Identification of fishing ground hotspot of traditional purse seine fisher at northern waters of Aceh – A community-based data collection approach

H A Haridhi¹², S Rizal¹, M Nanda³, Muhammad¹ and C R Wilson⁴

¹Department of Marine Sciences, Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh, Indonesia
²Marine and Fisheries Research Center, Syiah Kuala University, Banda Aceh, Indonesia
³Doctoral Program of Mathematics and Applied Science, Graduate School, Syiah Kuala University, Banda Aceh, Indonesia
⁴Asian Development Bank, Mandaluyong, Philippines

E-mail: haekal.azief.haridhi@unsyiah.ac.id

Abstract. Fishing grounds are among the most important key of information kept by the fishermen. Understanding the fishing ground locations are considered important as an evaluation of the fishing effort being reached by the fishermen as well as understanding the pressure being received to the fish stock at the surrounding water. The recent study has shown that a community-based data collection approach was found successful in recording and analyzing the fishing ground locations and its properties. One of the few projects implementing this concept is the Community-Based Bathymetric Survey (CBBS), which was realized by the Body of Rehabilitation and Reconstruction (BRR) Nanggroe Aceh Darussalam (NAD) – Nias with funding from the Asian Development Bank (ADB). As many as 151 GPS-transducer recording devices were installed to the fishermen boats along the coast of Aceh, with 45 devices were installed to the traditional purse seine fisher at the northern water of Aceh. These devices were configured to automatically record locations each time the boat moved 30 m. Other important information, such as water depth, time, speed, and sea surface temperature (SST) were recorded as well. This study aims to examine the fishing ground and its fishing hotspot of the traditional purse seine fisher in the northern waters of Aceh. The data collection was performed between June 2007 and May 2009 and gathered as many as 922 data sets consist of 6,170,648 data points, from the 45 purse seine boats. Trough the data, we are able to identify the typical fishing activities of purse seiner and as many as 1,619 data points were being detected. The results indicate that there are five main regions of the fishing ground hotspot in the northern waters of Aceh, i.e. 1. Western offshore of Lhok Nga, 2. Northern offshore of Ulee Lheue, 3. Western offshore of Aceh Islands, 4. Eastern offshore of Aceh Island, and 5. Northern offshore of Krueng Raya. Among the fishing ground hotspot analyzed, the Western offshore of Lhok Nga is the highest density of fishing ground, while the lowest is at the northern offshore of Krueng Raya. These findings suggest that the western offshore of northern waters of Aceh are likely more fertile than its north-northeastern offshore.

1. Introduction

The coastal community along the Indian Ocean on 26 December 2004 never had in mind to expect a mega-disaster would occur. The earthquake following tsunami mark as the greatest recorded number of victims claimed by a natural disaster in modern time with more than 283,000 victims [1] and not lesser.
than 186,000 number of victims were registered at Aceh province which 20% among them are fishermen [2]. The tsunami also destroyed countless fishing facilities and related infrastructures such as fishing boats and gears, telecommunications infrastructure, cold storage, port, and many others [3].

Thus, the tsunami not only claimed the largest number of victims but also generate a huge gap of fishing knowledge with the death of missing fishermen [4]. This practical fishing knowledge usually being passed from father to son through the daily fishing activity, even, some information somewhat important such as the fishing ground locations were kept secret among the fishermen, beside unwritten records of that information. Such an unprepared situation to deal with such a disaster, there were no written records for this important information being kept as well by the managers and government, consequently, the young, less-experienced, and surviving fishermen found perplexing period to reestablish the fisheries similar to the conditions before the earthquake and tsunami occurred.

To assist the fishermen to cope with that situation, the Body of Rehabilitation and Reconstruction (BRR) Nanggro Aceh Darussalam (NAD) – Nias with funding from the Asian Development Bank (ADB) support a project which enhancing the involvement of the coastal community. One of the few projects implementing this scenario is the Community-Based Bathymetric Survey (CBBS), which engaging collaboration between practitioners – academics, i.e. Marine Science Department, Syiah Kuala University – local traditional fishing authority, i.e. Panglima Laot. The collaborations within the CBBS project were divided to several managerial and other related activities, i.e. selection of participation and evaluation of the realization of the project to the fishermen done by the Panglima Laot, training and data collection as well as analyzing the data resulted from the survey were managed by the academics, while the practitioners communicating the result to stakeholder, managers, policymakers, and the fishermen as feedback to the data collection.

Figure 1. (a) Aceh province located at the northwestern edge of Indonesian archipelago. It is bounded by the Malacca Strait to the NNE and Indian Ocean to the SSW. The red square box in the northern waters of Aceh Province is indicate for the location of the study area. (b) The location of the coastal villages discussed in the text are shown by the red dots, and the fishing port Lampulo is shown by the blue square. The northern islands, i.e. Aceh Islands and Weh Island are shown with bold label. The colored countour: solid black line at the depth of 2000 to 500 meters with 500 meters interval, solid magenta line at the depth of 300 to 100 meters with 100 meters interval, and the solid orange line at the depth of 100 to 40 meters with 20 meters interval. The recent study of seasonal variation of fishing ground locations at Aceh Province indicates that the northern waters of Aceh are dynamic and fertile, which showed that a particularly targeted fish are abundant at a particular location within one monsoon, and were found less to the other monsoon season.
Thus, since the fishing ground locations are dynamic and are a piece of important information among the coastal community, the CBBS was found successful in identify and collect the necessary information directly from the fishermen activities [2,4]. This could be done, since, the CBBS project collects the data directly through a GPS-sounder data logging device that is installed at the fishermen boat.

It is common to expect that the oceanographic properties are acting as the major role to illuminate the fishing ground location as well as it's dynamic [6–10]. The availability of targeted commercially important fish species is also highly influenced by these factors besides the pristine oceanic condition such as the coral reefs [11–15].

This study aims to identify the fishing ground hotspot at the northern waters of Aceh by identifying the fishing pattern of a purse seiner fisher tracks utilizing the community-based data collection within the CBBS project.

2. Community based data collection approach

The CBBS project started from June 2007 – May 2009, engage with a number of fishing activities, such as purse seiner, gill net, hook, and line. A total of 151 GPS-sounders with data logging devices were distributed to a different type of fisher and among those 45 selected purse seiner fisher were chosen by the Panglima Laot were engaged through the course of the project. During those periods, the fishermen do not need any special action to collect the data, besides only by turning on the GPS-sounders unit. This device will automatically record time, position, speed, water depth, sea surface temperature (SST) every time the boat moved 30 m. Hence, the fishermen went out fishing as their usual daily activities.

The data was collected on a daily basis, either before the fishermen start their fishing journey or after the fishermen arrived at the fishing port. Through these data collection processes, a total of 922 boat track datasets consist of 6,170,648 data points were gathered at the completion of the project periods.

3. Method and analysis

3.1. Identification of fishing ground

Analyzing the purse seiner boat track, the characteristic of the track pattern when the fishermen deploy their fishing net or the fishermen actually spot a school of fish is shown in Fig. 2. The data points that are selected as the fishing ground location is indicated with the magenta color, which indicates the closing of the top of the net. The full description of the track analysis could be seen in [2].

Figure 2. A sample of purse seiner boat track fishing activities. The characteristic of the deploying net phase is shown by the red circle and the closing the top of the net is shown in magenta color. A full description of the track analysis could be seen in [2].
3.2. Fishing ground hotspot

Analyzing the fishing ground location, it is shown scattery distributed surrounding the northern waters of Aceh as it is shown in Fig. 3 (a). However, a possible grouping of those fishing ground could be seen at several locations.

To have a clear estimation of which locations were the fishing ground hotspot, which had a good density normalize to the total amount of the observed fishing ground (Gaussian) with an evenly distributed grid, we applied a Hexbin density, 2D histogram density, and finally calculated the Gaussian Kernel-Density-Estimate (KDE).

Applying these techniques to the scattered distribution of fishing ground, we could observe five main locations of the fishing ground hotspot as it is seen in Fig. 3 (b and c), i.e. 1. western offshore of Lhok Nga, 2. northern offshore of Ulee Lheue, 3. western offshore of Aceh Islands, 4. eastern offshore of Aceh Islands, and 5. northern offshore of Krueng Raya (see Fig. 1 for the coastal village names). Fig. 5 (d) shows the KDE distribution of fishing ground which indicate that the offshore Lhok Nga, western and eastern offshore of Aceh Islands were the largest fishing hotspot, followed by offshore of Ulee Lheue, while a narrow of the fishing ground hotspot is located at northern offshore of Krueng Raya.

Interestingly, the fishing ground hotspot locations are somewhat close to the surrounding coast, which about 20 – 30 km from the coastline. This may indicate the pristine oceanic condition are among the key factor contributing to the high fishing activities.

![Figure 3](image-url)

**Figure 3.** (a) Scatter plot of fishing ground locations is indicated by the red dots, (b) and (c) are the Hexbin and 2D histogram density of fishing ground location, with 555 number of the grid along the x- and y-axises with a scale bar of number of counts is shown on the right of each plot, (d) KDE of fishing ground location with normalized density scale bar is shown on the right.
4. Discussion
The CBBS project was found successful in identifying the fishing ground location in a whole new level of resolution, which is the most important piece of information on fishing activities kept by the fishermen. A similar method being applied elsewhere however the location of the fishing ground being received by direct interview to the fishermen [16]. It is clearly seen that the northern water of Aceh is highly productive, which most of the region showed a grouping of fishing ground. The high spatial and temporal resolution of CBBS data allows enhancing the dynamic spatial distribution of fishing ground.

The recent study of oceanographic properties at the fishing ground location has indicated that the fishing ground locations were highly influenced by the SST, which further implies that most of the time, the fishermen spot a school of fish within a limited range of SST [2]. Although Aceh Province is located in a tropical region, a significant difference of SST was found between the Northeast and Southwest monsoon which active between December, January, February (DJF), and July, August, September (JAS), respectively [2,6,9]. The productivity which is assumed to be in high and low condition trough those monsoons were found as suitable times of the optimum SST condition.

Another study that tries to estimate the abundance of targeted fish by a rapid appraisal method found that, indeed, the monsoonal systems highly influenced the abundance of the targeted fish as well as the Chlorophyll-a distribution at surrounding Aceh waters which is one of the indicators of the ocean productivity [5]. Up until now, there were no other datasets at Aceh Province which able to records in high temporal and spatial resolution of the actual fishing activities, thus, there is a need to assess the fishing pressure that is given to the marine environment at the northern water of Aceh.

As it is indicated by numerous studies, that the fisheries resources are declining [11–13], and another notable factor need to account to such as the climate change which will highly be impacted on the coral reefs [17], as well as the fishing ground located at about 20-30 km from the coast, thus, it is very timely to estimate the fishing pressure given by the fishing activity being received by the marine environment.

5. Conclusion
This study has shown a detailed distribution of fishing ground locations in the northern waters of Aceh. It is found that five main locations of the fishing ground hot spot 1. western offshore of Lhok Nga, 2. northern offshore of Ulee Lheue, 3. western offshore of Aceh Islands, 4. eastern offshore of Aceh Islands, and 5. northern offshore of Krueng Raya. These locations were found close to the coast with a distance of about 20 – 30 km. The implication as such fishing ground hot spot is whether or not the environment is sustainably healthy, and with the increasing amount of pressure, i.e. fishing activities as well as climate change, it is time to estimate the pressure that being received by the marine environment at this waters. The data that directly gathered by the fishermen, such as the community-based, is considered among the best approach to gain significantly high-resolution data, with considerable time, cost, and personnel. The engagement activity will be benefited to the involved party and gives a fruitful result that could further be used by the stakeholder, managers, and policymakers.

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