*Asian Fisheries Science* **29** (2016):14-27

ISSN 0116-6514

The Journal of the Asian Fisheries Society

# Population Dynamics and Fishery of Roughear Scad *Decapterus tabl* Berry 1968 (Perciformes: Carangidae) in Camotes Sea, Central Philippines

**CHARINA I. NARIDO[1,4*], HERMINIE P. PALLA[2,4], FRANCIS ALBERT T. ARGENTE[3,4] and PAUL JOHN L. GERALDINO[4]**

[1] Mathematics and Science Department, Holy Name University, Tagbilaran City, Bohol, 6300 Philippines

[2] College of Fisheries and Aquatic Science, Western Philippines University – Puerto Princesa Campus, Puerto Princesa City, Palawan, 5300 Philippines

[3] Department of Fisheries, Pangasinan State University – Binmaley Campus, Binmaley, Pangasinan, 2417 Philippines

[4] Marine Biology Section, Department of Biology, University of San Carlos, Cebu City, 6000 Philippines

## Abstract

Population dynamics and fishery status of the roughear scad, *Decapterus tabl* Berry 1968 caught from Camotes Sea, Central Philippines were investigated. Asymptotic length ($L\infty$) was 32.55 cm while growth coefficient ($K$) was 0.97 year$^{-1}$. Total mortality ($Z$) was 5.57 year$^{-1}$ while natural mortality ($M$) and fishing mortality ($F$) were 1.71 year$^{-1}$ and 3.86 year$^{-1}$ respectively. Exploitation level ($E$) was 0.69. The length at which 50% of the fish were retained by the gear ($L_{50}$) was 17.48 cm. The recruitment pattern was continuous with one major peak in the months of February-March. The coefficient "*b*" of the length-weight relationship (LWR) was 2.986 (±0.178) indicating isometric growth while results of the length-length relationships (LLRs) were highly correlated ($r^2$ =0.99, $p$<0.01).

The fishery of roughear scad revealed mean monthly catch per unit effort (CPUE) and income per unit effort (IPUE) ranging from 0.83-11.48 kg$\cdot$man$^{-1}\cdot$h$^{-1}$ and 73.10-1247.80 peso$\cdot$man$\cdot$h$^{-1}$ (1.72-29.39 USD) while total catch was estimated at 144,856 tonnes during the study period. High $Z$ and $F$ suggest that the roughear scad is facing high level of exploitation in the Camotes Sea. It is recommended that the reproductive biology should be studied to properly address the fishing pressure confronting this species.

*Corresponding author. E-mail address: charinanarido@gmail.com

## Introduction

The roughear scad, *Decapterus tabl* Berry 1968 is morphologically distinguishable from other red species of the genus *Decapterus* by its more rounded body, hooked upper jaw tip, partly serrated opercular membrane in adults and pectoral fin tips which do not reach vertically through the origin of the second dorsal fin (Berry 1968; Kimura et al. 2013). This species is reported to occur in 38 countries throughout the Pacific, Atlantic and Indian Oceans (Froese and Pauly 2015). In the Philippines, roughear scad is one of the target *Decapterus* fish resources and is subject to heavy exploitation by commercial fishing. *Decapterus* species, collectively known as roundscads is ranked first in the production of commercial fisheries in the country (DA-BFAR 2014).

Population assessment studies were conducted in some members of the genus *Decapterus* including *D. kurroides* Bleeker 1855 (Lavapie-Gonzales 1991), *D. macrosoma* Bleeker 1851 and *D. russelli* Cuvier 1833 (Ingles and Pauly 1984) in the northern and southern part of the Philippines using length frequency data. Most of the *Decapterus* related studies had gained momentum in the 70's, 80's and early 90's whereas published studies on life history patterns (e.g. biology & ecology) such as stock assessment for the roughear scad are not available elsewhere in the country.

Camotes Sea is one of the highly extracted marine habitats (DENR-PAWB 2009) and major source of fish in Central Visayas (Green et al. 2004). The roughear scad is one of the important small pelagic fishes supporting the commercial fishery in the area. This species has a high market demand locally due to its cheaper price relative to other pelagic fishes. Despite its significant contribution to the fishery and economic value, there are no adequate data pertaining to this species in the Camotes Sea or any part of the country. This study was undertaken to investigate the population dynamics and fishery of the roughear scad. Primarily, fish population assessments are conducted in order to generate accurate scientific data to provide advice on the optimum exploitation of the resource. The objectives of the present study were to establish the population parameters and fishery demographics of the roughear scad caught from Camotes Sea.

## Materials and Methods

This study was conducted at Danao City fish port, Cebu ($10^0$31.024'N, $124^0$01.745'E), a major fish landing area for commercial fishing from Camotes Sea (Fig. 1). Camotes Sea has an estimated area of 4,310 $km^2$ with majority of its portion within the Central Visayas jurisdiction (Green et al. 2004). A total of 6,160 length data of roughear scads caught by ring net and purse seine were collected monthly from August 2012 to July 2013. A minimum of 25 subsamples were gathered every month and brought to the laboratory for further processing. Total length (TL), fork length (FL) and standard length (SL) were determined to the nearest 0.1 cm while weight was measured to the nearest 0.01g. The individual sample was dissected for sex determination. Total length data were grouped at 2 cm intervals and subsequently analysed using the FISAT II software (Gayanilo et al. 2005).

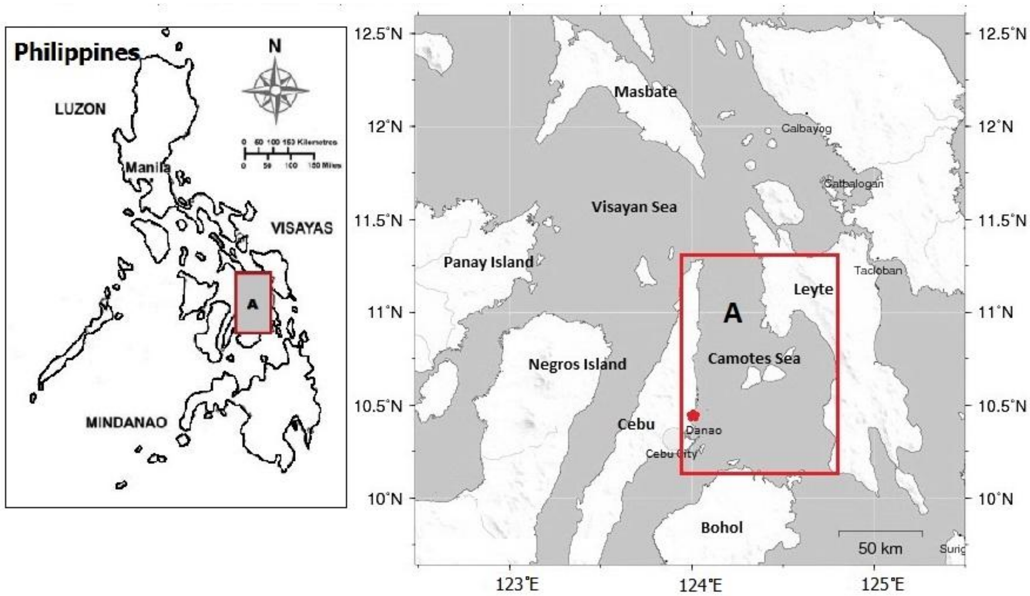


**Fig. 1**. Sampling site (star-shaped) where roughear scad caught from Camotes Sea were collected. Camotes Sea has an estimated area of 4,310 km$^2$ (Green et al. 2004).

Asymptotic length (L∞) and growth coefficient (K) of the von Bertalanffy growth function (VBGF) were estimated by means of ELEFAN I (Pauly and David 1981). The estimates of L∞ and K value were used to estimate the growth performance index (Φ') (Pauly and Munro 1984) using the equation: $\Phi' = 2\log10L\infty + \log10K$

The inverse von Bertalanffy growth equation (Sparre and Venema 1998) was used to find the lengths at various ages. The VBGF is defined by the equation: $Lt = L\infty\,[1 - e^{-k(t-to)}]$ where Lt is the mean length at age t, $L\infty$ the asymptotic length, $K$ the growth coefficient, t the age and $t_0$ is the hypothetical age at which the length is zero (Pauly and David 1981).

The total mortality (Z) was estimated by a length converted catch curve method (Pauly 1984). Natural mortality rate (M) was estimated using the empirical relationship of Pauly (1980):$\log_{10}M = -0.0066 - 0.279 \log_{10} L\infty + 0.6543 \log_{10}K + 0.4634 \log_{10}T$ where $M$ is the natural mortality, $L\infty$ the asymptotic length, $K$ refers to the growth coefficient of the VBGF and $T$ is the mean annual habitat temperature (taken at 28 $^0$C) of the water in which the stocks live. After the estimation of $Z$ and $M$, fishing mortality ($F$) was estimated: F = Z –M where $Z$ is the total mortality, $F$ the fishing mortality and $M$ is the natural mortality. The exploitation level (E) was estimated by the relationship of Gulland (1971): E = F/Z  F / (F+M).

Catch curve analysis was extended to estimate probabilities of capture using logistic transformation of $L_{25}$, $L_{50}$ *and* $L_{75}$ (lengths at which 25, 50 and 75% of *D. tabl* will be vulnerable to the gear). The recruitment pattern of the stock was determined by backward projection on the length axis of the set of available length–frequency data as described in FISAT. Levels of exploitation were also determined using the FISAT II software package.

The length-weight relationships were computed using the equation $W=aL^b$ (LeCren 1951) where W is the weight (g), L is the total length (cm), *a* is a coefficient related to body form and *b* is an exponent indicating isometric growth when equal to 3. The significance level of $r^2$ was estimated by linear regressions on the transformed equation, Log(W) = log a + b log (L). Moreover, (1) TL vs FL; (2) FL vs SL; and (3) SL vs TL relationships were calculated by linear regressions. To test for likely significant differences in both slope and intercept, covariance analysis was performed. All statistical analyses were evaluated at P<0.05 significance level.

For the fishery status of roughear scad, fishers from 34 commercial boats were interviewed from December 2012 to November 2013 using a prepared survey form. Pertinent information that were gathered included number of fishing days per week, type of gear and specification, number of fishers per boat, number of hours per fishing, number of hauls per fishing operation, fishing ground and depth, total catch per fishing operation and selling price per kilogram.

Catch Per Unit Effort (CPUE) was computed using the formula:

$$\text{CPUE} = \frac{\text{Total weight of catch (kg)}}{\text{No. of fishers (man)/ No. of hours spent in fishing (h)}}$$

Income Per Unit Effort (IPUE) was computed using the formula:

$$\text{IPUE} = \frac{\text{Total price of catch (peso)}}{\text{No. of fishers (man)/ No. of hours spent in fishing (h)}}$$

Catch estimate of roughear scad per month was standardised as kilograms per month and values were computed by direct relationship between mean monthly catch per unit effort (CPUE), actual fishing days and number of boat units. The total number of fishing days was computed by getting the mean number of fishing days operation per month excluding the days without fishing operation. The total number of boat units was based on the actual number of boat units operating each month. Catch was computed using the formula:

Catch estimate = mean monthly CPUE x actual fishing days x number of boat units

## Results

### *Population parameters*

The VBGF asymptotic length ($L\infty$) for the roughear scad was 32.55 cm and the growth coefficient ($K$) was 0.97 year$^1$ (Fig. 2). The observed maximum length was 31 cm and the predicted maximum length was 31.29 cm while the confidence interval was 28.47-34.10 cm (95% probability of occurence). The best estimated value for $K$ was 0.97 year$^1$ while the growth performance index ($\phi$') was 3.012.

The value of the third parameter in the von Bertalanffy growth equation is assumed to be 0 at $t_0$ (Pauly and David 1981). Hence the computed VBGF model of body length as a function of age generated the sizes reached by roughear scad at 12.73, 20.28, 25.20, 28.08, 29.83 and 31.64 cm at 0.5, 1, 1.5, 2, 2.5 and 3 years (Fig. 3). The average growth for the first year was 1.57 (+/- 0.46) $cm \cdot month^{-1}$, 0.58 (+/- 0.17) $cm \cdot month^{-1}$ in the 2nd year and 0.22 (+/- 0.06) $cm \cdot month^{-1}$ in the 3rd year. The maximum length recorded during the period of the study was 31.4 cm and the corresponding age was 3.4 years.

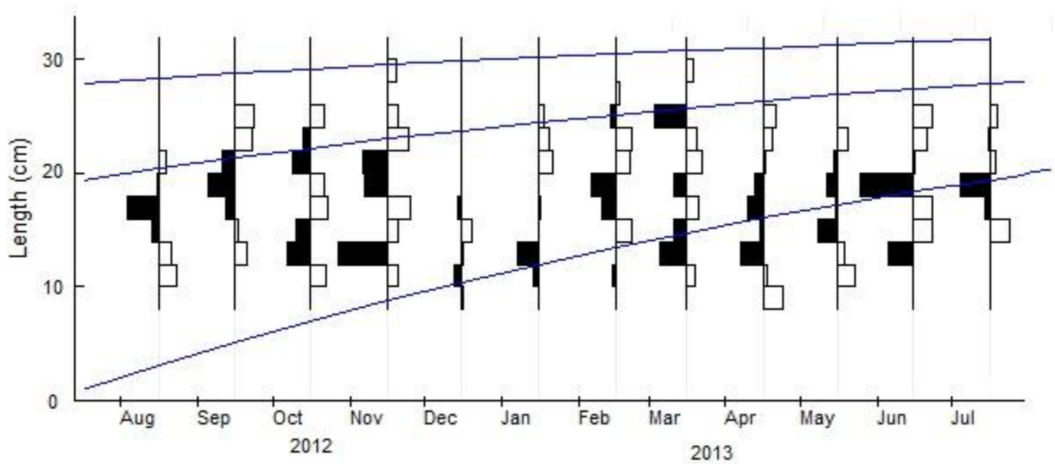


**Fig. 2**. Restructured length frequency data showing growth curves of roughear scad (n= 6,160).

The analysis of length converted catch curve generated a total mortality estimate of Z = 5.57 $year^{-1}$. The natural mortality (*M*) was estimated (for T=28 $^0$C) at 1.71 $year^{-1}$ and the fishing mortality was 3.86 $year^{-1}$. The current exploitation level was computed at 0.69 respectively (Fig. 4).

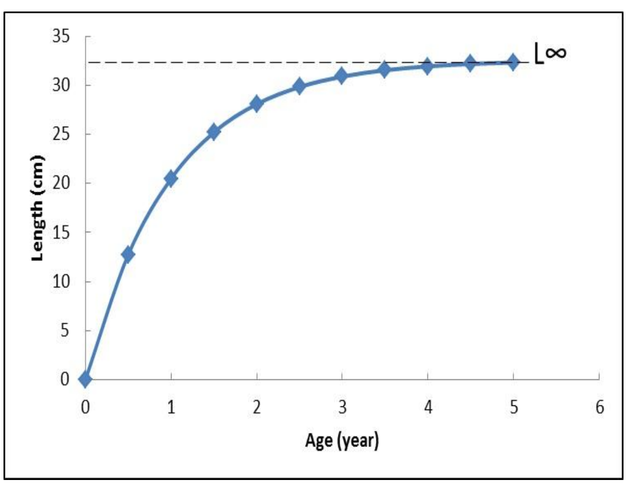


**Fig. 3.** Age and growth plot of roughear scad based on the computed parameters of the VBGF equation.

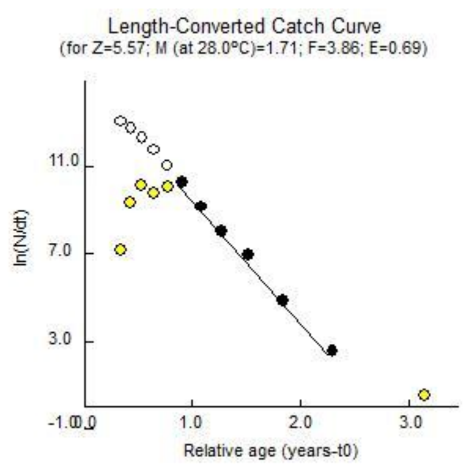


**Fig. 4**. Length converted catch curve of roughear scad.

The probability of capture for roughear scad was obtained from the analysis of length-converted catch curve using a logistic transformation to estimate $L_{25}$, $L_{50}$ and $L_{75}$. The linearised form of the logistic curve corresponded to regression values of $a$ = -10.61, $b$ = 0.61 and $r$ = 0.96, with $L_{25}$ = 15.67, $L_{50}$ = 17.48 and $L_{75}$ = 19.30 cm (Fig. 5).

The recruitment pattern of roughear scad was continuous through the year with a major peak observed during the months of February- March (Fig. 6). The observed peak of recruitment pulse during the study period was 38.16%.

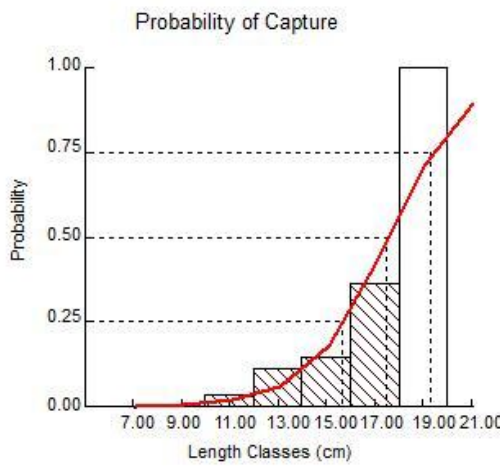


**Fig. 5**. Selection curve of roughear scad.

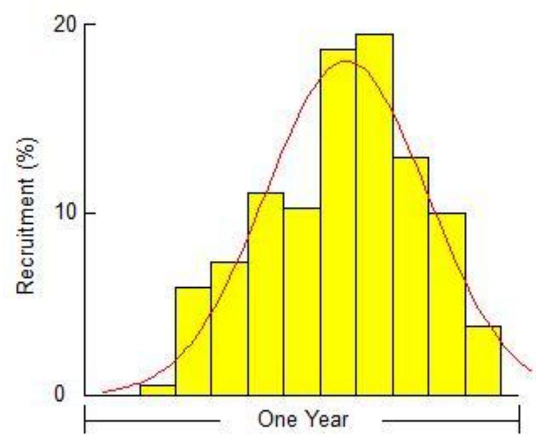


**Fig. 6.** Recruitment pattern of roughear scad.

Values acquired from the relative yield per recruit (Y'/R) analysis using selection ogive were used to determine the exploitation status. The exploitation status generated by the ratio of current exploitation rate ($E$=0.69) to the $E_{max}$ (0.69) ) indicated that *D. tabl* fishery in Camotes Sea has reached optimum exploitation ($E/E_{max}$ =1.0) while $E$ to $E_{10}$ (0.60) suggested overexploitation standing ($E/E_{10}$ = 1.148).

***Length-weight and length-length relationships***

Analysis of co-variance revealed non significant difference in growth in relation to length between the sexes hence the data for male and female were pooled together. The length of individual fish used to determine LWR ranged from 12.5- 31.4 cm and the weight from 15- 271.05 g (Fig. 7). The computed LWR equation in exponential form was $W = 0.0097L^{2.986}$, and in log form was log W = - 4.6325 + 2.9856log $L$ ($r^2$=0.98, p<0.05). The growth coefficient ($b$) was computed at 2.986 (±0.178) with $b$ values ranging from 2.63- 3.33. The $b$ value of LWR for roughear scad was not significantly different from 3 (T-test, $p$>0.05) indicating isometric growth.

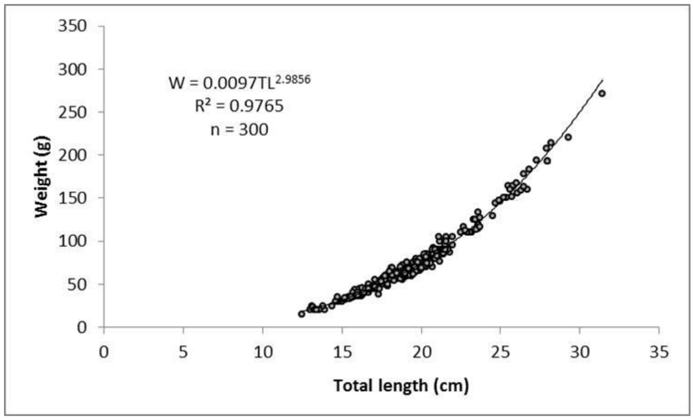


**Fig. 7.** Length- weight relationship of roughear scad.

The relationships between *TL*, *FL* and *SL* of roughear scad along with the estimated parameters of the length-length relationship and the coefficient of determination $r^2$ are presented in Table 1. All LLRs were highly significant ($p$<0.01), with all of the coefficient of determination values at 0.99.

**Table 1.** Descriptive statistics and length-length relationships between total length (TL), fork length (FL) and standard length (SL) of *Decapterus tabl* caught from Camotes Sea during August 2012 to July 2013.

| **Equation** | **n** | **L,mean ± SD ($L_{min}$ - $L_{max}$)** | ***a*** | ***b*** | ***r²*** |
|---|---|---|---|---|---|
| ***TL = a + b x FL*** | 317 | 18.36 ± 3.47 (8.3 – 31.4) | 0.089 | 1.003 | 0.99 |
| ***FL = a + b x SL*** | 317 | 16.63 ± 3.11 (7.5 – 28.5) | 0. 150 | 0.976 | 0.99 |
| ***SL = a + b x TL*** | 317 | 15.27 ± 2.90 (6.7 – 26.5) | - 0.216 | 1.011 | 0.99 |

(n: number of individuals, a: intercept, b: slope, $r^2$: coefficient of determination).

## *Fishery pattern*

Mean CPUE was highest in the month of February 2013 and lowest in June 2013 with values 11.48 and 0.83 $kg \cdot man^{-1} \cdot h^{-1}$. Mean IPUE was also highest in February 2013 and lowest in June 2013 with monetary values of 1247.80 (29.39 USD) and 73.10 (1.72 USD) $peso \cdot man^{-1} \cdot h^{-1}$ (Fig. 8). Mean monthly catch estimate was highest in February 2013 at 36,413 tonnes and lowest in June 2013 at 2,968 tonnes (Fig. 9). Mean CPUE, mean IPUE and mean monthly catch estimate were highly correlated ($p$<0.01). Total catch of roughear scad from December 2012 to November 2013 was estimated at 144,856 tonnes.

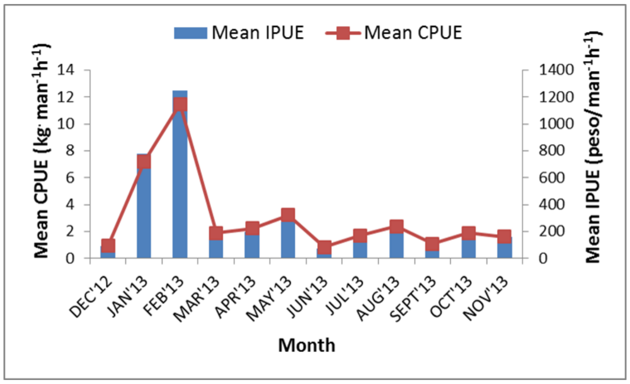


**Fig. 8.** Mean CPUE and Mean IPUE of roughear scad.

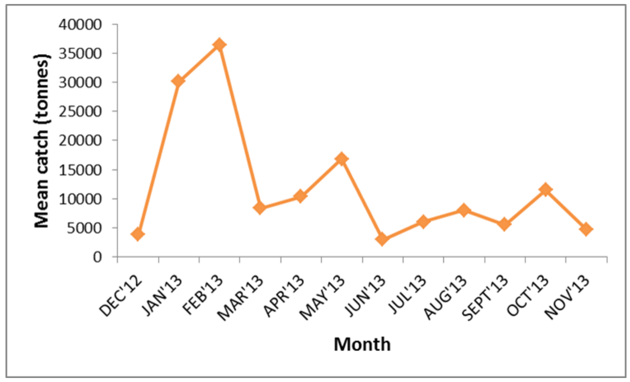


**Fig 9**. Mean monthly catch of roughear scad caught from December 2012 – November 2013.

## Discussion

### *Population parameters*

Despite of the utilisation of the roughear scad as one of the prime commodities in the fishery sector for years, it is confronted with a considerable dearth of information. However, its growth parameters, mortality rates and exploitation rates can be compared with other well studied congeners in the Philippines and in some parts of Asia (Table 2). The roughear scad is the largest *Decapterus* species in the Indo-west Pacific with a maximum size of 48 cm FL (Smith-Vaniz 1986); however the maximum size recorded in this study was only 31.4 cm TL. The smaller size obtained from this study could be the effect of fishing pressure resulting to growth overfishing or differences in environmental factors, particularly water temperature and food availability (Pauly 1998; Froese 2006). On the other hand, Ronquillo (1974) has indicated that scads may change from a pelagic to a demersal mode of life as they increase in size, hence larger fishes may not be caught by the gear. However, comparison using the available data on growth performance index (ϕ'), the value obtained for the roughear scad (ϕ'=3.012) suggested that it grows faster than the rest of its congeners locally and in other countries as well.

The length at age data extrapolated from VBGF equation (Fig. 3) revealed that roughear scad reached a size of 20.48 cm in 1 year which is about 62.9% of its asymptotic length. This result suggests that it grew very quickly in 1 year. The mean size at first capture, $Lc/L_{50}$ i.e. the length at which 50% of the fish is retained by the gear produced a value of 17.48 cm (Fig. 5) indicating that the species is exploited at the first year of its life. The annual mortality parameters, *Z*, *M* and *F* for roughear scad were estimated at 5.57, 1.71 and 3.86 year$^{-1}$. It is observed that fishing mortality (3.86 year$^{-1}$) was higher than natural mortality (1.71 year$^{-1}$) suggesting the unbalanced standing of the stock. Gulland (1971) has pointed out that a stock is optimally exploited if fishing mortality is equal to natural mortality; $F_{opt}=M$ or $E$=0.5 hence *E* higher than 0.5 suggests overexploitation.

**Table 2**. Population parameters of *Decapterus* species from the Philippines and from different countries.

| Location | Species | $L_\infty$ (cm) (TL) | K ($yr^{-1}$) | φ' | Z ($yr^{-1}$) | M ($yr^{-1}$) | E ($yr^{-1}$) | Source |
|---|---|---|---|---|---|---|---|---|
| Palawan | *D.macrosoma* | 30.0 | 0.74 | 2.82 | 5.79 | 1.47 | 0.75 | Ingles and Pauly 1984 |
| Manila Bay | *D.russelli* | 30.0 | 0.54 | 2.69 | 2.06 | 1.19 | 0.42 | Ingles and Pauly 1984 |
| Davao Gulf | *D.kurroides* | 25.0 | 0.80 | 2.39 | 4.31 | 1.62 | 0.62 | Lavapie-Gonzales 1991 |
| Leyte Gulf | *D.macrosoma* | 27.30 | 1.40 | ---- | 4.67 | 2.28 | --- | Lavapie-Gonzales et al. 1997 |
| Camotes Sea | *D.macrosoma* | 28.0 | 1.60 | | 5.13 | 2.47 | 0.51 | Lavapie-Gonzales et al. 1997 |
| Sulu Sea | *D.macrosoma* | 27.80 | 1.20 | --- | 7.25 | 2.05 | 0.72 | Lavapie-Gonzales et al. 1997 |
| Moro Gulf | *D.macrosoma* | 21.40 | 2.30 | --- | 4.25 | 3.38 | 0.20 | Lavapie-Gonzales et al. 1997 |
| Camotes Sea | *D.russelli* | 35.10 | 1.40 | --- | 6.71 | 2.13 | 0.68 | Lavapie-Gonzales et al. 1997 |
| Pujada Bay | *D.macarellus* | 24.30 | 1.80 | --- | 3.66 | 2.78 | 0.24 | Lavapie-Gonzales et al. 1997 |
| Tayabas Bay | *D.maruadsi* | 27.30 | 1.10 | | 5.39 | 1.95 | 0.64 | Lavapie-Gonzales et al. 1997 |
| Sulu Sea | *D.maruadsi* | 25.00 | 1.20 | --- | 3.51 | 2.11 | 0.40 | Lavapie-Gonzales et al. 1997 |
| Camotes Sea | *D.maruadsi* | 31.17 | 1.30 | --- | 6.86 | 2.10 | 0.69 | Lavapie-Gonzales et al. 1997 |
| Tawi-Tawi | *D.macrosoma* | 24.9 | 0.77 | 2.68 | 3.49 | 1.59 | 0.54 | Aripin and Showers 2000 |
| Camotes Sea | *D.tabl* | 32.55 | 0.97 | 3.01 | 5.57 | 1.71 | 0.69 | Present study |
| | | | | Other countries | | | | |
| Indonesia | *D.macrosoma* | 25.50 | 0.90 | 2.80 | ----- | ----- | ----- | Atmadja 1988 |
| Indonesia | *D. russelli* | 30.2 | 0.90 | | 4.8 | 1.80 | 0.60 | Widodo 1988 |
| India | *D. russelli* | 23.20 | 1.08 | ---- | 6.65 | 1.90 | 0.71 | Murty 1991 |
| Malaysia | *D.russelli* | 23.5-32.2 | 0.56-1.10 | 2.65 - 2.95 | 1.29 - 5.23 | 1.01-2.07 | 0.09-0.61 | Mansor and Abdullah 1995 |
| India | *D.russelli* | 24.0 | 1.42 | ---- | 7.75 | 2.63 | 0.66 | Jaiswar et al. 2001 |
| India | *D.macrosoma* | 23.8 | 0.75 | ---- | 1.78 | 1.42 | 0.2 | Rohit and Shanbhogue 2005 |
| India | *D. russelli* | 23.2 | 0.7 | ---- | 2.7 | 1.35 | 0.5 | Rohit and Shanbhogue 2005 |
| India | *D. russelli* | 27.10 | 1.22 | ---- | 3.79 | 2.08 | 0.49 | Manojkumar 2007 |
| India | *D. russelli* | 27.7 | 1.24 | | 6.66 | 2.1 | 0.68 | Poojary et al. 2011 |
| India | *D.russelli* | 25.60 | 0.95 | ---- | 4.61 | 1.81 | 0.61 | Panda et al. 2012 |

$L_\infty$ - Asymptotic Total Length; K - Growth Constant; **φ' –** Growth Performance Index; Z - Total Mortality; M -Natural Mortality; F - Fishing Mortality; E - Exploitation Rate

Based on Gulland's definition, the value of *E* (0.69) in this study appeared that roughear scad is overfished in the study area. On the other hand, $E_{max}$ value at 0.69 indicated that roughear scad has reached full exploitation at Camotes Sea and therefore catches were close to its maximum sustainable limits. Furthermore, based on $E_{10}$ which is the precautionary approach and is recommended by FAO code of conduct for responsible fisheries (FAO 1995), this present study obtained a value of 1.148 which suggests that it is already slightly overexploited. Given the high values of fishing mortality (*F*), exploitation rate (*E*) and ratio, it can be deduced that *D.tabl* stock in the study area is facing excessive fishing pressure. Similarly, the *E* values of scads that were studied at Camotes Sea revealed that *D.macrosoma* (0.51 $yr^{-1}$), *D. russelli* (0.68 $yr^{-1}$) and *D. maruadsi* (0.69 $yr^{-1}$) were also overfished including the majority of the scads in other locations (Table 2). The annual recruitment of roughear scad consisted of one seasonal pulse (Fig. 6) of which highest peak was observed in February and March with values 18.60 and 19.56 % respectively. This result suggests that only one cohort is produced per year. The unimodal recruitment pattern of *D. tabl* did not conform with the common bimodal recruitment seasons in the Philippines (Pauly and Navaluna 1984).

Moreover, single mode of recruitment was also observed in *D. macrosoma* and *D. russelli* from Palawan and Manila Bay waters (Ingles and Pauly 1984). In this study, roughear scad has protracted recruitment wherein major peak was observed at the end of the northeast monsoon. According to Pauly and Navaluna (1984), the onset of spawning and recruitment for most fish species in the Philippines are more likely an influence of monsoon seasonality. There is no published report on the spawning of *D. tabl* in the Camotes Sea; however the major recruitment peak observed in this study should conform to the spawning season of this species in the area. Conversely, a data from Fishbase acounted that this species from Suruga Bay, Japan (Iwasaki and Aoki 2001) showed a spawning activity from June to October; however no recruitment was reported.

***Length-weight and length-length relationships***

The growth coefficient *b* for most fishes lies within the expected range of 2.5- 3.5 (Froese 2006). Values of *b* closer to 3 indicate isometric growth while values that are significantly different from 3 suggest allometric growth (Pauly 1984). The estimated *b* (2.986) of the roughear scad was not significantly different from 3 (T-test, $p>0.05$) suggesting isometric growth. This result implies that the length and body weight of the fish increase in equal proportions (Pauly 1984) and small fish in the sample exhibit the same form and condition as large specimens (Froese 2006). The *b* values of male and female roughear scad caught from Camotes Sea were lower than those of the same species from Suruga Bay, Japan and Southwestern EEZ, Brazil (see Table 3). This study suggests that roughear scad from Camotes Sea has a slower growth resulting to its smaller size. According to Pauly (1998), metabolic rates increase with temperature and that growth is limited by respiratory metabolism thus tropical fishes generally tend to be smaller than their cold water counterparts. On the other hand, LLRs of the species are highly correlated ($p<0.01$) indicating that the increase of one length variable would also increase the growth of the other length variables (Table 1).

**Table 3**. Values of the coefficients "*a*" and "*b*" for roughear scad obtained from Fishbase.

| Location | Sex | Length (cm) | Length type | *a* | *b* | $r^2$ | Source |
|---|---|---|---|---|---|---|---|
| Suruga Bay, Japan | Female | 18 – 43 | FL | 0.00995 | 3.117 | 0.966 | Iwasaki and Aoki 2001 |
| Suruga Bay, Japan | Male | 18 – 43 | FL | 0.00979 | 3.185 | 0.968 | Iwasaki and Aoki 2001 |
| Southwestern EEZ of Brazil | Mixed | ______ | _____ | 0.00780 | 3.140 | ___ | Madureira and Rossi-Wongtschowski 2005 |
| Camotes Sea, Philippines | Female | 13.2-28.2 | TL | 0.0095 | 3.00 | 0.976 | Present study |
| Camotes Sea, Philippines | Male | 12.5-31.4 | TL | 0.0098 | 2.978 | 0.979 | Present study |
| Camotes Sea, Philippines | Mixed | 12.5-31.4 | TL | 0.0097 | 2.986 | 0.976 | Present study |

(*a*: intercept, *b*: slope, $r^2$: coefficient of determination, FL: fork length, TL: total length).

***Nature of fishery***

In the Camotes Sea, commercial catch was mostly composed of small pelagics of the carangid family that included *D. tabl, D. macrosoma, D. kurroides* and *Selar crumenophthalmus* Bloch 1793. Scads were caught daily except on occasions of bad weather and storm. During full moon, commercial fishing was aided by artificial light and sonar device. The current fishing gear used in the commercial fishery for scads was mainly operated by ringnet. During the study, 82% (28 boat units) were ring netters while 18% (6 boat units) were purse seiners. According to Green et al. (2004), trawl, bagnet and purse seine were the major fishing gears during the early 60’s but these have been replaced by ringnet during the 70’s. Ring netters and purse seiners set their operation during night time and they utilised "payaos" or fish aggregating devices, which were basically made up of floating bamboo and palm frond rafts with attached light that were anchored at the fishing ground. All fishing boats were highly motorised with gross tonnage from 10.35- 17.0. The length and depth of nets ranged from 220-400 m and 80-132 m respectively. Mesh size of nets ranged from 1.9-10.16 cm. Bigger boats had sonar device with associated boats that included a light boat and two carrier vessels while smaller boats had one light boat and a smaller carrier vessel. The number of fishers in the boat ranged from 20- 30 individuals. The depth at which they fished ranged from 40-180 m and the number of hauls varied from 1-4. Fishing operations lasted for 13-20 h including the time of departure from the landing area until they returned.

Based on the data extrapolated from the suvey (Dec. 2012-Nov. 2013), the mean CPUE and mean IPUE (Fig. 8) were highest in the month of February (11.48 $kg{\cdot}man^{-1}{\cdot}h^{-1}$/1247.80 $peso{\cdot}man^{-1}{\cdot}h^{-1}$ or 29.39 USD) and lowest in the month of June (0.83 $kg{\cdot}man^{-1}{\cdot}h^{-1}$/73.10 $peso{\cdot}man^{-1}{\cdot}h^{-1}$ or 1.72 USD). These results indicate that the higher the catch, the more revenue is generated from the resource even if prices are relatively low during peak season due to competition. The mean monthly catch started to increase in January with a pronounced peak in February followed by a minor peak in May (Fig. 9). On the contrary Trinidad et al. (1993) have reported that the highest production of its congeners in the Philippines happened between March and June ensuing the end of northeast monsoon and the beginning of southwest monsoon.

The finding of the present study is slightly advance since highest peak was detected at the end of the northwest moonsoon while the second less pronounced peak occurred in May. Dalzell and Penaflor (1989) opined that seasonal production rates of the bigeye scad *S. crumenophthalmus*, a close relative of *D. tabl* caught by ringnet at Camotes Sea could be due to a combination of actual changes in the biomass and behaviour of the fish. The same might be applied to roughear scad in the area. It was observed that *D. tabl* catch in the months of January and February showed bigger sizes than those that were caught in May. Disparity in the sizes may affect the production between these months. Furthermore, the slight deviation of the production peak of roughear scad from other members of the genus *Decapterus* as reported by Trinidad et al. (1993) may suggest some form of migratory behaviour of this species.

## Conclusion

There is no available literature dealing with the population dynamics and fishery of *D. tabl* in the Philippines hence no comparison can be made within the same species across the country. However, comparison can be made with others members of the genus *Decapterus*. The information given here provides a detailed investigation on the population dynamics and fishery of *D. tabl*. Furthermore, this study has shown high *Z* and *F* for *D. tabl* stocks in the Camotes Sea while *E* is beyond the optimum suggesting that this species is facing high level of exploitation. Moreover, it is recommended that the reproductive biology of the species should be studied so that effective scientific advice can be suggested to manage the fishery.

## Acknowledgements

The authors are grateful to the assistance provided by BFAR-VII NSAP Division during the preparation and implementation of the study. CIN, HPP and FATA thank the scholarship grant provided by PCAARRD-DOST. Finally, we sincerely extend our thankful appreciation to the three anonymous reviewers for their valuable comments which significantly improved the manuscript. This is a marine science contribution of the University of San Carlos, Cebu City, Philippines.

## References

Aripin, I.E and P.A.T. Showers. 2000. Population parameters of small pelagic fishes caught off Tawi-Tawi, Philippines. Naga, The ICLARM Quarterly 23:21-26.

Atmadja, S.B. 1988. Estimation of growth and mortality of round scad (*Decapterus macrosoma*) in the Java Sea, Indonesia. In: Contributions to tropical fisheries biology (eds. S.C. Venema, J. M. Christensen and D. Pauly), FAO Fisheries Report 389:324-345.

Berry, F. 1968. A new species of carangid fish (*Decapterus tabl*) from the Western Atlantic. Contributions in Marine Science 13:145-167.

Dalzell, P. and G. Penaflor. 1989. The fisheries biology of the big-eye scad, *Selar crumenopthalmus* (Bloch) in the Philippines. Asian Fisheries Science 3:115-131.

Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR). 2014. Statistics: Commercial fisheries production, 2013. Available at http://www.bfar.da.gov.ph/profile (accessed on 24 September 2015)

Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau (DENR-PAWB). 2009. Assessing progress towards the 2010 biodiversity target: The 4th national report to the Convention on Biological Diversity. DENR-PAWB, Quezon City, Philippines. 108 pp.

Food and Agriculture Organization (FAO). 1995. Code of conduct for responsible fisheries. Rome, FAO. 41 pp.

Froese, R. 2006. Cube law, condition factor and weight-length relationships: history, metaanalysis and recommendations. Journal of Applied Ichthyology 22:241-253.

Froese, R. and D. Pauly. (eds). 2015. FishBase 2015. World Wide Web electronic publication. Available at: http://www.fishbase.org (accessed on 28 July 2015).

Gayanilo, F.C.Jr., P. Sparre and D. Pauly. 2005. FAO-ICLARM stock assessment tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8, Rome, FAO. 168 pp.

Green, S.J., J.O. Flores, J.Q. Dizon-Corrales, R.T. Martinez, D.R.M. Nunal, N.B. Armada and A.T. White. 2004. The fisheries of Central Visayas, Philippines: Status and trends. Coastal 57 Resource Management Project of the Department of Environment and Natural Resources and the Bureau of Fisheries and Cebu City, Philippines. 159 pp.

Gulland, J.A. 1971. The fish resources of the ocean. Fishing news books, West Byfleet, England. 284 pp.

Ingles J. and D. Pauly. 1984. An atlas of the growth mortality and recruitment of Philippine Fishes. International Center for Living Aquatic Resources Management. Technical Report 123. 127 pp.

Iwasaki, Y. and M. Aoki. 2001. Length-weight relationship, maturity and spawning season of the northern mackerel scad *Decapterus tabl* Berry in Suruga Bay, central Japan. Bulletin Institute of Oceanic Research and Development, Tokai University 22:93-100.

Jaiswar, A.K., S.K. Chakraborty and R.P. Swamy. 2001. Studies on the age, growth and mortality rates of Indian scad, *Decapterus russelli* (Ruppell) from Mumbai waters. Fisheries Research 53:303-308.

Kimura, S., K. Katahira and K. Kuriiwa. 2013. The red-fin *Decapterus* group (Perciformes: Carangidae) with the description of a new species, *Decapterus smithvanizi*. Ichthyological Research 60:363–379.

Lavapie-Gonzales, F. 1991. Growth, mortality and recruitment of *Decapterus kurroides* in Davao Gulf, Philippines. ICLARM Fishbyte 9:6-9.

Lavapie-Gonzales, F., S.R. Ganaden and F.C. Gayanilo, Jr. 1997. Some population parameters of commercially-important fishes in the Philippines. Bureau of Fisheries and Aquatic Resources, Philippines. 114 pp.

Le Cren, E.D. 1951. The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal Animal Ecology 20:201-219.

Madureira, L.S.P. and C.L.D.B. Rossi-Wongtschowski. (eds). 2005. Prospecting pelagic fishery resources in the Exclusive Economic Zone of the Southeast-South of Brazil: hydroacoustic and biomass. Series Revizee documents: Score South, Oceanographic Institute, USP, São Paulo, Brazil. 144 pp .

Manojkumar, P.P. 2007. Stock assessment of Indian scad, *Decapterus russselli* (Rupell, 1830) off Malabar. Journal of the Marine Biological Association of India 49:76-80.

Mansor, M.I. and S. Abdullah. 1995. Growth and mortality of Indian mackerel (*Rastrelliger kanagurta*) and slender scad (*Decapterus russelli*) off the east coast of Peninsular Malaysia. Scientia Marina 59:533-547.

Murty, V.S.R. 1991. Observations on some aspects of biology and population dynamics of the scad, *Decapterus russelli* (Ruppell) (Carangidae), in the trawling grounds off Kakinada. Journal of the Marine Biological Association of India 33:396-408.

Panda, D., S.K. Chakraborty, A.K. Jaiswar, A.P. Sharma, B.C. Jha, B.T. Sawant, S.K. Bhagabati and T. Kumar. 2012. Fishery and population dynamics of two species of carangids, *Decapterus russelli* (Ruppell, 1830) and *Megalaspis cordyla* (Linnaeus, 1758) from Mumbai waters. Indian Journal of Fisheries 59:53-60.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal du Conseil / Conseil Permanent International pour l'Exploration de la Mer. 39:175–192.

Pauly, D. 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Studies and Reviews 8. 325 pp.

Pauly, D. 1998. Tropical fishes: patterns and propensities. Journal of Fish Biology, 53 (Supplement A) 1-17.

Pauly, D. and N. David. 1981. ELEFAN-I BASIC program for the objective extraction of growth parameters from length–frequency data. Meeresforschung 28:205-211.

Pauly, D. and J.L. Munro. 1984. Once more on the comparison of growth in fish and invertebrate. ICLARM Fishbyte 2: 21.

Pauly, D. and N. Navaluna. 1984. Monsoon-induced seasonality in the recruitment of Philippine fishes. In: Proceedings of the expert consultation to examine changes in abundance and species composition of neritic fish resources (eds. G. Sharp and J. Csirke). FAO Fisheries Report 3:262-271.

Poojary, N., L.R. Tiwari and S.K. Chakraborty. 2011. Stock assessment of the Indian scad, *Decapterus russelli* (Ruppell, 1830) from Mumbai waters. Indian Journal of Geo Marine Sciences 40:680-686.

Rohit, P. and S.L. Shanbhogue. 2005. Age and growth of *Decapterus russelli* and *Decapterus macrosoma* along Karnataka coast, India. Journal of Marine Biological Association of India 47:180-184.

Ronquillo, I.A. 1974. Status of the roundscad (*Decapterus* spp.) catch by purse seine. The Philippine Journal of Fisheries 12:102-113.

Smith-Vaniz, W.F. 1986. Carangidae. In: Smiths' sea fishes (eds. M.M. Smith and P.C. Heemstra), pp. 638-661. Springer-Verlag, Berlin.

Sparre, P. and S.C. Venema. 1998. Introduction to tropical fish stock assessment, Part 1-Manual. FAO Fisheries Technical Paper 306.1, Rev.2, Rome FAO. 407 pp.

Trinidad, A.C., R.S. Pomeroy, P.V. Corpuz and M. Aguero. 1993. Bioeconomics of the Philippine small pelagics fishery. ICLARM Technical Report 38. 74 pp.

Widodo, J. 1988. Population biology of russell's scad (*Decapterus russelli*) in the Java Sea, Indonesia. FAO Fisheries Report 389:308-323.

*Received: 10/11/2015; Accepted: 21/02/2016 (MS15-93)*