

# Trophic Dynamics and Reproductive Resilience: Implications for the Management of Kawakawa (*Euthynnus affinis*) in Western Sri Lankan Waters

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## Abstract

This study investigates the feeding ecology and reproductive biology of kawakawa (*Euthynnus affinis*) along the west coast of Sri Lanka. Samples (n=110) were collected from Negombo and Beruwala harbors situated in the western coast of Sri Lanka between January and December 2025. Results indicate that *E. affinis* is a predominantly piscivorous predator, with teleost fishes accounting for 93.87% of the Index of Relative Importance (IRI). Feeding intensity showed significant temporal variation, declining during the peak southwest monsoon (July) before recovering in August. Ontogenetic shifts were observed, with mature females (>39.79 cm FL) exhibiting significantly higher feeding activity than immature individuals. Reproductive analysis identified peak spawning periods in June and November to December, an estimated size at first maturity ( $L_{50}$ ) of 39.79 cm for females and 42.48 cm for males. The population exhibited isometric growth ( $b = 2.97$ ) and good physiological condition. Management recommendations include seasonal effort reductions during spawning peaks and maturity-based size regulations to ensure long-term stock sustainability.

## 1. Introduction

Kawakawa (*Euthynnus affinis*) is a critical component of Sri Lanka's neritic tuna fishery, contributing approximately 20.8% of landings. However, long-term data shows a decline in neritic tuna contributions to total production, dropping from 20% in 1997 to 4% in 2017 (Dalpathadu et al., 2023). Despite its economic importance, biological data for the west coast a region influenced by distinct south west monsoonal patterns remains limited. This study addresses these gaps by integrating feeding and reproductive data to support ecosystem approach fisheries management (EAFM).

Kawakawa, also known as mackerel tuna, is a medium-sized schooling pelagic fish distributed throughout the Indo-West Pacific waters, in water temperatures of 18–29°C (Pauly et al., 2016). It plays a crucial role in the pelagic ecosystem as a mid-level predator. As a member of the Scombridae family, *E. affinis* exhibits opportunistic feeding behavior and consumes a diverse range of prey, including crustaceans, mollusks, and small teleost fish (Griffiths, 2009).

Understanding the diet composition and feeding ecology of fish is essential for effective fisheries resource management and ecological studies. In ichthyology and fisheries science, knowledge of feeding habits plays a crucial role in decision-making processes concerning natural resource utilization and conservation (Mahesh et al., 2018). Fish gut content analysis provides an important insight into feeding patterns & quantitative assessment of feeding habits is an important aspect of fisheries management. Fish diet represents an integration of many important ecological components that include behavioral patterns, habitat use, energy intake, and both interspecific and intraspecific interactions within aquatic ecosystems. Stomach content analysis can additionally reveal ontogenetic dietary changes. (Chipps, 2007; Mahesh et al., 2018).

## 2. Materials and Methods

A total of 110 fish were obtained from longline and gillnet fishing in landings in Negombo and Beruwela, from January to December 2025. About 10 fish, on average, were examined monthly. The total length (TL), standard length (SL), total weight (TW), gutted weight (GW), gonad weight (GoW) and other 13 morphometric variables were measured using a measuring tape and vernier caliper. Fish gonads were evaluated macroscopically for sex and maturation stages. Five maturity stages were established for females and males, as follows: immature, maturing, mature, spawned, and resting. Fish sex ratio was tested monthly and annually for statistical differences ( $p < 0.05$ ) using chi-square ( $\chi^2$ ). Differences between sex for standard length and eviscerated weight over size range was tested.

Feeding intensity was assessed via the Vacuity Index (VI); ( $VI = \{\text{The no. of empty stomachs} / \text{total no. of examined stomachs}\} \times 100$ ), Gastro-Somatic Index (GaSI); ( $GaSI = (\text{Stomach weight} / \text{Total body weight}) \times 100$ ), and Stomach Fullness Index (SFI); ( $SFI = (\text{weight of stomach content}) \div (\text{body weight} - \text{weight of stomach content}) \times 100$ ).

Diet composition was quantified using the Index of Relative Importance (IRI) ( $(IRI) = (\%N_i + \%W_i) \times \%F_i$ ) ( $\%N_i$  = numerical abundance of prey item I,  $W_i$  = weight percentage of prey item i,  $\%F_i$  = frequency of occurrence of prey item I, And IRI standardized to  $\%IRI$  for each prey item i,  $\%IRI = IRI \text{ of a specific prey} / \sum IRI \text{ of all prey} \times 100$ . (Vigneshwaran et al., 2018)

Reproductive status was determined through the Gonadosomatic Index (GSI) ( $GSI = [\text{Gonad Weight}(g) / \text{Total Body Weight}(g)] \cdot 100$ ) macroscopic maturity staging, and batch fecundity estimations using the gravimetric method. Growth patterns were evaluated using the length–weight relationship ( $W = aL^b$ ).

## 3. Results and Discussion

### 3.1 Feeding Ecology

The diet of *E. affinis* is dominated by small pelagic fishes (families Engraulidae and Clupeidae), supplemented by minor amounts of gastropods (3.58%), shrimp (2.15%), and crabs (0.39%). Feeding intensity fluctuated significantly with the monsoon cycle. The Vacuity Index peaked in July (70.59%), coinciding with the Southwest Monsoon's onset, which likely increases turbidity and reduces prey encounter rates.

The results demonstrate that feeding intensity of *E. affinis* along the west coast of Sri Lanka is strongly seasonally structured, with short periods of feeding stress coinciding with peak monsoonal conditions, followed by rapid recovery when environmental conditions improve. These findings are consistent with global observations and confirm that kawakawa is a highly adaptable and opportunistic predator, capable of responding quickly to monsoon-driven environmental variability in the Indian Ocean (Sulistyaningsih et al., 2025).

A significant ontogenetic increase in feeding intensity was recorded. Mature females (>39.79 cm) displayed higher feeding activity (85.2%) compared to immature fish (<39.79 cm) (45%), reflecting the elevated energetic demands required for gonadal development and spawning. A Chi-square test of independence revealed a significant association between size group and feeding activity ( $\chi^2 = 6.79$ ,  $df = 1$ ,  $p = 0.009$ ), indicating that feeding frequency increases significantly with body size.

### 3.2 Reproductive Biology

The population exhibited prolonged or asynchronous spawning behavior. Monthly GSI values peaked in June and November–December. Monthly variation in GSI was assessed using the Kruskal–Wallis test. The results revealed a significant difference in GSI among months ( $\chi^2 = 33.51$ ,  $df = 9$ ,  $p < 0.001$ ). The results demonstrate a seasonal pattern in female gonadal development, characterized by fluctuating GSI values across months, consistent with prolonged or asynchronous spawning activity rather than a single, well-defined spawning peak.

Similar seasonal fluctuations have been reported in other regions. In Taiwan, spawning activity peaked between April and August (Chiou, 2004), while in the Arabian Sea, peak spawning occurred from December to March (Nissar et al., 2015). In Tanzania, two spawning peaks were observed during the northeast and southeast monsoons (Johnson, 2013). These regional differences indicate that spawning seasonality in *E. affinis* is strongly influenced by local environmental conditions such as temperature and productivity.

Of the 110 Kawakawa sample examined, 58 were females (58%) and 42 (42%) were males. However, there is no significant difference between male and female abundance in the total sample ( $\chi^2 = 19.45048$ ,  $p \geq 0.05$ ,  $df = 11$ ). Maturity stages of females and males were observed during the study period.

The size at first maturity ( $L_{50}$ ) was estimated at 39.79 cm FL for females and 42.48 cm FL for males. The results indicate that female kawakawa mature at a smaller size compared to males in the west coast population of Sri Lanka. Comparable  $L_{50}$  estimates have been reported elsewhere. In Taiwan, female maturity occurred at 48 cm FL (Chiou, 2004), while in the Arabian Sea, maturity was reported at 55–60 cm (Nissar et al., 2015). In Tanzania, maturity was observed at approximately 52 cm TL (Johnson, 2013). Differences among regions may reflect environmental variability, fishing pressure, or genetic stock differences (Gulland, 1979).

### 3.3 Growth and Condition Factor

The length–weight relationship ( $W = 0.0148 L^{2.97}$ ) revealed isometric growth ( $b = 2.97$ ), indicating that body proportions remain constant as the fish grow. The mean relative condition factor ( $K_n$ ) was 1.01, suggesting that the stock is in good physiological health. Similar strong correlations have been reported for kawakawa in other parts of Sri Lankan coastal waters ( $R^2 > 0.90$ ) by (Herath et al., 2018) and in Indonesian waters by (Agustina et al., 2019) ( $R^2 = 0.9665$ ), suggesting that the length–weight relationship of this species is consistently robust across different regions of the Indian Ocean.

## 4. Recommendations for IOTC Management

To ensure the sustainable exploitation of kawakawa in the Indian Ocean, the following measures are proposed:

- **Seasonal Protection:** Implement effort reductions or temporal closures during the identified peak spawning months of June and November–December.
- **Size Regulations:** Establish a minimum legal catch size of approximately 40–43 cm FL to ensure individuals can spawn at least once before recruitment into the fishery.
- **Ecosystem Management:** Since kawakawa is a specialist piscivore, management must include the protection of its primary prey small pelagic fish stocks to maintain the trophic balance.
- **Continued Monitoring:** Establish long-term biological monitoring programs to track shifts in sex ratios and maturity schedules, which are essential for adaptive management under changing environmental conditions.

## 5. Conclusion

The west coast population of *E. affinis* exhibits highly seasonal feeding and reproductive patterns driven by monsoonal dynamics. While the stock currently shows healthy growth patterns, the reliance on specific prey and the vulnerability of spawning aggregations necessitate targeted management interventions to prevent future overexploitation.

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