GROWTH AND FOOD CONVERSION IN JUVENILE SOUTHERN SEA BASS, *Centropristis melana* (GINSBURG), FED COMMERCIAL AND SEMINATURAL DIETS[1]

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ABSTRACT

Laboratory-reared juvenile southern sea bass, *Centropristis melana* (Ginsberg), were studied to evaluate effects of five diets on growth and food conversion. Diets studied were Marine Ration 20, squid, Marine Ration 30, Catfish Cage Chow, and Trout Chow; each diet had a different total protein content. Diet treatments were conducted using a completely random design in 2.36 x 0.97 x 0.50 m tanks with biological filtration. Fish were fed twice daily at 3% body weight day^{-1} and reduced to 2% body weight at the first signs of wastage. Body weights and total lengths were recorded every two weeks. The Marine Ration 20 diet was terminated at sampling period I due to diet rejection and high mortalities. Significant differences (α = 0.05) in mean body weights among remaining diets occurred by the eighth week, as demonstrated by Tukey's Honestly Significant Difference test. The experiment was terminated after ten weeks. Of all diet treatments taken to termination, juveniles fed squid suffered the highest number of mortalities. Food conversion (g feed g^{-1} gain) and mean percent body weight increase for Trout Chow, squid, Catfish Cage Chow, and Marine Ration 30 were 1.30 and 172.90%, 1.55 and 180.57%, 2.48 and 63.10%, and 3.55 and 36.00%, respectively. Results of all measured parameters show that Trout Chow was superior in rearing juvenile southern sea bass.

INTRODUCTION

Interest in culture of marine finfish is rapidly growing worldwide. System advancements have enabled the testing of culture potential of various species of marine finfish, enabling researchers to successfully

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spawn and rear larvae within these systems (Roberts et al., 1976). To date, however, research utilizing young juveniles in growth and food conversion studies to determine the feasibility of using marine species for commercial mariculture has been minimal. Most nutrition research with marine fish has been conducted with species of the families Pleuronectidae and Salmonidae (DeSilva and Balbontin, 1974), and relatively little has been conducted with other species.

Successful commercial mariculture will depend largely on development of inexpensive foods that promote optimal growth and survival. Because feeding represents a substantial cost in intensive fish farming, development of optimal dry feeds is a major concern of fish culture research (Tiews et al., 1976).

This study was undertaken to compare commercial feeds with a semi-natural feed as a growth ration for juvenile southern sea bass, Centropristis melana (Ginsburg). This species was selected as a test animal because of availability and compatability to mariculture technology. Laboratory-reared juvenile southern sea bass from the spawning and larval rearing studies of Roberts et al. (1976) were used in the present study.

MATERIALS AND METHODS

Fish were held in five 2.36 x 0.96 x 0.50 m biologically filtered concrete vaults sealed with non-toxic epoxy resin (Figure 1). Filters consisted of a network of 2.54 cm polyvinylchloride (PVC) pipe drilled 1.0 cm along its entire length, allowing water to be drawn by airlift through the network and filter bed respectively. The filter bed consisted of 1.25 cm grid fluorescent light louver material covered with 800 μm plastic screen. Sixteen cm of 98% aragonite (particle size 1 mm^3-1cm^3) served as the biological bed and buffering medium. Each tank was partitioned into three equal sections. Partitions were constructed of 1.25 cm grid louver with 800 μm plastic screen attached with monofilament fishing line. Construction allowed water flow within tank sections, but prohibited fish or food movement to adjacent sections. A 1.0 x 1.0 cm mesh seine net placed over each tank prevented fish from jumping out of the tank or into another section. All rearing tanks were enclosed in a 5.95 x 1.70 x 2.03 m visquine structure so that environmental parameters could be closely regulated.

Godcharles (Florida Department of Natural Resources Marine Research Laboratory, personal communication), determined the fastest growing period of southern sea bass to be the summer of their first year. Appropriate hydrographic data compiled by Joyce and Williams (1969) indicated that mean water temperature during this period was 26.5°C. A portable electric heater with thermostat (1650 w, 120 v) and aquarium heater probes (150 w) were used to maintain desired temperature. Water temperatures during this experiment ranged from 24.4 to 29.0°C. Photoperiod in the experimental area averaged 13 h light. Illumination was fluorescent full-spectrum Duro-Test Vita-Lights[1] mounted overhead. Salinity, measured by refractometer (American Optical), averaged 31 ppt (± 3 ppt) throughout the experiment.

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[1]Reference to trade names does not imply endorsement by the Florida Department of Natural Resources Marine Research Laboratory.

Water chemistry remained excellent for the entire experimental period. Nitrate levels were determined by the method of Kahn and Brezenski (1967) and never exceeded 3.558 mg l^{-1}. Nitrite levels, determined by a modification of Strickland and Parsons (1968), did not exceed 0.014 mg l^{-1}. Ammonia levels, determined using methods of Solorzano (1969), never exceeded 0.071 mg l^{-1}.

Four weeks prior to the beginning of the study, juveniles were conditioned to accept the feeds intended to be used. At initiation, 225 fish were selected and randomly assigned, 15 fish per section, to each of the 15 sections and diets were randomly assigned to each tank. All fish were 195 days old; body weights (BW) ranged from 7.19 to 10.03 g and total lengths (TL) ranged from 7.50 to 8.50 cm.

Four dry artificial diets and one seminatural diet were selected: these were Marine Ration 20, Marine Ration 30, Catfish Cage Chow, Trout Chow, and squid. Artificial diets were donated by the Ralston Purina Research Laboratory (Crystal River, FL) and the squid was purchased from a commercial seafood company. Only squid tentacles were used, thus assuring uniformity of the nutrient content of this diet. All feeds were prepared at a size easily consumed by the fish and gradually adjusted to correspond with growth.

Fish were hand-fed twice daily, six days a week, at 3% BW day^{-1}. This was reduced to 2% BW day^{-1} at the first signs of wastage. Feeding was discontinued when satiation occurred. Excess food was subtracted from the daily ration and recorded. Rations were based on dry matter content. Artificial diets were at least 90.0% dry matter and squid was 16.0% (Table 1). Food conversion efficiencies were expressed as the amount of food consumed divided by the live weight gain.

Weights and lengths were recorded for all fish at initial stocking and every two weeks thereafter. Food given each section (replicate) was determined from initial weights and adjustments were made after each sampling period. Mortalities were replaced only during the first week of experimentation. Weight and length data were recorded for replacements and mortalities.

Experimental design was based on the completely random model (Steele and Torrie, 1960). The experiment continued until significant differences ($\alpha = 0.05$) in mean BW $fish^{-1}$ occurred among diet treatments. Any treatments prematurely terminated due to diet rejection and/or high mortalities were not included in statistical analyses. Actual termination of the experiment occurred at the end of the fifth sampling period (69th day). An analysis of variance with unequal subsample numbers (Steele and Torrie, 1960) was used to test effects among treatments and among replicates of a specific treatment. Homogeneity of variance was tested in all cases using Bartlett's Chi-square procedure. Logarithimic transformations (base 10) were used when Chi-squares proved significant ($\alpha = 0.05$). Tukey's Honestly Significant Difference (HSD) test (Steele and Torrie, 1960) was used to test differences among treatment mean BW $fish^{-1}$ after each sampling period. The validity of this procedure when used with unequal subsample numbers was considered. At experiment termination, an analysis of variance with unequal subsamples was performed on survival rates and food conversion ratios; Tukey's HSD test was used to determine significance ($\alpha = 0.05$) within each of these parameters.

RESULTS

Five diet treatments were introduced for study; however, Marine Ration 20 was prematurely terminated. Fish response to this diet was satisfactory during the first week, but during the second week the fish refused to feed and many mortalities occurred (Figure 2). Therefore, all subsequent data and analyses exclude Marine Ration 20.

Mean BW and TL fish^{-1} showed identical trends of response during the experiment (Figure 3, Table 2). Mean percent BW increases in fish fed squid and Trout Chow were similar (180.57% and 172.90%). Fish fed Catfish Cage Chow and Marine Ration 30 increased 63.10% and 56.00% in mean BW. Squid and Trout Chow produced mean TL increases of 34.45% and 29.46%, whereas Catfish Cage Chow and Marine Ration 30 increased only 15.43% and 13.74%.

Total biomass and percent survival for each treatment showed slightly different results from those implied by body weight and total length gains (Figures 2-4, Table 2). The squid diet produced a high weight gain, but survival and resultant biomass were very low (13.3% and 128.01 g). Trout Chow produced the highest total biomass (748.84 g) and a survival rate slightly lower (78.9%) than Marine Ration 30 and Catfish Chow (80.0% each), which produced total biomass of 526.20 g and 542.23 g, respectively. Percent survival for fish on the squid diet was significantly lower ($\alpha = 0.05$) than Marine Ration 30, Catfish Cage Chow, or Trout Chow; the latter treatments were not significantly different among themselves.

Feeding response to diet treatments appears directly related to percent total protein (Table 3). There was daily variation in food intake and response in all replicates; however, response was best with Trout Chow (40.99% protein) and Catfish Cage Chow (36.10% protein). .Fish fed Marine Ration 30 (27.58% protein) displayed an overall satisfactory response, but this decreased considerably after sampling period IV. Response to squid (11.48 - 16.40% protein) was very good through sampling period II, but declined thereafter. Although daily rations were determined on a percent basis, feeding often ceased before consumption of the entire amount, except for fish fed Trout Chow where all daily rations were consumed. Fish fed squid never consumed the total daily ration, probably because the high moisture content of this diet resulted in an excessive ration as calculated on a dry matter basis.

Food conversion ratios within each replicate and mean food conversion ratios (g dry feed g^{-1} live weight gain) are given in Table 4. Trout Chow had the best mean conversion ratio (1.30), followed by squid (1.55), Catfish Cage Chow (2.48) and Marine Ration 30 (3.55). Multiple comparisons among treatment means showed that conversion ratios obtained from Trout Chow and squid were significantly different (i.e., better conversion ratios) than those of other diets.

Tables 5 and 6 summarize analyses of variance and significant differences ($\alpha = 0.05$) of mean BW fish^{-1} among treatments for each sampling period. There were no real differences among treatment means until sampling period IV, at which time Trout Chow was significantly different from Marine Ration 30 and Catfish Cage Chow. By sampling period V (experiment termination), all comparisons except Marine Ration 30/Catfish Cage Chow and Trout Chow/squid showed significant differences.

If minimal nutritional requirements are met, juvenile southern sea bass prove to be very hardy. Marine Ration 20 and squid apparently did not provide adequate nutrition. Termination of the Marine Ration 20 diet at the first sampling period was necessary due to diet rejection, resulting in very high mortalities. However, this diet was designed specifically for crustaceans, and we suspect that the low vitamin, protein, and amino acid composition did not meet the nutritional requirements of the fish. Nutritional deficiencies of squid were revealed over a longer time. This diet was acceptable to the fish, but at termination mortalities were so high that total biomass decreased 68.44% from the initial total biomass. A better designed diet conditioning program might have revealed the nutritional deficiencies of these two diets. Necropsies performed on mortalities associated with these diets revealed no pathogenic and/or parasitic organisms, substantiating apparent nutritional deficiencies.

Pandian (1967) states that growth potential of fish is influenced to a great extent by the food quality. Mortalities associated with these nutritionally deficient diets suggest the importance of total protein in diet composition. Low total protein levels of squid (11.48 - 16.40%) and Marine Ration 20 (21.47%) were definite factors contributing to high mortality. Results indicate that Marine Ration 30 (27.58%) appears to contain the minimal protein content needed by juvenile southern sea bass. As total protein levels increased within the tested diets, mean body weight and length, biomass, and survival increased and food conversion ratios decreased. Zeitoun et al. (1976) have shown increased percent weight gains in rainbow trout with increased dietary protein. Tiews et al. (1976), also using rainbow trout, have confirmed the correlation that regardless of the source of dietary protein (animal or plant), there is a definite relationship between increased dietary protein content and lower food conversion ratios.

The usefulness of the food conversion ratio (g feed g^{-1} live weight gain) as a parameter for measuring efficiency of food utilization varies among investigators. Weight gain has been criticized (Maynard and Loosli, 1969; Meyer and Garrett, 1969) as an inaccurate measure of growth because it may indicate fat deposit rather than true growth. Kinne (1960), DeSilva and Balbontin (1974), and Edwards et al. (1971) consider food conversion a valid parameter when evaluated over the periods of maximum growth and minimal fat deposition. Therefore, use of food converison ratios in this experiment is justified.

The high rate of growth, low food conversion ratio, and satisfactory percent survival of juvenile southern sea bass fed Trout Chow demonstrated this diet to be suitable for rearing juveniles to the sizes attained in this study. The other feeds did not produce better overall results when compared to Trout Chow. Although the squid diet produced a low food conversion ratio (1.55), this is quite misleading if mortalities are not considered. Therefore, despite similar mean body weight and length changes and food conversion ratios between the squid and Trout Chow diets, the low survival associated with the squid diet indicates that this diet should be avoided as a sole source of nutrition for juvenile southern sea bass. Marine Ration 30 and Catfish Cage Chow had survival rates (80.0%) each similar to that of Trout Chow (78.9%); however, food conversion ratios were significantly higher and per cent body weight increases were lower than obtained with Trout Chow.

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Table 1. Nutrient analysis of diet treatments

Diet	Total Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Dry Matter (%)
Squid	11.48-16.40	1.17	—	1.31	16.0
Marine Ration 20	21.47	9.97	3.6	12.51	93.0
Marine Ration 30	27.58	6.36	2.0	10.78	91.8
Catfish Cage Chow	36.10	3.57	3.4	8.70	90.3
Trout Chow	40.99	4.96	2.3	9.08	90.2

Table 2. Mean weight and length gain, % survival, and survial significance of experimental diet treatments.

Diet	No. Fish Stocked	Mean Initial Weight Fish-1 (g)	Mean Final Weight Fish-1 (g)	Mean Body Weight Change (g)	Mean Body Weight Increase (%)	Mean Initial Length Fish-1 (TL cm)	Mean Final Length Fish-1 (TL cm)	Mean Final Length Change (TL cm)	Mean Length Increase (%)	No. Fish Surviving	Survival (%)
Squid	45	9.01	25.28	16.27	180.57	8.04	10.81	2.77	34.45	6	13.3 [a, b*]
Marine Ration 30	45	9.41	14.68	5.27	56.00	8.15	9.27	1.12	13.74	36	80.0 [a]
Catfish Cage Chow	45	9.24	15.07	5.83	63.10	8.10	9.35	1.25	15.43	36	80.0 [a]
Trout Chow	45	9.04	24.67	15.63	172.90	8.08	10.46	2.38	29.46	31	78.9 [b]

* Values with the same superscript are significantly different ($\alpha = 0.05$). Statistical comparisons utilized the method of Tukey's Honestly Significant Difference test ($\alpha = 0.05$).

Table 3. Fish feeding responses toward diet treatments during each sampling period.

Diet	Total Protein (%)	Sampling Periods I	II	III	IV	V
Marine Ration 20	21.47	−				
Squid	11.48 - 16.40	+	+ → 0	0 → −	−	−
Marine Ration 30	27.58	+	+	+	+ → 0	0
Catfish Cage Chow	36.10	+	+	+	+	+ → 0
Trout Chow	40.99	+	+	+	+	+

\+ = Aggressively feeding, competing for food.

0 = Actively feeding, no significant competition for food.

− = Not actively feeding, lethargic.

Table 4. Treatment and replicate food conversion ratios of experimental diet treatments.

Diet	Replicate	Total Weights (g) Initial	Final*	Total Amount of Dry Food Consumed (g)	Replicate Food Conversion Ratios**	Mean Conversion Ratios***
Trout Chow	A	134.61	301.44	219.39	1.31	$1.30^{a,c}$
	B	138.68	289.38	203.47	1.35	
	C	133.69	315.68	224.58	1.23	
Squid	A	144.60	190.82	76.25	1.65	$1.55^{b,d}$
	B	123.31	157.24	60.08	1.77	
	C	137.69	191.84	67.16	1.24	
Catfish Cage Chow	A	129.53	217.57	195.35	2.22	$2.48^{c,d}$
	B	150.50	236.79	220.30	2.55	
	C	135.55	200.74	174.76	2.68	
Marine Ration 30	A	134.94	204.04	191.71	2.77	$3.55^{a,b}$
	B	145.86	210.83	200.15	3.08	
	C	142.65	181.92	188.26	4.79	

* Final weights included weights of mortalities.
** Food conversion ratio = g dry food consumed g^{-1} live weight gain.
*** Values with the same superscript, are significantly different ($\alpha = 0.05$). Statistical comparisons utilized the method of Tukey's Honestly Significant Difference test.

Table 5. Analysis of variance for all sampling periods.

Sampling Period	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio
I	Tanks	3	7.98333	2.66111	0.36288
	Sections within Tanks (EE)	8	58.66690	7.33336	0.33414
	Fish within Sections (SE)	163	3577.30727	21.94667	
	Total	174	3643.95750		
II	Tanks	3	81.63173	27.21058	1.39031
	Sections within Tanks (EE)	8	158.01232	19.57154	0.64560
	Fish within Sections (SE)	151	4619.71192	30.59412	
	Total	162	4859.35597		
III	Tanks	3	418.64579	139.54860	5.89407*
	Sections within Tanks (EE)	8	189.40894	23.67612	0.55533
	Fish within Sections (SE)	130	5542.48472	42.63450	
	Total	141	6150.53945		
IV	Tanks	3	977.28086	325.76029	11.41747*
	Sections within Tanks (EE)	8	228.25385	28.53173	0.50028
	Fish within Sections (SE)	111	6330.53709	57.03187	
	Total	122	7536.07181		
V	Tanks	3	0.96022	0.32007	12.49785*
	Sections within Tanks (EE)	8	0.20487	0.02561	0.54887
	Fish within Sections (SE)	97	4.52575	0.04666	
	Total	108	5.69084		

* Values significant at $\alpha = 0.05$.

Table 6. Statistical analysis of mean body weight fish-1 among treatments for each sampling period.

	Sampling Periods	
I–III	IV	V
All comparisons among treatment means proved insignificant. F–ratio of sampling period III was significant, but Tukey's HSD test proved insignificant.	Marine Ration 30 / Trout Chow*	Marine Ration 30 / Trout Chow*
	Catfish Cage Chow / Trout Chow*	Catfish Cage Chow / Trout Chow*
	Marine Ration 30 / Catfish Cage Chow	Marine Ration 30 / Catfish Cage Chow
	Marine Ration 30 / Squid	Marine Ration 30 / Squid*
	Catfish Cage Chow / Squid	Catfish Cage Chow / Squid*
	Trout Chow / Squid	Trout Chow / Squid

* Mean body weight fish−1 is significantly different ($\alpha = 0.05$). Statistical comparisons utilized the method of Tukey's Honestly Significant Difference test.

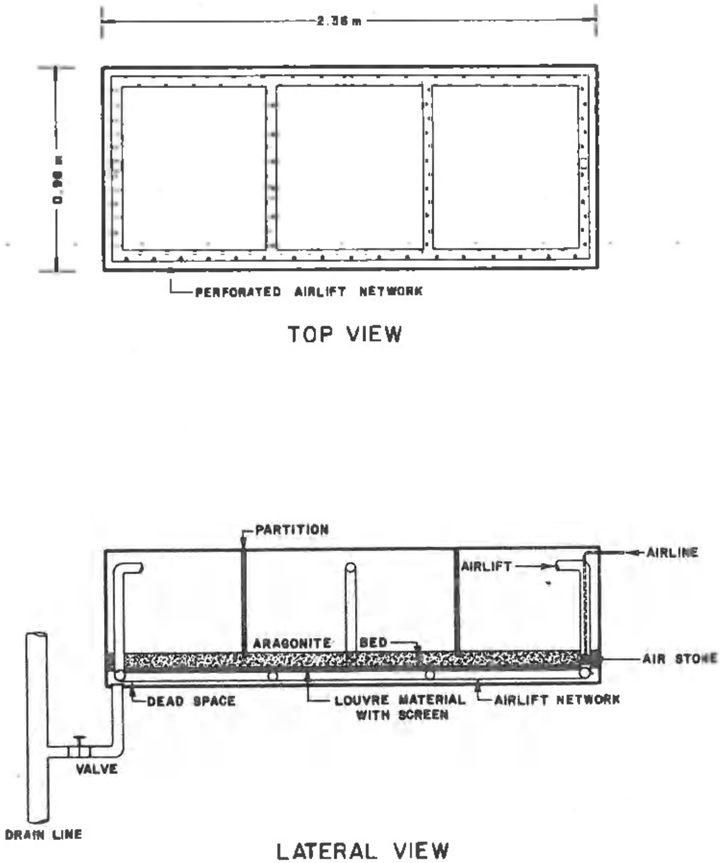

FIGURE 1. Schematic juvenile rearing tanks. Adapted from Roberts et. al., (1976).

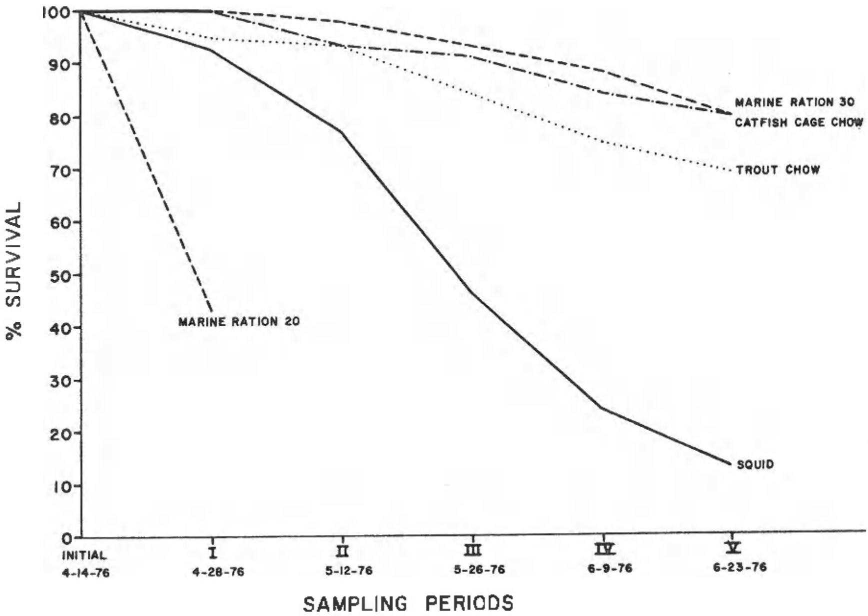

FIGURE 2. Percent survival of juvenile southern sea bass fed four different diets. Marine ration 20 was terminated at sampling period I due to diet rejection and early high mortalities.

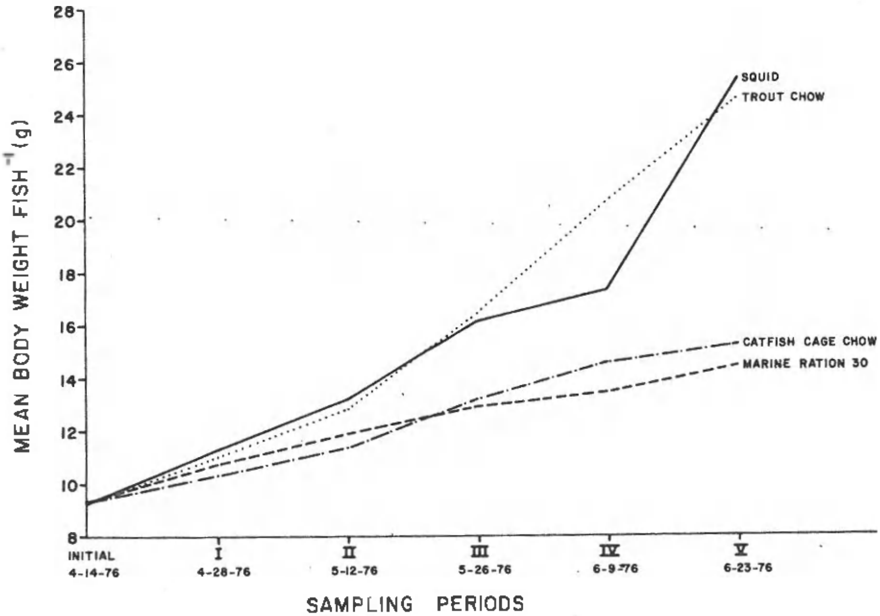

FIGURE 3. Mean body weight (BW) increase of juvenile southern sea bass fed four different diets.

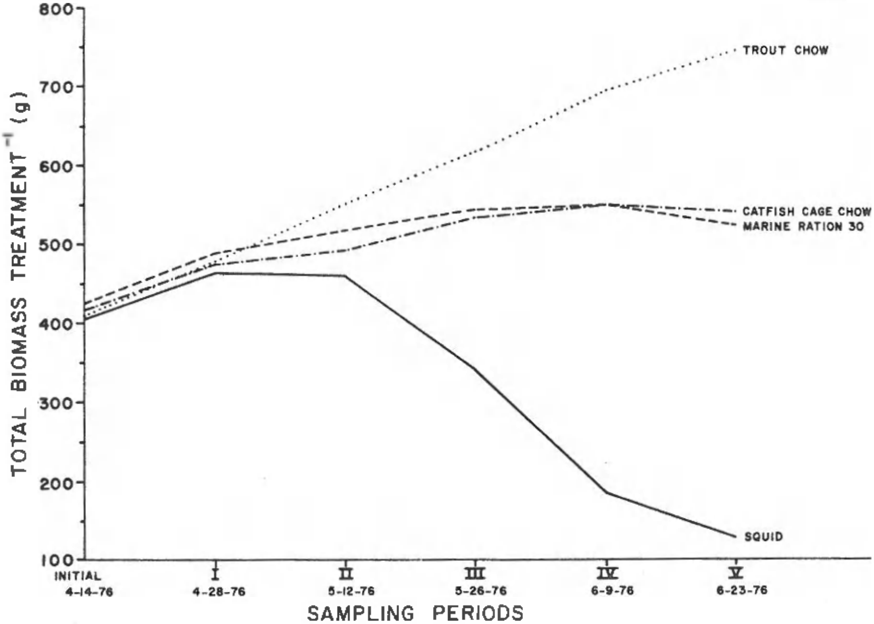

FIGURE 4. Total biomass change of juvenile southern sea bass fed four different diets.

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