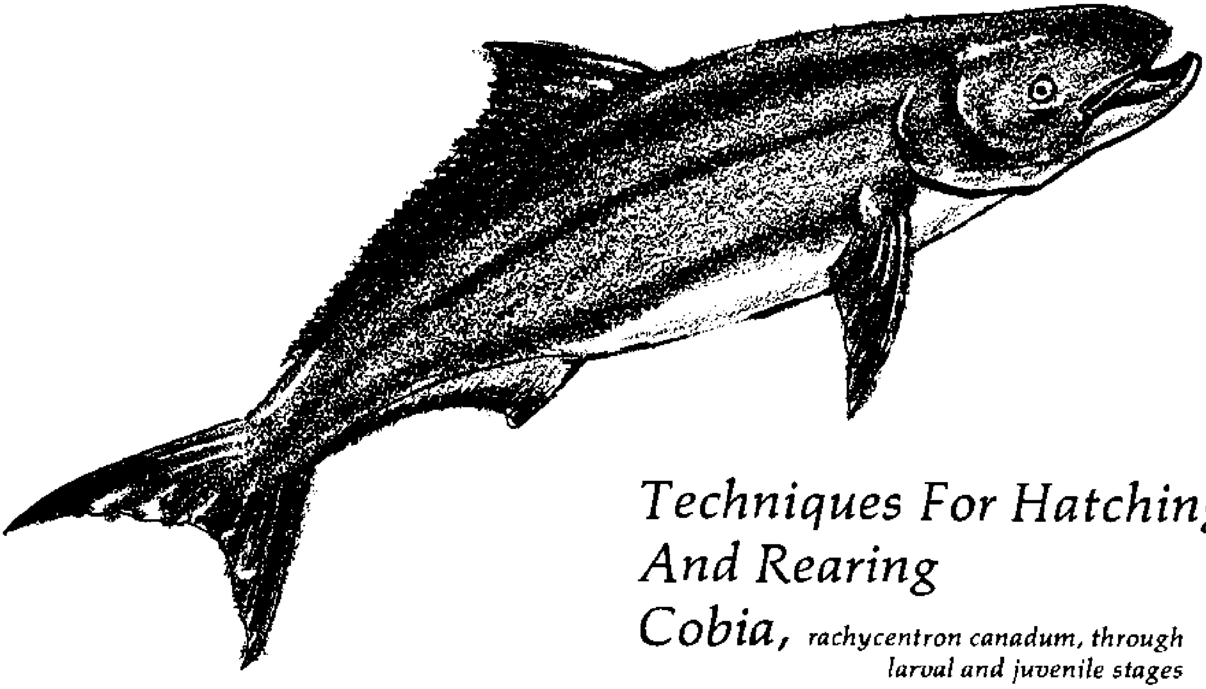

Techniques For Hatching And Rearing Cobia, rachycentron canadum, through larval and juvenile stages

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TECHNIQUES FOR HATCHING AND REARING COBIA, *RACHYCENTRON CANADUM*, THROUGH LARVAL AND JUVENILE STAGES

by

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and

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Introduction

Biologists have been interested in rearing marine fish for many years. Early attempts achieved limited success because little was known of the requirements of fish larvae from the time of hatching through the juvenile stage. This period proved to be a sensitive stage in the life history of marine fish. It has only been in the past decade that the basic requirements of pelagic, marine larvae have been recognized and the laboratory rearing of several species has been achieved (Blaxter, 1968: Hirano, 1969; Okamoto, 1969; Richards and Palko, 1969; Shelbourne et al., 1963; Houde et al., 1970; Houde and Palko, 1970 Houde and Richards, 1969). With modification, these laboratory techniques may be useful in the mass culture of some species.

Prior to this study, the cobia, Rachycentron canadum, was overlooked in fish rearing programs, but this species possesses several characteristics which are desirable in a cultured organism. The cobia has a worldwide distribution in tropical and subtropical areas (Briggs, 1960) and is found seasonally in temperate waters. Within this geographic range, cobia encounter both marine and estuarine environments and is therefore able to tolerate a wide range of environmental conditions. Although a well-established, commercial market has been precluded by the small and unpredictable nature of the catch, cobia is recognized as a fine food fish and is caught throughout its range by commercial and sport fishermen (Hassler, unpub. ms.). Cobia also has a rapid rate of growth. Hassler (unpub. ms.) observed growth up to 67 pounds for the first seven years of life, and Richards (1971) noted a similar size attained in Chesapeake Bay cobia in nine years.

This study was undertaken to further evaluate the cobia's potential as a cultured organism by developing techniques of collecting, identifying and maintaining cobia eggs, and to define the environmental conditions required for the growth and survival of larval and juvenile cobia. The results of this work were obtained under small-scale, laboratory conditions, however with modification their application in larger-scale projects may be possible.

Techniques

Egg Collection.

From May 23 to June 28, 1974 plankton tows were taken 15 to 30 miles east of Hatteras Village, North Carolina. Two one-meter nets (505 u and 707 u) were towed simultaneously inshore, offshore, and along the edge of the Gulf Stream. After towing for 10 to 20 minutes, the concentrated plankton sample was recovered and strained through a 1.5 mm dip net to remove large particulate matter. The filtrate was visually examined for cobia eggs before being placed in plastic barrels containing approximately 38 l (10 gal) of seawater. This water was continuously aerated to keep the eggs in suspension and to maintain the oxygen tension of the water. A wet canvas cover was placed over the barrels to prevent an excessive rise in temperature.

The plankton samples were reconcentrated in the laboratory using a 65 u Wisconsin net. The samples were then placed in 6-inch finger bowls, and the contents inspected over an illuminated table. Cobia eggs were aspirated from the finger bowls and identification was confirmed under a binocular microscope.

Tank Conditions

Most of the cobia eggs were hatched and the larvae reared in 38 l (10 gal) tanks; however, in some of the growth rate studies 76 l (20 gal) tanks were used. The use of 38 l tanks facilitated observation and counting of the eggs and larvae; whereas the 76 l tanks held more eggs and had been used with greater success in previous studies (Houde, 1973). Twenty-five eggs were added to each 38 l tank, but as many as 300 eggs were added in one case. Six hundred eggs were used in the 76 l tanks.

Water from the Gulf Stream and inshore ocean water were used in the tanks. The water was filtered through a 1 u filter before use in order to remove particulate matter.

Cobia larvae were reared in semi-static, subgravel, or externally filtered tanks. Young larvae were held in semi-static tanks in which 10 percent of the tank water was exchanged daily to maintain water quality. The water exchanges were initiated the day after food organisms were first introduced and continued thereafter. Older cobia larvae were transferred to tanks with subgravel or external filters, and daily water exchanges were performed only if the chemical conditions deteriorated.

The tanks were continuously aerated and illuminated. Two, 40-watt, cool white fluorescent bulbs suspended approximately 15 cm above the tanks provided adequate light to permit larval feeding and to enhance algal growth in the tanks. A piece of black plastic was attached to the back of the tanks to further facilitate feeding by making food organisms more visible. Aeration kept the eggs, larvae, and food organisms in suspension. Aeration was vigorous at first but more gentle after the larvae were able to swim effectively and had begun to feed.

A high concentration of algae, Anacystis sp., was maintained in the semi-static tanks to prevent the accumulation of waste products and to stabilize the oxygen concentration. The algae gave the tanks a rich green tint which normally indicated healthy tank conditions. However, regular additions of fresh Anacystis suspensions were necessary since the algae would eventually turn yellow and begin to decline in abundance. Anacystis stock cultures were maintained in 19 l (5 gal) carboys containing F/2 medium of Guillard and Ryther (1962). The cultures were continuously illuminated by two 40-watt, cool white, fluorescent bulbs and aerated.

Measurements of tank temperature, salinity, pH, dissolved oxygen, and nitrite concentration were made regularly. Aberrant chemical conditions were corrected by exchanging larger volumes of water.

Food Organisms.

Wild zooplankton from a salt marsh creek was used as food. Wild plankton was collected by suspending a light into the creek water at night.

The light attracted plankton and a concentrated sample was obtained by pumping water from this area. The sample was further concentrated and separated into size groups by passing the water through a series of plankton nets with the desired mesh sizes, as described under feeding procedures. Four 1 ml aliquots of each plankton size were counted to determine the concentration of food organisms.

A total of 1.33 food organisms per cc of tank capacity per day were added to each tank. Food organism concentrations were obtained by counting nine 1 ml samples from different regions of the aquarium. For a time, these counts were used to determine the number of food organisms to be added but were later discontinued due to the unreliability of the method.

The rotifer, Brachionus plicatilis, and brine shrimp, Artemia salina, were used as food for the first 12 to 14 days of larval growth in two 38 l tanks and one 76 l tank. The growth of these larvae was compared to the growth achieved by larvae reared on wild plankton over the same time period. Stock cultures of B. plicatilis were grown in 2 l Erlenmeyer flasks containing a heavy concentration of Anacystis sp.,   A. salina eggs were obtained from the commercial supplies and hatched in battery jars containing filtered seawater.

Growth Rates.

The growth of cobia larvae and juveniles was monitored through periodic length and weight measurements on specimens removed from the tanks. All specimens were preserved in 2.5% borax-buffered formalin. Specimens older than 20 days were either dead or sickly when they were removed.

Larval Growth in Low Salinity Seawater and Sound Water.

The tolerance of cobia eggs and larvae to a variety of salinities was determined. Twenty-five cobia eggs were placed in tanks containing seawater which had been diluted to salinities of 13, 19, 33, and 35^{o}/oo with distilled water. There were enough eggs available to run all the salinities in duplicate except 13^{o}/oo.

The effect of water from Pamlico Sound upon hatching success was determined by rearing cobia eggs in a tank containing 1 u filtered Pamlico Sound water. This estuarine water has a lower salinity (24^{o}/oo), higher dissolved organic concentration, and different ionic composition than standard seawater.

Results

Egg Collection.

A total of 1,979 cobia eggs was collected in 10 offshore trips between May 23 and June 28. All of these eggs were found in the Gulf Stream which suggests the possibility that this is the spawning site for cobia. Although the largest number of cobia eggs was collected between June 10 and 17, peak spawning activity could easily have been obscured by daily variations in collecting conditions. On good collecting days, Sargassum weed had gathered into long windrows, indicating areas where the prevailing winds and currents had concentrated the plankton. When weed lines were not found, eggs were widely distributed and collection of a large number of eggs was much more difficult.

Egg Description (Figure 1).

Cobia eggs have very distinctive characteristics which have been described in earlier work (Ryder, 1887 and Joseph *et al.*, 1964). The eggs are approximately 1.25 mm in diameter. A single, large, yellow oil globule is present. The embryo is also bright yellow, and both the oil globule and embryo are mottled with melanin pigment. The yolk is segmented, and the perivitelline space is reduced.

At times, dead or defective eggs were found and removed. These eggs were similar in appearance to normal eggs except the protein had begun to coagulate forming lumpy, white opaque masses in the yolk. The yellow pigment was faded or entirely absent.

Cobia Feeding and Tank Conditions.

Most of the eggs were obtained in a late stage of development and hatched within 12 to 20 hours after being placed in the aquaria. The yolk sac was usually absorbed and active feeding initiated by the third day after hatching.

Wild plankton was added to the tanks during the second day after hatching, while the larvae were still utilizing yolk for food. Plankton between 53 u and 202 u was introduced at this time, but was replaced by 93 u to 363 u plankton by the eighth day. After 13 days 202 u to 808 u plankton was added, and by 40 days the juvenile cobia's diet consisted solely of small mosquito fish, *Gambusia affinis holbrookii*. Shrimp, cooked blue fish, and ground trout chow were also used as food for the juveniles.

The dominant plankton food organism changed with successive mesh sizes. The 53 u to 202 u food organisms were dominated by copepod nauplii and occasionally by rotifers. In the larger mesh sizes, copepodites and adult copepods were the most numerous organisms.

The physical and chemical conditions of the tanks remained relatively stable during the study. Temperatures were held at 26.5^{o} C but in a few instances went as low as 24^{o} C and as high as 29^{o} C. Salinities were approximately 35^{o}/oo. The pH ranged from 7.1 to 9.0, but in most cases it was 8.3 $\pm$ 0.2. Nitrite levels remained below 1 ppm in all tanks fed wild plankton; however in tanks fed B. plicatilis, the nitrite concentrations reached 10 ppm in some cases. Dissolved oxygen concentrations were always above 5.5 mg/l.

Larval Hatching.

Hatching percentages were obtained from 38 l tanks containing 20 to 26 eggs. Of 355 eggs added to 17 tanks, 167 (47%) hatched successfully. However, the hatching percentage in individual tanks was highly variable, ranging from 24% to 76% (probably due to variations in the condition of the eggs collected on a particular day).

Cobia larvae and juveniles survived up to 131 days with the greatest mortality occurring during the first 10 days. The causes of the high mortality during this period were not identified, but parasites were noted in the wild plankton food and a number of the fish developed sores because of fungal and/or bacterial infections. Genetic failures, environmental stress, and an insufficient supply of food are also suspected but future work will be needed to further elucidate these problems.

After the first 10 days the survival of cobia larvae improved considerably. The mortalities which occurred after this period resulted from diseases and parasites. With adequate means to control these factors, prolonged survival should be possible. Prophylactic dips should reduce some of the mortality.

Figure 1. Cobia, 1.25 mm in diameter.

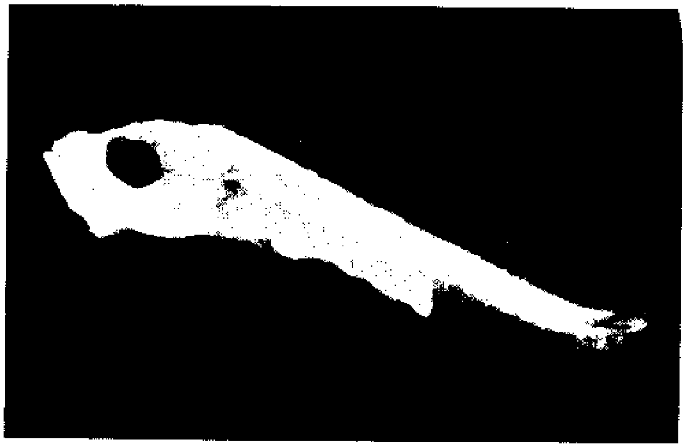

Figure 2. Cobia larva, 5.5 mm long after 8 days.

Figure 3. Cobia larva, 9.0 mm long after 13 days.

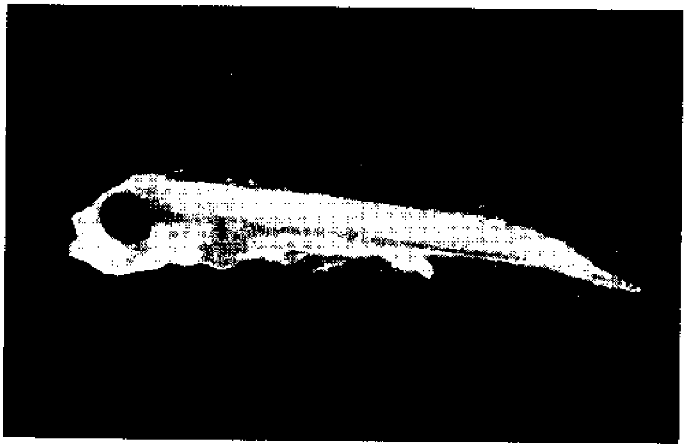

Figure 4. Juvenile cobia, 93.0 mm long after 31 days.

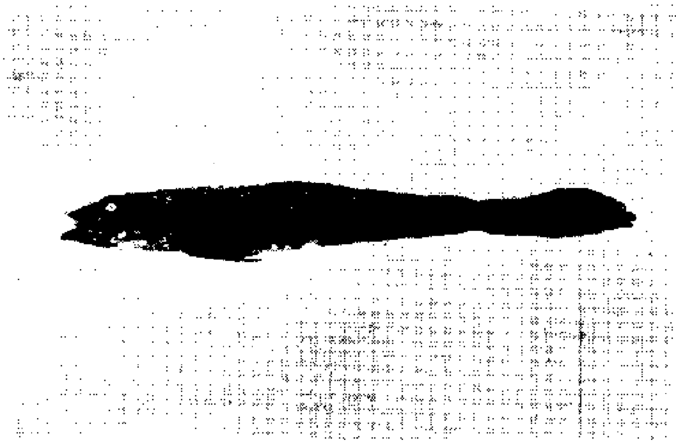

Figure 5. Juvenile cobia, 134.0 mm long after 83 days.

Larval and Juvenile Description.

One Day:

The one-day old larvae are approximately 3 mm long and colorless. Only a light green tint is to be noted in the area of the developing eye. The larvae have not yet begun to feed actively and the yolk sac is large and conspicuous. A single fin extends dorsally from the head and ventrally from the yolk sac to the posterior where it extends around the caudal tip of the body.

Five Days (Figure 2):

After five days the larvae are 4 to 5 mm long. The eyes are dark brown and prominent. The yolk sac is absorbed, and the development of the eye and mouth permits active feeding. A faint yellow streak extends the length of the body and scattered blotches of melanin pigment are evident. The fin structure is the same as the 1 day larvae, however limited swimming is now possible.

Ten Days (Figure 3):

By the tenth day, definite changes can be noted in the larvae. The mouth, head and eye are fully developed. The musculature is now apparent throughout the body, permitting prolonged, active swimming. The single fin persists and fin rays are beginning to appear in some areas. Pectoral fins are now present. The larvae are light brown and 5 to 10 mm in length.

Thirty Days (Figure 4):

The 30-day juvenile has begun to take on the appearance of the adult fish. Distinct dorsal, anal, caudal, pectoral and pelvic fins have developed. The dorsal fin extends from mid-body to a point just anterior to the caudal fin. The fin also ends just before the caudal fin and begins just behind the anus. The caudal fin is large and fan-shaped. Eight, short spines have developed just anterior to the dorsal fin.

Two color bands run from the head to the posterior tip of the 30-day juvenile. The white to yellow dorsal band and the black ventral band meet along the lateral line of the juvenile.

Fifty-nine Days:

After 59 days the juveniles have grown considerably but their general appearance is similar to the 30-day cobia. The most striking change has occurred in the banding of the fish, which now appears to be black with dorso-lateral and ventro-lateral gold or white bands. The dorso-lateral bands extend anteriorly over the head, just above the eye, and posteriorly to the caudal fin. The ventro-lateral band is not as distinct and extends from under the mouth to the caudal fin. The dorsal, anal, and caudal fins are black with light yellow tips.

One hundred and twenty Days:

The 120-day juveniles are very similar to the 59-day fish. The banding is identical except the black dorsal band of the 59-day juveniles is now a golden brown color (Figure 5).

Determination of the Physical Condition of Larvae and Juveniles.

With time it became possible to determine the physical condition of larval and juvenile cobia. During the larval stages swimming was the most important clue. Healthy larvae would swim steadily throughout the tank searching for food. Once food was located the body was flexed into an S or J shape and a strike was made. Larvae in poor physical condition remained stationary for long periods of time usually in the corners or at the bottom of the tank. Occasionally aimless darts would be made. As larvae became older and began feeding on live food, even the healthy fish would remain inactive for long periods of time. The health of these fish could still be determined by their ability to feed successfully.

Growth Rates.

Growth rates were computed from length and weight measurements of 87 cobia reared on wild plankton (Table 1). However, these rates should be considered as minimal since most of the specimens were either unhealthy or dead when removed from the aquaria. Also, no correction was made for the weight loss usually occurring during preservation in formalin (Engel, 1974).

Growth of the cobia larvae was variable during the first ten days but became exponential beyond this age (Figures 6 and 7). The exponential weight gain after the tenth day is presented in the expression:

$$\text{Log } W = 4.360 \text{ Log } X - 4.318$$

where:

Log W = log to the base 10 of the weight in mg.

Log X = log to the base 10 of the age in days.

Similarly, an exponential increase in length was noted in cobia larvae and juveniles after the first 10 days. This growth is described in the equation:

$$\text{Log } L - 1.425 \text{ Log } X - 0.587$$

where:

Log L = log to the base 10 of the length in mm.

The length-weight relationship of larval and juvenile cobia was also exponential (Figure 8) and is described by the expression:

$$\text{Log } W = 2.4035 \text{ Log } L - 1.3007$$

Tolerance to Seawater of Reduced Salinity.

Cobia eggs hatched successfully and the larvae appeared normal in the 35, 33, and 19^{o}/oo salinities (Table 2). However in the 13^{o}/oo tank, many of the larvae which hatched appeared abnormal with coagulated protein and twisted bodies. Nevertheless, one larva did succeed in growing to a juvenile stage in the 13^{o}/oo seawater.

Table 1

The age in days and average weight and length of larval and juvenile cobia.

Age in Days	Number of Specimens	Weight (mg) Average	Weight (mg) Range	Length (mm) Average	Length (mm) Range
1	5	1.00	-	3.00	-
2	5	2.20	2-3	3.60	3.0-4.0
3*	3	1.00	-	3.66	-
4*	3	2.66	2-3	3.66	3.5-4.0
5	3	8.66	8-9	4.66	4.5-5.0
6*	4	9.25	9-10	4.87	4.5-5.0
7*	3	8.00	7-10	4.83	4.5-5.0
8*	3	1.00	-	5.33	5.0-5.5
9	2	7.00	6-8	6.50	6.0-7.0
10	1	10.00	-	9.00	-
10*	1	4.00	-	6.00	-
12*	3	4.00	-	6.66	-
13*	1	9.00	-	9.00	-
14	1	30.00	-	16.00	-
15*	1	8.00	-	9.50	-
18	1	30.00	-	19.00	-
19	7	11.42	20-10	12.07	10.0-15.5
20	1	20.00	-	16.00	-
22	11	42.72	20-90	24.22	16.0-30.0
23	3	41.66	35-50	23.16	22.5-24.0

Table 1 (continued

The age in days and average weight and length of larval and juvenile cobia.

Age in Days	Number of Specimens	Weight (mg) Average	Range	Length (mm) Average	Range
24	13	46.92	20-120	24.23	19.0-33.0
25	1	90.00	-	24.50	-
28	1	60.00	-	29.00	-
30	1	90.00	-	29.00	-
36	1	920.00	-	65.00	-
43	1	130.00	-	34.00	-
51	1	3,750.00	-	93.00	-
59	8	4,140.00	1,350-7,500	98.25	69.0-120.0
71	2	19,745.00	6,900-12,590	138.50	128.0-149.0
73	1	12,480.00	-	141.00	-
83	4	10,425.00	8,900-12,520	141.50	134.0-148.0
88	2	22,865.00	22,390-23,340	165.50	165.0-166.0
99	1	25,350.00	-	183.00	-
102	1	33,610.00	-	196.00	-
107	1	43,200.00	-	201.00	-
109	1	34,300.00	-	187.00	-
110	1	12,000.00	-	127.00	-
111	1	25,000.00	-	178.00	-
112	1	71,000.00	-	205.00	-
120	1	64,000.00	-	210.00	-
124	1	74,000.00	-	225.00	-
131	1	80,000.00	-	231.00	-

* Larvae were reared on _B_. _plicatilis_ and _A_. _salina_

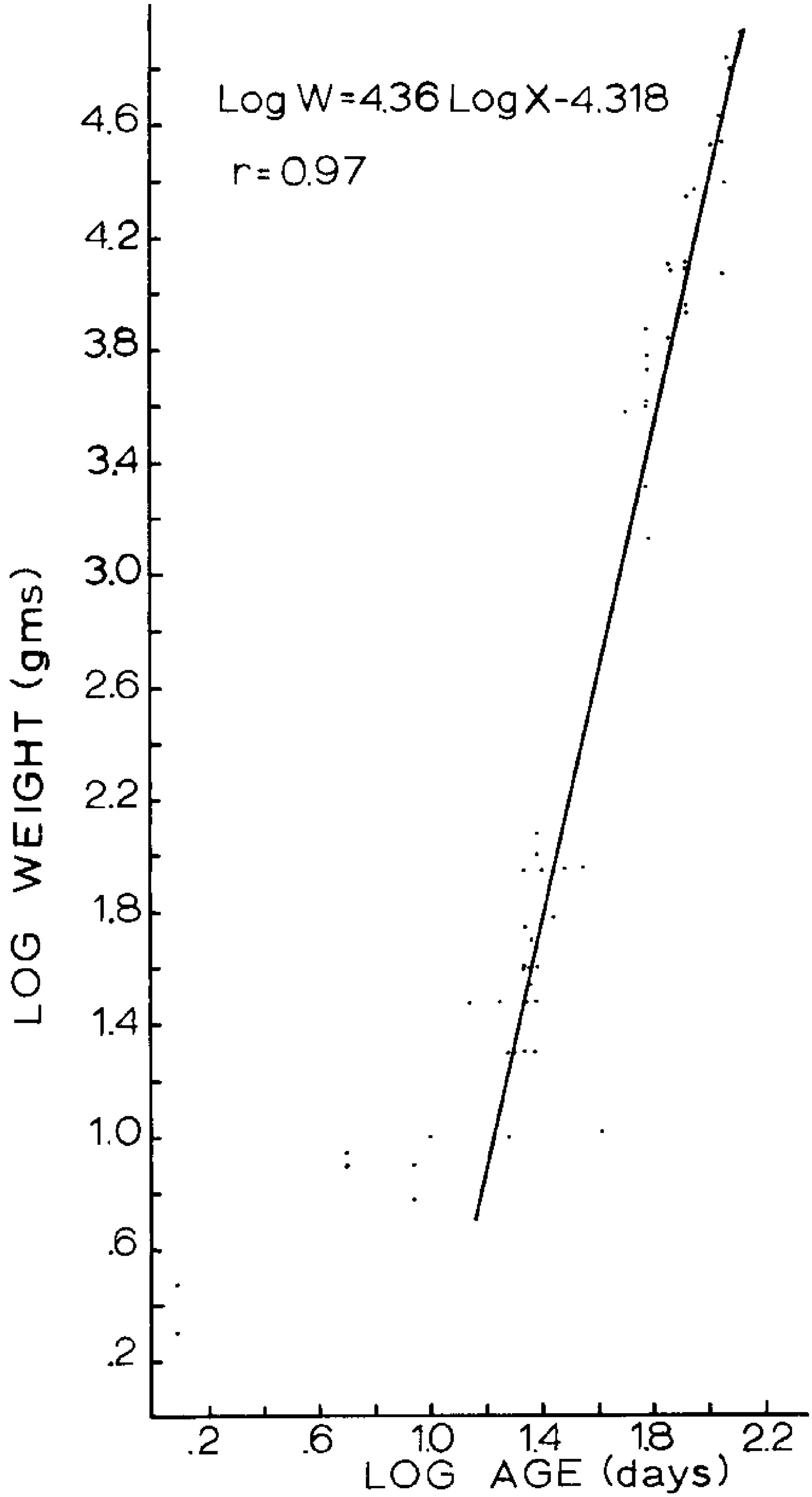

Figure 6. The exponential relationship of weight (mg) as a function of age in cobia larvae after the tenth day.

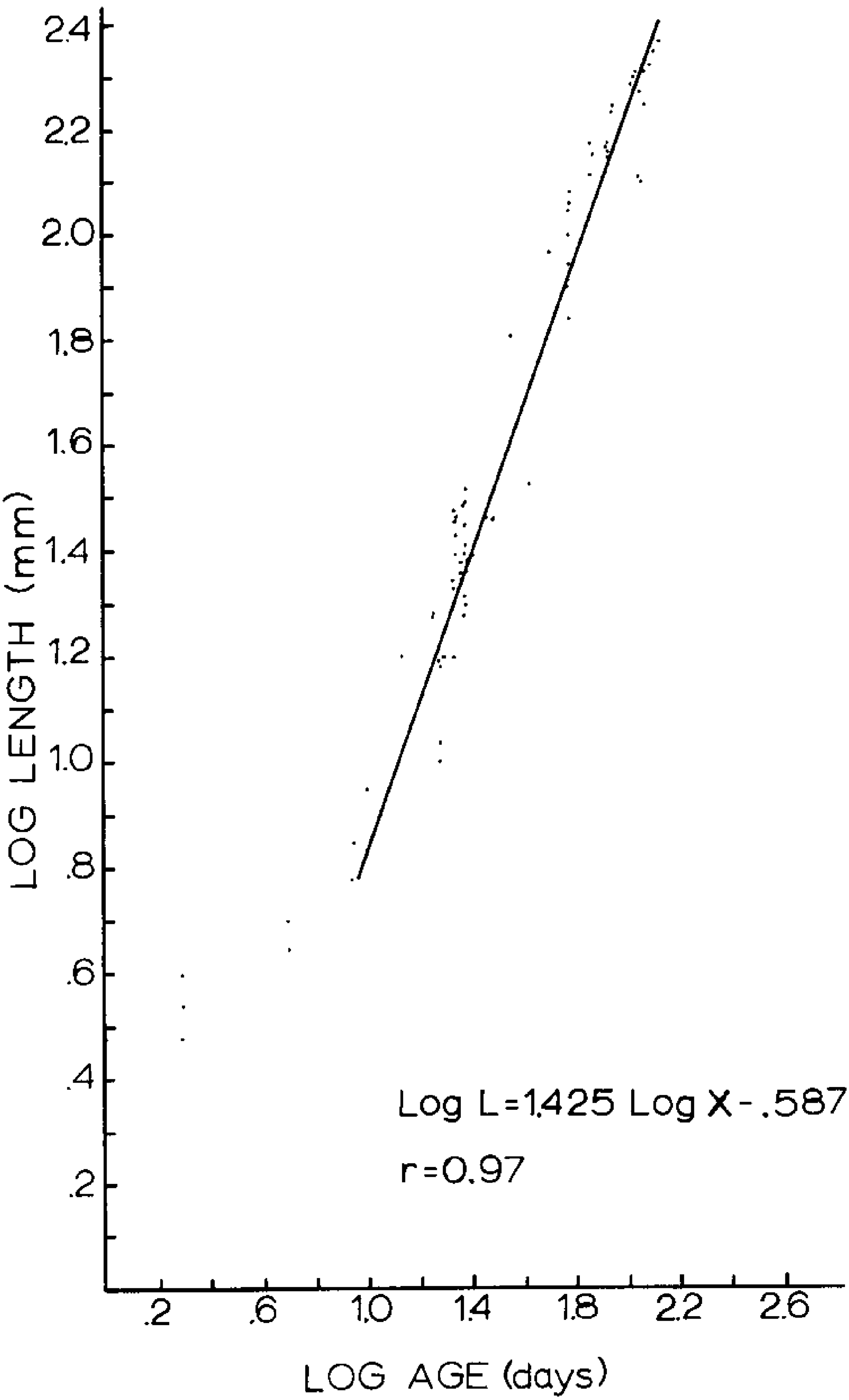

Figure 7. The exponential relationship of length (mm) as a function of age in cobia larvae after the tenth day.

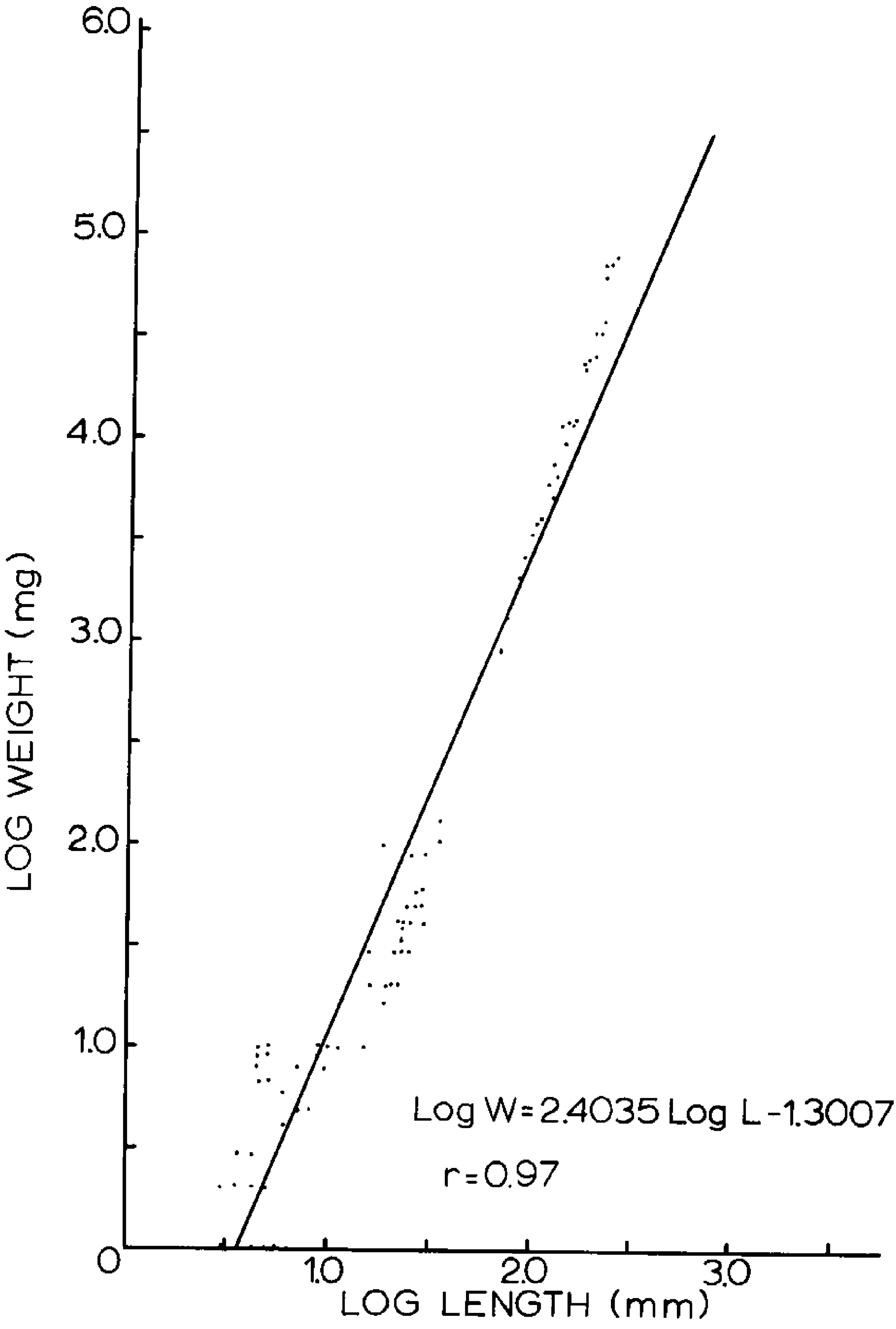

Figure 8. The exponential relationship of weight (mg) as a function of length (mm) in cobia larvae.

Table 2

The hatching percentage of cobia eggs in various salinities of seawater.

Tank No.	Salinity	Eggs	Larvae Hatched	Percentage
1	35	25	17	68
2	35	25	17	68
3	33	25	17	68
4	33	25	18	72
5	19	25	16	64
6	19	25	11	44
7	13	25	9	36
8	24*	25	16	64

*Sound water

Tolerance to Pamlico Sound Water.

We found no significant difference in the ability of cobia larvae to grow and survive in Pamlico Sound water as compared to seawater of comparable salinity (Table 2). Of the 25 eggs added, 16 larvae (64%) hatched and only one larva was malformed.

Food Organisms.

The rotifer, *Brachionus plicatilis*, and brine shrimp, *Artemia salina*, can be grown easily in the laboratory and have been used successfully as food organisms in other fish rearing projects (Theilacker and McMaster, 1971; Harada, 1970). The growth of larvae reared on *B. plicatilis* for the first eight days and then on *A. salina* was compared to the growth of larvae grown solely on wild plankton (mainly copepod nauplii and copepodites). The data were taken over the first 12 to 14 days of growth.

After only 8 days a striking difference was noted in the size of the larvae. The larvae reared on wild plankton were approximately twice as large as the larvae reared on *B. plicatilis* and *A. salina*. Despite the large variability inherent in the first few days of growth, the difference was statistically significant (99%) when comparing both rates on an exponential basis (Figures 9 and 10).

The growth of larvae fed *B. plicatilis* and *A. salina* was linear over time (Figures 11 and 12) and is described by the equations:

$$W = 0.3631X + 2.2838$$

and

$$L = 0.3734X + 3.0474$$

where:

L = the total length in mm

W = the weight in mg

X = the age in days

Whereas the growth on wild plankton was exponential (Figures 9 and 10) and is presented in the expressions:

$$\text{Log } W = 0.1236X + 0.0865$$

and

$$\text{Log } L = 0.0986X + 0.3970$$

where:

Log W = the log to the base 10 of the weight in mg

Log L = the log to the base 10 of the length in mm

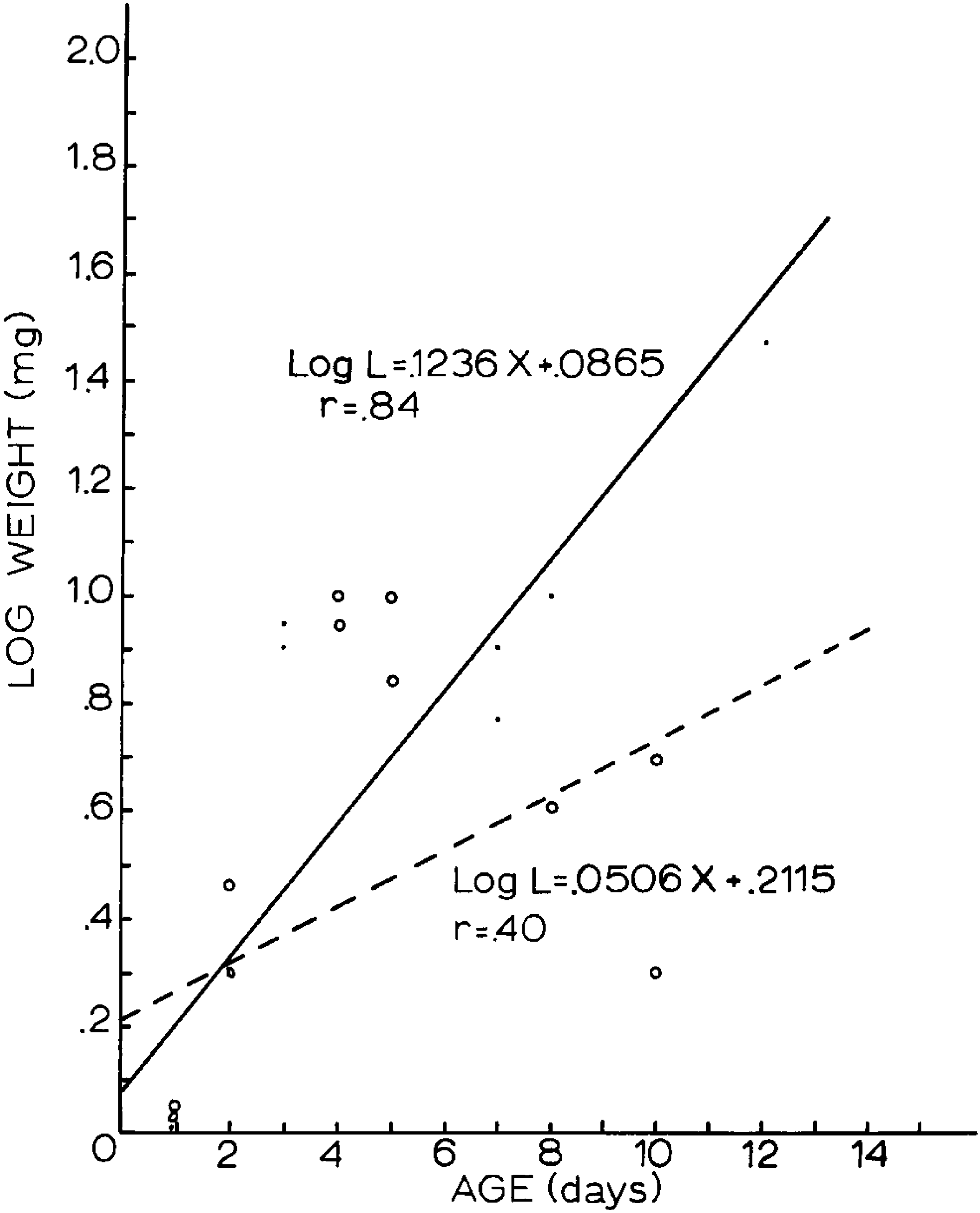

Figure 9. The exponential cobia weight (mg) as a function of age (days) comparing those fed wild plankton (solid line) to those fed rotifers plus brine shrimp (dashed line).

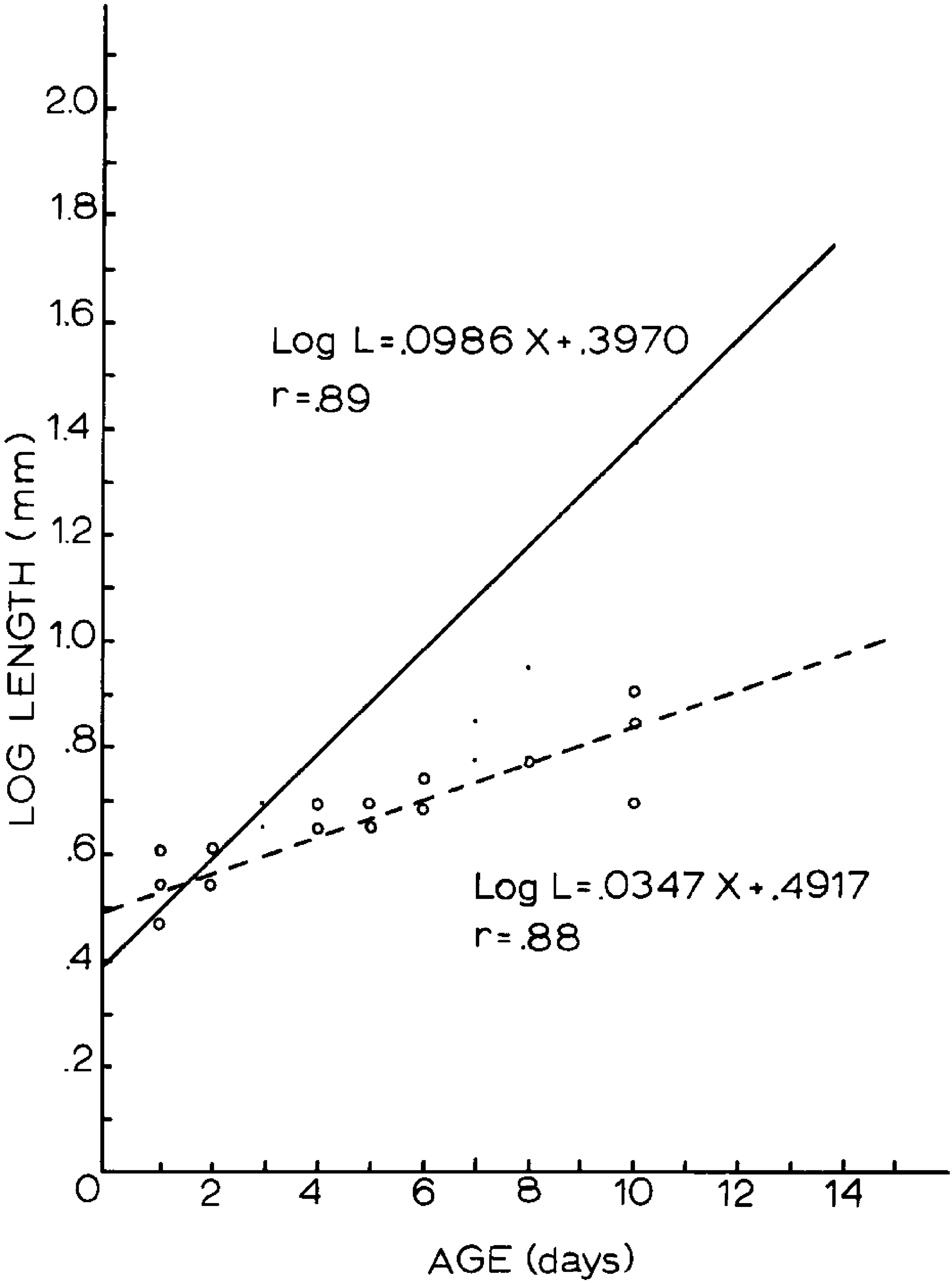

Figure 10. The exponential cobia length (mm) as a function of age (days) comparing those fed wild plankton (solid line) to those fed rotifers plus brine shrimp (dashed line).

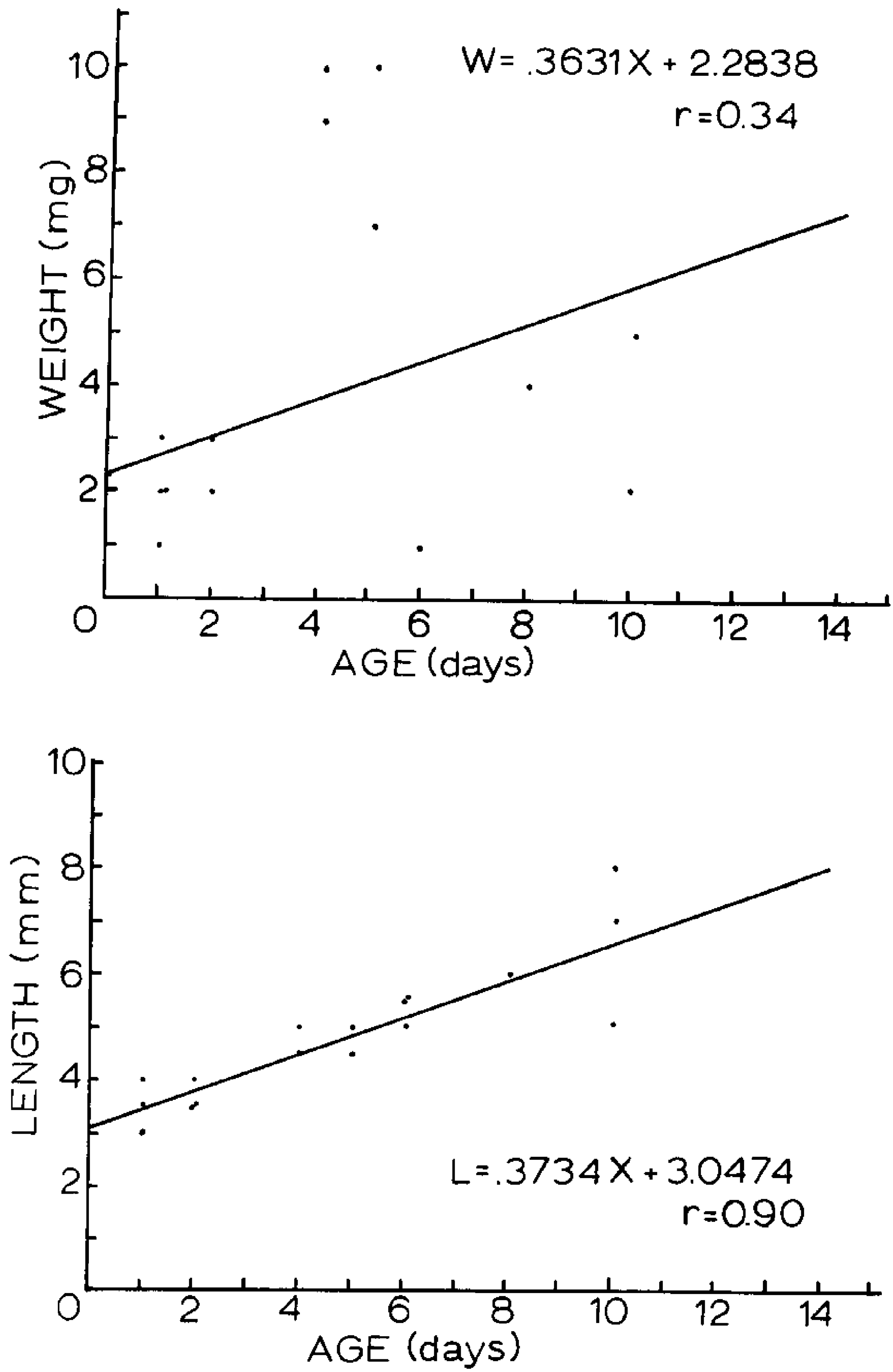

Figure 11. Cobia weight (mg) as a linear function of age (days) for larvae fed rotifers and brine shrimp.

The addition of _B. plicatilis_ to the tanks also resulted in the deterioration of chemical conditions. Once introduced, the rotifer multiplied by feeding upon _Anacystis sp._ Growth of the rotifer population resulted in a significant rise in the nitrite concentration and a lowering of the pH and dissolved oxygen. Only through the exchange of larger volumes of water were tank conditions maintained within limits suitable for larval growth.

Juvenile Transport and Temperature Tolerance.

Four 90 day or older juvenile cobia were successfully transported from Hatteras to Raleigh, N. C. in a tank containing approximately 190 l (50 gal) of continuously aerated water.

Once in Raleigh, the juveniles were observed under a range of temperatures extending from 17.7° C to 37.7° C. At 21.1° C, feeding activity was markedly reduced and ceased entirely at approximately 18.3° C. Edwin B. Joseph (personal communication) found that cobia could tolerate temperatures greater than 37.7° C; however, one of our juveniles died at this temperature. This death may have been due to an insufficient period of acclimation.

Suggestions.

Although we were successful in rearing cobia larvae, modifications of our techniques should result in faster growth rates and greater survival.

The use of antibiotics and flow-through systems should be considered. Only static tanks were used in these studies, and we relied either on algae, subgravel filters, or external filters to maintain water quality. The large surface area and stagnant water of these tanks provide ideal conditions for the multiplication of microorganisms and increase the possibility of larval diseases. This problem could be alleviated through the use of antibiotics and larger flow-through systems. Larvae younger than ten days cannot swim effectively against a current and therefore require a static tank. During this period, the use of antibiotics could keep the growth of microorganisms in check (Shelbourne, 1964). Older larvae could be reared in a flow-through tank or trough. In such a system waste products and decaying food organisms would be continually flushed out and the accumulation of microorganisms would be prevented. In addition, the current itself may stimulate the growth of cobia larvae. Our observations indicated that cobia habitually stationed themselves in available currents.

The use of other food organisms for both larvae and juveniles should be explored. In larger scale operations, the variable supply of wild plankton could not be tolerated. Maintaining cobia larvae on organisms which can be grown in large number in the laboratory should be investigated. A controllable food supply would insure an abundance of food organisms and alleviate the danger of introducing parasites with the food. Our older larvae and juveniles were fed a diet consisting almost entirely of fish. However, in nature cobia feed primarily on bottom organisms such as crabs and crustaceans (Knapp, 1950). The possibility of using some of these as food should be explored.

Summary

Cobia eggs were collected in the Gulf Stream, and the larvae were reared successfully under laboratory conditions. Younger larvae grew well in 38 l and 76 l tanks in which Anacystis sp. acted as biological filter. The physical and chemical conditions (temperature, salinity, pH, dissolved oxygen, and nitrite concentration) of the tanks were maintained by daily exchanging at least 10% of the water volume. Older larvae and juveniles continued to grow well in 114 l and 152 l tanks equipped with subgravel or external filters.

The young cobia were tolerant of variations in salinity, temperature and water quality. The larvae hatched and grew well in estuarine water with a lower

salinity (24°/oo), higher organic concentration, and different ionic composition than seawater, and in seawater diluted to 19°/oo. The juveniles were tolerant of temperatures ranging from 17.7° C to 37.7° C, but feeding activity ceased at 18.3° C.

Food types had a pronounced effect on larval growth. Larvae reared on wild plankton (copepod nauplii and copepodites) over the first 12 to 14 days grew significantly faster than larvae reared on *B. plicatilis* and *A. salina*.

Young cobia demonstrated characteristics which are desirable in an aquaculture organism. Larvae and juveniles grew exponentially under laboratory conditions and survived up to 131 days. Most of the mortality was due to diseases and parasites which could be controlled in future work. The young cobia were also found to be tolerant of variations in environmental conditions and were much easier to handle than larvae of dolphin, *Coryphaena hippurus*, and other marine species we reared at Hatteras, N. C. With future work, the mass culture of *Rachycentron canadum* may be realized.

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