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RESEARCH PAPER

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# A Study on Diet Composition and Feeding Habits of *Sphyraena putnamae* Jordan & Seale, 1905 from the Northern Arabian Sea

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## Abstract

The food and feeding habits of the *Sphyraena putnamae* (n=381) ranging from 16 to 99 cm were investigated the Karachi coast, the Northern Arabian Sea, Pakistan. *S. putnamae* consumed various prey items, which were divided into three categories: teleosts, molluscs, and crustaceans. Molluscs and crustaceans were the second preferred food component rather than teleost. The major constituents of the teleost group on basis of their ascendancy, were identified to be (dorosomatids; sciaenids; leiognathids; platycephalids; engraulids; carangids; bregmacerotids; nemipterids; scombrids; and synodontids). The empty stomach ratio and stomach fullness index did not differ significantly between the sexes and size classes. The stomach fullness index of juvenile barracudas (16-29 cm in length) was significantly higher as compared to adults in the medium (30-55 cm) and large (56-99 cm) size groups. Additionally, an analysis of dietary preferences revealed that small (juvenile) barracudas (16-29 cm) primarily consumed crustaceans, while medium-sized individuals (30-55 cm) preferred mollusks, and large individuals (56-99 cm) favoured teleost. The present study provides detailed information on the feeding ecology of the *S. putnamae*, for the first time from the Pakistan coast that will be useful for understanding trophodynamics of species developing effective management and conservation measures, ensuring the species' long-term viability.

## Introduction

Barracudas belong to family Sphyraenidae which are composed of voracious predators distributed in all equatorials, tropical and warm temperate seas (Allam *et al.,* 2004; Akadje *et al.,* 2013; Nelson *et al.,* 2016). Typically, barracudas may be observed swimming through seawater in pursuit of schools of fish that feed on plankton. Each member of this family is neritic and pelagic, and they can be found alone or in groups (Whitehead *et al.,* 1986), while adults of larger size species are solitary or less sociable, juveniles of all species and adults of small size species are gregarious and form schools (Sommer, 1995). A barracuda can move with quick bursts of speed to strike its prey before it can flee thanks to its long tail and matching anal and dorsal fins.

Sawtooth Barracuda *Sphyraena putnamae* has most recently been assessed for the IUCN Red List of Threatened Species in 2014 and it is listed as Least Concern (IUCN, 2014). Barracudas make up 2.0% of all the marine fish that are landed in the State of Karnataka, southeastern Arabian Sea (Rajesh *et al.,* 2020). Large predators such as these pelagic fishes play a top-down role in ecosystem control (Baum and Worm, 2009; Lotze and Worm, 2009; Hunsicker *et al*., 2012). Through the

trophic cascade, the extinction of such apex predators because of environmental change or overfishing affects lower tropic levels (McPeek, 1998; Chapin *et al*., 2000; Cury *et al*., 2003).

Globally, barracudas are represented by 29 species under the only genus *Sphyraena* (Froese and Pauly, 2021). Nine species of barracudas *S. acutipinnis*, *S. barracuda*, *S. forsteri*, *S. obtusata*, *S. pinguis*, *S. putnamae*, *S. qenie*, *S. jello* and *S. arabiansis* were reported from the Pakistani coastal waters (Manzoor *et al.,* 2020). According to Senou (2001), the sawtooth barracuda is a common fish in the Indo-Pacific region and tends to inhabit in shallow waters near shore, murky lagoons, bays, and reefs. They frequently travel in groups during the day but hunt for prey individually at night (Froese and Pauly, 2013; Schultz, 2019). *S. putnamae*, a dominant and commercially significant barracuda, accounts for about 46.5% of all barracuda landings in Karnataka (Rajesh *et al*., 2021). Limited knowledge about its biology and habitat hampers effective fisheries management. Gaining insights into these areas is crucial for enhancing sustainable fisheries yields and may serve as a valuable supportive factor in fisheries management (Mohammadizadeh *et al*., 2010). Overall, the catches of barracuda from Pakistan coast during (1978 to 2022) measured (1163 to 6882 metric tons). The statistical data indicates a substantial catch of barracuda in the recent years from the Pakistan coast (MFD, 2022). Only a few reports on fishing and distribution are available (Randall *et al.,* 1990; Senou, 2001; Jawad *et al.,* 2021; Gosh *et al.,* 2021). Previous studies on the feeding behaviour of *S. putnamae* have been documented by Mohammadizadeh *et al*. (2010) in Bandar-Abbas, located along the northern coast of the Persian Gulf, and by Rajesh *et al*. (2021) in the southeast Arabian Sea, India.

To the best of our knowledge, no investigations is available on the feeding habits of *S. putnamae* from the Pakistani coastal waters. Therefore, the aim of present study is to investigate the diet composition and feeding habits in *S. putnamae* from Karachi coast, Pakistan, Northern Arabian Sea.

## Materials and Methods

### Sample Collection

Karachi Fish Harbour (24.84°N 66.98°E) is in Karachi, Sindh, Pakistan (Figure 1). A total of 381 specimens of *S. putnamae* were collected on monthly basis from Karachi fish harbour from January to December 2021. Throughout the study twelve field trips were made for collection of fish specimens from the harbour. The fish samples were caught by trawler (mesh size 2.5 cm) and gill net (mesh size 12-14 cm). Specimens were immediately transferred to an insulated ice box and were brought to the laboratory for measurement of total length (cm) and weight (g). They were then dissected to analyse diet composition through stomach contents.

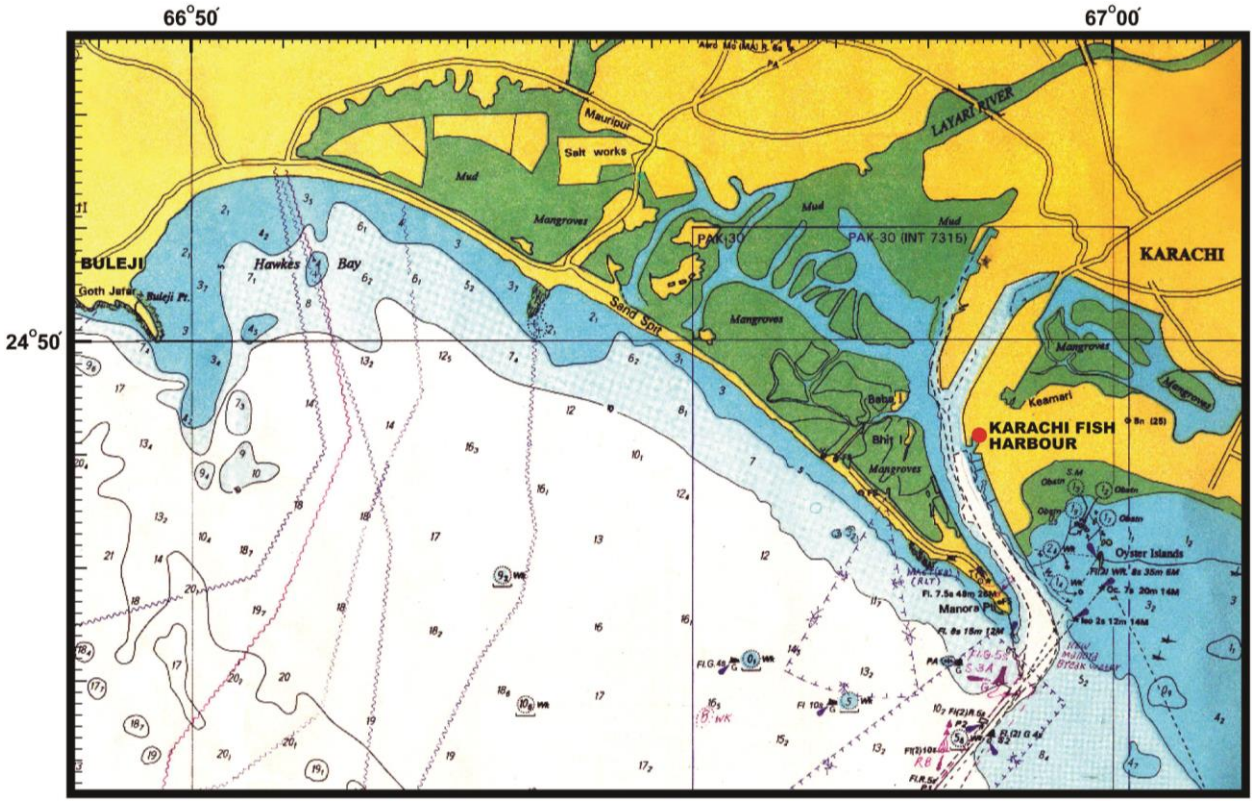


**Figure 1**. Study area map

**Gut Content Analysis**

The fish was cut open and the entire stomach was carefully removed for further detailed analysis. The total weight of the stomach contents was recorded, and recognizable food items were identified to the lowest possible taxon and counted. The partially digested fish and shrimp remains were grouped as unidentified fish and shrimp respectively. Each food item was weighed to the nearest 0.1 g.

**Fullness Index (FI)**

Fullness index (FI) was calculated through the following equation (Dadzie *et al.,* 2000)

$$FI=\frac{\text{No. of stomachs with the same degree of fullness}}{\text{total no. of stomachs examined}}x100$$

**Stomach Emptiness Index CV**

Stomach emptiness index (CV) was calculated through the following equation (Euzen, 1987)

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

ES= Empty stomachs
TS= Total no. of stomachs examined

**Gastro-Somatic Index (GaSI)**

Gastro-somatic index was calculated through the following equation (Desai, 1970)

$$GaSI=\frac{\text{Weight of gut}}{\text{Body weight}}x100$$

## Results and Discussion

Monthly variations in feeding habits and gut content analysis investigated in *S. putnamae* those presented in Table 1. The present research provides first and new information on diet composition and feeding habits of Sawtooth Barracuda from the Karachi coast. According to the present study Sawtooth Barracuda preferred teleosts to other groups like molluscs and crustaceans. The highest numerical percentage (71.4%) of teleosts in the diet was observed in June (Table 1) and the dominant teleost groups were identified as dorosomatids, sciaenids, leiognathids, platycephalids, engraulids, carangids, and scombrids. Small sizes total length 16 to 29 cm in total length preferred crustaceans, and medium size (30 to 55 cm) molluscs and large size (56 to 99 cm) teleost. The present study revealed that teleosts comprise the primary component of the diet of Sawtooth Barracuda. The prey species recorded in the current study were dorosomatids; *Sardinella* sp.*,* sciaenids; *Jhonius* sp.*, Otolithes* sp.*,* leiognathids; *Equulites* sp.*,* platycephalids; *Platycephalis* sp., engraulids; *Stolephorus* sp.*, Thryssa* sp.*,* carangids; *Alepes* sp.*, Carangoides* sp.*, Dectapterus* sp.*, Megalaspis cordyla.*, bregmacerotids; *Bregmaceros* sp.*,* nemipterids; *Nemipterus* sp.*,* scombrids; *Rastrelliger kanagurta* and synodontids; *Saurida* sp.*,*). The prey species identified in the present study was primarily pelagic fishes associated with surface waters. Similarly, Rajesh *et al.* (2021) also stated that teleosts were the favoured and predominant food component, while mollusks and crustaceans were secondary food components. The juveniles of both sexes exhibited a significantly higher stomach fullness index compared with the adults. Rajesh *et al*. (2021) found that *S. putnamae*'s feeding pattern shifted from crustaceans (<20 cm) to molluscs and teleosts in medium-sized fishes (30-60 cm), and teleosts alone in the gut of *S. putnamae* over 65 cm. Mohammadizadeh *et al*. (2010) reported that the diet of *S. putnamae* from Bandar-Abbas, located in the northern Persian Gulf, is predominantly carnivorous. Their findings revealed that more than 98% of the stomach contents consisted of teleost fish.

We examined the guts of 381 *S. putnamae* specimens: 308 were full and 73 were empty. The higher numbers of empty guts were observed in December (n=11), September (n=10) and July (n=8). During the spawning periods (March to May and November to January) fish guts were filled with crushed teleost, mollusc remains and other substances (detritus and gut fluid). The highest fish remains (4.679 g) and other substances (detritus and gut fluid) (1.928 g) were observed in June and September (Figure 2). Some of the stomach contents were observed to be fragile and in advanced stages of decomposition. The highest fullness of index (FI, 88.8%) and stomach emptiness index (CV, 30%) were measured in February and January, respectively (Table 2). The GaSI values exhibited a distinct seasonal pattern, with January showing the highest index value (0.951), while June and October recorded the lowest values (0.302 and 0.366, respectively) (Table 3, Figure 3), this pattern was consistent with the findings of Mohammadizadeh *et al*. (2010) who reported the highest GaSI values in January and July, and the lowest values in June and October. The reason could be that the amount of stomach contents increased during the early stages until the gonads matured, and then decreased when they reached maturity, or hatching time (Mohammadizadeh *et al*., 2010).

Following spawning, there was another increase in stomach contents, indicating an inclination to feed again. Similarly, Meshram *et al.* (2022) investigated diet composition and feeding behaviour of the *S. obtusata* in the southern Arabian, teleosts were the most dominating prey item in terms of frequency (87.80%), number (57.63%), volume (91.82%), and IRI (93.76%).

According to Allam *et al*. (1999), teleosts were also the primary food source of other barracuda species in the Egyptian Mediterranean waters off Alexandria. Osman *et al.* (2019) conducted research on the diet

**Table 1.** Monthly variation in food items of *S. putnamae* with numerical percentage (%) collected from the Karachi fish harbour from January to December 2021

| Feeding contents | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total length (cm) | TL (25-45) | TL (29.50-99) | TL (81-87) | TL (39-69) | TL (43.50-79.50) | TL (29-64) | TL (41-72) | TL (32.5-73) | TL (29-95) | TL (16-76) | TL (34-93) | TL (34-89) |
| Total weight | W(216.50-846) | W (370.50-3450) | W(2265-3102) | W(770.50-1878) | W(960.00-2634) | W(432-1486) | W(675-1900) | W(860-1800) | W(460-3400) | W(280-1850) | W(624-2800) | W(788.5-2984) |
| Crustaceans | 25% | 16.60% | 33.30% | 22.20% | 33.30% | 14.20% | 16.60% | 21.40% | 30.70% | 28.50% | 27.20% | 13.30% |
| Molluscs | 25% | 16.60% | 11.10% | 11.10% | 11.10% | 14.20% | 25% | 14.20% | 15.30% | 14.20% | 18.10% | 20% |
| Fish | 50% | 66.60% | 55.50% | 66.60% | 55.50% | 71.40% | 58.30% | 64.20% | 53.80% | 57.10% | 54.50% | 66.66% |
| **Feeding contents** | | | | | | | | | | | | |
| **Crustaceans** | | | | | | | | | | | | |
| Shrimps | 2 | 2 | 4 | 2 | 3 | 1 | 2 | 2 | 4 | 2 | 3 | 2 |
| Acetes sp. | | | 2 | | | | | 1 | | | | |
| **Molluscs** | | | | | | | | | | | | |
| *Loligo* sp. | 1 | 2 | 1 | | | 1 | 2 | 1 | 1 | | | 1 |
| Squid | 1 | | | | 1 | | | | | 1 | | 2 |
| *Sepia* sp. | | | 2 | 1 | | | 1 | | 1 | | 2 | |
| **Fish** | | | | | | | | | | | | |
| **Sciaenidae** | | | | | | | | | | | | |
| *Jhonius sp* | 1 | 2 | 1 | 1 | | | | | | 1 | 1 | |
| *Otolithes* sp. | | 1 | 1 | 1 | | | | | | 1 | | |
| **Dorosomatidae** | | | | | | | | | | | | |
| *Sardinella* sp. | 1 | | 2 | 2 | 2 | | 5 | 1 | 4 | | 1 | 2 |
| **Cynoglossidae** | | | | | | | | | | | | |
| *Cynoglossus sp.* | 1 | | 1 | 1 | | | | 2 | | | | |
| **Platycephalidae** | | | | | | | | | | | | |
| *Platycephalus* sp. | | 2 | | | | | | 1 | 2 | | 1 | |
| **Bregmacerotidae** | | | | | | | | | | | | |
| *Bregmaceros sp.* | | | | | 1 | | | | | 1 | | |
| **Scombridae** | | | | | | | | | | | | |
| *Rastrelliger kanagurta* | | 2 | 1 | | | 1 | | 1 | | | 1 | 1 |
| **Carangidae** | | | | | | | | | | | | |
| *Alpes* sp | | 1 | | | | | 1 | | | | | |
| *Carangoides* sp | | | 1 | 1 | | 1 | | | | | | |
| *Dectapterus* sp | | | | | 1 | | | | | 1 | | |
| *Megalaspis cordyla* | | | | | | 1 | | 1 | | | 1 | |
| **Engraulidae** | | | | | | | | | | | | |
| *Stolephorus* sp. | | | | | 1 | | 1 | 1 | | | | 1 |
| *Thryssa* sp. | | | 1 | | | | | 1 | | | 1 | 1 |
| **Nemipteridae** | | | | | | | | | | | | |
| *Nemipterus* sp | | | 1 | | | 1 | | 1 | | | | |
| **Synodontidae** | | | | | | | | | | | | |
| *Saurida* sp | 1 | | | | | 1 | | 1 | 1 | | | 2 |

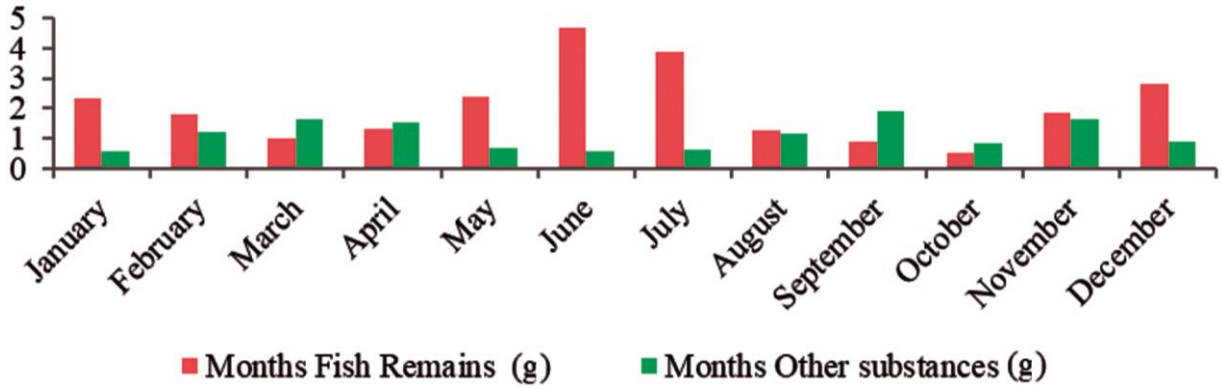


**Figure 2**. Weight (g) estimation of fish remains and other substances of *S. putnamae* collected from the Karachi Fish harbour from January to December 2021.

**Table 2.** Fullness index (FI %) and stomach emptiness index (CV %) of *Sphyraena putnamae* collected at the Karachi Fish harbour from January to December 2021

| Months | Total no. of Stomach examined | Full stomach | Empty Stomach | FI % | CV % |
|---|---|---|---|---|---|
| January | 20 | 14 | 6 | 70% | 30% |
| February | 18 | 16 | 2 | 88.8% | 11.1% |
| March | 40 | 33 | 7 | 82.5% | 17.5% |
| April | 19 | 15 | 4 | 78.9% | 21% |
| May | 18 | 15 | 3 | 83.3% | 16.6 % |
| June | 21 | 15 | 6 | 71.4% | 28.5% |
| July | 32 | 24 | 8 | 75% | 25% |
| August | 24 | 20 | 4 | 83.3% | 16.6% |
| September | 42 | 32 | 10 | 76% | 23.8% |
| October | 38 | 31 | 7 | 81.5% | 18.4% |
| November | 42 | 37 | 5 | 88% | 11.9% |
| December | 67 | 56 | 11 | 83.5% | 16.4% |

composition and feeding patterns of Barracuda fish (*S. chrysotaenia* and *S. flavicauda*) in the Gulf of Suez. The feeding intensity of *S. chrysotaenia* and *S. flavicauda* was calculated at 37% and 59.2%, respectively. Conversely, the prevalence of empty stomachs was 63% for *S. chrysotaenia* and 40.8% for *S. flavicauda*. *S. chrysotaenia* and *S. flavicauda* both had lower feeding activity before and during spawning season and amplified after spawning (Ragheb, 2003). According to Mohammadizadeh *et al.* (2010), the gut fullness index of *S. veredensis* in the North Persian Gulf peaks before spawning and declines during the spawning period.

Osman *et al*. (2019) reported that the value of the filled stomach index ranged from 0.6 to 2.0 for the 1/3 filled stomach, 2.1 to 2.9 for the 2/3 filled stomach, and 3 for totally filled stomachs. This study identified significant fluctuations in the GaSI, with the highest value recorded in January (0.951) and the lowest in June (0.301). Similarly, the principal food sources of *S. flavicauda* were fish, molluscs, and crustaceans. According to Whitehead *et al.* (1986) and Fischer *et al*. (1987), they mostly feed on fishes. *S. chrysotaenia* feeds largely on fish, particularly *S. aurita* and *E. encrasicolus*, followed by crustaceans (Ragheb, 2003). Carpenter *et al.* (1997) confirmed that *S. putnamae* feeds mainly on fishes. Similarly, Barreiros *et al*. (2002) reported that the stomach contents of *S. veridensis* primarily consisted of fish from the families Carangidae and Sparidae. The recorded food items for *S. chrysotaenia* and *S. flavicauda* in the Gulf of Suez were fishes, crustacean, and cephalopod (Randall, 1967; Sinha, 1987; Premaltha and Manjkumar, 1990; Carpenter et al., 1997). Blaber (1986) showed that the most commonly prey taken were Atherinidae and Gobiidae for *S. barracuda.* However, studies conducted in the Mediterranean have produced varying results, with the primary prey species for different *Sphyraena* species differing, for instance, Atherinidae, Centracanthidae, and Clupeidae have been reported as the primary prey families for *Sphyraena viridensis, S. sphyraena,* and *S. chrysotaenia*, respectively (Kalogirou *et al.,* 2012). According to Hosseini *et al.* (2009), the predominant food item for S. *jello* in Bushier provincial water was *Liza subviridis* and *Tenualosa illisia*. Several studies have confirmed that teleost are the preferred meal of other barracuda species from diverse places. The feeding behaviour of *S. putnamae* was studied by Rajesh *et al*. (2021) in the southeastern Arabian Sea, India. Their findings indicated that teleost fish were the primary dietary component, while mollusks and crustaceans served as secondary and

**Table 3.** Gastro-somatic index (GaSI) of *S. putnamae* collected from the Karachi Fish harbour from January to December-2021-2022

| Months | Mean of (GaSI) 2021 |
|---|---|
| January | 0.951±0.242 |
| February | 0.653±0.186 |
| March | 0.460±0.038 |
| April | 0.603±0.021 |
| May | 0.585±0.032 |
| June | 0.302±0.061 |
| July | 0.435±0.112 |
| August | 0.491±0.181 |
| September | 0.562±0.213 |
| October | 0.366±0.104 |
| November | 0.463±0.277 |
| December | 0.421±0.134 |

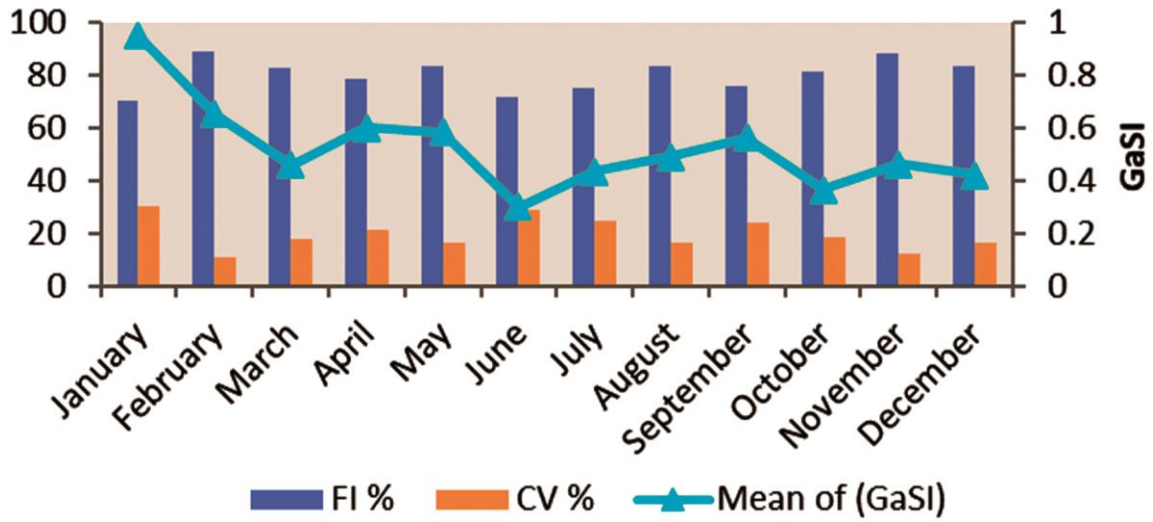


**Figure 3.** Monthly variation in (FI%), (CV% ) and Gastro-somatic index (GaSI) of *S. putnamae* from January to December 2021.

supplementary food sources. Similarly, Manzoor et al. (2019) analysed the diet of *Sphyraena jello* in Pakistan and found that mollusks were its preferred secondary food component, with fish being a major part of its diet. Moreno-Sanchez *et al*. (2019) reported the predominance of *Sardinops* spp. (Clupeidae), *Hemiramphus saltator* (Hemiramphidae) and *Opisthopterus dovii* (Pristigasteridae) as prey items in *S. ensis* caught in the Gulf of California.

The species composition of prey items varies by region, barracuda species prey preferences may vary due to differences in prey abundance, depth of capture, and foraging ability due to body size differences. *S. putnamae* exhibits selective feeding behaviour, as observed in this study and previously by Mohammadizadeh *et al*. (2010), showing a preference for both pelagic and bottom-dwelling teleost fish.

This investigation represents the first comprehensive research on the feeding habits of *S. putnamae* in the coastal waters of Pakistan (Northern Arabian Sea), providing valuable insights for future studies in this region.

## Conclusion

This study demonstrates that *S. putnamae* primarily preys on teleost fish rather than other groups such as mollusks and crustaceans. The significant presence of dorosomatids, carangids, scombrids, bregmacerotids, and engraulids in the stomach contents indicates a strong preference for pelagic teleosts. Additionally, the presence of crustaceans and mollusks suggests that *S. putnamae* employs vertical mobility to exploit a diverse range of food sources. Juveniles (16 to 29 cm in length) exhibit a significantly higher stomach fullness index compared to medium-sized (30 to 55 cm) and large-sized (56 to 99 cm) individuals. The diet of barracudas changes with growth: juveniles primarily consume crustaceans, medium-sized individuals shift to mollusks, and large individuals predominantly feed on teleosts. The highest Gastro-somatic index (0.951) was recorded in January and lowest (0.302) in June and October (0.366). Juvenile barracudas of both sexes showed higher stomach fullness indices than adults, likely due to the abundance of prey in near-shore or

coastal waters, where young individuals reside and complete their life cycle before migrating to offshore areas as they mature (Rajesh *et al*., 2021).

The highest level of stomach contents observed before and after spawning may be attributed to an increase in food intake during the early stages of egg maturation, followed by a decrease as the eggs reach in maturity. Further investigation into the composition of stomach contents is recommended to enhance our understanding of this species.

## Ethical Statement

Not applicable.

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The authors did not receive support from any organization for this study

## Author Contribution

Author Kashifa Zohra conception and designed the study, determine species in stomach, wrote the first draft, Farzana Yousuf data analysis, technical or material support, Quratulan Ahmed data acquisition and interpretation, Qadeer Mohammad Ali, Sabri Bilgin and Levent Bat read and correct draft and critical revision of the manuscript. All authors read and approved the final manuscript.

## Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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