

IDENTIFICATION OF FISHERY RESOURCES IN MADURA STRAIT BASED ON THE IMPLEMENTATION OF POTENTIAL FISHING ZONE INFORMATION FROM REMOTE SENSING

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Abstract. Spatial information of Potential Fishing Zone (PFZ) was used to identify the prospective location in the Madura Strait, where the fishermen from Fish Landing Port (FLP) around the Madura Strait conducted fishing activities. PFZ was aimed to determine fishing location, to identify the type of pelagic fish resources which were dominantly caught in the Madura Strait. Fish resource data were obtained by observing the FLP in the east of Madura Strait especially in Pondok Mimbo, Jangkar, Besuki, Probolinggo, Pamekasan, and Sumenep. Based on the application of PFZ spatial information and observation, the types of pelagic fish caught on west monsoon were dominated by *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.*, and *Trichiurus spp.*. In the first transition season, types of fish resources were a mix between *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.*, *Sardinella longiceps*, and *Trichiurus spp.*, however *Sardinella longiceps* were still dominated the catches. During the east monsoon fish resources at the Madura Strait was also dominated by *Sardinella longiceps*. This condition occurred until the second month of the second transition season followed by the mixing among *Sardinella longiceps.*, *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.* and *Trichiurus spp.*

Keywords: Fish Landing Port, NOAA-AVHRR, Potential fishing zone

1. Introduction

Indonesian National Institute of Aeronautics and Space (LAPAN) has been developing remote sensing application research for many years. The data used for the research is especially from National Oceanic and Atmospheric Administration - Advanced Very High Resolution Radiometer (NOAA-AVHRR). In the past, the research focused on the extraction of sea surface temperature information using the NOAA-AVHRR data. After that, the research has continuously developed and improved in order to detect the upwelling/thermal front in the Indonesian waters, such as the Java Sea, and the Madura Strait.

Furthermore, research in LAPAN has improved in identifying the correlation between upwelling/thermal fronts, obtained from remote sensing data and the fishing ground in Indonesian waters. In 1999, remote sensing application researches were developed to identify the fishing zone, which was utilized in fishery. The Madura Strait is one of the areas where the PFZ spatial information applied in their fishery. The utilization of PFZ was conducted by LAPAN in cooperation with the Marine Affair and Fisheries District Agency of Situbondo. Situbondo has lower fishery development comparing to other three areas in its surrounding, such as Banyuwangi, Probolinggo and Sumenep.

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The three areas mentioned earlier have better fishing technologies, infrastructure and also fish processing system than Situbondo. Based on that data, Situbondo fishermen should involve with the cooperation on using PFZ spatial information.

The problems that Situbondo fishermen face while fishing are the lack of information both spatial and temporal of prospective fishing zone everyday, and also the lack of information about the fish resource correlated to the season. This research has been conducted by utilizing the PFZ spatial information which obtained from remote sensing satellite data and the chlorophyll-a concentration in the fishing activity of Situbondo fishermen. This research is aimed to verify the accuracy of PFZ spatial information and to obtain data of fish resources types that are dominantly caught in correlation to the season. Furthermore, the PFZ spatial information could support fishing activity so the fishermen could easily determine fishing zone and fish resources that possibly caught. PFZ which obtained from remote sensing satellite data; fishermen feedback from fishing operation that guided by PFZ spatial information; and the characteristic of oceanography could be main data in planning the spatial and temporal management of fishing activity, fishing operation and fish processing for Situbondo fishermen.

2. Matters and Methods

The main data used in this research are (1) NOAA-AVHRR data which acquired from the LAPAN's environment and weather station, (2) chlorophyll-a content data from SeaWiFS which are timely correlate to NOAA-AVHRR data. Both data have already been analyzed to result in the daily PFZ spatial information in the Madura Strait, where the Situbondo fishermen do their fishing activity. To

improve the accuracy of produced information, the PFZ identification is supported with current data that is derived from Topex/Poseidon eventhough with global resolution.

Main equipments used in applying the PFZ spatial information are (1) NOAA-AVHRR data analysis facility and chlorophyll-a content data from Sea WiFS satellite, (2) facsimile to send PFZ spatial information to the Marine and Fishery Local District Agency of Situbondo; (3) the fish finder to detect fish schooling on PFZ location; (4) the Global Positioning System (GPS) to show the coordinate of PFZ distribution; (5) S-Band Communication Radio.

The PFZ spatial information has been made through some stages as follows:

- 1). Daily NOAA-AVHRR data compilation and aquisition, to get free cloud cover data;
- 2). Correcting geometric data referring to topographicall maps scale 1:50.000 and radiometric correction;
- 3). McMillin and Crossby method that is common to be used to determine SST distribution in LAPAN, such as: $SST = TW4 + 2,702 (TW4-TW5) - 273,58$, where TW4 and TW5: sea water temperature based on channel 4 and channel 5 remote sensing satellite NOAA-AVHRR; 273,58: reduction of Kelvin value to be 0° Celcius;
- 4). Detecting thermal front with this limitation there are SST gradient for every 3 pixel in range as 0,5° C;
- 5). Analyzing chlorophyll-a content value ($>0,3 \text{ mg/m}^3$);
- 6). Determining PFZ within 3 pixels or 6 pixels diameter which identical circle with 6 km diameter;
- 7). Managing fishing pattern by considering fishing zone border, referring to the maps on the area;
- 8). Printing and sending information letter through fascimile to the Marine and

- Fishery Local District Agency of Situbondo;
- 9). Planning fishing activity by involving motorboat owner to determine PFZ that is used as fishing location on trial at Madura Strait;
 - 10). Conducting fishing trial at prospective PFZ which are accessible by fishermen motorboat;
 - 11). Recording type of fish resources and total weight of fish that caught during the fishing trial;
 - 12). Evaluating fishing trial and total catches.

3. Results and Discussion

The PFZ spatial information has been applied in Situbondo by the fishermen at Besuki, Tanjung Jangkar and Pondok Mimbo FLP. Fishermen apply the PFZ

spatial information doing their fishing activity in Madura Strait. Based on the observation, fish that dominantly caught are *Sardinella longiceps*, *Decapterus* spp., *Euthynnus* spp., *Rastrellinger* spp., and *Trichiurus* spp. To make data analysis easier, fish catch information is divided into 3 categories: (1) PFZ with the catches result over 1,000 kg; (2) PFZ with the catches result about 200–1,000 kg; (3) PFZ with the catches result less than 200 kg. Integration of PFZ based on remote sensing satellite data and type of fish that caught in the implementation of PFZ spatial information in Selat Madura as shown in Figures 1-10.

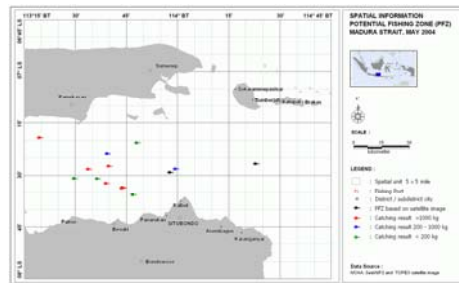


Figure 1. PFZ integrated with feedback data of May 2004.

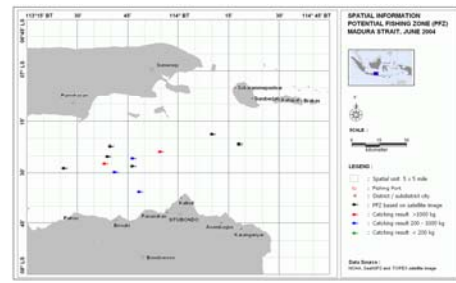


Figure 2. PFZ integrated with feedback data of June 2004.

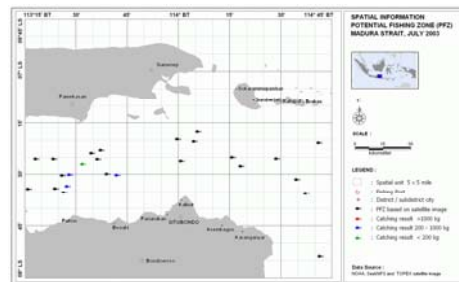


Figure 3. PFZ integrated with feedback data of July 2003.

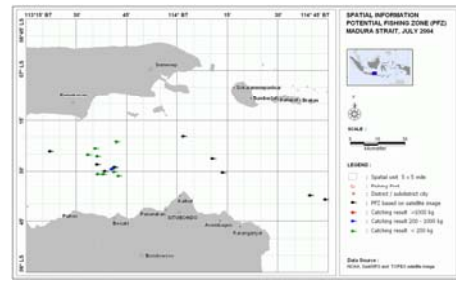


Figure 4. PFZ integrated with feedback data of July 2004.

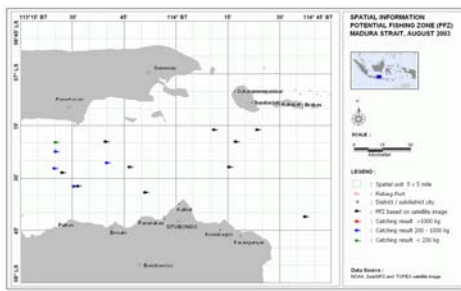


Figure 5. PFZ integrated with feedback data of August 2003.

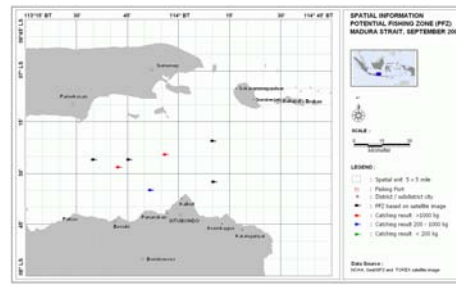


Figure 6. PFZ integrated with feedback data of September 2004.

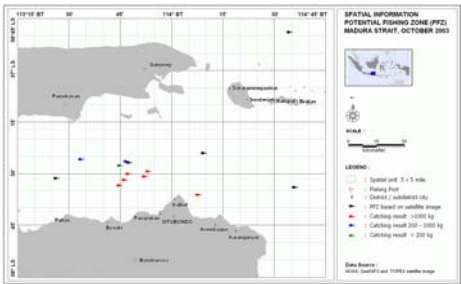


Figure 7. PFZ integrated with feedback data of October 2003.

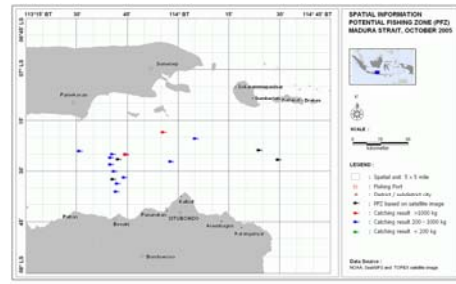


Figure 8. PFZ integrated with feedback data of October 2005.

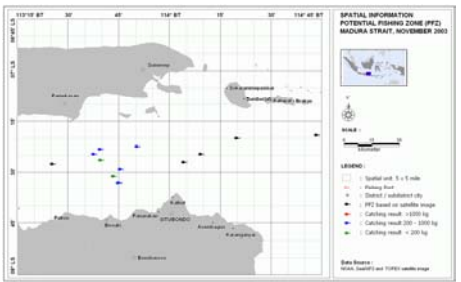


Figure 9. PFZ integrated with feedback data of November 2003.

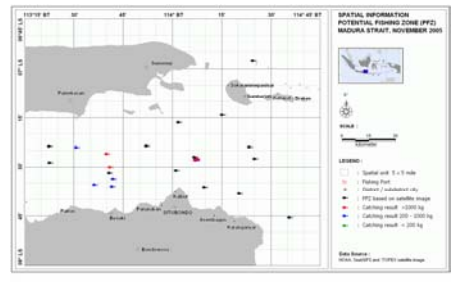


Figure 10. PFZ integrated with feedback data of November 2005.

3.1. PFZ Application Catches Result in May

PFZ spatial information, which was used as main data on fishing activity on May 2004, showed that there are prospective fishing zone concentration between the north Paiton and Besuki at the coordinate 113°33'59" – 113°44'3"E and 7°23'56"– 7°33'4"S (Tabel 1).

Fishing activity conducted at the south of Sampang at coordinate 113°19'42"E and 7°19'20"S resulted catches about 200 kg, in the other hand, fishermen feedback

said that fishing activity in PFZ at coordinate between 113°50'-114°E and 7°25' – 7°30'S or at the north Tanjung Pecinan had resulted catches about 500 kg. Based on observation of fishing activity conducted in 12 different zone between the coordinate of 113°19'42" – 113°59'30"E and 7°19'20"- 7°35'53"S, the type of fish that dominantly caught was *Sardinella longiceps*., with total catches variously about 50–500 kg, while other fish like *Trichiurus spp.* were caught fewer. The location of fish catching by fishermen that

directly correlated to PFZ based on satellite data lies between $113^{\circ}55'$ – $113^{\circ}00'$ E and $7^{\circ}25'$ – $7^{\circ}30'$ S, with catch result of 500 kg of *Sardinella longiceps*.

Table 1 shows that from 12 fishing activity applied from PFZ information, the catches result is dominated by *Sardinella longiceps*, with total catches of 16,870 kg, while a few of *Trichiurus spp.* are as subsidiary catches. Those data indicates that type of fish which dominated the total catches on May is *Sardinella longiceps*, it

is proved that fish resources in Madura Strait on the 3rd month of the first transition season is also dominated by *Sardinella longiceps*. During fishing activity, the problems that fishermen face are the unpredictable movement of high speed wind and wave height. The problems cause broken equipments. Meanwhile, the fishermen using new and upgrades equipments have an opportunity to get more catches.

Table 1. Feedback data from fishermen on May 2004 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type of Fish
1	10-5-2004	$113^{\circ} 29' 48''$	$7^{\circ} 31' 02''$	170	<i>Sardinella longiceps</i>
2	11-5-2004	$113^{\circ} 40' 01''$	$7^{\circ} 27' 29''$	1,500	<i>Sardinella longiceps</i> and <i>Trichiurus spp.</i>
3	12-5-2004	$113^{\circ} 48' 13''$	$7^{\circ} 20' 48''$	150	<i>Sardinella longiceps</i>
4	13-5-2004	$113^{\circ} 36' 38''$	$7^{\circ} 31' 04''$	100	<i>Sardinella longiceps</i>
5	17-5-2004	$113^{\circ} 47' 01''$	$7^{\circ} 35' 53''$	50	<i>Sardinella longiceps</i>
6	18-5-2004	$113^{\circ} 59' 30''$	$7^{\circ} 28' 17''$	500	<i>Sardinella longiceps</i>
7	19-5-2004	$113^{\circ} 19' 42''$	$7^{\circ} 19' 20''$	2,000	<i>Sardinella longiceps</i>
8	21-5-2004	$113^{\circ} 39' 10''$	$7^{\circ} 32' 27''$	4,000	<i>Sardinella longiceps</i>
9	24-5-2004	$113^{\circ} 39' 33''$	$7^{\circ} 23' 56''$	700	<i>Sardinella longiceps</i>
10	25-5-2004	$113^{\circ} 43' 52''$	$7^{\circ} 33' 52''$	1,700	<i>Sardinella longiceps</i>
11	26-5-2004	$113^{\circ} 33' 59''$	$7^{\circ} 28' 21''$	5,000	<i>Sardinella longiceps</i>
12	27-5-2004	$113^{\circ} 44' 03''$	$7^{\circ} 33' 41''$	1,000	<i>Sardinella longiceps</i>

3.2. PFZ Application Catches Result in June

Base on PFZ spatial information for June 2004, PFZ concentration in Madura Strait was located between the coordinate of $113^{\circ}38'20''$ – $113^{\circ}54'50''$ E and $7^{\circ}23'57''$ - $7^{\circ}35'56''$ S. On the fishing trial, type of fish resources that dominantly caught was *Sardinella longiceps*., with the total catches about 200–400 kg (Table 2).

The information is shown in Figure 2 shows there are 2 zone have same total catches of 400 kg, those zone are located at the coordinate between $113^{\circ} 35'$ - $113^{\circ} 40'$ E and $7^{\circ}25'$ – $7^{\circ}30'$ S, meanwhile PFZ located on $113^{\circ}45'$ - $113^{\circ}50'$ E and $7^{\circ}25'$

– $7^{\circ}30'$ S have total result of 1,000 kg. Total catches obtained from 5 PFZ distribution, that use fishing trial on June 12-24, 2004 is 8,260 kg. Based on PFZ from satellite data and fishing location from fishermen, there are 2 spatial units that directly correlated at $113^{\circ}35'$ – $113^{\circ}40'$ E and $7^{\circ}25'$ – $7^{\circ}30'$ S with fish catch *Sardinella longiceps* 4,000 kg, and at $114^{\circ}45'$ - $114^{\circ}50'$ E and $7^{\circ}25'$ – $7^{\circ}30'$ S also with fish catch of *Sardinella longiceps* 1,000 kg.

As fishermen feedback, some of their fishing trials were hampered by high speed wind and wave height. Although the PFZ distribution was located at the westward

specifically at the north Besuki, the PFZ distribution was still influenced by the east wind. On that condition, only fishermen using over 20GT motorboat have the

opportunity to get lots of *Sardinella longiceps* at over 20 km zone.

Table 2. Feedback data from the fishermen on June 2004 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type of Fish
1	16-6-2004	113° 48' 37"	7° 35' 56"	260	<i>Sardinella longiceps</i> .
2	21-6-2004	113° 46' 37"	7° 25' 54"	1,000	<i>Sardinella longiceps</i> .
3	22-6-2004	113° 38' 20"	7° 27' 30"	4,000	<i>Sardinella longiceps</i> .
4	23-6-2004	113° 41' 15"	7° 29' 56"	500	<i>Sardinella longiceps</i> .
5	24-6-2004	113° 54' 50"	7° 23' 57"	2,500	<i>Sardinella longiceps</i> .

3.3. PFZ Application Catches Result in July

PFZ spatial information for July 2003, which was obtained from NOAA-AVHRR remote sensing satellite and used as main data in fishing trial by Situbondo fishermen, shown that there are 26 PFZ distribution spread from Java Sea, Madura Strait, to the Bali Sea. This fishing trial only conducted at 3 concentration zones within Madura Strait, with various result about 120 - 250 kg (Tabel 3). Fishing date, coordinate of fishing zone, total catches, and the type of fish are shown in the Table 3, showed that there are prospective fishing zone concentration between the north Paiton and Besuki at the coordinate 113°33'59" – 113°44'3" E and 7°23'56" - 7°33'4" S.

Fishing zone located between the coordinate of 113°27'33" – 113°42'5" E and 7°27'10" - 7°33'46" S, or located at the north to northwest of Pajarakan have water depth level that was not suitable for *Sardinella longiceps*. From 4 locations of fishing activity by fishermen, there are 2 spatial units that correlated to PFZ from satellite data, that is located between 113°25' – 113°30' E and 7°30' - 7°35' S with fish catch of *Sardinella longiceps* of more than 200 kg, and between 113°40' – 113°45' E and 7°30' – 7°35' S with fish

catch of *Sardinella longiceps* about 250 kg. Fishing activity done at the west of Madura Strait was aimed to get more catches and also to reduce wind and wave influence.

Fishing trials using PFZ spatial information in July 2004 were conducted in July 12-28 2004 with low and unsatisfied result. Fishing activity was done on the 2nd, 3rd, and the 4th week of July. The integration of feedback data from the fishermen on July 2004 at Madura Strait with PFZ analysis have shown the PFZ distributions spread from Madura Strait to Java Sea (Figure 4). Based on PFZ spatial information, there were at least 10 PFZ distributions, but in fishing trial the fishermen found only 1 zone that resulted catches, on July 28, 2004 located on the coordinate of 113°40'45" E and 7°29'35" S, 200 kg *Sardinella longiceps*. were caught. The fish finder, installed on fishermen boat, indicated the fish schooling shown on PFZ location, but the fishing activity was impossible to do due to the influence of wave height and high speed wind whereas the sea temperature was cold.

Based on fishermen feedback data, PFZ were concentrated at the north of Besuki with coordinate at 113°36'38"- 113°42'47" E and 7°29'5"- 7°31'0" S and at the north of Tanjung Jangkar FLP, ±13 mile from coast side. Although the PFZ were near and

promising enough to gain more *Sardinella longiceps.*, the fishermen could not access the PFZ because the zone was influenced by high speed wind and wave height from the east.

Table 3. Feedback data from the fishermen on July 2003 in Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type of Fish
1	28-7-2003	113° 32' 07"	7° 27' 10"	120	<i>Sardinella longiceps.</i>
2	29-7-2003	113° 42' 05"	7° 30' 21"	250	<i>Sardinella longiceps.</i>
3	30-7-2003	113° 28' 12"	7° 30' 15"	215	<i>Sardinella longiceps.</i>
4	31-7-2003	113° 27' 33"	7° 33' 40"	230	<i>Sardinella longiceps.</i>

3.4. PFZ Application Catches Result in August

PFZ spatial information on August obtained from NOAA-AVHRR data showed some potential fishing location at Madura Strait. At least 19 PFZ distribution on this month, while as feedback data from the fishermen there were only 5 PFZ distribution to conduct the fishing activity (Table 4).

PFZ concentration located at coordinate 114°11'52"- 114°23'12" E and 7°16'47"- 7°20'1" S or at the south of Sepudi Island. During August 2003, there are PFZ distributions spread at the coordinate 113°25'00" - 113°31'17" E and 7°19'59"- 7°32'31" S. Based on feedback data, fishing zone located on Madura Strait with the coordinate 113°25'00"- 113°40'10"E and 7°20'00" - 7°32'32"S. PFZ coordinate showed that fishing activity moved to the west of Madura Strait and was located between Probolinggo and Pamekasan, so

the fishermen had fewer catches, because the water depth was not suitable for *Sardinella longiceps.* Feedback data also showed that from the catches on those location, the type of fish caught was still dominated by *Sardinella longiceps.*, with lower total catches about 160 - 300 kg.

From 5 locations of fishing activity by fishermen in August 2003, there are 2 spatial units in the north of Paiton (Problinggo) that is correlated to PFZ based on satellite data, which lies between 113°25' - 113°30' E and 7°25' - 7°30' S with catch result of *Sardinella longiceps* of more than 360 kg, and between 113° 40' - 113°45' E and 7°30' - 7°35' S also with catch result of *Sardinella longiceps* of about 310 kg. Based on fish catch result feedback from fishermen at 5 PFZ locations, it is proven that the closest fishing activity location to PFZ have the highest result.

Table 4. Feedback data from the fishermen on August 2003 at Madura Strait.

No.	Position		Location	Fish Catches	
	Longitude (E)	Latitude (S)		Kg	Type of Fish
1	113° 25' 20"	7° 20' 00"	Madura Strait	160	<i>Sardinella longiceps</i>
2	113° 25' 20"	7° 22' 30"	Madura Strait	220	<i>Sardinella longiceps</i>
3	113° 40' 10"	7° 25' 42"	Madura Strait	200	<i>Sardinella longiceps</i>
4	113° 25' 00"	7° 27' 20"	Madura Strait	360	<i>Sardinella longiceps</i>
5	113° 30' 40"	7° 32' 32"	Madura Strait	310	<i>Sardinella longiceps</i>

3.5 PFZ Application Catches Result in September

Fishing activity at Madura Strait by using PFZ spatial information for September took place at the north of Besuki and Tanjung Pecinan. Fishing zone at Madura Strait were located between the coordinate of 113°43'28.3" – 113° 56'12.3" E and 7°23'15.3" - 7°34'59" S was dominated by *Sardinella longiceps*, with total catches about 700-1,500 kg (Table 5).

PFZ distribution were concentrated at the north of Besuki with coordinate 113°35'46" – 113°26'13" E and 7°25'15"- 7°28'17" S or at the northwest of Tanjung Pecinan within the zone over 20 km at the

coordinate of 113° 51' 50"E and 7° 34' 59"S (Figure 5). Based on fishing activity location by fishermen in September 2004, from 3 fishing location there was 1 (one) PFZ in spatial unit in the north of Besuki (Situbondo) that correlated to PFZ from satellite data, which is in 113°40' - 113°45' E and 7°25' - 7°30' S with catch result of *Sardinella longiceps* of more than 1,200 kg. Fishing activity was still influenced by high speed wind and wave height, but the fishermen could be made out due to their motorboat ability.

Table 5. Feedback data from the fishermen on September 2004 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type of Fish
1	6-9-2004	113° 56' 12"	7° 24' 35"	1,500	<i>Sardinella longiceps</i>
2	7-9-2004	113° 51' 50"	7° 34' 59"	700	<i>Sardinella longiceps</i>
3	9-9-2004	113° 42' 28"	7° 28' 17"	1,200	<i>Sardinella longiceps</i>

3.6. PFZ Application Catches Result in October

PFZ spatial information for October showed that PFZ was located at the north Tanjung pecinan. The information was based on feedback data of fishing activity on October 2003 conducted at 10 PFZ distribution spread all over Madura Strait. Fishing zone were concentrated at the coordinate 113°26'37" – 114°7'42" E and 7°25'58"- 7°36'24" S. Total catches in every zone are various, while the type of fish resources caught were a mix between *Sardinella longiceps*, *Euthynnus spp.*, *laying*, and *Trichiurus spp.*, but was still dominated by *Sardinella longiceps* (Table 6).

Feedback of fishing activity done by fishermen in October 2003 showed that there are 3 catch location in 1 (one) PFZ spatial unit in the northeast of Besuki (Situbondo) that correlated to PFZ based on satellite data, which lies between

113°45' - 113°50' E and 7°25' - 7°30' S with catch result of *Sardinella longiceps* varied from less than 200 kg, between 200 – 1,000 kg, and over 1,000 kg.

Fishing zone movement in Java Sea on October 2005 was located at the coordinate 113°9'36" E and 6°31'23" S or in north side, and at the west Besuki to Pajarakan waters (Probolinggo). Feedback data from Besuki fishermen on October 2005 was located at the coordinate of 113°30'57" – 114°05'07" E and 7°18'42"- 7°36'11" S. Fishing activity that was done on the 2nd to the 4th week of October was still dominated by *Sardinella longiceps*, *Trichiurus spp.*, *Decapterus spp.* and *Euthynnus spp.* with total catches about 200 – 1,300 kg (Table 7).

PFZ spatial information showed that PFZ were concentrated in several location namely (1) at the north Besuki in the coordinate 113°40'9" – 113°44'35" E and 7°25'10"- 7°36'11" S at Giligenteng

waters; (2) at Sumenep between the coordinate 113°10'36" E and 7°18'42" S to the south of Sampang at 113°10'36" E and 7°24'10" S. PFZ distribution could be found at 12 mile in the north of Situbondo, at the waters in the north Besuki with the coordinate 113°41'46" E and 7°36'11" S.

Table 6. Feedback data from the fishermen on October 2003 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type of fish
1	16-10-1003	113° 33' 34"	7° 25' 58"	250	<i>Sardinella longiceps</i>
2	17-10-2003	113° 52' 07"	7° 30' 56"	2,000	<i>Sardinella longiceps</i>
3	20-10-2003	113° 53' 10"	7° 29' 28"	1,500	<i>Sardinella longiceps</i> , <i>Decapterus spp.</i> and <i>Euthynnus spp.</i>
4	20-10-2003	114° 07' 42"	7° 36' 24"	1,500	<i>Sardinella longiceps</i>
5	21-10-2003	113° 44' 46"	7° 33' 35"	1,000	<i>Sardinella longiceps</i> and <i>Euthynnus spp.</i>
6	22-10-2003	113° 47' 17"	7° 30' 12"	1,800	<i>Sardinella longiceps</i> and <i>Euthynnus spp.</i>
7	23-10-2003	113° 46' 14"	7° 31' 58"	1,500	<i>Sardinella longiceps</i>
8	24-10-2003	113° 46' 48"	7° 26' 36"	900	<i>Sardinella longiceps</i> and <i>Euthynnus spp.</i>
9	30-10-2003	113° 44' 54"	7° 27' 49"	20	<i>Trichiurus spp.</i> and <i>Euthynnus spp.</i>

Table 7. Feedback data from the fishermen on October 2005 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type
1	10-10-2005	113° 44' 37"	7° 25' 12"	800	<i>Sardinella longiceps</i>
2	11-10-2005	113° 44' 35"	7° 25' 20"	1,200	<i>Sardinella longiceps</i> and <i>Trichiurus spp.</i>
3	12-10-2005	113° 41' 46"	7° 36' 11"	600	<i>Sardinella longiceps</i>
4	13-10-2005	113° 44' 09"	7° 32' 02"	1,000	<i>Decapterus spp.</i> and <i>Euthynnus spp.</i>
5	14-10-2005	113° 40' 40"	7° 25' 11"	700	<i>Sardinella longiceps</i>
6	15-10-2005	113° 40' 09"	7° 28' 11"	600	<i>Sardinella longiceps</i> and <i>Trichiurus spp.</i>
7	22-10-2005	113° 40' 06"	7° 26' 11"	800	<i>Euthynnus spp.</i> and <i>Decapterus spp.</i>
8	24-10-2005	113° 41' 10"	7° 30' 14"	650	<i>Sardinella longiceps</i> and <i>Trichiurus spp.</i>
9	25-10-2005	113° 55' 38"	7° 18' 42"	1,300	<i>Sardinella longiceps</i> and <i>Decapterus spp.</i>
10	26-10-2005	114° 05' 07"	7° 20' 32"	700	<i>Decapterus spp.</i>
11	27-10-2005	113° 42' 06"	7° 33' 53"	600	<i>Euthynnus spp.</i>
12	28-10-2005	113° 30' 57"	7° 24' 13"	200	<i>Decapterus spp.</i>
13	29-10-2005	113° 53' 43"	7° 27' 21"	850	<i>Sardinella longiceps</i> and <i>Euthynnus spp.</i>

Based on PFZ and feedback of fishing activity location by fishermen in October 2005, there are several fishing locations that correlate to PFZ based on satellite data. Four locations are at 113°40' - 113°45' E and 7°25' - 7°30' S, also 4 PFZ coordinate 113°40' - 113°45' E and 7°30' - 7°35' S. The catch resulted were mixed of *Sardinella longiceps*, *Trichiurus spp.*, *Decapterus spp.* and *Euthynnus spp.*, which varied from 600 kg to 1,300 kg.

3.7. PFZ Application Catches Result in November

Based on PFZ spatial information used in fishing operation in November 2003, identify that fishing activity at coordinate 113°47'17.8" E and 7°30'12.9" S resulting *Sardinella longiceps* and *Euthynnus spp.* with their total catches about 1800 kg. Meanwhile on the other zone located at the coordinate 113°46'48" E and 7°26'38" S resulted 900 kg total catches. As feedback data, the location and catches on 8 PFZ at Java Sea were concentrated on the coordinate 114°4'17" - 114°9'0" E and 7°22'35"- 7°33'18" S or at the north of Tanjung Pecinan.

Fishing activity also be done at coordinate 113°37'41" - 113°51'35" E and 7°22'35"- 7°33'18" S. Total catches that fishermen get in November 2003 is 3,410 kg, with its description of 3,390 kg of *Sardinella longiceps* and 20 kg of *Euthynnus spp.* (Table 8). Local fishermen said that fishing activity during November,

was hampered by high speed wind and height wave, so the fishermen using small motorboat have difficulty to access the PFZ.

Based on feedback from fishermen, fishing activity locations in November 2003 were slightly different from PFZ locations from satellite data. This is because the feedback from Besuki fishermen, while the prospektif PFZ were in north and northeast of Tanjung Pecinan (Figure 9). From catch feedback by fishermen, the dominant fish in Madura Strait were mixed of *Sardinella longiceps*, and *Euthynnus spp.*

Fishing activity in November 2005 conducted on the 2nd to the 4th week at Madura Strait with the coordinate between 113°30'57" - 114°7'35" E and 7°24'13"- 7°33'53" S. Type of fish resources that caught during November mixed between *Euthynnus spp.*, *Decapterus spp.* and *Trichiurus spp.*, with total catches about 400-4000 kg, the catches dominated by *Euthynnus spp.* (Table 9). Integration between the result from the PFZ distribution in November 2005 and the result from fishing operation is shown in the Figure 10. In November, the last month of 2nd transition season, fishing activity could be done effectively because the wind dominantly comes from south, sometimes from the west with low speed so Madura Strait waters is quiet enough.

Table 8. Feedback data from the fishermen on November 2003 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type
1	1-11-2003	113° 39' 43"	7° 26' 31"	170	<i>Sardinella longiceps</i>
2	2-11-2003	113° 43' 30"	7° 31' 20"	120	<i>Sardinella longiceps</i>
3	4-11-2003	113° 50' 30"	7° 22' 35"	300	<i>Sardinella longiceps</i>
4	14-11-2003	113° 37' 41"	7° 24' 47"	900	<i>Sardinella longiceps</i>
5	15-11-2003	113° 45' 34"	7° 29' 15"	800	<i>Sardinella longiceps</i>
6	16-11-2003	113° 44' 57"	7° 33' 18"	20	<i>Euthynnus spp.</i>
7	17-11-2003	113° 45' 10"	7° 33' 15"	300	<i>Sardinella longiceps</i>
8	18-11-2003	113° 39' 34"	7° 23' 22"	800	<i>Sardinella longiceps</i>

Table 9. Feedback data from the fishermen on November 2005 at Madura Strait.

No.	Date	Position		Fish Catches	
		Longitude (E)	Latitude (S)	Kg	Type
1	10-11-2005	113° 40' 06"	7° 26' 11"	2000	<i>Euthynnus spp.</i>
2	11-11-2005	113° 41' 10"	7° 30' 14"	1,200	<i>Euthynnus spp.</i> , and <i>Trichiurus spp.</i>
3	12-11-2005	113° 42' 6.1"	7° 33' 53 "	800	<i>Euthynnus spp.</i>
4	14-11-2005	113° 30' 57"	7° 24' 13"	400	<i>Decapterus spp.</i> and <i>Trichiurus spp.</i>
5	19-11-2005	113° 36' 25"	7° 35' 39"	700	<i>Euthynnus spp.</i>
6	21-11-2005	114° 07' 05"	7° 27' 29"	4,000	<i>Euthynnus spp.</i>
7	22-11-2005	114° 07' 15"	7° 28' 00"	600	<i>Euthynnus spp.</i>
8	23-11-2005	114° 07' 05"	7° 28' 03"	1,700	<i>Euthynnus spp.</i>
9	24-11-2005	114° 07' 25"	7° 28' 05"	900	<i>Euthynnus spp.</i>
10	25-11-2005	114° 07' 35"	7° 27' 39"	1,200	<i>Euthynnus spp.</i>
11	26-11-2005	114° 07' 30"	7° 27' 50"	1,300	<i>Euthynnus spp.</i>
12	28-11-2005	113° 41' 46"	7° 36' 11"	800	<i>Euthynnus spp.</i>
13	29-11-2005	113° 42' 06"	7° 33' 53"	400	<i>Decapterus spp.</i>

Based on PFZ and feedback of fishing activity by fishermen in November 2005, there were several fishing activity locations that correlate to PFZ locations. Two PFZ locations were in north of Besuki in coordinate 113°40' - 113°45' E and 7°30' - 7°33' S, and four PFZ locations in northeast of Tanjung Pecinan in coordinate 114°05' - 114°10' E and 7°25' - 7°30' S. The dominant fish catch in these locations were mixed of *Euthynnus spp.*, *Trichiurus spp.*, and *Decapterus spp.*, which varied from 400 kg to 4,000 kg.

3.8. Correlation between type of fish with the season

From the observation of Fish landing Port along the east Madura Strait, identified that fish resource were caught during west monsoon are *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.* and *Trichiurus spp.* Those types of fish also caught at the east of Java Sea, so means that fish resources in or from the east of Madura Strait entered Madura Strait through the strait between Sepudi Island and Raas Island, Raas Island with Kangean

and the water at the east of Kangean Islands.

On the beginning of first transition season, which is March, fish resources at Madura Strait mixed between *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.*, *Trichiurus spp.* and *Sardinella longiceps*. On April, the 2nd month of first transition season, fish resources that caught are mixes between *Euthynnus spp.*, *Decapterus spp.* and *Sardinella longiceps*, also few catches of *Rastrellinger spp.* and *Trichiurus spp.*. At the end of first transition, May, fish resources at Madura Strait dominated by *Sardinella longiceps* while other type of fish such as *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.* and *Trichiurus spp.* has been decreased.

Based on the catches of Situbondo fishermen apply the PFZ at Madura Strait on the east season, known that *Sardinella longiceps* was dominated the catches, even another type of pelagis fish were barely caught. *Sardinella longiceps* domination in the catches Situbondo fishermen at Madura Strait also happens in fishing activity by Sampang fishermen (Santos, 2003).

On the beginning of second transition season, September and October, fish resources at Madura Strait still dominated by *Sardinella longiceps*. On the last month of second transition season fish resources at Madura Strait were mixed between *Sardinella longiceps*, *Euthynnus spp.*, and *Decapterus spp.*, although from the catches still dominated by *Sardinella longiceps*.

Based on the explanation above, type of fish that dominantly found in Madura Strait is *Sardinella longiceps*, which are caught from the middle of first transition season to the last month of second transition season. Meanwhile another type of fish such as *Euthynnus spp.*, *Decapterus spp.* and *Rastrellinger spp.* only dominated the catches during the west monsoon and the first month of first transition season. This condition in accordance with the production of 5 types of pelagis fish that dominantly caught by Situbondo fishermen for almost 5 years.

4. Conclusion

From 11 months of PFZ application in fishing activity in Madura Strait, 9 months of fishing activity were carried out in PFZ location, which have higher fish catch than that of away from PFZ location. One application was done quite far from PFZ location, and one application was failed due to high waves and wind speed, eventhough based on fish finder fish school was detected.

By applying PFZ spatial information, observation at Fish Landing Port alongside Madura Strait, and indentification of fish type with the season, this research showed that an effective and efficient fishing activity could not only determined by the abundant fish resources identified by fish schooling, but also depending on wind and wave conditions, motorboat size, and fishing equipment used in fishing activity.

Based on the catches of Situbondo fishermen and applying the PFZ at Madura Strait, fish resources caught during west

monsoon were *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.* and *Trichiurus spp.* On the first transition season, fish resources at Madura Strait were the mixing among *Euthynnus spp.*, *Decapterus spp.*, *Rastrellinger spp.*, *Sardinella longiceps* and *Trichiurus spp.* On the east season, *Sardinella longiceps* was dominated the catches. On the second transition season, fish resources were *Sardinella longiceps*, *Euthynnus spp.*, and *Decapterus spp.*

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