Portable Fish Aggregating Devices (FADs) as formers of fishing ground in coastal Palabuhanratu, Indonesia

[1]Roza Yusfiandayani, [1]Wibi P. Priangga, [1]Domu Simbolon, [1]Mulyono S. Baskoro, [2]Ibrahim Kholilullah

[1] Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University Dramaga, Bogor, Indonesia; [2] Marine Science and Technology Departement, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University Dramaga, Bogor, Indonesia. Corresponding author: R. Yusfiandayani, ocha_roza@apps.ipb.ac.id

Abstract. Portable FADs represent a technological development from conventional FADs that can be used to form a fishing area. The fishing ground is very important for fishermen in fishing operations. The aim of this research is to provide information about the composition and appropriateness of the catch, distribution pattern and the process of forming fishing grounds around portable FADs. Experimental fishing was applied in this research. The data determined was species and weight of captured fish, total length, length at fist maturity (lm) and echogram data. The results showed that the catch composition consists of 6 species of fish: yellowfin tuna (*Thunnus albacares*), big eye tuna (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), oilfish (*Ruvettus pretiosus*), double-lined fusilier (*Pterocaesio digramma*), and marlin (*Istiophoridae* sp.), with a total of 214 fish and a total weight of 438.7 kg. The catch of skipjack has a percentage of 97.14% maturity, while yellowfin tuna and big eye tuna captured are all immature. The observations of echograms showed that the average fish distribution pattern occurs at a depth of 3-7 m and depths above 50 m. Portable FADs can be used to form fishing grounds, and fish are thought to gather due to the influence of the sound attractor (EFA).

Key Words: catch, echogram, fishing ground, portable FADs.

Introduction. Palabuhanratu is a coastal area located in Sukabumi Regency, West Java, Indonesia. Palabuhanratu is the center of capture fisheries activities in Sukabumi Regency. Sukabumi Regency has the 4th largest capture fisheries production in the West Java region with a total production of 10236.10 tons year^{-1} in 2016 (BPS 2017). The potential of marine fish resources in West Java is estimated at 484382.84 tons year^{-1}. The spread of this potential is based on the area of capture. The potential of the fishery was 242191.24 tons year^{-1} (DKP 2005). According to Imron (2016), skipjack (*Katsuwonus pelamis*) production in 2012 reached 1199.9 tons and yellow fin tuna (*Thunnus albacares*) production in 2012 reached 4458.7 tons. This result is a large yield compared to other catches in Palabuhanratu. The fishing gear used by Palabuhanratu fishermen to catch skipjack and yellow fin tuna are long lines. The fishermen also use auxiliary gears namely fish aggregating devices (FADs).

FADs, according to the Minister of Maritime Affairs and Fisheries Regulation, Number PER 02/MEN/2011, are a tool to collect fish using various forms and types of decoys/attractors from solid objects that function to lure fish. Fishermen in Indonesia generally use coconut leaves as a material for making contractors. However, natural ingredients such as coconut leaves quickly decay (Wibiksana 2014). Another obstacle of making natural FADs is that the costs are high. Thus, fishermen form groups to share ownership of the FADs. According to Yusfiandayani et al (2013a), in general, both deep sea and shallow marine FADs consist of four main components: (1) buoys or floats; (2) a long rope; (3) fish attractors; and (4) ballast or sinkers.

Current FADs technology has increasingly developed, arriving to portable FADs. Portable FADs is are not placed permanently in the waters, but only when fishing activities will occur in the fishing area. Portable FADs were developed using the concept of fish response to sound frequencies, as well as the use of raffia ropes at FADs contractors. The FADs can be brought or moved to other areas during fishing operations, or stored when not in use (Yusfiandayani et al 2013b).

Fishing areas are waters where the target fish gather in large numbers and fishing operations can be carried out (Nusantara et al 2014). Information about the fishing area is very important for fishermen in conducting fishing activities. With information, fishing activities carried out can be more efficiently.

The formation of fishing grounds can occur naturally or artificially. The formation of fishing grounds naturally occurs due to oceanographic factors such as fronts and upwelling in waters. Meanwhile, the establishment of artificial fishing areas is done using light fishing and FADs (Bubun 2014).

Prayitno (2016) states that the use of FADs makes the surrounding waters potential fishing grounds. The FADs are able to attract various species fish of different sizes. Jeujanan (2016) states that FADs are installed in certain fishing areas, so that fish are attracted to gather there. The placement of FADs aims to facilitate fishermen in conducting fishing activities (Dempster 2003). The small fish that gather around the FADs invite bigger predatory fish (such as tuna, skipjack, etc.). The gathering of fish around FADs a fishing ground.

Traditional fishermen in Palabuhanratu tend to use traditional methods to determine fishing grounds like intuition or natural instincts. They have not been able to plan fishing operations due to oceanographic or weather changes that greatly affect fishing (Girsang 2008). Lack of information about the season and fishing grounds is one of the obstacles faced by fishermen, while changes in water conditions that occur dynamically will affect the pattern of movement of fish in the waters (Mustasim et al 2015). Uncertainty about the number of catches is also an obstacle, because fishermen have to spend more fuel to find catchments with more fish. Therefore, portable FADs are needed by fishermen to help determine fishing grounds faster.

This research aims to determine the composition of the catch, the feasibility of the catch, the distribution pattern of fish and the process of forming fishing areas around portable FADs. The composition of the catch at portable FADs is expected to provide information on the species of fish that can be targeted by fishermen. The feasibility of the catch is examined to determine the impact of the use of portable FADs on fish resources. Information about fish distribution patterns and the process of forming fishing areas can illustrate the formation of fishing areas around portable FADs.

Material and Method

Description of the study sites. This research was conducted from July 2017 to October 2018. The initial stage of this research was the preparation of portable FADs, namely assembling portable FADs and EFA (electric fishing aggregation). The data collection phase in the field began in August 2017, taking place south of the Sea of Palabuhanratu, precisely at latitude -08º57’986" and longitude 105º21’124". Materials and tools include ships, 1 set of portable FADs, fishing rods, GPS, Simrad EK15, scales, gauges, stationery, cameras, laptops and batteries.

Method*.* Capture data collection includes the total length of fish, length at fist maturity (lm) of species, weight and number of fish. The fishing operation was conducted every hour for five days of operation. The fishing operation times can be seen in Table 1. The captured fish were grouped by: 1) the total number of fish caught during the study; 2) the number of fish species caught per day; 3) the total weight of fish per day. The catch data was grouped and processed using Microsoft Excel. The processed data is presented in graphical form and analyzed descriptively. The formula used to calculate the proportion of catches is:

Pi=ni/N x 100%

Where: *Pi* - relative abundance of catches (%); *ni* - weight of species caught (kg); *N* - total weight of fishing lines (kg).

Table 1

Time of research data collection

Repetition	*Day-*				
	1	*2*	*3*	*4*	*5*
1	08.00 a.m. – 09.00 a.m.	08.00 a.m. – 09.00 a.m.	08.00 a.m. – 09.00 a.m.	08.00 a.m. – 09.00 a.m.	08.00 a.m. – 09.00 a.m.
2	09.00 a.m. – 10.00 a.m.	09.00 a.m. – 10.00 a.m.	09.00 a.m. – 10.00 a.m.	09.00 a.m. – 10.00 a.m.	09.00 a.m. – 10.00 a.m.
3	10.00 a.m. – 11.00 a.m.	10.00 a.m. – 11.00 a.m.	10.00 a.m. – 11.00 a.m.	10.00 a.m. – 11.00 a.m.	10.00 a.m. – 11.00 a.m.
4	11.00 a.m. – 12.00 a.m.	11.00 a.m. – 12.00 a.m.	11.00 a.m. – 12.00 a.m.	11.00 a.m. – 12.00 a.m.	11.00 a.m. – 12.00 a.m.
5	01.00 p.m. – 02.00 p.m.	01.00 p.m. – 02.00 p.m.	01.00 p.m. – 02.00 p.m.	01.00 p.m. – 02.00 p.m.	01.00 p.m. – 02.00 p.m.
6	02.00 p.m. – 03.00 p.m.	02.00 p.m. – 03.00 p.m.	02.00 p.m. – 03.00 p.m.	02.00 p.m. – 03.00 p.m.	02.00 p.m. – 03.00 p.m.
7	04.00 p.m. – 05.00 p.m.	04.00 p.m. – 05.00 p.m.	04.00 p.m. – 05.00 p.m.	04.00 p.m. – 05.00 p.m.	04.00 p.m. – 05.00 p.m.
8	05.00 p.m. – 06.00 p.m.	05.00 p.m. – 06.00 p.m.	05.00 p.m. – 06.00 p.m.	05.00 p.m. – 06.00 p.m.	05.00 p.m. – 06.00 p.m.
9	06.00 p.m. – 07.00 p.m.	06.00 p.m. – 07.00 p.m.	06.00 p.m. – 07.00 p.m.	06.00 p.m. – 07.00 p.m.	06.00 p.m. – 07.00 p.m.

Fish caught using hand line at different times were measured for total length. The fish measured were represented by 6 dominant species. This was done to determine the maturity of catches. Fish that had the total length determined were compared with Lm (length at first maturity) sourced from www.fishbase.org and Yusfiandayani et al (2013a).

Acoustic data was collected on August 15, 2017, during the operation of portable FADs, from 10.27.00 a.m. to 00.04.00 p.m. and from 05.52.00 p.m. until 06.57.00 p.m. Acoustic data was obtained using the SIMRAD EK15 instrument. SIMRAD EK15 is a hydroacoustic instrument used to retrieve data with a single beam echosounder single frequency (200 kHz) system. Output data recorded by the echosounder is in the form of amplitude with a file extension (*.raw). The data was then processed using Echoview 4 software, where the data is described as an echogram consisting of several pixels with various colors showing the strength of the backscattering value of the target in decibels (dB). The threshold value used in the processing of acoustic data ranges from -24 dB to -60 dB, so that values outside these value will be eliminated. According to Aisyah et al (2015), ranges from -24 dB to -60 dB are used because of the threshold value interval for small pelagic fish. From the echogram obtained, the vertical movement of fish vertically against the portable FADs from the existing fish collection was analyzed.

The observation time taken in the study starts from T1 to T7 (Tables 2 and 3). This is due to the observation of echogram results in the afternoon. The best data generated is only available at seven observation times. Therefore, in order to compare the observational data of day and evening, the results of observations during the day were adjusted to seven observations.

Results and Discussion

Catch composition of portable FADs. The composition of the catch consisted of 6 species. The species include yellowfin tuna, big eye tuna (*Thunnus obesus*), skipjack, oilfish (*Ruvettus pretiosus*), double-lined fusilier (*Pterocaesio digramma*), and marlin (*Istiophoridae* sp.). The total number of fish was 214. On the first day, 37 fish were captured; 42 fish were captured on the second day, 46 fish on the third day, 52 fish on the fourth day, and 37 fish on the fifth day. Daily catches fluctuate, with the highest total catch occurring on the 4th day. The composition of fish catches is presented in Figure 1.

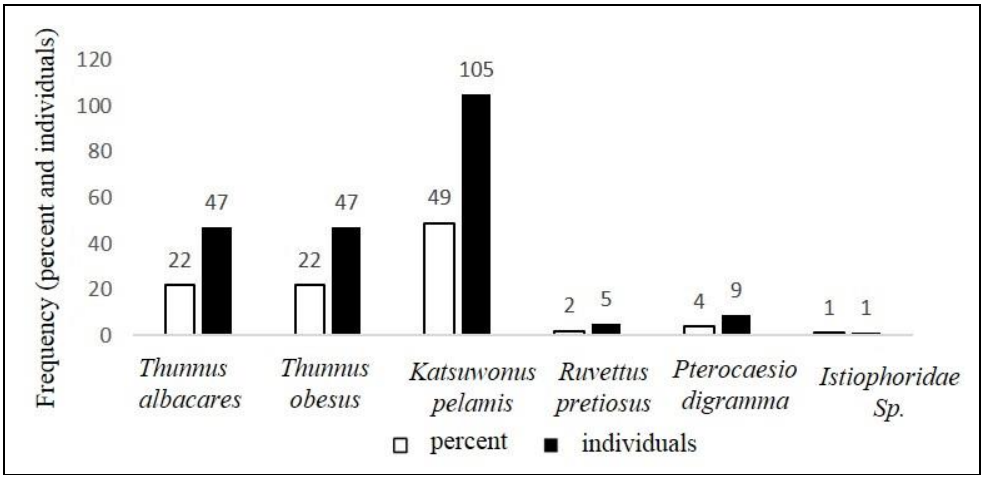

Figure 1. Composition of catch per species.

The total weight of the catch was 438.7 kg. The weight of the fish catch on the first day was 63.3 kg or 14.43%, the weight of the catch on the second day was 144.8 kg or 33.01%, the weight of the catch on the third day was 69.2 kg or 15.77%, the weight of the catch on the fourth day was 86.7 kg or 19.76%, and the weight of the catch on the fifth day was 74.7 kg or 17.03% (Figure 2).

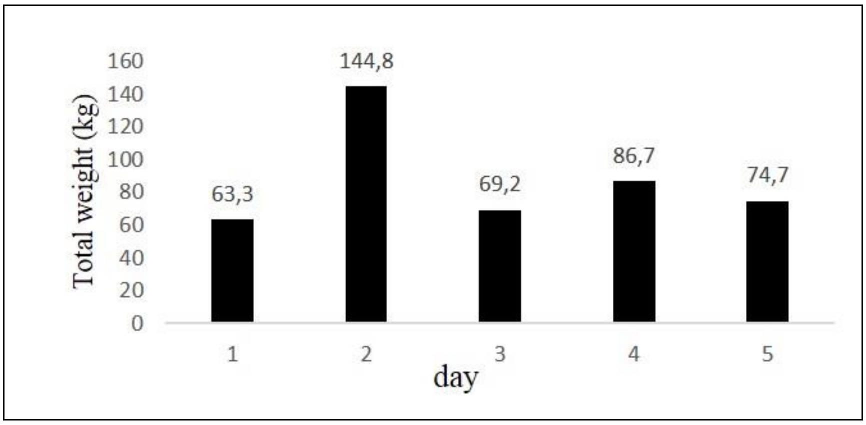

Figure 2. Weight of catch per day.

Capability eligibility. The fish caught represents decent catch conditions. Capable conditions mean that the fish are mature and can reproduce. The length of the fish when it is feasible to catch varies with species (Alamsyah et al 2014). According to Jatmiko et al (2015), the Lm of skipjack in the Eastern Indian Ocean is 42.9 cm, with a total length range between 41.6-44.3 cm. The tuna catches obtained are only 2.86%, with 3 fish undersized. 97.14% of the captured skipjack was of feasible size, 102 fish. The smallest length of skipjack obtained was 42 cm, while the biggest length of skipjack obtained was 69 cm. The total length of skipjack catches is presented in Figure 3.

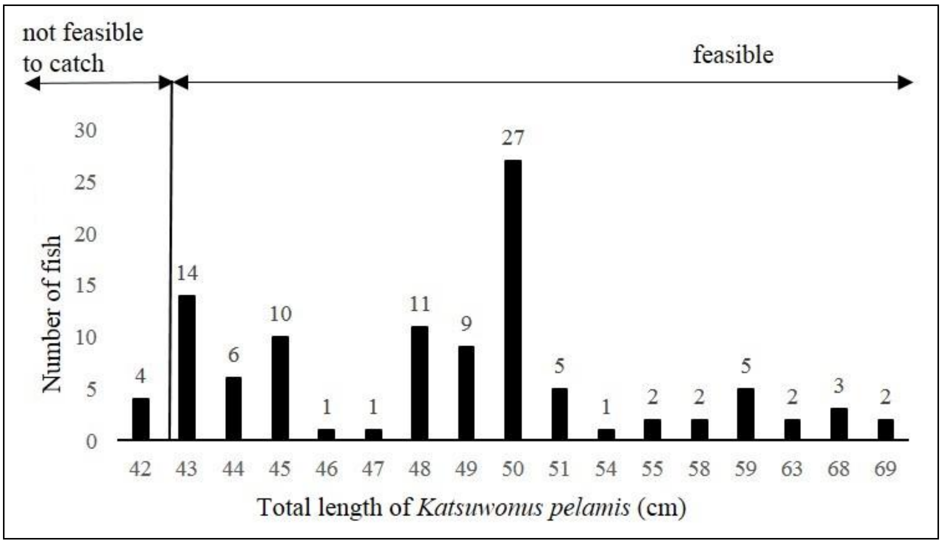

Figure 3. Total length of skipjack (*Katsuwonus pelamis*).

According to Wijaya (2012), the Lm of yellowfin tuna in coastal Palabuhanratu ranges between 78-158 cm. The catches of yellowfin tuna obtained were all still at a size that was not feasible for catch. 47 yellowfin tuna were caputured. The minimum length of yellowfin tuna was 45 cm, while the maximum length of yellowfin tuna was 57 cm. The spread of yellowfin tuna length is presented in Figure 4.

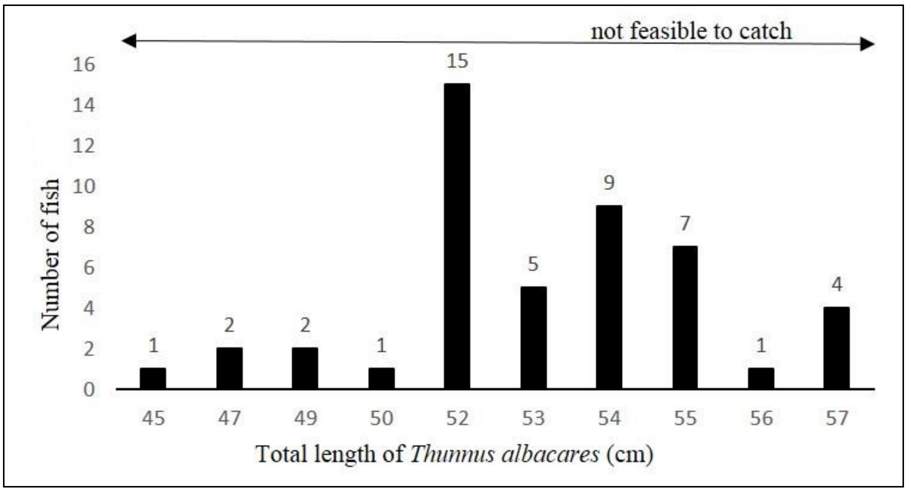

Figure 4. Total length of yellowfin tuna (*Thunnus albacares*).

According to Wijaya (2012) the Lm of big eye tuna fish in coastal Palabuhanratu ranges from 100 to 125 cm. The total catch of big eye tuna fish was 47 fish. No big-eye tuna catches were of feasible size. The lowest length of the catch of big eye tuna was 46 cm, while the maximum length was 58 cm (Figure 5). Figures 4 and 5 (yellow fin tuna and bigeye tuna) show that all tuna captured had a size below Lm, which means that all captured tuna were included in the unfit capture category. This probably happened because pelagic fish that approach the surface are generally young fish (Yusfiandayani 2004). In addition, the length of the fishing line used during the study was 100 m long, capturing surface fish. This assumption is in accordance with the results of Nurdin (2017), who states that yellowfin tuna with a length of 30-50 cm are found at a depth of 10-150 m vertically and 200 m horizontally from the center of the FADs. Yellowfin tuna with a length of 50-100 cm are found at a depth of 150-300 m vertically and 175 m horizontally from the center of the FADs; yellowfin tuna with a length of 100-200 cm (feasible to catch) were detected at a depth of 200-500 m vertically and 150 m horizontally from the center of the FADs (Nurdin 2017).

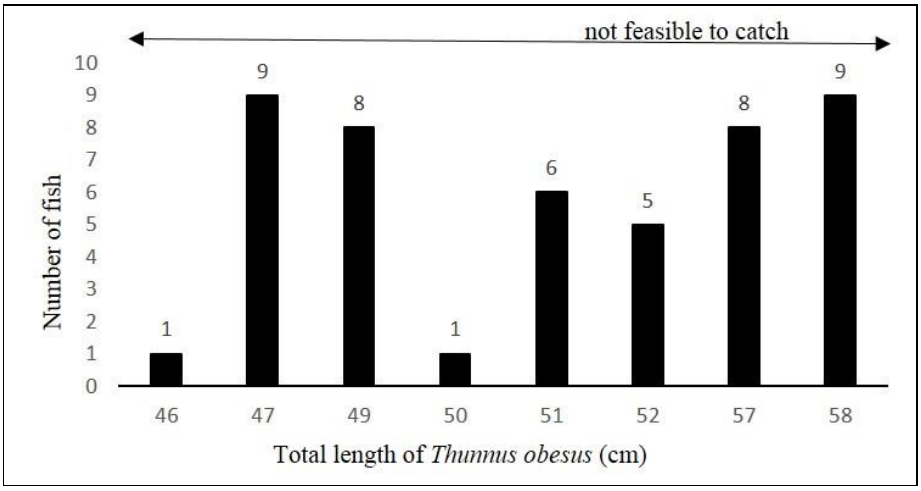

Figure 5. Total length of bigeye tuna (*Thunnus obesus*).

Echogram visualization to determine the pattern of fish distribution and the process of the formation of the catchment area. The echogram based on the results of observations in the afternoon and evening with the highest number of fish can be seen in Figure 6.

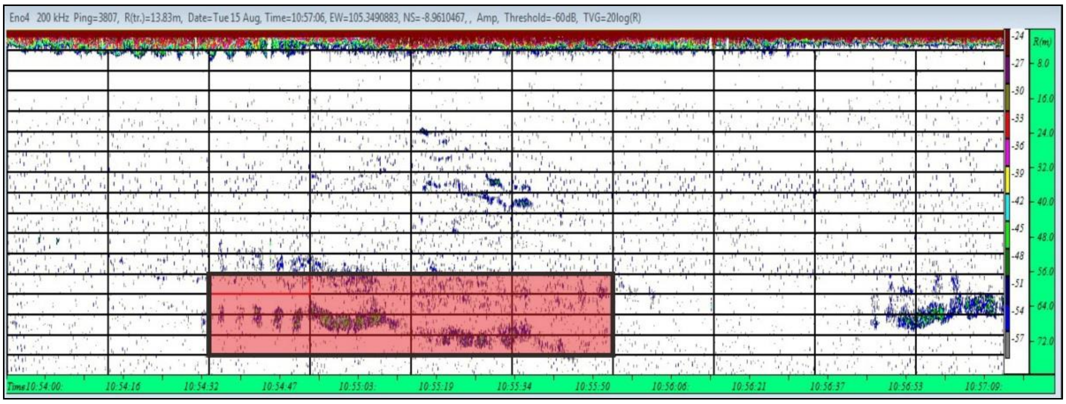

Figure 6. Echogram of fish movement during the day.

Figure 6 presents the echogram observed from 10.54.00 a.m. to 10.57.09 a.m., with the presence of fish seen from 10.54.32 a.m. to 10.55.54 a.m. depicted in red areas. The presence of fish can be seen at a depth of 57-75 m. The number of fish obtained by the analysis with the acoustic method is 1008 fish. This shows that portable FADs that use EFA (sound contractor) are able to collect fish at depths above 50 m.

Figure 7 presents the echogram observed in the afternoon at 06.29.09 p.m. - 06.32.20 p.m. it is known that the movement of fish appeared at 06.30.23 p.m. - 18.32.46 p.m. at a depth of 46-66 m. The number of fish obtained based on data processing using the acoustic method is 756 fish. This shows that in the afternoon the presence of fish decreased compared to during the day, and the movement of fish was at a lower depth compared to observations during the day (Figure 6). The schooling of fish was recorded and displayed on the echogram.

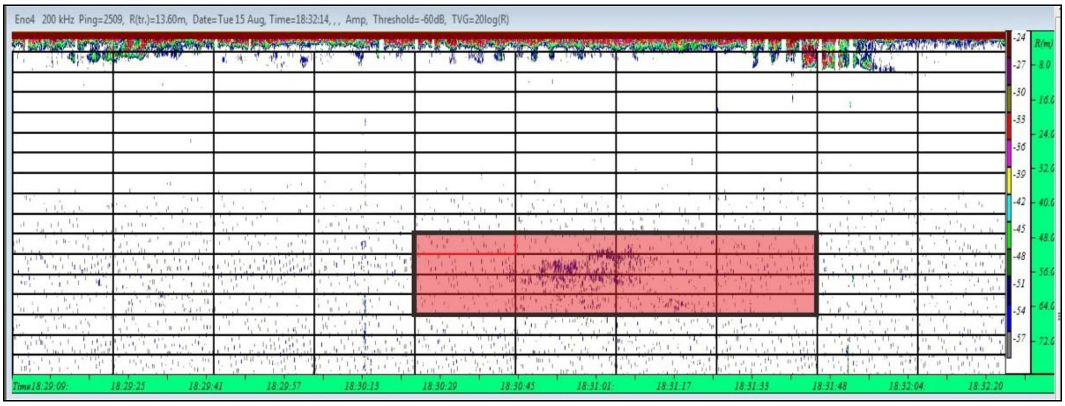

Figure 7. Echogram of fish movement in the afternoon.

Tables 2 and 3 show observations during the day and afternoon. The observations presented in Table 3 show that the number of fish obtained from observations during the day from 10.36.52 a.m. to 11.39.26 a.m. is 4915, with an average of 702. The highest number of fish during the daytime observations was 1008 at depths of 57-75 m, while the lowest number of fish was 434 at 33-51 m. The movement of fish during daytime observations is at an interval of 33-80 m.

Based on observations in the afternoon, it is known that the number of fish from 18:02:33 to 18:51:59 or T1 to T7, which is the best observation time in the afternoon, at a depth of 04-66 m, ranges from 72 to 765. The highest number of fish, (765), was found at the depths of 46-66 m, while the lowest number of fish, (72) was found at depths of 4-28 m. The movement of fish in the afternoon is at depths between 04 and 66 m.

Table 2

Observation of fish presence during the day

Observation	*Time*	*Depth (m)*	*Number of fish*
T1	10.36.52 a.m.-10.39.59 a.m.	33-51	434
T2	10.40.13 a.m.-10.44.20 a.m.	57-75	803
T3	10.54.00 a.m.-10.57.09 a.m.	57-75	1008
T4	10.57.44 a.m.-11.00.52 a.m.	60-80	731
T5	11.01.05 a.m.-11.04.13 a.m.	57-75	764
T6	11.22.02 a.m.-11.25.12 a.m.	43-61	691
T7	11.36.11 a.m.-11.39.26 a.m.	33-51	484
Range	10.36.52 a.m.-11.39.26 a.m.	33-80	434-1008
Amount			4915
Average			702

Table 3

Observation of fish presence in the afternoon

Observation	*Time*	*Depth (m)*	*Number of fish*
T1	06.02.33 p.m.-06.05.42 p.m.	28-46	315
T2	06.21.53 p.m.-06.25.05 p.m.	10-28	130
T3	06.25.44 p.m.-06.28.55 p.m.	14-33	193
T4	06.29.09 p.m.-06.32.20 p.m.	46-66	765
T5	06.36.25 p.m.-06.39.55 p.m.	04-28	72
T6	06.43.14 p.m.-06.56.25 p.m.	10-28	133
T7	06.47.06 p.m.-06.51.59 p.m.	18-38	193
Range	06.02.33 p.m.-06.51.59 p.m.	04-66	72-765
Amount			1801
Average			257

The fish distribution pattern shown by the echogram during the daytime observations occurred from 10.36.52 a.m. to 11.39.26 a.m. and in the afternoon from 06.02.33 p.m. to 06.51.59 p.m. The most fish were found at a depth of 57-75 m during the day and in the afternoon the distribution pattern of fish was mostly found at a depth of 46-66 m. The catchment area pictured on the echogram shows that some fish that are below 50 m will try to rise towards the surface in the afternoon. It is suspected that the sound effects issued by portable FADs affect the fish approaching the surface. According to Navila (2017), the speed of sound in seawater is 1530 m s^{-1}. Sound issued by portable FADs has a frequency of 11000 to 15000 kHz. Based on this, the sound issued from portable FADs will propagate quickly toward schooling fish and can cause fish to move towards the sound source. Therefore, it can be suspected that portable FADs are able to collect fish around the FADs with the help of sound contractors.

Yusfiandayani et al (2014) state that the use of portable FADs with sound contractors with a frequency of 10-1000 Hz and 1000-20000 Hz produces catches of five species: *Loligo duvauceli*, *T. albacares*, *K. pelamis*, *Coryphaena hippurus*, and *Scyphozoa*. This concides with two species that dominated the catch in this study, yellowfin tuna and skipjack, but big eye tuna, oilfish, double-lined fusilier, and marlin were also caught in large numbers. The dominant species in this study was skipjack.

In addition, the results of this study suggest that portable FADs with sound contractors can collect fish, forming areas of fishing. Figure 8 shows that during the day, the movement of fish tends to be in depths below 50 m. Schooling of fish at depths above 50 m only occurred in observations T1 and T7, the rest being under 50 m. Therefore, it can be assumed that during the day, fish prefer to be in high water depths, under 50 m. Figures 8 and 9 show observations of fish movement patterns based on the depth of the waters during the day and afternoon. This is influenced by sunlight, which reaches deeper waters during the day. Sunlight entering the waters helps fish detect food. The penetration of sunlight in deeper waters facilitate feeding.

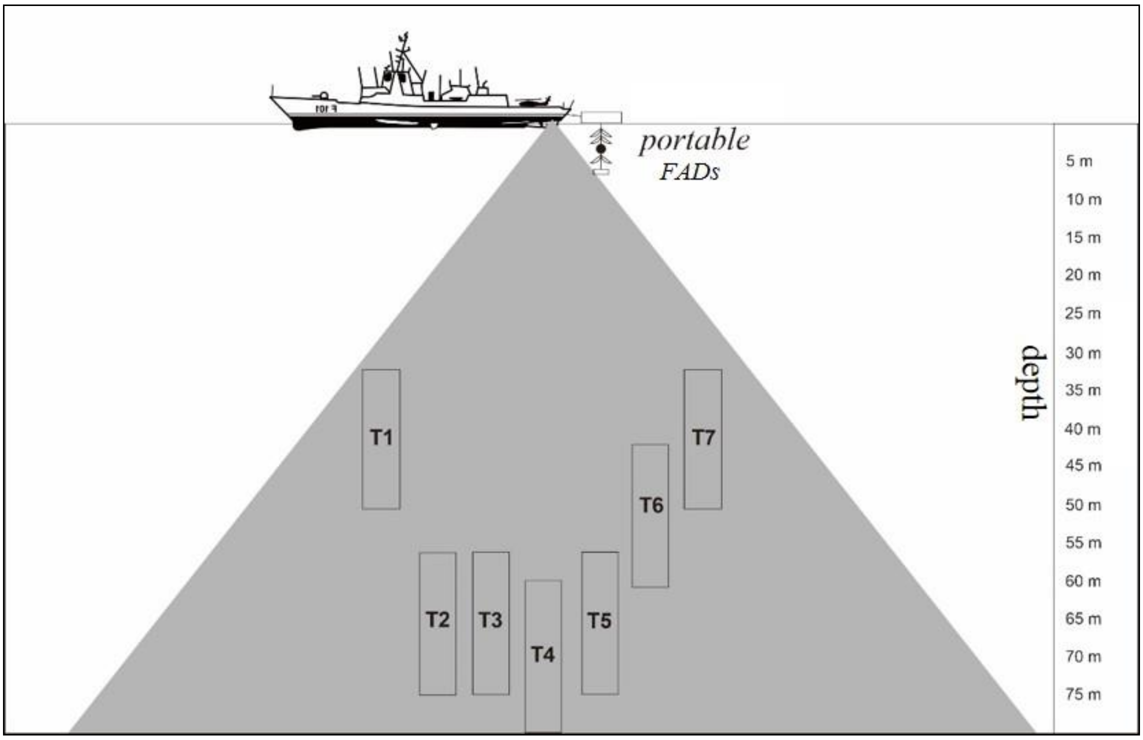

Figure 8. Movement of fish based on depth during the day; FAD - fish aggregating device.

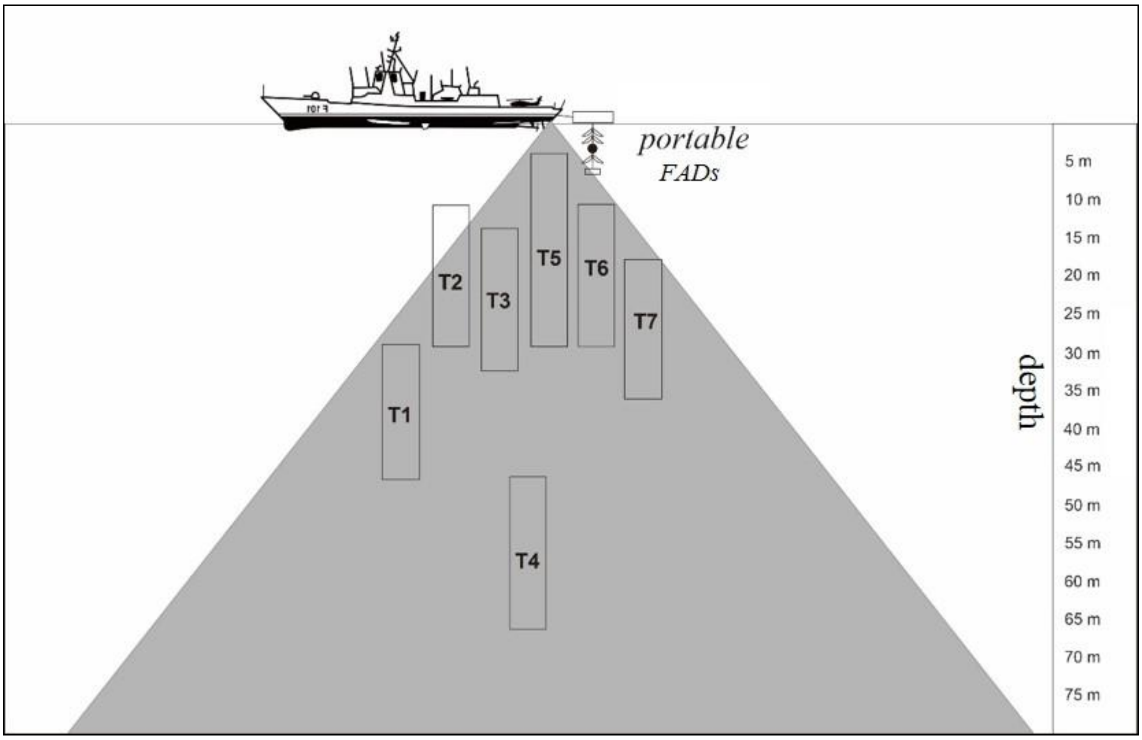

Figure 9. Fish movements based on depth in the afternoon; FAD - fish aggregating device.

Based on Figure 9, the movement of fish in the afternoon is at a lower water depth, above 50 m. Fish were found below 50 m at T4. Therefore, it can be expected that in the afternoon the fish would prefer to be in water depths above 50 m. This is allegedly due to the reduced intensity of sunlight, so that fish swim up to find food.

Conclusions. The composition of the catch of portable FADs in Palabuhanratu waters amounted to 214 fish, dominated by skipjack (49%), big eye tuna (21.96%), and yellowfin tuna (21.96%). The catch of skipjack in portable FADs has a percentage of 97.14% maturity and 2.86% were immature. Yellowfin tuna and big eye tuna captured were all immature. Fish distribution patterns in Palabuhanratu waters are found at depths of 3 to 7 m and depths above 50 to 80 m. The formation of fishing areas using portable FADs allegedly occurred due to the influence of sound issued by EFA, fish that were at depths above 50 m approaching the sound source (portable FADs).

Acknowledgements. The authors are grateful to Ministry of Research and Higher Education for funding this research, based on a Research Contract at State University Legal Entity Year 2017 budget between the Deputy for Strengthening Research and Development, Ministry Research and Technology with IPB University (Bogor Agricultural University) No. 1301/IT3.11/PN/2017. We also would like to thank the Wibi (undergraduate students) and fishermen in Palabuhanratu for the contribution in collecting data.

Conflict of Interest. All authors declare there is no conflict of interest with respect to this research or its funding.

References

Aisyah, Hestirianoto T., Pujiyati S., 2015 [Spatial distribution of backscattering strength volume of pelagic fish in Lake Ranau, South Sumatra]. Jurnal Teknologi Perikanan dan Kelautan 6(1):11-20. [In Indonesian].

Alamsyah R., Musbir, Amir F., 2014 [Size structure and decent size capture of skipjack tuna (*Katsuwonus pelamis*) in Bone Bay waters]. Jurnal Ipteks Pemanfaatan Sumberdaya Perikanan 2(1):11-20. [In Indonesian].
Bubun R. L., 2014 [The formation of fishing areas in light fishing and its impact on fisheries]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 118 p. [In Indonesian].
Dempster T., 2003 Biology of fish associated with moored fish aggregation devices (FADs): implications for the development of a FAD fishery in New South Wales, Australia. Fisheries Research 68(1-3):189-201.
Girsang H. S., 2008 [Study of determination of tuna fishing areas through mapping of chlorophyll-A distribution and catch results in Palabuhanratu, West Java]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 71 p. [In Indonesian].
Imron M., 2016 [The implementation of the capture fisheries minapolitan program in empowering small fishermen in Sukabumi Regency]. Jurnal Masyarakat & Budaya 18(2):249-262. [In Indonesian].
Jatmiko I., Hartaty H., Bahtiar A., 2015 [Reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Eastern Indian Ocean]. BAWAL 7(2):87-94. [In Indonesian].
Jeujanan B., 2016 [FADs as pelagic fishery management tools in Kei Islands waters]. Dissertation, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 172 p. [In Indonesian].
Mustasim, Zainuddin M., Safruddin, 2015 [Thermal and chlorophyll-a front in relation to catch skipjack tuna of the west-east transition season in Seram waters]. Jurnal IPTEKS PSP 2(4):294-304. [In Indonesian].
Navila Q. A., 2017 [Development of learning module physics for vibration and waves, sound and light for Class VIII SMP/MTS based on unity of sciences]. Thesis, Faculty of Science and Technology, Walisongo State Islamic University, Semarang, Indonesia, 224 p. [In Indonesian].
Nurdin E., 2017 [FADs as sustainable tuna fishery management tools; madidihang (*Thunnus albacares*)]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 124 p. [In Indonesian].
Nusantara R. A., Rosyid A., Boesono H., 2014 [Analysis of the difference in the depth of the fishing area to the composition of the catch in the cantrang fishing gear (boat seine) in Rembang Waters]. JFRUMT 3(3):96-103. [In Indonesian].
Prayitno M. R. E., 2016 [Utilization of deep sea FADs as fishing areas and their impact on the sustainability of fish resources]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 90 p. [In Indonesian].
Wibiksana C., 2014 [Comparison of productivity between FADs and FADs attractors and FADs with coconut leaf attractors in Tunda Island]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 25 p. [In Indonesian].
Wijaya H., 2012 [The catch of madididhang (*Thunnus albacares,* Bonnaterre 1788) with trolling line and its management at Nusantara Fishing Port Palabuhanratu, Sukabumi]. Thesis, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 117 p. [In Indonesian].
Yusfiandayani R., 2004 [The mechanism of small pelagic fish around Fish Aggregating Devices and its development in Pasauran waters, Banten Province.]. Dissertation, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 231 p. [In Indonesian].

Yusfiandayani R., Jaya I., Baskoro M. S., 2013a [Assessment of portable FADs for sustainable management of tuna and skipjack tuna]. Proceedings of the IPB Institute for Community Service and Development Seminar 1:274-291. [In Indonesian].
Yusfiandayani R., Jaya I., Baskoro M. S., 2013b [Catching trial around portable fish aggregating device at Palabuhanratu Waters. Jurnal Teknologi Perikanan dan Kelautan 4(1):89-98. [In Indonesian].
Yusfiandayani R., Jaya I., Baskoro M. S., 2014 [Construction and productivity of portable FADs in Palabuhanratu Waters, West Java]. Jurnal Teknologi Perikanan dan Kelautan 5(2):117-129. [In Indonesian].
***BPS (Central Bureau of Statistics of West Java Province), 2017 [West Java Province in figures 2017]. Central Bureau of Statistics of West Java Province, Bandung, Indonesia, 660 p. [In Indonesian].
***DKP (Department of Marine and Fisheries of West Java Province), 2005 [West Java Province Fisheries Statistics 2004] West Java Marine and Fisheries Service, Bandung, Indonesia, 88 p. [In Indonesian].
*** KKP (Marine and Fisheries Ministry), 2011 [Regulation of the Minister of Marine Affairs and Fisheries Number: PER 02/MEN/2011 concerning fishing routes and placement of fishing tools and fishing equipment in the fisheries management area of the Republic of Indonesia]. Ministry of Marine Affairs and Fisheries, Jakarta, Indonesia. [In Indonesian].

Received: 16 January 2021. Accepted: 25 February 2021. Published online: 14 August 2021.
Authors:
Roza Yusfiandayani, Fisheries Resources Utilization Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, 16680 Dramaga, Bogor, Indonesia, e-mail: ocha_roza@apps.ipb.ac.id
Wibi Prawira Priangga, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB University), 16680 Dramaga, Bogor, Indonesia, e-mail: thedrummer85@gmail.com
Domu Simbolon, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, 16680 Dramaga, Bogor, Indonesia, e-mail: domusimbolon@gmail.com
Mulyono Sumitro Baskoro, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, 16680 Dramaga, Bogor, Indonesia, e-mail: domusimbolon@gmail.com
Ibrahim Kholilullah, Marine Science and Technology Department, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, 16680 Dramaga, Bogor, Indonesia, e-mail: kholilullahibrahim@gmail.com

How to cite this article:
Yusfiandayani R., Priangga W. B., Simbolon D., Baskoro M. S., Kholilullah I., 2021 Portable Fish Aggregating Devices (FADs) as formers of fishing grounds in coastal Palabuhanratu, Indonesia. AACL Bioflux 14(4):2163-2173.