Marine Resource Surveys by Drift Gill Net in the Bay of Bengal

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Abstract

This paper presented the first time survey of marine resources in the Bay of Bengal in terms of catch composition; Catch per unit effort (CPUE) and catch per unit area (CPUA) by drift gill net (DGN). The survey was conducted in eight stations of three sub-areas during October–December 2007 under the mission of BIMSTEC collaborative project. The fishery research vessel, M.V. SEAFDEC (cruise No. 75-1/2007) was deployed in the proposed survey. A total catch of 137.60 kg from 108 fishing hours composed of 15 fish species (99.60% by weight) and one piece of diamondback squid (Thysanoteuthidae: *Thysanoteuthis rhombus*) was captured (0.40% by weight). The highest catch species of marine resources was skipjack tuna, *Katsuwonus pelamis*, (42.96% by weight). The CPUE was ranged from 0.15 to 2.08 kg h^{-1} and gave the average of 1.22 kg h^{-1}. The CPUA was ranged from 1.297×10^{-4} to 1.651×10^{-3} kg m^{-2} of net area and gave the average of 8.809×10^{-4} kg m^{-2} of net area. Average catch was not shown significant different among the three survey areas. Skipjack tuna was also the most important economical species (66.72% IRI) and widely distributed in the survey area especially in area A. Silky shark (*Carcharhinus falciformis*), which was the second important (10.55% IRI), was distributed only in area C whereas frigate tuna (*Auxis thazard thazard*), which was the third important (7.47% IRI), was distributed only in area A.

Key words: catch composition, marine resources, drift gill net, Bay of Bengal, BIMSTEC

Introduction

Drift netting is a fishing technique where nets, called drift nets, are allowed to drift free in a sea or lake. Usually a drift net is a gill net with floats attached to a rope along the top of the net, and weights attached to another rope along the foot of the net. Drift net can range in length from 25 m to 2.5 miles. (http://en.wikipedia.org/wiki/Drift_net) The nomenclature of drift net or drift gill net depends on the target species. The common species are mackerel, flying fish, tuna and tuna-like, manta ray and other pelagic species. These fish species require different mesh and twin sizes as well as material to maximize catch. For mackerel, flying fish, sardines and other small pelagic species the nets are made of nylon monofilament of 0.20 mm

to 0.40 mm diameter with mesh size from 25 mm to 90 mm. For tuna species, the material is nylon multifilament PA 210/12 to 210/18 in the main webbing whole iron rings and/or thicker multifilament nettings (210/30 to210/36) are used as weights. The mesh size ranges from 50 mm to 90 mm. There are 10 to 20 meshes of thicker netting acting as weights in the lower portion of the webbing. (http://map.seafdec.org/Monograph project/gill_net_2.php)

Drift nets have been commonly used by many countries in the coastal waters. This type of net was heavily used by many Japanese, South Korean and Taiwanese fishing fleets on the high seas in the 1980s to target tunas. Generally, fish which are smaller than the meshes of the gill nets are able to pass through unhindered, while those which are too large to push their heads through the meshes as far as their gills are not retained. This gives a selectivity ogive which is skewed towards medium size fish, unlike active fishing gears such as trawl nets in which the proportion of fish entering the nets which are retained increases with length. Although highly selective with respect to size class of the fish captured, practically gill nets are blamed for the impact on non-target species particularly dolphins, turtles and seabirds. In 1993 gill nets were banned by the United Nations in international waters, although their use is still permitted within 200 nautical miles (400 km) of a coast. (http://en.wikipedia.org/wiki/Gillnet)

However, in international waters which generally cover deep water areas, there are only a few types of fishing gear suitable for harvesting fishery resources. The important fishing gears suitable for fishing in deep water areas are purse-seine, pelagic longline and drift gill net (DGN). For pelagic fish commonly distribute in the upper layer, drift gill nets are widely deployed to catch these fishes because of the simplicity in operating. Thus, DGN is chosen to be one of the 3 types of fishing gear, besides pelagic longline and automatic squid jigging, for the survey and study of marine fishery resources in the Bay of Bengal and being the rationale of the sub-project on Marine Resource Surveys by Drift Gill Net in the Bay of Bengal. This sub-project aims to assess the potential of marine fishery resources captured by DGN in terms of species and catch composition, catch per unit effort (CPUE) and stock abundance in term of index of relative importance (IRI). The result from this research will support a useful background for effective fishery resource management in the Bay of Bengal. Furthermore, it will improve capabilities in fish stock assessment of the biologists and researchers in the member countries as well as to develop the academic ability in training the staff of the Faculty of Fisheries, Kasetsart University and establish a good collaboration among member countries in research and academic activities.

Materials and Methods

Area of Fishing Operation

The study was carried out in the Bay of Bengal during 25 October to 21 December 2007. Three sub-areas were defined namely area A: latitude $16°$N-$19°$N and longitude $88°$E-$91°$E (5 stations); area B: latitude $9°$N-$14°$N and longitude $82°$E-$85°$E (5 stations); and area C: latitude $10°$N-$12°$N and longitude $95°$E -$97°$E (5 stations) (Fig. 1).

Fishing Gear

The fishery research vessel, M.V. SEAFDEC, of the Southeast Asian Fisheries Development Center (SEAFDEC) was used in this study. Field sampling was conducted using two types of net materials for drift gill net (DGN), monofilament and multifilament nylon twines. Total length of monofilament DGN was 2,200 m with 100 mm of mesh size and 93 meshes at depth. Multifilament DGN was 2,500 m with 160 mm of mesh size and 100 meshes

at depth. Net material composition was separated into 2 types: the first 75 meshes from the head rope was polyamide (PA) and 25 meshes left was Saran. On the head rope of both nets, a float line made by polyethylene (4.0 mm diameter) with a plastic float (350 mm length, 95 mm diameter) was attached at every 10 m interval to keep the net floating. The foot rope composed of polypropylene (PP) (10 mm diameter) combination with lead which also acted as a sinker for stretching the net vertically. Radio buoys, flag and light buoys were attached to the end of the head rope at both sides for marking the net location. The sketch diagrams of DGN were described in fig. 2.
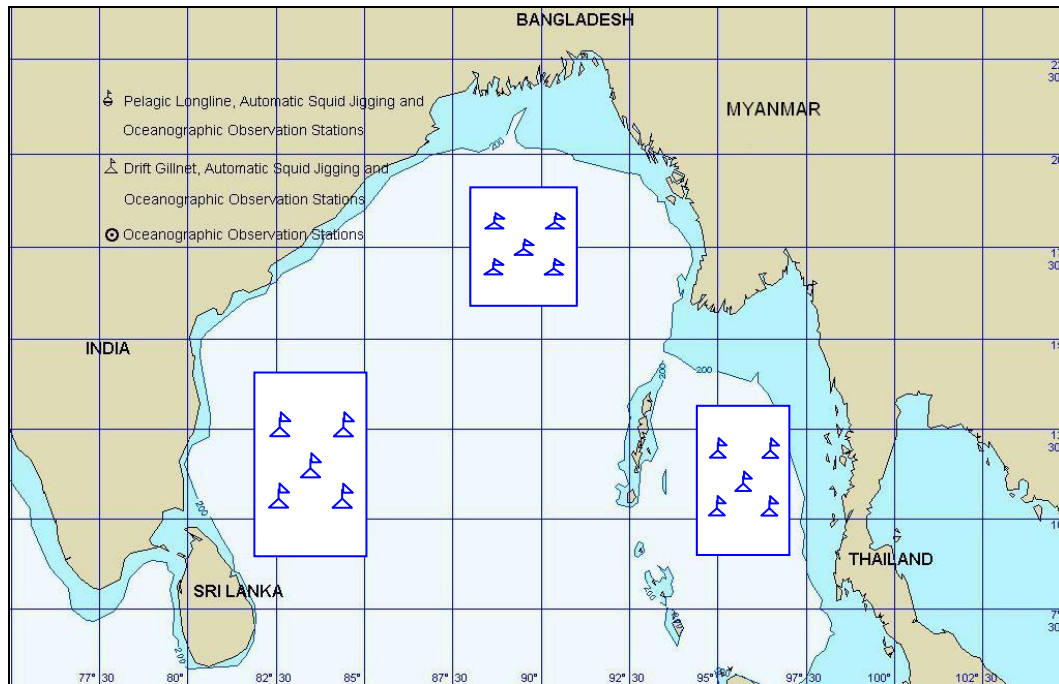

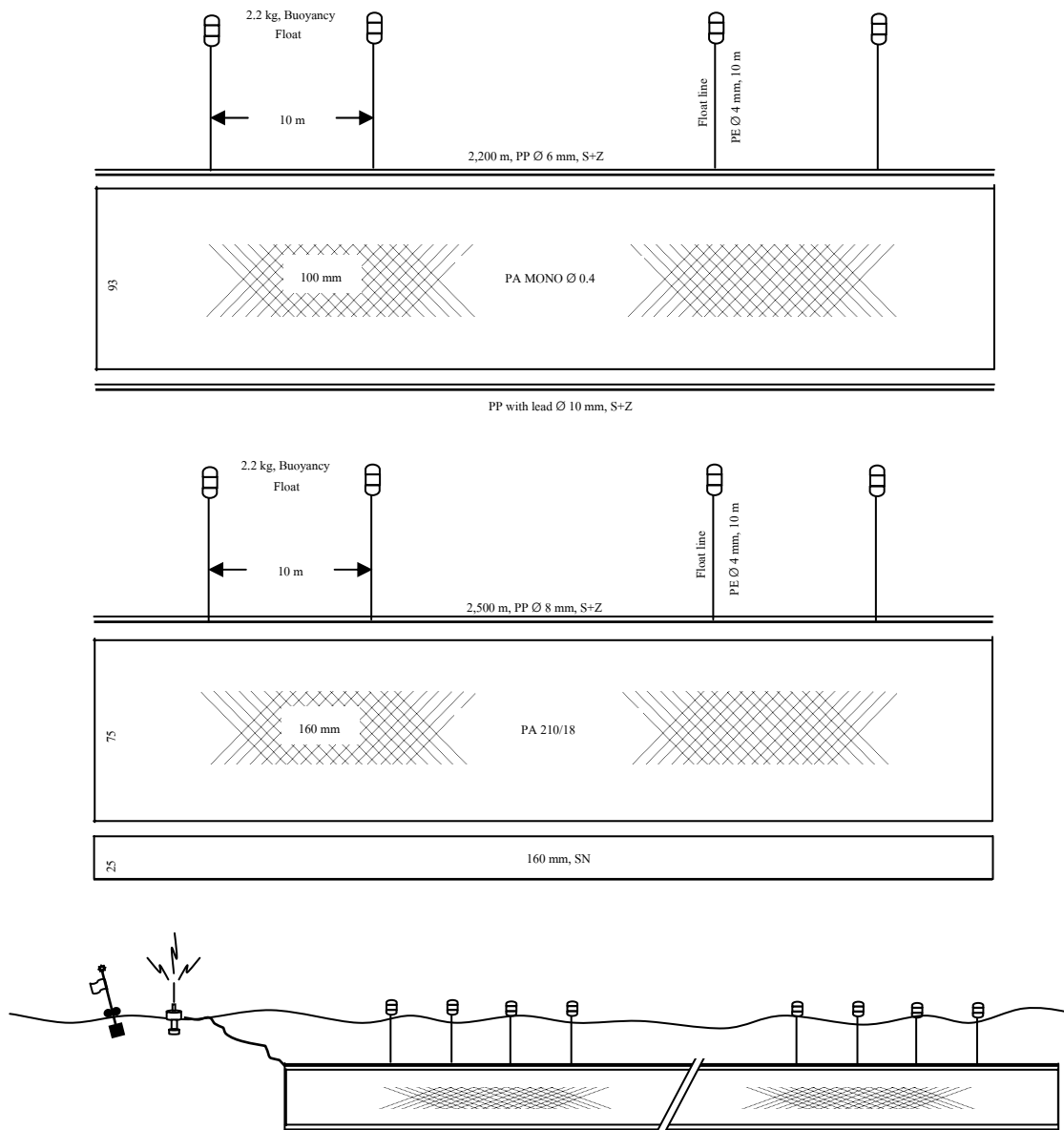**Figure 1** The assigned survey areas.

Figure 2 Drift gill net diagrams.

DGN was started shooting at the sun down and leaved overnight. The hauling was started in the next morning around 6.00 A.M. Depth of each sampling station and the immersion period were recorded.

Field Work and Data Collection

After marine resources were on board, identification was made at the species level. Overall fish size: total length (TL), fork length (FL), standard length (SL), head length (HL) and girth length (GL) were measured to the nearest 0.1 cm. and body weight (BW) was also recorded to the nearest 0.1 g. Primary sexual characters of the fishes were determined by dissecting. Testes were classified into two stages whereas ovaries were classified at least four stages of development. Ripening ovaries were collected in zip-log bags and deep frozen for further analyzed at laboratory. The data were recorded separately by sampling stations and areas.

Laboratory Study

Paired ovaries were carefully removed from zip-log bags, washed, cleaned with distilled water. Blotting paper was used to help the ovaries as dried as possible before weighting by electronic weighting machine to the nearest 0.01 g. Ovaries were fixed in 10% of buffered formaldehyde solution, shaken vigorously and stored in the dark at least fortnight. Then eggs were counted gravimetrically (Bagenal and Brown, 1978).

Data Analyses

1. Species and catch compositions:

Species composition was calculated in terms of percentages by weight and number. Catch per unit effort (CPUE) was calculated in term of weight per immersion period (kg h^{-1}). Catch per unit area (CPUA) was estimated in term of weight per net area (kg m^{-2}).

To avoid the zero-values in computing the mean and confidence limit of the mean, CPUE and CPUA were transformed applied from Emerson and Stoto (1983) as:

$$Y_i = \ln(x + \text{CPUE/CPUA})$$

Where x is a constant value that makes Y_i be positive.

One-way ANOVA was used for comparing the catches among three sub-areas.

2. Stock abundance and distribution:

The percentage of index of relative importance (% IRI; Green, 1979; Pinkas *et al.*, 1971) was applied to identify the importance of species in the community as:

$$\%IRI = \frac{(\%W_i + \%N_i)\%F_i}{\sum_{i=1}^{n}\{(\%W_i + \%N_i)\%F_i\}} \times 100$$

Where %W, %N were percentages in weight and percentage in number of the ith species, and %F was percentage in frequencies of occurrence of each species.

3. Fecundity:

Absolute fecundity was estimated on the basis of total weight of ovaries. The fecundity was obtained using the following ratio (Le Cren, 1951).

$$F = \frac{\text{No. of samples eggs} \times \text{Gonad weight}}{\text{Sample weight}} ;$$

and gonadosomatic index (GSI) was estimated from the formula:

$$GSI = \frac{\text{Weight of ovary}}{\text{Fish body weight}} \times 100$$

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Results and Discussion

At the first 15 stations, five stations per sub-areas, were assigned to operate by DGN. During the survey, the cyclone disaster 'Sidr' affected to the sea condition so rough that the survey stations hade been skipped out for safety. Practically DGN could only be operated in eight sampling stations: three in area C, four in area A and one in area B, respectively (Fig. 3).

Multifilament net was operated only both at the first and the second stations. According to the lack of sinkers in multifilament net, it was found that the net could not fully expand. Consequently, the monofilament net was used in the left six stations.
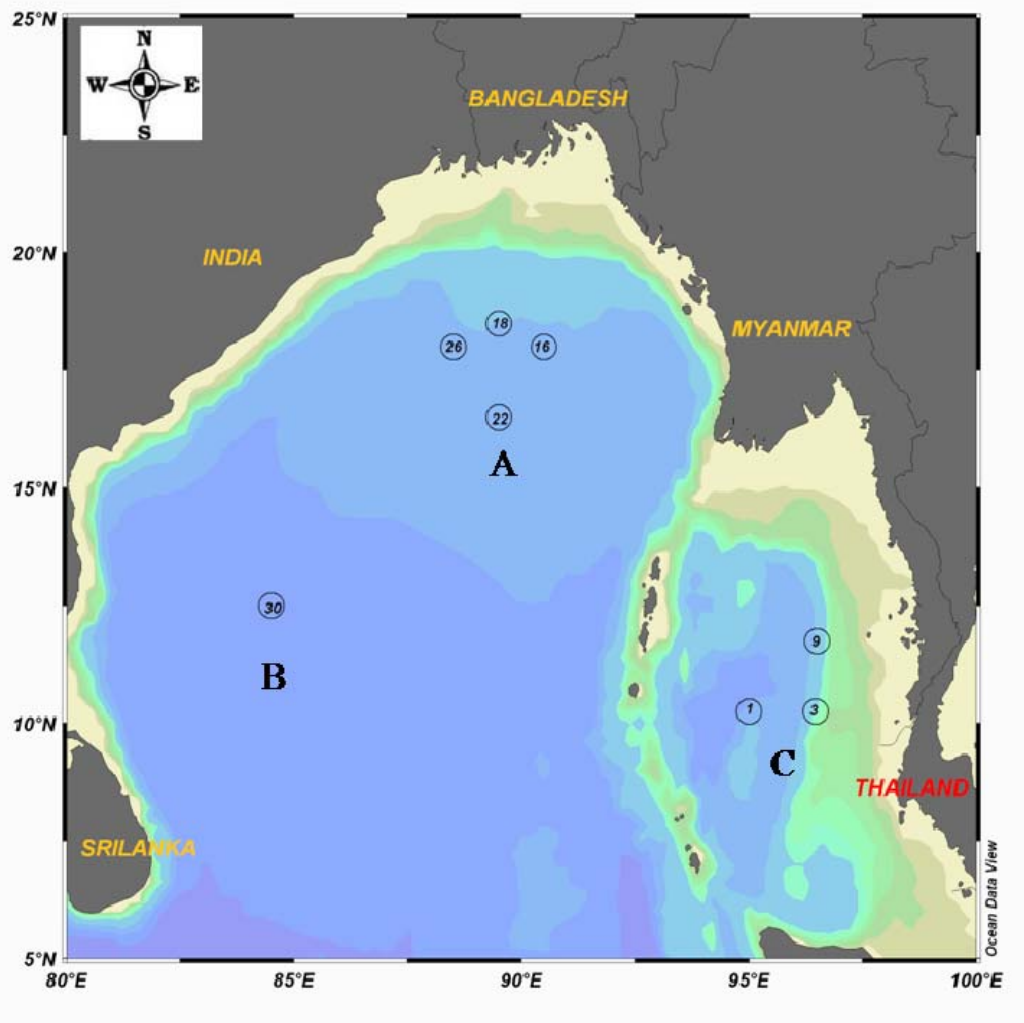

Figure 3 The practical DGN survey stations.

Species Composition

Total catch from this study was separated into two major groups: fishes and invertebrate. For fish composition, 15 species in 9 families were identified. For invertebrate, only one piece of diamondback squid, *Thysanoteuthis rhombus* Troschel, 1857 was identified (Table 1).

Table 1 Species list of marine resources in the Bay of Bengal separated by operations and area.

| No.	Family	Species	Operation Area C			Operation Area A				Operation Area B
			1	2	3	4	5	6	7	8
1	Carcharinidae	*Carcharhinus falciformis (*Müller & Henle, 1839)		✓				✓	✓	✓
2	Carangidae	*Caranx tille* Cuvier, 1833		✓						
3	Nomeidae	*Psenes cyanophrys* Valenciennes, 1833		✓						
4	Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758		✓	✓	✓			✓	
5		*Coryphaena hippurus* Linnaeus, 1758	✓						✓	
6	Echeneidae	*Remora remora* (Linnaeus, 1758)				✓				
7	Scombridae	*Auxis rochei rochei* (Risso, 1810)						✓		
8		*Auxis thazard thazard* (Lacepède, 1800)				✓	✓	✓		
9		*Euthynnus affinis* (Cantor, 1849)	✓			✓				
10		*Katsuwonus pelamis* (Linnaeus, 1758)	✓	✓		✓	✓	✓	✓	✓
11		*Thunnus albacares* (Bonnaterre, 1788)	✓							
12		*Thunnus obesus* (Lowe, 1839)	✓		✓			✓		
13	Gempylidae	*Ruvettus pretiosus* Cocco, 1833								✓
14	Xiphiidae	*Xiphias gladius* Linnaeus, 1758								✓
15	Lobotidae	*Lobotes surinamensis* (Bloch, 1790)								✓
16	Thysanoteuthidae	*Thysanoteuthis rhombus* Troschel, 1857						✓		

A total number of 93 individuals weighing about 137.6 kg from 108 h 8 min of fishing hours (immersion period) were identified. Among the fish species, *Katsuwonus pelamis* dominated the catch by number followed by *Auxis thazard thazard, Coryphaena hippurus, Thunnus obesus, Euthynnus affinis, Carcharhinus falciformis, Coryphaena equiselis* etc. The catch by weight, on the other hand, *Katsuwonus pelamis* was the dominant species followed by *Carcharhinus falciformis, Coryphaena hippurus, Auxis thazard thazard, Xiphias gladias* etc (Fig. 5, Appendix 1). In addition, the catch of marine resources had a low positive correlation with water depth (r=0.27).

Catch Composition

1. Catch per unit effort (CPUE)

The CPUE was varied from 0.15 to 0.28 kg h^{-1}. The seventh operation (station 26, area A) was the highest CPUE with 2.08 kg h^{-1} (20.21%) even though 4 species of fish were caught. The second highest catch was the fourth operation (station 16, area A) with CPUE 2.04 kg h^{-1} (19.83%) and composed of 5 fish species. The detail of catch composition was summarized in Appendix 2.

According to the low value of CPUE, the transformation was used by ln(3+CPUE) to compute the mean and 95% C.I. The average CPUE was 1.22 kg h^{-1} and gave the 95% C.I. of $0.61 \leq \overline{U} \leq 1.94$ kg h^{-1}.
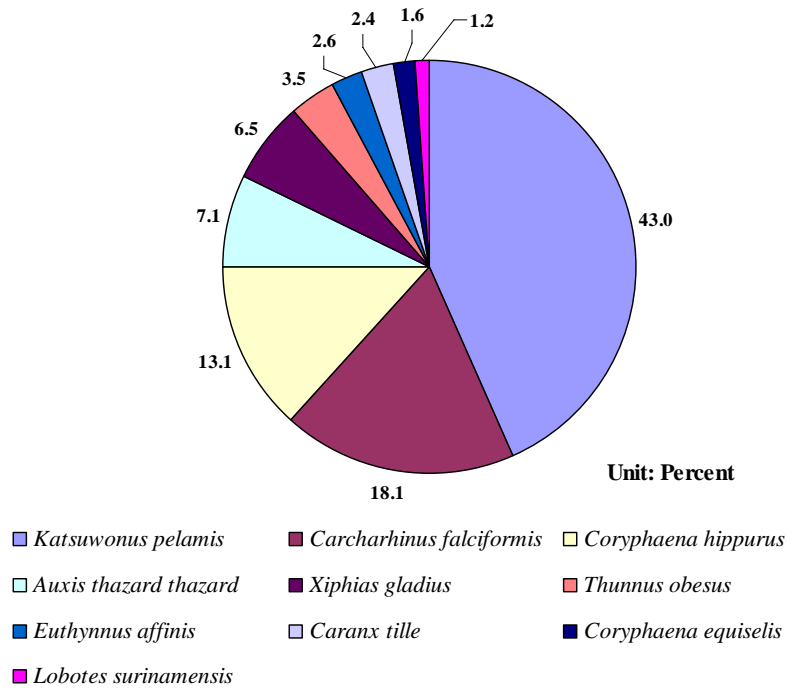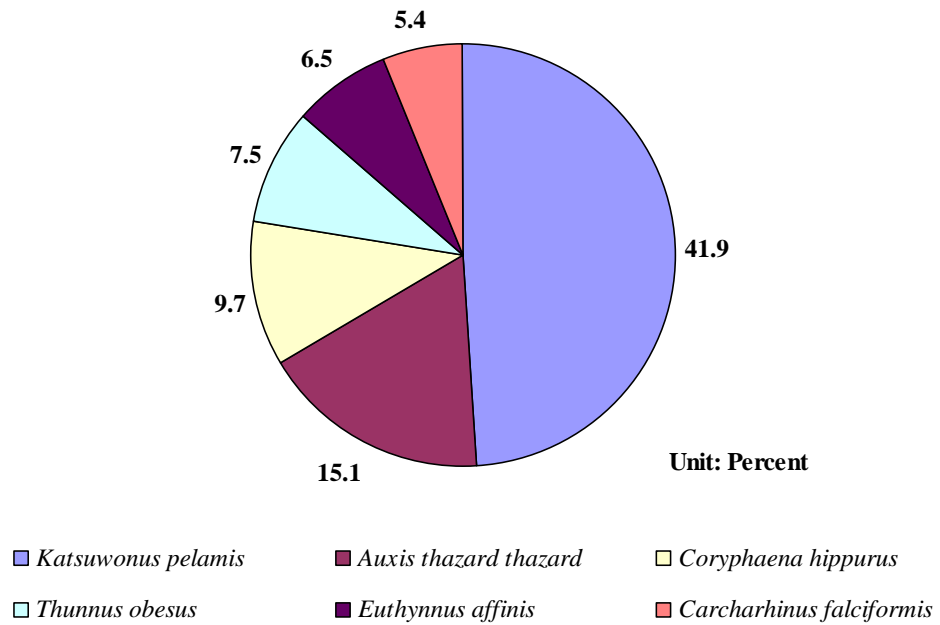
Figure 4 Species composition of dominant marine resources in the Bay of Bengal.
a. percentage by weight (top-ten)   b. percentage by number (top-six)

2. Catch per unit area (CPUA)

The net area of DGN in this study was estimated by rectangular area (length x depth). For the estimation of the net depth (D), hanging ratio (h) and number of meshes (n) was used as the following formula (Prado and Dremiere, 1990).

$$D = \sqrt{(1 - h^2)} \times (n \times m)$$

The hanging ratio of PA both in multifilament and monofilament were 0.5 while Saran was 0.47. Hence, the net area of multifilament was 34,807.44 m^2. The net area of monofilament, however, was 14,722.43 m^2 for the net length of 1,700 m and 14,722.43 m^2 for the net length of 2,200 m.

The CPUA was ranged from 1.297x10^{-4} to 1.651x10^{-3} kg m^{-2} of net area. According to the low value of CPUA, the transformation was used by $\ln(7 + CPUA)$ for computing the mean and 95% C.I. of mean. The average CPUA was 8.809x10^{-4} kg m^{-2} and gave the 95% C.I. of $3.923 \times 10^{-4} \leq \overline{A} \leq 1.369 \times 10^{-3}$ kg m^{-2}.

3. Area-based of catch composition

Overall, area-based of catch composition separated from survey stations were shown in appendix 3.

3.1 Area C:

DGN was operated in three survey stations, two for multifilament and one for monofilament. Nine species belong to five families of fish were caught in this area (Table 2). Total number of 17 fishes weighing about 28.91 kg were caught.

Table 2 Catch composition of marine resources in area C.

No.	Family	Species	Catch			
			No.	%	W (g)	%
1	Carcharinidae	*Carcharhinus falciformis* (Müller & Henle, 1839)	1	5.88	12,200	42.21
2	Carangidae	*Caranx tille* Cuvier, 1833	1	5.88	3,300	11.42
3	Nomeidae	*Psenes cyanophrys* Valenciennes, 1833	1	5.88	260	0.90
4	Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758	2	11.76	280	0.97
5		*Coryphaena hippurus* Linnaeus, 1758	1	5.88	3,700	12.80
6	Scombridae	*Euthynnus affinis* (Cantor, 1849)	2	11.76	140	0.48
7		*Katsuwonus pelamis* (Linnaeus, 1758)	4	23.53	6,600	22.83
8		*Thunnus albacares* (Bonnaterre, 1788)	1	5.88	220	0.76
9		*Thunnus obesus* (Lowe, 1839)	4	23.53	2,205	7.63
	Total		**17**		**28,905**	

3.2 Area A:

Monofilament net was operated in four survey stations. Nine species belongs to four families of fish and one individual of diamondback squid was caught in this area (Table 3). Total number of 67 fishes weighing about 82.50 kg was caught.

Table 3 Catch composition of marine resources in area A.

No.	Family	Species	Catch No.	%	W (g)	%
1	Carcharinidae	*Carcharhinus falciformis (*Müller & Henle, 1839)	3	4.41	10,570	12.73
2	Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758	2	2.94	1,880	2.26
3		*Coryphaena hippurus* Linnaeus, 1758	8	11.76	14,260	17.17
4	Echeneidae	*Remora remora* (Linnaeus, 1758)	1	1.47	560	0.67
5	Scombridae	*Auxis rochei rochei* (Risso, 1810)	1	1.47	320	0.39
6		*Auxis thazard thazard* (Lacepède, 1800)	14	20.59	9,770	11.76
7		*Euthynnus affinis* (Cantor, 1849)	4	5.88	3,430	4.13
8		*Katsuwonus pelamis* (Linnaeus, 1758)	33	48.53	40,860	49.20
9		*Thunnus obesus* (Lowe, 1839)	1	1.47	850	1.02
10	Thysanoteuthidae	*Thysanoteuthis rhombus* Troschel, 1857	1	1.47	550	0.66
	Total		**68**		**83,050**	

3.3 Area B:

Monofilament DGN was operated in only one survey station due to stormy sea conditions. In one operation six species belong to six families of fish were caught in this area (Table 4). Total number of 6 fishes weighing about 23.85 kg were caught.

Table 4 Catch composition of marine resources in area B**.**

No.	Family	Species	Catch No.	%	W (g)	%
1	Carcharinidae	*Carcharhinus falciformis (*Müller & Henle, 1839)	1	16.67	2,200	9.22
2	Scombridae	*Katsuwonus pelamis* (Linnaeus, 1758)	2	33.33	11,650	48.85
3	Gempylidae	*Ruvettus pretiosus* Cocco, 1833	1	16.67	300	1.26
4	Xiphiidae	*Xiphias gladius* Linnaeus, 1758	1	16.67	8,900	37.32
5	Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	1	16.67	800	3.35
	Total		**6**		**23,850**	

An ANOVA (single factor) was used to test the different catch among three sub-areas in term of CRD with unequal replication (Steel and Torrie, 1986). The result was not shown significantly different among the three sub-areas (p>0.05).

Abundance and Distribution

Index of relative importance (IRI) was the first mentioned in the study on feeding ecology (Green, 1979; Pinkas *et al*., 1971). This index shows how importance of food items in fish stomach followed by trophic level. Nowadays, the IRI was applied to explain how important of fish species in the community by multi-dimensions: percentage of weight, number and frequency of occurrence at the same time. IRI also applies for describing spatial stock abundance and distribution.

In this study, the IRI was used to examine the importance of marine resources captured by DGN both in holistic and station-based conditions. For holistic condition, IRI was estimated by summing the catch of all survey stations as represent to the Bay of Bengal

(Appendix 4). The top-eight important species in the Bay of Bengal was described as follow (Fig. 5):
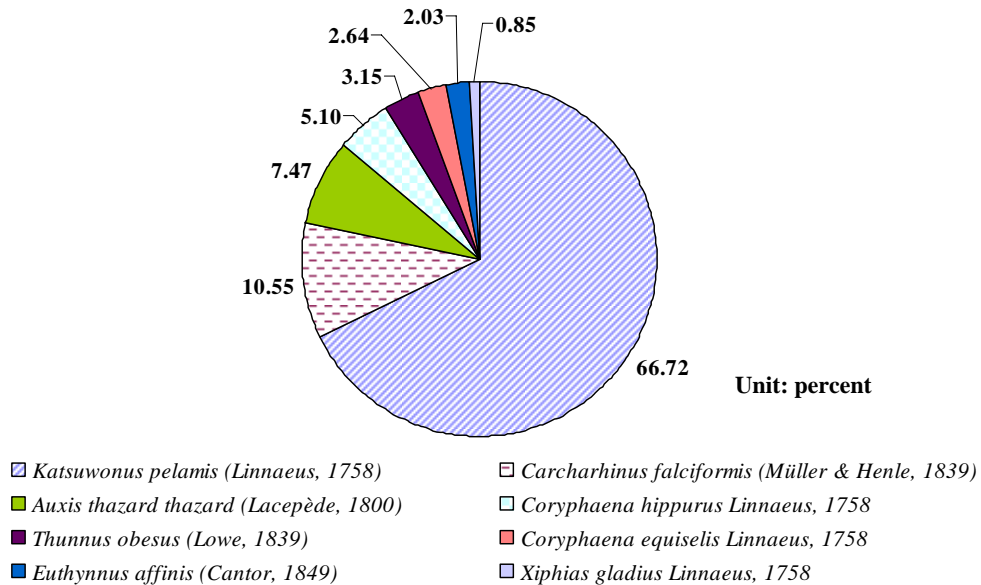

Legend:
- ▨ *Katsuwonus pelamis (Linnaeus, 1758)*
- ⊟ *Carcharhinus falciformis (Müller & Henle, 1839)*
- ▨ *Auxis thazard thazard (Lacepède, 1800)*
- ▢ *Coryphaena hippurus Linnaeus, 1758*
- ■ *Thunnus obesus (Lowe, 1839)*
- ■ *Coryphaena equiselis Linnaeus, 1758*
- ■ *Euthynnus affinis (Cantor, 1849)*
- ▨ *Xiphias gladius Linnaeus, 1758*

Figure 5 The top-eight important marine resources in the Bay of Bengal.

The result from fig. 5 revealed that, skipjack tuna was the most important species for DGN fishery in the Bay of Bengal. It can be occurred in every part of the survey area except in station 9 (area C). Silky shark was the second important species. It can be found in 4 survey stations from 3 sub-areas; area C in station 3, area A in station 22 and 26, and area B in station 30, respectively. In holistic view point, most of the important species in the Bay of Bengal were economic fishes.

The station-based IRI of the top-eight important species was explained as the following (Fig. 6):

Legend:
- ■ *Katsuwonus pelamis*
- ■ *Carcharhinus falciformis*
- ▢ *Auxis thazard thazard*
- ▢ *Coryphaena hippurus*
- ■ *Thunnus obesus*
- ■ *Coryphaena equiselis*
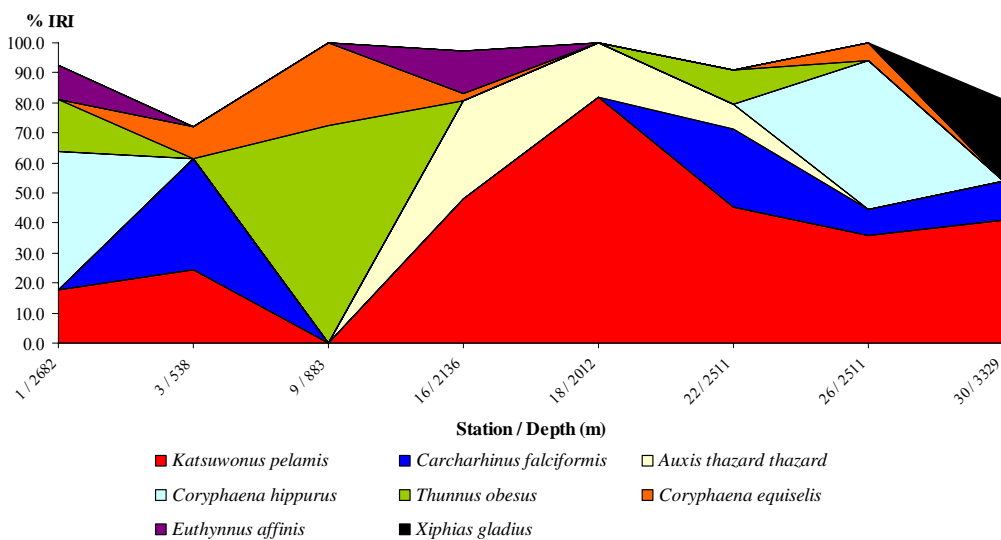- ■ *Euthynnus affinis*
- ■ *Xiphias gladius*

Figure 6 The station-based, top-eight important marine resources in the Bay of Bengal.

Fig. 6 shows the important of top-eight species according to survey stations and depths. It can be said that skipjack tuna (red colour), which was the most important species, distributed in every part of the survey area without any correlation with the depth whereas frigate tuna (yellow colour) was mainly important and distribute only in area A with the sea depth over 2,000 m but not more than 2,600 m. The distribution of silky shark (dark-blue colour) was more important in area A than the left but no correlate with the sea depth. Bigeye tuna (green colour) was more important in area C than area A and prefer to live in rather shallower water (<900 m) than other species as well as pompano dolphinfish (orange colour). In contrast with pompano dolphinfish, common dolphinfish (light-blue colour) seemed to prefer the deeper zone in area A and more important than pompano dolphinfish. Kawakawa (purple colour) distributed both in area A and area C in the same degree of important whereas swordfish (black colour) distributed only in area B which was the deepest sea.The area-based size distribution of skipjack tuna can be shown in table 5.

Table 5 Size distribution of skipjack tuna captured by DGN in the Bay of Bengal.

Area	No. of capture	Size range (FL; cm)	Mean FL (cm)
C	3	17.6 – 68.0	34.6
A	34	35.8 – 51.4	40.8
B	2	66.0 – 70.0	68.0

From the table 5, it was found that small skipjack tuna distributed in area C and the biggest lived in area B. The movement of this species followed by size range seemed to start from area C to area A, then from area A to area B. For further study, it should be concerned on the migratory route supporting from reproductive biology of this species.

Fecundity

There were 12 samples belonging to 2 species which were frigate tuna and common dolphinfish that could be collected to investigate the ripened ovaries (Table 6). For frigate tuna, all specimens were collected from area A. Fecundity ranged from 57,062 to 273,396 eggs, with a 95% C.I. of mean $67,226 \leq 184,131 \leq 301,037$ eggs. The mean relative fecundity, however, was 233.59 eggs g^{-1} body weight. In overall, the size (SL) of frigate tuna in area A (16 pieces) ranged from 23.60 to 36.0 cm with the mean length at 32.11 cm whereas the specimen that gave the ripened ovaries have a size range from 31.5 to 34.5 cm. According to this species, it could be caught only in the area A with some gravid females, area A should be concerned for fishing activities. Nevertheless, the study on reproductive biology and exploring for spawning ground are needed for clarifying the management regime in the Bay of Bengal.

From NOAA (http://www.nmfs.noaa.gov/habitat/habitat_protection/profile/ westernpacific/frigate_tunahome.htm, 22 July 2008), it is revealed that frigate tuna has fecundity estimates from 78,000 to 717,900 eggs. It will be noted that, even though the fecundity of frigate tuna in this study was not different to NOAA mentioned, but the specimens to investigate were very low number and it need more specimens to study for better comparison.

Table 6 Fecundity, GSI and relative fecundity of frigate tuna and common dolphinfish.

Auxis thazard thazard

Area	Fecundity	GSI	Relative fecundity (eggs g^{-1})
A	217,556	3.92	255.95
A	57,062	0.88	71.33
A	114,847	2.08	176.69
A	273,396	4.91	341.75
A	257,794	5.21	322.24

Coryphaena hippurus

Area	Fecundity	GSI	Relative fecundity (eggs g^{-1})
A	34,765	0.19	8.82
A	354,928	3.40	236.62
A	338,393	2.71	169.20
A	259,761	2.48	185.54
A	232,184	3.82	145.12
A	124,941	2.47	96.11

For common dolphinfish, on the other hand, all six specimens were collected from Area A. Fecundity ranged from 34,765 to 354,928 eggs, with a 95% C.I. of mean $93,765 \leq 224,162 \leq 354,560$ eggs. The mean relative fecundity, however, was 140.23 eggs g^{-1} body weight. This result conformed to the study of Masssuti and Morales-Nin (1997). They reported that the relative fecundity of common dolphinfish ranged from 71 to 197 eggs g^{-1} body weight, with a mean value of 120±31.3 eggs g^{-1}. The evidence of size distribution of oocytes, with at least two groups of oocytes in the ovaries, suggested that common dolphinfish was a multiple spawner.

In the study on fecundity of fish, it usually has a distinguishable different in the number of eggs at the same length, especially the large fish. Bagenal (1968) pointed out that large fish has a more variable number of eggs since the effect of multiple-spawner in one spawning season has occurred (Bagenal, 1966). Moreover, fecundity also varied with the seasons, climatic conditions, environmental habitat, nutritional status and genetic potential (Bromage *et al.*, 1992).

Conclusions and Recommendations

It can be concluded from all aspects of this study that skipjack tuna was the dominant species not only in number and weight but also be the most important for DGN fishery in the Bay of Bengal. Most of the capturing fishes were economic species. Area A seemed to be the richest area with the highest degree of species diversity, CPUE and high number of female gravidity. The reproductive biology of some economic species should be prioritized before studying. Area B is the deepest zone, even the catch was very low according to the rough sea condition but the catch here seemed to be composed of the biggest sized fish. Moreover, the migratory routes of fishes among the three sub-areas around the Bay of Bengal should be given precedence to study as well.

The magnitude of the importance of marine resources from this study will serve the understanding of pelagic community in the Bay of Bengal. It will also be beneficial to the DGN fishery management in the future.

Acknowledgements

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Appendix 1: Species composition of marine resources by number and weight.

Family	Local Name	Species	Catch			
			No.	%	W (g)	%
Carcharinidae	Silky shaek	*Carcharhinus falciformis* (Müller & Henle, 1839)	5	5.38	24,970	18.15
Carangidae	Tille trevally	*Caranx tille* Cuvier, 1833	1	1.08	3,300	2.40
Nomeidae	Freckled driftfish	*Psenes cyanophrys* Valenciennes, 1833	1	1.08	260	0.19
Coryphaenidae	Pompano dolphinfish	*Coryphaena equiselis* Linnaeus, 1758	4	4.30	2,160	1.57
Coryphaenidae	Common dolphinfish	*Coryphaena hippurus* Linnaeus, 1758	9	9.68	17,960	13.05
Echenidae	Common remora	*Remora remora* (Linnaeus, 1758)	1	1.08	560	0.41
Scombridae	Bullet tuna	*Auxis rochei rochei* (Risso, 1810)	1	1.08	320	0.23
Scombridae	Frigate tuna	*Auxis thazard thazard* (Lacepède, 1800)	14	15.05	9,770	7.10
Scombridae	Kawakawa	*Euthynnus affinis* (Cantor, 1849)	6	6.45	3,570	2.59
Scombridae	Skipjack tuna	*Katsuwonus pelamis* (Linnaeus, 1758)	39	41.94	59,110	42.96
Scombridae	Yellowfin tuna	*Thunnus albacares* (Bonnaterre, 1788)	1	1.08	220	0.16
Scombridae	Bigeye tuna	*Thunnus obesus* (Lowe, 1839)	7	7.53	4,845	3.52
Gempylidae	Oilfish	*Ruvettus pretiosus* Cocco, 1833	1	1.08	300	0.22
Xiphiidae	Swordfish	*Xiphias gladius* Linnaeus, 1758	1	1.08	8,900	6.47
Lobotidae	Atlantic tripletail	*Lobotes surinamensis* (Bloch, 1790)	1	1.08	800	0.58
Thysanoteuthidae	Diamondback squid	*Thysanoteuthis rhombus* Troschel, 1857	1	1.08	550	0.40
Total			**93**		**137.05**	

Appendix 2: Catch composition of marine resources in the Bay of Bengal.

Operation	Station no.	Depth (m)	Total Catch (kg)	%Catch by Station	Immersion Time (min)	CPUE (kg h^{-1})	Net Area (m^2)	CPUA (kg m^{-2})
1	1	2,682	4.52	3.28	803	0.34	34,807.44	1.297×10^{-04}
2	3	538	22.29	16.20	761	1.76	34,807.44	6.404×10^{-04}
3	9	883	2.10	1.53	846	0.15	14,722.43	$1.426 \times 10^{-0}4$
4	16	2,136	25.54	18.56	751	2.04	17,718.80	1.441×10^{-03}
5	18	2,012	11.29	8.21	840	0.81	17,718.80	6.372×10^{-04}
6	22	2,511	18.75	13.63	805	1.40	17,718.80	1.058×10^{-03}
7	26	2,511	29.26	21.27	844	2.08	17,718.80	1.651×10^{-03}
8	30	3,329	23.85	17.33	838	1.71	17,718.80	1.346×10^{-03}
Total			**137.60**		**108 h 8 min**			

Appendix 3: Area-based of catch composition separated from survey stations.

Operation no. 1
Station no. 1

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Coryphaena hippurus* Linnaeus, 1758	3,700	81.95	1	10.00
2	*Euthynnus affinis* (Cantor, 1849)	140	3.10	2	20.00
3	*Katsuwonus pelamis* (Linnaeus, 1758)	250	5.54	3	30.00
4	*Thunnus albacares* (Bonnaterre, 1788)	220	4.87	1	10.00
5	*Thunnus obesus* (Lowe, 1839)	205	4.54	3	30.00
Total		**4,515**	**100**	**10**	**100**

Operation no. 2
Station no. 3

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Carcharhinus falciformis (*Müller & Henle, 1839)	12,200	54.73	1	20.00
2	*Caranx tille* Cuvier, 1833	3,300	14.80	1	20.00
3	*Psenes cyanophrys* Valenciennes, 1833	260	1.17	1	20.00
4	*Coryphaena equiselis* Linnaeus, 1758	180	0.81	1	20.00
5	*Katsuwonus pelamis* (Linnaeus, 1758)	6,350	28.49	1	20.00
Total		**22,290**	**100.00**	**5**	**100.00**

Operation no. 3
Station no. 9

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Coryphaena equiselis* Linnaeus, 1758	100	4.76	1	50.00
2	*Thunnus obesus* (Lowe, 1839)	2,000	95.24	1	50.00
Total		**2,100**	**100.00**	**2**	**100.00**

Appendix 3: (cont.).

Operation no.	4
Station no.	16

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Coryphaena equiselis* Linnaeus, 1758	180	0.70	1	3.45
2	*Remora remora* (Linnaeus, 1758)	560	2.19	1	3.45
3	*Auxis thazard thazard* (Lacepède, 1800)	7,360	28.82	10	34.48
4	*Euthynnus affinis* (Cantor, 1849)	3,430	13.43	4	13.79
5	*Katsuwonus pelamis* (Linnaeus, 1758)	13,160	51.53	12	41.38
6	*Thunnus obesus* (Lowe, 1839)	850	3.33	1	3.45
Total		**25,540**	**100.00**	**29**	**100.00**

Operation no.	5
Station no.	18

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Auxis thazard thazard* (Lacepède, 1800)	1,840	16.30	2	20.00
2	*Katsuwonus pelamis* (Linnaeus, 1758)	9,450	83.70	8	80.00
Total		**11,290**	**100.00**	**10**	**100.00**

Operation no.	6
Station no.	22

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Carcharhinus falciformis (*Müller & Henle, 1839)	7,350	39.20	2	13.33
2	*Auxis rochei rochei* (Risso, 1810)	320	1.71	1	6.67
3	*Auxis thazard thazard* (Lacepède, 1800)	570	3.04	2	13.33
4	*Katsuwonus pelamis* (Linnaeus, 1758)	8,170	43.57	7	46.67
5	*Thunnus obesus* (Lowe, 1839)	1,790	9.55	2	13.33
6*	*Thysanoteuthis rhombus* Troschel, 1857	550	2.93	1	6.67
Total		**18,750**	**100.00**	**15**	**100.00**

*	Diamondback squid
Operation no.	7
Station no.	26

No.	Species	Weight (g)	% by wt.	Number	% by no.
1	*Carcharhinus falciformis (*Müller & Henle, 1839)	3,220	11.00	1	6.25
2	*Coryphaena equiselis* Linnaeus, 1758	1,700	5.81	1	6.25
3	*Coryphaena hippurus* Linnaeus, 1758	14,260	48.74	8	50.00
4	*Katsuwonus pelamis* (Linnaeus, 1758)	10,080	34.45	6	37.50
Total		**29,260**	**100.00**	**16**	**100.00**

Appendix 3: (cont.).

Operation no.	8				
Station no.	2				

No.	Species	Weight	% by wt.	Number	% by no.
1	*Carcharhinus falciformis (*Müller & Henle, 1839)	2,200	9.22	1	16.67
2	*Katsuwonus pelamis* (Linnaeus, 1758)	11,650	48.85	2	33.33
3	*Ruvettus pretiosus* Cocco, 1833	300	1.26	1	16.67
4	*Xiphias gladius* Linnaeus, 1758	8,900	37.32	1	16.67
5	*Lobotes surinamensis* (Bloch, 1790)	800	3.35	1	16.67
Total		**23,850**	**100.00**	**6**	**100.00**

Appendix 4: IRI of marine resources captured by DGN in the Bay of Bengal.

No.	Scientific Name	%IRI
1	*Katsuwonus pelamis* (Linnaeus, 1758)	66.72
2	*Carcharhinus falciformis (*Müller & Henle, 1839)	10.55
3	*Auxis thazard thazard* (Lacepède, 1800)	7.47
4	*Coryphaena hippurus* Linnaeus, 1758	5.10
5	*Thunnus obesus* (Lowe, 1839)	3.15
6	*Coryphaena equiselis* Linnaeus, 1758	2.64
7	*Euthynnus affinis* (Cantor, 1849)	2.03
8	*Xiphias gladius* Linnaeus, 1758	0.85
9	*Caranx tille* Cuvier, 1833	0.39
10	*Lobotes surinamensis* (Bloch, 1790)	0.19
11	*Remora remora* (Linnaeus, 1758)	0.17
12	*Thysanoteuthis rhombus* Troschel, 1857	0.17
13	*Auxis rochei rochei* (Risso, 1810)	0.15
14	*Ruvettus pretiosus* Cocco, 1833	0.15
15	*Psenes cyanophrys* Valenciennes, 1833	0.14
16	*Thunnus albacares* (Bonnaterre, 1788)	0.14
Total		**100.00**