Gillnet selectivity and food and feeding habits of *Sphyraena obtusata* and *Sphyraena jello* in the coastal waters off Negombo, Sri Lanka

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Abstract

Barracuda is popular with consumers due to its nutritive value and relatively low price compared to other species such as Seer fish and Tuna. The biology and fishery of Barracuda, however, have not been thoroughly investigated much and the literature is scanty. Barracuda by-catches are common in Herring gillnet fishery operations in the coastal waters off Negombo. Gillnet selectivity of *Sphyraena obtusata* and *Sphyraena jello* and food and feeding habit of *Sphyraena obtusata* were investigated over one fishing season from July to November 2006, using these by-catches.

Estimated values for gillnet selectivity of *S. jello* for 2.5 cm and 3.0 cm mesh sizes were 13.1-26.0 cm and 14.0-25.7 cm while those for *S. obtusata* were 15.2-25.4 cm and 12.8-27 cm respectively. Estimated L_{opt} for 2.5 cm and 3.0 cm mesh sizes were 27.61 cm and 33.12 cm for *S. jello* and 20.06 cm and 24.06 cm for *S. obtusata* respectively. Asymptotic length and growth constant of *S. jello* and *S. obtusata* were estimated to be 44.63 cm, 1.51 $year^{-1}$ and 22.8 cm, 1.00 $year^{-1}$ respectively. The length weight relationship of *S. obtusata* ($y = 2.3501x - 1.1387$) indicates isometric growth. The estimated relative gut length (y) and standard length (x) relationship ($y = -3E - 05x^2 + 0.0008x + 0.3085$) shows that the digestive tract of *S. obtusata* is morphologically adapted for ontogenetic variations for food and feeding. Relationship between Gastrosomatic index (y) and standard length (x) ($y = 0.0097x^2 + 0.471x + 7.9435$) of *S. obtusata* indicated higher feeding efficiency in smaller and larger length groups. Different fish species, crustaceans, molluscs, zooplankton and phytoplankton were found in the stomach contents. The most common food item was *Stolephorus indicus*. In multivariate analysis, food habits were found to be similar in all tested length classes (13 cm to >31 cm) except 13-15, 27-29 and 23-25 cm length groups at 52% similarity level.

Keywords: Barracuda, food and feeding habit, Gear selectivity, Gillnet catch, Population parameters.

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Introduction

Twenty percent of the total small pelagic fish catch in Sri Lanka is landed at Negombo and Chilaw fish landing sites (Dayaratne, 1984). These small pelagic fish, with a per capita consumption of 18 kg per year, contribute a significant part to the animal protein requirement of the country. Barracuda, being both nutritious and affordable, is of great importance as a small pelagic fish (Edirisinghe *et al.*, 2000). According to Silva (2001), the Barracuda catch in Sri Lanka was 890.8 mt in the year 2000.

Barracuda is a popular food fish due to its white flesh, lower fat and higher protein content (Silva, 2001). Pickhandle barracuda (*Sphyraena jello*) has considerably high (20.6%) protein being second only to *Carassius carassius* which has 24.3% (Edirisinghe *et al.*, 2000). It is also very popular among the low and middle-income group people as an affordable source of protein (Silva, 2001). Barracuda could, therefore, be useful in promoting the nutrition of the rapidly increasing population of developing countries, such as Sri Lanka, where protein/energy malnutrition is prominent.

Barracuda is a pelagic neritic fish, inhabiting surface and mid waters of the continental shelf area and is present in almost all coastal waters around Sri Lanka. Due to the schooling behaviour, especially in their younger stages, high densities of Barracudas can be observed in a particular habitat (Silva, 2001). De Bruin *et al.*, (1994) have recorded five species of Barracudas from Sri Lanka namely, *Sphyraena acutipinuis, Sphyraena barracuda, Sphyraena frosteri, Sphyraena jello* and *Sphyraena obtusata.* These Barracuda comprise voracious and predatory species feeding on other fast moving fishes and squids (De Bruin *et al.*, 1994).

Trolling line, hand line with live bait, large mesh driftnet and trawls are the main fishing methods used to catch Barracuda. In addition, large amounts of Barracudas are caught as the major by-catch in single-day boat gillnet fishery operations.

The biology and fishery of Barracuda have not been extensively studied and the literature is scanty. The present study was carried out, therefore, to investigate the Barracuda fishery, giving special emphasis to gillnet selectivity, growth, mortality as well as food and feeding habits. The information presented here will contribute to a better understanding of the biology and population aspects of Barracuda and will help to develop strategies for the sustainable utilization of this resource.

Materials and methods

The study was conducted at the Wellavediya fish landing site at (7° 10'N and 79 ° 50' E), Negombo in the Western province, during the fishing season from July to December 2006. The boats which operate gillnets with different mesh sizes (2.5cm and 3.0cm) were sampled at random on a weekly basis. Fishermen who were directly involved in the fishing operations were interviewed to gather additional information such as hours of operation and number of crafts used. Different Barracuda species in landings were identified according to De Bruine *et al.*, (1994).

Standard Length (SL) and the body depth (D) of Barracudas (n=568) were measured to the nearest 0.1 cm at the landing site. Relationship between SL and D was determined by linear regression. Length frequency data were adjusted for a unit of fishing effort to estimate the gillnet selectivity. The mesh-wise length frequency data were analyzed using the Baranov – Holt method (Baranov, 1948, McCombie and Fry, 1960, Holt, 1963, Regier and Robinson, 1966, Hamley, 1975, Jensen, 1986 and Amarasinghe and de Silva, 1994)

The corrected monthly length frequency distribution were analyzed using FiSAT computer package (Gayanilo and Pauly, 1997) to estimate the population parameters of *S. jello* and *S. obtusata.* Using the Power-Weatheral plot, the best growth curve was fitted and growth constant (K) was estimated. Instantaneous total mortality coefficient (Z) and fishing mortality coefficient (F) were estimated using length converted catch curve. The Pauly's multiple regression equation was used to calculate the natural mortality coefficient (M) (Pauly, 1980).

Individuals of *Sphyraena obtusata* injected with 10% buffered formalin through the anus at the landing site were brought to the laboratory for further study. Their body weight (W) and SL were measured to the nearest 0.01 g and 0.1 cm respectively. The relationship between SL and W was calculated by simple linear regression of log transformed data. Each fish was dissected and the length of the gut and the weight of the stomach contents were recorded in order to estimate the relationship between SL and relative gut length (RGL). As the fish had all been caught in the early morning hours, the relationship between SL and gastrosomatic index (GASI) was measured to understand the relationship of their feeding behavior with size. Percentage abundance of each visually observable gut particle was recorded and a 1 ml volume of diluted digested stomach contents were observed under the microscope in a Sedgwickrafter cell; percentage abundance of identified prey categories was recorded. A multivariate analysis was performed to test whether food and feeding habit is similar for different length classes.

Results

Barracuda fishery in Negombo coastal area

A total of 285 single-day crafts operated in the coastal waters off Negombo mainly targeting the Herring fishery. Barracudas are caught in large numbers as the main by-catch of this fishery. The fishing craft leave around 4 a.m. and return to the landing site between 7- 10 a.m. The number of gillnet pieces used varied from 50 to 65 and the commonest mesh sizes used were 2.5 cm and 3.0 cm.

Identification of Barracuda species

Table 1. The Barracuda species recorded in the study

Barracuda species	Mean length (cm) ± SD	Percentage abundance
Sphyraena obtusata	21.57 ± 3.60	63
Sphyraena jello	16.40 ± 3.11	35
Sphyraena frosteri	24.58 ± 3.5	02

Gillnet Selectivity

Relationships between the body depth and standard lengths of *S. jello* and *S. obtusata* are given in Fig.1 and 2 respectively.

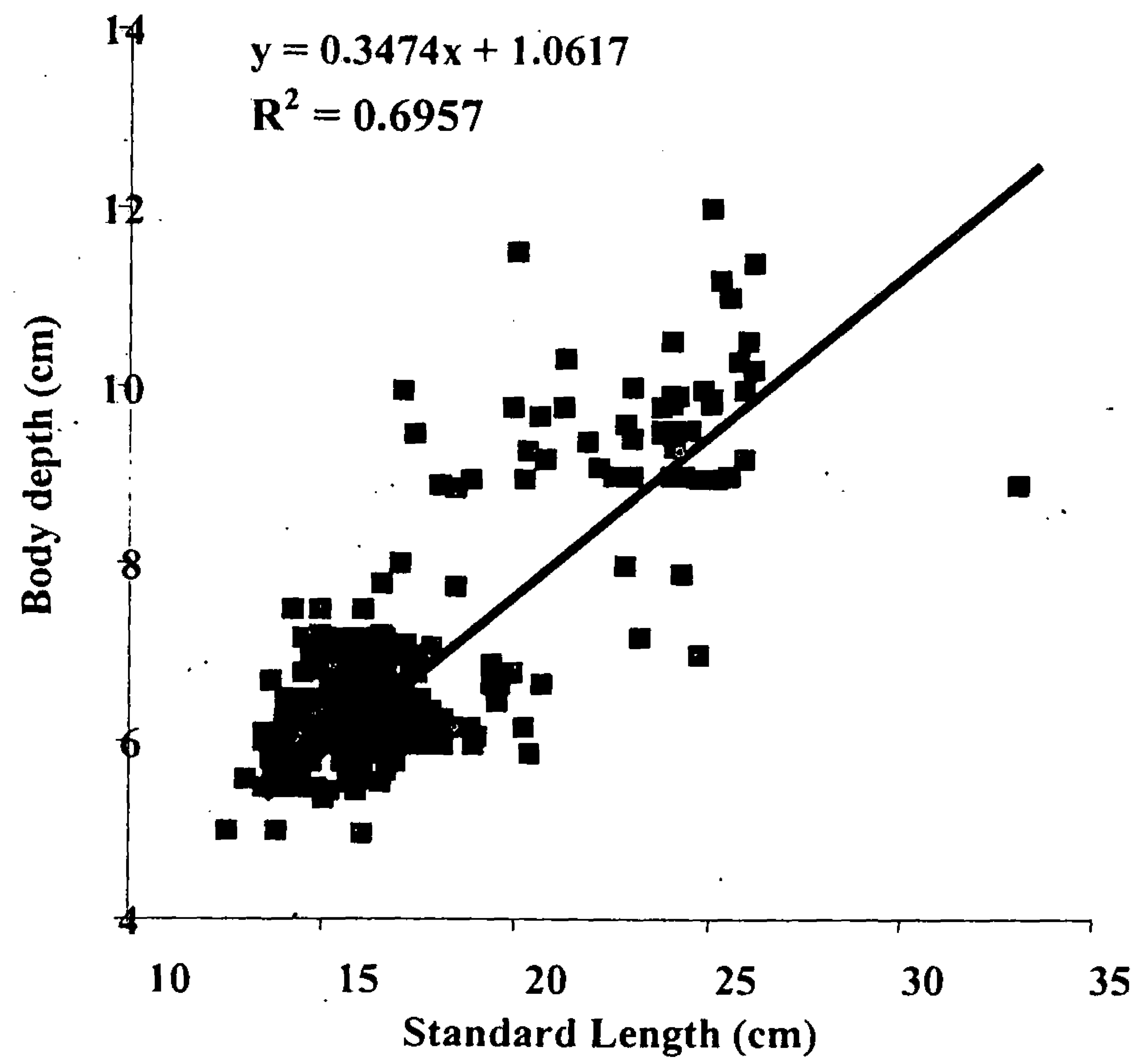

Fig. 1. Relationship between body depth and standard length of *S. jello*

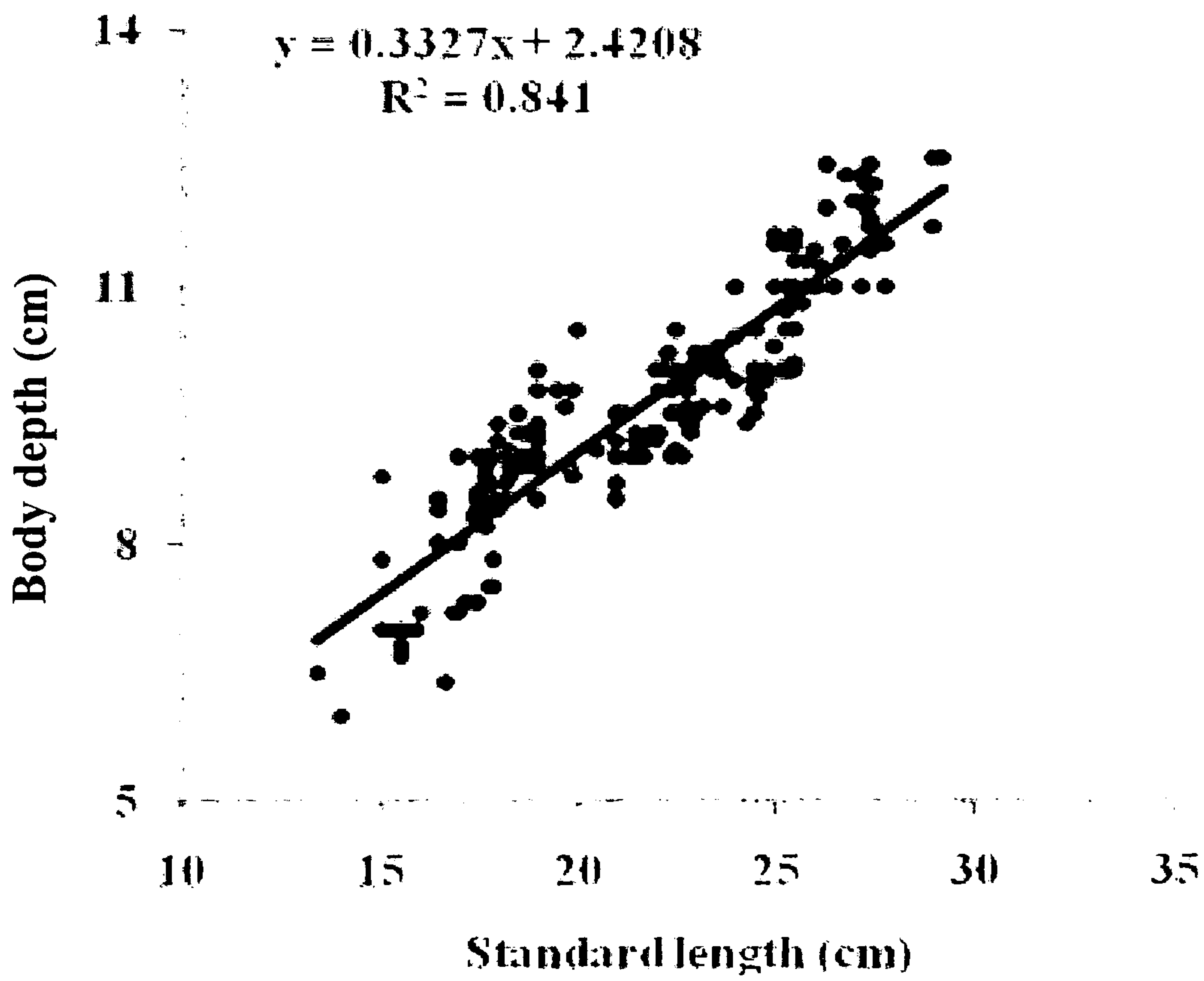

Fig. 2. Relationship between body depth and standard length of *S. obtusata*

Fig. 3 and 4 indicate the logarithmic scatter plots of catch ratios of 2.5 cm and 3.0 cm mesh sizes against the respective mid lengths. Those scatter plots exhibit linear relationships. The optimal length (L_{opt}) and selection ranges estimated for 2.5 cm and 3.0 cm mesh size gillnets are summarized in table 2 for *S. jello* and *S. obtusata.*

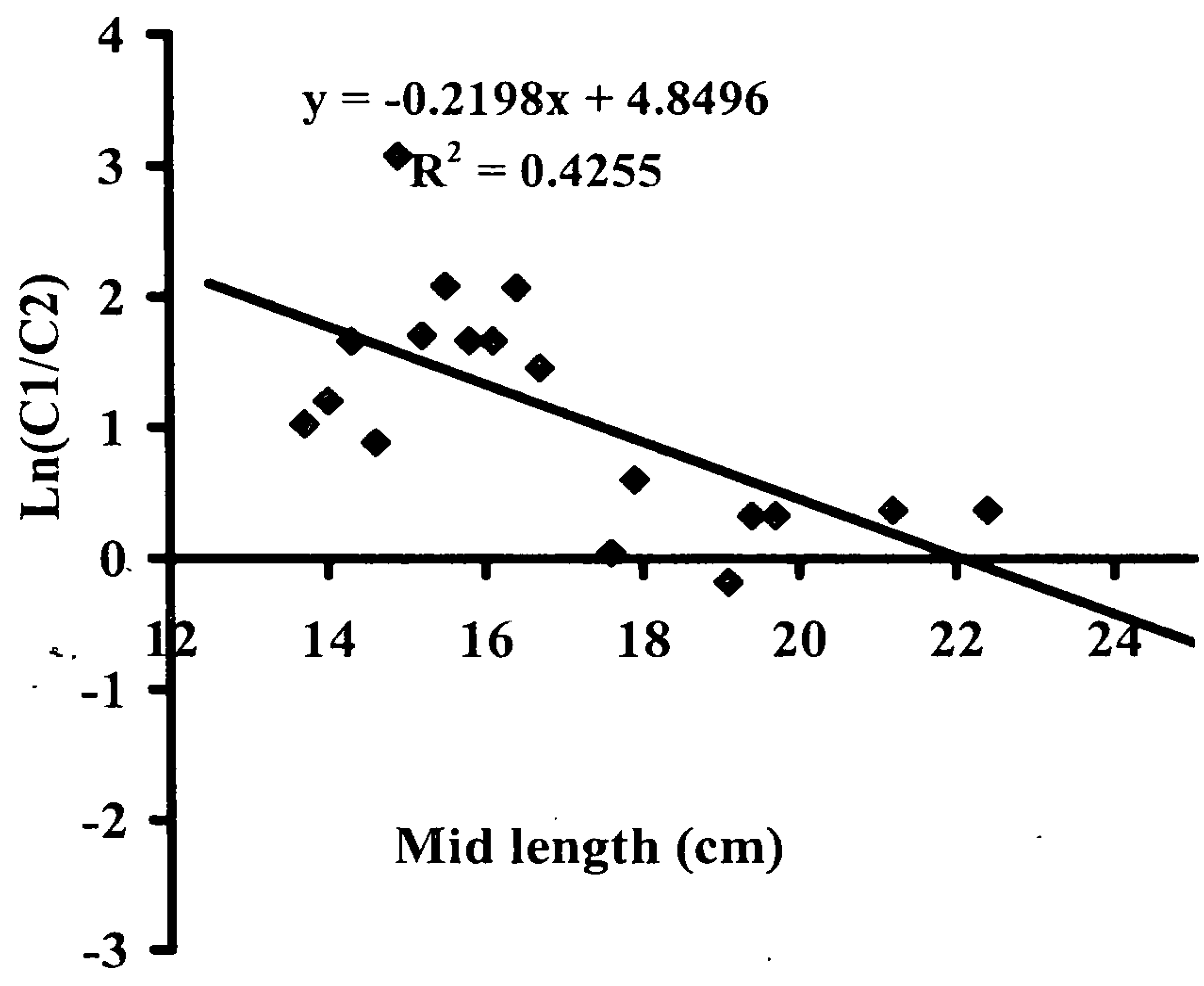

Fig. 3. Scatter plot of Ln catch ratio vs mid length of *S. jello*

Table 2. Gear selectivity and optimal lengths of *S. jello* and *S. obtusata*

Species	Selection range (cm)		Optimal length (cm)	
	2.5 cm mesh	3.0 cm mesh	2.5 cm mesh	3.0 cm mesh
S. jello	13.1-26 cm	14.0- 25.7 cm	27.61 cm	33.12 cm
S. obtusata	15.2-25.4 cm	12.8-27 .0 cm	20.06 cm	24.06 cm

Fig. 4. Scatter plot of Ln catch ratio vs mid length of *S. obtusata*

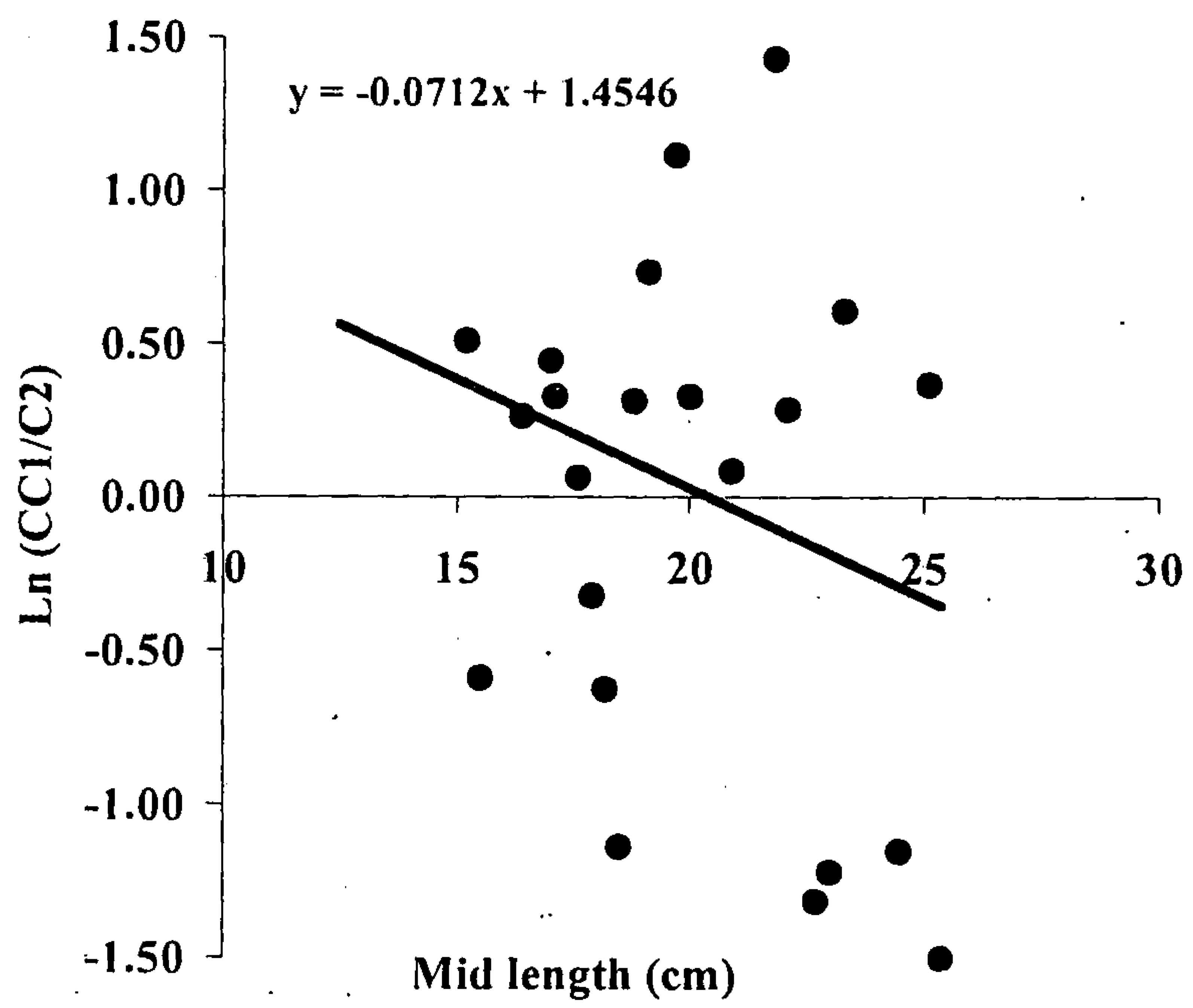

Fig. 5, 6, 7 and 8 show the selectivity curves constructed for *S. jello* and *S. obtusata* for 2.5 cm and 3.0 cm mesh sizes respectively.

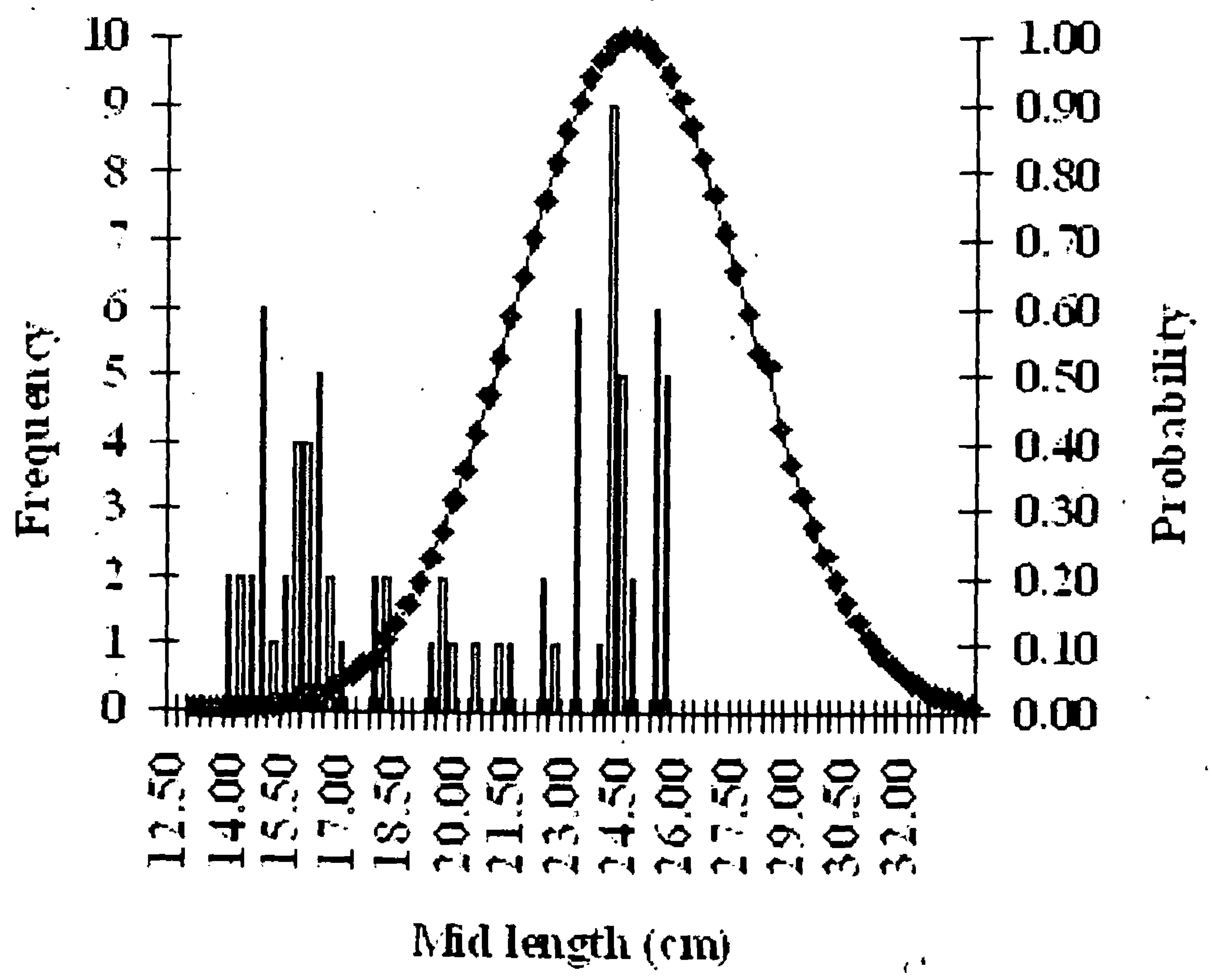

Fig. 5. Gill net selection curve of *S. jello* for the 2.5 cm mesh size

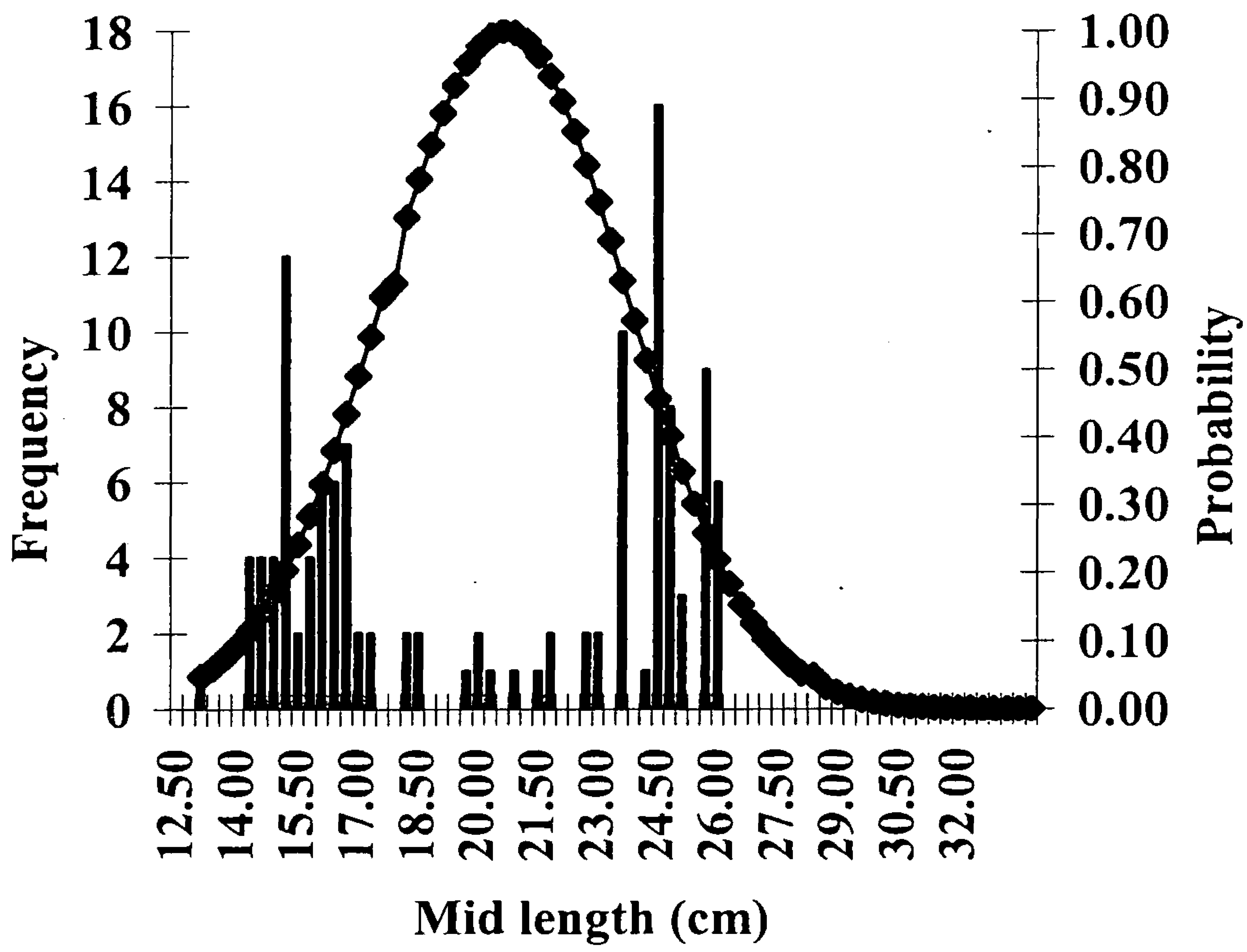

Fig. 6. Gill net selection curve of *S. jello* for the 3.0 cm mesh size

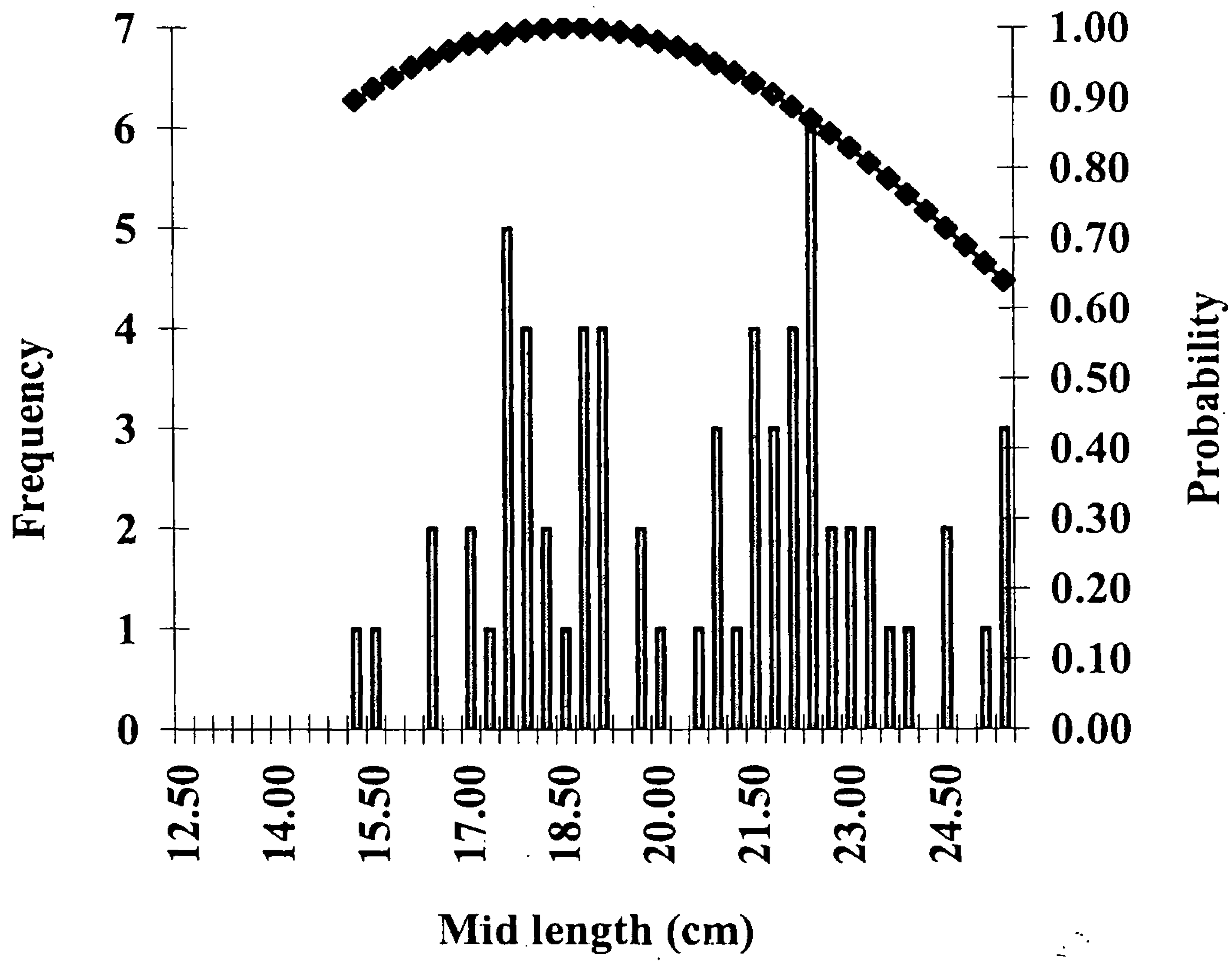

Fig. 7. Gill net selection curve of *S. obtusata* for the 2.5 cm mesh size

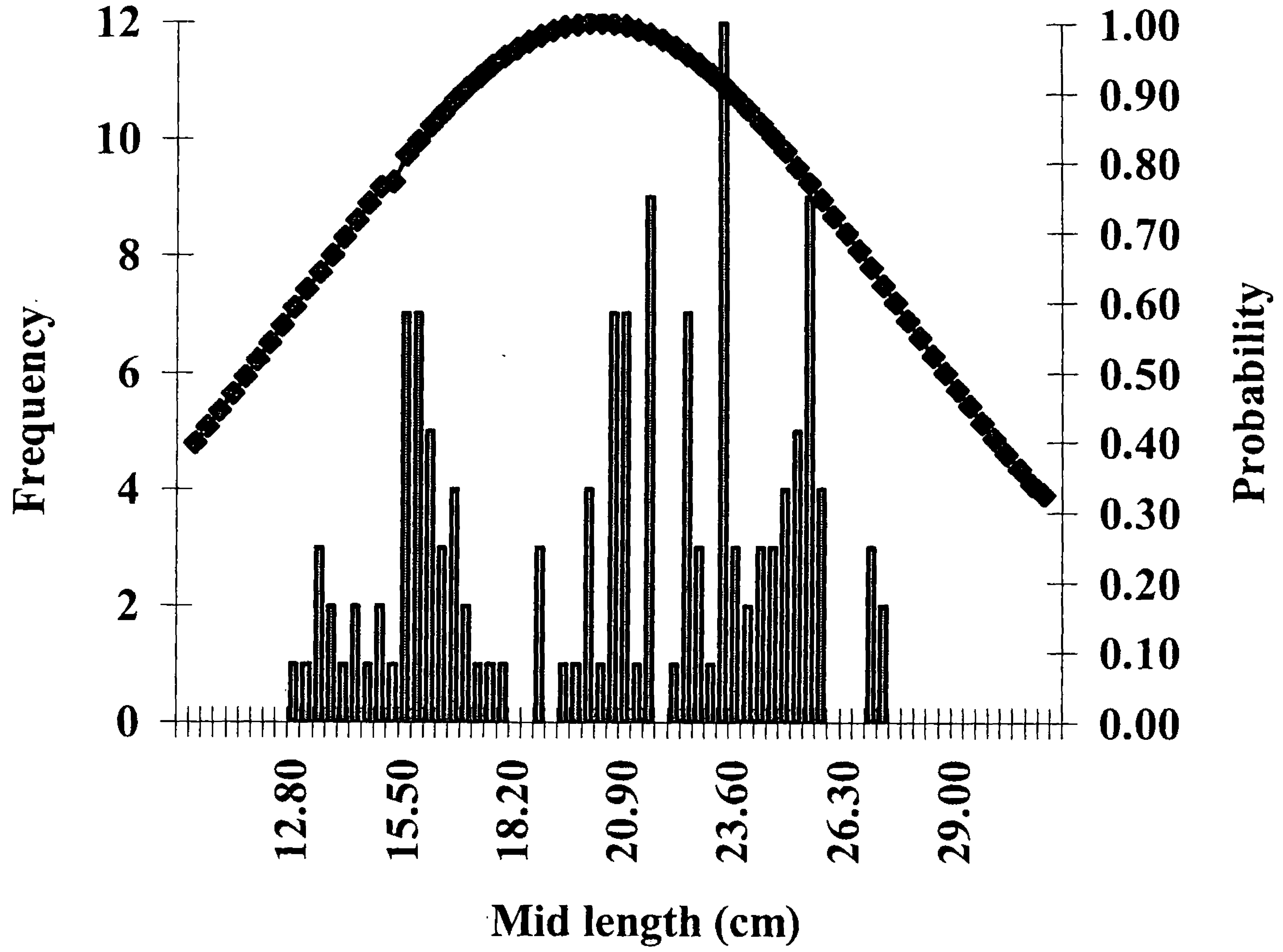

Fig. 8. Gill net selection curve of *S. obtusata* for the 3.0 cm mesh size

Population parameters

The estimated asymptotic lengths (L_α), the growth coefficients (K), and Instantaneous total (Z), Natural (M) and Fishing mortality coefficient (F) of *S. jello* and *S. obtusata* are summarized in table 3 .

Table 3. Growth and Mortality parameters for *S. jello* and *S. obtusata*

Barracuda species	K	L_α	Z	M	F
S. obtusata	1.00	22.8	3.62	1.51	2.11
S. jello	1.51	44.63	4.51	2.39	2.12

Length weight relationship

Fig. 9 indicates the logarithmic relationship between standard length and weight of *S. obtusata*.

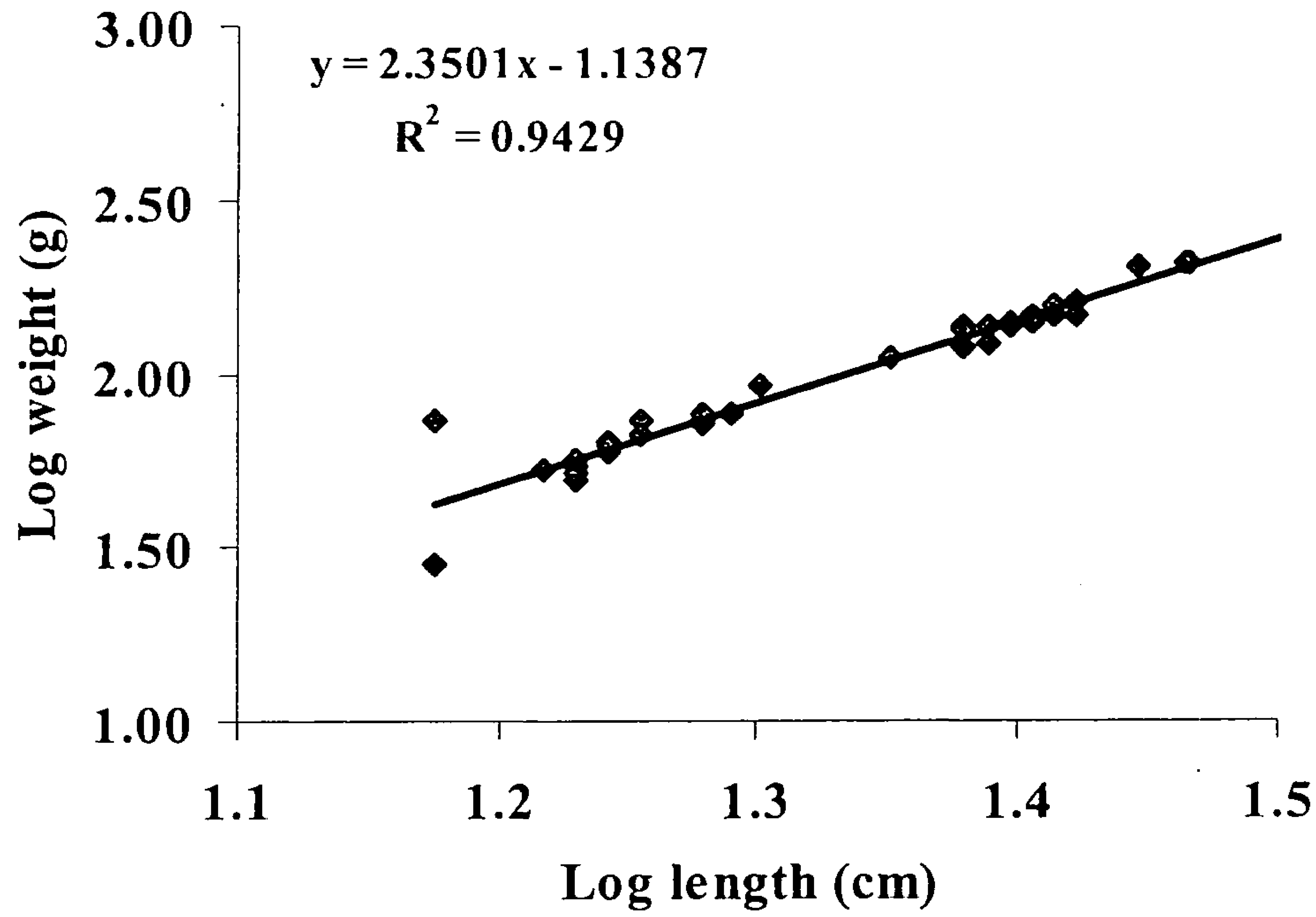

Fig. 9. Logarithmic relationship between standard length and weight of *S. obtusata*

Food and feeding habit of *S. obtusata*

Fig. 10 and 11 indicate the relationship between the RGL and SL and between GASI and SL of *S. obtusata* respectively. RGL-SL relationship shows a second order polynomial curve which indicates that digestive tract of this species is morphologically adapted for ontogenetic variations in feeding. Almost all length classes had relatively low GASI (Fig. 11).

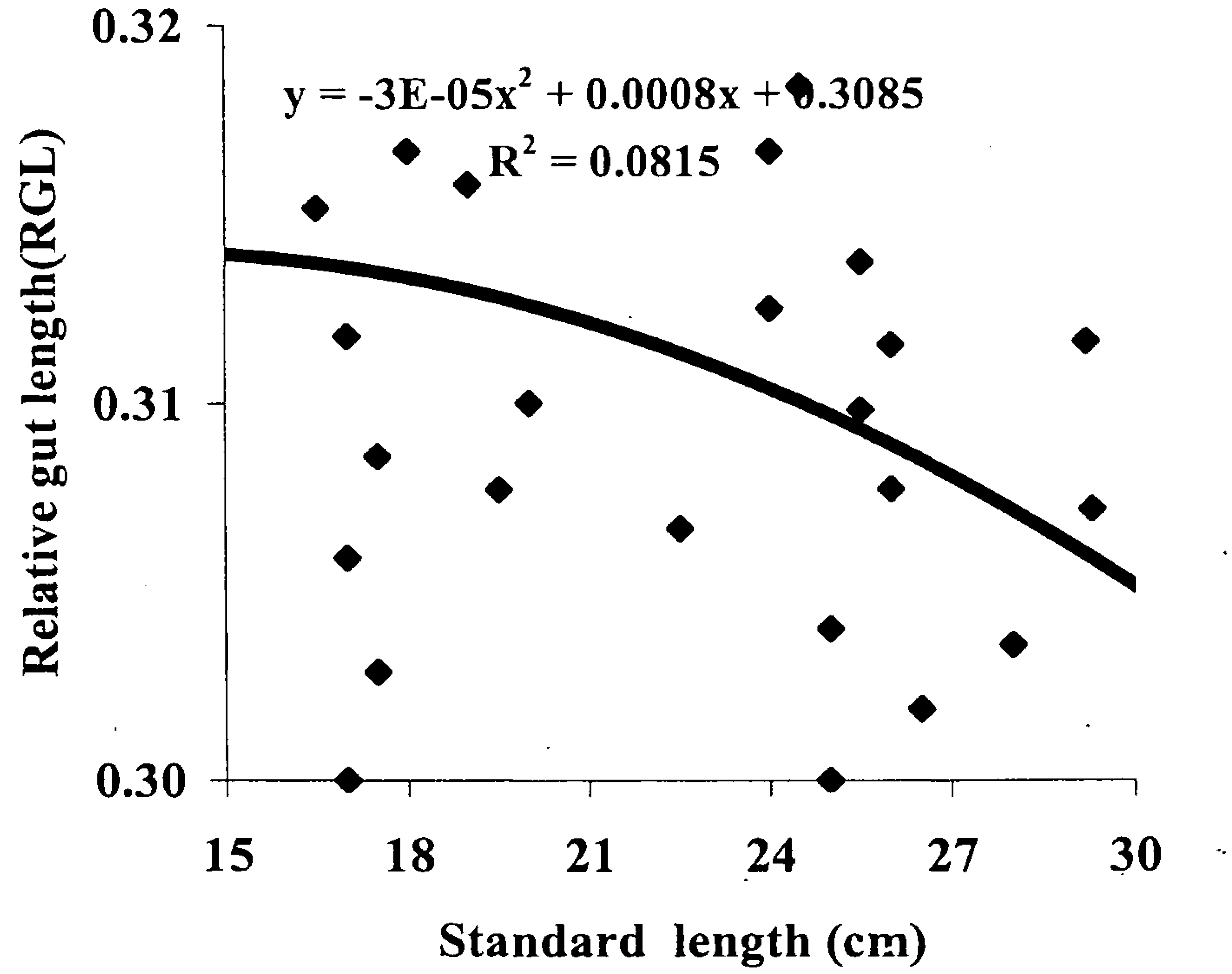

Fig. 10. Relationship between RGL and standard length of *S. obtusata*

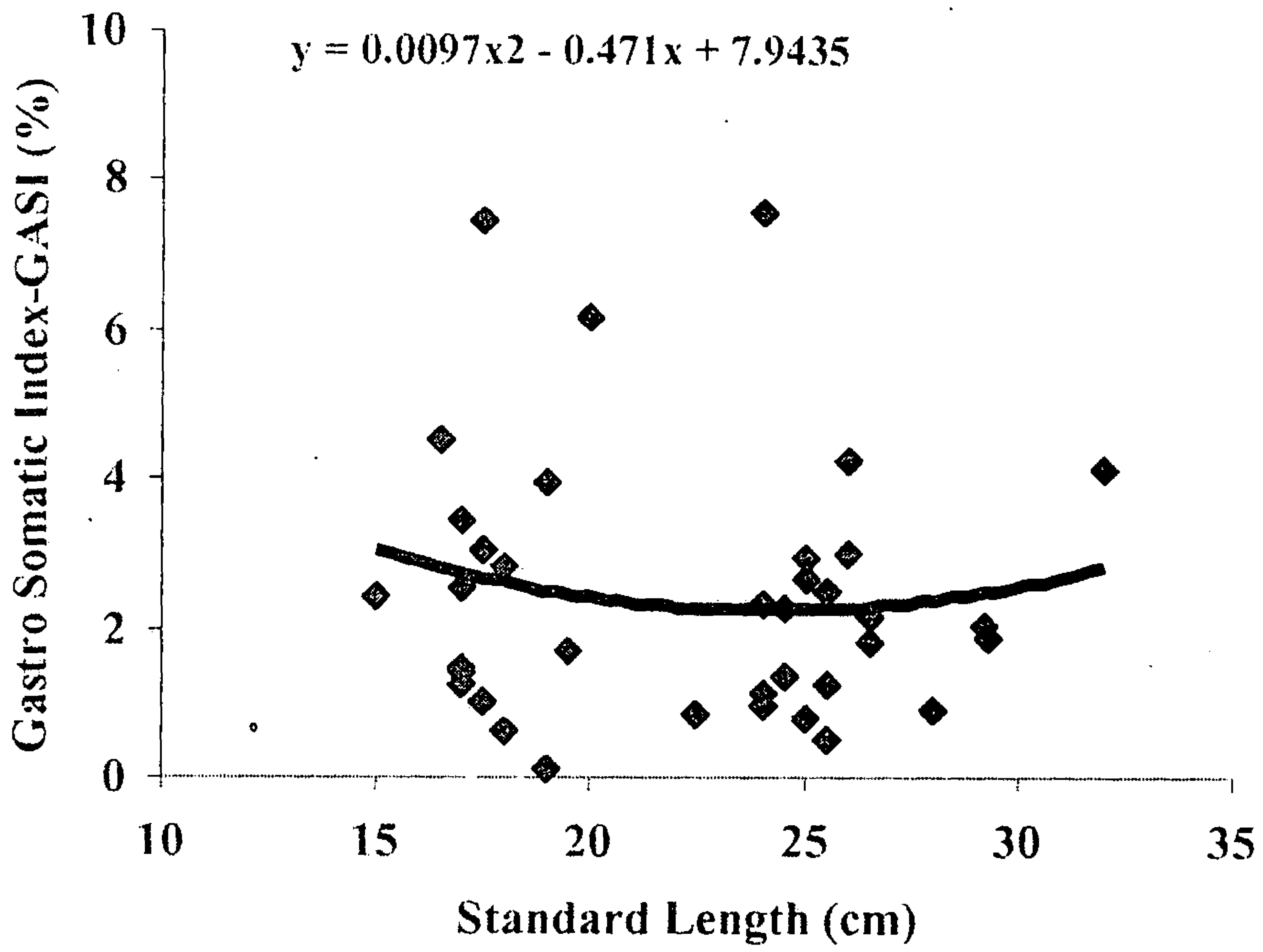

Fig. 11. Relationship between GASI and standard length of *S. obtusata*

Table 4 shows the Relative importance (%) of food items in the stomach contents of S. *obtusata*. In stomach contents fish species, crustaceans, molluscs, zooplankton and phytoplankton were present. Major food item found was *Stolephorus indicus*. Fig.12 shows the results from the multivariate analysis carried out in order to test whether the prey categories are (food and feeding habits) similar in the different length classes. Food habits were found to be similar at 52% similarity level in all tested length classes (13 cm to >31 cm) except 13-15 cm, 27-29 cm and 23-25 cm length groups. Food habits in all tested length classes were, however, no different at 30% similarity level.

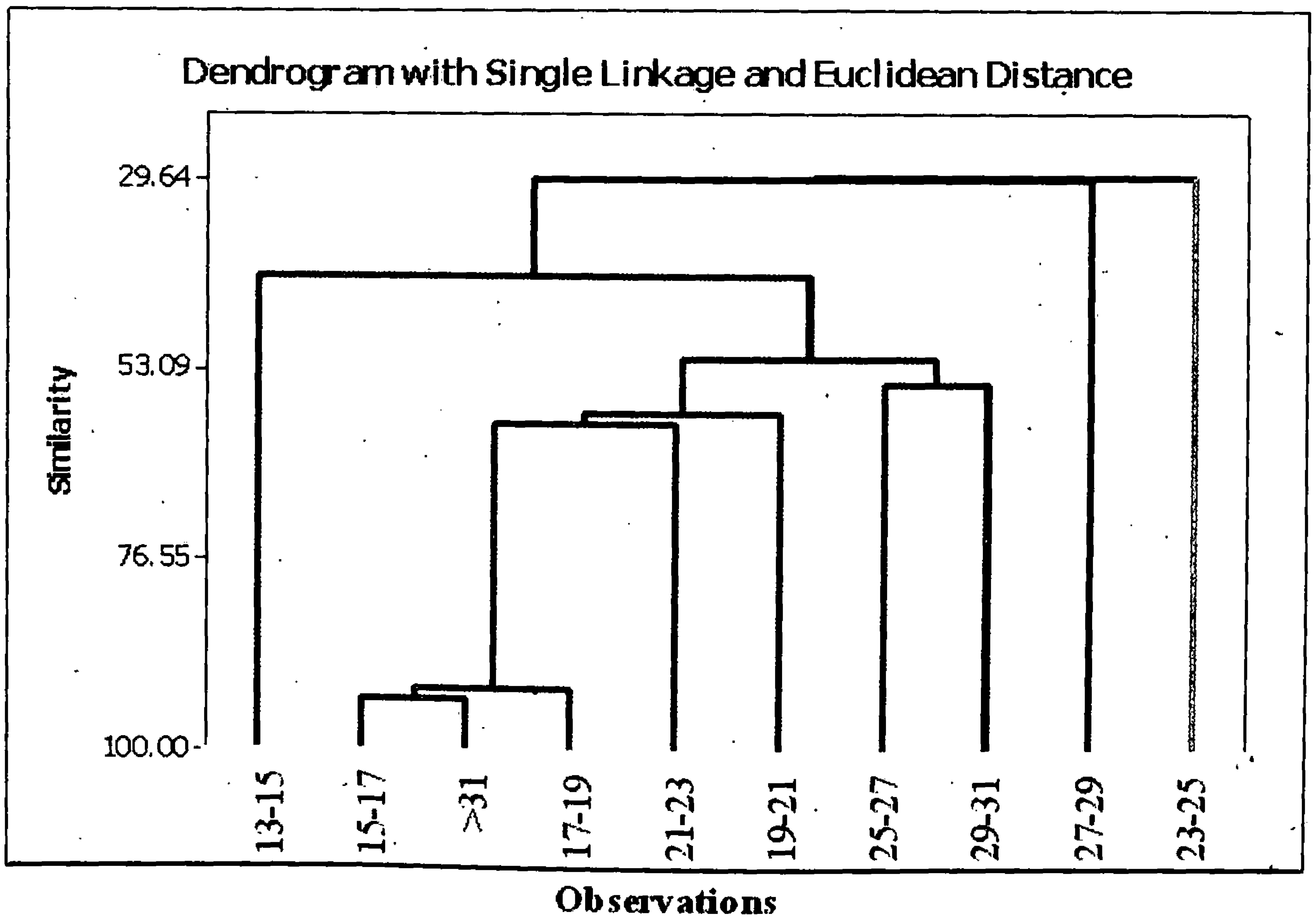

Fig. 12. Dendrogram of the cluster analysis of food category towards the length classes of *S. obtusata* (cm)

Table 4. Relative abundance (%) of food items in the stomach contents of different length classes of *S. obtusata*

Prey category	Length Classes (cm)									
	13-15	15-17	17-19	19-21	21-23	23-25	25-27	27-29	29-31	>31
Fish Species										
Stolephorus indicus	70	87.5	80.8	47.5	90	28.33	15	25	10	5
Sardinella sp.	-	-	15	35	-	10.55	-	-	-	-
Decapterous sp.	-	-	-	-	-	-	-	-	-	85
Red bait	-	-	-	-	-	17.78	31.43	-	-	-
Crustaceans									-	-
Penaeus indicus	-	-	-	-	-	-	2.15	-	-	-
Other Penaeid shrimps	-	-	-	-	-	-	2.86	-	-	-
Shrimp larvae	-	-	-	-	-	17-7	29.55	-	50	-

Prey category	13-15	15-17	17-19	19-21	21-23	23-25	25-27	27-29	29-31	>31
Molluscs										
Sepia	-	-	-	-	-	5.55	-	-	-	-
Zooplankton										
Megalopa larvae	-	0.8	-	-	-	-	-	-	-	-
Amphipoda	-	-	-	-	-	0.55	-	-	-	-
Phytoplankton	10.32	2	1.2	9	1.5	8	7.98	6.5	4.8	1
Miscellaneous										
Shrimp appendages	4.3	-	-	-	-	0.78	0.5	-	-	-
Spines	1.5	0.2	-	-	-	0.2	0.2	3.5	0.2	-
Eye balls of fish	-	-	-	-	-	0.96	0.45	10	-	-
Digested particles	13.9	9.5	3	9.5	8.55	9.6	9.88	55	35	9

Discussion

The Barracuda fishery off Negombo coast of Sri Lanka is highly seasonal from July to December. This is in conformity with the findings of Silva (2001) and De Bruin *et al.*, (1994), who have also recorded the peak fishing season for this species from August to October off the Western coast of Sri Lanka.

Though large numbers of juveniles are caught in small mesh gillnets, fishermen in Negombo are not interested in operating small mesh gillnets targeting Barracuda, as it is a very destructive fish species which cause extensive damage to the gillnets by their sharp teeth, thus reducing the durability of the nets and considerable economic losses to the fishermen. An independent gillnet fishery has not been established, therefore, for Barracuda and they are captured in gillnets as a by-catch.

For a fish of a particular length to be enmeshed in a gillnet there should be a relationship of the body depth to the mesh size. As there was a good statistical relationship between SL and Girth (G) of the selected Barracuda species, gillnet selectivity and size distributions of fish caught could also be expressed in terms of fish length.

This fishery was entirely based on gillnets of 2.5 cm and 3.0 cm mesh sizes. Selection ranges of *S. jello* and *S. obtusata* and their mesh wise length frequency distributions indicate that only a few size classes are present in the catch. Absence of larger size ranges and the presence of smaller size ranges in the fishing ground may be attributed to their feeding aggregations. This phenomenon can be supported by investigating food and feeding biology of *S. jello* and *S. obtusata* over a wide range of length classes. Larger *S. jello* and *S. obtusata* are caught in well established long line fishery while smaller sized individuals are susceptible to small-mesh gillnets, mainly due to their seasonal migratory pattern along the Sri Lankan coasts.

Estimated optimal lengths of different species are found to be different from each other. *S. jello* showed higher optimal lengths, irrespective of two mesh sizes, than S. *obtusata.* This might be due to differences in body shape between particular species as described by De Croos (2003). Larger body depth of *S. obtusata* compared to the *S. jello* may have resulted in this difference.

As only the smaller length classes are available in the catch, it does not represent the population size structure of the entire stock and mortality parameters will not give an accurate estimate. Combination of adjusted length data for the gillnets and long lines might be useful to get a better understanding about the population structure of the entire stock. As such, gillnet selectivity of small length classes is important in adjusting the data of small size classes for the determination of population parameters.

As described by Dayaratne and Silva (1991) and Fernando (2004), errors can occur when determining the growth and mortality estimates based on length frequency analysis, without other supporting biological information on growth, mortality and recruitment patterns. Calculations based on the age structure might, therefore, be more useful to confirm the accuracy of the above estimates.

S. obtusata was selected for the analysis of food and feeding habit as it was dominant during the study period. According to Wickramaratne and Amarasinghe (2001), although the length weight relationship is not directly relevant to the aspects on food and feeding, this estimate is useful as general information. It has been well established that RGL is a good index of digestive demand in fish (Wickramaratne and Amarasinghe 2001). The second order polynomial relationship between RGL and SL of *S. obtusata* may be due to their ontogenetic variations in feeding habits. Relatively low GASI recorded for almost all length classes indicates the low nocturnal food consuming efficiencies while relationship between the GASI and SL indicates the slightly higher feeding efficiency in smaller and larger length classes compared to medium length classes. This slightly higher food demand of the smaller length classes might be due to their rapid growth. In larger length classes, it might be due to their reproduction requirements.

Analysis of the stomach contents of *S. obtusata* indicated that they feed mainly on fish, crustaceans, molluscs, zooplankton and phytoplankton. De Bruin *et al.*, (1994) has also recorded that *S. obtusata* is a carnivorous fish species mainly feeding on other fast moving fishes, squids and shrimps. Major food item found in the stomach contents of *S. obtusata* was the fish *Stolephorus indicus*. Though *S. obtusata* is a carnivorous fish species, phytoplankton were also found in its' gut contents. The probable reason for the phytoplankton to be present in the stomach content may be that its' prey is found in plankton patches resulting in a considerable amount of phytoplankton being ingested while engulfing their prey. In addition, any phytoplankton present in the stomachs of the prey species would also appear in the stomach content of *S. obtusata* as well.

According to Dayaratne (1984), errors can occur in the analysis of stomach contents due to regurgitation by the fish; there is also a possibility that formaldehyde was not added to the samples immediately after capture, which would affect the state of digestion.

Results of the multivariate analysis suggested that the food habits of 13-23 cm and >29 cm length groups were similar at a similarity level of 29.64. This species does not show any large variations in food and feeding habit in their different length classes. It might be useful therefore, to analyze the food and feeding habit of longer fish classes in order to get a better understanding of the food resource utilization and feeding habits of the whole population of *S. obtusata*. For this purpose, longer *S. obtusata* individuals may be collected from the well established long line fishery on the Negombo coast.

The stomach content analysis indicated that *Stolephorus indicus* in the major food item of *S. obtusata*. According to the fishermen, the fishing season for both *S. obtusata* and *Stolephorus indicus* begins simultaneously indicating that *S. obtusata* may be following *Stolephorus indicus* in order to fulfill their food requirements.

As suggested by Fernando (2001), in order to maintain fish production as a significant part of the nations' food supply, the marine fishery resources have to be utilized rationally and effectively under an efficient fishery management policy. The present findings on the Barracuda fishery will be a useful contribution for the development of fisheries management strategies for marine fisheries.

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