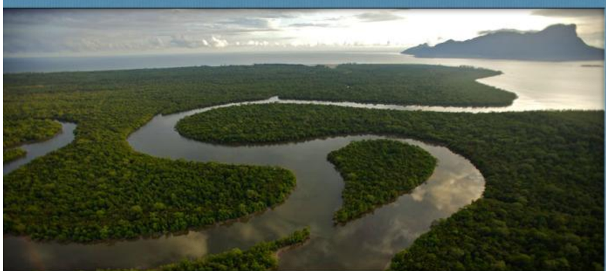
Bay of Bengal Large Marine Ecosystem Project



Stock assessment of Hilsa shad, *Tenualosa ilisha* in Myanmar

BOBLME-2015-Ecology-22

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Executive summary

Population dynamics and stock assessment of *Tenualosa ilisha* was undertaken using the length frequency based analysis of FiSAT software to evaluate the key parameters such as asymptotic length ($L\infty$), growth co-efficient (K), growth performance (ϕ'), total mortality (Z), natural mortality (M), fishing mortality (F), recruitment pattern (R), exploitation rate (E), length frequency distribution and catch rate in three different inland and three different marine regions in Myanmar waters. This study reveals that the *Tenualosa ilisha* fish are harvested at a higher level than the optimum fishing mortality. This fishing pressure should be reduced to obtain more sustained production. New policies for hilsa fishery should also be enforced.

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Acronyms used

ANOVA	Analysis of Variance
BFRI	Bangladesh Fisheries Research Institute
BOBLME	Bay of Bengal Large Marine Ecosystem
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ELEFAN	Stock assessment software package
FAO	Food and Agriculture Organization
ICLARM	International Centre for Living Aquatic Resources Management
LOA	Letter of Agreement
LWR	Length-Weight Relationship
RAP	Region Asia-Pacific
FiSAT	Fisheries Stock Assessment Tool

1. Introduction

The Government of the Union of the Myanmar has advocated "break away from poverty" as a long-term national development target. The fishery sector is considered as the most important one after the agriculture sector to fulfill the protein requirement of the people in Myanmar and to provide the food security as well as to get the opportunity for the employment to a large number of fisher communities and rural dwellers. Myanmar is endowed with rich natural resources both in freshwater and marine fisheries. Nowadays, the increasing pressures from industrial and urban development and increased demand for fish and fishery products owing to population growth as well as global climate change can cause damage and degradation of ecosystems including fisheries resources.

The Hilsa shad, *Tenualosa ilisha,* belongs to the sub-family Alosinae of family Clupeidae (Herring family). The scientific name of the species, *Hilsa ilisha* has been revised recently to *Tenualosa ilisha* (Hamilton, 1822), but the popular name "Hilsa" has been used for more than a century. Hilsa inhabits a wide range of distribution and is found in coastal shelf, estuaries and freshwater rivers of the western division of the Indo-Pacific region, and extends from Iran and Iraq in the Persian Gulf to the west coast of India in the Arabian Sea, and the Bay of Bengal in marine distribution. It also has been recorded from the coastal waters of Sri Lanka and Cochin China (Laos) (Pillay and Rosa, 1963, Preston, 2004).

In Myanmar, Hilsa fishery has been existing for a long-time and Hilsa fishery is a very old livelihood for Myanmar local people who live in the coastal region. Hilsa occurs in inland, marine, and coastal waters and is harvested throughout the year (Mya Than Tun, 2001). Generally, the two species of Hilsa fish (*Tenualosa ilisha* and *T. toli*) are found to be dominant (Hla Win *et al.*, 2008). *T. ilisha* (Hilsa shad) is locally known as, "Nga Tha Lauk" in Myanmar.

These species have a great commercial value, and is considered the commercial fish of the country and contribute to the national economy, employment and export (Hla Win *et. al*, 2008, San Aung 2003). The export in 2012-13 was 12 324 tonnes worth US$ 33.93 million and Hilsa ranks second to Rohu (cultured freshwater species) in terms of export volume and value. Considerable quantities of Hilsa are also consumed in Myanmar and the total landings are therefore higher than given in the official export records. However, no reliable data and Hilsa fish assessment survey program results were available in the past.

Different aspects of biological work of Hilsa have been investigated by different authors (San Aung,2003; Kalayar Win Maung, unpublished; Hla win *et al*., 2008; Khin Htwe Win, unpublished, Khin Thuzar Win, unpublished; Mya Than Tun, 2001) but there are no reliable data on stock assessment of this species in Myanmar.

In order to promote collaborative hilsa fisheries management plan between sub-regional working partners such as Myanmar, Bangladesh and India, FAO/BOBLME Project has provided support to identify hilsa stock structure through the measures of length weight frequency distribution of the catches in Myanmar. The Letter of Agreement (LOA/RAP/2012/36) was signed between the Department of Fisheries (Ministry of Livestock, Fisheries and Rural Development) and FAO country representative in Myanmar in September 2012.

The aim of this research is to develop a bio-economic model of the hilsa fishery which can be used as a first step towards improved management of this fishery. More precisely, the objectives of the present study are:

- ✓ To calculate the optimal sustainable yield for the hilsa fishery in Myanmar.
- ✓ To compare the current situation with the optimal fishery.
- ✓ To find an economically and socially acceptable path from the current level of fishing effort to the optimal sustainable yield level.

The present study was undertaken to estimate the key parameters of stock assessment and the population dynamics of *T. ilisha* such as asymptotic length ($L\infty$) , growth co-efficient (K), growth performance (ϕ'), total mortality (Z), natural mortality (M), fishing mortality (F), recruitment pattern (R), length frequency distribution and catch rate in three different inland and three different marine regions.

This study and results will provide baseline information concerning the bio-economics of the hilsa fishery. On that basis, recommendations for regulating the fishing effort over time leading to the hilsa recovery process may be derived. On the basis of our findings, policy makers will be able to design management policies based on a comprehensive optimal sustainable yield level for the hilsa fishery and thus, hopefully, prevent further biological and economic decline of the hilsa fishery.

2. Materials and methods

2.1. Study area.

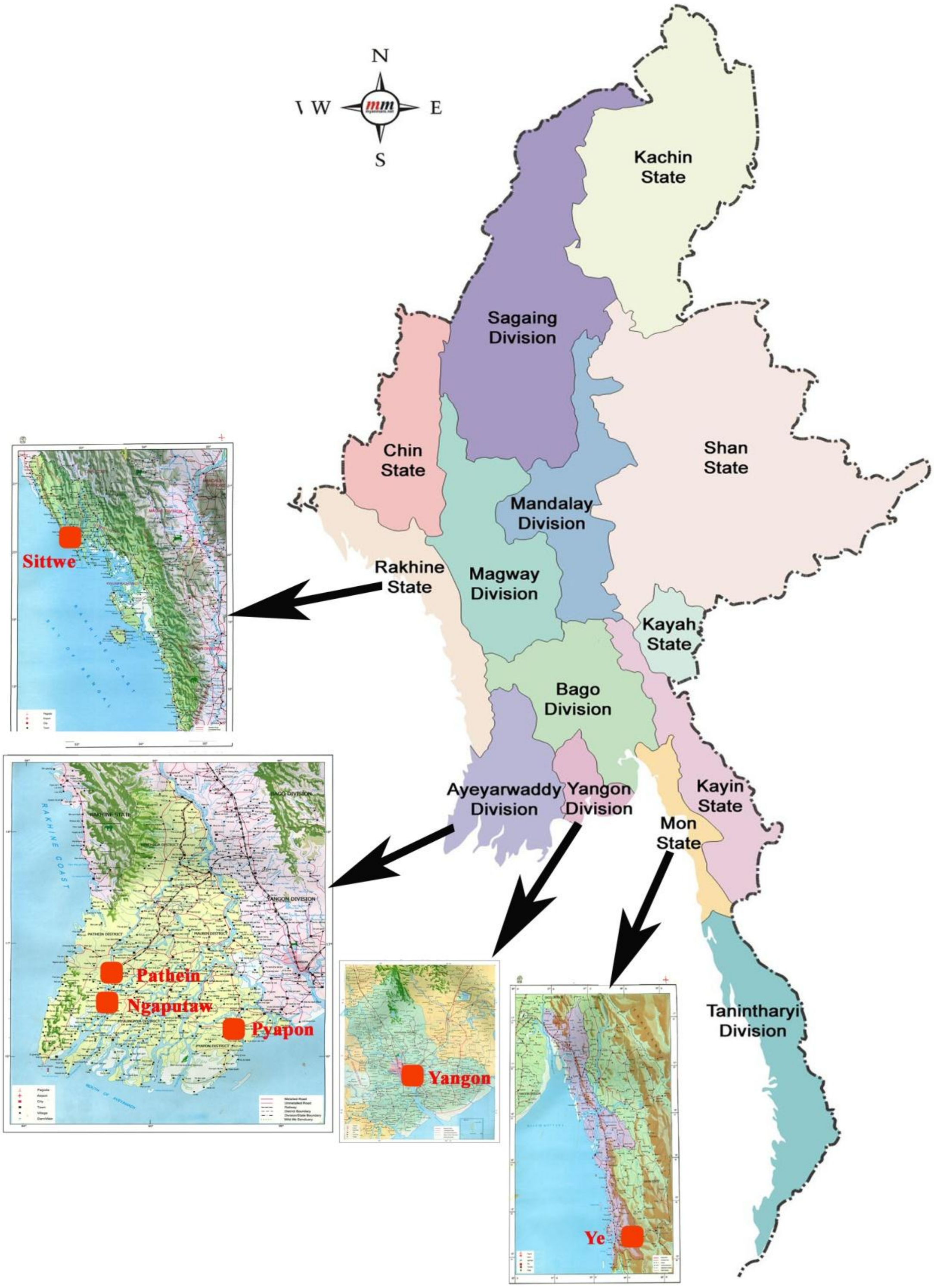

Figure 1. Geographical location of study areas in Myanmar.

As Inland stations, Pyapon, Eastern Delta (16°17′ 01.74′′N and 94°41′ 13.10′′E), Ngaputaw, Southern Delta (16°32′ 14.51′′N and 94°41′ 37.00′′E) and Pathein, Northern Delta (14°46′ 13.79′′N and 94°43′ 33.17′′E) were selected automatically, due to virtue of their importance to the hilsa fishery and the facilities available. To cover the marine and Inland, there are three marine stations that were selected namely Sittwe, East coast of the Bay of Bengal (20°08′ 36.89′′N and 98°53′ 50.89′′E), Yangon, Delta coast (16°46′ 55.13′′N and 96°07′ 14.33′′E) and Ye, Southern coast of Andaman Sea (15°14′ 58.79′′N and 97°51′ 20.50′′E). All sampling stations were designed based on previous hilsa information and preliminary survey (Figure 1).

2.2. Sampling and identification of specimens

Sample collections of hilsa fishes were conducted on fish landing sites. Colour patterns and measurements of the samples were recorded immediately after collections. Also for later studies, specimens were photographed, using digital camera and then preserved in 10 percent formaldehyde solution. The total body length (from the snout to the hind tip of the upper caudal lobe) or Total length (TL) of fish was measured by using both measuring tape and measuring board.

The standard texts such as Day (1878), Berg (1940), Munro (1955), Lagler, Bardack and Moller (1962), Tint Hlaing (1971), FAO species identification sheets (1974), Wan Tin (1976), Wynn Hhin (1980), Jayaran (1981), Polly Soe (1984), Whitehead (1985), FAO species identification sheets (1985), Walter (1990), Talwar and Jhingran (1991), De Bruin *et al.* (1995), Ye Ye Win (1997), Mya Than Tun (2001) and Hla Win *et al.* (2008) for identification and classification of the species. This study followed the following abbreviations proposed by Day (1878): D (Dorsal fin rays), P (Pectoral fin rays), V (Ventral fin rays), C (Caudal fin rays), A (Anal fin rays) and B (Branchiostegals).

2.3. Length frequency data

Length-frequency data of *T. ilisha* were collected monthly from the commercial catches from the landing stations of Pyapon, Ngaputaw, Pathein, Sittwe, Yangon and Yae from October 2012 to September 2013. These samples of *T. ilisha* were mainly caught by Trammel net in inland and drift gill net in marine waters. The total number of 7782 of T. ilisha was measured from the snout to the hind tip of the upper caudal lobe using measuring board or measuring tap calibrated in centimeters as total length. Fish were measured to the nearest centimeters and were weighed by balance, to the nearest gram (g). The data were then pooled monthly from different landing stations and subsequently grouped into classes of 2 cm intervals.

Finally, the length frequency data were analysed with FiSAT (Gayanilo *et al.* 2002) to estimate the population parameters such as asymptotic length (L_α), growth coefficient (K), natural mortality (M), fishing mortality (F) and exploitation level (E). The growth performance of hilsa population was computed using the index of Pauly and Munro (1984):

$$\phi' = \mathrm{Log}_{10}K + 2\ \mathrm{Log}_{10}\ L_\infty$$

Total mortality (Z) was estimated using the length converted catch curve method. Natural mortality rate (M) was estimated using Pauly’s empirical relationship (Pauly 1980):

$$\mathrm{Log}_{10}M = -\ 0.0066 - 0.279\ \mathrm{Log}_{10}\ L_\alpha + 0.6543\ \mathrm{Log}_{10}\ K + 0.4634\mathrm{Log}_{10}T$$

where, L_∞ is expressed in centimeters and T, is the mean annual environmental temperature in °C (28°C).

Fishing mortality (F) was obtained by subtracting M from Z and exploitation rate (E) was obtained from F/Z (Gulland 1971); where, F is the fishing mortality and Z is the total mortality.

2.4. Length-Weight Relationship (LWR)

This study is based on the random samples obtained monthly from the one landing station in Pyapon for the period of 12 months (October, 2012 to September 2013). The total length (TL) of *T. ilisha* was measured from the snout to the hind tip of the upper caudal lobe using measuring board or measuring tap calibrated in centimeter. Fish were measured to the nearest centimeter and were weighed by balance, to the nearest gram (g). Finally, the Length-Weight Relationship was determined by the methods of least square the formula, which was followed after Pauly (1983) as:

$W = a L^b$ where, W=weight of fish (g), L=Total length (TL) of fish (cm), a=constant (intercept), and b=length exponent (slope). When the parameter 'b' is equal to three, the growth is called isometric but the growth is positive allometric when the 'b' value is more than three and negative allometric when the 'b' value is less than three.

2.5. Catch rate

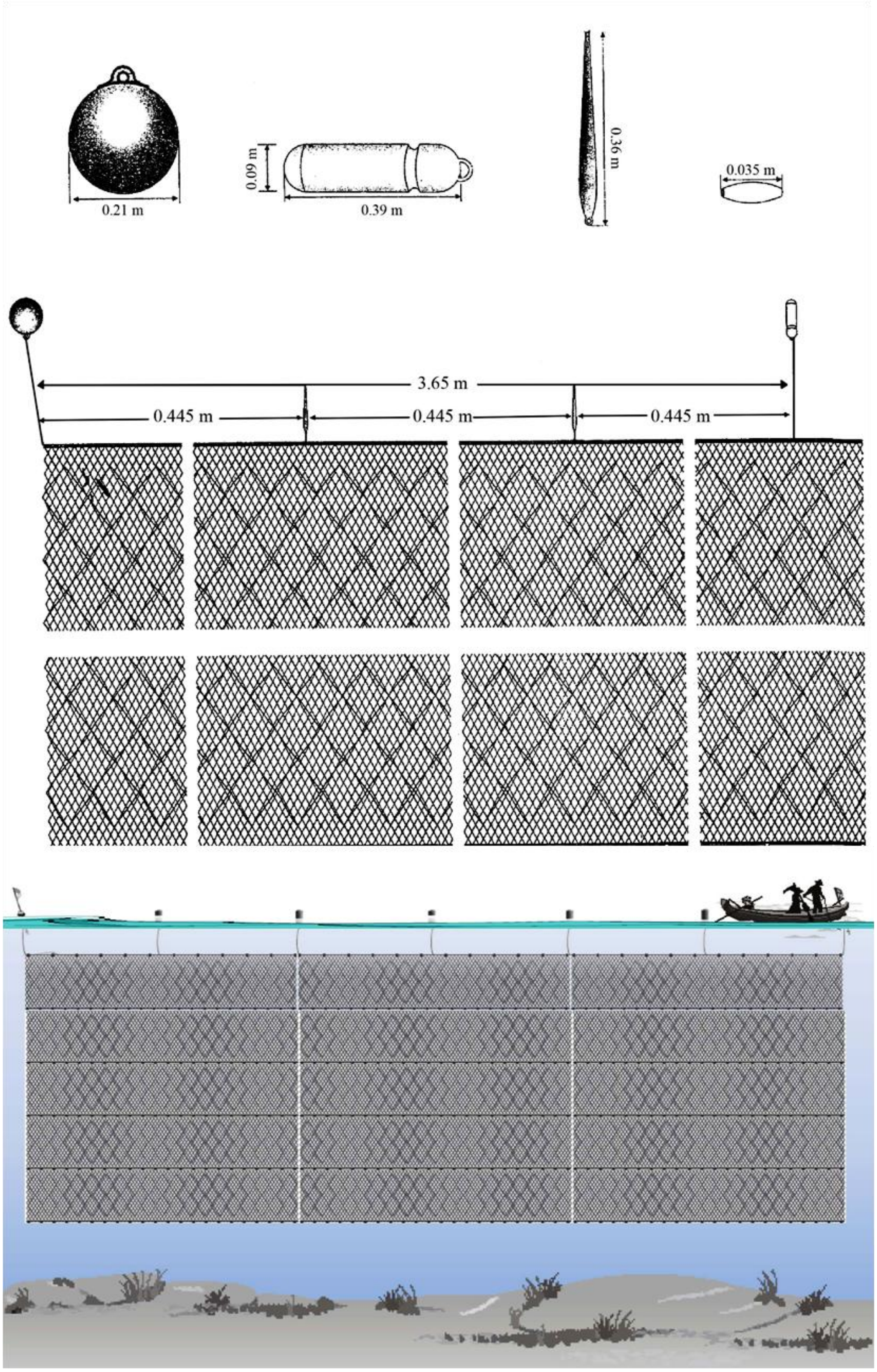

Figure 2. Trammel net in inland capture and its operating design

(Source: Inland fishing gear and method in Southeast Asia Myanmar, 2006).

In the inland stations (Pyapon, Ngaputaw and Pathein), there are 10 boats using trammel net, and sampling was conducted monthly from October 2012 to September 2013.

The length of the head rope of a net is 10 - 20 fathoms (18-36 m) and the height of the net is 4 – 5 fathoms (2-9 m). Depending on the river characters (i.e. water current), it is used by attaching three to four segments per net. The material of trammel net is made of nylon multifilament or monofilament. The mesh size of the inner net is 3½´´ – 4´´ (87.5 mm – 100.0 mm) and that of outer net is 18´´ – 20´´ (450 mm – 500 mm). Fishing by trammel net is operated either during day or night time and allowed to drift for one to two hours before hauling. One boat carries 2-3 fishermen and contains 20 – 25 nets (Figure 2).

In the marine stations (Sittwe, Yangon and Yae), there are 10 fishing vessel using drift gill net and sampling was conducted monthly from October 2012 to September 2013.

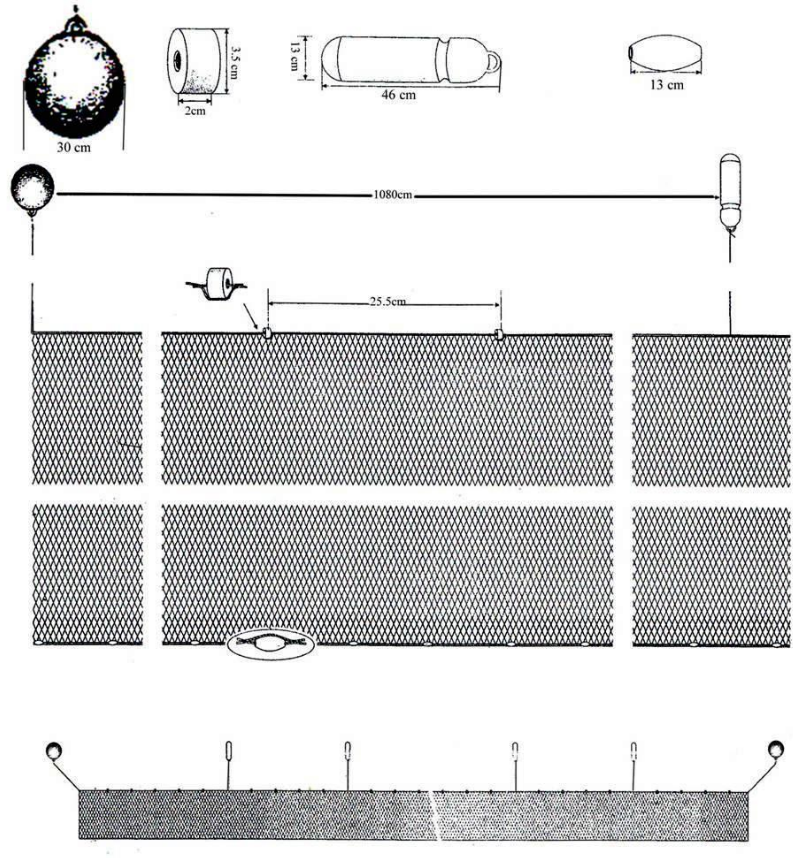

Figure 3. Drift gill net in marine capture and its operating design

There are many types of drift gill net used for different target species. Generally, their construction is a wall of net that is set across the water current and be allowed to drift according to the current direction. The head rope or float line is on the surface of the water or at mid–water buoyed by float. The lower part of the net is with or without a sinker line depending on the target species and the characteristics of the fishing ground. The head rope is kept on the surface or at a certain distance below it, supported by numerous floats (Sources: Khin Maung Aye *et al*., 2006). The length of the net varies, depends on the size of boat and financial ability of fishermen. It has an average length of 9 - 20 fathoms (16 m – 37 m) and height of the net is 4 - 5 fathoms (2 - 9 m). Depending on the target species and river characters, net is used by attaching three to four segments per net. The mesh sizes are from 2½´´ - 4½´´ (62.5 mm - 112.5 mm). It is made of multifilament and monofilament nylon. It is set at the depth of 17 - 28 fathoms (31 m - 51 m) (Figure 3).

Finally, the average catch rates (kg x boat^{-1} x month^{-1}) by observed boats were analyzed by one -way analysis of variance (ANOVA) in different study stations. If the overall ANOVA results were significant, Bonferroni pair-wise comparisons were calculated.

3. Results

3.1. Sampling and identification of specimens

There are two species under the subfamily of Alosinae, belonging to the family Clupeidae were recorded during the study periods as follow;

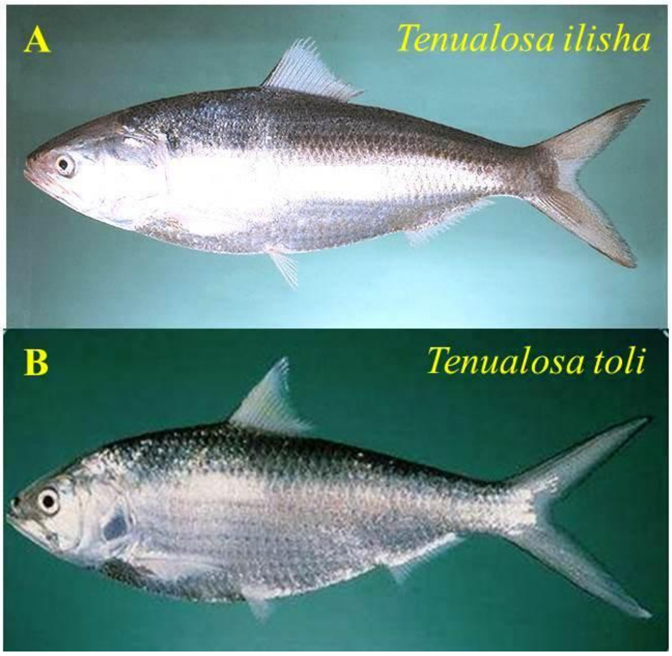

Figure 4. Different Hilsa species found in Myanmar.

Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Clupeiformes
Family	Clupeidae
Subfamily	Alosinae
Genus	*Tenualosa* (Fowler, 1934)
Species	*T. ilisha* (Hamilton-Buchanan, 1822) (Figure. 4 A)
	T. toli (Valenciennes, 1847) (Figure. 4B)

3.1.1. Tenualosa ilisha

Synonym	:*Clupanodon ilisha* Hamilton-Buchanan, 1822; *Clupea palasah* Cuvier,1829;*Macrura ilisha*, 1941; *Hilsa ilisha* Pillay, 1963; *Tenualosa ilisha* Wongratana, 1980
FAO name	: Hilsa shad.

Local name : Nga-Tha-Lauk

Meristic counts : Dorsal fin rays: 18-20; Pectoral fin rays: 14; Ventral fin rays: 7; Anal fin rays:18-21; Caudal fin rays: 24-28; Branchiostegals: 6.

Size : Maximum to 1 cm

Body oblong, compressed and fairly elongated in shape, brilliant silvery, dark blueish green on dorsal; a series of small spots along flanks in immature but present or absent spots in the adults; fins hyaline; tips of the caudal fin black, sometimes in its entire circumference; abdomen serrated with 18 pre-ventral scutes and 14 post ventral scutes; its depth is one fourth of total body length.

Head is moderate, compressed and high; its length is about one fourth of total body length; the top of head smooth with no fronto-parietal striae.

Mouth is terminal; lower jaw is slightly projects when open; maxillary cleft not extending to post orbit; both jaws are with thick lips and absent teeth, a distinct median notch present in upper jaw. Operculum is broad and moderately thick, with 3 – 4 opercles; pre-opercles rounded but post-opercle sub-rectangular and numerous faint striations present on it.

Eyes are large, lie in upper portion of the head region and nearer to the snout than the hind edge of the operculum, with yellowish iris and covered by broad adipose lids; its diameter is about one-fourth of pectoral fin.

Dorsal fin is moderately large and seems to be stout, inserts in advance of ventral fin origin and the upper edge of it is more or less concave. Pectoral fin commences below at the hind edge of the operculum and seems to be covered its origin by operculum and is as long as the dorsal fin. Ventral fins are small and as one half of the pectoral length. Anal fin is moderately long. Caudal is as deep as long, its lobes equal. All fins are soft with no species and branched at tips.

Scales are large, smooth, thin and cycloid type; cover the whole body and reach of the fin bases; with no on head; lateral line absent.

Occurrence : At all collecting landing stations.

3.1.2. Tenualosa toli

Synonyms : *Alausa toli* Valenciennes, 1847; *Alausa ctenolepis* Bleeker, 1852; *Macrura sinensis* Fowler, 1941; *Hilsa toli* Whitehead, 1965.

FAO name : Toli shad.

Local name : Nga-Tha-Lauk-Yaukpha.

Meristic counts : Dorsal fin rays: 17; Pectoral fin rays: 13-14; Ventral fin rays: 7-8; Anal fin rays: 19-20; Caudal fin rays: 24-26; Branchiostegals: 6.

Size : Maximum to 60 cm, common to 25-40 cm.

Body is fusiform, strongly compressed and fairly elongated in shape, silvery in colour and golden shot on flanks when fresh; dark greenish blue on back and on snout; a diffuse dark spot present on shoulder; fins are hyaline; Abdomen rounded with 17 pre-ventral scutes and 13 post-ventral scutes; its depth is about one-fourth of total length.

Head is short, compressed and high; its length is less than one- fifth of total body length; top of head is smooth with no fronto-parietal striae. Snout is short and rounded, a little more than eye's diameter, with a pair of slip-like nostrils.

Mouth is terminal; lower jaw slightly projects when open; lips are moderately thick; a distinct notch present at the centre of upper jaw; posterior part of maxillary blade reaches to below the middle of orbit; teeth absent on both jaws. Operculum is broad and thick, with 3 – 4 opercles , pre-opercles rectangular but post-opercle rounded; numerous faint striations present on it.

Eyes one large and with reddish iris, lie in upper portion of head region, nearer to the snout than the hind edge of operculum; its diameter is about one- third of pectoral length, and is covered by broad adipose lids.

Dorsal fin is moderate, originates a little advance of ventral fin origin; its base reaches to above as the origin of ventral fin; the pectoral is as long as dorsal, commences close below at the hind edge of operculum; the ventral fin is half of dorsal fin length; anal fin is short and two times of ventral fin; the caudal fin deeply forked and longer than the head length, its lobes are equal; all fins have no spines and branched at tip.

Scales are large and fairly thick, cycloid type, the arrangement of it is seemed to be rougher than that of it in *T. ilisha*; cover the whole body and at fin base, except on the pectoral and the ventral, which have axillary scale at base; no scales on head.

Occurrence : At all collecting landing stations.

3.2. Length-Weight Relationship

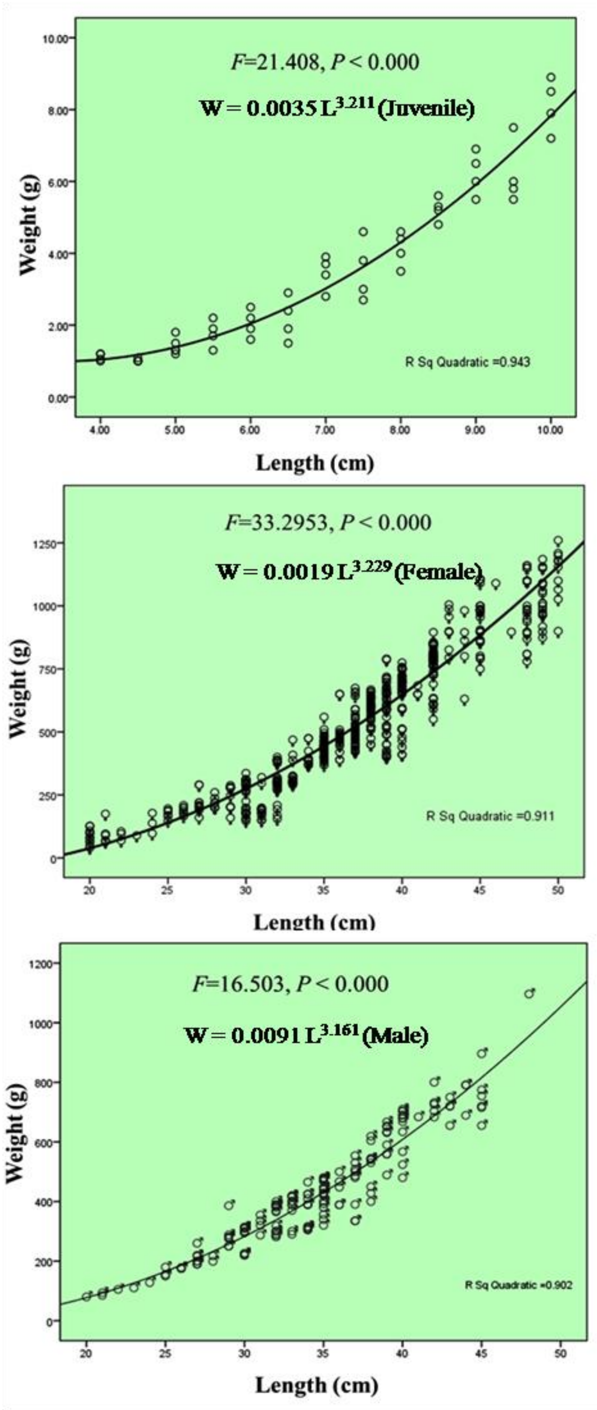

Figure 5. Length-Weight Relationship of *T. ilisha in* juvenile, male and female.

The Length-Weight Relationships of *T. ilisha* were significantly differed in juvenile, male and female. The Length-Weight Relationship was determined by the methods of least square using the formula, $W = a L^b$ for juvenile male and female are $W = 0.0035\ L^{3.211}$ (Juvenile), $W = 0.0091\ L^{3.161}$ (Male) and $W = 0.0019\ L^{3.229}$ (Female) respectively (Figure. 5).

3.3. Growth and mortality parameter

Table 1.Population parameters of *Tenualosa ilisha* in Myanmar water

(From October, 2012 to September 2013)

Parameters	Study areas					
	Inland water			Marine water		
	Ngaputaw	Pyapon	Pathein	Sittwe	Yangon	Yae
Asymptotic length (L_∞) cm	61.95	53.55	61.95	60.90	59.85	59.85
Growth constant (K) yr^{-1}	0.700	0.980	0.850	0.800	0.740	0.880
Growth performance (ф')	3.429	3.449	3.514	3.472	3.423	3.499
Natural mortality (M) yr^{-1}	1.154	1.498	1.310	1.266	1.208	1.271
Fishing mortality (F) yr^{-1}	2.810	1.299	1.954	2.198	2.207	1.873
Total mortality (Z) yr^{-1}	3.964	2.797	3.264	3.464	3.415	3.144
Exploitation level (E)	0.708	0.464	0.598	0.635	0.646	0.596
Sample number (N)	1477	971	1163	1485	1109	1577

The asymptotic length (L∞) and growth co-efficient (K) for *T. ilisha* were estimated in different study area respectively during October 2012 to September 2013 (Table 1). The computed growth curve with these parameters is superimposed over the restructured length distribution (Figure.6). The asymptotic length (L∞) varied from 53.55 to 61.95 cm. The lowest value of L∞ (53.55 cm) was recorded in Pyapon (Inland) while the highest value of L∞ (61.95 cm) was recorded in Ngaputaw and Pathein (Inland). The values of K varied from 0.70 to 0.98 yr^{-1}. The lowest value of K (0.70 yr^{-1}) was observed in Ngaputaw while the highest value of K (0.980 yr^{-1}) was in Pyapon. The values of growth performance index (ф') varied in the different areas from 3.423 to 3.499 (Table 1). Total mortality coefficient (Z) was estimated using length converted catch curve while the lowest value of total mortality of 2.797 yr^{-1} was in Pyapon (Figure 7). The natural mortality varied between 1.154 and 1.498 yr^{-1} in different areas and showed a little variation. However, fishing mortality estimates were more variable from 1.299 to 2.810 yr^{-1} (Table 1). The highest fishing mortality (2.810 yr^{-1}) was observed in Ngaputaw while the lowest (1.299 yr^{-1}) was in Pyapon (Table 1).

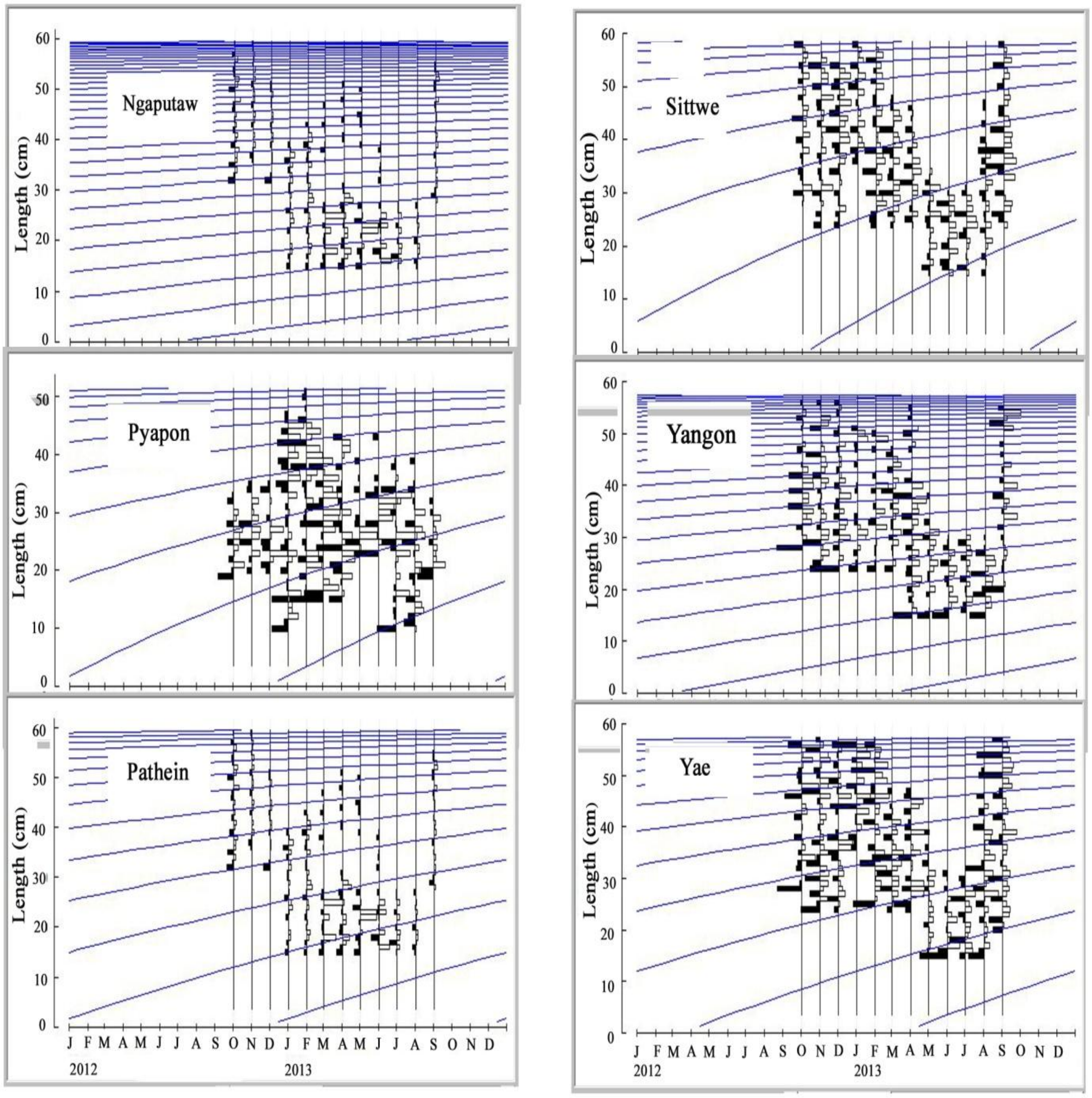

Figure 6. Growth curve of *T. ilisha* from different areas by ELEFAN I superimposed on the restructured length-frequency diagram.

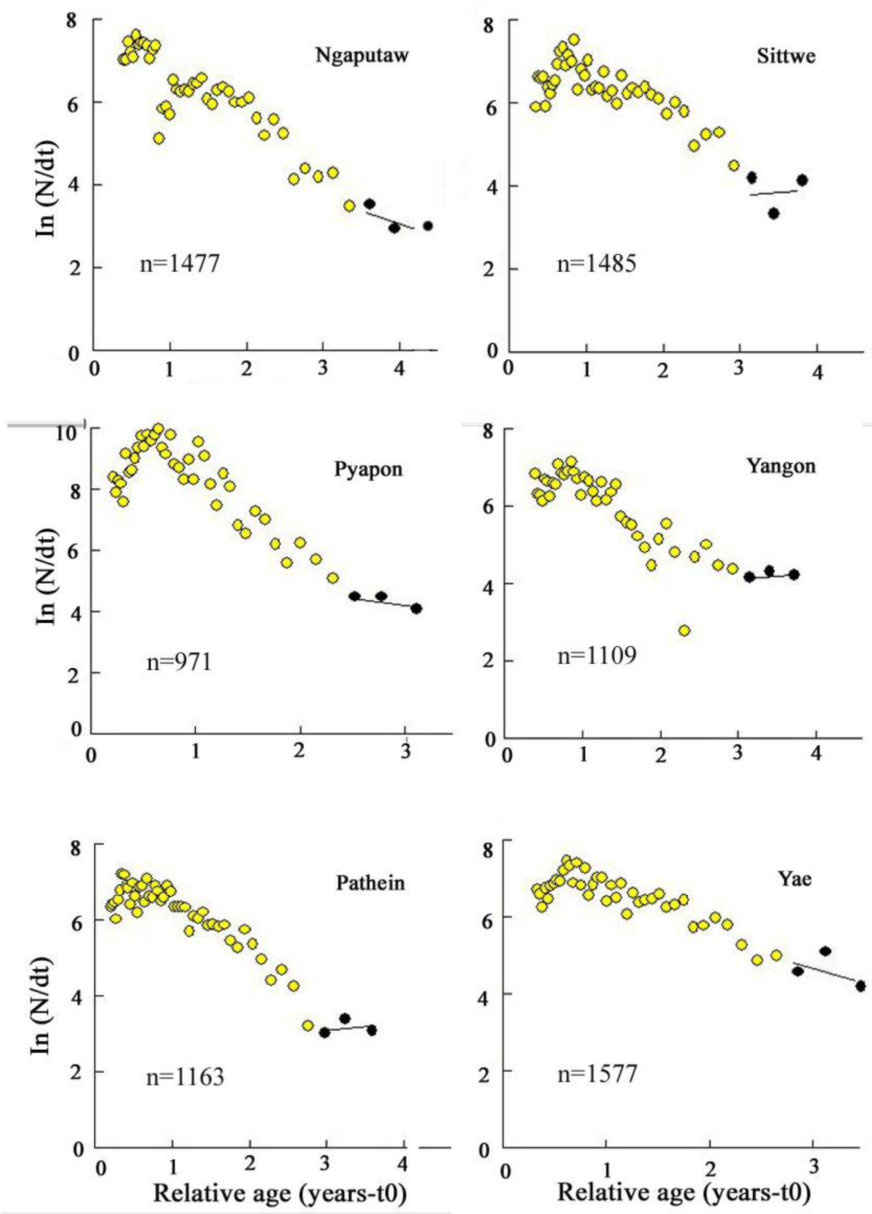

Figure 7. Length converted catch curve of *T. ilisha* in different study area

(The darkened full dots represent the points used in calculating through least square linear regression. The open dots represent the point not fully recruited).

3.4. Exploitation rate

The exploitation rate (E) estimate varied between 0.330 and 0.708 in different study areas. The exploitation rate Gulland (1971) assumed that suitable yield is optimized when F=M i.e., when E is more than 0.50, the stock is generally considered to be overfished. Therefore, exploitation rate 0.330 in Sittwe and 0. 464 in Pyapon were estimated as under the exploitation level (Table 1). Meanwhile, the E_{max} value recorded as 0.708 in Ngaputaw, 0.598 in Pathein, 0.646 in Yangon and 0.595 in Yae. The highest E_{max} value 0.708 is recorded in Ngaputaw. The higher value of E is indicated over fishing (Table 1).

3.5. Recruitment pattern

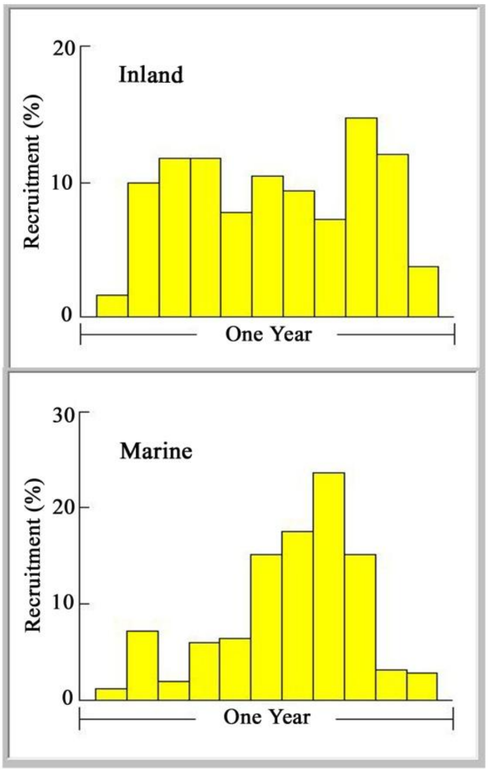

Figure 8. Recruitment pattern of *T. ilisha* in inland and marine water in Myanmar.

The recruitment pattern showed that *T. ilisha* was recruited in the fishery throughout the year with one peak in marine water and major peak and minor peak occurred in inland water (Figure 8).

3.6. Catch rate (weight) or catch composition

Average catch rate or catch composition (kg/boat^{-1}/month^{-1}) of *T. ilisha* was randomly collected at the study areas. These catch data had been recorded separately for inland water and marine capture.

3.6.1. Ngaputaw (Inland):

Different months showed significantly different catch rates (F=111.521, p <0.000, Figure 9). The average catch weight was high in October and November, accounted to 12.80 kg (18%) and 14.80 kg/boat (21%) respectively. After that the average catch weight were dwindled down until May but, the average catch weight was increased gradually from 2.6 kg in June to 7.0 kg in September. The lowest catch weight is occurred, accounted to 1.4 (2%) in May. The average catch were not significantly different in different months of December, January, February, March, April, July, August, September and May, June (Bonferroni pair-wise comparisons, Figure 9).

3.6.2. Pyapon (Inland):

Different months is significantly affected on catch weight (F=61.557, p <0.000, Figure 9). The fishing season of *T. ilisha* was observed from mid-January to February, which is the best time of the year for the catch of this species and the catch weight was high in January, amounted to 10.00 kg (20%) and 11.60 (11.60%) respectively. Another next season of catch was found from June to August while the catch weight was low during the periods October to December and March – May (Figure 9). At the lowest catch weigh was 0.6 kg in December. The average catch weight of *T. ilisha* observed in October, November, December, March, May and September was significantly lower than that found in January and February which differed significantly (Bonferroni pair-wise comparisons, Figure 9).

3.6.3. Pathein (Inland):

The average catch weight was significantly different from October 2012 to2013 February (F=73.980, p <0.000, Figure 9). The higher catch weight was 8.8 kg in February. Unfortunately, there was no data from 2013 March to 2013 September.

3.6.4. Sittwe (Marine):

Different months is significantly affected on catch weight (F=74.346, p <0.000, Figure 9). The highest catch weight was observed in November, amounted to 256 kg. The lowest catch weight had been recorded in June and July, amounted to 40 kg and 42.3 kg. The average catches weights of *T. ilisha* were not significantly different in the rest months (Bonferroni pair-wise comparisons, Figre 9).

3.6.5. Yangon (Marine):

Different months is significantly affected on catch weight (F=44.764, p <0.000, Figure 9). The best time for fishing is from October to February, with peak in December accounted to 495 kg respectively. The lowest catch weight was observed in May, amounted 124.80 kg. The average catches weight *T. ilisha* fished in March, April, June, July, August and September was significantly lower than that catch weight in November, December and February (Bonferroni pair-wise comparisons, Figure 9).

3.6.6. Yae (Marine):

Different months is significantly affected on catch rate (F=138.394, p <0.000, Figure 9). The average catch weight of *T. ilisha* was increased in April and May with amounted to 408 kg and 509.20 kg respectively. The next good fish month is observed in September. The average catch weights of remaining months were not significantly differed (Bonferroni pair-wise comparisons, Figure 9).

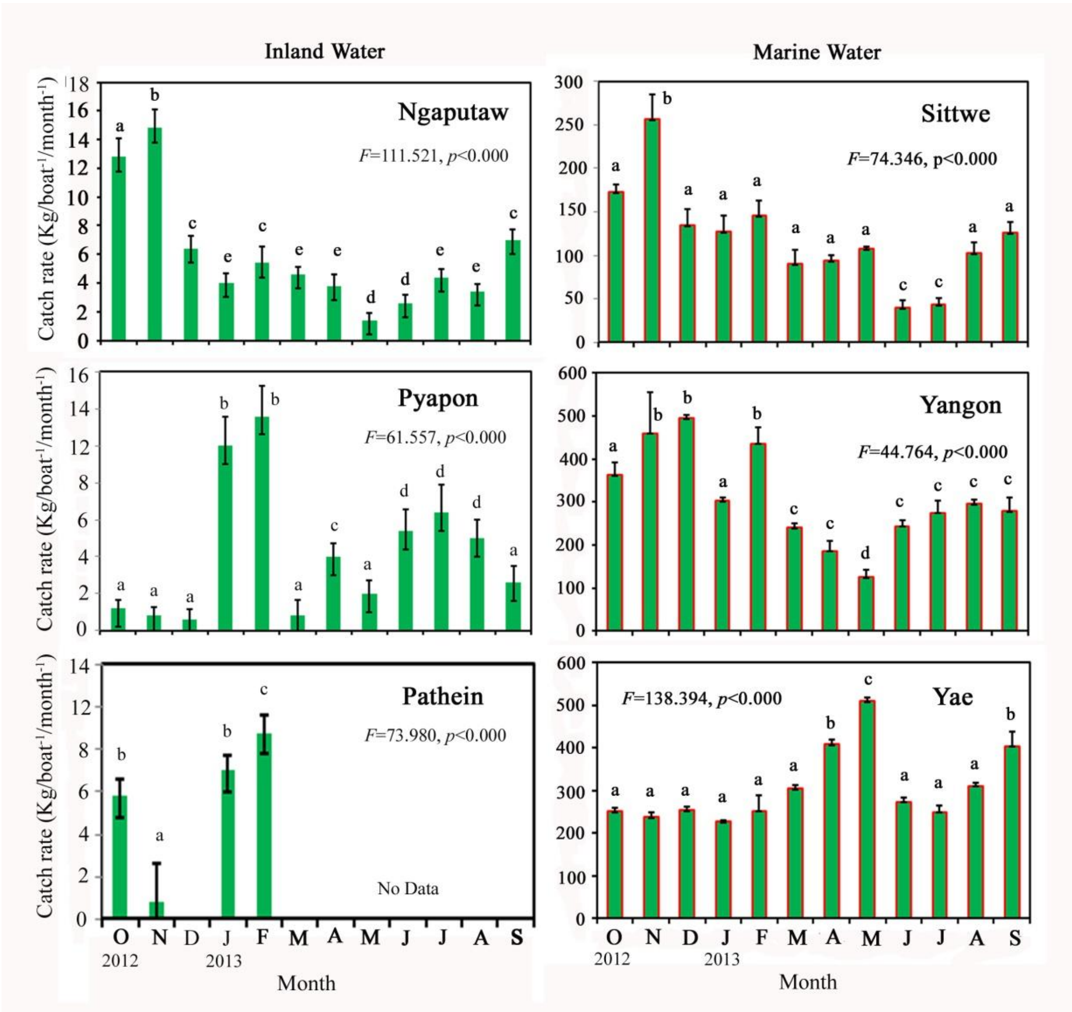

Figure 9. The average catch rate (kg × boat^{-1} × month^{-1}) in different study areas.

4. Discussion

In Myanmar, hilsa fishery has existed for a long-time and hilsa fishery is a very old livelihood for Myanmar local people who live in the coastal region. Hilsa occurs in inland, marine, and coastal waters and is harvested throughout the year (Mya Than Tun, 2001). These species have a great commercial value, and is considered the commercial fish of the country and contributes to the national economy, employment and export (Hla Win *et al.*, 2008, San Aung 2003). The export in 2012-13 was 12 324 tonnes worth US$ 33.93 million and Hilsa ranks second to Rohu (cultured freshwater species) in terms of export volume and value (DoF, Myanmar, 2013). Considerable quantities of Hilsa are also consumed in Myanmar and the total landings are therefore higher than given in the official export records.

The species *Tenualosa ilisha* was first reported as *Clupanodon ilisha* by Hamilton and Buchanan in 1822. In 1829, Cuvier has described it as *Clupea palasah*. Day (1878) had recorded this species as *Clupea ilisha*. In 1941, Fowler had compiled a list of shads and described the name of this species as *Macrura ilisha*. Rosa and Pillay (1963) had synopsized this species and reported it as *Hilsa ilisha*. In 1934, Fowler had included this species under the genus *Tenualosa*. In 1965, Whitehead had reported this species as *Hilsa* (*Tenualosa*) *ilisha*. Misra has described this species in his book of "Fauna of India" as *Macrura ilisha* in 1976. The earlier authors had described this species in various genera such as *Clupanodon*, *Clupea*, *Macrura* and *Tenualosa*. Although many authors included this species in the genus *hilsa*, Whitehead (1985) had replaced this species in the genus *Tenualosa* as *T. ilisha*. In 1991, Talwar and Jhingran followed this name for this species in "Inland Fishes of India and Adjacent countries". The name given by Whitehead (1985) is used here.

The estimated values of the growth parameters $L\infty$ and K for *T. ilisha* were 61.95 cm and 0.700 yr^{-1} in Ngaputaw, 53.55 cm and 0.980 yr^{-1} in Pyapon, 61.95 cm and 0.850 yr^{-1} in Pathein, 60.90 cm and 0.800 yr^{-1} in Sittwe, 59.85 cm and 0.740 yr^{-1} in Yangon, 59.85 cm and 0.880 yr^{-1} in Yae respectively. These values did not show much difference when compared to the $L\infty$ and K values estimated by the previous studies for the same species of Bangladesh waters (Rahman *et al.* 1998 and Rahman *et al*. 2000) and India waters (Krishna Swarup, 1965).

According to the previous studies mentioned that Length-Weight Relationship of any fish in any water bodies may be allometric (b < 3, 3> b) or isometric (b = 3) growth. In this study, the LWR of hilsa shad (*Tenualosa ilisha*) in different six areas have been measured during this study period. The length weight relationship of *T. ilisha* was found to be $W = 0.0035\ L^{3.211}$ (Juvenile), $W = 0.0091L^{3.161}$ (Male) and $W = 0.0019\ L^{3.229}$ (Female) respectively where 'b' value are 3.211 for juvenile, 3.161 for male and 3.229 for female so the growth of hilsa shad is observed to be positive allometric in nature. Additionally, one-way analysis of variance (ANOVA) showed that p value is less than 0.05 for both sex and juvenile. Reuben *et al*. (1992) established the LWR of Hilsa shad from northeast coast of India and the relationship is $W=0.00003693321\ L^{2.8053}$. The LWR of hilsa shad $W=0.00305\ L^{3.381}$ was calculated by Nurul Amin *et al*. (2005) from Bangladesh water and Sachinandan Dutta *et al*. (2012) described that $W=0.000006\ L^{3.109}$ in India water, which are indicating that the weight increases with the cube of length in Myanmar water.

The highest fishing mortality was calculated as 2.810 yr^{-1} in Ngaputaw while the lowest was observed as 1.299 yr^{-1} in Pyapon. The instantaneous total mortality (Z) estimated using the length converted catch curve during the present study was 3.964 yr^{-1}. This value is higher than that of the Z values estimated for the same species in Bangladesh water, which were 3.77 yr^{-1} (S.M.Nurul Amin *et al*.2002).

The exploitation rate (E) estimate varied between 0.464 and 0.708 in different study areas. The exploitation rate Gulland (1971) assumed that suitable yield is optimized when F=M *i.e.*, when E is more than 0.50, the stock is generally considered to be overfished. In this study, the exploitation rate is more than 0.50 in five study areas and, the rest one exploitation rate also very close to 0.50

which indicates that the high overfishing condition of hilsa fishery in Myanmar as compared to Bangladesh where the exploitation rate is 0.66 (S.M. Nurul Amin *et al*. 2002).

In this study, the recruitment pattern were observed that this species was recruited in the fishery throughout the year with one peak in marine water but, more than one time recruited in inland water. These findings are consistent with those of previous studies that mentioned that the highest GSI value (18.89 ± 8.49) with the ovarian weight (114.51 ± 81.64 g) was recorded in October, which was the major peak and the lowest GSI value (0.11 ± 0.28) with the ovaries weight (0.65 ± 0.53 g) was found in July in inland water of Myanmar (Khing Myat Myat Htwe, 2012, Unpublished). Faltas (1983) also mentioned that mature and ripe stages of some species of family Clupeidae and other pelagic fishes were dominant during the months of summer and autumn. Therefore, spawning time may occur twice a year in inland water.

Average catch weight or catch composition (kg × boat^{-1} × month^{-1}) of *T. ilisha* differed significantly in all studied areas. In accordance with catch composition in marine water, it is more favorable in Yangon than in Sittwe and Yae. On the whole, the best times for exploitation of Hilsa from marine capture is from September to February but April to May is much better in Yae. In inland capture, the catch composition of hilsa in the Ngaputaw is better than that of Pyapon and Pathein although this species shows difference in composition in seasonal abundance in these areas. On the whole, the best time to capture the hilsa from inland in the Ngaputaw started from September to November, while that in Pyapon, from January to February and June to August.

5. Conclusions

Since production of a specific population is the combination of the growth increments and survival of individuals, the numbers of individuals present, their individual weight and their growth, curve in weight are basic parameters in estimating production and very important for proper exploitation and management of the population of fish species. The information on LWR of these commercially important *T. ilisha* fish helps to manage their stock in Myanmar. The results clearly indicate that *T. ilisha* species is over-exploited in Myanmar. Therefore, the exploitation rate of adults should be reduced either by decreasing the number of fishing boats or by mesh size regulations. From the above results it could be concluded that the recruitment pattern of the fish revealed that it recruits in the fishery throughout the year. Hence, measures need to be taken to minimize the juvenile hilsa fishery by banning the use of nets that catch juveniles and increasing community awareness of the issue of juvenile catch among the fishers. This would greatly help to minimize juvenile hilsa fishery in Myanmar. According to the present study finding, fishing pressure is very high and it is essential to reduce this to obtain more sustained production. New policies for hilsa fishery should also be enforced.

In order to promote awareness of the need for a comprehensive study of an important hilsa fishery in Myanmar, the program should be more extensive in scope and more intensive in some areas; it requires fairly sizeable funding and should be undertaken during the future second phase of the Bay of Bengal Large Marine Ecosystem Project.

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