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Distribution and density of demersal fishes in Youtefa Bay, Papua, Indonesia: A study using hydroacoustic technology

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ABSTRACT

A study was conducted to estimate the distribution and density of demersal fish in Youtefa Bay, Papua, Indonesia, using hydroacoustic technology. The hydroacoustic survey was carried out using a single beam echosounder SIMRAD EK-15 which operates at a frequency of 200 kHz. The hydroacoustic data was processed using Echoview software with a threshold between -70.00 to -34.00 dB. Schooling fish were detected at a maximum distance of 3 m from the seabed, with average volume backscattering strength ranging between -60.13 and -42.01 dB. The demersal fish density in the Youtefa Bay ranged from 0.09 to 42.19 fish m^{-3} with an average density of 12.62 fish m^{-3}. The schools of demersal fish were dominantly detected in the coastal waters of Enggros Village to Abe Pantai Village. The condition of substrate and water depth seems to influence the spatial and vertical distribution of demersal fish in the Youtefa Bay.

Keywords: Demersal fish, Fish schooling, Hydroacoustic technology, Volume backscattering strength, Youtefa Bay

Introduction

Youtefa Bay in Papua Province, Indonesia supports several fish species. But the local fishermen have not been able to utilise the potential of these resources optimally, due to lack of accurate information on fish distribution in the Bay. Hydroacoustic technology has been often utilised for fish characterisation and classification and fisheries surveys (Davison *et al*., 2015; Thompson *et al*., 2015; Melvin, 2016; Pujiyati *et al*., 2016; Wurtzell *et al*., 2016) and for analysis and mapping of the seabed (Pujiyati *et al*., 2007; Cutter and Demer, 2014; Calvert *et al*., 2015; Hamuna *et al*., 2018a, b).

Measurement of fish population density has important applications especially for studying and management of fisheries (Gunderson, 1993). Hydroacoustic technology is considered to be an efficient fishery survey method to overcome the limitations of traditional survey methods (Hewitt *et al*., 2002) and has several advantages compared to the swept area trawl method because it can detect wider water columns continuously and simultaneously (McQuinn *et al*., 2005). The utilisation of hydroacoustic technology for fishing is one of the effective methods to detect the existence of fish directly, quickly and accurately (Simmonds and MacLennan, 2005) and to study the fish and their habitat (Pujiyati, 2008).

The objective of the present study was to apply hydroacoustic technology to estimate the distribution and density of demersal fish in Youtefa Bay, Indonesia as such information is very important for fisheries management. The results of this study can support formulating strategies for the management of demersal fish resources in the Youtefa Bay and is expected to help the local fishermen in the Youtefa Bay to identify potential areas for demersal fishing activities.

Materials and methods

This study was conducted in April 2017 in Youtefa Bay waters, in Jayapura, Papua, Indonesia. Hydroacoustic data recording was carried out in Youtefa Bay along 12.51 km of the survey line (Fig. 1), using a single beam echosounder SIMRAD EK-15 (200 kHz). Instrument specification and parameter setting during hydroacoustic data recording are listed in Table 1. Hydroacoustic data acquisition was carried out continuously with a maximum ship speed of 4-5 knots.

The Echoview 4.8 software was used for processing data. The elementary sampling distance unit (ESDU) used in data processing was 100 pings (Mello and Rose, 2009) and the hydroacoustic data obtained was divided into 320

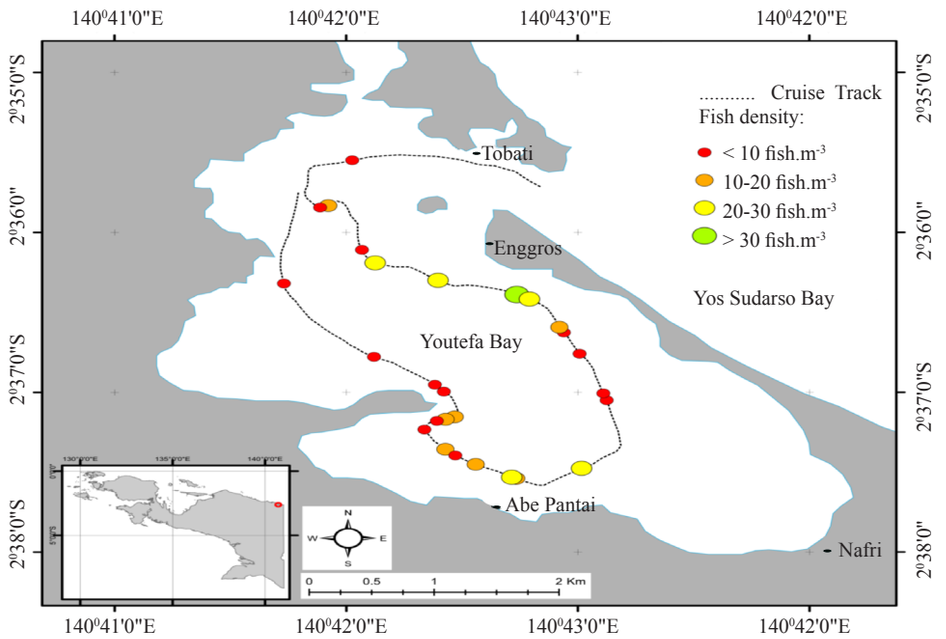

Fig. 1. Hydroacoustic cruise track and spatial distribution of demersal fish in Youtefa Bay, Indonesia

Table 1. Parameters settings during the hydroacoustic survey

Parameter	Value
Frequency (kHz)	200
Power transmit (watt)	50
Beam width (deg)	26
Transducer depth (m)	0.5
Ping rate (Hz)	>40
Pulse length (ms)	0.160
Pulse duration (ms)	0.128
Sound velocity (m s^{-1})	1545.87
Absorption coefficient (dB m^{-1})	0.01872
Transducer gain (dB)	14.20

ESDU. The processing data used a minimum threshold of -70.00 dB and a maximum of -34.00 dB (Manik and Nurkomala, 2016; Park *et al*., 2016). Considering that the habitat of demersal fish is at the seabed or near the seabed, integration and analysis of hydroacoustic data was focused at a distance of 3 m from the seabed. Distance from the seabed was added to 0.12 m ($c\tau/2$; c = sound velocity; τ = pulse length) above the seabed line detected in order to avoid the entry of sea bed echo.

Target strength (TS) and volume backscattering strength (Sv) are important parameters for estimating fish densities. TS is a logarithmic measure of the proportion of the incident energy which is backscattered by the target (Simmonds and MacLennan, 2005). Sv is the key measurement for estimation of acoustical fish density and abundance (Parker-Stetter *et al*., 2009). The accuracy of TS determines the accuracy of estimates of fish density and abundance (Kim *et al*., 2018). Data on the length of demersal fish (L) obtained in this study was used to determine the TS value of demersal fish using the following equation (Hjellvik *et al*., 2003):

$$TS = 20 \log L - 68$$

The TS value thus obtained was converted into a backscattering cross section ($<\sigma_{bs}>$) by linearising the TS value using the following equations (Simmonds and MacLennan, 2005):

$$TS = 10 \log_{10} (\sigma_{bs})$$

$$\sigma_{bs} = 10^{(TS/10)}$$

The result of data processing was an acoustic data matrix of Sv from fish schooling. The logarithmic equation for measuring Sv value and volume backscattering coefficient (s_v) is as follows:

$$Sv = 10 \log_{10} (s_v)$$

$$s_v = 10^{(Sv/10)}$$

The spatial and vertical distribution of demersal fish in Youtefa Bay during hydroacoustic surveys has been presented. Grouping of demersal fish density in each range of 5 m depth was done to find out the distribution in each of these depth ranges. The density of fish was calculated using Sv and σbs values. This method is sometimes referred to as Sv/TS scaling considering that this density estimate depends on the value of the integration of echo (Sv) and

σbs. The Sv is defined as fish density (ρ) multiplied with the average backscattering cross section (<σbs>) (Parker-Stetter *et al*., 2009):

$$s_v = \rho v \, . \, <\sigma_{bs}>$$

The density of demersal fish per unit volume (ρv) was obtained using the following equation (Parker-Stetter *et al*., 2009):

$$\rho v = s_v / <\sigma_{bs}>$$

Results

Detection of demersal fish schooling

During the hydroacoustic survey, 27 schools of demersal fish were recorded. The position of demersal fish schools based on water depth is presented in Table 2. Based on the result of hydroacoustic detection, schooling of demersal fish was found in the shallow waters of Youtefa Bay. The schools of demersal fish in the Youtefa Bay were found at an average distance of 0.26-2.93 m above the sea bed with the height of the schools ranging between 0.49 and 1.70 m. Based on the integration results for demersal fish, Sv values obtained ranged from -60.13 to -42.01 dB with an average Sv value of -54.66 dB.

Table 2. The demersal fish school depth of occurrence based on echo integration

No	ESDU	Water depth (m)	Demersal fish school depth (m)
1	31	34.53	33.44
2	62	28.85	27.07
3	78	12.15	11.70
4	81	11.68	10.20
5	90	7.93	6.66
6	92	8.71	6.72
7	94	8.92	7.48
8	98	8.92	8.17
9	106	8.41	6.47
10	109	8.21	7.58
11	114	7.73	5.46
12	123	7.17	4.54
13	124	7.09	5.39
14	141	7.32	6.30
15	168	9.58	8.78
16	170	9.94	7.01
17	184	9.27	7.36
18	192	9.03	7.33
19	194	7.73	5.47
20	206	5.24	4.33
21	209	4.61	3.34
22	227	5.90	4.26
23	242	4.60	4.34
24	247	13.78	11.29
25	266	8.13	5.27
26	268	15.70	15.00
27	290	8.08	7.55

Demersal fish distribution in the Youtefa Bay

The vertical distribution of Sv value for demersal fish schools is presented in Table 3. The spatial distribution of demersal fish was recorded mainly in the coastal waters from Enggros to Abe Pantai villages (Fig. 1). The Sv values of demersal fish were in the range of -59.00 to -52.00 dB. High Sv value (>-43 dB) was only found at one school around the waters of Tobati Village. The high number of demersal fish detected in the coastal waters from Enggros to Abe Pantai villages could be due to the influence of the seabed substrate, which was dominated by seagrass and mud.

Demersal fish density in the Youtefa Bay

The demersal fish aggregations could be clearly seen on echograms, through hydroacoustic detection. The vertical distribution of demersal fish density in Youtefa Bay is presented in Table 4. Based on 320 ESDU which contained 27 fish schools, highest demersal fish density of 42.19 fish m^{-3} was recorded at a depth of 0-5 m. The average density of demersal fish detected in Youtefa Bay waters was 12.62 fish m^{-3}.

Discussion

Results of the study indicate that in Youtefa Bay, demersal fish abundance was comparatively more in shallow waters and decreased with increase in water depth. The density of demersal fish was concentrated at the depths upto 10 m. The detected size of demersal fish in Youtefa Bay was small. This explains that small fish prefer shallow water zones as their habitat (Chang *et al*., 2012). Small demersal fish are important in marine ecosystems in connecting the lower and upper levels in the food chain (Thangavelu *et al*., 2012; Chouvelon *et al*., 2015).

There are 36 demersal fish families that were caught by local fishermen in the Youtefa Bay, which is mostly commercial fish (Tebaiy *et al*., 2014). Commercially important fish were dominant in the shallow water zone (Labropoulou and Papaconstantinou, 2004). The dominant species caught by local fishermen are *Siganus fuscescens*, *S. canaliculatus*, *Apogon ceramensis*, *Mugil cephalus*, *Aeoliscus strigatus*, *Scolopsis lineata*, *Parupeneus barberinus*, *Atherinomorus lacunosus* and *Upeneus subvittatus*.

The high number of demersal fish detected in the present stduy, in the coastal waters from Enggros Village to Abe Pantai Village was probably because of the nature of sea bed. The shallow water habitat at the location of

Table 3. Vertical distribution of demersal fish schools based on hydroacoustic detection in Youtefa Bay, Indonesia

Sv (dB)	Demersal school depth (m)							No. of fish schools
	< 5	5–10	10–15	15–20	20–25	25–30	>30	
>(-43)	-	1	-	-	-	-	-	1
(-43)–(-46)	-	-	-	-	-	-	-	-
(-46)–(-49)	-	1	-	-	-	-	-	1
(-49)–(-52)	1	1	1	-	-	-	1	4
(-52)–(-56)	2	6	1	-	-	-	-	9
(-56)–(-59)	2	5	1	1	-	1	-	10
<(-59)	-	2	-	-	-	-	-	2

Table 4. Demersal fish density based on hydroacoustic detection in Youtefa Bay, Indonesia

Demersal schooling depth (m)	Σ Schools	Fish density (Fish m^{-3})		
		Average	Max.	Min.
<5	5	28.37	42.19	22.91
5–10	16	11.49	28.54	0.09
10–15	3	3.95	4.59	3.50
15–20	1	2.13	2.13	2.13
20–25	-	-	-	-
25–30	1	0.65	0.65	0.65
>30	1	0.43	0.43	0.43

this study is dominated by seagrass. Habitat is important and influences the distribution of demersal fish (van der Kooij *et al*., 2011). Seagrass vegetation and presence of benthic invertebrates in the fish habitat support fish abundance (Gillanders, 2006; Goldman and Sedberry, 2011). The substrate type is very important in controlling the distribution of demersal fish because it affects the distribution of invertebrates which are important as fish food (Lowe-McConnell, 1987).

Several studies have shown that there is a high correlation between demersal fish distribution and water depth (Rainer and Munro, 1982; Moore *et al*., 2009; Suyatna *et al*., 2010; Zintzen *et al*., 2012; Samphan, 2016). The results of hydroacoustic surveys in Indonesia at a depth of 5-40 m have shown similar results, where demersal fish are dominant in shallow waters (Fahmi, 2008; Pujiyati, 2008). Shifts in the abundance and richness index of demersal fish have also been associated with a water depth gradient (Labropoulou and Papaconstantinou, 2004; Sudhakar *et al*., 2013; Perangin-angin *et al*., 2017).

The results of this study provide baseline information on the distribution and density of demersal fish in Youtefa Bay waters, based on hydroacoustic survey, which will be useful to make fisheries management policies and to help the local fishermen to identify potential areas for demersal fishing activities in the bay.

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