ISBN: 4-925135-08-2

TUF - JSPS International Project
Volume 8 March 2000

Proceedings of

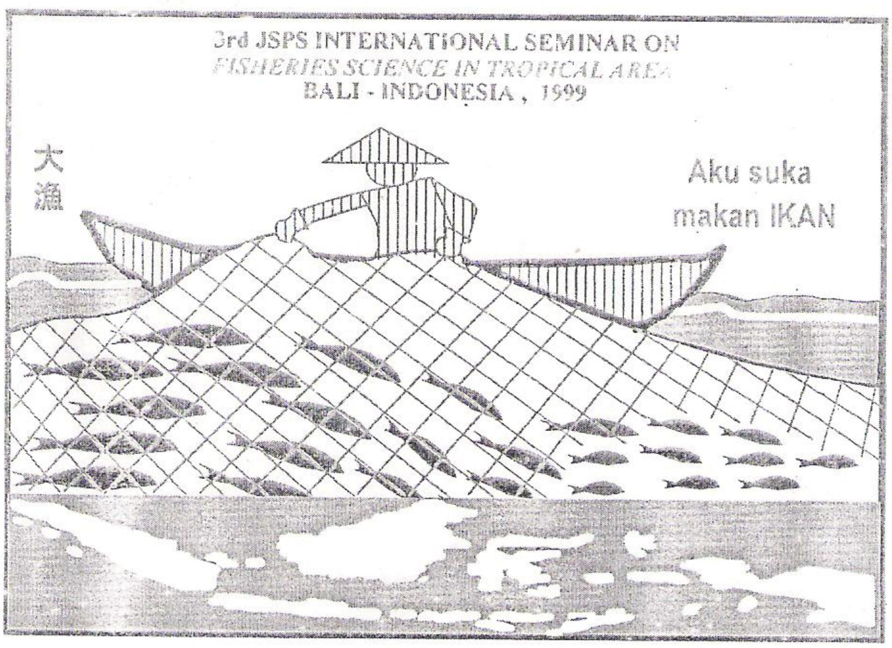
The 3rd JSPS International Seminar on

Fisheries Science in Tropical Area

Bali Island - Indonesia, 19-21 August 1999

Sustainable Fishing Technology in Asia towards the 21st Century

Edited by T.Arimoto and J.Haluan



Tokyo University of Fisheries
4-5-7, Konan, Minato-ku
Tokyo 108-8477 JAPAN

Institut Pertanian Bogor
Kampus IPB Darmaga
Bogor 16680 INDONESIA

Diponegoro Univeristy
Jl. Hayam Wuruk 4A
Semarang INDONESIA

Author Index

STUDY ON FISH DENSITY USING SPLIT BEAM ACOUSTIC SYSTEM AND ITS RELATION WITH OCEANOGRAPHIC FACTORS AT SUNDA STRAIT

Syarif Syamsuddin[1)], Bonar P. Pasaribu[2)],and Djisman Manurung[2)]

[1)] Academy of Fisheries, Pasar Minggu, Jakarta, INDONESIA
[2)] Bogor Agricultural University Darmaga Campus, Bogor 16680, INDONESIA

The utility of marine fish resources in a certain seawater can be optimized if fish density data in that area is known. The hydroacoustic devices such as split beam acoustic system can be applied to obtain the accurate fish density. Study on fish density by using this acoustic system and its relation with oceanographic factors was conducted in Sunda Strait in last March 1998. R.V. Madidihang (300 GT) and various marine research instruments were employed during acoustic cruising tracks. The results show that fish densities in the upper sea water layer of cruising legs are 1 to 4 fish/1000 m^3 with fish length until 31,6 cm, at around thermocline layer 8 - 21/ 1000 m^3 with fish length until 63 cm and at deep seawater layer 65 - 258 fish/1000 m^3 with fish length until 178 cm. The fish density is abundant at front area because seawater mass exchange of different temperature and salinity. There is indication that fish densities are found surrounding thermocline layer.

Introduction

The assessment of fish resources abundance by hydroacoustic methods has several comparative advantages, i.e. straight fish resources estimation in real time, high accuracy, covering relatively large seawater area within short time, data processing can be done in-situ, and the system does not harm the fish resources and its environment.

Fish resources habitat is much influenced by oceanographical factors, Seawater temperature and salinity are two factors which are always interested to be considered. In some ways the two parameters data are very useful for commercial fishing especially when defining abundant fishing ground prospect.

This paper is the research report on fish density assessment by means of hydroacoustic method. The research has been done in Sunda Strait seawater during March 1998 to assess fish resources density by split beam acoustic system. Mapping of fish density vertical distribution is drawn based on depth stratification. The relation between fish density and oceanographical factors (temperature and salinity) is analyzed.

Research Methods

Measuring Instrument

Acoustical data was taken by Scientific Echo Sounder SIMRAD EY 500 using split beam transducer consisted of 4 quadrant, and equipped by echo integrator. The computer apparatus was connected to acoaustical instruments, so the data acquisition was controlled through keyboard. Specification of SIMRAD EY 500 is 70 kHz frequency, 50 W transmission power, detection range can be arranged in water depth stratification, and the effective detectable area varied from 1 m to 400 m. The echogram is displayed in 12 colours associated with target strength and backscattering volume value, where each colour containing values difference within 3 dB.

The oceanographical instrument used in this research was CTD (Conductivity Temperature and Depth) Seabird which is able to measure temperature, salinity, dissolved, oxygen, and pH at any short depth interval until desired sea depth (say 200 m).

Cruise Track

The vessel cruise track in Sunda Strait seawater area was designed as systematic parallel transect with distance 6 n.m. between legs and leg length varied depended upon areal condition. The first oceanographic and acoustic station was located carefully at 05° 51 ' S - 105° 58' E. The other stations were placed at the end of each acoustical ESDU (Elementary Sampling Distance Unit) 6 n.mi. with oceanographic data acquisition interval at every one hour. The research cruises were done in March 1998, both following same cruise tracks.

Analysis Method

The oceanographic data (temperature and salinity) obtained from CTD Seabird are tabulated and processed by using SURFER software to obtain vertical distribution of temperature and salinity for the whole detected area. Stratification is done based on thermocline layer, and fish density is computed from each ESDU in observed legs. The echo integration is done variably depend upon seawater depth and thickness of thermocline layer which formed at each station.

The computation process on acoustical data is done by using Echo Processor 500 (EP 500) software containing mathematical equation of backscattering area $Sa = 4 \pi r_o . \{\int_{r1}^{r2} S_v d_r\} . (1852 \text{ m/nm})^2$ then volume backscattering cross section is obtained as $S_v = S_a / 4 \pi$

KEYWORDS: Acoustic split-beam system, oceanographic factors, Sunda Strait

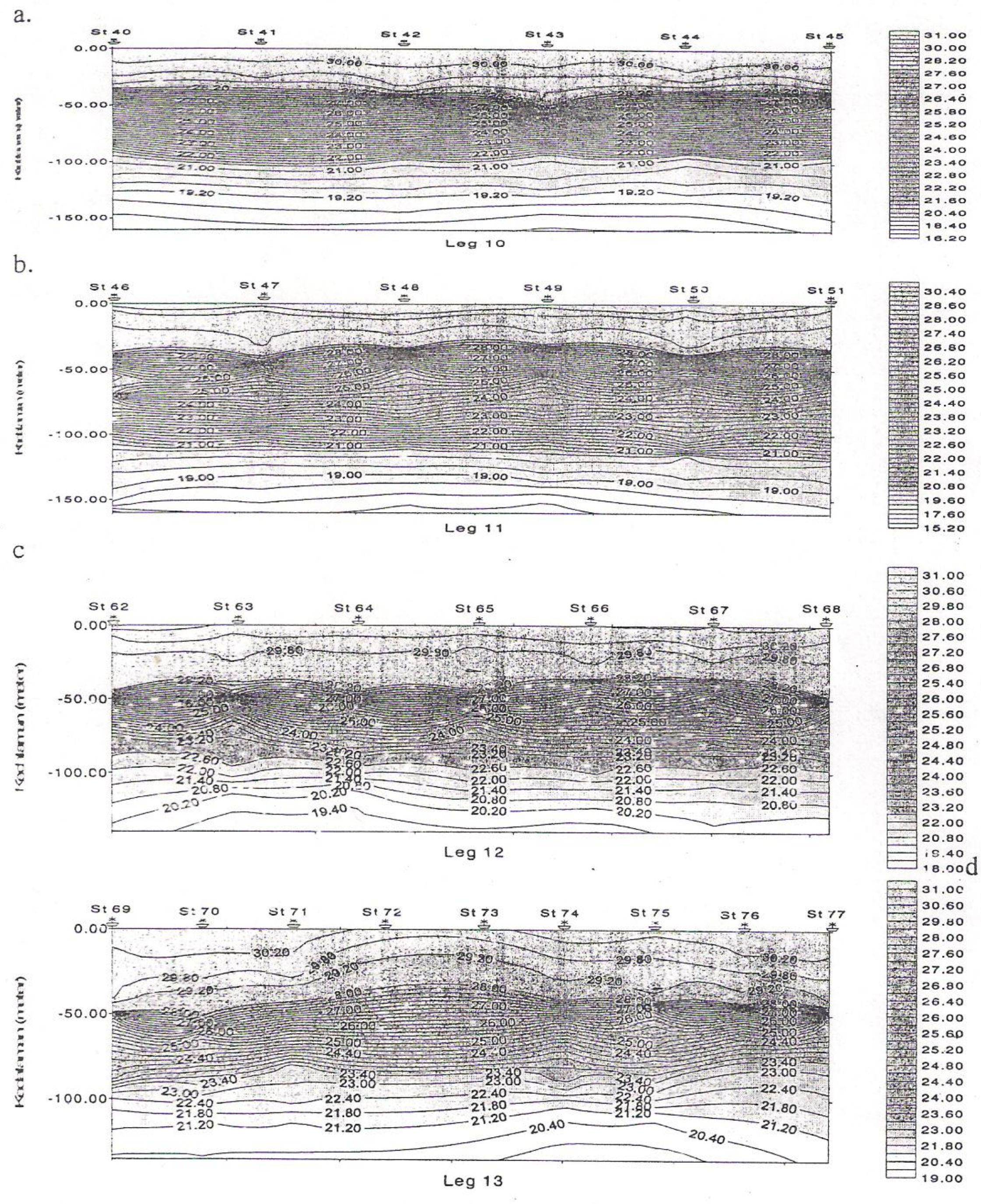


Fig. 1. Thermocline vertical distribution at deep sea Sunda Strait, March 1998 (a. leg 10, b. leg 11, c. leg 12, d. leg 13)

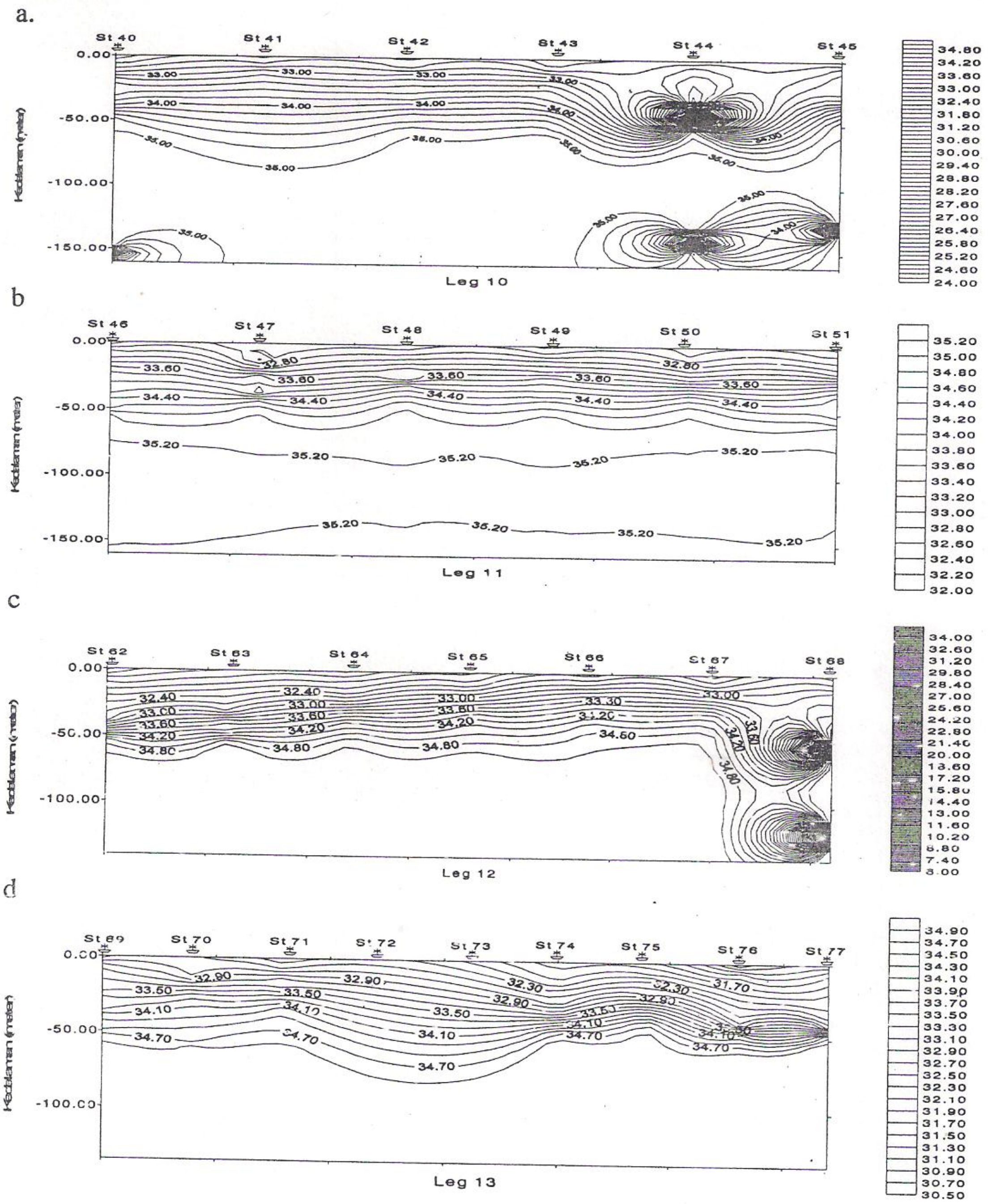


Fig.2. Salinity vertikal distribution at deep sea Sunda Strait, March 1998 (a. leg 10, b. leg 11, c. leg 12 d. leg 13).

This condition is supported by water mass of lower salinity which originally comes from deep layer. The assumption of vertical migration is also indicated by detected small fish of the same size about 7.8 to 11.0 cm (-47 to – 41 dB) with large densities at both layer.The target strength data of single fish shows different size variation at each layer (Fig. 4). In surface layer, the fish length range is –50 to – 38 dB (7.9 to 31.6 cm) with single fish composition becomes ess for bigger fish. In thermocline layer, all fish sizes in small number. This is considered that only certain species can survive in this layer, because temperature range is high. In deep layer, single fish sizes are varied. The big fish of 177.8 cm length (-23 dB) is detected in this layer. A good environment in deep layer is assumed contributed by relative stable oceanographic condition.

a.

b.

c.

d.

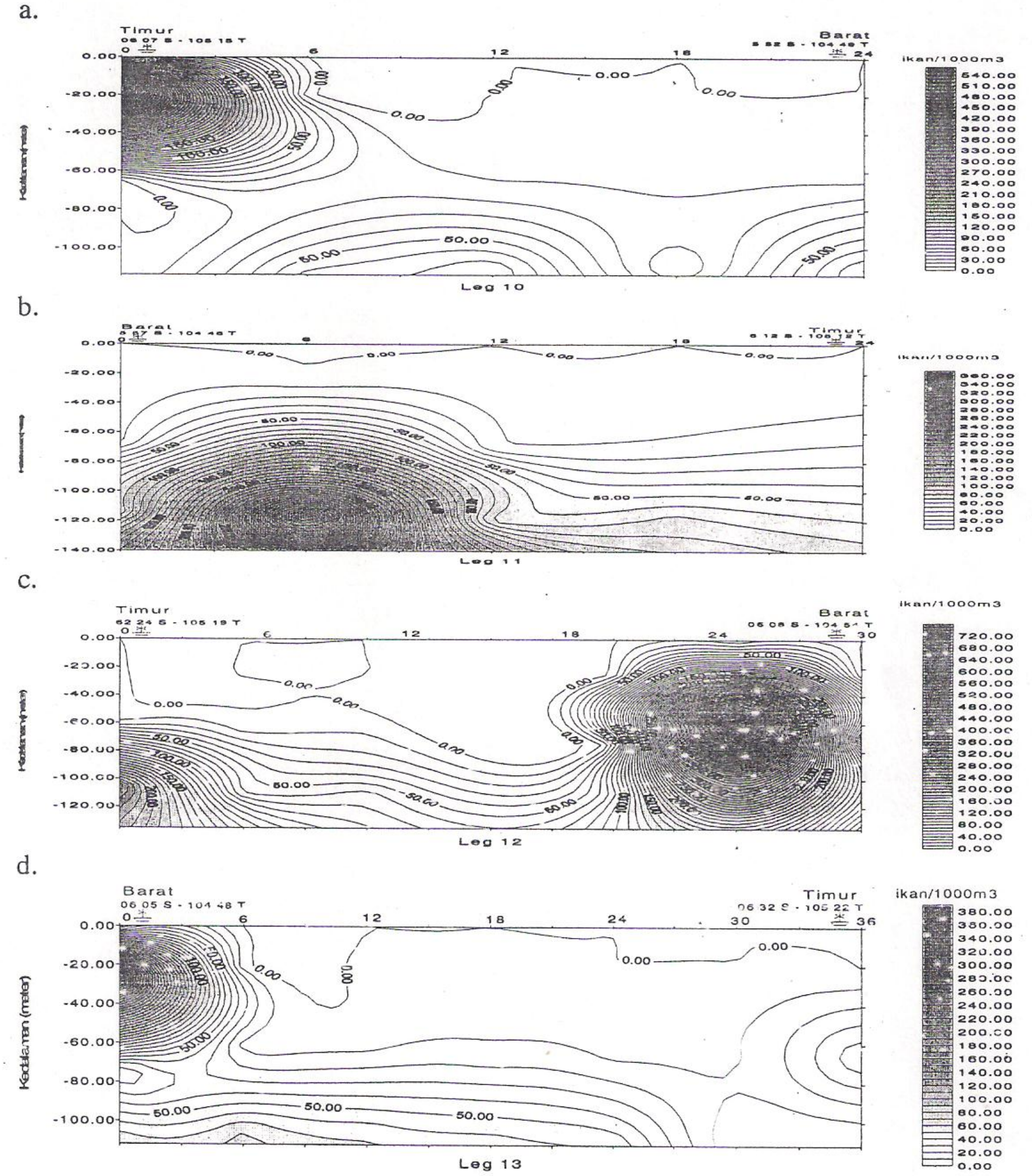


Fig 3. Fish density vertical distribution at deep sea Sunda Strait, March 1998. (a. leg 10, b. leg 11, c. leg 12, d leg 13).

r_o^2 (1852 m/nm)^2 (r_2 - r_1), and the average acoustic backscattering of single fish $\sigma_{bs} = 10^{Tsi/10}$. Fish density in a scattering area is $\rho_A = S_a / \sigma_{bs}$. . There are many single fish detected, so that $\sigma_{bs1}, \sigma_{bs2}, ..., \sigma_{bs}n$ according to fish class 1, 2, 3 ..., n which happened at frequency 1, 2, 3, ..., fn. Distribution of fi is normalized, si that $\sum$ fi = 1. Then Sa = $\rho A \sum fi\, \sigma_{bs}$ or $\rho_A = Sa / \sum fi\, \sigma_{bs}$ Fish density becomes ρ_i = fi ρ_A and fish density volume will be $\rho_v = \rho_A (r_1 - r_2)$. Computation on fish density is done at each ESDU, and presented in average fish density per volume unit.

Result and Discussion

Temperature

Seawater depth stratification based on vertical distribution of isotherm is used to classify thermocline layer. The surface layer has temperature range of 30.2° C to 28.2° C in deep stratum until 35 m to 50 m from seawater surface. The isotherm distribution indicates thermocline layer thickness within 28.2° C to 24.4° C isotherm. The isotherm closeness in thermocline layer is fluctuative at 2 outer legs toward South. It is considered happened because sea bottom topography condition gradually increased from isodepth 1000, 200, 100 and 50 m. Influences the water mass movement.

In leg 10 where station number 40, 41, 42, 43, 44, and 45 lie, the temperature distribution is more stable except at stn 43 indicates closest isotherm in upper thermocline layer. Four legs which lie in deep water (leg no. 10, 11, 12 and 13) shows the same pattern forming tracture of vertical temperature profile averagely started from 40 m depth (Fig. 1).

Thermocline layers at leg 11, 12, and 13 indicate the same phenomena, i.e. the sharp temperature decrease on the upper an lower parts, it seemed the layer is parted by other layer which has more split temperature change closeness.

The isotherm closeness is more stable at thermocline layer in leg 10. The upper limit of thermocline layer moved toward surface started from outer leg to inner legs. This phenomena indicates the existence of water mass passage which is considered caused by sea bottom tpography and southwest current.

In deep water, generally the isotherm closeness is relatively constant. That means the temperature decrease in this layer changes in small value in accordance with additional depth. The temperature range in this layer is 3.6° C in vertical distance until 150 m depth.

Salinity

The salinity increase with additional depth is limited to 35.2°/oo, then the value is relatively constant in more deeper depth. Generally, at all observation stations, the maximum salinity is Found at 55 m to 90 m depth (Fig. 2).

The vertical salinity change in outer leg (no. 13) shows isohaline distribution more closer toward the area nearer to Java Island. The low salinity value in this area is caused by water mass flow from Java Sea which bring low salinity water. Water mass in Sunda Strait always move toward south direction (Wyrtki, 1961).

The same pattern is also found at leg 12, and the isohaline distribution is relatively constant. An interesting phenomena is occured between stn 67 and 68, where water mass of low salinity is found around 60 m and 120 m depth.

In leg 11, the salinity value increases up to 35°/oo at 60 m depth. Then, the additional salinity is relatively small up to 35.2°/oo within 15 m to 30 m layer thickness. The deeper depth of 40 m to 80 m thickness has isohaline of 35.2°/oo. The salinity is gradually decreased up to 35.0°/oo at 150 m depth.

Stn 40 – 45 at leg 10 show the same pattern as in leg 12, i.e. the existence of water mass with lower salinity than its surrounding at 120 m to 150 m depth as appeared in stn 44 and 45

Vertical Distribution of Fish Density

The fish concentration is found at the surface layer with fish density value of 58,923 fish/1000 m3 detected in the east of leg 10. This is an ordinary number.The area is located above 200 m isodepth near Krakatau Islands. The other fish concentration is also found at leg 13 in the west part (Fig. 3).

In thermocline layer, the average fish density is 8 – 21 fish/1000 m3 with uniformed distribution within water column, except on leg 12 in west part which has density of 2007 fish/1000 m3. The acoustic detection result show that only this thermocline layer area containing highest fish density.

The deep layer shows fish density value which is generally higher and equally distributed compared with its above 2 layers (thermocline layer and surface layer). The lowest fish density is 56 fish/1000 m3 and the highest is 385 fish/1000 m3.

ESDU 66 presented fish densities of 107 fish/1000 m3 at surface layer, 2007 fish/1000 m3 at thermocline layer and 304 fish/1000 m3 at deep layer, while ESDU 47 indicated 1 fish/1000 m3, 128 fish/1000 m3, and 385 fish/1000 m3 respectively. ESDU 66 is passing sea mount of 955 m height measured from isodepth in its south at 06° 10' S - 104° 57' E. The sea mount top was detected at 46 m depth. ESDU 47 also passing a sea mount located 1 n.mi. from acoustic axis track at 05° 58' S - 104° 52' E with 900 m sea mount height and the top is at 94 m depth

Relation between Fish Density and Oceanographic Factors

Fish density during March 1998 is generally distributed in deep layer near lower thermocline layer. This condition is different from January Cruise where density was distributed at 20 – 40 m (Pasaribu, 1998) This difference is considered because of fish vertical migration due to depth change and thermocline layer thickness. There is indication that the upper limit of thermocline layer in March is moved toward surface and magnitude of water mass passage is stronger, so that thermocline layer is thinner than in January case

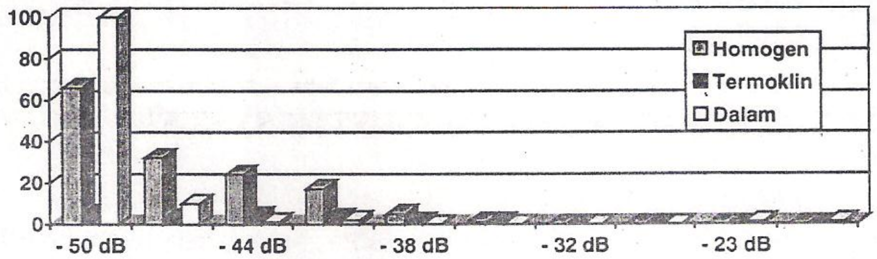


Fig 4. Single target of fish in water stratification at Sunda Strait, March 1998.

Water mass of lower salinity than its surrounding in deep layer is assumed contributing to condusive condition for fish during March. This relation is clearly shown in leg 11 and 12. In leg 11, the lower salinity of water mass extended from west to east direction is followed by equal distribution with high enough fish density in deep layer (Fig. 2b and 3b). The same condition is also found at leg 12 (fig. 2c) at stn 67 – 68 followed by high fish density (Fig. 4c) in water depth near the station. It is observed that high fish density is not exactly located on water mass of lower salinity point, but fish concentration is found in marginal area which is front of different water masses. There are many research findings state the front area is fertile for fish life, because water mass mixing which distributes minerals and other compounds as feed for plankton.

Conclusion

(1) Fish density at surface layer as a whole 1 – 4 fish/1000 m^3. Fish density concentration in west part of Krakatau Island is 58.923 fish/1000 m^3 and single fish target strength is –50 to –47 dB. In south part of Sunda Strait, the highest fish density is 38.789 fish/1000 m^3 and target strength is –50 dB (7.9 cm).

(2) Fish density in thermocline layer is distributed equally with 8 – 21 fish/1000 m^3 . Fish concentration in south area is 2007 fish/1000 m^3 with fish size up to 63 cm (-32 dB).

(3) Fish density in deep layer is distributed equally with high enough density 65 – 258 fish/1000 m^3 of varied fish size, a big fish of 178 cm (-23 dB) was detected.

(4) Fish density is abundant at vertical front area from water mass mixing of different temperature and salinity. There is indication that appropriately high fish density is found surround thermocline layer.

Acknowledgement

The authors deeply appreciate the Management of Academy of Fisheries Pasar Minggu – Jakarta, for their help and hospitality to provide R/T.V Madidihang (300GT) in this research work. The authors also wish to thank Indonesian Institute of Science and Agency of Technology Assessment and Application to provide research grant (RUT – V)

References

1). Burczynski, J, 1986. Introduction to the use of Sonar System for Estimating Fish Biomass. FAO. Fisheries Technical Paper No 199. Revision 1.
2). Foote, K.G. 1987. Fish Target Strength for Use in Echo Integrator Surveys, J. Aconst Soe. Am Page 981 – 987.
3). MacLennan, D.N. and E. Jonh Simmonds. 1992. Fisheries Acoustic. Chapman and Hall. London – New York – Tokyo – Melborne – Madras. 325p.
4). Pasaribu, B, Nainggolan. C. 1998. Pengembangan Algoritma untuk Pemetaan Sumberdaya Ikan dengan Teknologi Akustik di Perairan Selat Sunda. Laporan Riset RUT-V. Kantor Menteri Negara Riset dan teknologi. Dewan Riset Nasional. Jakarta.
5). SIMRAD EY 500. 1995. Portable Scientific Echo Sounder. Horten. Norway. 186p.
6). Wyrtki, K. 1961. Naga Report Volume 2. Physical Oceanography of the South East Asia.