Environmental assessment of the set-net operation in Rayong Province, Thailand

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Environmental assessment of set-net operation in Mae Rumphueng Beach, Rayong Province was evaluated during 2013-2014. Field surveys around the set-net fishing ground were conducted in the beginning (October 2013), middle (January 2014), ending (April 2014) periods of the operation and six months after the operation ending (October 2014). The results of paired t-test showed that acid volatile sulfide (AVS) of the bottom sediments within set-net A, set-net B and the reference area from four periods were not significantly different (p>0.05). Additionally, average amount of AVS including set-net A, set-net B and the reference area in the beginning (0.0011±0.0018 mg/g dry), middle (0.0026±0.0029 mg/g dry) ending (0.0028±0.0028 mg/g dry) and after-ending (0.0053±0.0117) were much lower than the criteria value for critical farm (2.5 mg/g dry proposed by Yokoyama, 2003). The density of benthic macro-fauna during middle and ending periods in set-net area were significantly higher than those in other areas; whereas those during beginning and after-ending periods were not significantly different. These results indicated that set-net operation did not relevant to the polluted substance, AVS, but had an influence in the increasing of benthic macro-fauna density during the operation season, which was recovered to the initial condition after removal of gear construction.

Keywords:
set-net, acid volatile sulfide (AVS), benthic macro- fauna, environmental assessment

I. Introduction

The marine fishing in Thai territorial waters has been operated in the Gulf of Thailand and Andaman sea with coastline of 1,972 km facing to the Gulf of Thailand and 1,037 km facing to Andaman Sea. It is rich in nutrient brought in by many rivers [Wanttayakorn, 2014] and bottom in shallow water is either muddy or sandy suitable for fishing operation. The annual marine production from fishing, which was 150,000 tons in the 1950s, increased sharply to 1,000,000 tons in 1968 and reached to 3,380,300 ton in 2005. During the last decade marine fisheries, however, it was continuously declined which that marine production remained 1,614,500 tons in 2013 [DOF 2016]. The destructive fishing gear and fishing pressure on coastal fisheries resources considered as one of the main causes of resource deterioration. In order to alleviate mentioned problem by organizing group cooperation for Eco-friendly fishing operation, set-net has been experimentally operated in Mae Rumphueng beach, Rayong Province, since 2002. Recently, there were 5 set-net experimental operations in Thailand waters at Rayong, Chonburi and Prachuap Khiri Khan Province

Set-net is a type of stationary fishing gears with a large-scale trap net. It is used in coastal waters to intercept migrating fish schools in the leader net, subsequently entrapping them inside the chamber trap. The set-net has been operated in Thailand waters over decades. Long term of set-net operation probably had the potential to effect the environment around it by functional as sediment trap. However, environmental assessment of set-net operation has not been conducted. Most of researches studied in related with Thailand set-net were fishing techniques [Manpasit 2005], catch profit [Manajit 2011] and management [TD 2008]. Therefore, the Research Institute for Human and Nature (RIHN), Eastern marine Fisheries Research and Delevopment Center, DOF, Thailand (EMDEC) and Southeast Asian Fisheries Development Center (SEAFDEC) conducted collaborative project aiming to conduct environmental condition survey in order to determine environmental assessment of the set-net operation focusing on the water quality, total acid volatile sulfide (AVS) and benthos around set-net fishing ground.

II. Materials and Methods

The study sites were located at Mae Rumphueng beach, Rayong Province, Thailand. There were 22 survey stations including 8 stations around the set-net A (4 stations at the edge of set-net and 4 stations with 100 m far away from edge of set-net), 8 stations around the set-net B (4 stations at the edge of set-net and 4 stations with 100 m far away from edge of set-net) and 6 reference stations (Station number 1, 2, 3, 4, 5 and 6). Location of the survey stations and survey activities are shown in **Figure 1.**

Field surveys were conducted at different period namely beginning (October, 2013), middle (January, 2014) and ending (April, 2014) period of operation and six months after operation ending (October 2014). The field surveys were carried out on board, namely Bangphe 14. Water profile including temperature, salinity, dissolved oxygen (DO) and pH were measured by using multivariate devices (Mantaray Model I). Water sample at surface, middle and bottom were collected by van dron with that chlorophyll-a were measured according to [Michell and Kiefer, 1984]. Sediment samples were collected by Ekman grab with that sediment grain size, total acid volatile sulfides (AVS) and benthic macro-fauna were analyzed as follow;

-The sediment grain size samples were carefully collected in surface layer and kept in plastic bag and put in ice-boxes then was transferred to laboratory for analysis. Five sub-sambles of each station were weighed out approximately 100 g for each sub-sample. Each sample was then dried in drying oven at 100 ^{o}C for 24 hr and dry weight were recorded. Then the sample were dry sieved through series of sieves including 2mm, 1mm, 0.5mm, 0.125 mm and 0.063mm mesh size. The samples were separated and weighed on balance to +/-0.01 g accuracy.

-AVS samples with three replicates in each station were carefully kept in plastic box and put in ice-boxes then was transferred to laboratory for analysis. It was assayed by changing sulfide in various from into hydrogen sulfide (H_2S) using 18N sulfuric acid (H_2SO_4). The amount of H_2S in the sediment was then measured using Hedrotek column (AVS test column).

Samples for benthic macro-fauna were washed and sorted through a 0.5mm mesh sieve and preserve in 5% seawater formalin added Rose Bengal solution. Benthic specimens were identified to class level under stereo-microscope with the aid of published figures and description of Arnold and Birtles (1989); Rouse and Pleijel (2001). The density of benthic

macro-fauna was standardized to number of individuals per square-meter (ind/m^2) in order to compare the differences between sampling period and between sampling site.

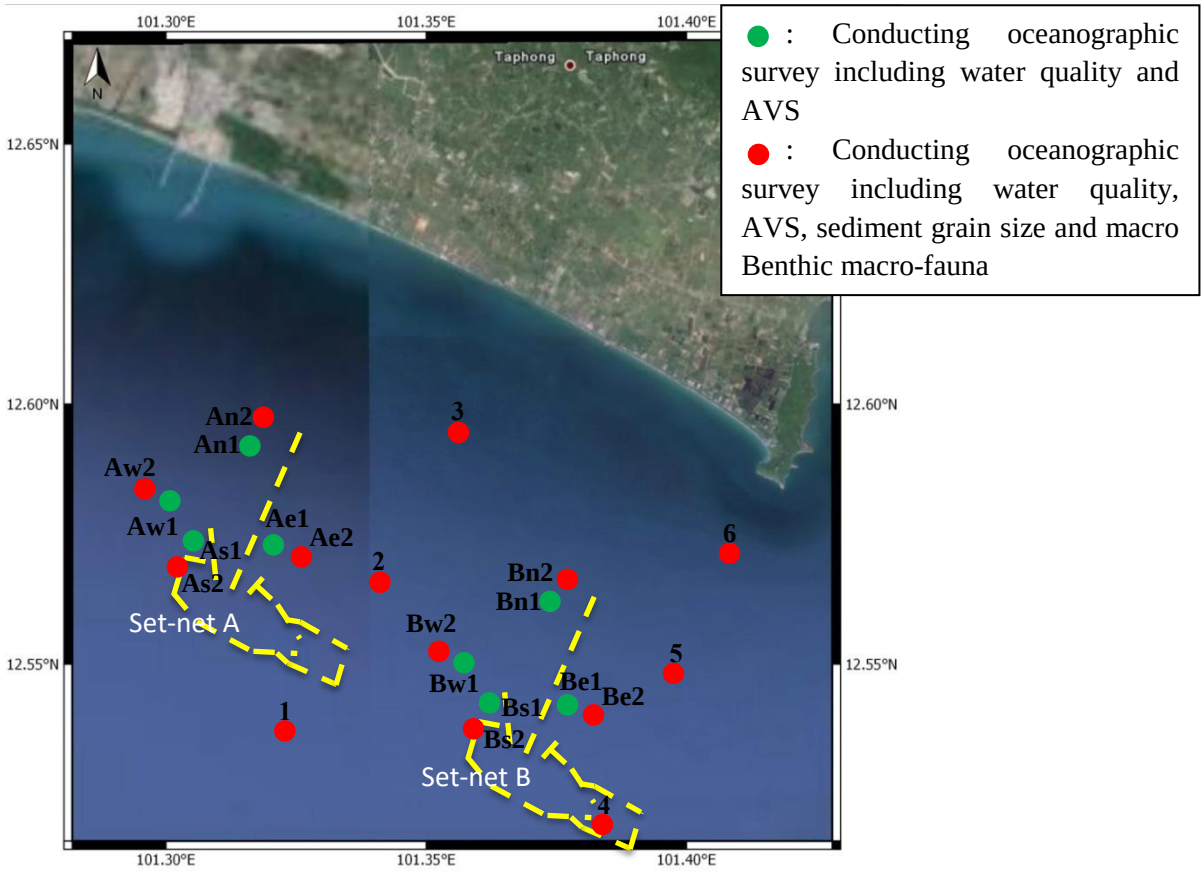

Figure 1. Survey location and activities conducting at Mae Rumphueng beach, Rayong Province, Thailand during October 2013 to October 2014. *Remark: Sediment grain size were only conducted in beginning period*

III. Results and Discussion

Water quality

Set-net was constructed in flat area with average depth of 12.5 meter. Average temperature, salinity, dissolved oxygen, pH and chlorophyll-a at surface, middle and bottom layer in the whole study period were shown as **Table1**. The results showed that fresh water flux input effected to saline in the study area in October which average salinity in 2013 and 2014 were 30.5 and 31.5, respectively. The fresh water flux input lead to the high chlorophyll-a concentration in October due to it normally brought nutrients from terrestrial to water. The Chlorophyll-a concentration were high at the bottom layer through all study period. The study area was located close to the shore. Therefore, it possible strongly effected from wave and tidal current, which lead to high Chlorophyll-a concentration at the bottom by nutrient re-suspension from the bottom sediment. In addition, it was found that water column was well mixed situation except in October 2014 when weakly water stratification was observed which average salinity in surface, middle and bottom were 29.3, 31.7 and 33.7, respectively.

Table 1. Physiochemical properties of sea water in all periods

Parameter (n=24)	Layer	Beginning	Middle	Ending	After-ending
Temperature (^oC)	Surface	29.60±0.23	27.40±0.19	31.49±0.16	30.23±0.32
	Mid	29.16±0.12	27.31±0.10	31.45±0.11	30.32±0.09
	Bottom	29.04±0.08	27.31±0.09	31.43±0.11	30.01±0.13
Salinity (PSU)	Surface	30.16±0.11	34.01±0.05	34.16±0.07	29.32±0.27
	Mid	30.47±0.23	34.00±0.06	34.16±0.09	31.66±1.08
	Bottom	30.75±0.10	34.00±0.08	34.15±0.08	33.74±0.18
Dissolved oxygen (mg L^{-1})	Surface	6.55±0.15	7.27±0.34	6.68±0.15	no data
	Mid	6.44±0.10	6.95±0.10	6.26±0.06	no data
	Bottom	6.30±0.42	6.91±0.11	6.16±0.05	no data
pH	Surface	8.15±0.03	8.04±0.09	8.17±0.05	8.23±0.09
	Mid	8.15±0.03	8.25±0.01	8.20±0.04	8.30±0.05
	Bottom	8.15±0.03	8.26±0.01	8.22±0.04	8.27±0.05
Chlorophyll-a (ug L^{-i})	Surface	0.490±0.162	0.264±0.076	0.351±0.073	0.435±0.113
	Mid	0.474±0.119	0.242±0.084	0.431±0.134	0.756±0.358
	Bottom	0.888±0.268	0.307±0.111	0.465±0.137	0.981±0.169

Sediment grain size

Standard grain size terms of sedimentary particles using in the present study were ; clay and silt (<0.063mm), very fine sand (0.063-0.125mm), fine and medium sand (0.125-0.5mm), coarse sand (0.5-1.0mm), very coarse sand (1.0-2.0mm), gravel (>2.0mm)

The results of analysis of grain-size distribution are shown in **Figure 2.** The grain size deposited in the survey area consisted of 0.1 to 3.2% clay and silt, 0.3-17.5% very fine sand, 25.5-74.3% fine and medium sand, 8.1-30.8% coarse sand, 3.9-23.4% very coarse sand and 0.2-8% gravel. Fine and medium sand fractions were predominant, the component of clay and silt making up a small amount in the study area.

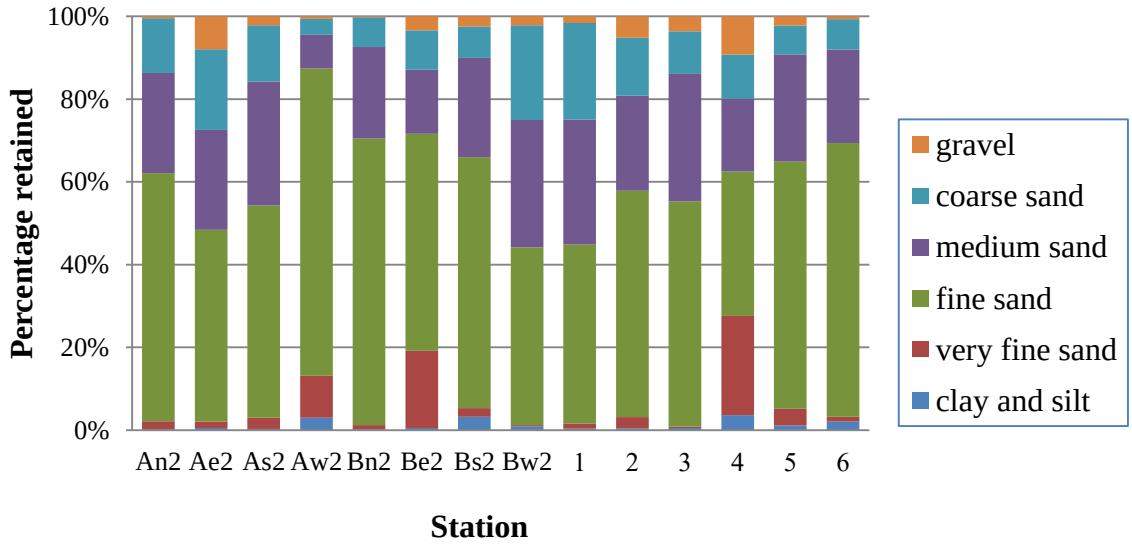

Figure 2. Percentage of grain size composition of surface sediments in each station retained by type of sediment fractions

Total acid volatile sulfides (AVS)

Sulfides have been used as possible indicators of toxicity in sediment. Sulfide in various forms occurred in the sediment had caused by biological and chemical process. AVS is a sediment parameter that is operational defined as sulfide accumulated in the sediment.

The results showed that the average amount of sulfides accumulated in the sediments collected from set-net operation area were 0.0007±0.0008, 0.0016±0.0024, 0.0034±0.0034 and 0.0040±0.0059 mg/g dry (set-net A) and 0.0016±0.0024, 0.0036±0.0031, 0.0022±0.0019 and 0.0028±0.0050 mg/g dry (set-net B) in the beginning, middle ending and after ending period, respectively. While the average amount of sulfides accumulated in the sediments collected from reference area were 0.0014±0.0018, 0.0044±0.0066, 0.0080±0.0140 and 0.0106±0.0130 mg/g dry in the beginning, middle ending and after ending period, respectively (Fig. 3). The average hydrogen sulfide contents in sediment of set-net area A and set-net B were mostly not higher than the reference area through study period. Additionally, It was also found that sulfide in the set-net A area increased with set-net operations but the differences were small amount compared with SD and sulfide in the set-net B area was quite fluctuated in which the maximum did not find during ending period.

The results of paired t-test, within set-net A, set-net B and reference area from four periods showed that they were non significantly different of sulfide in each period (p>0.05) and also with the results from Two Factor ANOVA showed that there were non significantly different of sulfide between set-net area and reference area (p>0.05). Therefore, it could be concluded that there was no relationship between amount of sulfide and set-net operation. In the other words, set-net may not cause the accumulation of sulfide in sediment at Mae Rumphueng beach, Rayong Province, Thailand.

The average amount of AVS in the study area combining set-net A, set-net B and the reference area in the beginning (0.0011±0.0018 mg/g dry), middle (0.0026±0.0029 mg/g dry) ending (0.0028±0.0028 mg/g dry) and after-ending (0.0053±0.0117) periods were lower than the other reports [Salaenoi, 2015] and much lower than the criteria value for critical farm [2.5 mg/g dry proposed by Yokoyama, 2003]. The characteristics of sediment corresponded to the accumulation of hydrogen sulfide which sand had less ability to absorb hydrogen sulfide than clay and silt. The less amount of sulfide content in these study area may be due to the sediment character which was predominant by fine and medium sand.

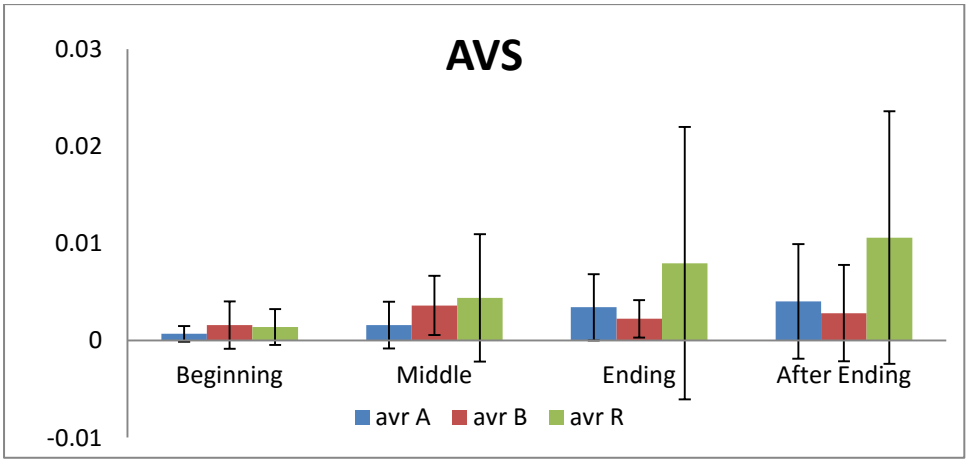

Figure 3. The average concentrations of Total Acid Volatile Sulfide (AVS) with standard deviation from set-net A, set-net B and reference area

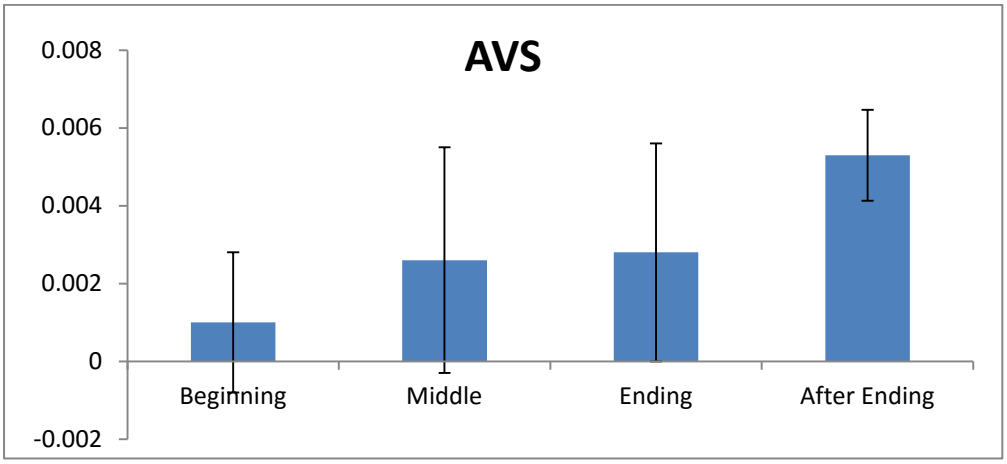

Figure 4. The average amount of Total Acid Volatile Sulfide (AVS) with standard deviation from every station in four periods

Benthic marco-fauna

Two thousand and four specimen belonging to 6 phyla 11 classes from 14 stations were sampled that including Nematoda, Annelida (Polycheta), Mollusca (Gastropoda and Bivalvia), Arthropoda (Ostracoda, Copepoda and Malacostraca), Echinodermata (Ophiuroidea, Echinoidea and Holothuroidea) and Chordata. The major group of benthic macro-fauna was Polychaeta which average percentage composition through study period was 33.36% followed by Malacostraca (23.00%) and Bivalvia (18.23%). Polychaeta and Malacostrace were the most frequent group occurring in all 14 stations, while other groups were found only in some stations (Fig 5).

Benthic macro-fauna density was seasonal with highly in April and low in October. The average density and average density ration of benthic macro-fauna around set-net A, set-net B and reference area are shown in table 2. It was found that range of average density ration of set-net A/reference area and set-net B/reference area was 0.81-1.03 in beginning and after-ending period and higher than 1.37 and 1.39 in middle and ending period, respectively.

The results from pair t-test showed that density of benthic macro-fauna during middle and ending periods in set-net area were significantly higher than those in other areas; whereas those during beginning period and after-ending were not significantly different at 95 confident interval. These results indicated that set-net operation had an influence in the increase of benthic macro-fauna density during the operation season, which was recovered to the initial condition after removal of gear construction.

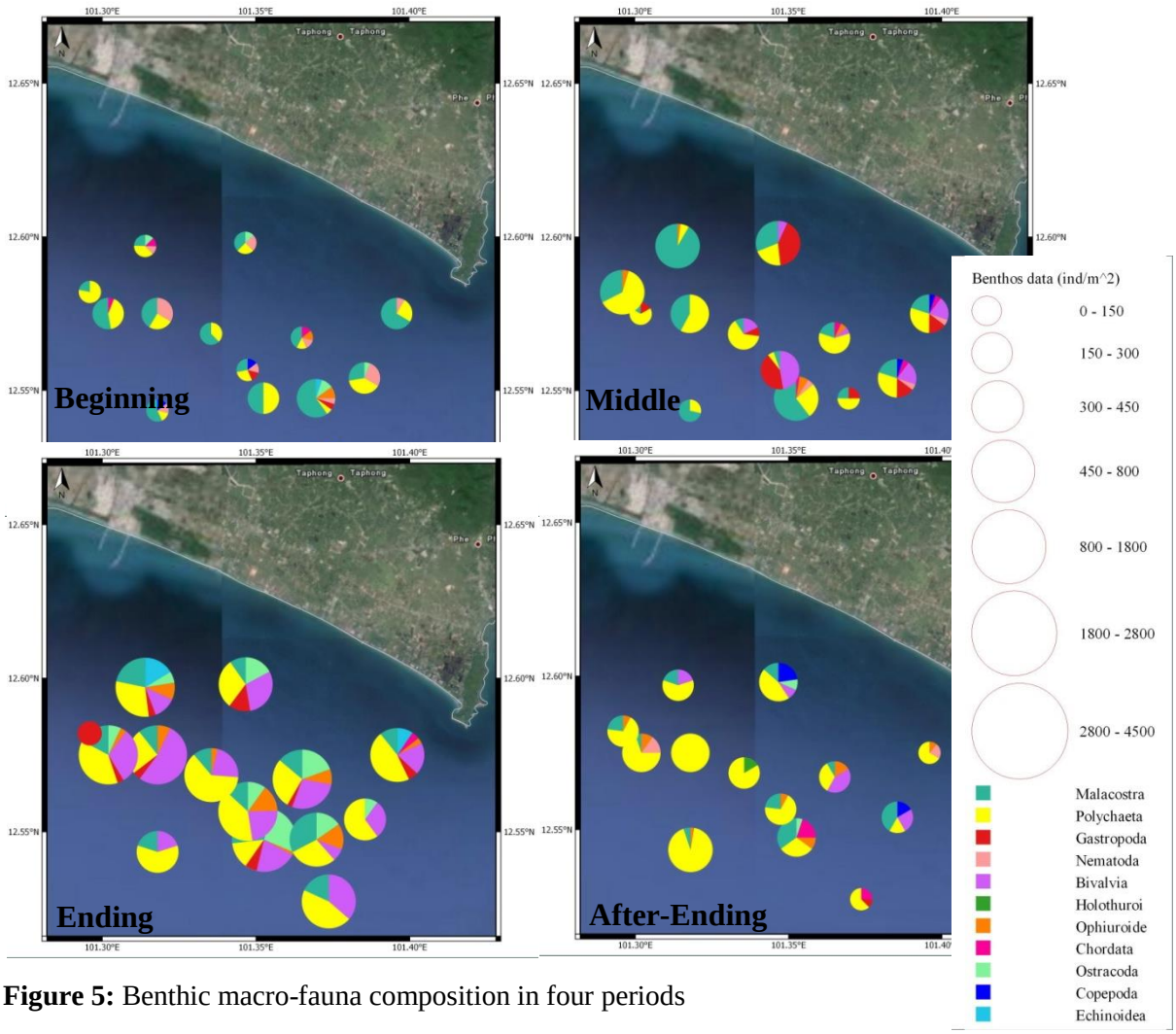

Figure 5: Benthic macro-fauna composition in four periods

Table. Average density and average density ration of benthic macro-fauna of benthic macro-fauna in set-net A, set-net B and the reference area

		Beginning	Middle	Ending	After-ending
Average density (ind/m^2)	Set-net A	192	513	1500	263
	Set-net B	183	354	2442	225
	Reference area	186	258	1083	278
Average density ration	Set-net A/Ref.	1.03	1.99	1.39	0.95
	Set-net B/Ref.	0.98	1.37	2.25	0.81

IV. Conclusion

1) Set-net is one type of friendly fishing gear in term of environmental impact.

2) There is no relationship between amount of sulfide and set-net operation. In the other words, set-net may not cause the accumulation of sulfide in sediment at Mae Rumphueng beach, Rayong Province, Thailand.

3) Set-net operation had an influence in the increasing of benthic macro-fauna abundance during the operation season, which was recovered to the initial condition after removal of gear construction.

V. Acknowledgement

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