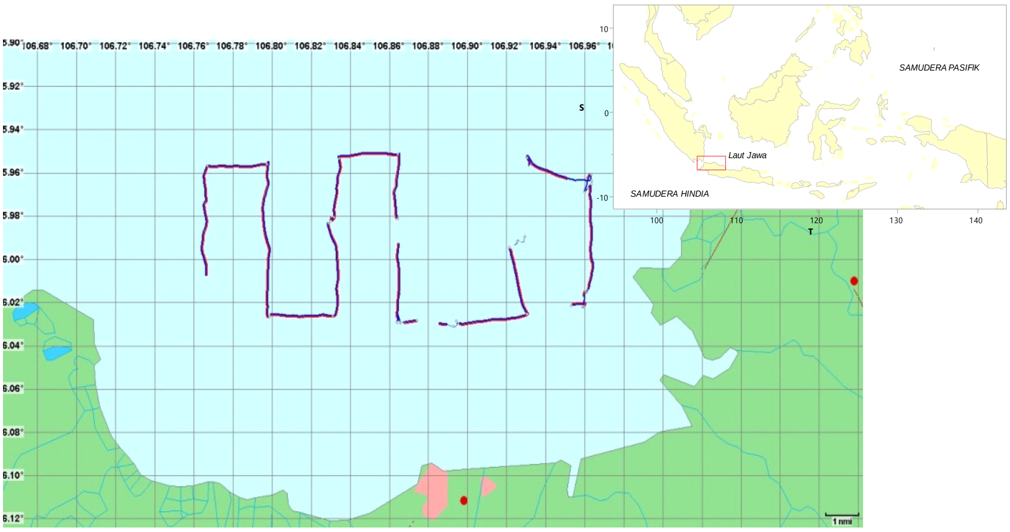

Figure 1. Map of study area and information of hydro-acoustic (line) and port-sampling (diamond) sites.

target strength-length relationship model then can be obtained densities of fish. Therefore, biological data consist of length and weight distribution were collected from fishing port and direct sampling of fishing boat in the study area.

Data Analysis

Raw hydro-acoustic backscatters data made with SIMRAD EY60 were post processed using the Large Scale Survey System (LSSS) software version 1.25. Echo intensities per nautical mile are integrated continuously during the survey and mean values per 0.1 nautical mile were recorded for mapping and further calculations. Contributions from the seabed, false echoes and were sorted and are deleted.

Backscattered hydro-acoustic energy was converted to fish density using target strength (TS) - fish length function:

$$TS = 10.\log\left(\frac{\sigma}{4\pi}\right) = 20\log L - b(dB) \quad \text{.................(1)}$$

where,
b = constant parameter of TS,
σ = backscattering cross section
L = fish length (cm).

Table 1. TS function is according to references.

Species	TS function
Short-bodied mackerel (*Rastrelliger brachysoma*)	TS = 20 log L – 67.5 (Musse, 1999)
Spiny hairtail (*Lepturacanthus savala*)	TS = 20 log L – 68.3 (Zhao, 2006)
Croaker (*Johnius Sp*)	TS = 20 log L – 67.35 (Mun *et al.*, 2006)
Ponyfish (*leiognathus sp*)	TS = 20 log L – 66 (Furusawa, 1990)

TS parameters for different species of interest are reffering to references (Table 1).

The average $\overline{s_A}$ was obtained using a weighted mean of the transect means:

$$\overline{s_A} = \frac{\sum_{i=1}^{n} \overline{s_{A,i}}.Li}{\sum_{i=1}^{nj} Li} \qquad \text{...(2)}$$

where n is the number of transects and $\overline{s_{A,i}}$ is average S_A on transect *i*. The weighted mean calculation can be used when data consists of frequencies or some data points are not contributing equally to the final average (Finch, 2009). Length of the transect L_i corresponds to number of observations. Area density of scatters of *i* length group was calculated as:

$$\rho_{Ai} = \left(\frac{\overline{s_A}}{\sigma_{Ai}} \right) \qquad \text{...(3)}$$

where is backscattering cross section of *i* length group in survey area. Echo density is then converted into fish density per length-group by:

$$N_i = \rho_{Ai}.C_i \qquad \text{...(4)}$$

where denotes proportion of *i* length group is calculated as:

$$C_i = \frac{p_i.i^2}{\sum_{i=1}^{n} p_i} \qquad \text{...(5)}$$

is length frequency of *i* length group, which on this study 1 cm length groups. The total numbers of fish can be obtained directly by summing the numbers of fish of all length group. Biomass indice is then calculated from multiplier number of fish to the average of length weight conversion of fish observation:

$$W = e^{\alpha}.L^{\beta} \qquad \text{..(6)}$$

RESULTS AND DISCUSSION

Results

Spatial Patterns of Fish

The distribution of area backscatter values as proportional to densities was concentrated in the eastern and central part of bay, while the lowest density was found in the western part of the bay and area close to the shipping line (Figure 2). There were massive fishing activities observed along the area where the highest density of fish are detected.

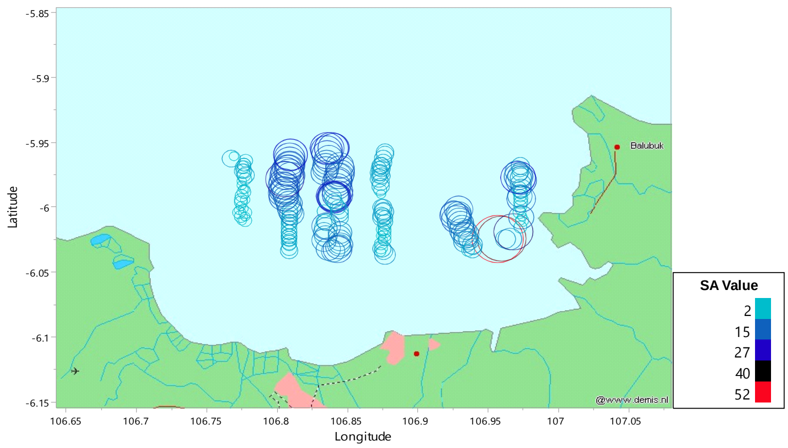

Figure 2. The spatial distribution of fish within survey area. Color and diameter represent different species and densities.

Abundance and Biomass

The result of hydro-acoustic data analysis indicates that the most abundant fish in the Jakarta Bay are Short-bodied mackerel (*Rastrelliger brachysoma*), Ponyfish (*Leiognathus* sp.), Croaker (*Johnius* sp.) and Spiny hairtail (*Lepturacanthus savala*) respectively. Furthermore, biomass estimates for those species showed short-bodied mackerel has the highest biomass followed by spiny hairtail, croaker, and ponyfish (Table 2).

The numbers of fish detected per km^2 corresponding to densities of 1,883 fish or equivalent to 125 kg, 299 fish or equivalent to 72.54 kg, 600 fish or equivalent to 43.21 kg, and 1,247 fish or equivalent to 29.11 kg for short-bodied mackerel, spiny hairtail, croaker, and pony fish respectively. Biomass estimates and predicted economic value of species of interest for total area of the Jakarta Bay are shown in Table 3.

Table 2. The average of hydro-acoustic backscatter for observed species within survey area.

Species	Abundance	Biomass
Short-bodied mackerel	159,560 fish (3,487 fish/nmi^2)	10.6 tons (232.2 kg/nmi^2)
Spiny hairtail	25,380 fish (555 fish/nmi^2)	6.1 tons (134.3 kg/nmi^2)
Croaker	50,856 fish (1,111 fish/nmi^2)	3.7 tons (80.02 kg/nmi^2)
Ponyfish	105,649 fish (2,309 fish/nmi^2)	2.5 ton (53.9 kg/nmi^2)

Table 3. Predicted biomass and value of species of interest for total area.

Species	Biomass
Short-bodied mackerel	64.5 ton
Spiny hairtail	37.28 ton
Croaker	22.21 ton
Ponyfish	14.96 ton

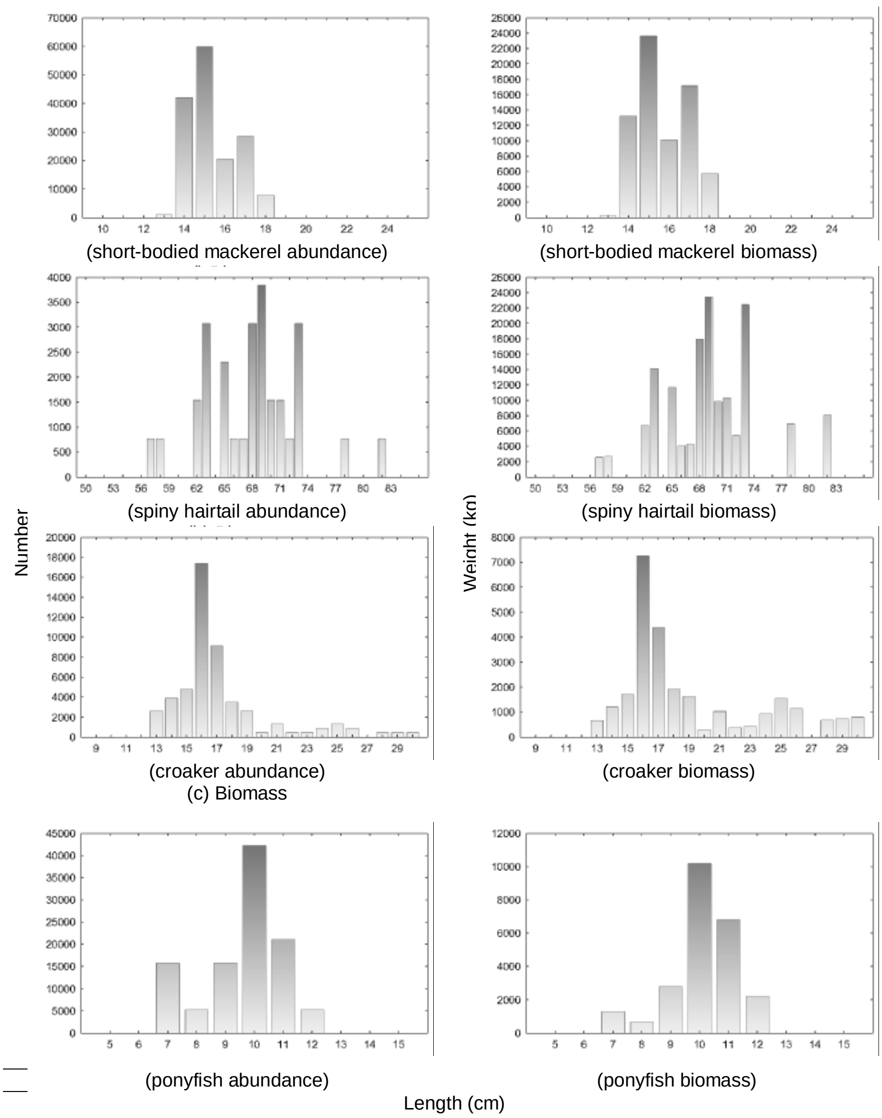

Figure 3. Abundance and biomass estimates per length group (cm).

The size distribution of short-bodied mackerel, spiny hairtail, croaker, and ponyfish in the Jakarta Bay respectively were covering size range 13-18 cm dominated by a group of modal peak 15 cm, size range 52-82 cm dominated by a group of modal peak 69 cm, size range 13-30 cm dominated by a group modal peak 16 cm, and size range 7-12 cm dominated by a group of modal peak 10 cm (Figure 3).

Discussion

Large numbers of fish were detected in the area depths of 15-25 m. Highest density of fish is observed in the eastern and central part of bay apparently correlated in salinity and dissolved oxygen. Hartati *et al.* (2014) found that the salinity level in the eastern and central part of bay was relative similar about 31.5 ‰ and the dissolved oxygen (DO) level was high throughout the bay. These circumstances are associated with rich density of phytoplankton and zooplankton on those areas characterized by bottom up control interaction (Severiano *et al*., 2012; Hartati *et al*., 2014). Estuarine plankton has main effects on fish communities assemblages, while others indirect factors were river flow and temperature. Relative high density of fish was correlated with rich density of planktonic species (Dolbeth *et al.*, 2008).

Short-bodied mackerel is pelagic neritic species, it feeds predominantly on phytoplankton. A pattern of high density of short-bodied mackerel is present in the eastern and central part of bay due to presence of food. This is consistent with rich density of phytoplankton and zooplankton on both areas. Suwarso (2010) described that short-bodied mackerel performs migration along the north coast of Java driven by food availability and spawning purpose. Moreover, Suwarso & Hariati (2003) suggested that variability of size distribution consisting of immature and larger number of spawner compared to other places confirm that the Jakarta Bay is close to the spawning ground. Furthermore, a pattern of high density of pony fish is also present in relative similar areas to short-bodied mackerel is observed. This is likely due to the rich presence of phytoplankton as their main diet. Wide range of size distribution is common found considering typical local stock of pony fish which is inhabits restricted in the inner coastal areas or can be contained of metapopulation recruitment (Jennings *et al.*, 2001). Assemblages pattern of spiny hairtail and croaker might be associated with the presence of juvenile or small fish observed within study area. Those fish are feeding near the bottom and feeds on a wide variety of small fish (Nakamura & Parin, 1993).

CONCLUSION

Fish assemblages were concentrated in the eastern and central part of bay. Salinity and DO associated with rich density of phytoplankton and zooplankton that may explain the spatial variability of planktivorous fish short-bodied mackerel and pony fish, while assemblages pattern of spiny hairtail and croaker might be driven by the availability of small planktivorous fish as their diet. Positive indirect responses are observed for density of fish in relation to environmental variables such as relative higher salinity and DO levels. The most abundant commercial fish in the Jakarta Bay are Short-bodied mackerel (*Rastrelliger brachysoma*), Ponyfish (*Leiognathus* sp.), Croaker (*Johnius* sp.) and Spiny hairtail (*Lepturacanthus savala*) respectively. Biomass estimates for those species showed short-bodied mackerel has the highest biomass followed by spiny hairtail, croaker, and ponyfish.

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