Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 5 (3): 179-190, 2010
ISSN 1816-4927

A Study on Diet Composition and Feeding Habitats of Sawtooth Barracuda (*Sphyraena putnamae*) in Bandar-Abbas (North of Persian Gulf)

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Abstract: The present study investigated feeding habits and diet composition of Sawtooth barracuda (*Sphyraena putnamae*) by regular monthly collection throughout 13 months from November 2006 to November 2007 in the Northern Persian Gulf. Sawtooth barracuda is considered as one of the valuable fishes in the Persian Gulf. The 486 specimens of *Sphyraena putnamae* were examined. The highest and the lowest observed Fork length and body weight was 10.6 and 93.0 cm and 8.03 and 40.0 g, respectively. The fork length-weight relationships was $W = 0.0071\ FL^{2.9295}$ ($R^2 = 0.99$). Studies have showed that this fish, having the Relative Length of Gut RLG = 0.34±0.002, is strongly carnivorous (meat-eater, often fish-eater), proven by the fact that more than 98% of its stomach contents are fish. The CV = 0.47% indicates the middle alimentary of this fish. Index of condition factor (K_f), increasing in March and decreasing in June. Gastro-Somatic Index (GaSI), indicating the highest level in the month of January and July and lowest level in June and October. The Fullness Index (FI) increases in March before spawning and decreases in June and September during spawning.

Key words: Sawtooth barracuda, feeding habits, gastro-somatic index, relative length of gut, Persian Gulf

INTRODUCTION

Sawtooth barracuda (*Sphyraena putnamae*) belongs to family of Sphyranidae, but is commonly known as sea wolf by the locals because of its fierce nature. However, *Sphyraena putnamae* is considered as an economically valuable fish.

Sphyranidae includes only one genus, *Sphyrenae* and having 21 species (Nelson, 2006). It is a pelagic to demersal fishes (Carpenter and Niem, 2001). There are some species of Barracudas in the Persian Gulf and Oman Sea that are seen as supplementary catches through different methods of fishing, such as Trolling, Trawling, Pole and lines, Gillnets, etc.

Barracuda has been an increasing source of fish supply to the Fisheries, as they are found traveling upon the surface of the Persian Gulf and Oman Sea waters more often than

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before in the recent years and thus, it has been considered among the ten prevailing species of fish living in these two significant hydro-ecosystems (Valinassab *et al*., 2004).

Four species of barracuda have been reported in the study area that are as follows:

- Big eye barracuda (*Sphyraenae forsteri*)
- Abtuse barracuda (*Sphyraena obtusata*)
- Pick handle barracuda (*Sphyraenae jello*)
- Sawtooth barracuda (*Sphyraenae putnamae*) (Asadi and Dehghani, 1997)

Gudger (1918) studied the morphology, habits and history of *Sphyraena barracuda*. Randall (1967) surveyed the feeding habits of two species of sphyraenidae (*Sphyraena barracuda* and *Sphyraena picudilla*) in West waters of Indian ocean. Sinha (1987) studied morphology and anatomy of the olfactory organs of a marine fish *Sphyraena jello*. Behavioral ecology of great barracuda represented by Paterson (2000). Barreiros *et al.* (2002) worked on food habits, schooling and predatory behaviour of the yellow mouth barracuda, *Sphyraena viridensis* (perciformes: Sphyraenidae) in the Azores. Porter and Motta (2004) studied on a comparison of strike and prey capture kinematics of three species of piscivorous fishes: Florida gar (*Lepisosteus platyrhincus*), redfin needlefish (*Strongylura notata*) and great barracuda (*Sphyraena barracuda*). Allam *et al.* (2004) studied reproductive biology of *Sphyraena* species in the Egyption Mediterranean waters of Alexandria, Egyption. Bachok *et al.* (2004) searched diet composition and feeding habits of demersal fishes in Terengganu in West coast of Penisular in Malaysia and in their study diet composition of *Sphyraena jello* and *Sphyraena obtusata* represented. Grubich *et al.* (2008) surveyed the functional morphology of bite mechanics in the great barracuda (*Sphyraena barracuda*). Hosseini *et al.* (2009) studied on feeding and spawning of *Sphyraena jello* in the North-West of Persian Gulf.

Sawtooth barracuda (*Sphyraenae putnamae*), is one of the most significant and abundant species among this family and due to its economic significance and due to the lack of any kind of information, considering that knowledge about the biological and habitat particulars of a aquatic animal can be valuable and is going to be an effective facilitating factor to increase the stable catches of the Fisheries, this present study has been undertaken.

It is noteworthy that, no studies have been so far done regarding the feeding habit of this fish in the Persian Gulf (Iran), therefore, this research can be considered the first one to be conducted in this field.

MATERIALS AND METHODS

Monthly sampling was done from November 2006 to 2007 through randomly sampling from landing in Bandar Abbas (Fig. 1) during 13 months. In May 2007 the Gonu storm occurred in Hormozgan Province and all fishing activities were banned until end of May because of the strong wind and the rough sea.

The samples were collected through different ways, including presence in the fish-sellers market, sampling from shrimp trawlers and also by taking samples of fish caught by the research cruises for the determination of the biomass of demersal fishes conducted by R/V Ferdows-1. Fish were captured by Trolling, Trawling, Gillnets and line and hook.

During the 13 months study and discussion, totally 486 *Sphyraenae putnamae* were completely assessed biometrically and in the biometric assessment, total length and fork length were measured with the accuracy of 0.5 cm, total weights and the stomach weights

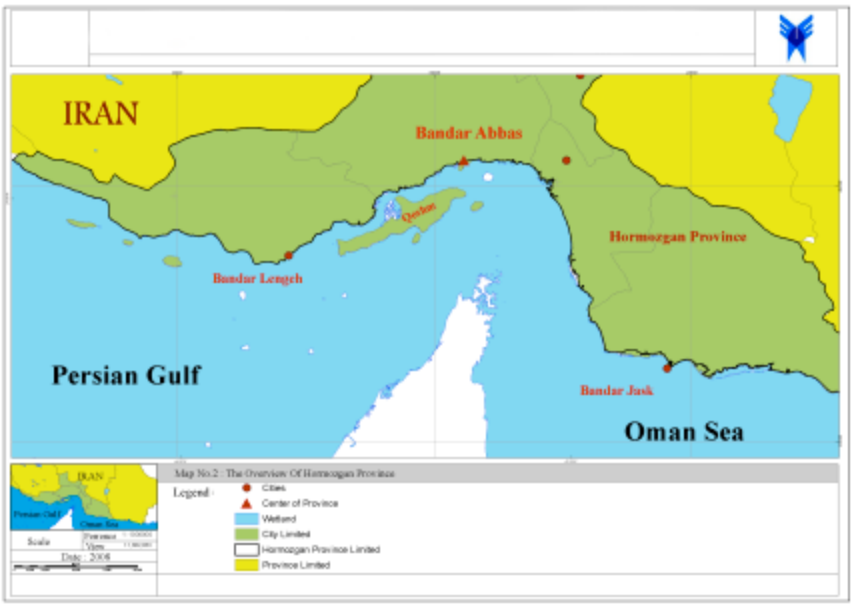

Fig. 1: The map of the sampling area of *Splyraenae putnamae*

of the sampled fishes were measured with the accuracy of 0.1 g through the use of a digital balance.

The weight of the stomach and the intestine along with the contents and then the weight of the contents of stomach and intestine were measured to be approximately 0.01 g and then was recorded along with the determination of the type of eaten food and thereby determining the feeding strength (digestive ability) in the stomach and intestine of *Splyraenae putnamae*. All food items in the gut were identified to the most precise taxonomic level, i.e., genera, whenever possible (Asadi and Dehghani, 1997; Fischer and Bianchi, 1984; Randall, 1995).

The weight method was used to analyze the stomach contents (Biswas, 1993). The length of gut was measured with the accuracy of 0.5 cm in order to obtain the Relative Length of Gut (RLG) and the same value was recorded. The Relative Length of Gut (RLG) was calculated through the following equation (Al-Husainy, 1949):

$$RLG = \frac{\text{Length of gut}}{\text{Total length}}$$

If the amount of RLG is less than 1, the fish will be carnivorous (meat-eater) and if more than 1, it tends to be herbivore and the medium size indicates it to be omnivore.

Calculation of Gastro Somatic Index (GaSI) is a useful and an efficient way for comparing the scale of feeding (food consumption) during various months and for determining the environmental and physiological effects on feeding habits. The Gastro-Somatic Index, GaSI, for each month was obtained through the following equation (Desai, 1970):

$$GaSI = \frac{\text{Weight of gut}}{\text{Body weight}} \times 100$$

Condition factor (k_f) resulting from feeding habit was calculated through the following formula (Hile, 1936; Biswas, 1993):

$$K_f = (W/L^3)\times 100$$

Where:
K_f = Condition factor
W = Body weight
L = Total length

Based upon the stretch of the muscles of the stomach and the volume of the food within it, the degree of Fullness Index (FI) was divided into three categories: full, semi-full and empty and FI was calculated through the following equation (Dadzie *et al*., 2000):

$$FI = \frac{\text{No. of stomachs with the same degree of fullness}}{\text{Total No. of the stomachs examined}}\times 100$$

Stomach emptiness index (CV) determines the amount of the fish's appetite for feeder (food). The stomach emptiness index was obtained through the following equation (Euzen, 1987):

$$CV = (ES/TS)\times 100$$

Where:
CV = Stomach emptiness index
ES = Empty stomachs
TS = Total stomachs examined

The interpretation of the obtained CV is determined under the following conditions (Euzen, 1987). If,

- $0 \le CV < 20$, the logical conclusion is that the fish is gluttonous
- $20 \le CV < 40$, the fish is comparatively gluttonous
- $40 \le CV < 60$, the fish is middle alimentary
- $60 \le CV < 80$, the fish is comparatively hypoalimentative
- $80 \le CV < 100$, the fish is hypoalimentative

Given that the stomach content of this fish *Sphyraenae putnamae* consisted of more than 98% of different types of fishes, therefore, it was impossible to calculate the food preference in this research.

The relation between length and weight of this fish, based on the modeling for all the population, was obtained through the following equation (Biswas, 1993):

$$W = aL^b$$

Where:
W = Body weight (g)
L = Total length (cm)
a = Coefficient
b = Slope

RESULTS

In this study, 486 *Sphyraenae putnamae* were examined. The minimum and maximum FL was 10.6 and 96.5 cm, respectively and the lowest and the highest body weight was 8.03 and 4140.0 g. The most fork length frequency of the females was between 44-48 and of the males between 39-43 cm and the peak of weight frequency of the females and the males, in weight groups, was 451-600 and 301-450 g, respectively.

Based on the information about the obtained fork length and weight, the exponential relation between length-weight characterized by male, female and male-female was calculated using an exponential equation.

Amount of inclined line (gradient curve) according to sex, were as follow: 2.8857, 2.9049 and 2.9995. The exponential relation of fork length-weight in males is:

$$BW = 0.0086\ FL^{2.8857}\ (R^2 = 0.99)$$

The exponential relation between Fork length-weight in females is:

$$BW = 0.0078\ FL^{2.9049}\ (R^2 = 0.98)$$

The exponential relation between the fork length-weight in both males and females = $0.0071\ FL^{2.9295}$ ($R^2 = 0.99$).

The calculated b (line gradient) amount in the above relations is a figure near 3 (2.8 and 2.9) which indicates an isometric growth in Sawtooth barracuda ($p>0.05$) (Fig. 2).

The achieved results have shown that the stomach emptiness index (CV) in this fish is 47.3%. So this fish is middle alimentary. The stomach emptiness index (CV) increased in February and October in females and in December and April in males which is related to reproduction. The average Fullness Index (FI) during 13 months was 52.7%. Also, the stomach Fullness Index (FI) for both males and females increased in March before spawning (Fig. 3).

Also, the average Relative Length of Gut (RLG) was 0.34 ±0.002 and in total, has had an average range of 0.14 to 0.68 that shows this fish is a carnivorous fish. The amount of condition factor (K_f) is between 0.22 to 0.75, averaging 0.42±0.002.

This index varied in the examined months, as it has had an increase in March and a decrease in June.

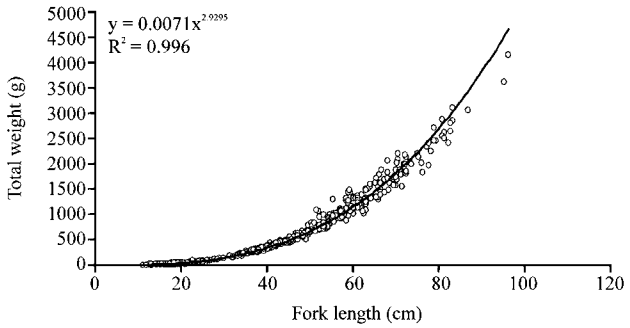

Fig. 2: Correlation between fork length-weight of *S. putnamae* in the Persian Gulf waters

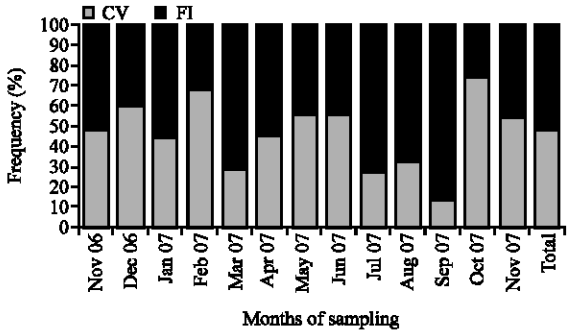

Fig. 3: The process of variations in (CV) and (FI) in *S. putnamae* in the Persian Gulf

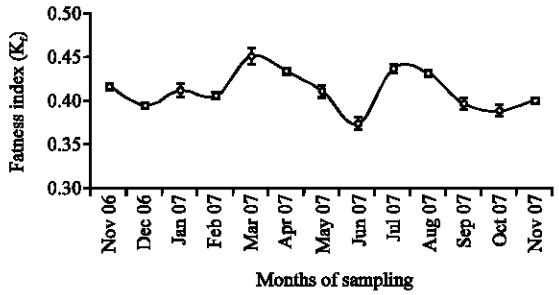

Fig. 4: Changes of condition factor *S. putnamae* in the Persian Gulf

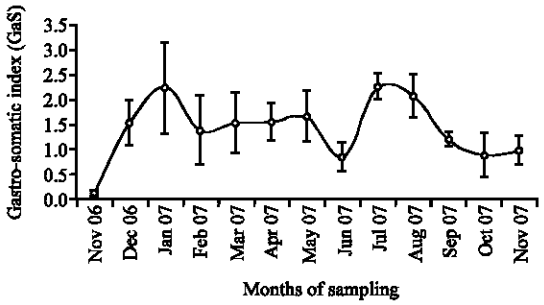

Fig. 5: Changes of Gastro-Somatic index (GaSI) in *Sphyraenae putnamae* in the Persian Gulf

A study of the relation between feeding habit and spawning habits has shown that the amount of the stomach contents increased during the initial steps until the maturity of the spawned eggs and decreased when they reached maturity, that is, at hatching time. In the steps after spawning, there was another increase in the stomach contents indicating its inclination to feed again (Fig. 4).

The Gastro-Somatic Index (GaSI) varied in the studying months, as it had the highest level in January and July and the lowest in June and October. The highest level observed before and after spawning (Fig. 5).

The information obtained from this study indicated that more than 98% of the contents of the stomach of Sawtooth barracuda (*Sphyraenae putnamae*) contained fish fragments and so it was finally proved to be a fish-eater (Fig. 6, 7).

Fig. 6: The fragments of a *Rustrelliger kanagurta* fish found in the stomach of this fish

Fig. 7: Some fish pieces found in the stomach of *Sphyraenae putnamae*

Table 1: Major fishes fed by Sawtooth barracuda

No.	Fishes
1	*Rustrelliger kanagurta*
2	Engraulidae
3	*Stolephorus indicus*
4	Clupeidae
5	*Sardinella longiceps*
6	Carangidae
7	*Atule mate*
8	Leiognathidae
9	*Sectur insidator*
10	Myctophidae
11	Synodontidae
12	Nemipteridae
13	Mullidae
14	Istiophoridae
15	Dreparidae
16	Sphyraenidae
17	Gobiidae

The major fishes fed by this fish aer shown in Table 1. Other discovered food items, contained in the stomach, were zooplankton and a cephalopod (*Sepia* sp.).

DISCUSSION

In this study, the average Relative Length of Gut (RLG) in *Sphyraenae putnamae* was measured as 0.34. Al-Husaainy (1949) stated that if RLG is <1, the fish is a carnivore. Therefore, based on this theory, since the measurement of *Sphyraenae putnamae* is found as RLG = 0.34 therefore, it is categorized as a carnivorous fish. Hosseini *et al*. (2009) stated the average relative length of gut in the *Sphyraena jello* to be 0.64. Also, other researchers such as De-Sylva (1963), Williams (1965), Randall (1967), Blaber (1982) and Bachok *et al*. (2004) have stated the carnivorousness of Barracuda.

The calculated average CV was 47.3% and since this value is more than 40 and less than 60 (40≤CV = 43.7% <60), therefore, this fish is middle alimentary. Of course, given that this fish is a carnivoure, having stronger digestive enzymes herbivores and also since, the samples were provided from the fish market i.e., there was a long time interval between the catching time of the samples, thus provided (i.e., night time) and the time of the study, the digestive enzymes had sufficient time to dissolve and digest fish fragments in the stomach of this fish and consequently it cannot be announced for sure whether *Sphyraenae putnamae* is among the fishes with average feeding habit or not. Hosseini *et al*. (2009) stated the CV value of the pick handle Barracuda (*Sphyraenae jello*) is 0.13%, indicating the gluttonous of this fish.

Figure 4 (changes in GaSI) showed that the stomach fullness index was at the highest level before and after spawning and it was observed that during these 2 peaks, the fish has had the highest feeding (food consumption). This fact notes that its feeding habit has a close correlation with its reproduction.

Examining the stomach contents, it was determined that other fishes are the main food of *S. putnamae* (Fig. 5, 6). Carpenter *et al*. (1997) stated the Sawtooth barracuda (*Sphyraenae putnamae)* mainly feeds on other fishes. Hosseini *et al*. (2009) stated the main food of the *Sphyraena jello* in Bushehr province waters are two types of fishes, namely *Liza subviridis* and *Tenualoza illisia*, respectively contributing to 49.8 and 39.8% of the stomach contents of this fishes and to a lesser extent fragments of a juvenile compound fish, *Sepia pharanois*, was 5.9% of the stomach contents. Randall (1967) stated 95.5% of the stomach contents of *Sphyrenae barracuda* and 82.1% of the stomach contents of *Sphyrenae picullida*, present in Western Indian ocean, contain fish fragments. Paterson (2000) stated that the large *Sphyrenae barracuda* is a fish eater. Also, Barreiros *et al*. (2002) discussed the feeding habit of the *Sphyraena viridensis*, in Azores islands and it was found that in the stomach of this fish there was other fishes present as the only found catch. Blue Jack Makerel, *Trachurus picturatus*, contained 82.2% of the stomach contents of this fish and so its main food. They stated that the average size of the hunt depends on the average size of the *Sphyraena viridensis* and they observed the behaviors and the gathering types of this fish during 550 h period and stated that, Barracuda gather together in small groups in winter and in large groups in Summer times. Porter and Motta (2004) stated the same conclusion about the great barracuda *Sphyrenae barracuda*, as was stated by Randall (1967) that is by the manner of its attacking its prey and catching method it is definitely carnivorous and its main diet is fish. Bachok *et al*. (2004) have examined the feeder of two other types of this species: *Sphyrenae jello* and *Sphyrenae obtusata* in the East Coast Peninsular of Malaysia, Terengganu waters and found that the Pick handle Barracuda (*Sphyraenae jello*), being also a fish-eater mainly feeds on Yellowstripe scad and Bigeye scad.

Also, Grubich *et al*. (2008) confirmed the *Sphyrenae barracuda* to be a fish-eater and studied the functional morphology of bite mechanics in the great barracuda (*Sphyrenae*

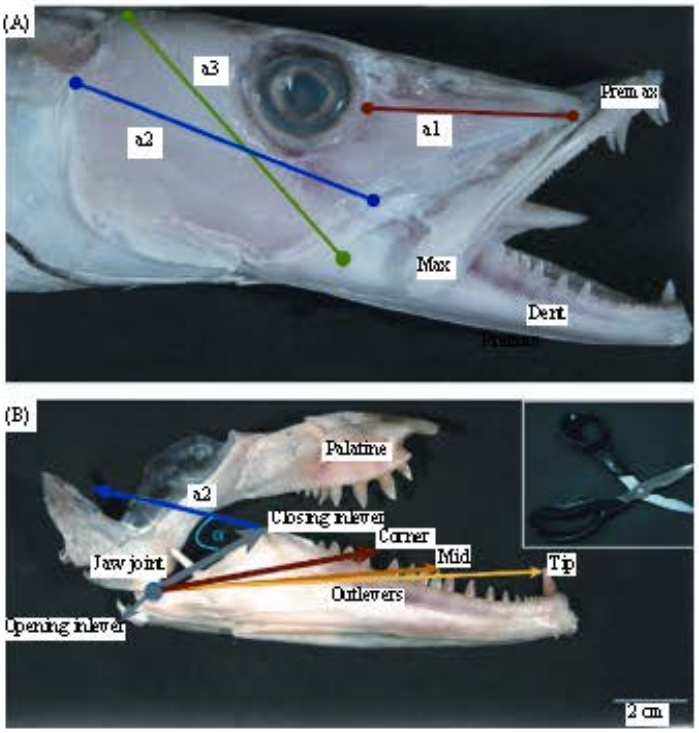

Fig 8: (A) Dissection of *S. barracuda* jaw anatomy showing lines of actions of adductor mandibulae muscle subdivisions that control biting (a1, a2, a3), (B) skeletal elements of the lower jaw and suspensorium revealing lever mechanics and the robust toothed palatine bone against which the rear of the lower jaw bites in a scissor-like action in *Sphyraena barracuda* (Grubich *et al*., 2008)

barracuda) (Fig. 8A, B). De-Sylva (1963) reported that *Sphyrenae baracuda* swallows its food thoroughly from head and tail and or it may divide the food into two or three pieces. He observed that in a quick attack, the big *Sphyrenae barracuda* divided its food into two equal parts, then turns slowly around them before swallowing them up. Sinha (1987) stated that the *Sphyrenae barracuda* is a quick fish-eater by using its sharp visual power and strong olfactory sensation to find its food. Barreiros *et al*. (2002) examined the catching behaviours in *Sphyrenae viridensis* in Azores islands waters and introduced four ways that this hunter catches its prey as follows:

- One predator chasing one prey
- Several predators chasing one prey
- One predator chasing several preys
- Several predators chasing several preys

In the first method, after approaching the food, the hunter suddenly and quickly attacks. It occurs when a catcher (hunter) attacks another one. This kind of attack was seen during the entire year.

Fig. 9: The jaws and the location of teeth in the mouth of *Sphyraena putnama*

In the second method, 2 to 8 hunters simultaneously go after one prey. These hunters were all of the same size and did not show any reaction towards each other. The chasing speed was high; it took 6 to 48 sec to finish the hunt. This catching method was seen during July to September.

This method was seen in the entire year: a hunter goes after a group of preys several times. Blue Jack mackerel, which was the main food of *Sphyraena viridensis* were caught through this method. This part of the study's observations was carried out at night (artificial light had no effects on the behavior of the preys, nor the hunter). The hunter, while frequently attacking to a group of fishes, gradually disperses the group into smaller groups.

The following was a catching method which was mostly seen in Summer. In this method, 3 states occurred:

- Prey were near the surface. Predators located in the upper part of the school attacked first, while animals located lower dispersed laterally and attacked from the sides
- Prey were in midwater position. Midwater and bottom placed predators made a straight attack. Animals on top almost never interfered
- Prey located in deeper water were attacked only by the large individuals from this area

Given the findings mentioned above, 98% the stomach contents of the main subject fish in this study i.e., *Sphyraena putnamae*, were the fragments of other fishes, most of which, being complete fishes or large parts of them, were identified and were recorded. The fact of the location of the mouth (the upper part of mouth or palate) indicates that the feeding habit of the fish (and the species in general), i.e., the upper parts of prey's body is bitten off or cut off first and the rest is eaten then. Having sharp, saw-like teeth confirms the fish's carnivorous (Fig. 9), quick hunting method and its feeding habits and method as mentioned earlier.

CONCLUSION

This study shows that *Sphyraena putnamae* is carnivorous and fish-eater. Most of stomach contents being complete fishes or large parts of them. This fish has medium feeding habit. Relation between feeding habits and spawning habits has shown that the amount of the stomach contents increased during the initial steps until the maturity of the spawned eggs and decreased when they reached maturity, that is, at hatching time. In the steps after spawning, there was another increase in the stomach contents indicating its inclination to

feed again. The highest level of Gastro-somatic index (GaSI) observed before and after spawning. The calculated b indicates an isometric growth in Sawtooth barracuda.

ACKNOWLEDGMENTS

We express our thanks and appreciations to Eng. (Salarpoor, Behzadi, Darvishi, Kamali, Shojai,. Tavakoli Kolur, Mrs. Khatami and Mrs. KhajKeramoAlddini) for their cooperation and involvement in conducting this project.

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