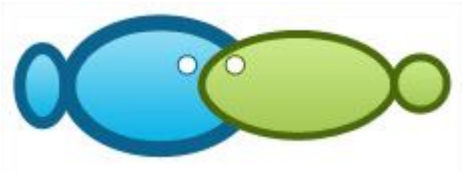

Determination of potential fishing ground for hairtail (*Trichiurus* sp.) fishing based on chlorophyll-*a* distribution and sea surface temperature in Pangandaran waters, West Java, Indonesia

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Abstract. Optimization of fishing activities is supported by various factors determining the success of fishing operation. One of the determining factors is the determination of fishing ground. Fishing ground is the area where the target fish is located. This area has certain parameters such as chlorophyll-*a*, temperature, and salinity which can be utilized for efficient and optimum fishing operation. Hairtail (*Trichiurus* sp.) is one of the commodity with high economic value in Pangandaran. Fishermen in Pangandaran generally still use natural instinct in finding hairtail fishing ground, resulting to the uncertain amount of catch. This study aims to improve the catch effectivity by establishing potential fishing zonation for hairtail fishing in Pangandaran, West Java, Indonesia. This research was conducted in October-November 2017. The method used is spatial analysis method by collecting data of chlorophyll-*a*, temperature and hairtail fishing production data. The results showed that there are 7 areas scattered in Pangandaran waters which can become potential fishing ground for hairtail fishing.
Key Words: fishing activities, optimum fishing operation, chlorophyll-*a*, sea surface temperature, hairtail, Pangandaran.

Introduction. According to Indonesian Law No. 31 year 2004, fisheries management should be able to support the welfare of fishermen, create employment opportunities, optimize and maintain the sustainability of fish stock resources. Fisheries as part of the national economic development have goals to improve the fishermen's living standards and welfare. Fishery development can be implemented through optimum fisheries management.

Fishing optimization is supported by various factors determining the success of fishing operation, namely: skill, technology, fishing method, fish behavior and fishing ground determination (IFC 2015). Fishing ground is the area where the fish are gathered and fishing operations can be done productively and profitably. The fishing ground are still determined by traditional fishing methods based on repeated experience and gathering information from fellow fishermen (Nurdin et al 2015). One of the traditional ways to determine the fishing area is by observing the conditions aquatic environment with their five senses. However, due to the limitation of five senses, it is practically hard to rely on it to answer the various challenges of natural phenomenon (Jufri et al 2014). The optimization of fishing ground determination techniques require a science-based method for the smaller error value (Nurdin et al 2015). Finding fishing ground do not only depends on the experiences, but also the knowledge of habitat of fish. The habitat of fish is closely related to certain value of oceanographic properties, such as sea surface temperature and chlorophyll-*a* (Semedi & Hadiyanto 2013). Predictive modelling for

species geographic distribution based on environmental conditions is known to be an important technique in biological analytics (Peterson & Shaw 2003).

The use of advanced technology such as Global Positioning System (GPS) as navigational system through oceanographic imagery satellite are still rare among the Indonesian traditional fishermen. Therefore, the role of scientists and technologies such as the rapidly evolving applications of satellites images are needed. Various literatures have proven the successful application of science and technology in determining fishing ground. Syah (2010) summarizes that remote sensing methods for fishing activities may increase the efficiency of fuel, reduced fishing trips and lower cost for ship maintenance. With the reduced fishing operation time, the operational costs will be lower and also better safety for fishermen.

Determination of fishing ground has a high urgency in Indonesian waters to support fishing activities, leading to the success of fishing operations. Ministry of Marine Affairs and Fisheries (2016) states that these conditions are closely linked to several reasons such as the distribution and fish availability which is highly dependent on the dynamic condition of fishing ground according to the oceanographic parameters. One of the oceanographic parameters which influence the determination of potential fishing ground is sea surface temperature and chlorophyll-*a* (Semedi & Hadiyanto 2013). Therefore, the variability of the fishing ground is very influential toward the composition of species and the number of catches.

Pangandaran waters have a vast potential of marine resources. Therefore, marine fish resources in Pangandaran waters should be optimally utilized. Sustainable fishery resources will continue to support fishing activity in Pangandaran waters, increasing fishery production. In addition, the establishment of Pangandaran Regency as a new autonomous region based on Law of Indonesian Republic No. 21 of 2012 will be a great opportunity for this region in optimization the fisheries potential. Mapping the potential of fishing ground for certain important commodities is a concrete effort as the initial step for catch fisheries management in Pangandaran Regency. The aims of this study are to investigate the relationship between the distribution of chlorophyll-*a* and sea surface temperature for determining the potential fishing grounds of hairtail in Pangandaran waters, Indonesia.

Material and Method. The research was conducted on the West and East Coast of Pangandaran (Figure 1), by operating gillnet for 7 days of fishing trip in October and November 2017. This research was conducted in two stages. The first stage is data collection in Pangandaran waters, West Java and Pangandaran Fish Landing Port (FLP) during October to November 2017. The second stage was performed by downloading the chlorophyll-*a* and temperature satellite images in February 2018 from the website http://oceancolor.gsfc.nasa.gov/cms.

Method. The method used in this research is spatial analysis method. The data used in this research are chlorophyll-*a*, sea surface temperature (SST), hartail's fishing production and hairtail's total length. Chlorophyll-*a* and SST satellite images data were downloaded from the above mentioned website. Satellite data in fisheries can be utilized to estimate the potential fishing grounds by detecting chlorophyll-*a* and sea surface temperature as a suspected presence of fish in waters (Widodo 1999). Hairtail fishing production data were obtained from gillnet fishing operation in 7 different stations of Pangandaran waters. Furthermore, these data were processed by using software (ArcGIS) to produce profile maps. The maps were then analyzed descriptively. In addition, interviews with fishermen in Pangandaran Fish Landing Port were conducted to validate the obtained position of fishing ground. Respondents were determined by using purposive sampling, namely crew, captain or ship owner.

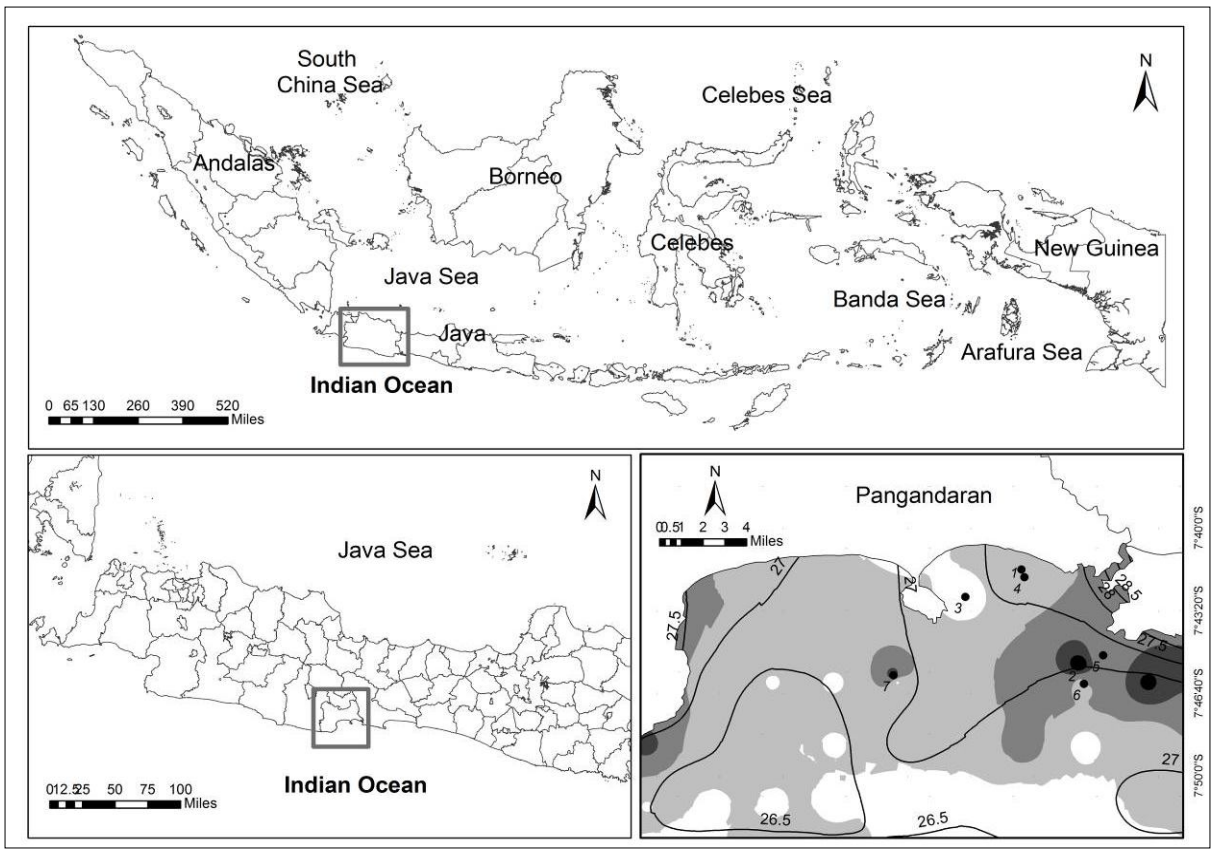

Figure 1. Research location.

Data analysis. The correlation between catch and the chlorophyll-*a* variable was analysed by SPSS software. Correlation between catch and chlorophyll-*a* is expressed by correlation coefficient (r). The higher of "r" value indicates that the correlation is getting closer (Walpole & Myers 1995). The range of correlation coefficient values is: $-1 \leq r \leq +1$. The correlation is close if $r \geq 0.7$ and $r \leq -0.7$, and the correlation is not close if: $-0.7 < r < 0.7$.

Potential fishing grounds were determined based on three indicators, namely the number of fish, size, and distribution of chlorophyll-*a* in the waters. The size of fish were measured by scoring method based on subjective assessment of hairtail's total length. The catch criteria in Table 1 are based on hairtail's maturity in tropical waters, which is 40 cm (Collete & Naueun 1983 in Ismajaya 2006).

Table 1

The catch criteria based on the length of the fish (TL)

Total length of fish (cm)	*Criteria*	*Score*
x < 56 cm	Undersize	1
x ≥ 56 cm	Legal-sized	2

Source: Collete & Naueun (1983) in Ismajaya (2006)

The same measurement was also performed on chlorophyll-*a* concentration in the waters, where the assessment was subjectively categorized in Table 2 according to Nontji (1984).

Table 2

Classification of chlorophyll-*a* concentration

Chlorophyll-a concentration (mg m^{-3})	*Criteria*	*Score*
< 0.3	Low	1
0.31-1	Moderate	2
> 1	High	3

Source: Nontji (1984)

Results and Discussion. Chlorophyll-*a* in a water is closely related to the food chain, where high chlorophyll-*a* content will increase zooplankton productivity, thus creating a food chain supporting fish productivity in a water. Nababan (2008) states that the concentration of chlorophyll-*a* suggests the presence of phytoplankton as a producer for higher trophic organisms. The increasing or decreasing trend of chlorophyll-*a* in the waters and the catch is almost the same, but the peak increase in chlorophyll-*a* and fish catch does not occur at the same time. This shows that the chlorophyll-*a* content does not directly affect the catch of fish in a water. Chlorophyll-*a* requires time lag to eventually be utilized by fish (Chanda & Musuka 2012). According to Simbolon & Girsang (2009), the time lag between the increases in chlorophyll-*a* and the increase in fish catch is 30 days.

Hairtail is a dominant catch which is landed at Pangandaran Fish Landing Center (PPI), West Java Province, Indonesia. In general, many hairtail is caught in every season, especially in west monsoon. According to Department of Marine, Fisheries and Food Security (2016), hairtail's production in Pangandaran during 2015-2016 was relatively stable. Therefore, there was a decrease in 2016 due to bad weather and the difficulty to obtain operational permits to sail. Most of hairtail in Pangandaran are caught by fishermen using gillnet with adjusted mesh size according to hairtail's size. Hairtail production is fairly high during October and November in Pangandaran waters.

The concentration of chlorophyll-*a* in Pangandaran waters indicates the abundance of phytoplankton, thus will attract anchovy to come for feed. The schools of anchovy will attract animals in higher trophic level, including hairtail. However, these process will occur within the next 1 to 2 months due to the growth process for each trophic level. Thus, causing the time interval before the concentration of chlorophyll-*a* in waters may increase the amount of catch in waters (Langkong 1984 in Kuswanto et al 2017). According to analysis and validation of interviews with coastal communities of Pangandaran, there are 7 points of suspected potential fish ground (Figure 2), namely: 07°41'41.7" S and 108°43'41.9" E (Site 1); 07°45'32.4" S and 108°46'0.7" E (Site 2); 07°42'47.8" S and 108°41'27.4" E (Site 3); 07°42'0.4" S and 108°43'49.1" E (Site 4); 07°45'9.2" S and 108°46'57.7" E (Site 5); 07°46'18.4" S and 108°46'11.5" E (Site 6); 07°45'57.3" S and 108°38'35.6" E (Site 7).

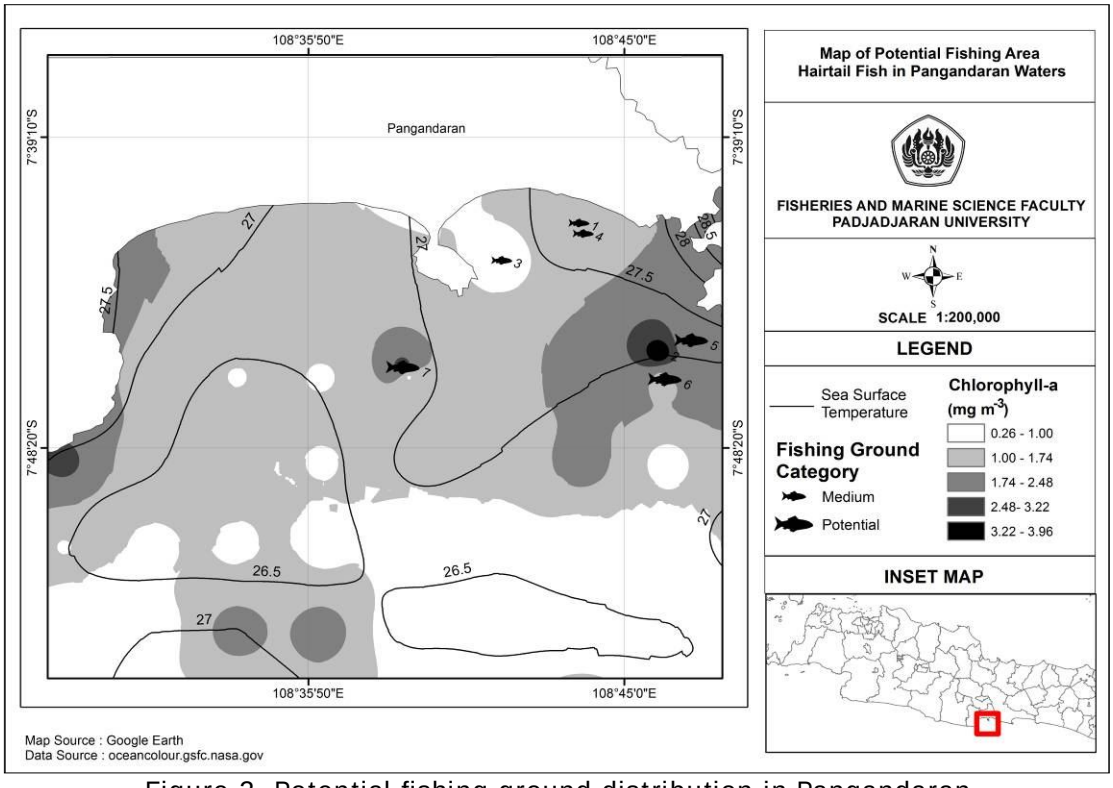

Figure 2. Potential fishing ground distribution in Pangandaran.

Temperature is one of the limiting factors for the life of biota, including phytoplankton. In addition, temperature affects the indirect increase of nutrients in the sea. Chlorophyll-*a* tends to increase as the temperature decreases due to upwelling, bringing nutrients to the surface. Upwelling is an indirect indicator of biological productivity or the presence of fish food (Zainuddin et al 2013). However, there is no upwelling phenomenon in this research location and the temperature distribution ranges from 26.5 to 27°C, which is a common value in the waters. The temperature range for large pelagic fish is 26-31°C (Son et al 2012; Zainuddin et al 2013; Angraeni et al 2014; Safruddin et al 2014). Sea surface temperature distribution (SST) in the research area is shown in Figure 2.

The result showed that fishing operation in station 3 got the lowest catch compared to other stations (Figure 3). This is presumably due to bad weather which happened during fishing operation. Meanwhile, fishing operation in station 7 got a huge amount of hairtail catch by 340,2 kg and was the highest among 7 stations. This is presumably due to high chlorophyll-*a* level and an indication of upwelling occurrence in that area. Nontji (1987) in Veldhuis et al (1997) states that in fishing season, upwelling area will cause an increase in plankton productivity which will invite small fish to gather. Potier & Boely (1990) in Hendiarti et al (2005) state that fishing activities are affected by seasons and environmental conditions of the waters. In west monsoon, southern equatorial stream is gradually moving to the south and the mass of water on northern coast of Java is moving away from the coast. This mass movement of water led to a massive water void in northern coast of Java, causing upwelling phenomenon.

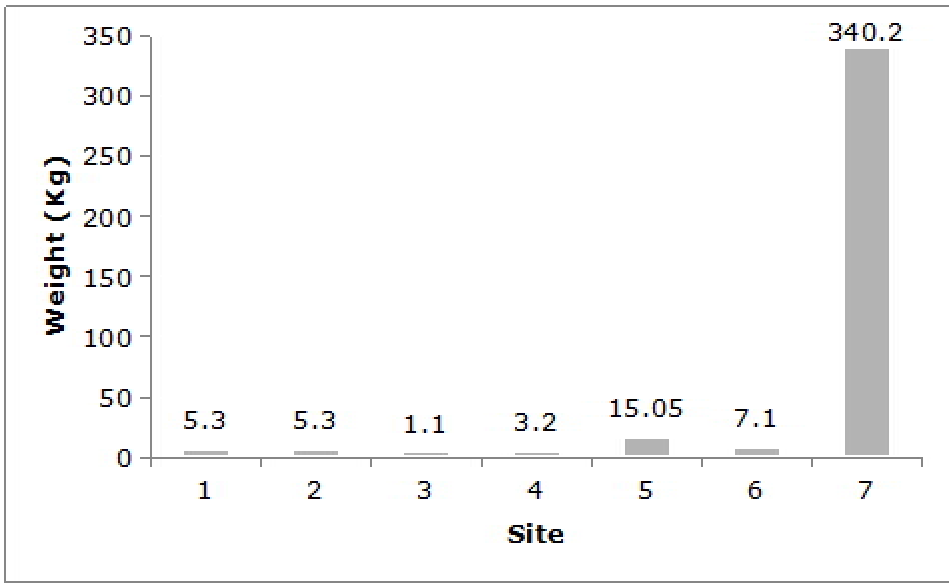

Figure 3. Hairtail productivity in 7 stations.

The size of the catch can be used to determine if the catch already reach its legal sized or not. The size of catch during October to November 2017 was ranged from 47 to 83 cm. The length at fish maturity (Lm) was analyzed based on gonad maturity level (GML) which refers to Cassie classification (1956) in Effendie (2003). GML is a particular stage of gonads development before and after fish spawning. Lm were analysed by using Spearman-Karber method (Hamilton et al 1977 in Grisolia et al 2004).

Hairtail length at first maturity (Lm) has ranged from 55.7 to 60 cm. Therefore, 97% of hairtail catch in this research already hit its legal sized (Figure 4). Differences in the size of hairtail are also influenced by external and internal factors. Internal factors are factors that are difficult to control such as sex, age, parasites and disease. While external factors that usually affecting the size are temperature and food (Effendie 2003). This condition indicates that the waters of Pangandaran are suitable for the growth of hairtail.

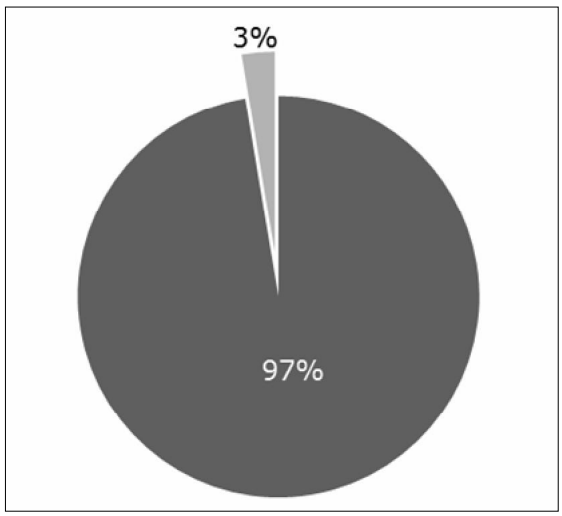

Figure 4. Percentage of legal sized and undersized hairtail catch.

The fishing ground is an important factor determining the success of fishing operation. This is in accordance with statement from Matrutty et al (2017) who states that informations related to fishing ground distribution, fish species and fish distribution are essential for optimization of fishery utilization. A water can be regarded as a fishing ground if there is interaction between targeted fish with fishing technology. Based on the results of interviews with fishermen, hairtail's fishing grounds are scattered around the West Coast and East Coast Pangandaran. Fishermen used motor boat to the fishing ground and catch it using gillnet.

There is a relationship pattern between water quality, biological condition of waters, and chlorophyll-*a* content to catch (Mujib et al 2013). There are three categories of hairtail fishing ground, namely potential, moderate and less potential based on three indicators such as fish catch, size and chlorophyll-*a* concentration around fishing area in Pangandaran waters. These three indicators were then used in determination of potential fishing ground. The result of potential fishing ground determination for hairtail fishery is presented in Table 3.

Table 3

Results of potential fishing ground determination for hairtail fishing

Fishing ground	*Potential fishing ground indicators*			*Categories*
	Catch (kg)	*Catch size (cm)*	*Chlorophyll-a concentration (mg m^{-3})*	
Site 1	5.3	49-71	1.78	Potential
Site 2	5.3	47-83	3.95	Potential
Site 3	1.1	56-78	0.57	Moderate
Site 4	3.2	55-74.8	1.09	Moderate
Site 5	15.05	57.3-74.8	1.74	Potential
Site 6	7.1	49.3-65.2	0.39	Potential
Site 7	340.1	57.3-78.3	2.93	Potential

Chlorophyll-*a* concentration in research locations were ranged from 0.39 to 3.95 mg m^{-3}. These values have exceeded the average value of chlorophyll-*a* concentration in Indonesian waters. According to Birowo & Soegiarto (1975), the average value of chlorophyll-a in Indonesian waters is 0.19 mg m^{-3}. This value increases to 0.24 mg m^{-3} in east monsoon and decreases to 0.16 mg m^{-3} in west monsoon.

There are 5 coordinates points which categorized as potential fishing ground for hairtail fishing and 2 coordinates points as moderate (Table 3). Fishing ground distribution mapping is made based on the number of catch, size and the optimum chlorophyll-*a* for hairtail fishing activity in Pangandaran waters.

Conclusions. Based on the result, it can be concluded that there are 7 points of hairtail's potential fishing ground in Pangandaran Regency. These fishing grounds were determined by the catch which is already legal sized, chlorophyll-*a* distributions, and sea surface temperature (SST). According to the interview with fishermen in Pangandaran, potential fishing time for hairtail is in October and November. In addition, gillnet is the gear which is often used for hairtail fishing.

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