Application of quantitative echosounder EK500 to detect fish density distribution in the waters at the eastern region of Alor Island

Izmiyaqin¹, I Jaya¹* and H M Manik¹
Dept of Marine Science and Technology, Faculty of Fisheries and Marine Science, IPB University, Bogor 16680, Indonesia

*e-mail: indrajaya@apps.ipb.ac.id

Abstract. Information on fish resources and its distribution in the waters around Alor Island, East Nusa Tenggara is still relatively unknown. For that matter, the objective of this study is to determine the distribution of fish density horizontally (latitude or longitude) or vertically (depth) in the waters at the eastern region of Alor Island, using acoustic scientific echosounder SIMRAD EK500 instrument. This instrument is equipped with split beam echosounder transducer system with operating frequency of 38 kHz and 120 kHz. The acoustic survey was conducted in the waters off the north, east and south coast of eastern part of the Alor Island. The result of the survey showed that fish density detected in the surface water dominated by 0,1-100 individual/m³ fish density, in 60-80 meters depth was dominated by 0,1-10 individual/m³, and in 80-200 meters depth was dominated by 0,1-100 individual/m³ of fish density. In addition, the 38 kHz detect higher density of fish compare to 120 kHz.

1. Introduction
Indonesia has abundant fish resources, but there are still many who have not been utilizing it optimally. Fish resources have a great potential in supporting Indonesia's economy. Therefore, it is necessary to explore the potential of the fish resources on a water to determine the estimation of fish stocks on a water by using calculation in predicting fish populations [1]. A method that can be used to know the fish resources in a water is hydroacoustic method. The method is used to detect an underwater object by utilizing sound waves. They have ability to detect targets by propagating beneath the water to reach the bottom of water or lower layer [2]. The propagating sound waves will cause echoing when the wave reached target [3]. In addition to knowing the fish resources in a water, hydroacoustic methods can also be used to suspect the depth of water, the abundance of fish, as well as detecting the type of fish or target [4].

SIMRAD EK500 has a split beam echosounder transducer system with 38 kHz and 120 kHz of frequency which is usually used in the hydrography to measure depth and detect the basic waters and also direction of a single fish target [5]. Estimation of fish stocks in the water can be found based on the value of fish density produced by the instrument. The fish density is derived from the integrated echo calculation that comes from the detected fish group [6].
Alor Regency is one of the largest districts in East Nusa Tenggara (NTT). Conservation area established on 16 June 2015 through the decree of Minister of Maritime and Fisheries No. 35/KEPMEN-KP/2015 with an area of 37.14% of the total waters area of Alor Regency. The potential of marine resources in this region is very high reaching 18,000 tons of fishery production in 2016 [7].

High potential of fish resources (26.1%) of the total 1,699.4 tons in East Nusa Tenggara derived from Alor island waters corresponding to the decree of Minister of Maritime and Fisheries No. 45 Year 2011 on estimation of potential fish resources in the fisheries Management Area of the Republic of Indonesia, East Nusa Tenggara Province (NTT). In addition, this research needs to be conducted to get the location of fish spread and as a reference in fulfilling the production of capture fisheries in the waters of East Alor Island.

2. Methods

2.1. Study area

This research was conducted in the eastern region of Alor Island waters. Data processing was carried out in March-June 2019 at the Marine Acoustic and Instrumentation Laboratory, Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, IPB University. The acoustic survey track in the eastern region of Alor island waters was shown in figure 1.

![Research location in the eastern region of Alor Island waters.](image)

2.2. Tools and materials

Acoustic data was collected using split beam echosounder type SIMRAD EK500 with 38 kHz and 120 kHz of frequency. Echogram Software MATLAB, ArcGIS, and Microsoft Excel were used for acoustic data analysis. This research also used Ocean Data View Software and computer.

2.3. Processing data

The processing of acoustic data was conducted to get the value of fish density in the waters and known the abundance of fish in the water. First, data of SIMRAD EK500 was obtained from acoustic survey like navigation text, sounding time (date and time) and Nautical mile text are entered and filtered to get fish distribution. The data is calculated using Microsoft Excel to determine the value of fish density by equation (4). Then, it is processed using MatLab to determine the amount of density by using charts. The fish density obtained is made in the form of maps based on data that has been calculated using Microsoft Excel.
Fish density is calculated by using echo integration from detected fish groups. The detected group of fishes formed layers of waters with thickness corresponding to the thickness of fish groups, so echo integration is occurred thoroughly to the volume of waters. Volume backscattering strength ($S_v$) is required to calculate fish density. Volume backscattering strength ($S_v$) is the value of reflection produced by a single target group and the target is at a volume of water [8]. The Volume of backscattering strength ($S_v$) derived from the water layer can be calculated by:

$$S_v = \frac{\partial \sigma}{\partial v} / 4\pi r^2$$  \hspace{1cm} (1)

Split Beam Echosounder System has TVG function ($20 \log r + \alpha r$) to reduce the impact of attenuation caused by sound absorption when propagating into the water [9]. Where $r$ is the near field distance or the distance between the target and the transducer and $\alpha$ is the coefficient of attenuation caused by absorption in the unit distance. The value of area backscattering cross section ($S_A$) (m$^2$/nm$^2$) is obtained from $S_v$ that has been extrapolated [10] by the equation:

$$S_A = (1852 \text{ m/nm})^2 \sigma_A$$  \hspace{1cm} (2)

$$S_A = 4\pi r^2 \times (1852 \text{ m/nm})^2 \times \text{mean} \left( \int_{r_1}^{r_2} S_v \, dr \right)$$  \hspace{1cm} (3)

After getting the $S_A$ value, it can be known the scattering area of the fish which is then converted into fish density MacLennan and Simmonds [11] by the equation:

$$S_a(\text{mean}) = \text{fish density} = \frac{S_A}{4\pi}$$  \hspace{1cm} (4)

In addition, temperature and salinity data were used in this research to support acoustic data. They were obtained from http://marine.copernicus.eu/ that processed using the Ocean Data View 4.0 software by determining the location of the station representing each section in the eastern region of Alor Island waters. This island was divided into north, east and south section.

3. Results and discussion

3.1. Fish abundance in the eastern region of Alor Island

This is amount of fish density occurrences were detected by using 38 kHz and 120 kHz of frequency which presented in figure 2. Estimation of fish abundance can be found based on the value of fish density in a water. The fish density detected by SIMRAD EK500 with a frequency of 38 kHz and 120 kHz has difference occurrences values presented in figure 2. The fish density detected in 20-40 meters of depth has the largest occurrences in frequency of 120 kHz. But, in 40-200 meters of depth, the largest occurrences of fish density were detected by frequency of 38 kHz.

The difference in amount of fish density in the waters of Alor Island can be caused by changes in the depth of waters that affecting fish's environmental conditions. Amount of fish density occurrences were obtained by using 38 kHz of frequency indicates larger than using 120 kHz of frequency. The use of different frequencies in conducting research will give different results [12]. It is caused by frequency value that is strongly influenced by the level of absorption that occurs in a medium (sea water). Absorption in the waters will affect the ability of sound waves in reflecting the sound that comes from the target. High absorption can be caused by higher frequency so the energy reflected from target will be fewer and causes low neutrality and also frequency range will be reduced. Low frequency will have a greater reflection energy from target that caused by at least the absorption rate that occurs, so the range of frequency will be further and can travel to the deep waters [13].
3.2. Fish density distribution in the eastern region of Alor Island

Alor island waters has clusters and individuals of fish that spread at some point in surface layer until deep layer. It can be seen in figure 3a, in 20-40 meters fish density was dominated by 1-100 fish/m\(^3\) of fish density that indicated by green and orange bubbles. Fish density in 40-100 meters was detected at the range of 0.1-100 fish/m\(^3\). Depth of 100-200 meters was dominated by fish density at the range of 0.1-10 fish/m\(^3\) that
indicate group of fish dominate in that depth. It also shows that condition of waters in this depth layer allows to obtain more fish than above depth [14].

This is fish density distribution that detected by using frequency of 38 kHz and 120 kHz which presented in figure 3 and figure 4.

**Figure 3.** Fish density distribution by using 38 kHz of frequency.
Figure 4. Fish density distribution by using 120 kHz of frequency.

Fish density range (X) (Ind/m³):

- $0 < X < 0.1$
- $0.1 < X < 1$
- $1 < X < 10$
- $10 < X < 100$
- $100 < X < 1000$
The fish density was detected by using 120 kHz of frequency in 20-40 meters was dominated by range 1-100 fish/m³ (figure 4a). The depth of 40-60 meters was dominated by fish density at the range of 0.1-100 fish/m³. The depth of 60-100 meters was dominated by fish density at the range of 0.1-10 fish/m³ which can be seen in figure 4c. The depth of 80-100 meters was dominated by fish density of 0.1-10 fish/m³. The depth of 100-200 meters can be seen in figure 4e, indicating it was dominated by range fish density of 1-10 fish/m³.

The depth layer with high fish density was indicated as small-size fish that swim schooling from surface to the bottom layer. Schooling fish at the near of water base can also be indicated as demersal fish. The 0-1 fish/m³ of fish density shows that the fish was individuals of large fish. Generally, large-size fish tend to be individual and it usually live in the waters with fluctuating temperature and salinity conditions. However, large-size fish also have survival capability to environmental change such as surface layer that have small fluctuation [15].

The fish density is an important thing to know fisheries potential in Alor Island. Potential fish stock in Alor Island waters are tuna, skipjack tuna, long jawed mackerel, and mackerel which are pelagic fishes; schooling fishes are yellow fish tails, Snapper which are demersal fishes. In addition, bappenas.go.id said that fisheries and marine potential in the district of Alor are various types of fish such as grouper fish, shark, Teri, and mackerel. Based on www.fishbase.in, the type of pelagic fishes such as tuna, skipjack tuna, long jawed mackerel, and mackerel are usually found in the depth of 0-150 meters with the temperature range of 15°C – 30°C on tropical and subtropical areas. The types of demersal fish such as grouper fish, yellow fish tail, and snapper are lived in demersal layer or near the water base and associated with the coral reefs.

3.3. Oceanographic in the eastern region of Alor Island

Alor Island was located in East Nusa Tenggara which borders the Ombai Strait in the south and the Flores Sea in the north. Therefore, the waters of Alor Island are heavily influenced by the condition of oceanographic of the Ombai Strait and the Flores Sea. The Center for Research and Development of the Sea and Coastal Resources (PSDLP) states that the Indian Ocean streams the masses of warm water through the Makassar Strait, Lombok Strait, Timor Sea and Ombai Strait. It is commonly known as Indonesian Through Flow (ITF) or ARLINDO. Arlindo water masses affect the marine and coastal ecosystems in Indonesian waters included Alor Sea, and can also affect the migration patterns of fish found in the Arlindo path [16]. Arlindo has considerable impact on the spread of sea-level temperatures especially if the Pacific Ocean and the Indian Ocean experience considerable pressure gradients [17].

The influence of the monsoon in Indonesian waters is quite strong, this also happened in the Flores Sea in December to February are the west monsoon are dominance where winds blow from Java Sea to the ears and southeast monsoon (June to August) are oppositely. The southeast monsoon winds that blow in the month have an impact on the value of temperature and salinity in the waters [18]. Oceanographic conditions have a great influence on the living environment of biota in the sea especially the spread and abundance of fish in the sea. There are several factors affecting the life environment of biota, such as physical factors, chemical factors, and biology. The factors that have the greatest influence on the environment are physical factors such as temperature and salinity [19].
Sea surface temperature in Alor Island is 27.5°C in depth range of 0-60 m at north, east, and south sections which presented in figure 5 and figure 6. Based on surface temperature, it can be seen that this condition is suitable for tropical fish because the fish have a tolerance to temperature range of 27-32°C [20]. Basically, fish do metabolic process with a relatively narrow temperature of the range of 0-40 °C. The temperature has a close connection to the metabolic rate of fish that includes growth, food processing, body activity such as pool speed. However, each type of fish has a different temperature, so that the metabolisms rate differs [21].

Figure 5. Transect of temperature and salinity.

Figure 6. Temperature and salinity distribution in Alor island: (a) North section, (b) East section, (c) South section.
Salinity distribution in Alor Island shows greater salinity value as depth increases figure 6. The salinity in north section is 33.8-34.7‰ and can be seen in figure 3 and figure 4 that the fish density of this section has the least number of occurrences. In east section, it can be seen that the fish density of the part has the highest occurrence with salinity of 33.75-34.75‰, while the emergence value of fish density in the north is less than the east section with salinity of 33.8-34.7‰. The study was conducted from June to July in the eastern season, during which time the Indonesian waters had a higher salinity value [22]. It shows salinity in the east section according to the fish environment was found in Alor Island waters. If the fish is in an environmental condition that is not suitable, the fish will respond to adjust or seek a new habitat that has conformity to the condition of the fish [23].

4. Conclusion
Based on research, it can be known that the difference amount of fish density in the eastern of Alor Island waters was caused by depth change that affecting the fish's environmental condition. In surface layer, it was dominated by 0.1-100 fish/m³ of fish density, depth of 60-80 m was dominated by 0.1-10 fish/m³ of fish density, and in 80-200 m was dominated by 0.1-100 fish/m³ of fish density. Based on fish density measurements, it is known that there is a difference in detection results using a frequency of 38 kHz and 120 kHz which indicates the greater number of detected densities at low frequency

5. References
[1] Charef A 2010 Estimation of pelagic fish distribution and biomass in the East China sea using hydroacoustic methods [Dissertation] (Tokyo (JP): University of Tokyo)
[2] Balk H 2011 Development of hydroacoustic methods for fish detection in shallow water [Dissertation]. (Oslo (NO): University of Oslo)
[3] Brown C J, Smith S J, Lawton P and Anderson J T 2011 Benthic habitat mapping: a review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques Estuarine Coastal and Shelf Science (92) 502-520
[4] Widodo J 1992 Prinsip dasar hidroakustik perikanan Oseana 17(3) 83-95
[5] Bird K J B and Lawson G L 2015 Ecological insights from pelagic habitats acquired using active acoustic techniques. Annu. Rev. Mar. Sci. 8(21) 1-21
[6] Sudjianto 2004 Teknik pengolahan dasar (postprosessing) data akustik split beam untuk pendugaan stok ikan. Buletin Teknik Ltitkayasa Sumber Daya dan Penangkapan (2): 25-32
[7] Badan Pusat Statistik Kabupaten Alor 2017 Kabupaten Alor dalam Angka 2017. Kalabahi (ID): BPS Kabupaten Alor
[8] Lurton X 2002 An Introduction to Underwater Acoustic: Principles and Applications. (Chincester)
[9] Randhi Z, Hestirianoto T and Pujiyati S 2017 Akustik dibandingkan dengan densitas ikan: kombinasi metode aktif dan pasif. Jurnal Teknologi Perikanan dan Kelautan 8(2) 187-198
[10] Kloser R J, Koslow J A and Williams A 1996 Acoustic assessment of the biomass of a spawning aggregation of orange roughy (Hoplostethus atlanticus, Collet) off South-eastern Australia Marine and Freshwater Research 47 1015-1024
[11] MacLennan D N and Simmonds E J 2005 Fisheries Acoustics (London (UK): Chapman and Hall)
[12] Saleh M 2010 Seabed classification using sub-bottom profile [Thesis] (Delft (NL): Delft University of Technology)
[13] Baigo H, Pujiyati S and Hestirianoto 2014 Karakterisasi pantulan akustik karang menggunakan Echosounder Single Beam Jurnal Integrasi 6(2) 129-133
[14] Manik H M, Sujatmiko T N, Ma'mun A and Priatna A 2018 Penerapan teknologi hidroakustik untuk pengukuran sebaran spasial dan temporal ikan pelagis kecil di Laut Banda Marine Fisheries 9(1): 39-52
[15] Priatna A and Natsir M 2007 Distribusi kepadatan ikan pelagis di pantai utara Jawa bagian timur, Pulau-pulau Sunda, dan Laut Flores J. Lit. Perikan. Ind 13(3) 223-232

[16] Cahya C N, Setyohadi D and Surinati D 2016 Pengaruh parameter oseanografi terhadap distribusi ikan. Oseana 41(4) 1-14

[17] Tubalawony S, Kusmanto E and Muhadjirin 2012 Suhu dan salinitas permukaan merupakan indicator upwelling sebagai respon terhadap angin muson tenggara di perairan bagian utara Laut Sawu Ilmu Kelautan 17(4) 226-239

[18] Tomascik T, Mah A J, Nontji A and Moosa 1997 The Ecology of Indonesian Seas: The Ecology of Indonesia Series 7 (Hongkong (HK): Periplus Eds.)

[19] Laevastu T and Hela I 1970 Fisheries Oceanography (London (UK): Fishing News MacLennan DN)

[20] Brown A and Rengi P 2014 Pelagic fish stock estimation by using the hydroacoustic method in Bengkalis Regency waters Berkala Perikanan Terubuk 24(1) 21-34

[21] Tangke U, Karuwal J W C, Mallawa A and Zainuddin M 2015 Analisis hubungan suhu permukaan laut, salinitas, dan arus dengan hasil tangkapan ikan tuna di perairan bagian barat Pulau Halmahera. Jurnal IPTEKS PSP 3(5) 368-382

[22] Safitri M, Cahyarini S Y and Putri M R 2012 Variasi arus arlindo dan parameter oseanografi di Laut Timor sebagai indikasi kejadian Enso. Jurnal Ilmu dan Teknologi Kelautan Tropis 4(2) 369-377

[23] Laevastu T and Hayes M 1981 Fisheries Oceanography and Ecology (London (UK): Fishing News Books)