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DISTRIBUTION OF PELAGIC FISH IN SOUTH CHINA SEA USING GEOSTATISTICAL APPROACH

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ABSTRACT

Pelagic fish are spesies that live in water column at depth of 100 to 200 meters from surface. They migrate as a group looking for nutrient and spawning place. Potential fisheries comodities in Indonesia including pelagic fish have high economic value. Then, stock assessment of pelagic fish measurement is important to researched. The research was conducted in May – June 2016 surrounding South China Sea waters using Madidihang 02 Research Vessel operated by Marine Fisheries Affair (MFA) Republic of Indonesia. To estimate the density of pelagic fish hydro-accoustic equipment and oceanography parameters were used and measured during the campaign. The split beam echosounder was use in aim to obtain precission position and number of fish target. The highest density of fish was found around Tambelan Island and Anambas Island. Statistically pelagic fish density has correlation with chlorophyll-a, salinity, temperature, and sea current velocity. The statistical analysis between pelagic fish density and those oceanography parameters (as statistic variables) yields positive vector correlation.

Keywords: Pelagic Fish, South China Sea, Hydroacoustic, Fish Density

INTRODUCTION

Southern part of South China Sea is categorized as shallow water and still as a part of Sunandese Shelf. (Nurhakim *et al*. 2007). South China Sea is well-known to have much variety of productivity and abundance of biodiversity. The biodiversity consist of plant and animal, especially fish as the main commodity of sea resources (Matsunuma *et al*. 2011).

Pelagic fish is a kind of fish which able to move to overseas even of state territory, spatial structure and distribution is known not random (Suman *et al*, 2016). It is difficult to decide or estimate the fish stock, particularly the pelagic one. Sea surface temperature (sst) has been believed influence the fish distribution (Solanki *et al*, 2005). In addition, sst also influences growth of phytoplankton in open sea. The concentration of chlorophyll-a indicating the abundance of phytoplankton (Bertrand *et al*, 2002). Distribution of pelagic fish has correlation with migration which is influenced by sea current. Another physical environment of oceanography is salinity (Kang, 2014). Pelagic fish habitat is affected by salinity. Fishing activities in South China sea which local fisherman have been doing until today is based on.experience, so location for fishing is not determined accurately and environmentally unsafe. An approach that may be implemented to establish the fishing ground in South China sea is hydroacoustic method. The Development of data recording technology using hydroacoustic method has been operated commercially in the fisheries field (Melvin *et al*, 2015). Hydroacoustic technology has a concept to utilize sound waves propagation in sea water medium. The application of hydroacoustic method has advantages in terms of data recording, accuracy, and it is not harmful for living organism in sea water environment (Priatna and Wijopriono 2011). This paper will discuss the correlation between pelagic fish density distribution with oceanography factors at South China sea using hydroacoustic approach in order to propose fishing potential zone.

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MATERIALS AND METHODS

Time and Location

Data collection has conducted in Mei 2016 – June 2106 in South China Sea that is part of Indonesian territory. This research was a part of survey activities by Marine Fisheries Research Board of Research and Development of Marine and Fisheries Republic of Indonesia. Data processing and analysis carried out in acoustic laboratory of Bogor Agricultural University and acoustic laboratory of Marine Fisheries Research Board of Research and Development of Marine and Fisheries Republic of Indonesia. Data recording was done along 1580,1 Nm (Nautical Mile) covering Bintan Island waters, Anambas Islands, Natuna Besar Island, Natuna Kecil Island, west Singkawang (Borneo Island), and Tambelan Island waters. (Figure 1)

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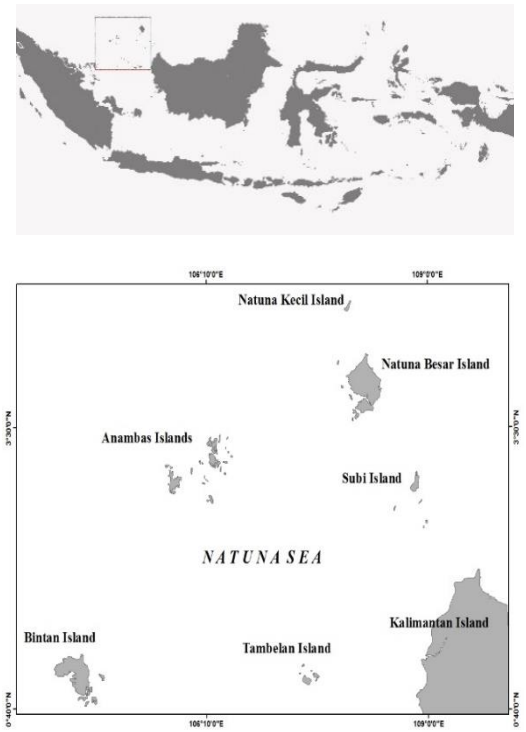

Figure 1. Research location in South China Sea, Indonesia territory.

Hydroacoustic Data Sampling

Hydroacoustic data recording using Echosounder type Simrad EK 80. Transmitter and receiver waves pulse using Split Beam Transducer ES200-7C frequency in 200 kHz, angle beam 70 made from composite material. The split beam transducer commonly divide the transducer into four different functional part (Figure 2). These equipments then were connected to GPS to record the location of data. All tools was placed in ship, then data record data may doing simultaneously during ship tracking.

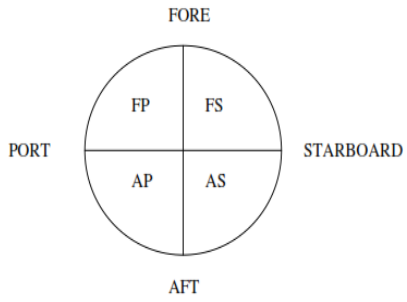

Figure 2. The Configuration of Split Beam Transducer (Simmonds and MacLennan, 2005)

Oceanographic Data Sampling

The oceanographic data was collected by using digital equipment. Samples have been taken from stations that represent the sea water environment. The equipment is CTD-set (Conductivity Temperature Depth) that record every layer of depth. Data recorded were include temperature, salinity, chlorophyll-a, and sea current.

Acoustic Data Analysis

Hydroacoustic data was analyse using Target Strength (TS) concept to measure size and length of fish target. The equation to measure TS was (Johannesson and Mitson 1983):

$$TS = 10 \log \frac{\sigma}{4\,\pi}$$

Where:
TS = Target strength
σ =scattering cross-section

Pelagic fish density (fish/hm^3) may estimate by Scattering Volume (SV). The formula to calculate SV was:

$$SV = [\rho . TS/V]$$

Where:
SV = Scattering Volume
ρ = Water Density
V = Water Volume
TS = Target Strength

The average depth of recording data is 50 meter, then the formula to calculate Scattering Area (SA in fish/km2) was adding Δd_{50} to form the equation as:

$$SA = SV.1.852^2 \Delta d_{50}$$

RESULTS AND DISCUSSION

Figure 3 (a) shows horizontal distribution of temperature at South China Sea derived from insitu data. Data collection was conduct in three different time in a day, i.e morning time, noon, and night, therefore it were shown huge temperature different in some areas. The lowest temperature was 30.45 (^{o}C) and the highest was 32.22 (^{o}C). Syaifullah (2015) state that sea surface temperature (SST) at Indonesian Sea has a range between 30 – 31 ^{o}C, yet with the contribution of global warming causes the anomaly in SST with positive (increase) or negative (decrease) trend. The southern part of study area have SST around 30 – 31 ^{o}C, while in northen part at the value was dominantly reach 32 ^{o}C. These SST distribution may caused by water mass mixing process in shallow water zone, meanwhile in deeper water of northen part the water mass may not be perfectly mixed, so the sea surface get the optimum temperature. Tubalawony (2002) stated that the difference of mass temperature occured because of the water mass removal vertically. Sadhatomo (2006) stated that the horizontal distribution of sea surface temperature is affected by seasonal factor.

The horizontal distribution of chlorophyll-a is shown in Figure 3. The very high values (1.5 mg/ L – 5 mg/L) was found around the coast of Borneo, and the value of the open waters is more homogeneous (0.1 mg/L - 0.2 mg/L). These results matched with the statement of Kurniawati *et al*. (2015) that

horizontal concentration of chlorophyll-a around the coast area may higher then the offshore. The chlorophyll-a distribution is related to nutrient input from surrounding mainland. In this case the mainland were Borneo, Natuna Besar, and Anambas.

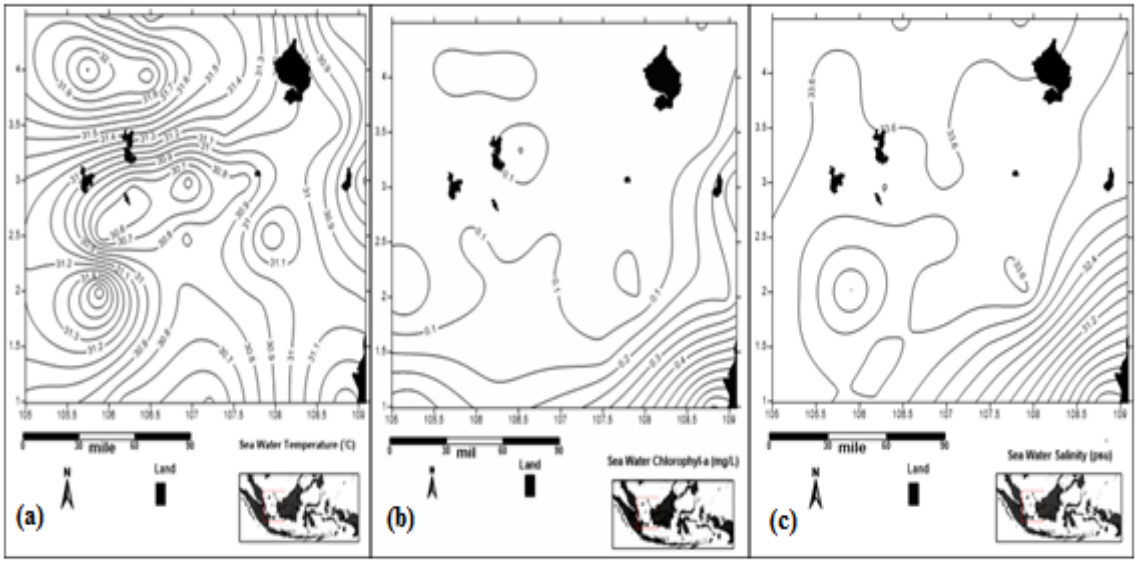

Figure 3. The Horizontal Distribution of sea surface temperature (a), chlorophyll-a (b) and salinity (c) at South China Sea

The horizontal distribution of salinity is described in Figure 2. The higher salinity (32 psu – 33 psu) was found at open water area, while lower salinity was mainly distribute at near coasts (28 psu – 30 psu in range). It can be occurs because of the circulation of mass transport was coming from North side of South China Sea and then mixed with the freshwater from inland. It support by Simanjuntak (2009) that the water mass at open water may moving from the water column to the surface and led to input higher salinity to the shore area. The variation of salinity coefficient at open waters was about 1 psu indicating that water salinity was homogeneous.

The Target Strength (TS) of fish can be used to estimate the fish abundance. In some cases, the fish abundance gathered by hydroacoustic method may use to assess fish stock (Kang, 2014). The variation of fish density is depend on the amount of fish in waters area. There were some part of water surveyed have high fish density. Maximum density has been found was 161.800 fishes/mile^2, and the minimum number was 0 or no fish detected. Fish density can be seen by echogram that shown at Figure 4

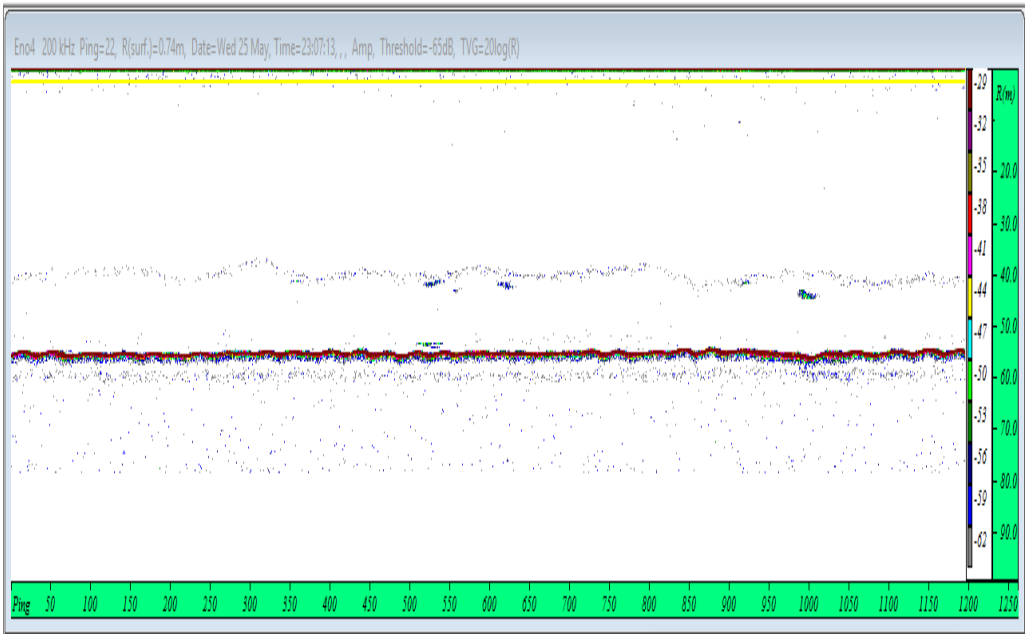

Figure 4. Echogram show the fish density distribution

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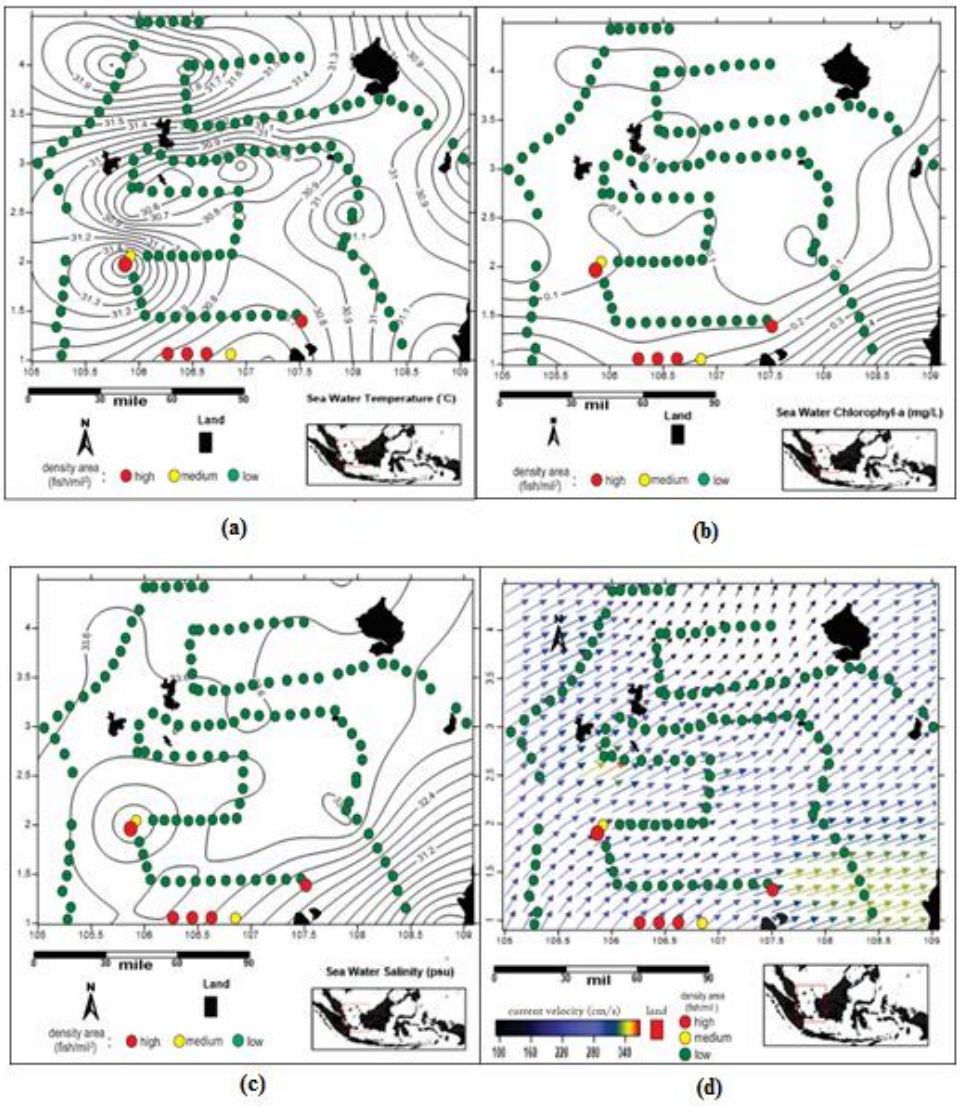

Figure 5. Fish density depending on temperature (a), Chlorophyll-a (b), salinity (c), and sea current velocity (d)

There were 3 locations found had high fish density. The first place was at the waters area between Borneo and Natuna Island, the second area was around Anambas Islands, and the last wast the waters near Tambelan Island. Sea surface temperature of those waters at were around 30.5^{o}C – 31^{o}C, lower than other survey areas. The average of Chlorophyll-a concentration was 0.1 - 0.2 mg/L and the salinity was around 32 psu – 33 psu.Safruddin (2014) said that the watermass with lower temperature than its surrounding area may indicated as upwelling area. The location where upwelling occur may correlated to high nutrient concentration and attract pelagic fish to concentrate. Zainuddin *et al*. (2013) remark that pelagic fish showing their consistency at chlorophyll-a 0.2 - 0.3 mg/L and SST at 30^{o}C – 31^{o}C in sea water. This study found that density level at area surveyed may categorize to low level (0–100 fish/mil^2), middle level (100–200 fish/mil^2) and high level (more than 200 fish/mil^2) Generally sea surface currents are generated by winds that propagate along the sea level. Current velocity is affected by pressure on sea surface which has decreased over sea level of depth (Pond and Pickard, 1978). Spawning and migration pattern of pelagic fish are influenced by sea current velocity (Laevastu, 1993). Result of recorded data survey claimed that sea current velocity and current direction tend to move from South (Java Sea) to North (South China Sea). Similar research by Akhir (2012) also showed that the sea current was move from South China Sea to Java Sea in November until March and vice versa in April to August.Figure 6 describes oceanographic factors that contribute to pelagic fish density refer to Principal Component Analysis result. The first component show that temperature had close correlation to fish density and sea current velocity had far correlation to fish density. The chlorophyll-a was the only oceanographic factors that contribute positive value in second component, that means chlorophyll-a is important for waters environment. The temperature

affect phytoplankton life as producer of chlorophyll-a. The sea current play an important role in distribution of nutrient where fish always looking for nutrient and ideal habitat to life.

The lowest sea current velocity recorded was 90.385 cm/s and the highest was 224.368 cm/s (Figure 5). High fish density tends to be found at current velocity 130 cm/s. This result similar to research by Rasyid *et al*. (2014) that stated maximum current velocity for fish was at 120 cm/s. Then based on this water current velocity, fish within this water mass layer may migrate to the Pacific through by South China Sea.

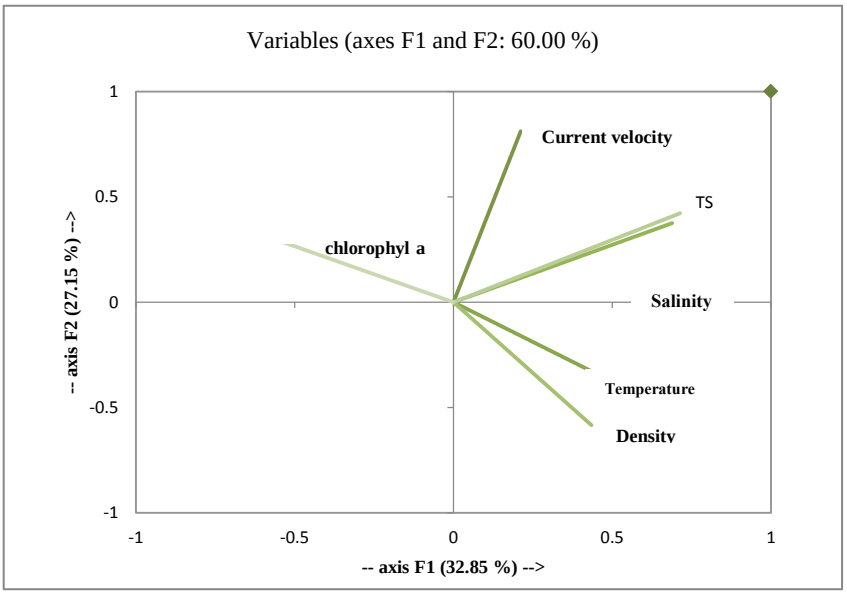

Figure 6. Biplot analysis fish density on oceanography factors

CONCLUSION

The highest density of pelagic fish was found near in around Tambelan Island, and Anambas Waters. The oceanographic condition in those spots area were have temperature at 30.5oC – 31oC, salinity at 32 psu – 33 psu, chlorophyll-a at 0.2 - 0.3 mg/L, and sea current velocity at 130 cm/s. The environment temperature was prove has close correlation to fish density. Based on spatial analysis, areas in high fish density are potential to state as fishing ground. Statistically, there were two parameters that most influential on pelagic fish density in this research; temperature and sea current velocity.

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