"Strategies for Trawl Fisheries By-catch Management"

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Biodiversity, abundance and distribution of fish larvae in Ao Trat, Thailand.

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1. Background:

Ao Trat is a fertile marine area in the Eastern region of Thailand, with high abundance of aquatic resources. Its fertility is due to the significant freshwater run off to the Gulf of Thailand and the dense mangrove areas, sea grass beds and extensive coral reefs around islands. Ao Trat is a spawning ground and nursery rearing area for many aquatic animals. Moreover this area is an important for capture fisheries such as shrimp, crab and fish with many different types of fishing gears being used, including some destructive fishing gears such as Fix traps[1].

Overfishing of aquatic resources is resulting in resource degradations also resulting in conflict between commercial fisheries and traditional fisheries, especially around the Chang Channel Island since 2000. Trat Provincial Announcement issued a regulation on March 28, 2000, prohibiting this area for fishing with otter trawl, purse seine and cockle rakes, in order to protect eggs, larvae, and brood stock of economic aquatic animal from capture.

Following the prohibiton of fishing gears, Siri *et a.l* (2005) studied the fish larvae in AoTrat from May 2003 to March 2004. The result showed 30 families of fish larvae, with Gobiidae being the dominant family followed by Clupeidae and Engraulidae, respectively.

2 Methodology for study

2.1. Sampling stations

9 stations were identified for fish larvae sampling area in Ao Trat and Chong Chang, Trat Province. (Figure 1.)

Figure 1. Fish larvae sampling stations at Ao Trat and Chong Chang between March 2014 and January 2015 (modified from Google Earth)

[1] Fixed traps (16 traps) (Suchada and Tossaporn, 2004). The main species caught by fixed trap is mackerel but the trap is a destructive fishing gear as it blocks the migration path of small aquatic animals. The study shows that there were 25 such fishing gears in Ao Trat (Kamolphan and Somdech, 1994; Somporn, 2000, Wichan and Santi, 2009; Aucha *et al.*, 2011)

2.2. Sampling and preservation.

Specimens were sampled from all stations during 6 periods between March 2014 and January 2015.

- 1st sampling in March 2014 was representative of summer
- 2nd sampling in May 2014 was representative of rainy season
- 3rd sampling in July 2014 was representative of rainy season
- 4th sampling in September 2014 was representative of rainy season
- 5th sampling in November 2014 was representative of winter
- 6th sampling in January 2015 was representative of winter

The fish larvae were collected by a with a 60 centimeter diameter Bongo net. The mesh sizes used were 500 and 300 micrometers, A flow meter were placed at the mouth of bongo net and the trawling duration was 15 minutes/haul at a speed of 2 knots. Specimens were preserved in 10% formalin solution during sampling and then analyzed and identified in the laboratory after which they were changed to 4% formalin solution and then kept in 70% ethyl alcohol.

3. Analysis

The fish larvae were identified through keys provided by Okiyama (1988) and Neira *et al*. (1998) Guideline and systems for taxonomic identification, Nelson (2006). The study on the development of fish larvae Apichart (2003 and 2005) was also used for fish larvae identification purposes. This included separating the fish larvae into 4 stages;

1. Pro-larva stage, from hatching yolk sac present until yolk sac completely absorbed;
2. Larval stage, from no yolk sac to urostyle curled up;
3. Post-larval stage, developed muscle, fin and organs until pectoral fin completely developed;
4. Juvenile phase, external characteristics, used for meristic characters of fish larvae completed, body shape is similar to adult including scale and color spot pattern excluding smaller sizes, uncompleted reproductive system, not developed.

The data collected (counting and identification) were analyzed for the abundance of fish larvae per 1,000 cubic metres of water, at the different sampling stations to compare the distribution of fish larvae abundance and diversity.

3.1. A <u>Richness index</u> was used to calculate the number of species and fish larvae at each station. (Odum, 1971).

$$R = (S-l)/ \ln (n)$$

Where R = richness index;
S = number of species;
ln = natural logarithm;
n = total number of founded fish larvae.

3.2 <u>Evenness index</u> or equitability index indicate the distribution of species and number of fish larvae these are similar in quantity and distribution. In principle, an abundant ecosystem must have an equable distribution of species. (Smith, 1992).

$$E = H/\ln S \text{ or } H/H_{max}$$

Where E = Evenness index
H = Diversity index
S = number of species in each sampling station
H_{max} = probable maximum diversity index in the samesampling station

3.3 <u>Diversity index</u>, Shannon and Weaver (1949) suggest a method to calculate the diversity (H) where H is the maximum value when the number of each species is equal. If there is only one species, H is zero. To calculate

$$H = -\sum_{i=1} (Pi) (\log_2 Pi)$$

$$Pi = n_i / N$$

Where H = Diversity index
Pi = ratio of number of species
n_i = number of species i
N = total number of founded species

3.4. Cluster analysis is the multivariate statistical analysis that characterizes the diversity and abundance of clusters. In principle, calculations and comparisons by Bray-Cutis converts the data to a normal distribution before calculation. The result shows in dendrograms or tree diagrams in hierarchical clustering pattern by the different levels of Bray-Cutis similarity index. (Brian *et al*, 2011)

3.5. Ordination multi-dimension scaling, MDS is the multivariate statistic characterization of data distribution by figures and dimensions to compare abundance and diversity. The figure of distribution characterizes the distance between two sampling stations and indicates the level of similarity, Close stations should shows more similarity than those at longer distance. (Jae, 2010) The stress value indicates the reliability of the analytical results. Thus:

- Stress value < 0.05 the figure have a high precision and extremely reliable.
- Stress value < 0.10 the figure have a high precision and reliable, not wrong analyze.
- Stress value < 0.20 the figure have a precision and potential adoption.
- Stress value > 0.20 the figure have a low precision and low reliable.

3.6. Simpler analysis by percentage is the straightforward comparison of the level of similarity and differentiation of fish population between different areas. Comparisons of the average similarity value and dissimilarity value for the total number of fish larvae in the fish population present in each sampling data, can be analyzed. (Clake, 1993)

4. Results

4.1. Composition of fish larvae species

Fish larvae from 7 orders 31 families 35 genera were identified. See Table 1 overleaf.

Table 1. Occurrence of the species composition of fish larvae at Ao Trat and Chong Chang.

Order		Family			Genus/Species	
1	Clupeiformes	1	Anchovies	Engraulidae	1	*Stolephorus* spp.
		2	Sardine	Clupeidae	2	*Sardinella*spp.
2	Gadiformes	3	Codlet	Bregmacerotidae	3	*Bregmaceros* spp.
3	Atheriniformes	4	Silversides	Atherinidae	4	*Atherina* spp.
4	Scorpaeniformes	5	Scorpion fish	Scorpaenidae	5	*Scorpaenodes* spp.
		6	Velvetfish	Synanceiidae	6	*Minous* spp.
		7	Flatheads	Platycephalidae	7	*Platycephalus* spp.
5	Perciformes	8	Lates perches	Latidae	8	*Lates* spp.
		9	Cardinalfish	Apogonidae	9	*Apogon*spp.
					10	*Cheilodipterus* spp.
		10	Triple tail	Lobotidae	11	*Lobotes* spp.
						Lobotes surinamensis
		11	Threadfin breams	Nemipteridae	12	*Nemipterus* spp.
		12	Croaker	Sciaenidae	13	*Sciaena* spp.
		13	Sickle fish	Drepaneidae	14	*Drepane* spp.
		14	Anemone fishes	Pomacentridae	15	*Amphiprion* spp.
		15	Tigerperch	Terapontidae	16	*Terapon* spp.
		16	Bigeyes	Priacanthidae	17	Priacanthus spp.
		17	Blenny	Blenniidae	18	*Omobranchus* spp.
		18	Rabbitfish	Siganidae	19	*Siganus* spp.
		19	Comber	Serranidae	20	*Serranus* spp.
		20	Sillago	Sillaginidae	21	*Sillago* spp.
		21	Trevally	Carangidae	22	*Caranx* spp.
					23	*Gnathanodon speciosus*
					24	*Scomberoides* spp.
					25	*Selar* spp.
					26	*Trachinotus* spp.
		22	Ponyfish	Leiognathidae	27	*Leiognathus* spp.
		23	Mojarra	Gerreidae	28	*Gerres* spp.
		24	Goatfish	Mullidae	29	*Upeneus* spp.
		25	Dragonet	Callionymidae	30	*Callionymus* spp.
		26	Goby	Gobiidae		
		27	Barracuda	Sphyraenidae	31	*Sphyraena* spp.
6	Pleuronectiformes	28	Lefteye flounders	Bothidae	32	*Bothus* spp.
		29	Tonguefish	Cynoglossidae	33	*Cynoglossus* spp.
7	Tetraodontiformes	30	Filefish	Monacanthidae	34	*Aluterus* spp.
		31	Puffer	Tetraodontidae	35	*Tetraodon* spp.

4.2. Abundance and distribution

The amount of fish larvae collected in Ao Trat and Chong Chang were 1,377 individuals, (equivalent to 8,133 individuals per 1,000 cubic meters), Gobiidae was the dominant family. (188 individuals/1,000 cubic meters) making up 23.60% of the total number of fish larvae. The second was Carangidae, (21 individuals /1,000 cubic meters) making up 10.68% of total, followed by Clupeidae, (20 individuals /1,000 cubic meters) making up 12.75% of the total.

By the period, the most abundant fish larvae was in March found in the sample, i.e. 3,513 fish/1,000 cubic meters, the second is 1,763.81 individuals per 1,000 cubic meters in September 2014, 1,032 individuals per 1,000 cubic meters in May 2014, 861.15 individuals per 1,000 cubic meters in July 2014, 552.87 individuals per 1,000 cubic meters in January 2015 and the least is 407.17 individuals per 1,000 cubic meters in November 2014. The result shows that the density of fish larvae depend on the monsoon season or breeding and spawning season, the northeast monsoon season in March is the most abundant fish larvae. The fish larvae in Chong Chang and AoTrat from March 2014 to January 2015 are show below in Table 3 and Annex table 2-7).

Table 2. Abundance of fish larvae at Ao Trat and Chong Chang between March 2014 and January 2015

	Family	Average (ind./ 1,000 m^3)	Percentage
1	Gobiidae	1,920	23.56
2	Clupeidae	1,038	12.74
3	Nemipteridae	935	1.47
4	Carangidae	869	10.66
5	Apogonidae	864	10.60
6	Blenniidae	793	9.73
7	Callionymidae	430	5.28
8	Leiognathidae	340	4.17
9	Sphyraenidae	115	1.41
10	Cynoglossidae	111	1.36
11	Aploactinidae	98	1.20
12	Engraulidae	80	0.98
13	Sciaenidae	78	0.96
14	Sillaginidae	78	0.96
15	Bothidae	48	0.59
16	Platycephalidae	40	0.49
17	Pomacentridae	37	0.45
18	Gerreidae	37	0.45
19	Terapontidae	37	0.45
20	Monacanthidae	33	0.40
21	Bregmacerotidae	29	0.36
22	Siganidae	26	0.32
23	Lobotidae	23	0.28
24	Atherinidae	18	0.22
25	Serranidae	18	0.22
26	Mullidae	14	0.17
27	Latidae	8	0.10
28	Uranoscopodae	7	0.09
29	Tetraodontidae	7	0.09
30	Scorpaenidae	6	0.07
31	Drepaneidae	6	0.07
Unidentified		7	0.09
	Total	8,150	100.00

Table 3. Abundance of fish larvae divided by sampling periods at Ao Trat and Chong Chang between March 2014 and January 2015

Order	Family	Genus	2014					2015
			Mar.	May	Jul.	Sep.	Nov.	Jan.
Clupeiformes								
	Engraulidae	Stolephorus	42	26	-	14	-	-
	Clupeidae	Sardinella	826	76	12	62	69	5
Gadiformes								
	Bregmacerotidae	Bregmaceros	-	-	6	-	-	24
Atheriniformes								
	Atherinidae	Atherina	13	-	-	-	7	0
Scorpaeniformes								
	Scorpaenidae	Scorpaenodes	-	-	6	-	-	-
	Aploactinidae	Minous	31	-	25	7	-	39
	Platycephalidae	Platycephalus	-	-	12	20	-	10
Perciformes								
	Latidae	Lates	-	-	-	8	-	-
	Apogonidae	Apogon	95	14	11	14	-	37
		Cheilodipterus	272	-	245	76	17	95
	Lobotidae	Lobotes	7	-	17	-	-	-
	Nemipteridae	Nemipterus	385	92	57	331	47	37
	Sciaenidae	Sciaena	-	-	67	7	-	5
	Drepaneidae	Drepane	-	-	6	-	-	-
	Pomacentridae	Amphiprion	-	-	-	27	-	10
	Priacanthidae	Priacanthus	7	-	-	-	-	-
	Blenniidae	Omobranchus	577	14	57	64	72	20
	Siganidae	Siganus	27	-	-	-	-	-
	Serranidae	Serranus	18	-	-	-	-	-
	Sillaginidae	Sillago	11	-	25	37	8	-
	Carangidae	Caranx	-	-	-	8	-	-
		Gnathanodon	-	7	-	-	-	-
		Scomberoides	-	-	6	-	-	-
		Selar	59	594	41	62	20	34
		Trachinotus	29	21	-	-	-	-
	Leiognathidae	Leiognathus	25	61	164	60	21	14
	Gerreidae	Gerres	-	7	12	15	-	5
	Mullidae	Upeneus	7	-	-	8	-	-
	Terapontidae	Terapon	33	-	-	-	-	5
	Callionymidae	Callionymus	88	-	24	277	9	43
	Gobiidae	-	830	126	35	629	155	159
	Sphyraenidae	Sphyraena	97	-	-	14	5	-
Pleuronectiformes								
	Bothidae	Bothus	41	-	-	-	-	10
	Cynoglossidae	Cynoglossus	7	-	51	46	-	9
Tetraodontiformes								
	Monacanthidae	Aluterus	19	-	-	-	-	15
	Tetraodontidae	Tetraodon	7	-	-	-	-	-
	Total		3,553	1,038	879	1,786	430	576

It show that the sampling of the main fish larvae were which year round but the peak were March and September but the March spawning peaks was grater the September peak.

4.3. Ecological indices

The species richness index indicates the diversity of fish larvae. (Table 4) Analysis using the species richness index found the maximum value to be in March 2014 at the 6th station.

The Evenness index characterizes the diversity of fish larvae. (Table 4). The maximum value was in July 2014 at the 4th station

The Diversity index characterizes the diversity of fish larvae in sampling period. (Table 4) The maximum value is in July 2014 and by the station, 6th and 9th station are the maximum values.

Table 4. Ecological index of fish larvae divided by sampling periods at Ao Trat and Chong Chang between March 2014 and January 2015

	Species	Individuals	Richness index	Evenness index	Diversity index
Sampling period					
Mar. 2014	24	3,553	4.45	0.90	2.89
May 2014	11	1,038	2.26	0.90	2.15
Jul. 2014	19	879	4.03	0.95	2.83
Sep. 2014	20	1,786	3.99	0.92	2.79
Nov. 2014	10	430	2.46	0.94	2.24
Jan. 2015	18	576	4.01	0.95	2.81
Stations					
St. 1	13	658	2.01	0.61	1.61
St. 2	17	1,132	2.42	0.67	1.93
St. 3	20	1,771	2.68	0.66	2.01
St. 4	14	492	2.27	0.84	2.27
St. 5	14	568	2.22	0.77	2.09
St. 6	20	845	2.98	0.75	2.29
St. 7	19	928	2.79	0.75	2.25
St. 8	12	813	1.79	0.72	1.86
St. 9	18	1,055	2.59	0.79	2.32

From the species richness in dry showed that the sampling March collected the high number of species and the number in July and January were high than other sampling period. Moreover, station number 6 was the highest number of sampling species and station number 8 was the lest number of species in there sampling.

For the evenness was index most of the sampling period had not much different among the number of species and individuals.

The diversity index showed that in March, July, January and Saptember had a high number of species and also high at station number 9, 6 and 7.

4.4. Cluster analysis and Ordination multi-dimensional scaling: MDS is the study of the distribution of (fish larvae) species by means of structural analysis and the amount of (fish larvae) species that indicate the population structure in sampling stations, in order to compare the similarity and levels of composition and amounts.

The result shows that in terms of the sampling periods and the sampling stations, the fish larvae populations were not statistically different. (p-value< 0.05) (Figure 2 and 3)

It means that there were no differences among the fish larvae species by considering only the stations data analysis. Focusing on the sampling months and stations can separate the fish larvae into 6 groups that are statistically different (p-value > 0.05) with the biggest population in the 1st group. (Figure 5 and Table 5)

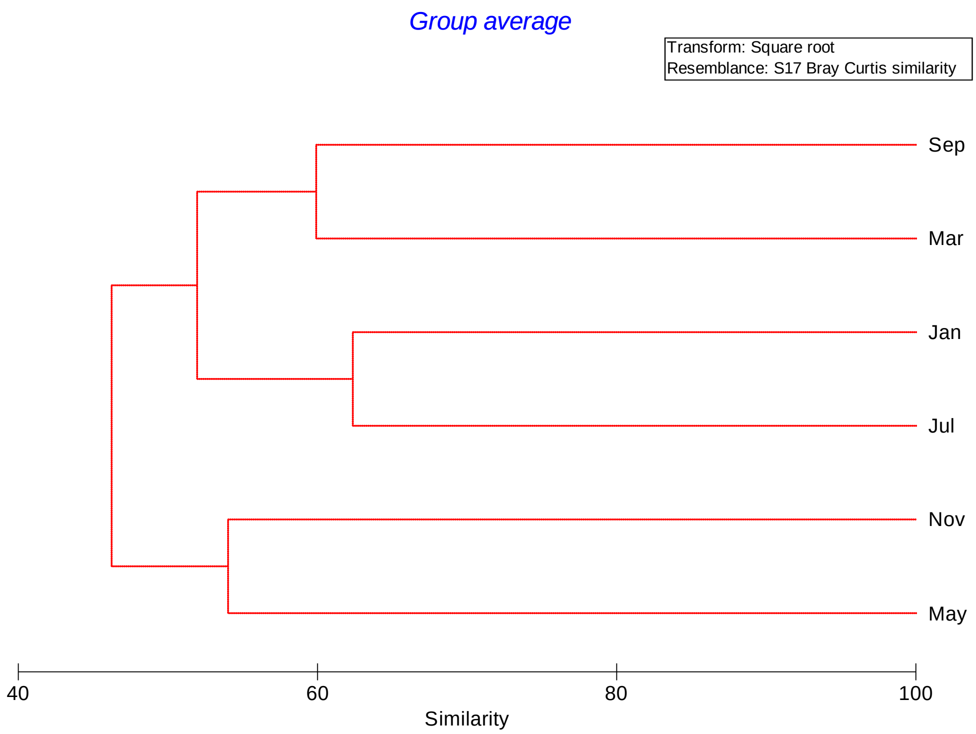

Figure 2. Dendrogram from cluster analysis of fish larvae divided by sampling periods at Ao Trat and Chong Chang between March 2014 and January 2015

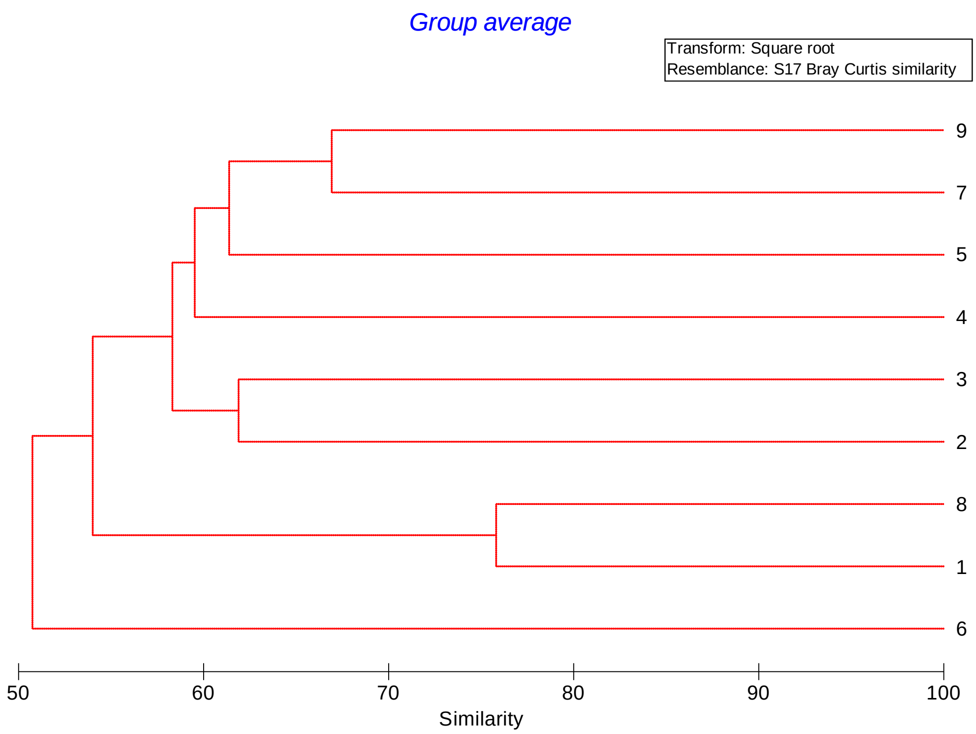

Figure 3. Dendrogram cluster analysis of fish larvae divided by stations at Ao Trat and Chong Chang between March 2014 and January 2015

There were difference among the fish larvae population including species and density by using temporal and spatial analysis. There were divided into 7 groups.

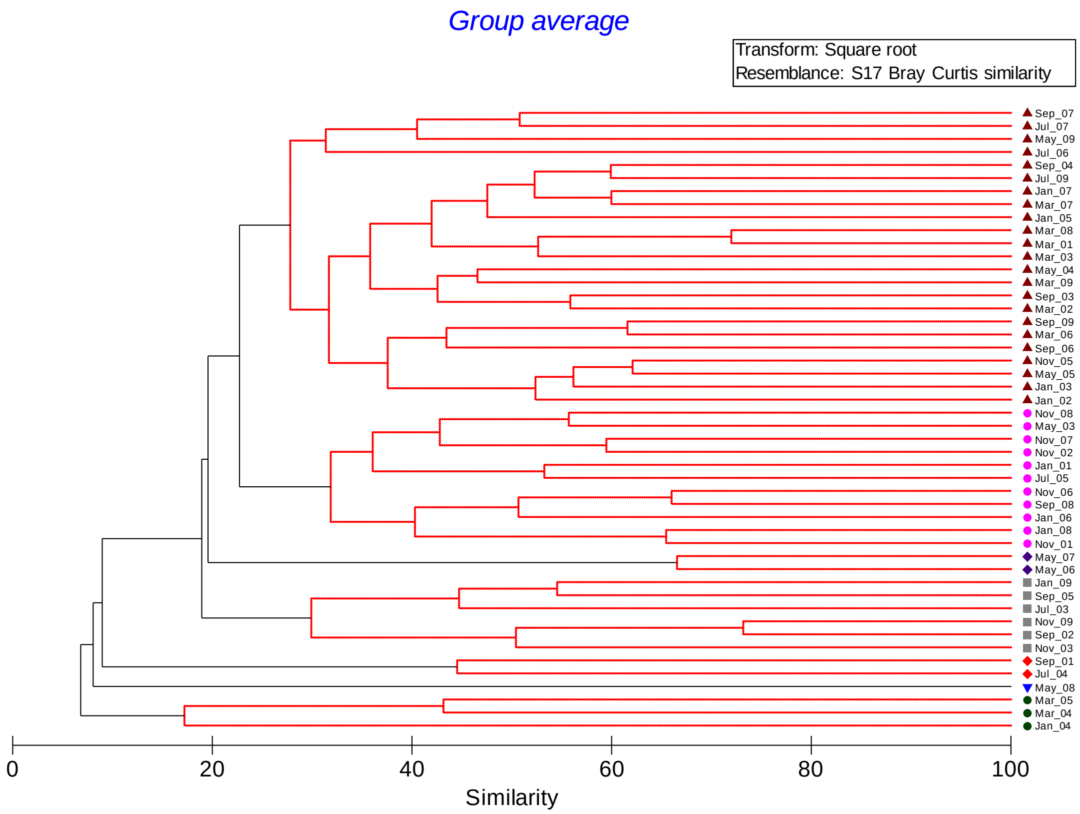

Figure 4. Dendrogram from cluster analysis of fish larvae divided by both sampling periods and stations at Ao Trat and Chong Chang between March 2014 and January 2015

Table 5. Population groups of fish larvae from each sampling station and during each period, in Ao Trat and Chang channel between March 2014 and January 2015

Population	Sampling periods and stations					
Population 1	Mar. St. 01	Mar. St. 02	Mar. St. 03	Mar. St. 06	Mar. St. 07	Mar. St. 08
	Mar. St. 09	May St. 04	May St. 05	May St. 09	Jul. St. 06	Jul. St. 07
	Jul. St. 09	Sep. St. 03	Sep. St. 04	Sep. St. 06	Sep. St. 07	Sep. St. 09
	Nov.St. 05	Jan. St. 02	Jan. St. 03	Jan. St. 05	Jan.St. 07	
Population 2	May St. 03	Jul. St. 05	Sep. St. 08	Nov. St. 01	Nov.St. 02	Nov.St. 06
	Nov. St. 07	Nov. St. 08	Jan. St. 01	Jan. St. 06	Jan.St. 08	
Population 3	May St. 06	May St. 07				
Population 4	Jul. St. 03	Sep. St. 02	Sep. St. 05	Nov. St. 03	Nov. St. 09	Jan.St. 09
Population 5	Jul. St. 04	Sep. St. 01				
Population 6	May St. 08					
Population 7	Mar. St. 04	Mar. St. 05	Jan. St. 04			

Table 6. Similarity analysis showing the percentage similarity index of the population of fish larvae Dendrogram of Cluster analysis of fish larvae in AoTrat and Chang channel between March 2014 and January 2015

Within groups	Average similarity	Genus	Similarity percentage
1	34.26	Gobiidae	26.74
		Nemipterus	21.88
2	37.39	Gobiidae	64.20
3	66.51	Selar	74.60
4	39.11	Nemipterus	82.00
5	44.49	Cynoglossus	100.00

Conclusion

From the data collected among March 2014-January 2015 showed that the fishes were spawning year round but the spawning peaks were March and September. And the March spawning was greater than September. The spawning areas were near shore closed to the open sea. Furthermore, the study of the spawning area of the fish larvae needs more sampling data at least3 or 4 years data. This study data was only one year study, the result was only an approximated.

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