CATCH RATE AND CATCH COMPOSITION OF FISH TRAWL BASED IN SIBOLGA, NORTH SUMATERA

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ABSTRACT

To obtain data and information of fish trawl fishery performance operated in the Indian Ocean, a research was carried out through observation on board by observers as well as port sampling in Sibolga Fishing Port by enumerators in September 2007, with the aimed to study the performance fish trawl fishery. These include fleet structure, trawl net design and construction, catch, fishing trip, fishing ground, and fishing operation. Results of research showed that there were 71 registered fish trawlers in Sibolga Fishing Port and only 25 boats active due to increasing of fuel price. The fleet structure of fish trawler consist of boat with size 31-114 GT which can be classified into 3 categories i.e. small (<60 GT), medium (60-150 GT), and large fish trawler (>150 GT). Design and construction of fish trawl net indicated that fish trawl net operates in the Indian Ocean was high opening trawl with head and ground rope of 27.8-41.5 m and 29,7-45.8 m, respectively. Fishing trip generally 10-12 days with effective days 7-9 days per trip and the number of net setting was 5-6 times each day. The fishing grounds of fish trawl based in Sibolga were the coastal waters area with maximum depth of 91 m. At least 40 species of fishes and shrimps identified during research and dominant fish species was ponyfish (*Leiognathus* spp.) threadfin bream (*Nemipterus* spp.), tall fin goatfish (*Upeneus* spp.), sea catfish (*Arius* sp.) as well as yellow striped goatfish (*Upeneus vitattus*). The average of catch of fish trawler fleet in the year of 2007 was 249.3 kg/haul and that number seems smaller than average of catch/haul previous years. This situation indicates that decreasing of catch per haul of fish trawlers based in Sibolga continues occurring and in other hand price of fuel raises significantly so that big fish trawlers size 150 GT with engine power more than 600 HP are not able to continue their fishing operation.

KEYWORDS: **fish trawl, fishery, Sibolga**

INTRODUCTION

Fish trawl was one of very productive fishing gear operates in Indonesian *Exclusive Economic Zone* including Indian Ocean. The operation of fish trawl has been regulated through Decree of Ministry of Agriculture 770/Kpts./IK.120/10/1996 on the Use of fishnet in the Indonesian *Exclusive Economic Zone* of West Sumatera and Aceh waters and being updated by Minister of Marine Affairs and Fisheries Regulation Nomor: 11/Men/2009 on the use of fishnet in the Indonesian *Exclusive Economic Zone*. Trawlers fishing allowed operating in the Indonesian *Exclusive Economic Zone* waters of the Indian Ocean especially west of Sumatera, the waters around Aceh Province in the coordinates of 4°N-96°E.

According to the Decree of the Minister of Agriculture 770/Kpts./IK.120/10/1996 and Minister of Marine Affairs and Fisheries Regulation Nomor: 11/Men./2009, fish trawl was allocated to fish in the mid waters layer (bathy pelagic). The Ministerial Regulation also defined that fish trawl as fishing nets equipped with a pair of otter board to open the net mouth. Widodo (2008) indicated that fish trawl classified into the group of bottom trawl net because the technical character is exactly similar with bottom trawls.

Decreasing of catch year by year is a serious issue facing by fish trawling fleet in Sibolga currently. According to Muharam (2006) that catch average of fish trawlers in the year of 2005 was 357 kg/haul and in 2006 was 287 kg/haul. In other hand the price of fuel is increasing significantly so that large fish trawler with engine power >600 HP has no longer to operate. The research is aimed to study of some aspects of the fish trawl fishery including fleet structure, design and construction of fish trawl, fishing operation, and fish catch.

MATERIALS AND METHODS

The primary data consist of fleet structure, trawl design and construction, fishing strategy, and the catch is collected in September 2007. Fleet structures data obtained from Sibolga Nusantara Fishing Port whilst design and construction of fish trawl net obtained through an observation and measurement of some boats sample which is taken randomly. Fishing

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strategy data includes fishing ground, fishing time, net towing duration, and the number of catch per haul were collected through onboard observation by three trained observers in the three fish trawlers. Three fish trawlers were randomly selected i.e. KM. Alam Jaya (55 GT), KM. Harapan Makmur (83 GT), and KM. Istana Samudera Indonesia (114 GT). Species composition and size of catch obtained through sampling of fish trawlers unloading in the private fishing port called as *tangkahan*. Sampling activities are carried out by three enumerators.

Sampling activities is proceed when the vessels unloading their catch. The sample taken from each vessel was 3 baskets which the volume of each basket was around 40-50 kg. Moreover, samples are sorted by species. The species identification is referred to Compagno (1999); Cressey & Waples (1984); Sainsbury, Kailola, & Leyland (1985); Sommer, Schneider, & Poutiers (1996). Finally, data analyzed by using descriptive method and presented as tables and graphics.

RESULTS AND DISCUSSION

Result

a. Fleet

The fish trawl fleet based in Sibolga was wooden boat with the size 31-130 GT and powered by diesel engine 280-1,200 HP. The number of registered fish trawler in Sibolga Nusantara Fishing Port is 71 boats and the active boat about 25 fleet, structure showed in Table 1 (Appendix 1) and Figure 1. Result of analysis showed that the active of fish trawlers fleet dominated by boats of 51-100 GT with engine power of 350-600 HP.

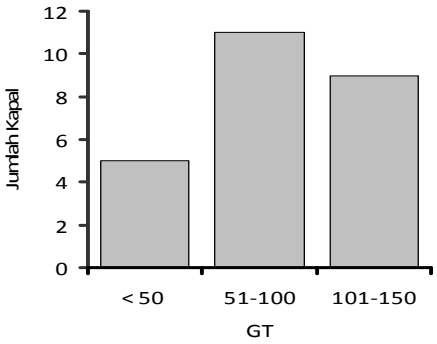

Figure 1. Fleet structure of active fish trawler operating in Indian Ocean year of 2007.

b. Fishing Gear

It has been explained that fish trawl actually the bottom trawl targeting the demersal fish. The main part (section) of fish trawl net consists of wing net, body net, and codend. Design and construction of fish trawl net is obtained from observation and measurement to a sample of KM. Alam Jaya (55 GT). The result of observation showed that fish trawl net has a head rope 30.0 m and ground rope 33.0 m. Mesh size of wing net around 240-480 mm, body of net around 30-180 mm and codend was 20 mm. Net materials was polyamide with yarn diameter varies for each part (section). Yarn diameter on wing part is 3-4 mm, body part 2-3 mm, and codend 2 mm (Figure 2). Fish trawl equipped with a pair of otter boat sized 170x120 cm. Along the head rope attached 62 reinforced plastic floats diameter 20 cm and 196 cylindrical rubber bobbin combined wit steel chain diameter 13 mm along ground rope as sinker. The size of each bobbin was 12 cm in diameter and 18 cm in length. Results of head and ground rope measurement of the fish trawl nets were 27.8-41.5 m and 29,7-45.8 m, respectively (Table 2 on Appendix 2).

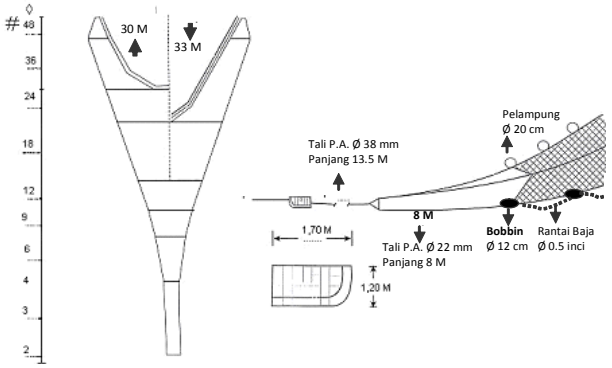

Figure 2. The design and construction of fish trawl net of KM. Alam Jaya (55 GT).

c. Fishing Operation

The number of crew of fish trawlers were generally 10-12 people whilest fishing trips were 10-12 days with 7-9 effective days and number of net setting was 5-6 times a day. The net setting was only occurred on the day i.e. during 4:00 am to 06:00 pm. During the night time, fish trawl do not operate to avoid conflict with purse seine fishers who engage fishing operations in the same fishing ground. Towing speed average was around 2-2.5 knots with average of towing duration was 2.04 hours. Catch usually preserved with ice, but there were some fish trawler equipped refrigeration machine that serve to maintain the ice not to melt. In

general, fishing ground is the coastal area between 30-100 m depth. The observers reported that there were 4 locations of fishing ground of 3 fish trawlers i.e. KM. Alam Jaya (55 GT), KM. Tunas Harapan (83 GT), and KM. Istana Samudera Indonesia (114 GT) as shown in Figure 3. Based on Figure 3 it can be explained that KM. Alam Jaya operates in the coastal around of Sinabang Islands (FG-1) and along of coastal between Sibolga and Meulaboh (FG-2). KM. Tunas Harapan operates in the coastal west of Sinabang Islands (FG-4), while the KM. Istana Samudera Indonesia operates in the fishing ground coded FG-3 or coastal of Meulaboh. The fishing grounds of fish trawl based in Sibolga were a coastal waters area with maximum depth of 91 m.

Figure 3. Fishing grounds of KM. Alam Jaya, KM. Tunas Harapan, and KM. Istana Samudera Indonesia in September 2007.

d. Catch

1. Catch per hauling

Result of onboard observation showed that average of catch of MV. Alam Jaya from the fishing ground FG-1 and FG-2 were 206.46 kg/haul, MV. Tunas Harapan in the F.G-4 was 240.4 kg/haul and MV. Istana Samudera Indonesia was 301.10 kg/haul (Appendix 3, 4, and 5). The average of catch of each fish trawler in the year of 2007 was 206.5, 240.4, and 301.1 kg/haul or 249.3 kg/haul in average (Tabel 1).

As mentioned previously that the catch rate average of fish trawls 2005 and 2006 were 357, kg/haul 287 kg/haul respectively. Seeing the results of research in 2007, so that the of fish trawl catch rate average is steadily declining.

2. Species composition

Identification of sample caught by KM. Tunas Harapan and KM. Istana Samudera Indonesia indicate that at least there were 36 species of fish and 4 shrimp caught in the Indian Ocean (Table 2). From the 36 species, splendid pony fish (*Leiognathus spenden*) was the highest percentage i.e. 10.81% of total catch. Other species in large number were threadfin bream (*Nemipterus japonicus*) 9.82%, tall fin goatfish (*Upeneus indicus*) 8.32%, spotted catfish (*Arius maculatus*) 6.81%, as well as yellow striped goatfish (*Upeneus vitattus*) 6.76%. However, the highest percentage of the catch i.e. 12.3% was trash fish or by local fishers called as *ikan pasifik*. This thrash fish usually used as a raw material of fish meal.

Table 1. Catch per haul of fish trawler in the year of 2007

Parameters	Fish trawler			Average
	MV. Alam Jaya	MV. Tunas Harapan	MV. Istana S.Indonesia	
Number of haul	29	26	22	25.7
Minimum catch/haul (kg)	177	151.7	200.4	176.4
Maximum catch/haul (kg/haul)	251.5	371.5	470	364.3
Average catch (kg)	206.5	240.4	301.1	249.3
Standard deviation	18	52.1	66.7	45.6
Coefficient of variant (CV)	8.7	21.7	22.1	17.5

Table 2. Species composition and the percentage of catch of fish trawl base in Sibolga in the year of 2007

No.	English name	Indonesian name	Scientific name	Species compsition			
				Catch of MV. ISI (kg)	Catch of MV. TH (kg)	Total (kg)	%
I.	**Fish**	**Ikan**					
1.	Strawberry grouper	Kerapu merah	*Cephalopholis analis*	48	12	60	0.31
2.	Threadfin bream	Kurisi	*Nemipterus japonicus*	850	1,040	1,890	9.82
3.	Red snapper	Kakap merah	*Lutjanus* sp.	360	60	420	2.18
4.	Spotted catfish	Manyung	*Arius maculatus*	820	490	1,310	6.81
5.	Giant cat fish	Manyung	*Arius thalassinus*	340	270	610	3.17
6.	Great barracuda	Alu-alu	*Sphyraena barracuda*	500	430	930	4.83
7.	Pickhandle barracuda	Alu-alu	*Sphyraena jello* (Cuvier,1829)	320	210	530	2.75
8.	Chub mackerel	Banyar	*Rastrelliger kanagurta*	400	140	540	2.81
9.	Spendid ponyfish	Petek	*Leiognathus splenden*	1,100	980	2,080	10.81
10.	Razor trevally	Eteman	*Mene maculata*	80	0	80	0.42
11.	Emperor	Lencam	*Lethrinus elongata*	31	20	51	0.27
12.	Tall-fin goatfish	Kuniran	*Upeneus indicus*	870	730	1,600	8.32
13.	Hairtail	Layur	*Trichiurus* spp.	218	120	338	1.76
14.	Golden rabbit fish	Baronang	*Siganus guttatus*	70	37	107	0.56
15.	Pearly spinefoot	Baronang	*Siganus canaliculatus*	125	20	145	0.75
16.	Batfish	Kambing-kambing	*Aluterus* sp.	55	15	70	0.36
17.	Big eye	Swanggi	*Priacanthus* spp.	168	80	248	1.29
18.	Bluefin trevally	Kue	*Caranx melampygus*	45	22	67	0.35
19.	Silver grunt	Tigawaja	*Pomadasys* sp.	130	230	360	1.87
20.	Hammer head shark	Cucut martil	*Sphyrna lewini*	35	82	117	0.61
21.	Silky shark	Cucut layaman	*Charcarinus falciformis*	71	0	71	0.37
22.	Big jawed jumber	Kapasan	*Lactarius lactarius*	640	300	940	4.89
23.	Greater lizard fish	Bloso	*Saurida tumbil*	470	260	730	3.79
24.	Indopacific mackerel	Kembung	*Rastrelliger brachysoma*	600	155	755	3.92
25.	Largescaled terapon	Kerong-kerong	*Terapon theraps*	460	290	750	3.90
26.	Yellow striped goatfish	Bijinangka	*Upeneus vitatus*	790	510	1,300	6.76
27.	Redbelly yellowtail fusilier	Ekor kuning	*Caesio cuning* (Bloch,1791)	270	190	460	2.39
28.	White ppmfret	Bawal	*Pampus argenteus*	15	24	39	0.20
29.	Black pomfret	Bawal hitam	*Formio niger*	26	11	37	0.19
30.	Mullet	Belanak	*Mugil cephalus*	3	0	3	0.02
31.	Blotched javelin fish	Gerot-gerot	*Pomadasys maculatus*	49	38	87	0.45
32.	Indian spiny turbot	Ikan sebelah	*Psettodes erumi*	23	0	23	0.12
33.	Flatfish/halibut	Ikan lidah	*Pseudorombus* spp.	16	0	16	0.08
34.	Solefish	Ikan lidah	*Cynoglossus* spp.	12	0	12	0.06
35.	Spotted sicklefish	Ketang-ketang	*Drepane* spp.	68	15	83	0.43
36.	Grouper	Kerapu sunu	*Ephinepelus* sp.	0	23	23	0.12
II.	**Shrimp**	**Udang**					
1.	Tiger prawn	Udang windu	*Penaeus semisulcatus*	8	0	8	0.04
2.	Banana shrimp	Udang putih	*Penaeus indicus*	13	4	17	0.09
3.	Flathead lobster	Udang kipas	*Thenus orientalis*	7	2	9	0.05
4.	Endeavour shrimp	Udang krosok	*Metapenaeus endeavouri*	16	6	22	0.11
III.	**Other**	**Lainnya**					
1.	Trash fish	Ikan rucah	Thrashfish	1,400	900	2,300	11.96
	Total			**11,522**	**7,716**	**19,238**	**100**

Remarks: KM. ISI = KM. Istana Samudera Indonesia; KM. TH = KM. Tunas Harapan

DISCUSSION

Result of this research showed that fish trawl fleet structure is began from smallest to the biggest i.e. 31-144 GT. Based on the range of gross tonnage, the fish trawl gears can be grouped into 3 categorizes i.e. small (<60 GT), medium (60-150 GT), and large (>150 GT). In this case the small vessel represented by KM. Alam Jaya (55 GT), medium vessel represented by KM. Tunas Harapan (83 GT) and KM. Istana Samudera Indonesia (114 GT). None large category fish trawler represented to be observed in the research because there is no large fish trawler is still active.

Large fish trawler with engine power >600 HP has no longer operates since the increase of fuel price. The fishing industry is highly dependent on the fuel energy propulsion of the fishing boats and operation of the fishing gear, the recent situation in the high price of fuel price has created problem to fisheries both in developed and developing countries including Indonesia because the increased operation cost usually do not follow by increased fish price.

Fuel consumption of fish trawlers with the engine power d”600 HP is relatively low. The estimation of fuel consumption of boat with engine 600 HP was 110-130 L/hour (Personal Communication with Chief Engine of KM. Harapan Makmur, 2007). The average of fuel consumption of KM. Harapan Makmur is 117 L/hour. He informed also that the total cost for purchasing of fuel reach 65-68% of the total fishing operations cost. From the aspect of a fishing business, fish trawler powered by engine less than d”600 HP is still profitable.

Fish trawl designed in such a way to have a high vertical mouth opening (high opening mouth). This design eventually impacted to the small pelagic fish caught. The results of this research noted that the number of small pelagic fish caught was 17.7%. As a result, it creates a confusion to many people deemed that fish trawl is mid water trawl but actually bottom trawl. The size of head rope is 5-10% shorter than the length of its ground rope, whereas one of characteristic of mid water trawl is the size of head rope must longer than its ground rope.

The differences of catch between the three fish trawlers i.e. KM. Alam Jaya, KM. Tunas Harapan, and KM. Istana Samudera Indonesia were 206.46, 240.4, and 301.10 kg/haul, respectively due to different of fishing ground, lengths of head rope, and duration of towing time. However, the stock abundance of fish in each of fishing ground mentioned above still unknown. If the abundance of fish stock in each fishing ground can be assumed equally, then the differences in length of head rope is an important factor of differences in catch per haul of each fish trawler. Results of previous studies showed that the average catch per haul fish trawlers in 2005 was 357.1 kg/haul and in 2006 was 286.9 kg/haul (Muharam, 2006). The average of catch per haul of three fish trawlers above is 249.3 kg/haul. This result of research indicates that the decline in fish catch trawling still occurs.

CONCLUSION

The fishing industry including fish trawl is highly dependent on the fuel energy, large fish trawler with engine power >600 HP in Sibolga has no longer operates since the increase of fuel price. The average of catch of fish trawler fleet in the year of 2007 is 249.3 kg/haul and that number seems smaller than average of catch/haul previous years. At least 40 species of fishes and shrimps identified during research and dominant fish species is ponyfish (*Leiognathus spenden*) threadfin bream (*Nemipterus japonicus*), tall fin goatfish (*Upeneus indicus*), sea catfish (*Arius* sp.) as well as yellow striped goatfish (*Upeneus vitattus*).

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REFERNCES

Cressey, R. F. & R. S. Waples. 1984. *Synodontidae*. *In* W. Fischer & G. Bianchi (eds.) Food and Agriculture Organization Species Identification Sheets for Fishery Purposes. Western Indian Ocean (Fishing Area 51). Volume 4. Food and Agriculture Organization. Rome.

Compagno, L. J. V. 1999. *The Living Marine Resource of the Western Central Pacific*. Food and Agriculture Organization. Rome. 3: 1,398-1,529.

Muharam, D. 2006. Studi kelayakan usaha pukat ikan dilihat dari aspek teknis dan aspek finansial pada KM. Harapan Makmur, Sibolga. *Karya Ilmiah Praktek Akhir*. Sekolah Tinggi Perikanan. Jakarta (Unpublished).

Sainsbury, K. J., P. J. Kailola, & G. G. Leyland. 1985. *Continental Shelf Fishes of Nothern and North Western Australia*. CSIRO Division of Fisheries Research-Canbera-Autralia. 375 pp.

Sommer, C., W. Schneider, & J. M. Poutiers. 1996. Food and Agriculture Organization species identification field guide for fishery purposes. *The Living Marine Resources of Somalia*. Food and Agriculture Organization. Rome. 376 pp.

Widodo, A. A. 2008. Teknologi *trawl* yang beroperasi di Laut Arafura dan sekitarnya. Sumber Daya, Pemanfaatan, dan Opsi Pengelolaan Perikanan di Laut Arafura. *BIODINEX 2 Laut Arafura (Buku Bunga Rampai)*. Balai Riset Perikanan Laut. Pusat Riset Perikanan Tangkap. Badan Riset Kelautan dan Perikanan. 21-33.

Appendix Table 1. The list of active fish trawlers based in Sibolga operating in Indian Ocean in the year of 2007

No.	Boat name	Gross tonnage (GT)	Engine power (HP)
1.	KM. Agung Samudera Nauli	111	700
2.	KM. Elina	40	370
3.	KM. Harapan Makmur	83	600
4.	KM. Harapan Makmur I	80	600
5.	KM. Hasil Karya Sukses I	101	600
6.	KM. Hasil Karya Sukses II	103	600
7.	KM. Hasil Karya Sukses III	104	600
8.	KM. Hasil Karya Sukses Indah I	100	600
9.	KM. Hasil Karya Sukses Indah II	103	600
10.	KM. Jala Jaya I	120	600
11.	KM. Jimmy 02	35	350
12.	KM. Jimmy 03	60	350
13.	KM. Karya Budi Nelayan VI	31	350
14.	KM. Naga Mas Baru	85	350
15.	KM. Nusantara	69	350
16.	KM. Samudera Era Mas Abadi XII	35	280
17.	KM. Sumber Cipta	128	600
18.	KM. Sumber Maju	90	350
19.	KM. Sumber Rezeki Bersama 03	37	350
20.	KM. Tapian Nauli	70	300
21.	KM. Tunas Rezeki	74	350
22.	KM. Tunas Harapan	83	700
23.	KM. Alam Jaya	55	350
24.	KM. Istana Samudera Indonesia	114	600
25.	KM. Angkasa Surya Agung	90	350
Average		**80.04**	**474.0**
Standard deviation (SD)		**28.81**	**143.4**
Coefficient of variance (CV)		**36%**	**30%**

Appendix Table 2. Length of head and ground ropes of 25 active fish trawl nets vessel operating in Indian Ocean and base in Sibolga in the year of 2007

No.	Boat name	Gross tonnage (GT)	Lenght of ropes (m)	
			Head rope	Ground rope
1.	KM. Agung Samudera Nauli	111	39.6	42.5
2.	KM. Elina	40	27.8	29.7
3.	KM. Harapan Makmur	83	34.4	36.5
4.	KM. Harapan Makmur I	80	37.1	39.4
5.	KM. Hasil Karya Sukses I	101	39.2	42.3
6.	KM. Hasil Karya Sukses II	103	39.9	43.1
7.	KM. Hasil Karya Sukses III	104	38.0	40.2
8.	KM. Hasil Karya Sukses Indah I	100	37.6	39.7
9.	KM. Hasil Karya Sukses Indah II	103	38.1	41.6
10.	KM. Jala Jaya I	120	40.0	42.9
11.	KM. Jimmy 02	35	31.8	33.9
12.	KM. Jimmy 03	60	32.1	34.2
13.	KM. Karya Budi Nelayan VI	31	26.2	28.3
14.	KM. Naga Mas Baru	85	36.1	38.3
15.	KM. Nusantara	69	33.2	35.4
16.	KM. Samudera Era Mas Abadi XII	35	32.4	34.7
17.	KM. Sumber Cipta	128	41.5	44.8
18.	KM. Sumber Maju	90	37.0	39.1
19.	KM. Sumber Rezeki Bersama 03	37	32.8	34.2
20.	KM. Tapian Nauli	70	34.1	36.6
21.	KM. Tunas Rezeki	74	34.7	36.9
22.	KM. Tunas Harapan	83	35.2	37.6
23.	KM. Alam Jaya	55	30.4	33.0
24.	KM. Istana Samudera Indonesia	114	40.0	42.9
25.	KM. Angkasa Surya Agung	90	38.1	40.3
Average		**80.04**	**35.65**	**37.79**
Standard deviation (SD)		**28.81**	**4.25**	**4.47**
Coefficient of variance (CV)		**36%**	**12%**	**12%**

Appendix Table 3. Catch of KM. Alam Jaya in the fishing ground FG-1 and FG-2 in September 2007

No. Setting	Position (Lat-Lon)	Depth range (m)	Towing duration (minute)	Towing speed (knot)	Catch (kg)
1	2º05'N-97º25'E	43-61	101	2.8	209.0
2	2º06'N-97º28'E	66-68	120	3.0	223.0
3	2º08'N-97º26'E	32-54	115	2.9	194.0
4	2º11'N-97º24'E	41-62	120	3.0	199.9
5	2º12'N-97º24'E	43-48	120	3.1	187.8
6	2º10'N-97º29'E	36-44	130	3.0	183.0
7	2º13'N-97º28'E	51-53	110	2.9	208.7
8	2º13'N-97º27'E	66-68	120	3.1	178.0
9	2º12'N-97º21'E	42-47	120	3.0	197.0
10	2º10'N-97º24'E	38-41	130	2.9	251.5
11	2º11'N-97º21'E	55-57	120	3.0	204.7
12	2º13'N-97º20'E	51-54	130	3.0	233.8
13	2º15'N-97º19'E	62-67	120	3.1	194.0
14	2º14'N-97º18'E	39-44	120	3.0	210.7
15	2º16'N-97º14'E	30-33	110	3.0	206.8
16	2º19'N-97º15'E	62-69	130	3.0	204.0
17	2º17'N-97º18'E	64-68	130	3.1	197.6
18	2º21'N-97º19'E	46-51	120	2.9	201.3
19	2º18'N-97º21'E	33-38	130	3.0	202.0
20	2º19'N-97º22'E	45-48	130	2.9	232.0
21	2º19'N-97º22'E	61-63	120	3.0	228.5
22	2º17'N-97º27'E	44-46	120	3.0	221.0
23	2º17'N-97º27'E	53-60	130	2.9	198.0
24	2º15'N-97º26'E	61-63	130	3.0	225.8
25	2º15'N-97º30'E	32-45	130	3.0	222.4
26	2º11'N-97º30'E	66-69	120	3.1	177.0
27	2º10'N-97º29'E	27-36	120	3.0	178.0
28	2º11'N-97º31'E	45-47	120	2.8	208.8
29	2º12'N-97º31'E	56-59	130	2.7	209.0
Average		**38-69**	**122.28**	**2.97**	**206.46**
Standard deviation (SD)		**-**	**7.41**	**0.10**	**18.03**
Coefficient of variance (CV)		**-**	**6%**	**3%**	**9%**

Appendix Table 4. Catch of KM. Tunas Harapan in the fishing ground FG-4 in September 2007

No. Setting	Position (Lat-Lon)	Depth range (m)	Towing duration (minute)	Towing speed (knot)	Catch (kg)
1	2°30'N-96°01'E	45-48	110	2.9	183.5
2	2°25'N-96°02'E	55-59	100	3.0	282.8
3	2°24'E-96°01'N	29-37	120	3.0	210.0
4	2°30'N-96°03'E	41-62	130	3.0	371.5
5	2°29'N-96°04'E	43-48	110	3.0	287.9
6	2°27'N-96°01'E	36-44	115	2.9	151.7
7	2°27'N-96°02'E	51-53	125	2.8	181.4
8	2°30'N-96°02'E	66-68	110	3.0	195.0
9	2°31'N-96°01'E	42-47	120	2.9	221.0
10	2°32'N-96°01'E	38-41	130	2.9	204.4
11	2°33'N-96°01'E	51-54	120	3.0	367.8
12	2°30'N-96°01'E	62-67	110	3.1	243.8
13	2°31'N-96°01'E	39-44	130	2.9	200.6
14	2°30'N-96°00'E	30-33	110	3.0	217.6
15	2°33'N-96°01'E	32-45	125	2.9	226.3
16	2°28'N-96°09'E	55-57	120	2.9	251.8
17	2°27'N-96°04'E	67-71	110	3.0	223.0
18	2°28'N-96°09'E	41-62	120	3.0	258.5
19	2°29'N-96°07'E	43-48	120	3.0	199.0
20	3°34'N-96°50'E	36-44	120	2.9	226.5
21	2°26'N-96°10'E	51-53	115	3.0	291.5
22	2°28'N-96°08'E	44-46	120	3.0	273.0
23	2°26'N-96°09'E	53-60	120	2.9	214.8
24	2°29'N-96°08'E	61-63	110	3.0	242.1
25	2°30'N-96°05'E	32-45	110	2.9	283.2
26	2°21'N-96°06'E	54-56	120	2.3	241.3
Average		**32-71**	**117.31**	**2.93**	**240.38**
Standard deviation (SD)		**-**	**7.51**	**0.14**	**52.10**
Coefficient of variance (CV)		**-**	**6%**	**5%**	**22%**

Appendix Table 5. Catch of KM. Istana Samudera Indonesia in the fishing ground FG-3 in September 2007

No. Setting	Position (Lat-Lon)	Depth range (m)	Towing duration (minute)	Towing speed (knot)	Catch (kg)
1	3°41'N-96°50'E	41-53	100	3.1	470.0
2	3°44'N-96°45'E	50-57	110	3.0	244.2
3	3°32'E-96°44'N	71-75	125	3.2	264.9
4	3°38'N-96°46'E	67-89	120	3.2	278.7
5	3°32'N-96°50'E	80-88	110	3.0	371.4
6	3°28'N-96°36'E	37-44	120	3.0	296.0
7	3°25'N-96°53'E	87-91	120	2.9	292.6
8	3°30'N-96°58'E	45-48	120	3.1	302.0
9	3°30'N-96°58'E	57-63	110	2.7	394.0
10	3°27'N-97°01'E	66-74	130	3.0	200.4
11	3°31'N-96°55'E	71-83	120	3.0	367.4
12	3°40'N-96°53'E	53-61	110	3.3	226.0
13	3°32'N-96°50'E	71-73	120	3.0	268.4
14	3°34'N-96°52'E	67-72	125	3.1	273.5
15	3°33'N-96°50'E	36-47	120	3.0	202.9
16	3°34'N-96°49'E	51-59	100	3.0	328.0
17	3°31'N-96°50'E	84-87	120	3.1	335.3
18	3°32'N-96°49'E	71-76	125	3.0	377.5
19	3°32'N-96°49'E	80-93	120	3.0	311.6
20	3°34'N-96°50'E	77-82	130	3.0	219.5
21	3°35'N-96°51'E	53-77	130	2.9	301.3
22	3°33'N-96°52'E	41-62	120	3.0	299.1
Average		**36-91**	**118.41**	**3.03**	**301.12**
Standard deviation (SD)		**-**	**8.51**	**0.12**	**66.69**
Coefficient of variance (CV)		**-**	**7%**	**4%**	**22%**