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THE CAGE CULTURE OF SOME MARINE FISHES IN THE INTAKE AND DISCHARGE CANALS OF A STEAM-ELECTRIC GENERATING STATION, GALVESTON BAY, TEXAS

Prepared by
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ABSTRACT

The Cage Culture of Some Marine Fishes in the Intake and Discharge Canals of a Steam-Electric Generating Station, Galveston, Bay, Texas (August 1972)

Rocco Anthony Marcello, Jr. and R. Kirk Strawn

Croaker (*Micropogon undulatus*), pinfish (*Lagodon rhomboides*), pompano (*Trachinotus carolinus*), white mullet (*Mugil curema*), pigfish (*Orthopristis chrysoptera*), Gulf kingfish (*Menticirrhus littoralis*), silver perch (*Bairdiella chrysura*), spot (*Leiostomus xanthurus*), and black drum (*Pogonias cromis*) were stocked in cages in the intake canal, and croaker, pinfish, and pompano were stocked in cages in the discharge canal of the P. H. Robinson Generating Station on Galveston Bay, Texas, to determine survival, food conversion, length-weight relationship, condition, and growth. The survival of croaker, pinfish, pompano, white mullet, spot, and black drum in the intake canal was on the average 70% or greater, while that of pigfish, Gulf kingfish, and silver perch was less than 70%. With the exception of pinfish, survival of caged fish in the discharge canal was extremely poor. Gas-bubble disease was implicated as the cause of their poor survival and nitrogen-saturation levels should be determined before investing in fish culture in a thermal discharge. Overall food conversion ranges for croaker, pinfish, pompano, white mullet, pigfish, and silver perch were 1.008 to 2.498, 2.302 to

5.678, 3.334 to 7.266, 5.819, 10.769 to 89.043, and -3.138, respectively. Food conversions were generally less efficient with the increasing size of the fish. Length-weight relationships of croaker, pinfish, pompano, white mullet, pigfish, Gulf kingfish, silver perch, spot, and black drum were calculated and compared. Croaker and pinfish were heavier per unit length than were fish from natural environments. Final condition values of croaker, pinfish, pigfish, Gulf kingfish, spot, and black drum were generally higher, while those of pompano and silver perch were lower than the initial condition values. Fish in the intake canal grew little if at all after water temperatures dropped below 20 C. During December 1971 through February 1972, growth of pinfish in the discharge canal was greater than that of pinfish in the intake. The use of peripheral feeding rings in cages for the culture of pompano, and feeding rings of submerged trays for the remaining species is recommended. Placement of cages in flowing water with velocities greater than about 0.4 m/sec is not recommended because of the excessive force exerted on the cages and the mooring systems. Pinfish were very efficient at keeping the wire mesh of cages free from fouling. Croaker, pinfish, and pompano were rated acceptable in terms of appearance, mouthfeel, flavor, and overall satisfaction by a 12-member taste panel. Mean scores for each of the evaluation categories

were not significantly different. Average dressing percentages for croaker, pinfish, and pompano were 55.8, 66.5, and 62.4.

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INTRODUCTION

The demand for high quality fishery products in the United States, as well as other countries, has steadily increased. This increased demand can be attributed to a variety of factors, among them: improved handling techniques resulting in better quality products; improved processing techniques allowing for rapid and more extensive distribution; and increased promotional advertising stressing the nutritional value of fishery products (Iversen, 1968).

With the world population increasing at an annual rate of 3%, the demand for food, including fishery products, is expected to continue rising (Young, 1970). The United States, the world's largest market for fishery products, imports approximately 58% of its consumable fishery goods, and its consumption rate has increased 19% since the late 1950's (Avault and Allen, 1970). The United States commercial fishing industry, however, has not been able to meet this demand. Developmental interest in fish farming as a means of helping meet the growing demand for quality fishery products has recently increased.

Fish farming, utilizing ponds, raceways, and cages can provide greater yields than that which occurs naturally by the proper application of management techniques (Avault and Allen, 1970; Ryther and Matthiessen, 1969). Although preliminary results indicate that tremendous yields are attainable, there are still many limiting factors affecting this form of fish production. Among them has been the limiting factor of temperature on fish growth. The desired goal of culturing a marketable product within one growing season has not always been possible due to a limited growing season determined by low winter temperature. Overwintering a commercial stock requires additional expenditure for fish maintenance, and the possibility always exists of complete mortality brought about by low winter temperatures. The possible utilization of thermal discharges from electric generating stations to extend the growing season for fishes has created much recent interest (Anon., 1968; Anon., 1970; Collins, 1970b; Gaucher, 1970; Gribanov et al., 1968; Gustrom, 1970; Hickling, 1968; Hochman, 1969; Iles, 1963; Iversen and Berry, 1968; McNeil, 1970; Murphy and Lipper, 1970; Nash, 1968, 1969; Shelbourne, 1970; Strawn, 1969; Tilton and Kelley, 1970; Yee, 1971).

Gaucher (1970) estimates that in 1965 the unutilized United States production of fish and shellfish in thermally enriched waters

ranged from 0.62 to 1.25 billion pounds. This amounts to 25 to 50% of the total United States production from traditional food fisheries.

As the population continues to grow and the demand for power production becomes greater, thermal discharges will significantly increase (Shelbourne, 1970). In 1968, 5×10^{13} gallons of water were required for cooling purposes in the electric generating industry, and estimates indicate that 1×10^{14} gallons will be needed by 1980 (Krenkel and Parker, 1969). The possibility of utilizing such immense quantities of heated water for the production of many species of fishes exists, and demands thorough scientific investigation.

Originally this research was designed to contribute information on the feasibility of utilizing thermal discharges in the cage culture of some marine fishes. This objective was not completely achieved due to an almost complete mortality of the fish shortly after their stocking in the heated effluent. As a result of this mortality, only limited data is available for evaluation. However, the possible cause of this mortality is discussed as a potential problem associated with the future utilization of thermal effluents for the culture of fish. This thesis will also report on the survival, food conversion, length-weight relationship, condition, and growth of several species of marine fishes cultured in cages. Information on the

suitability of cage design and construction materials will also be provided.

Although the primary objective of mariculture is to produce food products, emphasis must also be placed on the quality as well as the quantity produced (Cobb, 1971). Therefore information on the general acceptability of croaker, pinfish, and pompano cultured during this study will be reported.

This research was conducted during the period of January 1971 through March 1972. The first 5 months were used to purchase materials, equipment, and construct fish cages. Approximately 1 month was spent collecting marine fishes for the culture experiments. The remaining time period was used to conduct the culture experiments.

LITERATURE REVIEW

Cage culture refers to the method of raising fishes to marketable size in structures made of a variety of materials which do not inhibit water circulation into and out of the enclosure (Schmittou, 1969). Among the advantages of this method are: low investment; adaptability to a variety of situations; easier and more economical treatment of diseases; potential for a combination of cultures within one body of water; and ease of harvest (Schmittou, 1969; Kuronuma, 1968).

Cage culture originated in Asia. In Thailand, floating cages, 2 x 5 x 1.5 m deep, have been used to culture the freshwater Pangasius catfishes since the 1880's (Thiemmedh, 1961; Aguru, undated). Bardach and Ryther (1968) and Hickling (1962) report that floating cages of similar construction are used in Cambodia to culture Pangasius and Clarius catfish, and in Ceylon, East Pakistan, India, and Thailand for the culture of Clarius. In Indonesia the culture of Pangasius catfish and the common carp (Cyprinus carpio) differs only in that submerged rather than floating cages are used (Hickling, 1962; Vass and Sachlan, 1956). Increased yields by cage raising fish in flowing water has been reported. Thiemmedh (1961) reports that yields of 180 to 240 kg of fish per m^3 have been

achieved although feeding of fish was not intensive. The primary limiting factor in Asian cage culture has been the unavailability of sufficient quantities of nutritionally complete feeds (Collins, 1970a; Schmittou, 1969).

In Japan, cage culture of the common carp was first attempted in 1951 (Kuronuma, 1968). He stated that after the success with carp culture, efforts were expanded into the culture of rainbow trout (Salmo gairdneri), ayu (Plecoglossus altivelis), yellowtail (Seriola quinqueradiata), and puffers (Fugu rubripes). Pen production of yellowtail in 1963 accounted for 84% of the total Japanese marine production from the Inland Sea, and in 1966 over 20 million fish were stocked in floating pens (Bardach and Ryther, 1968).

Research in the cage cultivation of carp in Russia has concentrated on nutritional requirements, optimum stocking density, optimum feeding rates, and the use of thermal effluents (Gribanov et al., 1968). These authors have demonstrated the feasibility of utilizing thermal effluents in the cage production of carp. Preliminary results indicate that 100 kg of fish per m^3 can be produced. They also reported that the growth rate of cage-reared carp is generally lower than for fish raised in ponds, although cage-reared fish have a higher protein content. Vass and Sachlan (1956), however, have

shown that in Indonesia carp grown in cages are of greater weight than those grown in rice fields.

Interest in cage culture in the United States has developed only within the last decade. Reports on current research and commercial production of cage-raised fish in the United States are numerous (Allen, 1971; Armbrester, 1970; Collins, 1970a, b, c, 1971a, b; Grizzel, 1971; Heffernan, 1971; Lewis, 1970; Mahnken et al., 1970; Novotny and Mahnken, 1971; Tilton and Kelley, 1970; Pagan, 1969, 1970; Schmittou, 1969; Séguin, 1970; Swingle, 1970; Swingle and Tatum, 1971).

The majority of this literature deals with the cultivation of fresh-water catfish (Ictalurus spp.), although research on the feasibility of cage culturing salmonids (Mahnken et al., 1970; Novotny and Mahnken, 1971; Séguin, 1970) and marine fishes (Finucane, 1970b; Swingle, 1970; Swingle and Tatum, 1971) is being conducted. Because of the desirability of culturing a marketable size product in one growing season, much of this research has concerned itself with the factors affecting the growth rate of fishes.

Cage design can affect the growth rate of fish. Collins (1970a) and Schmittou (1969) report that the use of a peripheral feeding ring can result in a significant loss of food during vigorous feeding activity by feed being swept outside the feed retainer. They

recommend the use of a deep feeding ring located in the center of the cage to correct this situation. A cage equipped with a peripheral feeding ring also allows the food to come in close proximity of the cage exterior which results in large groupings of fish being attracted to the cage. The major problem caused by attraction of fish to the cage is the loss of large quantities of feed (Collins, 1971b). Up to 25% of the feed can be flushed out of a cage by currents created from dense groupings of wild fish swimming against a cage (Collins, 1971b). Grizzel (1971) and Collins (1970d, 1971b) state that these dense groupings of fish seem to intimidate the caged fish such that growth is not as rapid as in cages that have not been bothered. Evidence also seems to indicate that these groupings of fish outside a cage serve as reservoirs of disease organisms that can be transmitted to the caged fish (Collins, 1971a).

Collins (1971a) has shown the benefit of using larger cages (greater than 1 yd^3) for culturing channel catfish (Ictalurus punctatus) and blue catfish (I. furcatus) raised in reservoir lakes. He states that these larger cages are more efficiently built and operated, and that fish grow more rapidly with more efficient food conversions. Although he has used cages up to 12 yd^3, the maximum cage size prior to a decrease in growth rate or food conversion has not been determined.

Schmittou (1969) has demonstrated that the mesh size of the material used to enclose a cage is important. Survival, growth rate, and mean weights of channel catfish raised in cages of 1/4-inch mesh was significantly less than for fish grown in 1/2-inch mesh cages.

Galvanized welded wire, generally used in cage construction, is subject to corrosion. Grizzel (1971) and others have suggested the use of asphalt base solutions to coat welded wire and reduce the problem of corrosion.

Schmittou (1969) and others have reported that fish receive mouth injuries during periods of hyper-activity by swimming head-on into the welded wire. These injuries could lead to bacterial or fungal infections. Collins (1970a) has not observed any abrasions or injuries as a result of the welded wire in his culturing experiments.

Cage placement relative to other cages and water currents can affect fish growth. Schmittou (1969) and Mahnken et al. (1970) have shown that fish exposed to conditions of maximum water exchange exhibit better growth and feed conversion than do fish in less dynamic conditions. Moving water eliminates the build-up of metabolic wastes which can inhibit fish growth (Hickling, 1962).

Preliminary experimentation on the feeding percentage rate and frequency of feeding required to sustain maximum growth have been

conducted. Collins (1970a) has demonstrated the need for more research on the correct feeding percentage rate required to sustain maximum growth throughout the growing season with catfish. He has shown that small catfish (less than 0.25 lb) should be fed greater quantities of food (up to 3 times as much) than they are usually fed in culture operations. He also demonstrated that fish fed twice per day exhibited only slight gain over fish fed once daily. Swingle (1970) and Swingle and Tatum (1971), however, had to increase the frequency of feeding from once to three times per day in order to increase survival of juvenile striped bass (Morone saxatilis) and pompano (Trachinotus carolinus). Armbrester (1970) has demonstrated that Tilapia aurea can be produced in cages without feeding, although supplemental feeding enhanced production. Mahnken et al. (1970) have used artificial illumination at night to attract zooplankton which supplemented the feeding of anadromous salmonids raised in floating pens. The fish in lighted pens grew 12% faster than those in unlighted pens. The fish in the lighted pen were fed a pelleted feed at 2% of the total weight of fish in the cage. After 45 days the fish in the lighted pen were of comparable size to fish cultured in an unlighted pen fed at 3% of the total weight of fish in the cage.

Pagan (1970) and Schmittou (1969) have examined the effect of stocking density on fish growth in cages. Pagan (1970) found that

the best growth of Tilapia aurea occurs at lower densities (286 fish per m^3), but that the highest production per unit area was observed in cages of highest density (857 fish per m^3). Schmittou (1969) has demonstrated that channel catfish averaging 0.43 lb can achieve an average weight of 0.83 lb in 40 days when stocked at a density of 500 fish per m^3. He concludes that stocking rates in excess of 500 fish per m^3 could probably still produce fish of 0.8 lb or greater.

If a marketable sized product cannot be produced in one growing season it becomes necessary to maintain the fish through the winter. Collins (1970a) has successfully over-wintered channel catfish in cages in a reservoir lake near Conway, Arkansas. Survival was 100% and the fish lost only 0.5 ounces in 4 months of over-wintering.

The use of thermal effluents to extend the growing season of fishes appears promising (Collins, 1970b). Tilton and Kelley (1970) cultured channel catfish in cages placed in the discharge effluent of the Morgan Creek Power Plant, Lake Colorado City, Texas. In terms of growth, food conversion, and survival the preliminary experiments were considered a success.

Swingle (1970) and Swingle and Tatum (1971) have cultured several species of marine fishes in cages, and have made recommendations on appropriate stocking size, handling, and transportation

methods for fish. They have also successfully used striped mullet (*Mugil cephalus*) to control fouling on cages containing other species of fish. Caillouet (1972) has suggested a novel approach to help control fouling of cages used in the marine environment. He designed a cylindrical cage that is rotatable on its horizontal axis. By periodically rotating the cage, cleaning maintenance can be more easily performed since removal of the cage from the water is not required.

Pagan (1969) has shown that *Tilapia aurea* will not reproduce in cages and as a result cage culture can be used to control reproduction of *T. aurea* in ponds used for the intensive production of marketable size fish.

Allen (1971) reported that the growth rate of catfish intentionally subjected to noise was 20 to 30% less than fish not subjected to noise. Collins (1970a) and Schmittou (1969) report that the handling of their catfish retarded the resumption of feeding activity. Collins (1970b) reports that catfish anesthetized with Quinaldine before handling resumed feeding immediately after recovery.

DESCRIPTION OF THE STUDY AREA

This study was conducted at the Houston Lighting and Power Company's P. H. Robinson Generating Station located on State Highway 146 near Bacliff, Texas (Fig. 1). The plant began operating in 1966 and consisted during the study period of three generating units with a combined output of 1465 megawatts. Together these generating units were capable of pumping 4.8×10^7 gallons per hour of cooling water through the condensers. A fourth unit with a generative capacity of 750 megawatts was under construction and was scheduled to begin functioning in 1974.

Cooling water required for the plant's operation was drawn from Dickinson Bay, a subsystem of Galveston Bay, via a 3.7-km intake canal. After passing through the condensers the water was returned to Galveston Bay between Bacliff and San Leon, Texas via a 3.2-km discharge canal. A 423-m by-pass canal connecting the intake and discharge canals began pumping operations on 2 July 1971 for the purpose of dilution cooling of the discharge effluent during periods of maximum thermal discharge. The by-pass canal pump station was capable of pumping 1.6×10^5 gallons of water per minute.

The intake canal was approximately 45 m wide except at the plant intake structure where it widened to 60 m. Depth at the center

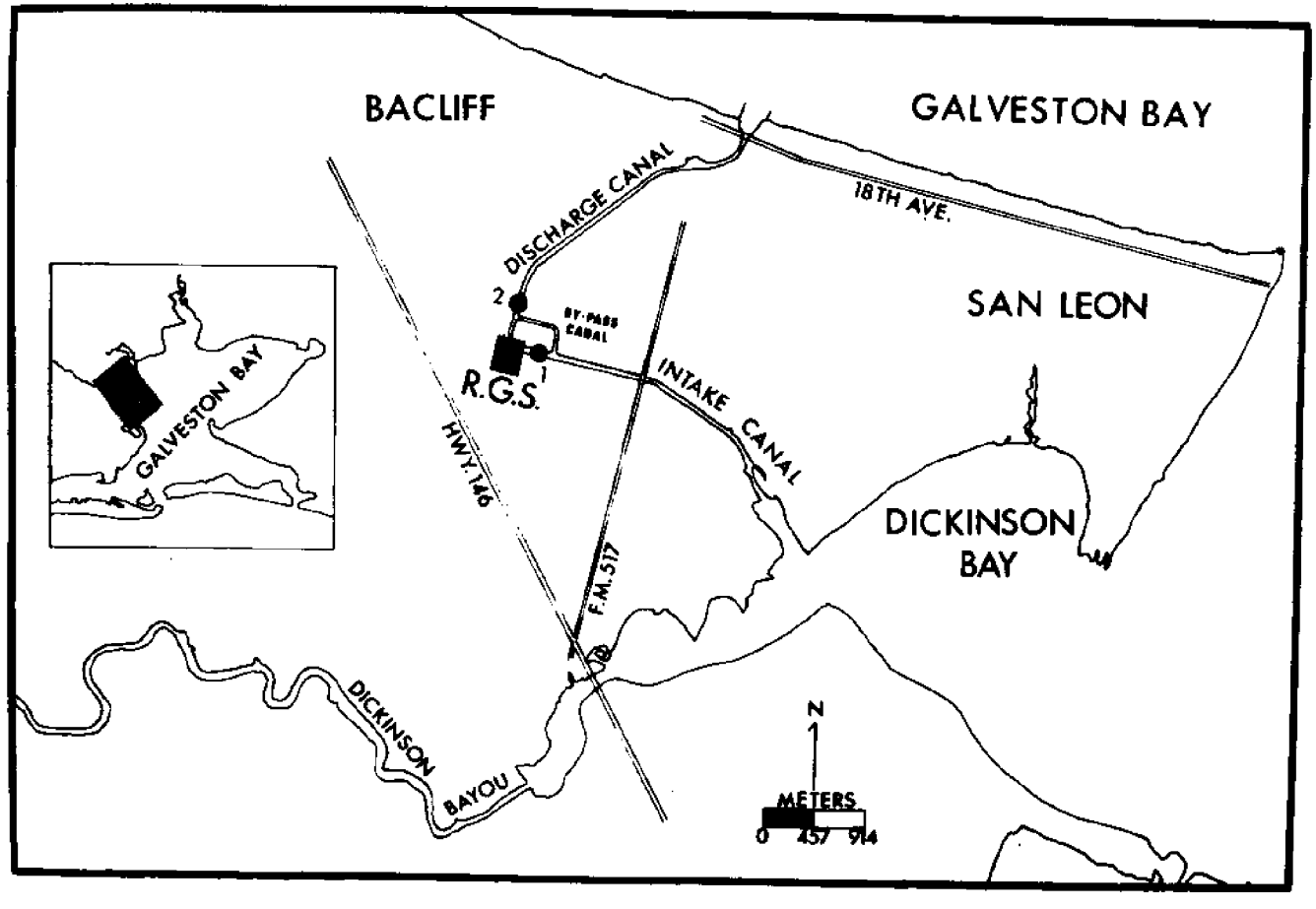

FIGURE 1.--Location of P. H. Robinson Generating Station (R.G.S.). Arabic numerals 1 and 2 indicate the intake and discharge culture sites, respectively.

of the intake canal varied with tidal fluctuation, but was about 6 m over a substrate of fine silt-sand. Average tidal range was between 0.3 and 0.4 m. A 49-m wooden platform built across the canal was positioned approximately 76 m upstream of the plant intake structure. Intake platform hydrological stations were numbered from the north canal bank and were spaced 15 m apart with stations 1, 2, and 3 being located 19 m, 34 m, and 49 m respectively from the north end of the platform.

The discharge canal was about 45 m wide and had an average depth of 3.6 m over a substrate of fine silt and scattered oyster shells. The discharge canal water level was not normally affected by tidal fluctuations due to the presence of a 2.3 m drop structure near the mouth of the canal as it enters Galveston Bay. A 42-m wooden platform, similar in construction to the intake platform, was located about 120 m downstream of the plant discharge structure. Discharge hydrological stations were numbered from the west canal bank and were spaced 14 m apart with stations 4, 5, and 6 being located 14 m, 28 m, and 42 m respectively from the west end of the platform.

MATERIALS AND METHODS

Cage Construction and Location

A total of 40 rectangular cages 3 x 4 x 3 ft deep (floating volume of 1 m^3) were constructed and used in culture experiments (Fig. 2). The cage frame was constructed of 1 x 1/8-inch angle iron with two 3-inch inside diameter hook eyes and with three 1 x 1/8-inch flat iron bottom reinforcement bars. Wire baskets 3 x 4 x 3 ft deep were made of 1/2 x 1-inch mesh galvanized welded wire (16 gauge) fastened together by rings applied with a W. C. Products Model 1787 compressed air cage ringer. Completed wire baskets were then inserted into the cage frames. Flat iron steel straps, 1 x 1/8 x 30 inches long were used to secure the wire baskets in the frames by bolting the iron straps against the wire to the inside of the frame. The cages were then dip-treated with Lagotex Black No. 599 (International Paint Company, Inc.) to protect the metal surfaces from the corrosive action of salt water. Polystyrene flotation blocks 8 x 8 x 48 inches long inserted into polyethylene film tubing were covered by 1-inch mesh galvanized poultry cloth and attached to the cage by 16-gauge galvanized merchant's wire. Cage covers 3 x 4 ft were constructed of 1/4-inch exterior plywood with 1 x 2-inch pine support framing. Rectangular openings, 12 x 18 inches, were

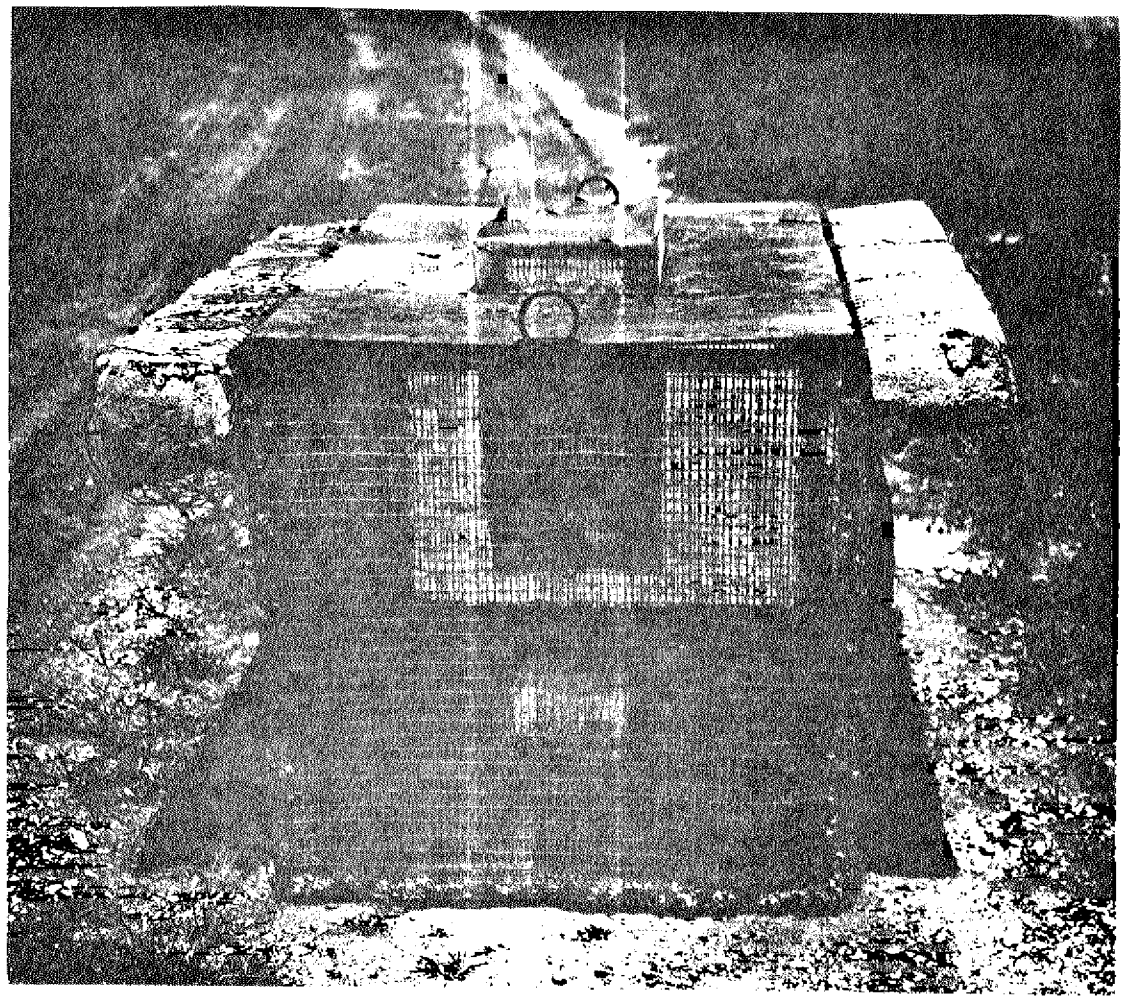

FIGURE 2.--Floating fish cage (m^3) used during culture experiments.

cut in the middle of the cage covers to allow for the installation of feeding rings 12 x 18 x 24 inches deep constructed of 1/8-inch mesh galvanized hardware cloth with top and bottom open. The feeding rings were positioned such that 4 inches extended above the cage cover and 20 inches extended into the cage interior. Cage covers were treated with Lagotex Black No. 599. Completed cages weighed about 75 lb.

In June 1971 two rows of 15 cages were positioned acorss the intake canal with an approximate space of 0.9 m between rows. There was a space of about 0.3 m between cages within each row. Cages were directly attached to the intake platform using 7/16-inch twisted nylon rope. Inside row cages (upstream) were numbered 1 through 15 beginning at the south end of the platform. Outside row cages (downstream) were numbered 16 through 30 starting at the north end of the platform.

The remaining 10 cages were positioned in one row across the discharge canal just prior to the time that one-half of the fish being cultured in the intake were to be transferred to the discharge for an intake-discharge comparative study (5 November 1971). Five additional cages were moved from the intake to the discharge canal after the first group of fish was transferred. There was a space of about 0.3 m between discharge cages. Cages were directly attached to

the discharge platform using 7/16-inch twisted nylon rope. Discharge cages were designated as positions 31 through 45 beginning at the east end of the platform.

Procurement of Stock

The fish used in the cage experiments were obtained from several locations in Galveston County using a variety of collecting equipment. Trawl collections were made with a 3-m (distance between the doors) Texas box trawl with a 2.5-cm stretched mesh in the body and a 1.9-cm stretched mesh in the cod end, and a 6-m Texas balloon trawl with a 3.8-cm stretched mesh in the body, and a 2.5-cm stretched mesh in the cod end. Species collected by trawling were the Atlantic croaker (*Micropogon undulatus*) and the spot (*Leiostomus xanthurus*). A 91.4-m 2.5-cm mesh beach seine was used to obtain Florida pompano (*Trachinotus carolinus*), Gulf kingfish (*Menticirrhus littoralis*), and black drum (*Pogonias cromis*). White mullet (*Mugil curema*) were obtained using a 1.8 x 10.7 m long nylon bag seine. The body of the net had a stretched mesh of 0.9 cm, with a 0.5-cm stretched mesh in the bag. The bag measured 1.8 x 1.8 x 1.8 m. Pinfish (*Lagodon rhomboides*), pigfish (*Orthopristis chrysoptera*), and silver perch (*Bairdiella chrysura*) were caught using hook and line fishing tackle.

During field collections fish were kept in 121.1-liter plastic trash cans aerated at a rate of 6 ml/min with compressed oxygen. Fish were transported to the Bacliff plant facility in a pick-up truck equipped with a 757-liter Hurley Hauling fiberglass tank also aerated at a rate of 6 ml/min with compressed oxygen. Fish were then transferred to three intake canal cages and maintained until sufficient numbers were obtained for stocking. No food was provided during this holding period since it was believed that sufficient natural food was available.

Cage Stocking and Growth Sampling

When sufficient fish were obtained, stocking procedures were initiated. Holding cages were lifted nearly out of the water, concentrating the fish to facilitate dip-netting. The fish were removed from the cages and placed in a number 3 galvanized wash tub containing a solution of Quinaldine (Eastman Kodak) at a concentration of 26 parts per million (ppm). No solvent agent was used in the anesthetizing operation. Once the fish were anesthetized, standard length in millimeters (Hubbs and Lagler, 1964), and weight to the nearest gram were recorded. Weights were obtained with a 1000 g capacity, temperature compensated spring balance (HOMS Model 1000, Douglas Homs Corporation). Fish were then placed into

another number 3 wash tub without anesthetic for recovery. Both tubs were aerated at a rate of 6 ml/min using compressed oxygen. Before stocking an attempt to administer a 15-min prophylactic treatment of 200 ppm formalin for parasite control was made, but was terminated after only several such treatments due to inadequate treatment facilities. All fish were utilized and there was no sorting for size. Cages were stocked at a density of 25 fish per cage, although some cages did not receive a full complement of fish. Table 1 lists the date of stocking, cage number, number of fish, and average length and weight stocked for each species cultured. After 8 October 1971, spot in cage 16 and black drum in cage 18 were added to cage 14 which contained Gulf kingfish. To facilitate tabulation of data, spot and black drum retained their original cage number.

Growth sampling was made at approximate 1-month intervals following the same handling procedure described for the initial stocking operations. However, a portable boom (Fig. 3) was now utilized to lift the cages nearly out of the water. All cages were completely inventoried. Fish were not fed supplemental feed on the days that they were to be weighed and measured. Other observations recorded were cage condition, extent of fouling, and apparent

TABLE 1.--Summary of stocking data (standard length in millimeters and weight in grams) for each species cultured.

Stocking date	Species	Cage number	Number of fish	Average length	Average weight
1971					
7-21	Croaker	1	25	112.5	38.5
7-21	Croaker	2	25	100.2	26.7
7-21	Croaker	5	25	104.7	30.0
7-21	Croaker	6	25	117.8	32.4
7-21	Croaker	7	25	104.3	27.0
7-21	Croaker	11	14	126.3	53.1
7-21	Croaker	28	25	137.4	59.4
7-21	Croaker	29	25	137.3	58.0
7-21	Pinfish	3	25	149.4	124.8
7-21	Pinfish	9	23	131.7	78.2
10-8	Pinfish	15	25	106.2	40.2
10-8	Pinfish	16	25	108.4	41.9
10-8	Pinfish	17	25	106.0	39.4
10-8	Pinfish	18	25	105.5	39.2
10-8	Pinfish	26	25	100.5	33.6
10-8	Pinfish	30	25	104.9	37.5
7-21	Pompano	12	25	106.0	40.6
7-21	Pompano	13	25	105.8	41.9
7-21	Pompano	17	8	101.2	40.2
8-12	Pompano	20	14	137.0	85.3
8-12	Pompano	21	25	130.4	74.9
8-12	Pompano	22	25	128.1	75.4
8-12	Pompano	23	25	125.1	65.0
8-12	Pompano	24	25	118.3	57.5
10-9	White mullet	25	25	94.6	21.1
10-9	White mullet	27	25	89.3	16.2
7-21	Pigfish	8	25	164.1	109.0
7-21	Pigfish	10	11	147.6	90.7
7-21	Gulf kingfish	14	25	208.3	153.5
7-21	Silver perch	4	10	154.6	88.9
7-21	Spot	16	7	155.7	106.7
7-21	Black drum	18	2	211.0	234.0

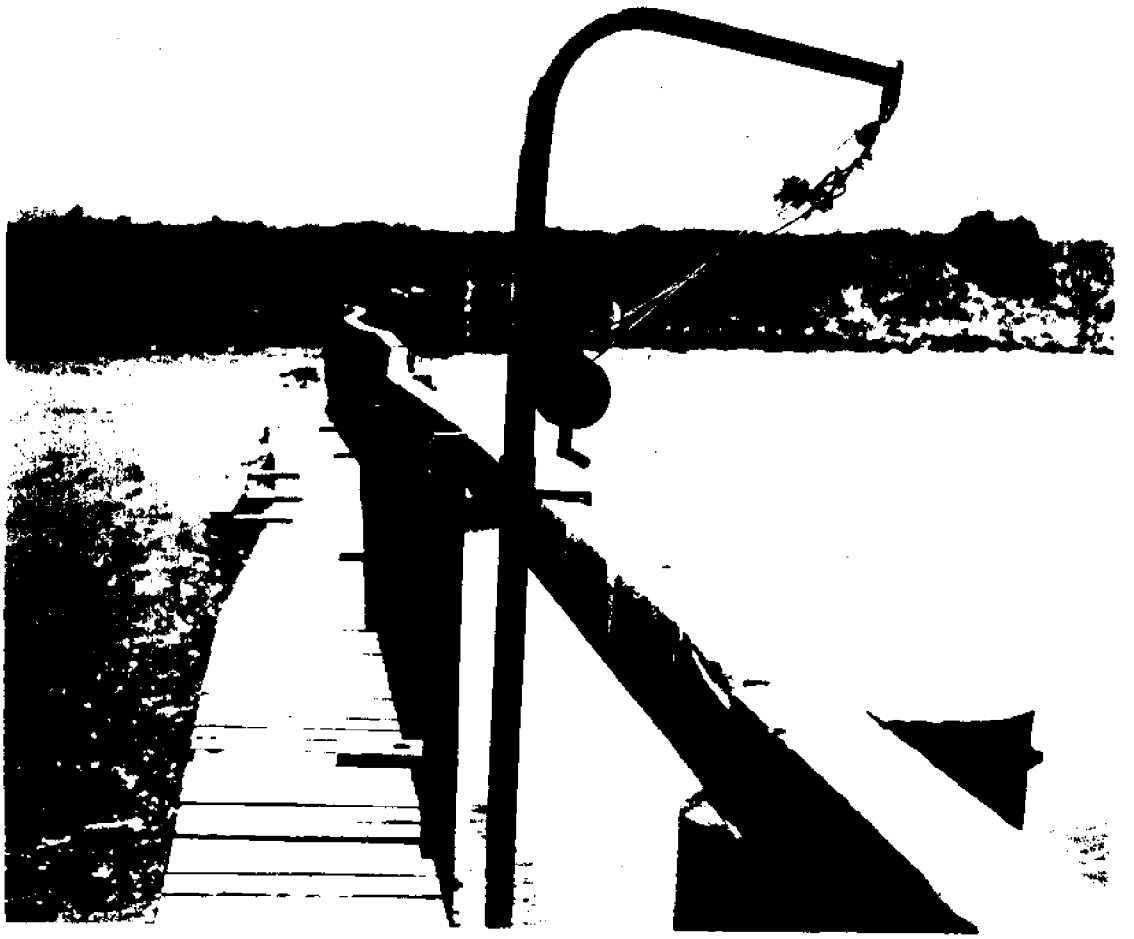

FIGURE 3.--Portable boom used to lift cages out of the water during growth sampling and harvesting.

condition of the fish. Average length, average weight, and percent survival were calculated for each growth sampling period.

At the termination of the experiments, fish were removed from the cages, measured and weighed. Gulf kingfish, pigfish, spot, and white mullet were transferred to the Houston Lighting and Power Company's Cedar Bayou Generating Station in Baytown, Texas for utilization in other mariculture and water quality studies. The final handling of croakers, pinfish, and pompano is reported in the organoleptic evaluation section (page 27).

Food and Feeding

The floating feed used in these culture experiments was Purina Trout Chow (40% protein). A pellet size of 7 x 5 mm was used throughout the experiments. Pompano were fed at 5% of their total weight in a cage throughout the experiment except for the period from 21 July to 3 September 1971 when pompano in cages 12, 13, and 17 were fed at 3% of their total weight in a cage, and from 12 August to 21 August 1971 when pompano in cages 20 through 24 were fed at 3% of their total weight in a cage. All other species were fed at 3% of their total weight in a cage, except for the period from the September to October 1971 growth sampling during which they were fed at 5% of their total weight in a cage.

Adjustments in the daily feed ration were made following the periodic growth sampling of the caged fish. The daily ration of feed was weighed on a 5 kg capacity, fandial dietary scale (Model I-10, Pennsylvania Scale Company). The feed was then placed into labeled plastic bags to be later distributed to the respective cages. The fish were fed once daily in the morning, 6 days per week. After the feed was placed within the feeding ring, the cage was tapped several times in an attempt to condition the fish as to the presence of feed. The conditioned response in this study was the immediate initiation of feeding activity by the fish. In preliminary trials some of the fish responded immediately to the conditioning stimulus, therefore, it was decided to provide food before tapping to insure the presence of a reward for a positive conditioned response.

During the initial period of the culture experiments, the surface feeding activity of species cultured other than pompano was poor, infrequent, or never observed. It was therefore decided to discontinue the feeding of select cages in an attempt to determine whether supplemental feeding was of any benefit. Croaker (cages 2, 6, and 28), pinfish (cages 16, 17, and 26), and white mullet (cage 27) did not receive supplemental feed after the October 1971 growth sampling. Also, after the December 1971 growth sampling, all pinfish (cages 15, 26, and 30) and black drum (cage 18) did not receive supplemental feed.

When appropriate, food conversion ratios were determined for each growth period as well as the overall study period. Food conversion ratios were calculated according to Avault and Shell (1968) using the following formula:

$$\text{Food Conversion (C)} = \frac{\text{grams of food added}}{\text{net grams of fish produced}}$$

Transfer of Fish to the Discharge Canal

In early November 1971 intake water temperatures began to drop below those considered favorable for maximum growth, i.e., less than 20 C. It was planned to transfer one half of the fish being cultured in the intake to the heated discharge to examine the potential of utilizing this energy source to extend the optimum growth period of fish. On 5 November 1971, pompano in cages 13, 20, 21, and 24 were transferred to discharge cage positions 31, 36, 44, and 41, respectively. On 11 November 1971, croaker in cages 6, 7, 11, and 29 were moved to discharge cage positions 32, 43, 37, and 42, respectively. Fish were measured and weighed and then transferred to the discharge in 121.1-liter plastic trash cans aerated at a rate of 6 ml/min with compressed oxygen. Fish were transferred directly to the discharge water with no attempt at temperature acclimation due to inadequate acclimation facilities. The transferring operation was

not completed because of a fish kill on 12 November 1971 of those species already in the discharge (pompano and croaker). Until this mortality could be attributed to some possible cause it was decided that further transfer of the remaining few specimens would be undesirable since taste panel experiments were to be conducted to evaluate the general acceptability of the cultured products. However, on 8 December 1971, pinfish in cage 15 not used in the taste study were transferred to discharge cage position 42 employing the same methods as were used in the initial transfer.

Organoleptic Evaluation

Taste panel experiments were performed on pompano (cages 12, 22, and 23), pinfish (cages 3 and 9), and croaker (cages 1, 2, and 5). Feeding was stopped 3 days prior to the harvesting of these fish. On the day of harvest, fish were removed from the cages, packed in clean chipped ice, and brought to the laboratory facility where length and weight were recorded. The fish were then headed, evicerated, and reweighed. Dressing percentages were calculated for each cage by dividing the dressed total fish weight by the total fish weight before heading and eviceration, and then multiplying by 100%. The sexual development of these fish was noted. The pompano were filleted, placed in plastic freezer bags filled with tap water,

and frozen at -10 C. The pinfish were packed in ice inside styrofoam coolers and stored overnight. The next day the pinfish were filleted, placed in freezer bags filled with tap water, and frozen at -10 C. The croakers were also frozen in water at -10 C. Croakers were filleted just prior to the taste experiments. The frozen fish were packed in ice inside styrofoam coolers and transported to the Main Campus, College Station, Texas.

The frozen fish were thawed under cold, running tap water. All fish fillets were skinned. The fillets were cut into equal pieces (2.5 x 5.0 x 1.3 cm thick). These samples without condiment were baked in individual covered aluminum pans at 163 C for 25 minutes in Hot Point ovens.

The baked samples were number coded and submitted simultaneously to a taste panel of 12 judges at individual stations in a quiet room. The taste panel was composed primarily of untrained members. Judges were solicited on the basis of availability from among the faculty and students of the Department of Wildlife and Fisheries Sciences, Texas A&M University. Judges were informed of the general nature of the experiment. A glass of water was provided, and the judges were asked to drink a small amount of water before tasting each sample. The samples were evaluated by the judges for appearance, flavor, mouthfeel, and overall satisfaction. A

questionnaire was developed utilizing a hedonic scale of 1 to 8 showing extreme dislike to extreme like to score each category (Fig. 4). This scoring was designed to force taste panel members to make a decision of either like or dislike.

Mean scores, standard deviations, and percent acceptance were calculated. Two-way analyses of variance (Croxton, 1953) were calculated to determine if statistical differences existed between mean scores for each category. All significance levels used in this thesis are 0.01 unless otherwise stated.

Length-Weight Relationship and Condition

Information on the relationship between lengths and weights of fish are often utilized in fisheries research. The analysis of length-weight data has been directed towards describing the mathematical relationship between length and weight so that one measurement can be converted to the other (LeCren, 1951; Lagler, 1956).

The length-weight relationship of most fish can be adequately described by the exponential function:

$$W = aL^b$$

where W = weight, L = length, a = constant, and b = exponents ranging from 2.5 and 4.0 (Hile, 1936; Martin, 1949).

NAME_____

QUESTIONNAIRE_____

Texas A&M Fish Palatability Study

Please score the sample of fish for the various characteristics according to the following scoring system:

Score	Description
8	Like extremely
7	Like very much
6	Like moderately
5	Like slightly
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

I. a) Palatibility Score (eating the fish):

Appearance			
Flavor			
Mouthfeel			
Overall satisfaction			

b) Any other comment (write in)_____

_____

II. How often do you eat fish? (write the frequency per month)

FIGURE 4.--Questionnaire for organoleptic evaluation by a taste panel.

To analyze length-weight data in terms of linear regression, some means of linear transformation is required. This can be accomplished by plotting the log of length against the log of weight. Based on this log transformation, the above equation can now be rewritten in the linear form of $Y = a + bx$.

$$W = aL^b$$

$$\log W = \log (aL^b)$$

$$\log W = \log a + b (\log L)$$

Log a represents the log W axis intercept, and b represents the slope of the line (LeCren, 1951).

A separate plot of the individual standard lengths in millimeters (x-axis) and weight in grams (y-axis) was made for all cages of each species cultured. All within species length-weight data for fed fish was transformed into logs and combined. Overall regression lines were calculated using a Monroe Model 1785 programmable calculator. Regression lines were fitted by the method of least squares (Croxton, 1953). The equations for calculating the slope (b) and the Y-intercept (log a) are:

$$b = \frac{\sum X \sum Y - N \sum XY}{(\sum X)^2 - N \sum X^2}$$

$$\log a = \frac{b \sum X - \sum Y}{-N}$$

where X = log length, Y = log weight, and N = number of paired observations. A measure of the goodness of fit of the regression line to the data, provided by the mean square deviation from regression ($s^2_{y \cdot x}$) and a measure of the degree of closeness of the linear relationship between length and weight, provided by the correlation coefficient (r) were also determined using methods described by Steel and Torrie (1960).

Variations of individual or similar size groupings of fish from the length-weight relationship are usually analyzed by means of a condition factor. The values of the condition factor have been used, among others, as an indication of fatness, relative robustness of fish, and suitability of the environment (LeCren, 1951; Lagler, 1956; and others).

Coefficient of condition values were calculated using the formula:

$$K_{SL} = \frac{W \times 10^5}{L^3}$$

where W = weight in grams, L = standard length in millimeters, and K_{SL} = condition factor.

For each growth sampling date, average condition factors of fish in the cages were calculated. To determine whether supplemental feeding affected the condition of croaker, pinfish, and white mullet, comparisons between the condition values of fed and non-fed fish

were made. Statistical comparisons between the mean condition of fed (cages 1, 7, and 29) and non-fed (cages 2, 6, and 28) croaker, fed (cages 15, 18, and 30) and non-fed (cages 16, 17, and 26) pinfish, and fed (cage 25) and non-fed (cage 27) white mullet were accomplished by using the analysis of variance (Croxton, 1953), analysis of variance and t-test (Snedecor and Cochran, 1967), and the t-test, respectively. If the resultant F-values from the analysis of variance were significant, differences between the mean condition values were distinguished by using an extension of Duncan's New Multiple Range Test (Kramer, 1956). The average condition of pinfish in the intake (cage 30) and the discharge (cage 15) were compared by the t-test.

Growth

Growth was determined by using the differences in the average lengths and weights between consecutive growth sampling dates to calculate the average daily increments in length and weight. This absolute growth is calculated from the formula:

$$\text{Absolute Mean Growth} = \frac{A^{t_2} - a^{t_1}}{t_2 - t_1}$$

where A^{t2} = average weight in grams or standard length in millimeters at time t_2, a^{t1} = average weight in grams or standard length in millimeters at time t_1, where t_2 is later than t_1.

The relative growth in weight expressed as a percentage was calculated for each species from the following formula:

$$\text{Relative Growth} = \frac{W^{t2} - w^{t1}}{w^{t1}} \times 100\%$$

where W^{t2} = average weight in grams at time t_2, w^{t1} = average weight in grams at time t_1, where t_2 is later than t_1.

To determine whether supplemental feeding affected the growth in weight of croaker, pinfish, and white mullet, comparisons were made between the average weights attained by fed and non-fed fish. Statistical comparisons between the average weights attained by fed (cages 1, 7, and 29) and non-fed (cages 2, 6, and 28) croaker were accomplished using two tests. Since croaker in cages 28 and 29 were of much smaller size than the others, their average weights were compared separately by the t-test. Average weights attained by croaker in cages 1, 2, 6, and 7 were compared using the analysis of variance and t-test. The average weights attained by pinfish that received supplemental feed (cages 15 and 18) were compared to average weights attained by unfed pinfish (cages 16 and 17) by using the analysis of variance test. If the resultant F-values from the

analysis of variance were significant, differences between the means were distinguished by using an extension of Duncan's New Multiple Range Test (Kramer, 1956). Since pinfish in cages 26 (not fed) and 30 (fed) were sampled at a later date than pinfish in cages 15, 16, 17, and 18, the average weights they attained were compared separately by the t-test. The average weights attained by pinfish in the intake canal (cage 30) and the discharge (cage 15) were compared by the t-test.

Hydrological Data

Hydrological data were taken after each morning feeding period. Water temperature, dissolved oxygen content, conductivity-salinity, hydrogen-ion concentration (pH), and water velocity were recorded. Only surface readings were taken for all hydrological parameters.

The hydrological parameters were measured as follows:

1. Temperature. Water temperature in degrees Celsius was measured with the thermistor probe of a Yellow Springs Instrument Company (YSI) Model 51 galvanic cell oxygen analyzer. Readings were made to a 0.1 degree although it is doubtful that accuracy was better than 0.5 degrees.
2. Dissolved Oxygen. The YSI Model 51 galvanic cell oxygen

analyzer was used to measure dissolved oxygen in parts per million (ppm).

3. Hydrogen-ion concentration (pH). A Hach DR EL Engineer's Laboratory was used to take pH readings to the 0.01 unit.
4. Conductivity-Salinity. A YSI Model 31 conductivity bridge was used to measure conductivity in micromhos/cm. A Beckman conductivity meter (Solu Bridge RB 3-3341) and probe (CEL-VSO2-2-VH20-KP.X10250) was also used periodically. A nomograph was used to convert conductivity readings to salinity in parts per thousand (ppt).
5. Water Velocity. Water velocity was measured using a Durant (Model 5-Y-8822-R-CL) flow meter. Readings were taken in revolutions per minute and converted to m/sec.

Standard Length-Total Length Conversion Equation

Many of the scientific papers on the biology of the croaker list only total lengths. Since only standard lengths were recorded during this study, information on the relationship between the two measurements was needed so that one length measurement could be converted into the other and thus allow comparisons between length-related data obtained during this study to other reported data. No published conversion equations for croaker were found in the literature.

To provide an equation for the conversion of standard length to total length, croaker were collected throughout Galveston Bay from March through May 1972 using collecting gear similar to that previously described. Standard and total lengths of croaker were recorded and plotted on graph paper (x-axis = standard length; y-axis = total length). Examination of the length plots revealed a linear relationship. However, a slight change in the slope of the relationship for small, intermediate, and large size groupings was apparent (i.e., the relative length of the tail tended to decrease with the increasing length of the fish). Therefore, three separate regression lines were calculated for the small, intermediate, and large size groupings of croaker (28 to 95 mm; 102 to 159 mm; and 168 to 255 mm). Regression lines of the general form:

$$Y = a+b\,X$$

where Y = total length in millimeters, and X = standard length in millimeters were fitted to the data by the method of least squares (Croxton, 1953). The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were also calculated. The standard length-total length conversion equations for croaker presented in this thesis are also presented in a thesis prepared by Gary Matlock, graduate student, of the Department of Wildlife and Fisheries Sciences, Texas A&M University.

RESULTS

Hydrological Data

Hydrological data recorded during this study are presented in Appendix Tables 1 through 5. Temperature data are found in Appendix Table 1; salinity data in Appendix Table 2; dissolved oxygen data in Appendix Table 3; hydrogen-ion concentration (pH) data in Appendix Table 4; and water velocity data in Appendix Table 5.

Water Temperature

During the study, water temperatures in the intake canal ranged from a low of 5.5 C at station 2 on 5 January 1972, to a high of 31.0 C at station 3 on 27 August 1971, and at stations 1 and 3 on 28 August 1971. Among intake recording stations, temperatures varied less than 1 C per day. Mean monthly temperatures below 20 C occurred from November 1971 to March 1972.

Water temperatures in the discharge canal were usually 7 to 10 C higher than those in the intake (Fig. 5). A low of 8.3 C was recorded at station 6 on 9 February 1972. The highest temperature recorded was 32.8 C occurring at station 4 on 17 November 1971. There were isolated instances when temperatures recorded at station 4 were one to several degrees warmer than at station 6. These

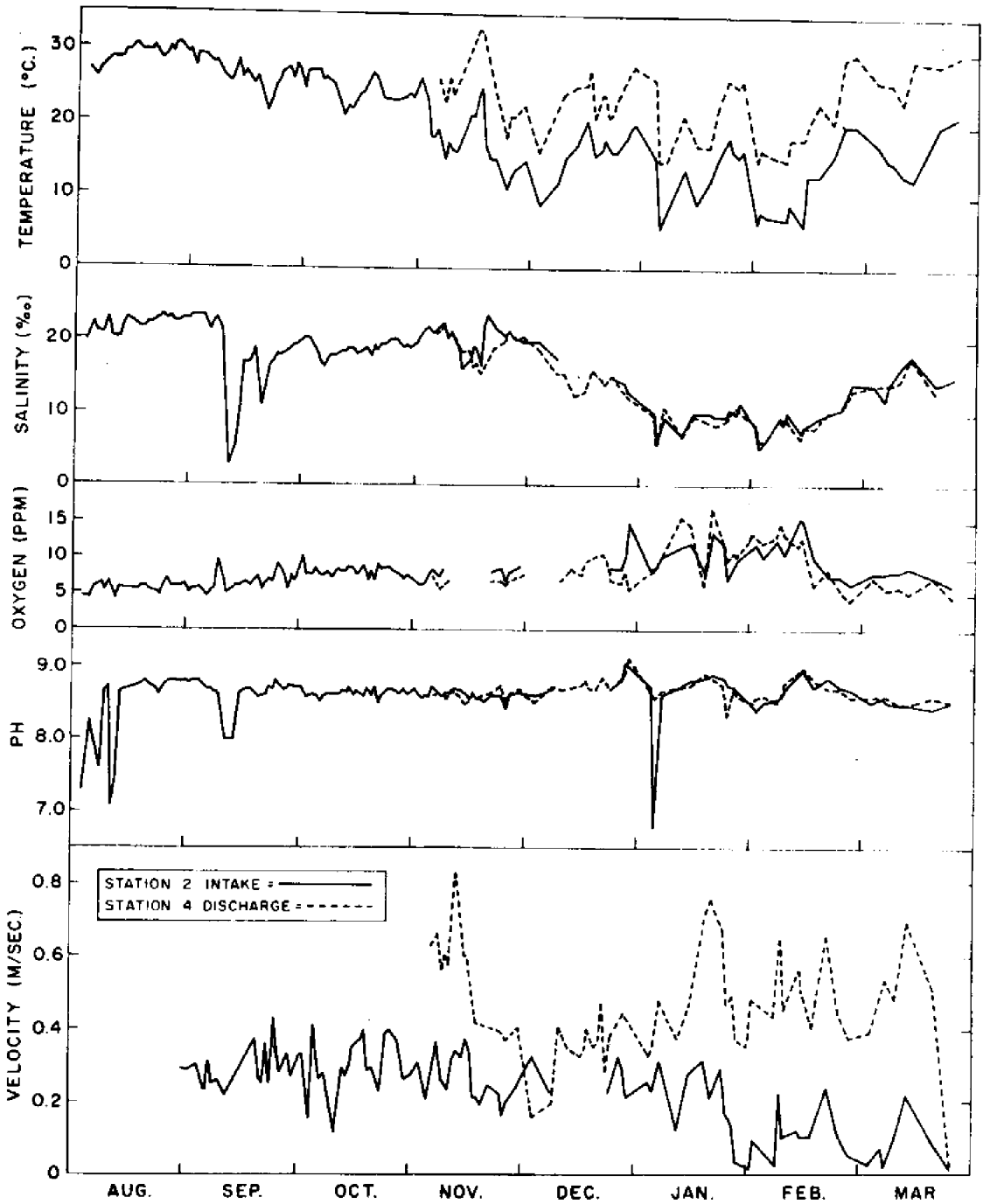

FIGURE 5.--Temperature (C), salinity (‰), oxygen (ppm), pH, and velocity (m/sec) values recorded at intake canal station 2 (solid line) and discharge canal station 4 (dashed line) during 3 August 1971 through 25 March 1972. The absence of dashed and/or solid line indicates the particular parameter was not taken.

temperature differences did not appear to follow any pattern, except that differences greater than 5 C between station 4 and 6 were recorded when the by-pass pump station was operating.

Salinity

A maximum intake salinity value of 23.6 was recorded on 20 November 1971 at stations 1, 2, and 3. Highest salinities were recorded from August through December 1971. A low of 2.6 ppt was recorded at stations 1, 2, and 3 on 11 September 1971. This minimum reading was probably the result of several days of heavy rain associated with Hurricane Fern. Lowest salinities were recorded during the months of January through March 1972, and also appear to be the result of increased precipitation and surface run-off. Salinity values among recording stations usually varied less than several tenths of a ppt per day.

Salinity values recorded in the discharge varied slightly from those in the intake (Fig. 5, page 39), and ranged from a low of 5.7 ppt recorded at stations 4 and 6 on 5 January 1972, to a high of 22.5 ppt at stations 4, 5, and 6 on 8 November 1971.

Dissolved Oxygen

Dissolved oxygen levels in the intake ranged from a low of 4.0 ppm recorded at station 1 on 3 August and 4 August 1971 and at stations 1, 2, and 3 on 12 August 1971, to a high of 17.5 ppm recorded at station 3 on 14 February 1972. Mean monthly dissolved oxygen levels were highest during December 1971 through February 1972.

Discharge dissolved oxygen levels ranged from a low of 4.3 ppm at station 4 on 28 February 1972, to a high of at least 17.0 ppm (a maximum scale reading, i.e., 25.0 ppm, was recorded before compensating for temperature) at stations 4 and 6 on 21 January 1972. Discharge dissolved oxygen levels were generally higher than those in the intake during the month of January and the first half of February 1972 (Fig. 5, page 39).

Hydrogen-ion Concentration (pH)

In the intake canal, the lowest pH value of 6.78 was recorded on 5 January 1972 at station 3. The maximum pH value of 9.05 was recorded on 28 December 1971 at station 2. pH readings varied only slightly (usually less than several tenths of a unit) between stations, and generally ranged from 8.40 to 8.80.

Discharge canal pH readings generally varied only slightly from those recorded in the intake (Fig. 5, page 39). A minimum value of

8.42 was recorded on 26 November 1971 and 25 January 1972 at stations 5 and 6, respectively, while a maximum reading of 9.20 occurred on 29 December 1971 at station 6.

Water Velocity

In the intake canal water velocities at stations 2 and 3 were generally at least twice those recorded at station 1. Water velocities at station 2 were usually slightly higher than those at station 3. Average monthly water velocity values for intake stations 1, 2, and 3 ranged from 0.047 (November 1971) to 0.109 m/sec (September 1971), 0.075 (March 1972) to 0.300 m/sec (October 1971), and 0.064 (March 1972) to 0.335 m/sec (September 1971), respectively. A minimum velocity of 0 m/sec was recorded several times throughout the study at station 1, while a maximum reading of 0.545 m/sec was recorded at station 3 on 13 September 1971.

In the discharge canal, water velocities at station 4 were usually higher than those at station 6. Average monthly water velocity values for discharge stations 4, 5, and 6 ranged from 0.351 (December 1971) to 0.714 m/sec (November 1971), 0.460 (December 1971) to 0.684 m/sec (November 1971), and 0.265 (February 1972) to 0.387 m/sec (November 1971), respectively. A minimum velocity of 0.047 m/sec was recorded on 25 March 1972 at station 6, while a

peak velocity of 0.842 m/sec was recorded at station 5 on 13 November 1971. Discharge water velocities were generally two to three times greater than those in the intake (Fig. 5, page 39).

Cage Culture

The length-weight data compiled during this study are presented by cage number by sampling period in Appendix Tables 7 to 38.

Atlantic Croaker (*Micropogon undulatus*)

Summaries of the production data recorded for croaker cultured in cages 1, 2, 5, 6, 7, 28, and 29 are presented in Tables 2 to 9, respectively.

Survival.--The survival of croaker cultured for 131 days in cages 1, 2, and 5 averaged 85.3% and ranged from a low of 80.0% (cage 2) to a high of 92.0% (cage 5). The survival of croaker cultured for 113 days in cages 6, 7, and 11 ranged from 76.0% (cage 7) to 96.0% (cage 6) and averaged 88.3%. The survival of croaker during a 52-day culture period in cage 28 and for a 34-day culture period in cage 29 was 100%.

The only mortality of croaker in cages 5, 6, and 11 occurred during the period between the initial stocking and the first growth

TABLE 2.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 1 from 21 July to 29 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		112.5	38.5	962					2.468	75-185
9-15	56	23	92.0	161.2 (48.7)	111.7 (73.2)	2569	0.848	0.9	1.3	190.2	2.629	144-193
10-6	21	21	91.3	171.6 (10.4)	142.6 (30.9)	2995	3.253	0.5	1.5	27.6	2.769	152-197
11-11	36	21	100.0	181.9 (10.3)	173.8 (31.2)	3650	3.847	0.3	0.9	21.8	2.844	161-211
11-29	18	21	100.0	182.3 (0.4)	169.5 (-4.3)	3560	-13.444	0.0	-0.2	-2.1	2.759	163-212
Overall	131		84.0	(69.8)	(131.0)		2.493	0.5	1.0	340.5		

*Increment in parenthesis

TABLE 3.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 2 from 21 July to 29 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		100.2	26.7	668	.				2.456	75-168
9-8	49	21	84.0	153.9 (53.7)	98.8 (72.1)	2076	0.582	1.1	1.5	269.9	2.672	137-168
10-6	28	20	95.2	169.8 (15.8)	138.0 (39.2)	2760	3.345	0.6	1.4	39.5	2.797	153-198
11-11	36	20	100.0	181.3 (11.5)	165.9 (27.9)	3319	**	0.3	0.8	20.2	2.770	163-205
11-29	18	20	100.0	182.3 (1.0)	163.8 (-2.1)	3276	**	0.0	-0.1	-1.2	2.692	165-206
Overall	131		80.0	(82.1)	(137.1)		**	0.6	1.0	513.0		

*Increment in parenthesis
**Fish were not fed

TABLE 4.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 5 from 21 July to 29 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		104.7	30.0	750					2.117	86-184
9-8	49	23	92.0	155.6 (50.9)	103.6 (73.6)	2384	0.652	1.0	1.5	245.5	2.715	140-194
10-6	28	23	100.0	170.7 (15.1)	145.0 (41.4)	3387	2.747	0.5	1.5	39.9	2.886	150-201
11-11	36	23	100.0	184.1 (13.4)	185.6 (40.6)	4271	2.997	0.4	1.1	27.9	2.955	165-205
11-29	18	23	100.0	184.6 (0.5)	183.4 (-2.2)	4219	-27.076	0.0	-0.1	-1.2	2.895	163-203
Overall	131		92.0	(79.9)	(153.4)		2.275	0.6	1.2	511.4		

*Increment in parenthesis

TABLE 5.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 6 from 21 July to 11 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		117.8	32.4	809					2.082	89-182
9-8	49	24	96.0	156.8 (45.0)	108.8 (76.4)	2612	0.545	0.9	1.6	236.3	2.734	134-206
10-6	28	24	100.0	171.9 (15.1)	147.0 (38.2)	3529	3.142	0.5	1.4	35.1	2.817	155-215
11-11	36	24	100.0	181.3 (9.4)	167.2 (20.2)	4014	**	0.3	0.6	13.7	2.753	160-220
Overall	113		96.0	(69.5)	(134.8)		**	0.6	1.2	416.8		

*Increment in parenthesis
**Fish were not fed

TABLE 6.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 7 from 21 July to 11 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		104.3	27.0	675					2.318	73-163
9-8	49	24	96.0	154.1 (49.8)	104.3 (77.3)	2504	0.448	1.0	1.6	286.4	2.800	141-197
10-6	28	22	91.6	168.2 (14.1)	140.6 (36.3)	3095	4.653	0.4	1.3	34.8	2.914	152-209
11-11	36	19	86.3	178.3 (10.1)	165.5 (24.9)	3146	51.058	0.3	0.7	17.6	2.869	164-220
Overall	113		76.0	(74.0)	(138.5)		2.498	0.6	1.2	513.2		

*Increment in parenthesis

TABLE 7.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 11 from 21 July to 11 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		14		126.3	53.1	744					2.127	93-186
9-3	44	13	92.8	171.2 (44.9)	128.3 (75.2)	1668	0.904	1.0	1.7	141.4	2.397	150-223
10-8	35	13	100.0	187.0 (15.8)	185.9 (57.6)	2417	3.102	0.5	1.6	44.9	2.711	160-235
11-11	34	13	100.0	200.3 (13.3)	235.2 (49.3)	3058	2.960	0.4	1.4	26.6	2.803	180-247
Overall	113		92.8	(74.0)	(182.1)		2.189	0.6	1.6	342.6		

*Increment in parenthesis

TABLE 8.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 28 from 8 October to 29 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		137.4	59.4	1487					2.219	123-184
11-11	34	25	100.0	150.0 (12.6)	83.6 (24.2)	2092	**	0.4	0.7	40.6	2.441	137-189
11-29	18	25	100.0	151.8 (1.8)	85.2 (0.6)	2105	**	0.1	0.0	0.6	2.372	139-186
Overall	52		100.0	(14.4)	(24.8)		**	0.3	0.5	41.5		

*Increment in parenthesis
**Fish were not fed

TABLE 9.--Summary of production data (standard length in millimeters and weight in grams) for croaker in cage 29 from 8 October to 11 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		137.3	58.0	1451					2.179	121-170
11-11	34	25	100.0	155.6 (18.3)	101.6 (43.6)	2541	1.008	0.5	1.3	75.1	2.669	143-178
Overall	34		100.0	(18.3)	(43.6)		1.008	0.5	1.3	75.1		

*Increment in parenthesis

sampling in September 1971. Thereafter, survival was 100%. Mortality of croaker in cages 1 and 2 ceased after October 1971. Poorest survival of croaker was observed in cage 7 (76.0%), where progressive mortality occurred throughout the culture period. No mortality known to be caused by handling during growth sampling procedures was observed.

After October 1971, the survival of croaker not receiving supplemental food (cages 2, 6, and 28) was as good, and in one instance better than the survival of croaker that were being fed (cages 1, 7, and 29).

Croaker did not survive in the discharge canal. A complete mortality of croaker in cages 6, 7, 11, and 29 was discovered on 12 November 1971. The mortality occurred within an 18-hour time period after the transfer of the fish from the intake to the discharge canal. All croaker showed features of pronounced exophthalmos ("pop-eye"). Also, the abdomens of nearly all the croaker were ruptured.

Croaker that were near the west side and middle of the discharge canal (cages 7, 11, and 29) were in a more advanced state of bacterial decomposition than were croaker located near the east side of the discharge canal (cage 6).

Feeding and food conversion.--Croaker accepted and consumed the commercial trout pellets used during these culture experiments, however surface feeding activity was poor and not consistent from day-to-day. When it occurred, feeding activity would begin within 2 to 10 minutes after the food was placed inside the feeding ring. A few fish would come up within the feeding ring, rapidly take some food, and return back down. During feeding, water currents of sufficient magnitude were created within the feeding ring to cause the pelleted food to be pulled several inches under water. Cage tapping after the addition of food did not appear to increase the probability of a feeding response. Total consumption of the feed, even over a period of several hours, was never observed. The handling of croaker during growth sampling usually caused a cessation of surface feeding activity for a period of 3 to 6 days.

Food conversion rates were calculated for each cage of fed croaker for each culture period (Tables 2 to 9, pages 44 to 51). Food conversion rates of croaker cultured from an average initial weight of about 53 g to a final average weight of about 253 g was 2.189.

The food conversion rates of croaker cultured from an average weight of 30 g to an average weight of about 105 g were less than 1 and ranged from 0.448 to 0.848. Food conversion became less efficient as fish size increased. The food conversion rates of

croaker for the period from 11 November to 29 November 1971 were negative, i.e., the total weight of the fish at the end of the culture period was less than the weight at the beginning.

Standard length-total length conversion equation.--Length data used to calculate the following conversion equations are presented in Appendix Table 6. The Standard length-total length relationship of croaker from Galveston Bay for each size grouping examined can be described by the following formulae:

1. Standard length range 28 to 95 mm

   $Y = 1.21592 + 1.26753\ X$

   $r = 0.998 \quad s^2_{y \cdot x} = 1.34545 \quad N = 179$

2. Standard length range 102 to 159 mm

   $Y = 9.70548 + 1.17538\ X$

   $r = 0.990 \quad s^2_{y \cdot x} = 2.41050 \quad N = 73$

3. Standard length range 168 to 255 mm

   $Y = 19.88505 + 1.10952\ X$

   $r = 0.993 \quad s^2_{y \cdot x} = 2.78200 \quad N = 37$

where X = standard length in millimeters, Y = total length in millimeters, r= correlation coefficient, $s^2_{y \cdot x}$ = mean square deviation from regression, and N = number of paired observations. The calculated line for each size grouping and the plotted empirical data are shown in Figure 6.

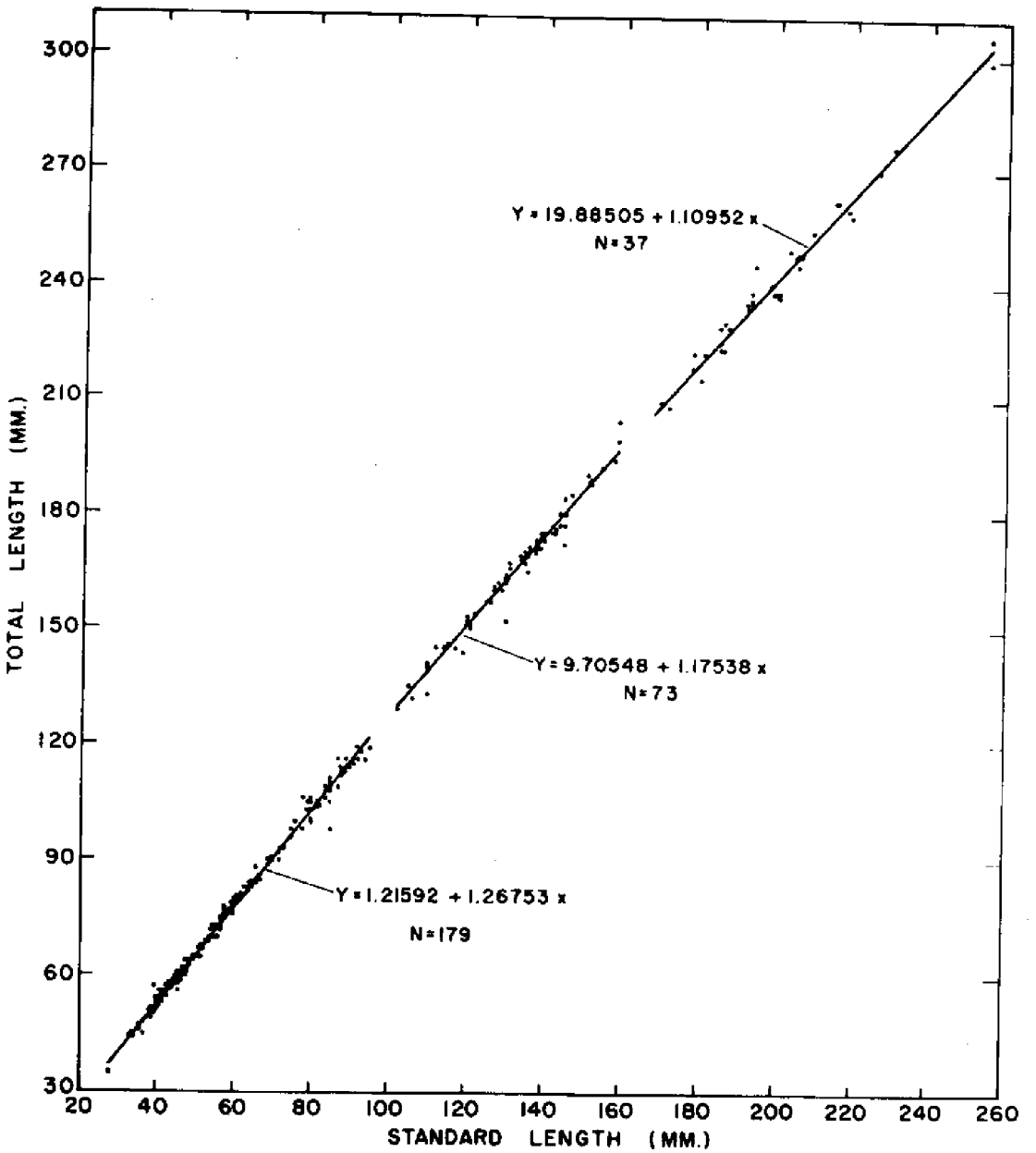

FIGURE 6.--Standard length-total length relationship of croaker from Galveston Bay, Texas. Dots represent empirical data and the lines are calculated.

Length-weight relationship and condition.--The calculated length-weight relationship of croaker cultured in cages during this study was based on 586 length-weight observations, and can be described by the formula:

$$\text{Log } W = -5.20037 + 3.28130 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 73 to 247 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y \cdot x}$) were 0.97997 and 0.00462, respectively. The sums, sums of squares, and sum of cross products used in calculating the croaker length-weight regression equation are:

$$\sum X = 1273.82961$$

$$\sum X^2 = 2775.07625$$

$$\sum Y = 1132.40206$$

$$\sum Y^2 = 2256.25714$$

$$\sum XY = 2481.47630$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values is shown in Figure 7. Empirical length-weight data recorded for croaker in cages 2 and 11 are plotted.

In all instances, mean condition values for croaker were lowest at the start of the experiments (Tables 2 to 9, pages 44 to 51). Thereafter, condition was comparatively high with maximum values

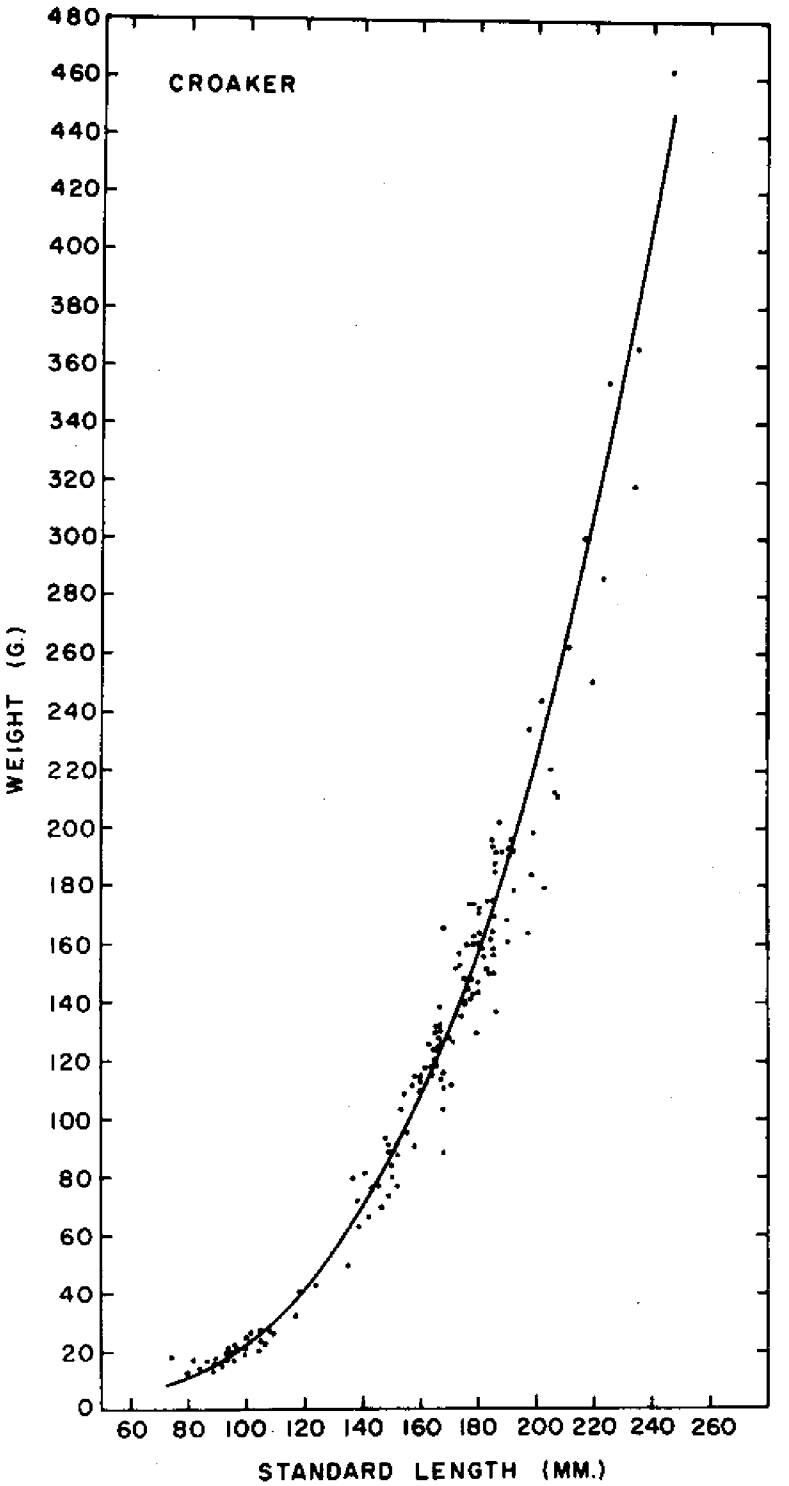

FIGURE 7.--Length-weight relationship of croaker cultured in cages. Empirical data for croaker in cages 2 and 11 are plotted and the line represents the calculated antilog values of the equation Log W = -5.20037 + 3.28130 Log L (N = 586).

occurring in October or November. Maximum condition values of croaker in cages 2, 6, and 7 were calculated for October 1971, and ranged from 2.797 (cage 2) to 2.914 (cage 7). Condition values were highest for croaker in cages 1, 5, 11, 28, and 29 on 11 November 1971 and ranged from a low of 2.441 (cage 28) to a high of 2.955 (cage 5). Condition decreased slightly after these maximum values were reached. Final condition values were higher than initial values.

The results of the comparisons among the average condition values of fed (cages 1, 7, and 29) and non-fed (cages 2, 6, and 28) croaker are presented in Tables 10 to 12. The F-test showed that initially there were differences among the average condition coefficients (Table 10, page 59). A modification of Duncan's New Multiple Range (DMR) test was applied to distinguish between means. The resulting differences are also presented in Table 10. Condition values of croaker in cages 1, 2, 6, and 7 were not significantly different. Average condition values of croaker in cages 28 and 29 were also not significantly different, however they were significantly lower than the condition values of croaker in cages 1, 2, 6, and 7.

Table 11 (page 60) summarizes the results of the analysis of variance and DMR test among condition values on 11 November 1971. After approximately 36 days from the start of the experiment, average condition values of croaker in cages 1, 2, 6, and 7 were

TABLE 10.--Analysis of variance among cages and Duncan's Multiple Range Test on the condition coefficient of croaker in cages 1, 2, 6, 7, 28, and 29 at the start of the fed vs. non-fed comparisons in October 1971.

Source	d.f.		SS	MS		F
Total	136		18.015			
Among Cages	5		12.724	2.544		63.004**
Within Cages	131		5.291	0.040		
N	25	25	21	20	24	22
Cage	29	28	1	2	6	7
Mean K	2.179	2.219	2.769	2.797	2.817	2.914

**Significant at 0.01

TABLE 11.--Analysis of variance among cages and Duncan's Multiple Range Test on the condition coefficient of fed (cages 1, 7, and 29) and non-fed (cages 2, 6, and 28) croaker on 11 November 1971.

Source	d.f.	SS	MS	F
Total	133	8.346		
Among Cages	5	2.817	0.563	13.043**
Within Cages	128	5.529	0.043	

N	25	25	24	20	21	19
Cage	28	29	6	2	1	7
Mean K	2.441	2.669	2.753	2.770	2,844	2.869

**Significant at 0.01

TABLE 12.--Analysis of variance among cages and Duncan's Multiple Range Test on the condition coefficient of fed (cage 1) and non-fed (cages 2 and 28) croaker on 29 November 1971.

Source	d.f.	SS	MS	F
Total	65	4.136		
Among Cages	2	1.991	0.995	29.239**
Within Cages	63	2.145	0.034	
N	25	20	21	
Cage	28	2	1	
Mean K	2.372	2.692	2.759	

**Significant at 0.01

not significantly different. However, the average condition of croaker in cage 29 (fed) was now significantly higher than the average condition of croaker in cage 28 (not fed).

Table 12 (page 61) shows the results of the analysis of variance and DMR test among condition values for 29 November 1971. After 54 days, the average condition of croaker in cages 1 and 2 was not significantly different from each other, but remained significantly higher than the average condition of croaker in cage 28.

Growth.--On an average basis, croaker in cages 1, 2, and 5 reached a final length and weight of about 182 mm and 172 g within 131 days from stocking (Tables 2, 3, and 4, pages 44, 45, 46). The mean increase in average length and weight was about 76 mm and 141 g. This represented an absolute growth rate in length and weight of about 0.6 mm/day (18.0 mm/month) and 1.1 g/day (33.0 g/month), respectively. The relative growth in mean weight averaged about 457%. Croaker in cages 6 and 7 showed similar results after only 113 days from stocking (Tables 5 and 6, pages 47 and 48). Croaker in cage 11 had the highest absolute growth rate in length (0.6 mm/day, or 18.0 mm/month) and weight (1.6 g/day, or 48.0 g/month), and attained an average length and weight of about 200 mm and 235 g within 113 days from stocking (Table 7, page 49).

Croaker in cages 28 and 29 were cultured for only 52 and 34 days, respectively, and did not attain as high an average length or weight as did the croaker in the other cages (Tables 8 and 9, pages 50 and 51). The maximum length (247 mm) and weight (463 g) was recorded for croaker in cage 11.

Greatest absolute and relative growth rates were recorded for the period from 21 July 1971 to the first growth sampling in September 1971. Thereafter, relative and absolute growth decreased. There was a general cessation of mean growth in weight after 11 November 1971 (Figs. 8 and 9). In Figure 9, croaker in cages 11, 28, and 29 were actually sampled on 8 October 1971, however difficulties encountered in graphic illustration (time spacing) required that they be grouped with the cages sampled on 6 October 1971. Croaker that were sampled on 29 November 1971 (cages 1, 2, and 5) showed a decrease in average weight of about 2.5 g.

Table 13 summarizes the results of the analysis of variance among average weights of croaker in cages 1, 2, 6, and 7 at the start of the fed vs. not-fed experiments. Average weights of croaker were not significantly different. The average weights of the smaller croaker in cages 28 and 29 were also not significantly different ($t = 1.362$; d.f. = 49).

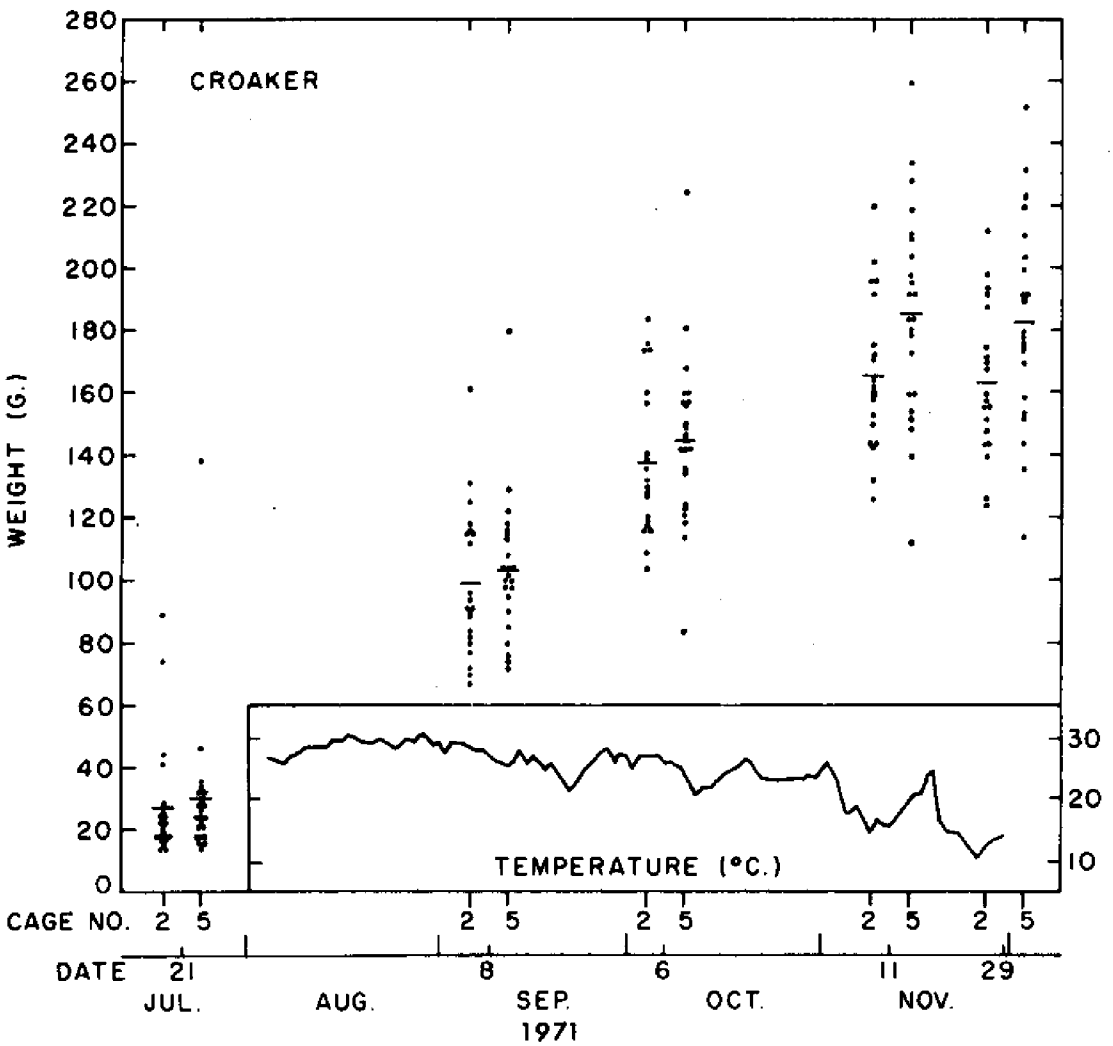

FIGURE 8.--Changes in weight of croaker in cages 2 and 5. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

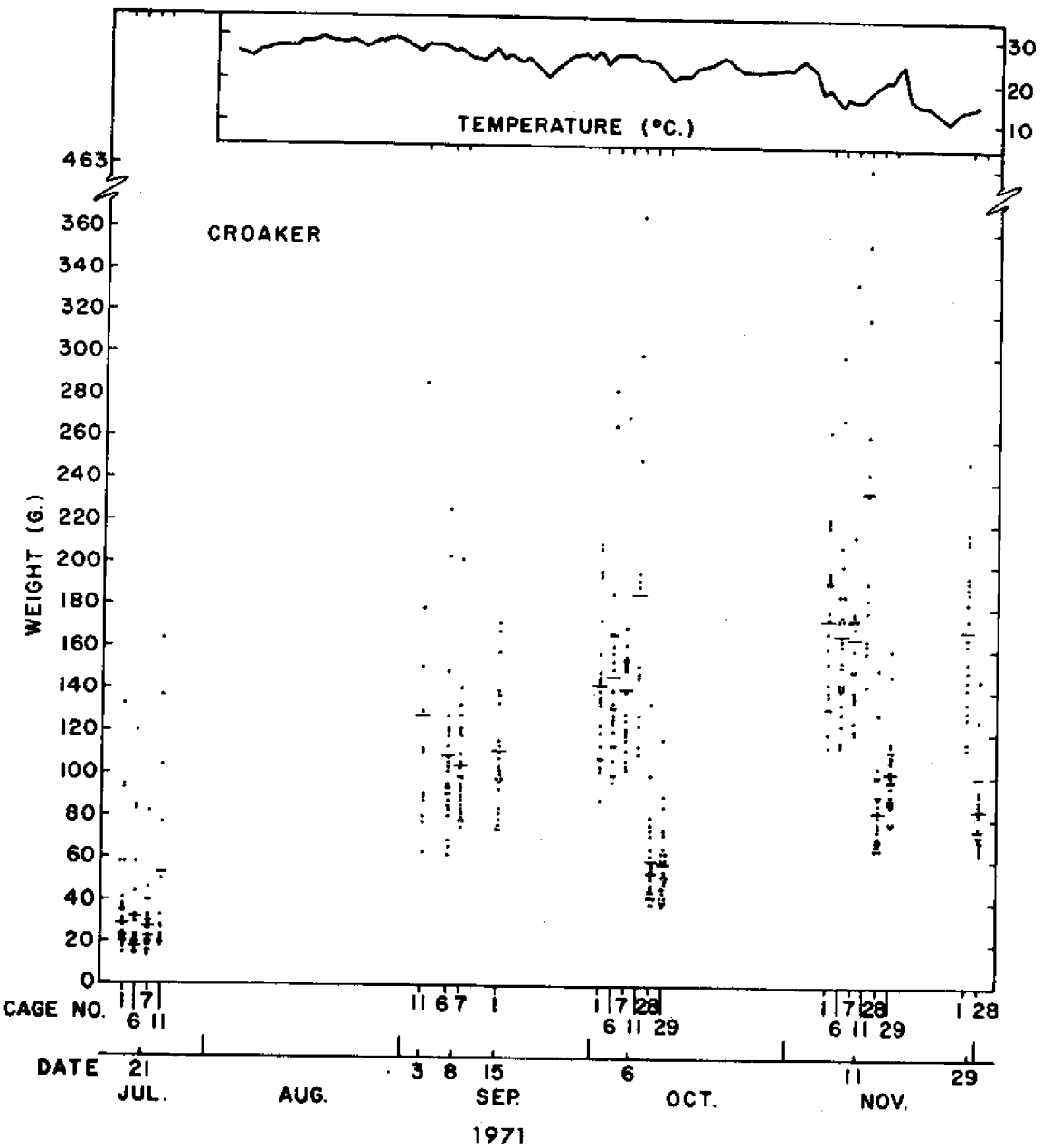

FIGURE 9.--Changes in weight of croaker in cages 1, 6, 7, 11, 28, and 29. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

TABLE 13.--Analysis of variance among cages on the average weight of croaker in cages 1, 2, 6, and 7 at the start of the fed vs. non-fed comparisons in October 1971.

Source	d.f.	SS	MS	F
Total	86	114291.815		
Among Cages	3	969.132	323.043	0.236
Within Cages	83	113322.683	1365.301	

Table 14 presents the results of the analysis of variance among average weights of croaker in cages 1, 2, 6, and 7 for 11 November 1971. After 36 days from the start of the feeding tests, the average

TABLE 14.--Analysis of variance among cages on the average weights of fed (cages 1 and 7) and non-fed (cages 2 and 6) croaker on 11 November 1971.

Source	d.f.	SS	MS	F
Total	83	129385.558		
Among Cages	3	914.239	304.743	0.189
Within Cages	80	128471.319	1605.875	

weights of fed and non-fed croaker were not significantly different. However, the average weight of fed croaker in cage 29 was now significantly higher than the average weight of unfed croaker in cage

28 (t = 3.134 significant at 0.01; d.f. = 49). After 54 days from the beginning of the feeding experiments, the average weights of croaker in cages 1 (fed) and 2 (not fed) on 29 November 1971 were not significantly different (t = 0.588; d.f. = 40).

The total weight of croaker in each cage (standing crop) at the last growth sampling ranged from 2105 g to 4219 g (Tables 2 to 9, pages 44 to 51). Croaker in cages 1, 2, and 5 dressed out at 55.2%, 56.5%, and 55.8% of their live weight (average of 55.8%).

Sexual development.--Croaker that were examined on 11 and 29 November 1971 were sexually mature with well developed testes and ovaries. The ovaries were greatly extended and occupied nearly all of the body cavity.

Pinfish (*Lagodon rhomboides*)

Summaries of the production data recorded for pinfish cultured in cages 3, 9, 15, 16, 17, 18, 26, and 30 are presented in Tables 15 to 22, respectively.

Survival.--Pinfish survived exceptionally well in cages (Tables 15 to 22, pages 68 to 75). The overall mean survival of pinfish cultured for 154 days in cages 15, 26, and 30 was 98.6%. The overall mean survival of pinfish cultured for 129 days in cages 3 and 9 was 96.0%. The overall survival of pinfish cultured for 61 days in cages

TABLE 15.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 3 from 21 July to 27 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		149.4	124.8	3122					3.632	75-173
9-8	49	23	92.0	172.5 (23.1)	205.3 (80.5)	4724	2.405	0.5	1.6	64.4	3.945	127-193
10-8	30	23	100.0	178.9 (6.4)	231.5 (26.2)	5325	8.638	0.2	0.9	12.7	3.999	140-202
11-13	38	23	100.0	188.8 (9.9)	275.4 (43.9)	6336	4.747	0.3	1.2	18.9	4.061	160-214
11-27	14	23	100.0	188.6 (-0.2)	256.3 (-19.1)	5895	-4.308	0.0	-1.4	-6.9	3.792	163-212
Overall	129		92.0	(39.2)	(131.5)		5.678	0.3	1.0	105.2		

*Increment in parenthesis

TABLE 16.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 9 from 21 July to 27 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		23		131.7	78.2	1799					3.303	88-162
9-3	44	24**	100.0	157.7 (26.0)	148.7 (70.5)	3569	3.355	0.6	1.6	90.1	3.724	133-181
10-8	35	24	100.0	165.7 (8.0)	187.8 (39.1)	4508	5.307	0.2	1.1	26.3	4.090	145-185
11-13	36	24	100.0	176.9 (11.2)	227.1 (39.3)	5452	4.004	0.3	1.1	20.9	4.077	160-196
11-27	14	23***	100.0	177.5 (0.6)	219.6 (-7.5)	5053	-4.110	0.0	-0.5	-3.2	3.899	160-195
Overall	129		100.0	(45.8)	(141.4)		5.022	0.4	1.1	180.8		

*Increment in parenthesis
**Miscount on number stocked
***Mortality due to handling, not included in percent survival

TABLE 17.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 15 from 8 October 1971 to 10 March 1972.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		106.2	40.2	1004					3.309	99-127
11-13	36	25	100.0	123.2 (17.0)	72.0 (31.8)	1801	1.053	0.5	0.9	79.3	3.843	117-135
12-8**	25	25	100.0	126.1 (2.9)	71.9 (-0.1)	1799	-459.0	0.1	0.0	-0.1	3.574	120-139
1972												
2-4	58	25	100.0	137.8 (11.7)	89.3 (17.4)	2233	****	0.2	0.3	24.1	3.386	128-157
3-10	35	20***	100.0	142.8 (5.0)	94.1 (4.8)	1882	****	0.1	0.1	5.3	3.209	133-160
Overall	154		100.0	(36.6)	(53.9)			0.2	0.4	134.3		

*Increment in parenthesis
**Fish transferred to the discharge (position 42)
***Five fish showing gas bubble disease symptoms were removed 18 February 1972 (not included in overall survival)
****Fish were not fed

TABLE 18.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 16 from 8 October to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		108.4	41.9	1049					3.208	91-155
11-13	36	25	100.0	121.8 (13.4)	66.2 (24.3)	1657	**	0.4	0.7	57.9	3.632	110-160
12-8	25	25	100.0	123.2 (1.4)	60.8 (-5.4)	1520	**	0.1	-0.2	-8.2	3.199	111-160
Overall	61		100.0	(14.8)	(18.9)		**	0.2	0.3	44.5		

*Increment in parenthesis
**Fish were not fed

TABLE 19.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 17 from 8 October to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		106.0	39.4	985					3.230	86-132
11-13	36	25	100.0	121.2 (15.2)	65.6 (26.2)	1641	**	0.4	0.7	66.5	3.662	108-130
12-8	25	25	100.0	122.8 (1.6)	59.7 (-5.9)	1494	**	0.1	-0.2	-8.9	3.205	111-130
Overall	61		100.0	(16.8)	(20.3)		**	0.3	0.3	51.6		

*Increment in parenthesis
**Fish were not fed

TABLE 20.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 18 from 8 October to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		105.5	39.2	980					3.311	96-117
11-13	36	24	96.0	123.0 (17.5)	73.5 (34.3)	1764	1.035	0.5	1.0	87.5	3.937	118-132
12-8	25	24	100.0	125.6 (2.6)	71.8 (-1.7)	1724	-22.5	0.1	-0.1	-2.2	3.616	119-135
Overall	61		96.0	(20.1)	(32.6)		2.302	0.3	0.5	83.2		

*Increment in parenthesis

TABLE 21.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 26 from 8 October 1971 to 10 March 1972.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		100.5	33.6	840					3.287	88-109
11-13	36	25	100.0	115.6 (15.1)	56.7 (23.1)	1419	**	0.4	0.6	68.9	3.665	107-123
12-24	41	24	96.0	121.0 (5.4)	57.9 (1.2)	1390	**	0.1	0.0	2.0	3.263	111-126
1972												
2-4	42	24	100.0	121.3 (0.3)	58.2 (0.3)	1398	**	0.0	0.0	0.5	3.250	112-126
3-10	35	24	100.0	124.8 (3.5)	64.0 (5.8)	1538	**	0.1	0.2	10.0	3.281	118-130
Overall	154		96.0	(24.3)	(30.4)		**	0.2	0.2	90.7		

*Increment in parenthesis
**Fish were not fed

TABLE 22.--Summary of production data (standard length in millimeters and weight in grams) for pinfish in cage 30 from 8 October 1971 to 10 March 1972.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-8		25		104.9	37.5	938					3.209	90-118
11-13	36	25	100.0	121.6 (16.7)	71.2 (33.7)	1782	0.895	0.5	0.9	89.9	3.802	112-131
12-24	41	25	100.0	127.2 (5.6)	70.4 (-0.8)	1761	-42.904	0.1	0.0	-1.1	3.412	118-136
1972												
2-4	42	25	100.0	128.3 (1.1)	70.9 (0.5)	1773	**	0.0	0.0	0.6	3.356	119-136
3-10	35	25	100.0	131.8 (3.5)	74.8 (3.9)	1870	**	0.1	0.1	5.4	3.255	124-140
Overall	154		100.0	(26.9)	(37.3)		**	0.2	0.2	99.3		

*Increment in parenthesis
**Fish were not fed

16, 17, and 18 averaged 98.6%. Generally, any mortality that was recorded for pinfish occurred during the period between the initial stocking and the first growth sampling.

The survival of pinfish not receiving supplemental food (cages 16, 17, and 26) was as good as the survival of pinfish that were fed (cages 15, 18, and 30). Pinfish in cage 15 in the discharge canal (position 42) survived as well as those in the intake (cages 26 and 30).

Feeding and food conversion.--Pinfish did not adapt to surface feeding in cages. Surface feeding activity was observed only seven times throughout the study. Only pinfish in cage 9 (four times), cage 30 (two times), and cage 15 (one time) were observed feeding on the trout pellets. When feeding activity was observed, it was brief and never lasted more than a few minutes. Those fish that were observed feeding would come up within the feeding ring, take some food, and rapidly return back down.

Feed conversion rates of pinfish cultured from initial average weights of about 78 g and 125 g to final average weights of about 220 g and 256 g were 5.022 and 5.678, respectively (Tables 15 and 16, pages 68 and 69). The food conversion of pinfish raised from average weights of about 39 g to average weights of about 72 g was

2.302 (Tables 17 and 20, pages 70 and 73). Food conversion became less efficient as fish size increased. The conversion rates of pinfish for the period from November to December 1971 were negative, i.e., the total weight of the fish at the end of the period was less than the weight at the beginning.

Length-weight relationship and condition.--The calculated length-weight relationship of pinfish cultured in cages during this study was based on 533 length-weight observations, and can be described by the formula:

$$\text{Log } W = -5.00560 + 3.26526 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 75 to 214 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y \cdot x}$) were 0.99191 and 0.00166, respectively. The sums, sums of squares, and sum of cross products used in calculating the pinfish length-weight regression equation are:

$$\sum X = 1135.53548$$

$$\sum X^2 = 2424.31291$$

$$\sum Y = 1039.83171$$

$$\sum Y^2 = 2083.87045$$

$$\sum XY = 2231.97117$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values is shown in Figure 10. Empirical length-weight data recorded for pinfish in cages 3 and 18 are plotted.

Condition values for pinfish were relatively low at the start of the experiments and ranged from 3.208 to 3.632 (Tables 15 to 22, pages 68 to 75). Thereafter, condition increased with maximum values occurring primarily in November 1971. Maximum condition values of pinfish in cages 3, 9, 15, 16, 17, 18, 26, and 30 were 4.061, 4.090, 3.843, 3.632, 3.662, 3.937, 3.665, and 3.802, respectively. Condition decreased after these maximum values were reached. Final condition values of cages 3, 9, 18, and 30 were higher, while final condition values of cages 15, 16, 17, and 26 were lower than initial values.

The results of the comparisons among the average condition values of fed (cages 15, 18, and 30) and non-fed (cages 16, 17, and 26) pinfish are presented in Tables 23 and 24. The F-test showed that initially there were no significant differences among the average condition values.

Table 24 summarizes the results of the analysis of variance and DMR test among average condition values of pinfish in cages 15, 16, 17, and 18 for 8 December 1971. After 61 days, the average condition

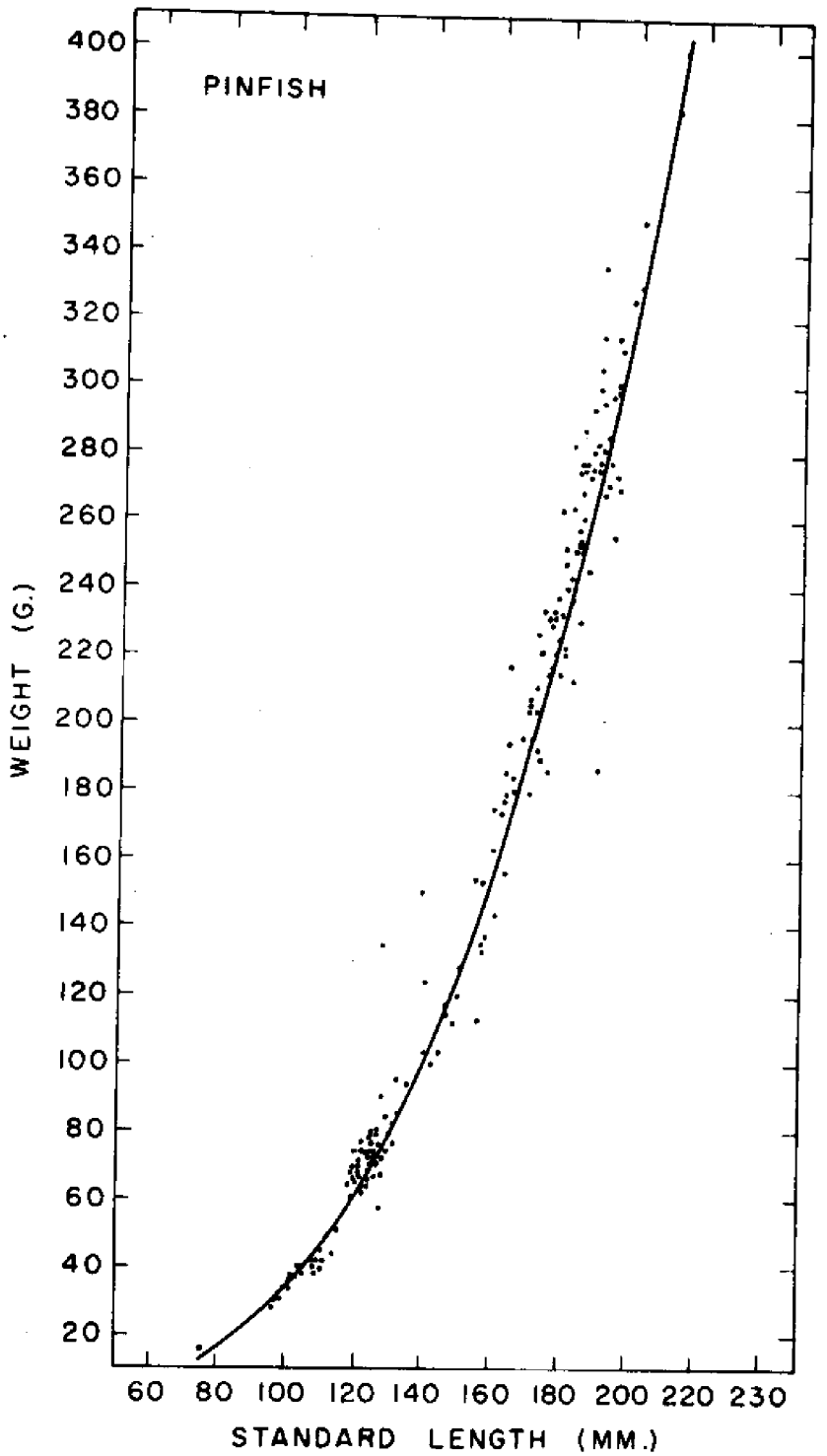

FIGURE 10.--Length-weight relationship of pinfish cultured in cages. Empirical data for pinfish in cages 3 and 18 are plotted and the line represents the calculated antilog values of the equation Log W = -5.00560 + 3.26526 Log L (N = 533).

TABLE 23.--Analysis of variance among cages on the condition coefficients of pinfish in cages 15, 16, 17, 18, 26, and 30 at the start of the fed vs. non-fed comparisons in October 1971.

Source	d.f.	SS	MS	F
Total	149	5.464		
Among Cages	5	0.299	0.059	1.685
Within Cages	144	5.164	0.035	

TABLE 24.--Analysis of variance among cages and Duncan's Multiple Range Test on the condition coefficient of fed (cages 15 and 18) and non-fed (cages 16 and 17) pinfish on 8 December 1971.

Source	d.f.	SS	MS	F
Total	98	7.210		
Among Cages	3	3.820	1.273	36.371**
Within Cages	95	3.390	0.035	
N	25	25	25	24
Cage	16	17	16	18
Mean K	3.199	3.205	3.574	3.616

**Significant at 0.01

of pinfish that received supplemental food was significantly higher than the average condition of pinfish that were not fed. After 77 days, the average condition calculated on 24 December 1971 for fed pinfish in cage 30 was significantly higher than the average condition of pinfish in cage 26 that were not fed ($t = 4.009$; d.f. = 48).

At the start of the intake-discharge comparison in December 1971, discharge pinfish in cage 15 (position 42) had a significantly higher condition value than did intake pinfish in cage 30 ($t = 3.743$; d.f. = 49). Average condition of pinfish in the intake and discharge was not significantly different on 4 February 1972 ($t = 0.612$; d.f. = 49) or on 10 March 1971 ($t = 0.885$; d.f. = 44).

Growth.--On a mean basis, pinfish in cages 3 and 9 reached a final average length and weight of about 183 mm and 238 g within 129 days from stocking (Tables 15 and 16, pages 68 and 69). The mean increase in average length and weight was about 42 mm and 136 g. This represented an average absolute growth rate in mean length and weight of about 0.3 mm/day (9.0 mm/month) and 1.0 g/day (30.0 g/month), respectively, and a mean relative growth in average weight of 134.3%. The maximum length (214 mm) and weight (390 g) was recorded for pinfish in cage 3.

Intake pinfish in cages 15 and 18, which received supplemental food, attained an average length and weight of about 126 mm and 72 g within 61 days from stocking (Tables 17 and 20, pages 70 and 73). This was an increase of 20 mm and 32 g in average length and weight, and represented an absolute growth rate in length and weight of about 0.3 mm/day (9.0 mm/month) and 0.5 g/day (15.0 g/month). The relative growth in weight averaged 81.1%. Pinfish in cages 16 and 17 that did not receive supplemental food reached an average length and weight of about 123 mm and 60 g within 61 days from stocking (Tables 18 and 19, pages 71 and 72). Average length and weight increased about 16 mm and 20 g, which represented an absolute growth rate in length and weight of about 0.3 mm/day (9.0 mm/month) and 0.3 g/day (9.0 g/month). The relative growth in mean weight averaged 48.1%.

Within 93 days from stocking in the discharge canal, pinfish in cage 15 (position 42) attained an average length and weight of about 143 mm and 94 g (Table 17, page 70). This was an increase in mean length and weight of about 17 mm and 22 g, and represented an absolute growth rate in length and weight of about 0.2 mm/day (6.0 mm/month) and 0.2 g/day (6.0 g/month). The relative growth in average weight was 30.7%. During approximately the same time period, pinfish in cage 30, located in the intake canal, reached an

average length and weight of about 127 mm and 70 g (Table 22, page 75). Average length and weight had increased only about 5 mm and 4 g, which represented an absolute growth rate in length and weight of about 0.1 mm/day (3.0 mm/month) and 0.1 g/day (3.0 g/month). The relative growth in average weight was 6.1%.

Greatest absolute and relative growth was recorded during the period from the initial stocking to the first growth sampling. During the period from 13 November to 27 November 1971, pinfish in cages 3 and 9 showed a decrease in average weight of about 19 g and 8 g, respectively (Fig. 11). With the exception of pinfish in cage 26, a reduction in average weight was recorded for all other cages of pinfish during the period from November to December 1971 (Fig. 12). Pinfish in cages not receiving supplemental food showed a greater reduction in average weight (about 5.6 g) than did pinfish that were receiving supplemental food (about 0.9 g).

Table 25 summarizes the results of the analysis of variance among average weights of intake pinfish in cages 15, 16, 17, 18, 26 and 30 at the start of the fed vs. not fed experiment. Average weights of the pinfish were not significantly different.

Table 26 summarizes the results of the analysis of variance and DMR test among average weights of intake pinfish in cages 15, 16, 17, and 18 for 8 December 1971. After 61 days from the start of the

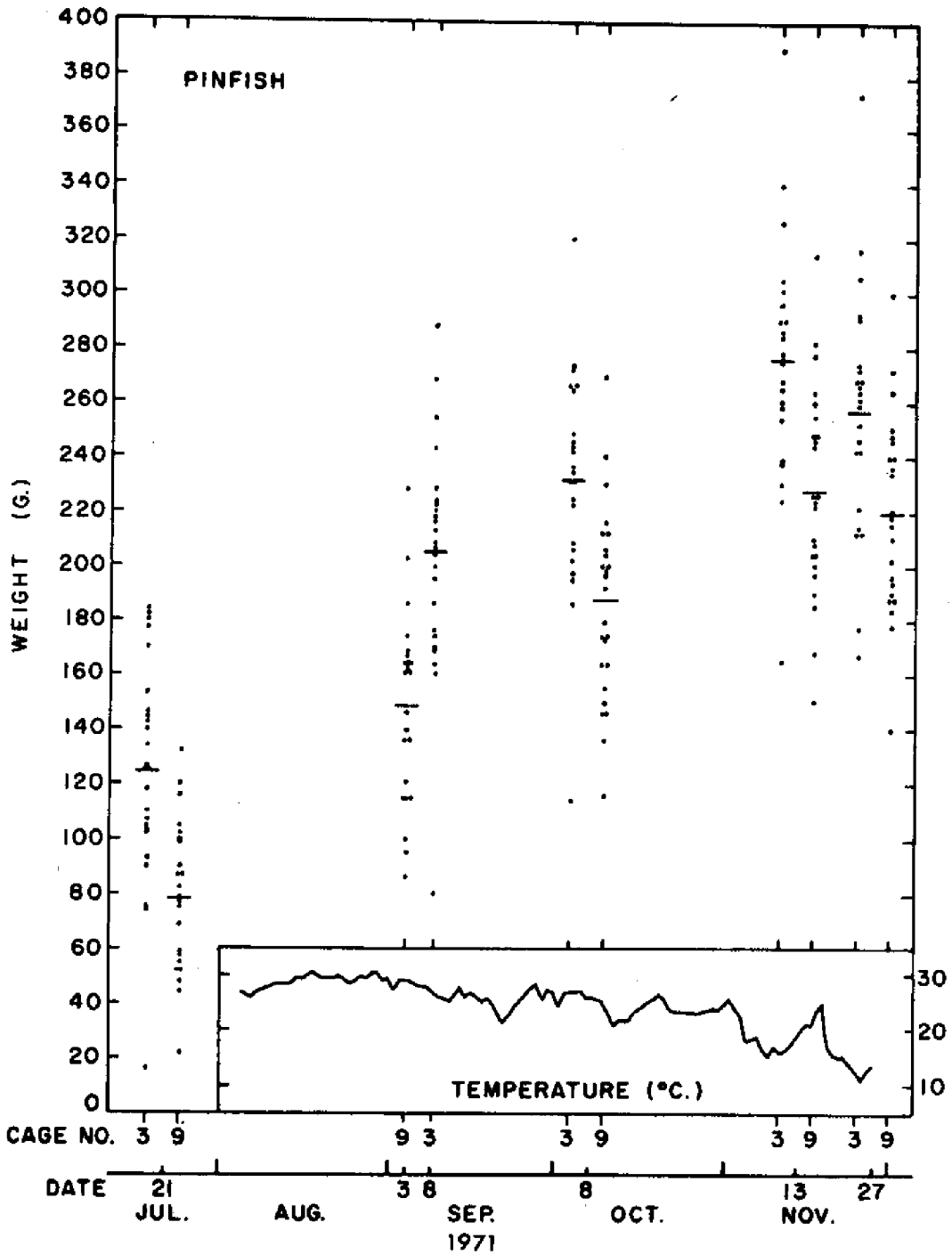

FIGURE 11.--Changes in weight of pinfish in cages 3 and 9. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

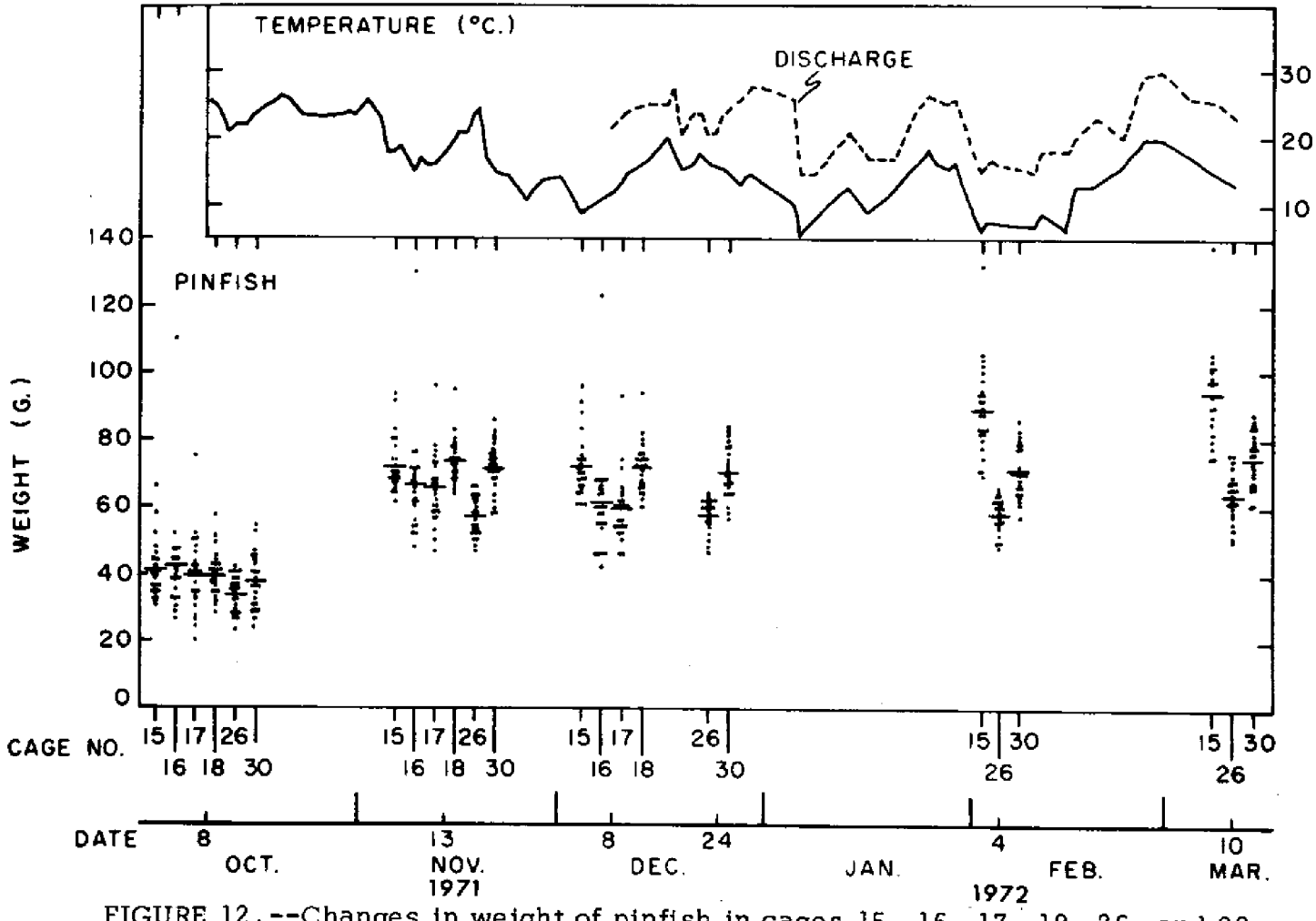

FIGURE 12.--Changes in weight of pinfish in cages 15, 16, 17, 18, 26, and 30. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 and discharge canal station 4 are represented by the solid and dashed lines, respectively.

TABLE 25.--Analysis of variance among cages on the average weight of pinfish in cages 15, 16, 17, 18, 26, and 30 at the start of the fed vs. non-fed comparisons in October 1971.

Source	d.f.	SS	MS	F
Total	149	14930.560		
Among Cages	5	1022.000	204.400	2.116
Within Cages	144	13908.560	96.583	

TABLE 26.--Analysis of variance among cages and Duncan's Multiple Range Test on the average weights of fed (cages 15 and 18) and non-fed (cages 16 and 17) pinfish on 8 December 1971.

Source	d.f.	SS	MS	F
Total	98	14584.908		
Among Cages	3	3354.055	1117.999	9.457**
Within Cages	95	11230.853	118.210	
N	25	25	24	25
Cage	17	16	18	15
Mean Weight	59.7	60.8	71.8	71.9

**Significant at 0.01

feeding tests, the average weights of fed (cages 15 and 18) pinfish were significantly higher than the average weights of non-fed (cages 16 and 17) pinfish.

After 77 days, the average weight calculated on 24 December 1971 for fed pinfish in cage 30 was significantly higher than the average weight of pinfish in cage 26 which were not fed ($t = 6.873$; d.f.= 48).

Mean weights of pinfish in cages 15 (discharge position 42) and 30 (intake) at the start of the intake-discharge comparison in December 1971 were not significantly different ($t = 0.636$; d.f.= 49).

After an approximate 90-day comparative culture period, the average weight of pinfish in the discharge canal was significantly higher than the average weight of pinfish in the intake ($t = 5.416$; d.f. = 44).

The total weight of pinfish in each cage (standing crop) at the last growth sampling ranged from 1494 g to 5895 g (Tables 15 to 22, pages 68 to 75). Pinfish in cages 3 and 9 dressed out at 68.8% and 64.3% of their live weight (average of 66.5%).

Gas-bubble disease.--On 4 February 1971, two pinfish in cage 15 (position 42) in the discharge canal were observed exhibiting external symptoms of gas-bubble disease (Fig. 13). The pinfish

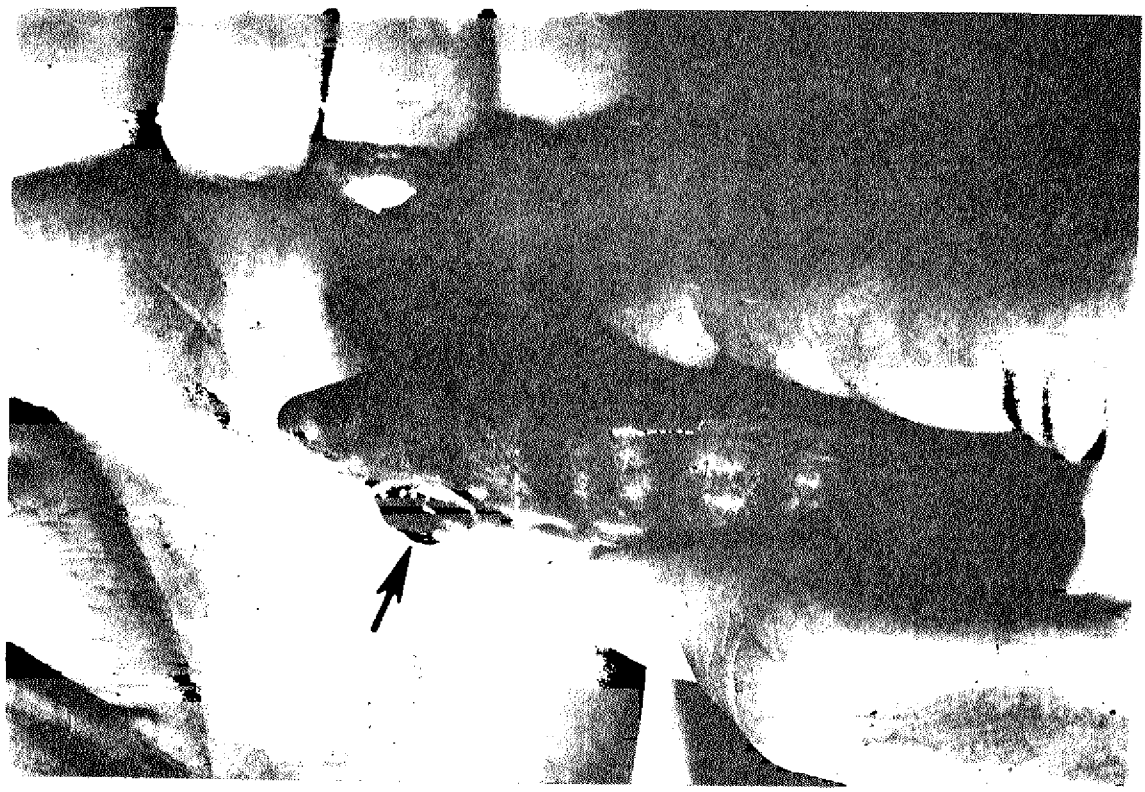

FIGURE 13.--Pinfish exhibiting the gas-bubble disease symptom of exophthalmos.

showed pronounced exophthalmos, and had large pockets of gas trapped beneath the corneal surface of the eye. After examining the fish, they were returned to the discharge cage.

On 18 February 1972, five discharge pinfish were observed exhibiting similar external symptoms as described above. In addition, one fish was experiencing hemorrhaging in the eyes, and all fish had gas bubbles in the fin integument. These fish were transported live in a styrofoam cooler to the main campus of Texas A&M University, College Station, Texas. The fish were examined by Dr. G. W. Klontz (Department of Veterinary Microbiology, Texas A&M College of Veterinary Medicine), who diagnosed the condition as gas-bubble disease. These fish were not returned to the discharge cage.

On 10 March 1972, one additional pinfish was observed exhibiting the external symptoms of gas-bubble disease described above.

Sexual development.--Pinfish in cages 3 and 9, examined on 27 November 1971, had gonads that appeared to be in the resting to active phase (Vladykov, 1956). The ovaries were elongated, and of a bright orange-yellow color. Blood vessels were clearly visible on the ovary surface. The testes were narrow and elongated and of a creamy-white color.

Florida Pompano (*Trachinotus carolinus*)

Summaries of the production data recorded for pompano cultured in cages 12, 13, 17, 20, 21, 22, 23, and 24 are presented in Tables 27 to 34, respectively.

Survival.--The survival of pompano cultured for 129 days in cage 12 was 68.0%. The survival of pompano cultured for 107 days in cages 13, 22, and 23 averaged 77.3% and ranged from a low of 64.0% (cage 13) to a high of 88.0% (cage 22). The mean survival of pompano cultured 85 days in cages 20, 21, and 24 was 86.9% and ranged from 80.0% (cage 21) to 92.8% (cage 20). The survival of pompano cultured for 78 days in cage 17 was only 50.0%. With the exception of pompano in cage 23, excellent survival was recorded for pompano after 7 October 1971. Poorest survival of pompano was observed in cages 12, 13, and 17. No mortality known to be caused by handling during growth sampling procedures was observed.

Overall survival of pompano in the discharge canal was extremely poor. A mortality of pompano in the discharge was discovered on 12 November 1971, 7 days after their transfer from the intake canal. A complete mortality of pompano in cages 21 and 24 occurred. Only 11.1% survived in cage 13 (2 out of 18 fish) and 69.2 survived in cage 20 (9 out of 13 fish). On 16 November 1971

TABLE 27.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 12 from 21 July to 27 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		106.0	40.6	1015					3.297	78-137
9-3	44	18	72.0	137.0 (31.0)	88.3 (47.7)	1590	1.982	0.7	1.1	117.5	3.473	78-158
10-7	34	16**	88.8	140.8 (3.8)	102.6 (14.3)	1642	41.538	0.1	0.4	16.1	3.560	122-172
10-22	15	18	100.0	151.6 (10.8)	115.7 (13.1)	2084	5.529	0.7	0.9	12.8	3.186	128-188
11-5	14	18	100.0	153.5 (1.9)	119.5 (3.8)	2151	13.970	0.1	0.2	3.2	3.118	128-195
11-27	22	17	94.4	152.2 (-1.3)	117.1 (-2.4)	1991	-10.800	-0.1	-0.1	-1.9	3.177	129-193
Overall	129		68.0	(46.2)	(76.5)		7.266	0.4	0.6	188.4		

*Increment in parenthesis
**Added two fish

TABLE 28.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 13 from 21 July to 5 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		105.8	41.9	1049					3.457	84-139
9-3	44	16	64.0	134.5 (28.7)	83.4 (41.5)	1335	4.118	0.6	0.9	98.8	3.352	110-153
10-7	34	16**	100.0	138.3 (3.8)	97.0 (13.6)	1553	8.298	0.1	0.4	16.3	3.569	116-171
10-22	15	18	100.0	150.0 (11.7)	115.5 (18.5)	2080	6.032	0.8	1.2	19.0	3.258	125-184
11-5	14	18	100.0	153.2 (3.2)	118.6 (3.1)	2135	17.018	0.2	0.2	2.6	3.066	125-193
Overall	107		64.0	(47.4)	(76.7)		4.651	0.4	0.7	182.6		

*Increment in parenthesis
**Added two fish (not included in overall survival)

TABLE 29.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 17 from 21 July to 7 October 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		8		101.2	40.2	322					3.870	87-113
9-3	44	4	50.0	141.7 (40.5)	99.5 (59.3)	398	5.000	0.9	1.4	147.2	3.453	129-152
10-7	34	4	100.0	157.2 (15.5)	142.0 (42.5)	568	3.176	0.5	1.2	42.7	3.616	146-167
Overall	78		50.0	(56.0)	(101.8)		3.739	0.7	1.3	252.7		

*Increment in parenthesis

TABLE 30.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 20 from 12 August to 5 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
8-12		14		137.0	85.3	1194					3.262	120-154
9-15	34	14	100.0	157.5 (20.5)	143.2 (57.9)	2005	1.879	0.6	1.7	67.9	3.635	140-172
10-7	22	13	92.8	169.9 (12.4)	178.7 (35.5)	2324	5.956	0.6	1.6	24.8	3.602	152-185
10-22	15	13	100.0	180.4 (10.5)	197.3 (18.6)	2565	5.775	0.7	1.2	10.3	3.315	163-194
11-5	14	13	100.0	184.5 (4.1)	208.8 (11.5)	2715	7.680	0.3	0.8	5.8	3.271	165-200
Overall	85		92.8	(47.5)	(123.5)		3.923	0.6	1.4	144.8		

*Increment in parenthesis

TABLE 31.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 21 from 12 August to 5 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
8-12		25		130.4	74.9	1822					3.216	108-155
9-15	34	21	84.0	149.5 (19.1)	123.4 (48.5)	2592	3.096	0.6	1.4	64.8	3.648	125-167
10-7	22	20	95.2	163.7 (14.2)	157.8 (34.4)	3156	4.379	0.6	1.6	27.8	3.562	138-179
10-22	15	20	100.0	173.9 (10.2)	182.9 (25.1)	3658	3.776	0.7	1.7	15.9	3.437	148-192
11-5	14	20	100.0	180.3 (6.4)	198.9 (16.0)	3979	5.130	0.4	1.1	8.7	3.356	155-199
Overall	85		80.0	(49.9)	(124.0)		3.892	0.6	1.5	165.6		

*Increment in parenthesis

TABLE 32.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 22 from 12 August to 27 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
8-12		25		128.1	75.4	1885					3.551	108-157
9-15	34	24	96.0	148.3 (20.2)	119.6 (44.2)	2872	2.424	0.6	1.3	58.7	3.637	137-170
10-7	22	22	91.6	162.9 (14.6)	155.5 (35.9)	3423	4.965	0.7	1.6	30.0	3.585	148-183
10-22	15	22	100.0	172.5 (9.6)	174.0 (18.5)	3828	5.066	0.6	1.2	11.8	3.364	158-195
11-5	14	22	100.0	177.1 (4.6)	190.5 (16.5)	4193	4.709	0.3	1.2	9.5	3.408	162-202
11-27	22	22	100.0	178.3 (1.2)	192.8 (2.3)	4242	68.571	0.1	0.1	1.1	3.379	163-202
Overall	107		88.0	(50.2)	(117.4)		5.201	0.5	1.1	155.7		

*Increment in parenthesis

TABLE 33.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 23 from 12 August to 27 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
8-12		25		125.1	65.0	1627					3.279	102-142
9-15	34	23	92.0	143.3 (18.2)	109.9 (44.0)	2509	2.336	0.5	1.3	67.6	3.681	122-157
10-7	22	22	95.6	159.3 (16.0)	142.5 (33.5)	3137	3.781	0.7	1.5	30.7	3.506	141-173
10-22	15	22	100.0	168.6 (9.3)	157.9 (15.4)	3474	5.590	0.6	1.0	10.7	3.275	152-183
11-5	14	22	100.0	172.7 (4.1)	168.0 (10.1)	3696	7.054	0.3	0.7	6.3	3.227	152-187
11-27	22	20	90.9	174.1 (1.4)	173.1 (5.1)	3462	-12.649	0.1	0.2	3.0	3.248	154-189
Overall	107		80.0	(49.0)	(108.1)		5.910	0.5	1.1	165.9		

*Increment in parenthesis

TABLE 34.--Summary of production data (standard length in millimeters and weight in grams) for pompano in cage 24 from 12 August to 5 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment	Average weight and increment	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
8-12		25		118.3	57.5	1438					3.362	101-154
9-15	34	23	92.0	139.5 (21.2)	102.0 (44.5)	2348	2.007	0.6	1.3	77.4	3.687	120-175
10-7	22	22	95.6	157.0 (17.5)	140.1 (38.1)	3084	3.020	0.8	1.7	37.3	3.570	140-197
10-22	15	22	100.0	165.8 (8.8)	151.1 (11.0)	3326	7.636	0.6	0.7	7.8	3.264	150-207
11-5	14	22	100.0	170.0 (4.2)	166.1 (15.0)	3655	4.541	0.3	1.1	9.8	3.319	155-212
Overall	85		88.0	(51.7)	(108.6)		3.334	0.6	1.3	188.8		

*Increment in parenthesis

further mortality was discovered. No pompano were found in cage 13, and only two pompano were found alive in cage 20. Pompano in cage 20 were last observed alive on 1 February 1972. No pompano were found in cage 20 on 7 February 1972. Dead pompano showed features of pronounced exophthalmos ("pop-eye"), and were in advanced stages of decomposition.

Feeding and food conversion.--Pompano adapted quickly to feeding in the cages. They accepted and readily consumed the trout pellets on the first day that it was offered. Feeding activity began almost immediately after the food was placed within the feeding ring. During feeding, the fish would swim up within the feeding ring and congregate at the surface. The pompano usually remained at the surface, eating continuously, until all the food was consumed. Feeding activity was quite vigorous at the onset, and then decreased slightly. Total consumption of the food generally occurred within 15 minutes.

Some, if not all, of the pompano responded consistently to the cage tapping stimulus. A response occurred regardless of whether food was present within the feeding ring. Handling during growth sampling did not affect the subsequent feeding of pompano. The fish would resume feeding immediately after recovery from the anesthetic.

Smaller pompano were often seen swimming along the inside perimeter of a cage, while the majority of the fish in the cage were actively feeding.

Feeding activity of pompano decreased when water temperatures dropped to about 21 to 22 C. The fish would still respond to the cage-tapping stimulus, but the feeding activity lasted only a few minutes and the feed was not totally consumed. By repeatedly tapping a cage, further feeding activity of the fish resulted and a slight increase in the consumption of the food was achieved.

Feeding activity of pompano in the discharge canal varied. No feeding activity of pompano in cage 13 was observed. Pompano in cage 20 fed poorly, and pompano in cages 21 and 24 fed well. After the mortality of pompano in the discharge, no feeding activity of the remaining fish was observed.

Food conversion rates for pompano cultured from initial average weights of about 75 g to final average weights of about 195 g averaged 4.353 and ranged from 3.892 to 5.201. An average conversion of 5.958 was calculated for pompano cultured from initial average weights of about 41 g to final average weights of about 117 g. The mean food conversion for pompano cultured from an average initial weight of about 70 g to an average final weight of about 170 g was 4.622. The highest (7.266) and lowest (3.334) food conversion rates

were calculated for pompano in cages 12 and 24, respectively. Food conversion became less efficient as fish size increased. The conversion rates of pompano in cages 12 and 23 for the period from 5 November to 27 November 1971 were negative, i.e., the total weight of the fish at the end of the period was less than the weight at the beginning due to mortality.

Length-weight relationship and condition.--The calculated length-weight relationship of pompano cultured in cages during this study was based on 783 length-weight observations, and can be described by the formula:

$$\text{Log } W = -4.30555 + 2.92500 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 78-212 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were 0.98650 and 0.00134, respectively. The sums, sums of squares, and sum of cross products used in calculating the pompano length-weight regression equation are:

$$\Sigma X = 1701.46603$$

$$\Sigma X^2 = 3701.74024$$

$$\Sigma Y = 1605.54615$$

$$\Sigma Y^2 = 3331.20925$$

$$\sum XY = 3501.85111$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values is shown in Figure 14. Empirical length-weight data recorded for pompano in cages 13 and 21 are plotted.

With the exception of pompano in cage 17, average condition values of pompano were relatively low when the cages were first stocked and ranged from 3.216 to 3.551 (Tables 27 to 34, pages 91 to 98). Thereafter, average condition increased, with maximum values calculated on 7 October 1971 for pompano in cages 12 and 13, and on 15 September 1971 for pompano in cages 20 to 24. Maximum condition values ranged from 3.560 (cage 12) to 3.870 (cage 17). Condition decreased after maximum values were attained. Final mean condition values were generally lower than initial condition values.

Table 35 summarizes the results of the analysis of variance and DMR test among average condition values of pompano in cages 12, 13, 20, 21, 22, 23, and 24 on 5 November 1971.

Average condition values of pompano in cages 20 to 24 were similar and were significantly higher than the average condition of pompano in cage 13. The average condition of pompano in cages 12 and 13 was similar. Condition of pompano in cages 12, 20, and 23

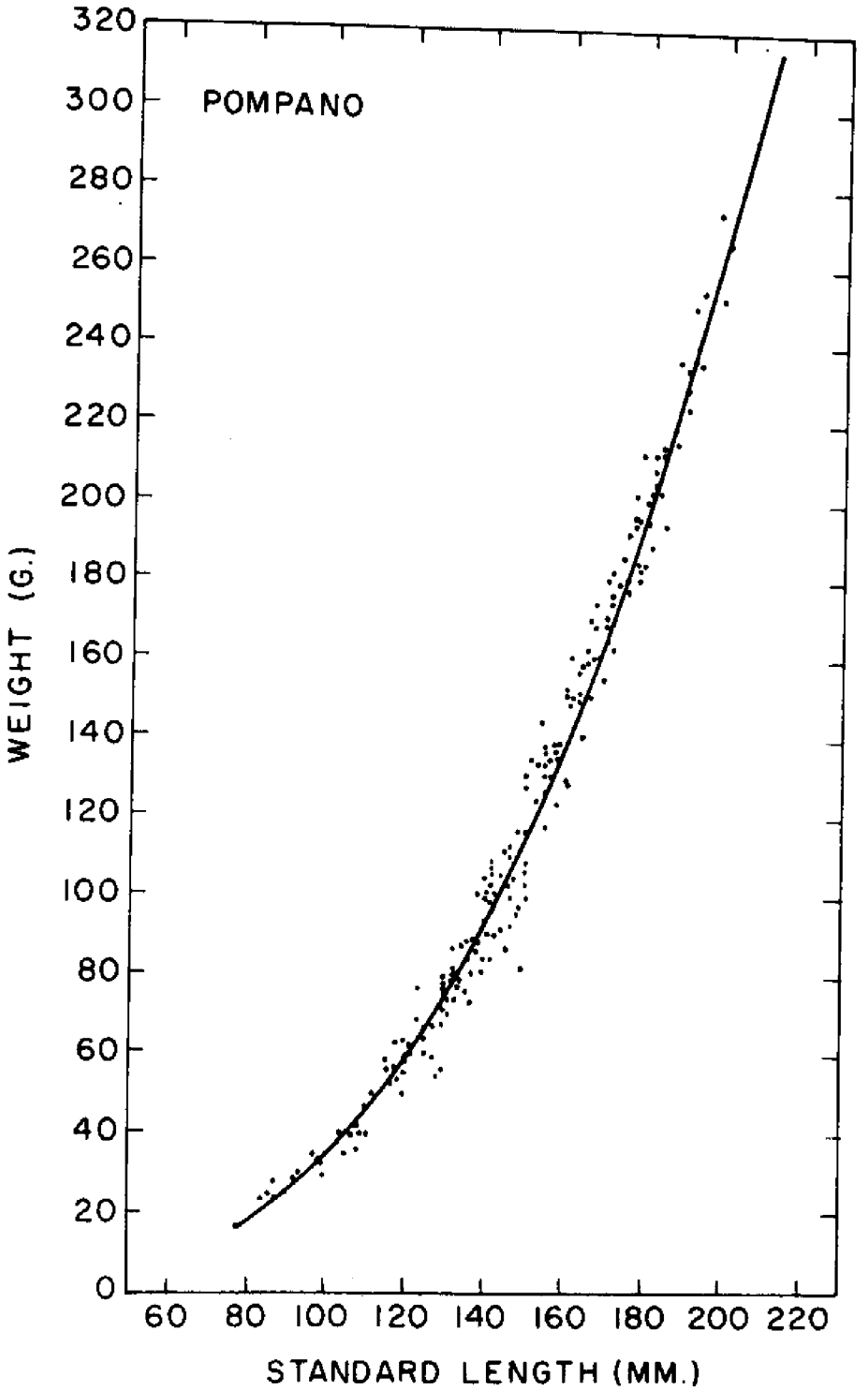

FIGURE 14.--Length-weight relationship of pompano cultured in cages. Empirical data for pompano in cages 13 and 21 are plotted and the line represents the calculated antilog values of the equation Log W = -4.30555 + 2.92500 Log L (N = 783).

TABLE 35.--Analysis of variance among cages and Duncan's Multiple Range Test on the condition coefficients of pompano in cages 12, 13, 20, 21, 22, 23, and 24 on 5 November 1971.

Source		d.f.	SS		MS		F
Total		134	5.115				
Among Cages		6	1.804		0.301		11.576**
Within Cages		128	3.311		0.026		
N	18	18	22	13	22	20	20
Cage	13	12	23	20	24	21	22
Mean K	3.066	3.118	3.248	3.271	3.319	3.356	3.379

**Significant at 0.01

was also similar. Average condition of pompano in cages 21, 22, and 24 was significantly higher than the average condition of pompano in cage 12.

Table 36 presents the results of the analysis of variance among final average condition values of pompano in cages 12, 22, and 23. Final mean condition values of pompano in cages 12, 22, and 23 were not significantly different.

TABLE 36.--Analysis of variance among cages on the final condition coefficients of pompano in cages 12, 22, and 23.

Source	d.f.	SS	MS	F
Total	58	12.442		
Among Cages	2	0.418	0.209	0.976
Within Cages	56	12.024	0.214	

Growth.--Pompano in cages 12 and 13 grew at a slower rate than did pompano in the other cages (Tables 27 and 28, pages 91 and 92). Pompano in cages 12 and 13 attained an average final length and weight of about 152 mm and 117 g within 129 and 107 days, respectively. The increase in mean length and weight was about 46 mm and 76 g. This represented an absolute growth rate in length and weight of 0.4 mm/day (12.0 mm/month) and 0.6 g/day (18.0 g/month) for pompano in cage 12, and 0.4 mm/day (12.0 mm/month) and 0.7 g/day (21.0 g/day) for pompano in cage 13. The relative growth in mean weight averaged 185.5%.

On an overall mean basis, pompano in cages 20, 21, and 24 attained an average length and weight of about 178 mm and 191 g within 85 days from stocking (Tables 30, 31, and 34, pages 94, 95, and 98). The mean increase in average length and weight was about

50 mm and 118 g. This represented an absolute growth rate in length and weight of about 0.6 mm/day (18.0 mm/month) and 1.4 g/day (42.0 g/month). The relative growth in mean weight averaged 166.4% and ranged from 144.8% (cage 20) to 188.8% (cage 24). Pompano in cages 22 and 23 were cultured for 107 days and reached an average length and weight of about 176 mm and 182 g (Tables 32 and 33, pages 96 and 97). Average length and weight increased about 50 mm and 113 g, for an average absolute growth rate in length and weight of 0.5 mm/day (15.0 mm/month) and 1.1 g/day (33.0 g/month). The relative growth in mean weight averaged 160.8%. Pompano in cage 17 were cultured for 78 days and attained an average length and weight of about 157 mm and 142 g (Table 29, page 93). The absolute growth rate in length and weight was 0.7 mm/day (21.0 mm/month) and 1.3 g/day (39.0 g/month). The relative growth in mean weight was 252.7%. The largest pompano recorded was 212 mm and 306 g (cage 24).

Greatest relative growth in weight was recorded for pompano early in the study. Thereafter, relative growth decreased. With the exception of pompano in cage 12, growth in mean weight occurred throughout the study (Figs. 15 and 16). However, only slight increases in average weight occurred after 5 November 1971 (Fig. 16). Pompano in cage 12 showed a decrease in average length and weight

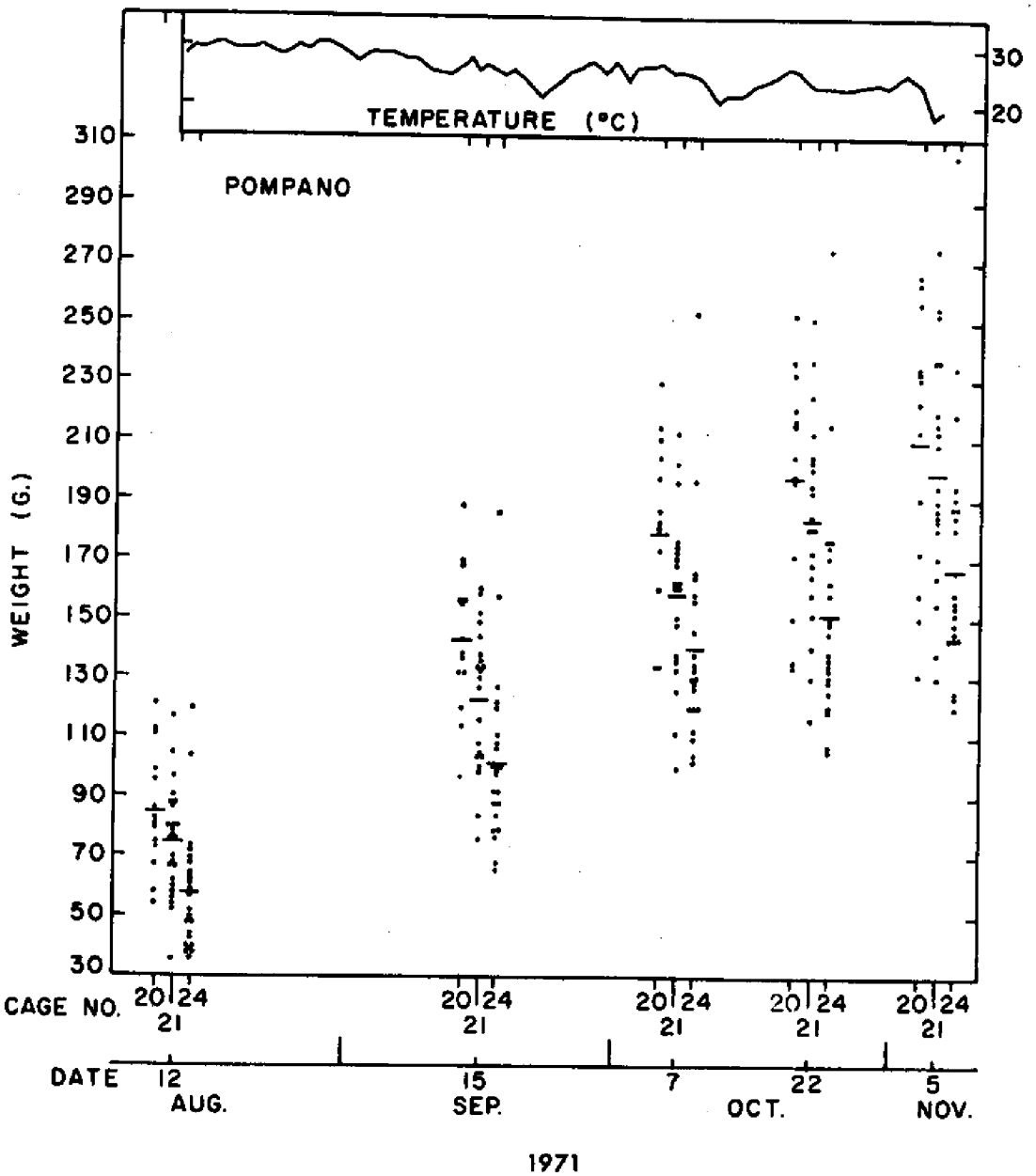

FIGURE 15.--Changes in weight of pompano in cages 20, 21, and 24. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

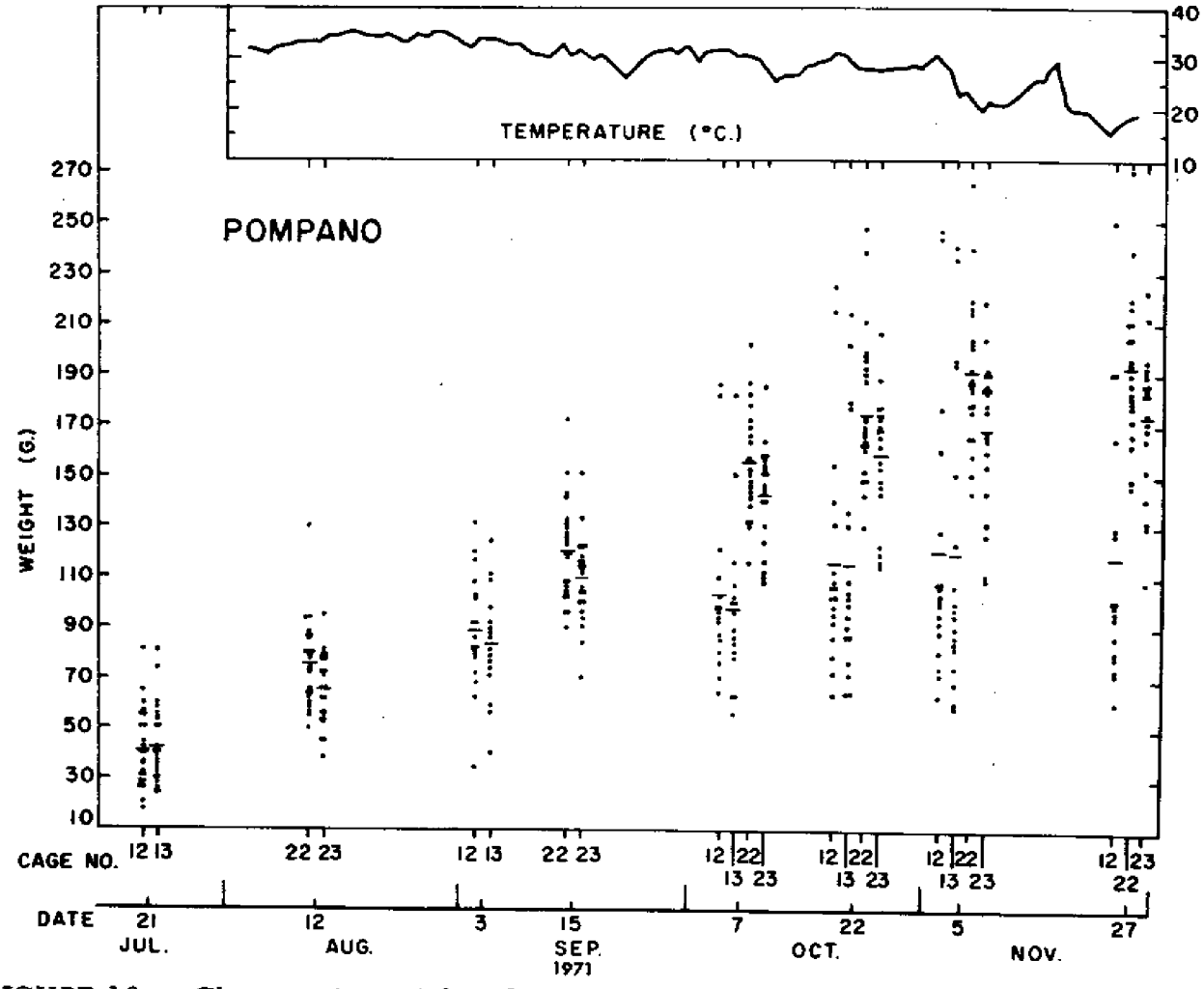

FIGURE 16.--Changes in weight of pompano in cages 12, 13, 22, and 23. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

of about 1 mm and 2 g during the period from 5 November to 27 November 1971.

Table 37 summarizes the results of the analysis of variance and DMR test among average weights of pompano in cages 12, 13, and 20 to 24 on 5 November 1971.

TABLE 37.--Analysis of variance among cages and Duncan's Multiple Range Test on the average weights of pompano in cages 12, 13, 20, 21, 22, 23, and 24 on 5 November 1971.

Source		d.f.	SS		MS		F
Total		134	371065.733				
Among Cages		6	138218.404		23034.999		12.663**
Within Cages		128	232847.329		1819.062		
N	18	18	22	22	22	20	13
Cage	13	12	24	23	22	21	20
Mean Weight	118.6	119.5	166.1	168.0	190.5	198.9	208.8

**Significant at 0.01

The average weights of pompano in cages 12 and 13 were similar but were significantly lower than the average weights of pompano in cages 20 to 24.

Table 38 presents the results of the analysis of variance and DMR test among final average weights of pompano in cages 12, 22, and 23 on 27 November 1971. The average weights of pompano in cages 22 and 23 were similar and significantly higher than the average weight of pompano in cage 12.

TABLE 38.--Analysis of variance among cages and Duncan's Multiple Range Test on final average weights of pompano in cages 12, 22, and 23.

Source	d.f.	SS	MS	F
Total	58	133828.880		
Among Cages	2	57206.043	28643.021	20.955**
Within Cages	56	76542.837	1366.821	

N	17	20	22
Cage	12	23	22
Mean Weight	117.1	173.1	192.8

**Significant at 0.01

The total weight of pompano in each cage (standing crop) at the last growth measurement ranged from 568 g (cage 17) to 4242 g (cage 22). Pompano in cages 12, 22, and 23 dressed out at 58.1%, 65.0%, and 64.2%, respectively, of their live weight (average of 62.4%).

White Mullet (*Mugil curema*)

Summaries of the production data recorded for white mullet cultured in cages 25 and 27 are presented in Tables 39 and 40, respectively.

Survival.--Survival of white mullet in cages was excellent. The survival of white mullet cultured for 60 days in cages 25 and 27 was 100%.

Feeding and food conversion.--White mullet did not adapt to feeding in cages. Surface feeding activity was never observed.

Only white mullet in cage 25 received supplemental food. The food conversion rate for the period from 9 October to 17 November 1971 was 2.840. The food conversion rate for the period from 17 November to 8 December 1971 was negative, i.e., the total weight of the fish at the end of the period was less than the weight at the beginning. The overall food conversion for white mullet cultured from an initial average weight of about 21 g to a final average weight of about 26 g was 5.819.

Length-weight relationship and condition.--The calculated length-weight relationship of white mullet cultured in cages during this study was based on 100 length-weight observations, and can be

TABLE 39.--Summary of production data (standard length in millimeters and weight in grams) for white mullet in cage 25 from 9 October to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-9		25		94.6	21.1	527					2.247	74-147
11-17	39	25	100.0	101.7 (7.1)	27.8 (6.7)	696	2.840	0.2	0.2	32.0	2.373	77-168
12-8	21	25	100.0	101.2 (-0.5)	26.4 (-1.4)	660	-8.166	0.0	-0.1	-5.1	2.262	78-168
Overall	60		100.0	(6.6)	(5.3)		5.819	0.1	0.1	25.2		

*Increment in parenthesis

TABLE 40.--Summary of production data (standard length in millimeters and weight in grams) for white mullet in cage 27 from 9 October to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
10-9		25		89.3	16.2	405					2.174	77-131
11-17	39	25	100.0	96.1 (6.8)	21.0 (4.8)	525	**	0.2	0.1	29.6	2.232	82-148
12-8	21	25	100.0	96.0 (-0.1)	19.4 (-1.6)	487	**	-0.0	-0.1	-7.2	2.028	80-149
Overall	60		100.0	(6.7)	(3.2)		**	0.1	0.1	20.2		

*Increment in parenthesis
**Fish were not fed

described by the formula:

$$\text{Log } W = -4.43623 + 2.89376 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 74 to 168 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y \cdot x}$) were 0.99618 and 0.00035, respectively. The sums, sums of squares, and sum of cross products used in calculating the white mullet length-weight regression equation are:

$$\Sigma X = 197.85480$$

$$\Sigma X^2 = 392.01369$$

$$\Sigma Y = 128.92058$$

$$\Sigma Y^2 = 170.83326$$

$$\Sigma XY = 256.66270$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values is shown in Figure 17. Empirical length-weight data recorded for white mullet in cage 25 are plotted.

Average condition was lowest for white mullet in cage 25 at the initial stocking, and lowest for white mullet in cage 27 at the termination of the culture period (Tables 39 and 40, pages 112 and 113). Maximum average condition values were calculated for white mullet in both cages on 17 November 1971. The final mean condition value

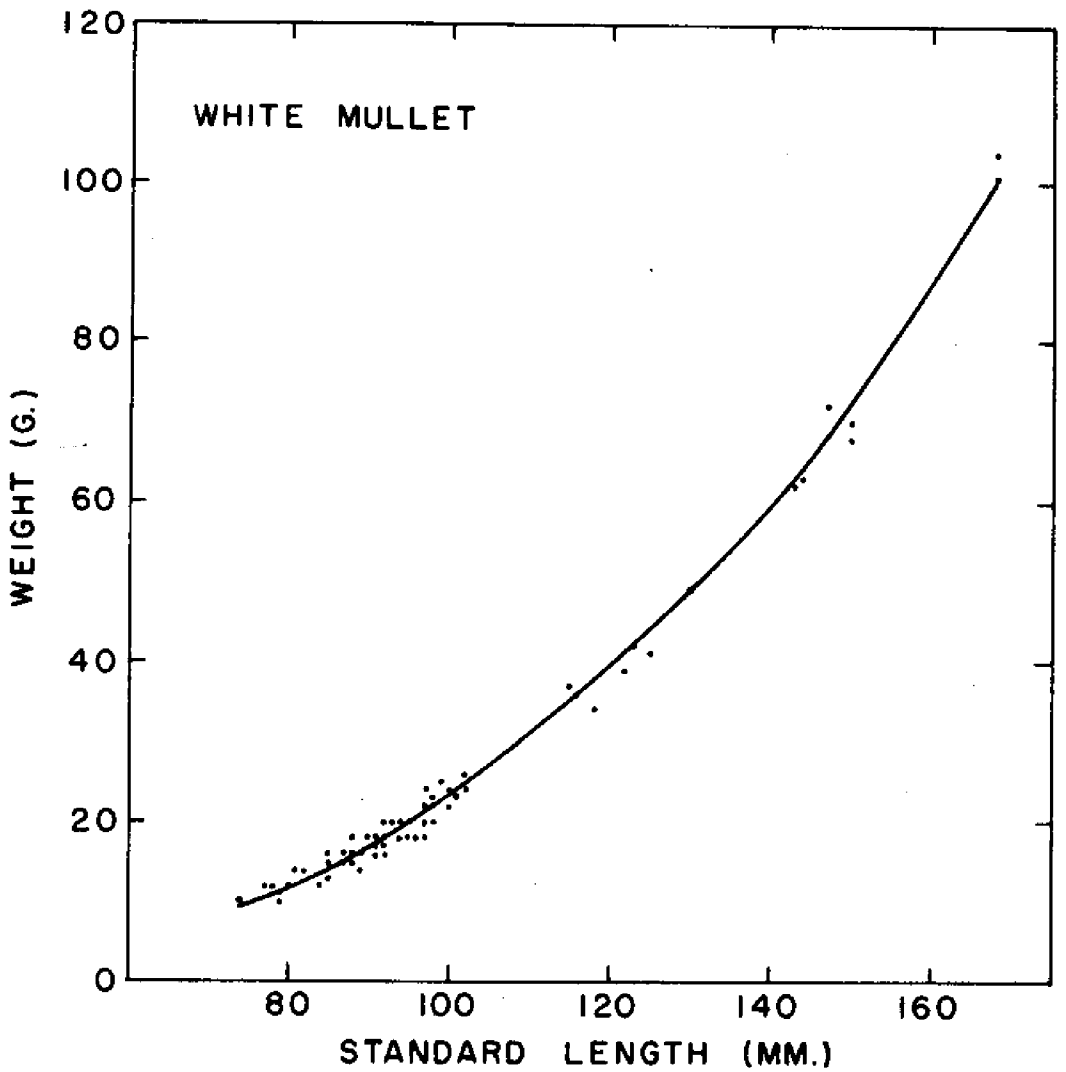

FIGURE 17. Length-weight relationship of white mullet cultured in cages. Empirical data for white mullet in cage 25 are plotted and the line represents the calculated antilog values of the equation Log W = -4.43623 + 2.89376 Log L (N = 100).

of white mullet in cage 25 was slightly higher than the initial mean condition value, whereas the final mean condition value of white mullet in cage 27 was lower than the initial mean condition value.

The initial mean condition values of white mullet in cages 25 and 27 were not significantly different ($t = 1.486$; d.f. = 49). After a 60-day culture period, the average condition of white mullet in cage 25 that received supplemental food was significantly higher than the average condition of white mullet in cage 27 that were not fed ($t = 5.401$; d.f. = 49).

Growth.--Growth of white mullet in cages was poor (Fig. 18, Tables 39 and 40, pages 112 and 113). White mullet in cage 25 reached a final length and weight of about 101 mm and 26 g within 60 days from stocking. The increase in mean length and weight was about 7 mm and 5 g. This represented an absolute growth rate in length and weight of 0.1 mm/day (3.0 mm/month) and 0.1 g/day (3.0 g/month). The relative growth in weight was 25.2%. Within 60 days from stocking, white mullet in cage 27 attained an average length and weight of about 96 mm and 19 g. This was an increase in average length and weight of about 7 mm and 3 g, and represented an absolute growth rate in length and weight of 0.1 mm/day (3.0 mm/month) and 0.1 g/day (3.0 g/month). The relative growth in weight

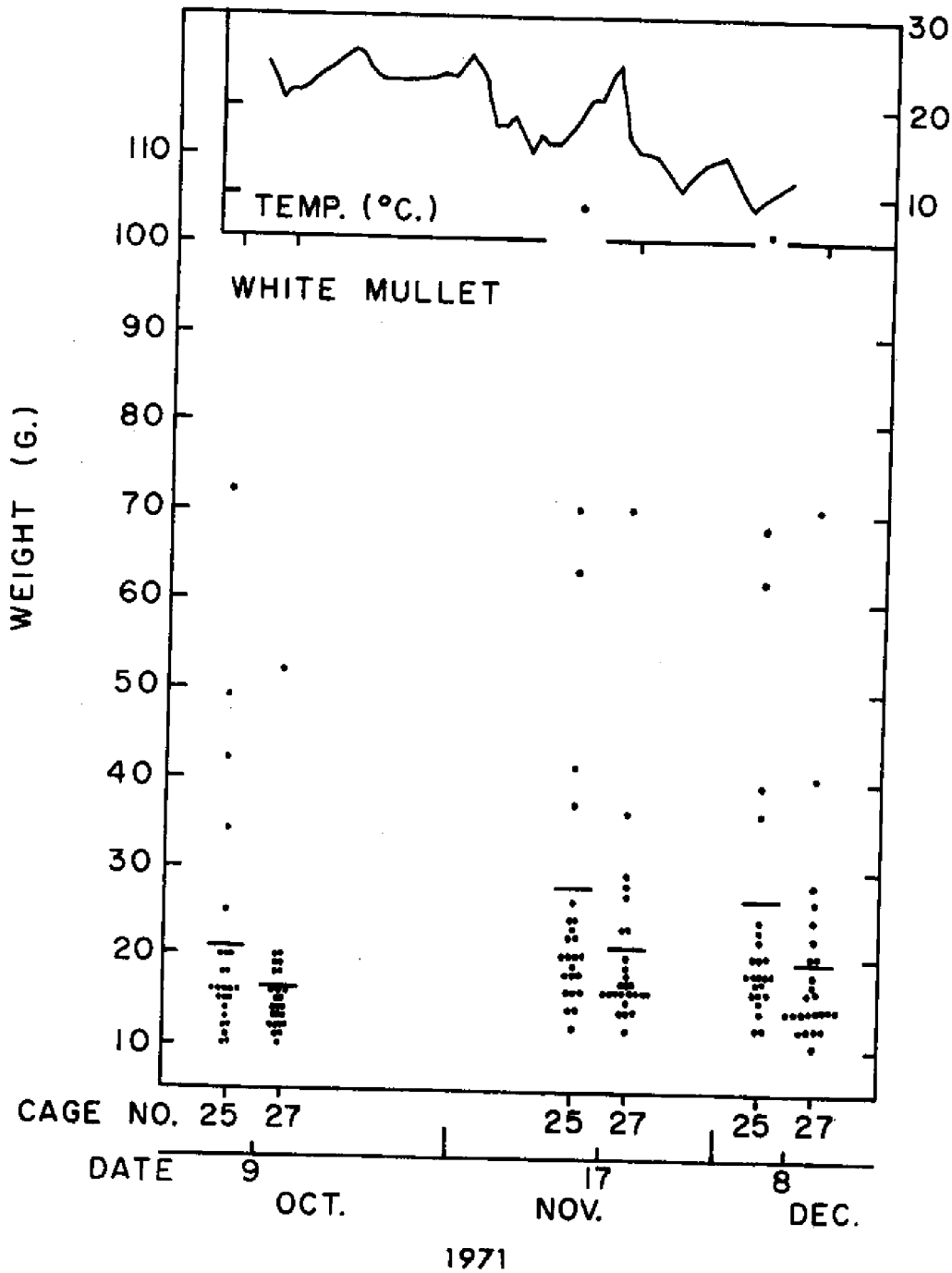

FIGURE 18.--Changes in weight of white mullet in cages 25 and 27. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

was 20.2%. The maximum length (168 mm) and weight (104 g) was recorded for white mullet in cage 25.

Greatest absolute and relative growth was recorded for the period from the initial stocking to 17 November 1971. A slight decrease in average length and weight was recorded for white mullet in both cages during the period from 17 November to 8 December 1971.

Initially, average weights of white mullet in cages 25 and 27 were similar ($t = 1.466$; d.f. = 49). After 60 days, the average weight of white mullet in cage 25 that received supplemental food was not significantly different from the average weight of white mullet in cage 27 that were not fed ($t = 1.421$; d.f. = 49).

Total weight of white mullet in cages 25 and 27 at the last growth sampling was 660 g and 487 g, respectively.

Pigfish (*Orthopristis chrysoptera*)

Summaries of the production data recorded for pigfish cultured in cages 8 and 10 are presented in Tables 41 and 42, respectively.

Survival.--Survival of pigfish in cages was poor (Tables 41 and 42, pages 119 and 120). The overall survival of pigfish cultured for 140 days in cages 8 and 10 was 68.0% and 36.4%, respectively. No

TABLE 41.--Summary of production data (standard length in millimeters and weight in grams) for pigfish in cage 8 from 21 July to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		164.1	109.0	2726					2.431	143-193
9-8	49	21	84.0	171.4 (7.3)	157.0 (48.0)	3299	5.867	0.2	1.0	44.0	2.924	151-195
10-6	28	18	85.7	179.2 (7.8)	177.9 (20.9)	3203	-37.812	0.3	0.7	13.2	3.721	155-201
11-17	42	17	94.4	190.5 (11.3)	219.6 (41.7)	3734	5.966	0.3	1.0	23.4	3.149	168-209
12-8	21	17	100.0	191.7 (1.2)	224.4 (4.8)	3815	19.358	0.1	0.2	2.1	3.160	169-211
Overall	140		68.0	(27.6)	(115.4)		10.769	0.2	0.8	105.8		

*Increment in parenthesis

TABLE 42.--Summary of production data (standard length in millimeters and weight in grams) for pigfish in cage 10 from 21 July to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		11		147.6	90.7	998					2.557	85-187
9-8	49	9	81.8	161.4 (13.8)	150.5 (59.8)	1355	3.445	0.3	1.2	65.9	3.356	118-192
10-6	28	5	55.5	183.8 (22.4)	202.2 (51.7)	1011	-4.348	0.8	1.8	34.3	3.089	132-202
11-17	42	4	80.0	201.5 (17.7)	253.0 (50.8)	1012	990.000	0.4	1.2	25.1	3.088	199-206
12-8	21	4	100.0	202.7 (1.2)	261.0 (8.0)	1044	13.125	0.1	0.4	3.1	3.126	201-207
Overall	140		36.4	(55.1)	(170.3)		89.043	0.4	1.2	187.6		

*Increment in parenthesis

mortality was recorded after 6 October 1971 for pigfish in cage 8 and after 17 November 1971 for pigfish in cage 10.

Feeding and food conversion.--Pigfish did not adapt to surface feeding in cages. Only pigfish in cage 8 were observed feeding on the trout pellets (six times). Observed feeding activity was poor and never lasted more than a few minutes. Those fish that were observed feeding would come up within the feeding ring, take some food, and return back down.

The food conversion of pigfish cultured from an initial average weight of about 109 g to a final weight of about 224 g was 10.769 (Table 41, page 119). The food conversion for pigfish raised from an initial average weight of 91 g to a final average weight of 261 g was 89.043 (Table 42, page 120). Food conversion rates for pigfish for the period from 8 September to 6 October 1971 were negative, i.e., the total weight of fish at the end of the period was less than at the beginning, due to mortality. Food conversion became less efficient as fish size increased.

Length-weight relationship and condition.--The calculated length-weight relationship of pigfish cultured in cages during this study was based on 131 length-weight observations, and can be described by the formula:

$$\text{Log } W = -4.60993 + 3.03383 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 85 mm to 211 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were 0.95993 and 0.00356, respectively. The sums, sums of squares, and sum of cross products used in calculating the pigfish length-weight regression equation are:

$$\sum X = 293.51963$$

$$\sum X^2 = 658.24926$$

$$\sum Y = 286.59158$$

$$\sum Y^2 = 632.84465$$

$$\sum XY = 643.91981$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values is shown in Figure 19. Empirical length-weight data recorded for pigfish in cages 8 and 10 are plotted.

Average condition values were lowest at the start of the experiments (Tables 41 and 42, pages 119 and 120). Maximum condition values for pigfish in cage 8 (3.721) and cage 10 (3.356) were calculated on 6 October 1971 and 8 September 1971, respectively. Thereafter, condition was relatively high. Final condition values were higher than initial values.

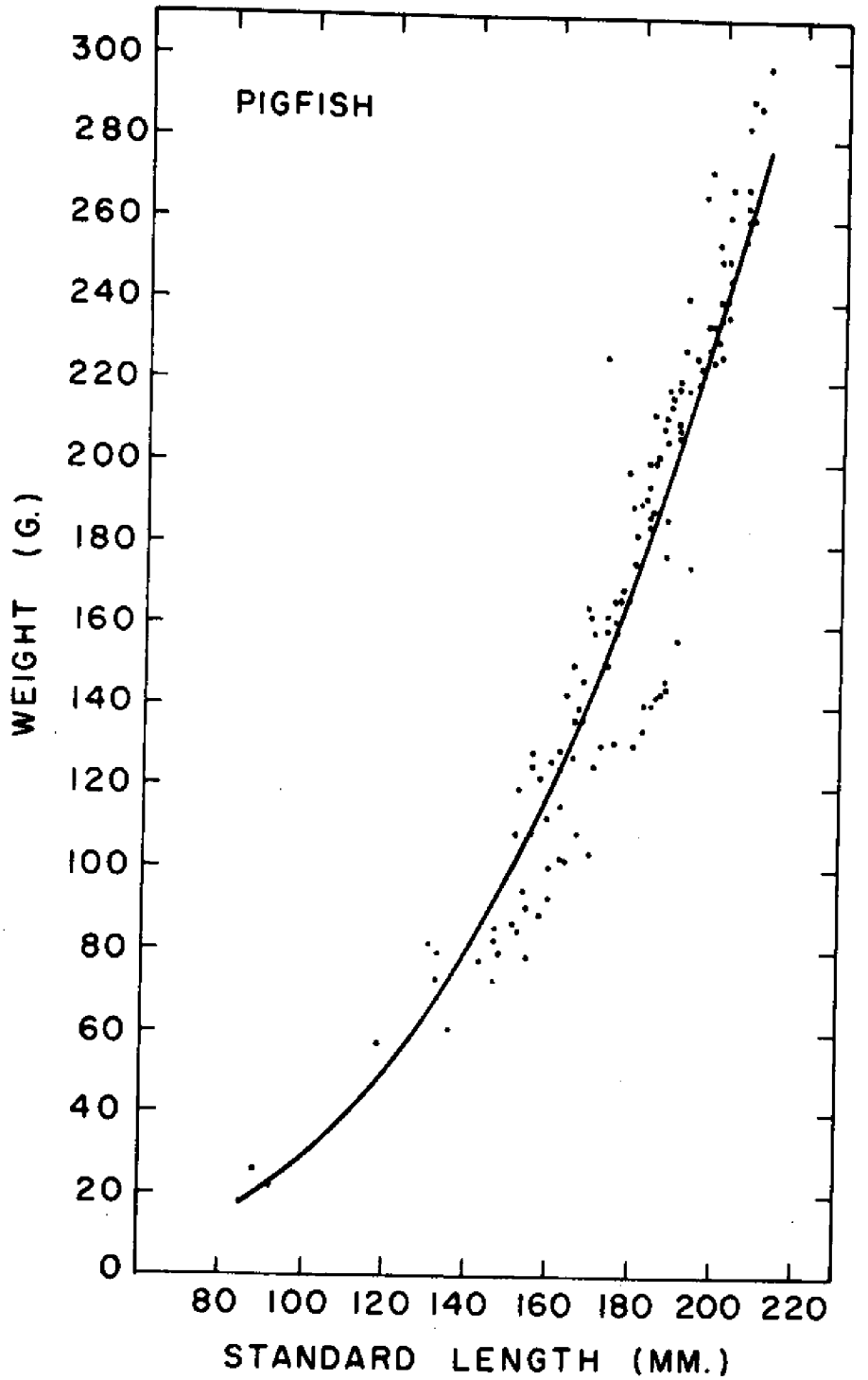

FIGURE 19.--Length-weight relationship of pigfish cultured in cages. Empirical data for pigfish in cages 8 and 10 are plotted and the line represents the calculated antilog values of the equation Log W = -4.60993 + 3.03383 Log L (N = 131).

Growth.--Pigfish in cage 8 attained a final length and weight of about 192 mm and 224 g within 140 days from stocking (Table 41, page 119). Average length and weight increased about 28 mm and 115 g, and represented an absolute growth rate in length and weight of 0.2 mm/day (6.0 mm/month) and 0.8 g/day (24.0 g/month). The relative growth in average weight was 105.8%. Pigfish in cage 10 reached an average length and weight of about 203 mm and 261 g within 140 days from stocking (Table 42, page 120). The increase in mean length and weight was about 55 mm and 170 g, which represented an absolute growth rate in length and weight of 0.4 mm/day (12.0 mm/month) and 1.2 g/day (36.0 g/month). Average weight increased 187.6%. Greatest absolute and relative growth of pigfish occurred early in the study, and thereafter decreased (Fig. 20). The maximum length (211 mm) and weight (298 g) attained was recorded from pigfish in cage 8. Total weight of pigfish in cage 8 and 10 at the last sampling date was 3815 g and 1044 g, respectively.

Gulf Kingfish (*Menticirrhus littoralis*)

Production data recorded for Gulf kingfish in cage 14 is presented in Table 43.

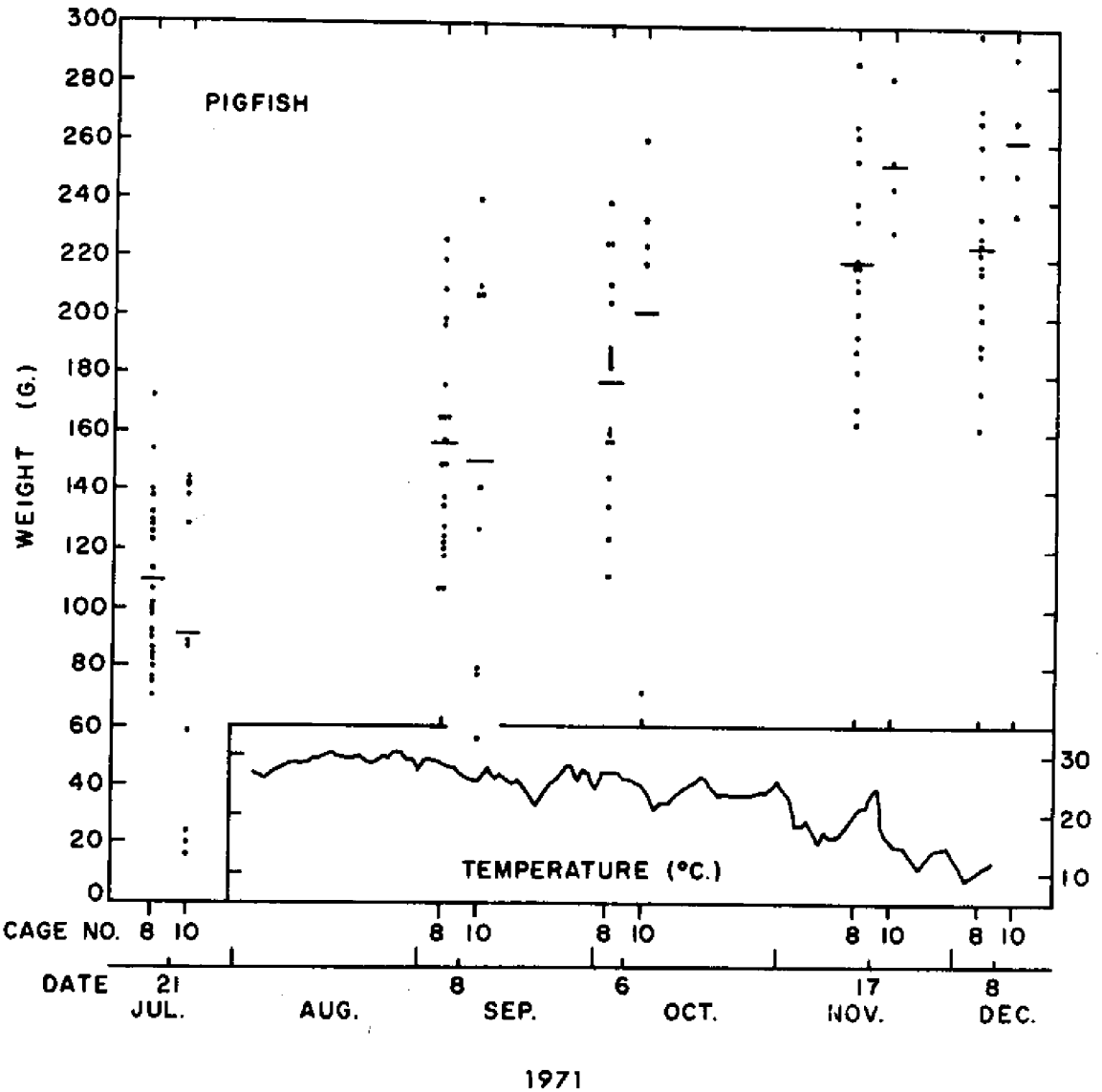

FIGURE 20.--Changes in weight of pigfish in cages 8 and 10. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

TABLE 43.--Summary of production data (standard length in millimeters and weight in grams) for Gulf kingfish in cage 14 from 21 July to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		25		208.3	153.5	3839					1.572	127-277
9-3	44	7	28.0	215.0 (6.7)	159.2 (5.7)	1115	-1.632	0.2	0.1	3.7	1.534	178-262
10-8	35	6	85.7	216.3 (1.3)	175.0 (15.8)	1050	-34.431	0.0	0.4	9.8	1.652	172-264
11-17	40	5	83.3	219.4 (3.1)	202.4 (27.4)	1012	**	0.1	0.7	15.6	1.829	186-275
12-8	21	5	100.0	221.6 (2.2)	198.2 (-4.2)	991	**	0.1	-0.2	-2.0	1.752	188-276
Overall	140		20.0	(13.3)	(44.7)		**	0.1	0.3	29.0		

*Increment in parenthesis

**Cage contained other species of fish, therefore conversions for Gulf kingfish could not be calculated

Survival.--Survival of Gulf kingfish in cage 14 was poor. Only 20% survived the 140-day culture period. Lowest survival (28%) was recorded for the 44-day period from the initial stocking to 3 September 1971. After 17 November 1971, survival of Gulf kingfish was 100%.

Feeding and food conversion.--Gulf kingfish did not adapt to surface feeding in cages. Feeding activity was observed only three times throughout the study. When it occurred, feeding activity was poor and never lasted more than a few minutes. Those fish that were observed feeding would come up within the feeding ring, take some food, and return back down.

Food conversion rates were negative, i.e., the total weight of fish at the end of the culture period was less than at the beginning due to mortality (Table 43, page 126). After 8 October 1971, other species of fish were added to cage 14 and food conversion rates could not be calculated for Gulf kingfish.

Length-weight relationship and condition.--The calculated length-weight relationship of Gulf kingfish cultured in cage 14 was based on 48 length-weight observations, and can be described by the formula:

$$\text{Log } W = -4.27572 + 2.77744 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 125 mm to 277 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y \cdot x}$) were 0.97998 and 0.00199, respectively. The sums, sums of squares, and sum of cross products used in calculating the Gulf kingfish length-weight regression equation are:

$$\sum X = 111.42451$$

$$\sum X^2 = 258.93938$$

$$\sum Y = 104.24078$$

$$\sum Y^2 = 228.66530$$

$$\sum XY = 242.76963$$

where X = log standard length, and Y = log weight. The smooth curve of the calculated antilog values and empirical length-weight data recorded for Gulf kingfish in cage 14 were plotted (Fig. 21).

Average condition was lowest at the initial stocking (1.572) and increased to a maximum of 1.829 on 17 November 1971. The final mean condition value was higher than the initial value (Table 43, page 126.

Growth.--Gulf kingfish attained a final average length and weight of about 222 mm and 198 g within 140 days from stocking (Table 43, page 126; Fig. 22). Average length and weight increased

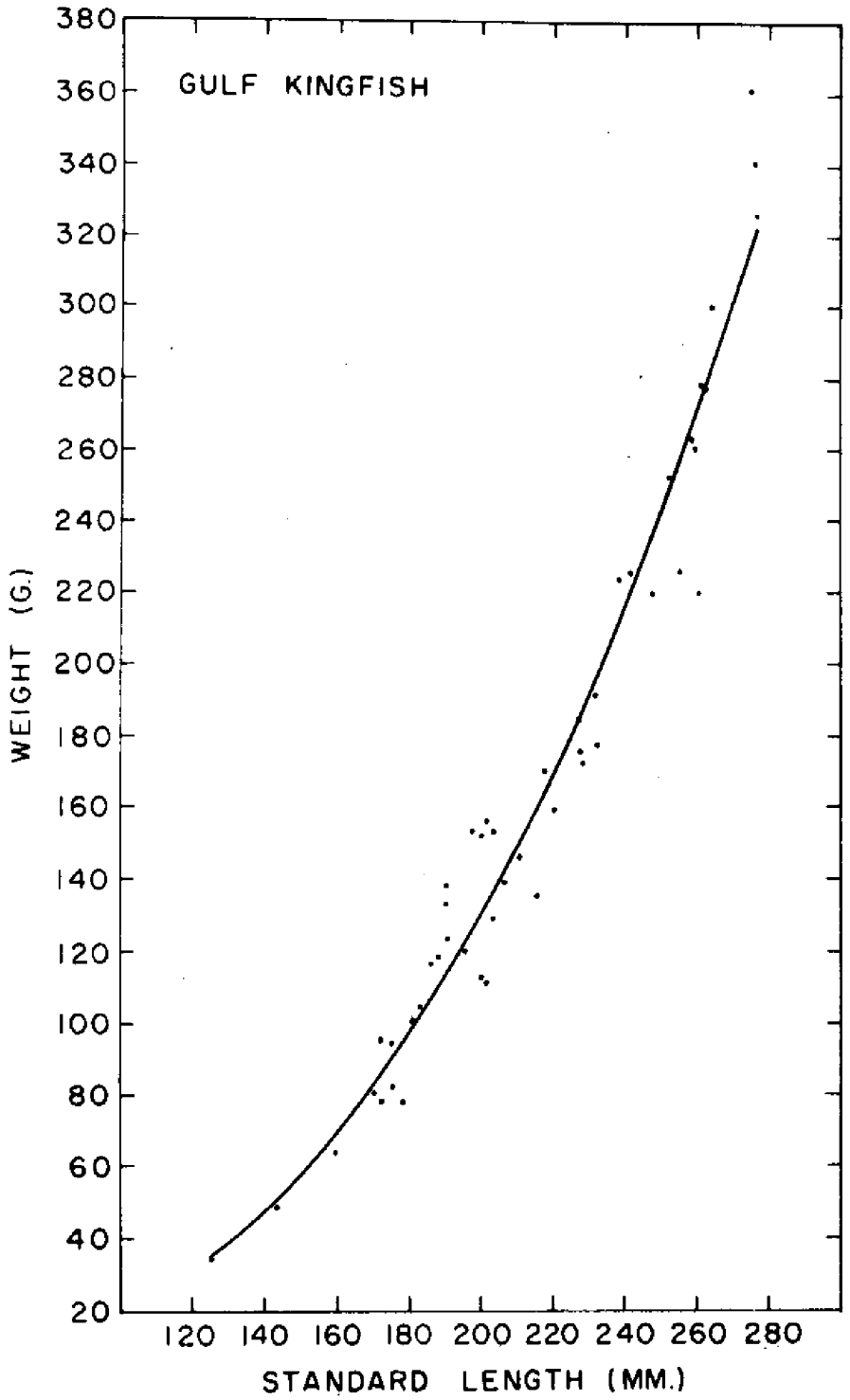

FIGURE 21.--Length-weight relationship of Gulf kingfish cultured in a cage. Empirical data for Gulf kingfish in cage 14 are plotted and the line represents the calculated antilog values of the equation Log W = -4.27572 + 2.77744 Log L (N = 48).

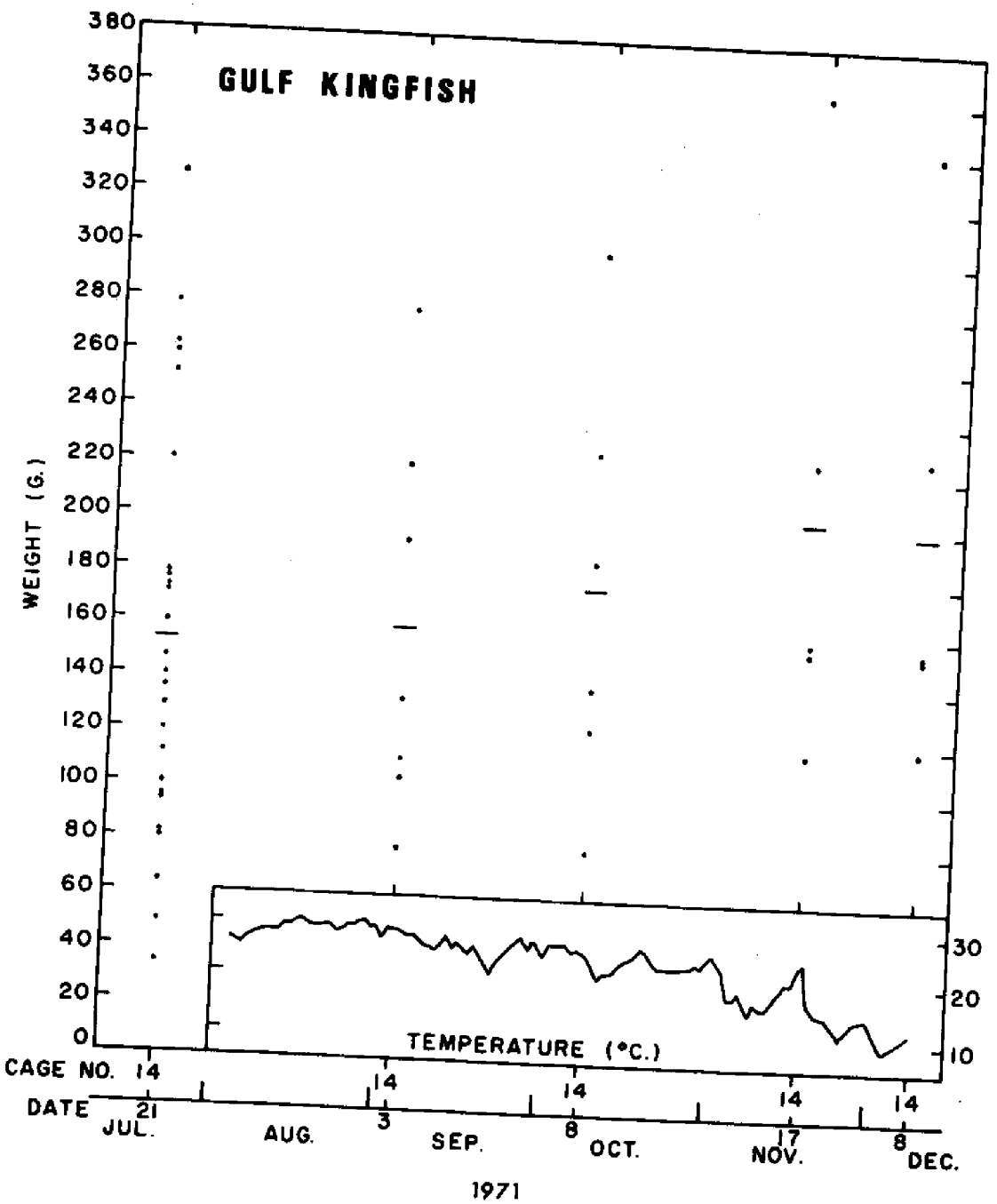

FIGURE 22.--Changes in weight of Gulf kingfish in cage 14. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

about 13 mm and 45 g, and represented an absolute growth rate in length and weight of 0.1 mm/day (3.0 mm/month) and 0.3 g/day (9.0 g/month). The relative growth in average weight was 29.0%. Relative growth in average weight increased until 17 November 1971 and was negative for the period from 17 November 1971 to 8 December 1971. A maximum length and weight of 275 mm and 361 g was recorded. Total weight of Gulf kingfish in cage 14 at the last growth sampling was 991 g.

Silver Perch (*Bairdiella chrysura*)

Production data recorded for silver perch in cage 4 is presented in Table 44.

Survival.--Overall survival of silver perch in cage 4 was poor (Table 44, page 132). Only 40% survived the 119-day culture period. All mortality occurred early in the study and survival after 8 September 1971 was 100%.

Feeding and food conversion.--No surface feeding activity of silver perch was observed during the study. The overall food conversion rate of silver perch was negative (-3.138) since the total weight of fish at the end of the culture period was less than at the start due to mortality. The food conversion for the period from

TABLE 44.--Summary of production data (standard length in millimeters and weight in grams) for silver perch in cage 4 from 21 July to 17 November 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		10		154.6	88.9	889					2.323	120-172
9-8	49	4	40.0	150.2 (-4.4)	67.0 (-21.9)	268	-1.782	-0.1	-0.4	-24.6	1.972	126-163
10-6	28	4	100.0	152.2 (2.0)	71.7 (4.7)	287	15.052	0.1	0.2	7.0	2.053	131-165
11-17	42	4	100.0	150.5 (-1.7)	74.5 (2.8)	298	42.000	0.0	0.1	3.8	2.199	132-160
Overall	119		40.0	(-4.1)	(-14.4)		-3.138	0.0	-0.1	-16.1		

*Increment in parenthesis

21 July to 8 September 1971 was also negative (-1.782). Food conversion rates for the periods from 8 September to 6 October 1971 and from 6 October to 17 November 1971 were 15.052 and 42.000, respectively.

Length-weight relationship and condition.--The calculated length-weight relationship of silver perch cultured in cage 4 during this study was based on 22 length-weight observations, and can be described by the formula:

$$\text{Log } W = -4.00702 + 2.69846 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 120 mm to 172 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were 0.85766 and 0.00462. The sums, sums of squares, and sum of cross products used in calculating the silver perch regression equation are:

$$\Sigma X = 48.00143$$

$$\Sigma X^2 = 104.76885$$

$$\Sigma Y = 41.37548$$

$$\Sigma Y^2 = 78.16482$$

$$\Sigma XY = 90.37182$$

where X = log standard length, and Y = log weight.

The average condition of silver perch was highest at the initial stocking (Table 44, page 132). The lowest mean condition was calculated on 8 September 1971. Thereafter, mean condition increased.

Growth.--As a result of mortality, average length and weight decreased during the period from 21 July to 8 September 1971, and absolute growth rates in length and weight were negative (Table 44, page 132). Thereafter, absolute and relative growth was minimal (Fig. 23). Overall absolute and relative growth was also negative. The final average length and weight attained was about 150 mm and 74 g. The maximum length and weight recorded was 172 mm and 142 g.

Spot (*Leiostomus xanthurus*)

Production data recorded for spot in cage 16 is presented in Table 45.

Survival.--The overall survival of spot cultured 140 days was 71.4% (Table 45, page 136). Survival after 3 September 1971 was excellent (100%).

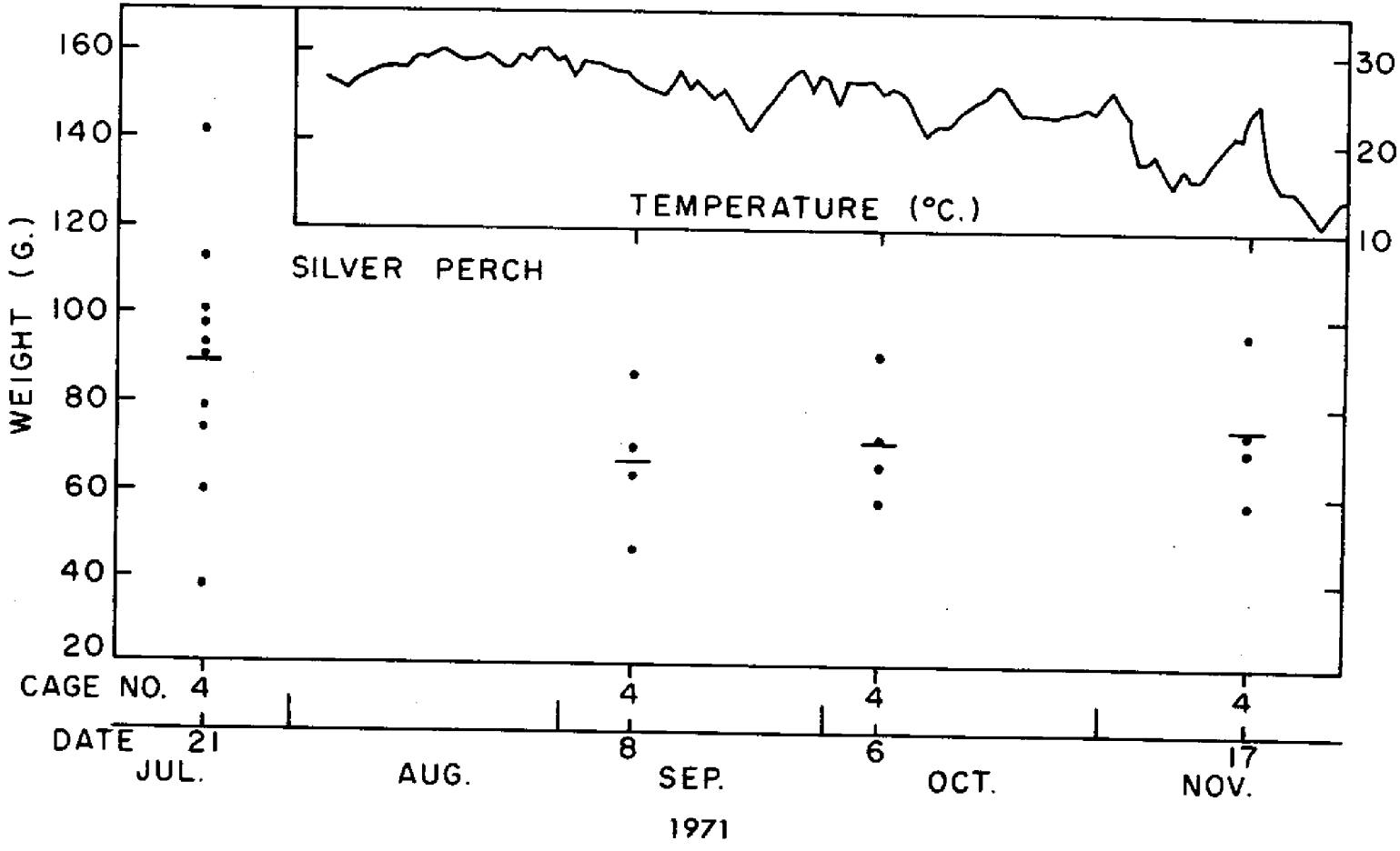

FIGURE 23.--Changes in weight of silver perch in cage 4. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

TABLE 45.--Summary of production data (standard length in millimeters and weight in grams) for spot in cage 16 from 21 July to 8 December 1971.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		7		155.7	106.7	747					2.588	89-177
9-3	44	5	71.4	181.0 (25.3)	165.8 (59.1)	829	10.195	0.6	1.3	55.3	2.768	163-188
10-8	35	5	100.0	185.8 (4.8)	190.6 (24.8)	953	11.480	0.1	0.7	14.9	2.953	172-190
11-17	40	5	100.0	194.6 (8.8)	227.0 (36.4)	1135	**	0.2	0.9	19.0	3.064	182-199
12-8	21	5	100.0	197.6 (3.0)	241.8 (14.8)	1209	**	0.1	0.7	6.5	3.109	185-209
Overall	140		71.4	(41.9)	(135.1)			0.3	1.0	126.5		

*Increment in parenthesis
**Cage contained other species of fish, therefore conversions for spot could not be calculated

Feeding and food conversion.--Spot did not adapt to surface feeding in cages. No feeding activity of spot was observed during the study.

Food conversion rates for spot during the periods from 21 July to 3 September 1971, and from 3 September to 8 October 1971 were 10.195 and 11.480, respectively (Table 45, page 136). Thereafter, spot were in a cage containing other species of fish and spot food conversions could not be calculated.

Length-weight relationship and condition.--The calculated length-weight relationship of spot cultured during this study was based on 27 length-weight observations, and can be described by the formula:

$$\text{Log } W = -5.12535 + 3.25834 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 89 to 202 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were 0.98702 and 0.00140, respectively. The sums, sums of squares, and sum of cross products used in calculating the spot length-weight regression equation are:

$$\sum X = 60.82804$$

$$\sum X^2 = 137.16589$$

$$\Sigma Y = 59.81379$$

$$\Sigma Y^2 = 133.89086$$

$$\Sigma XY = 135.16767$$

where X = log standard length, and Y = log weight.

Average condition of spot increased from a low of 2.588 at the initial stocking to a high of 3.109 at the last growth sampling on 8 December 1971 (Table 45, page 136).

Growth.--Spot attained an average length and weight of about 198 mm and 242 g within 140 days from stocking (Table 45, page 136; Fig. 24). Average length and weight increased about 42 mm and 135 g, and represented an absolute growth rate in length and weight of 0.3 mm/day (9.0 mm/month) and 1.0 g/day (30.0 g/month). The relative growth in average weight was 126.5%. Greatest absolute and relative growth occurred early in the study. A maximum length of 202 mm and weight of 270 g was recorded.

Black Drum (*Pogonias cromis*)

Production data recorded for black drum in cage 18 is presented in Table 46.

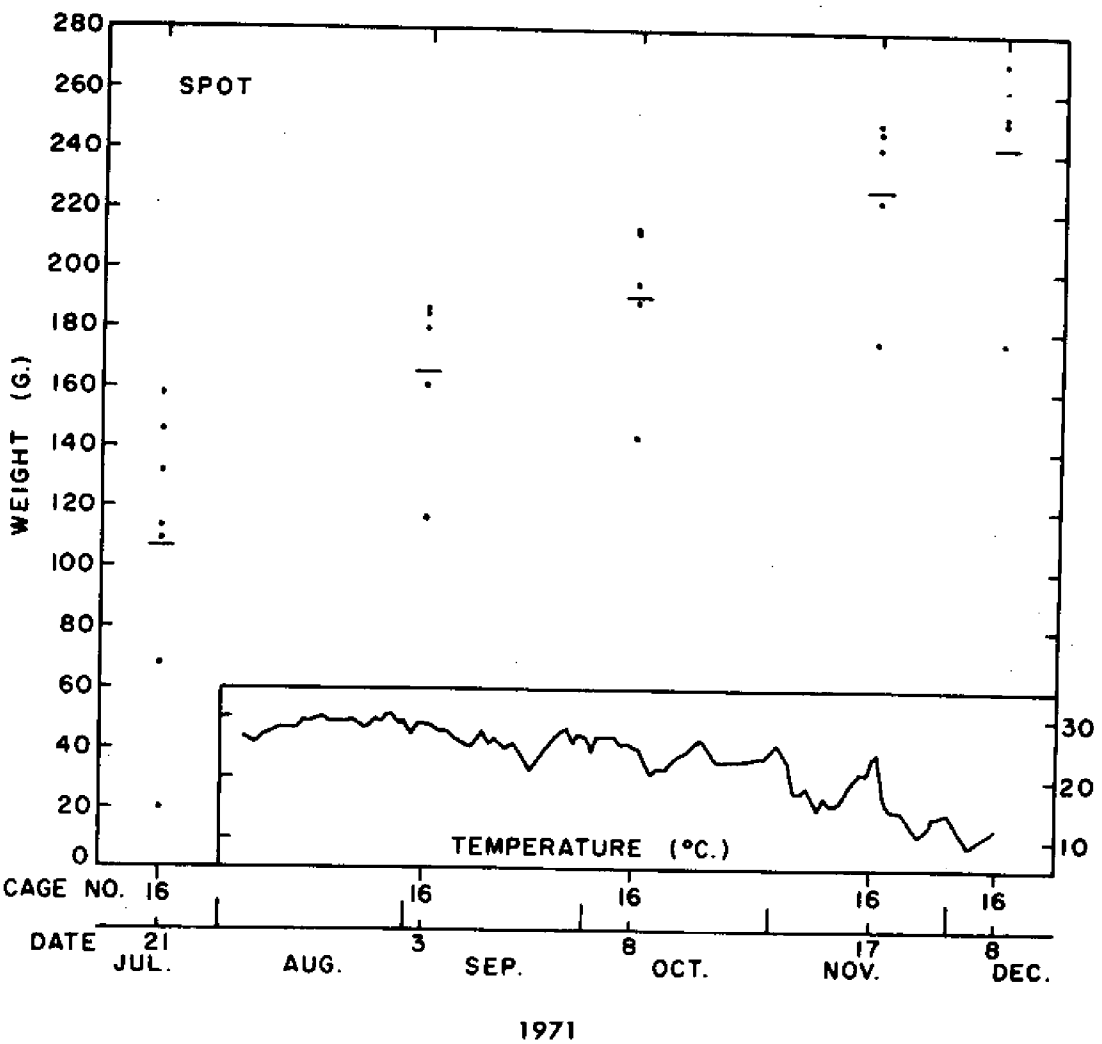

FIGURE 24.--Changes in weight of spot in cage 16. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

TABLE 46.--Summary of production data (standard length in millimeters and weight in grams) for black drum in cage 18 from 21 July 1971 to 10 March 1972.

Sampling date	Days of growth	Number of fish	Percent survival	Average length and increment*	Average weight and increment*	Total weight	Food conversion (C)	Absolute growth mm/day	Absolute growth g/day	Relative growth in weight (percent)	Average condition (K)	Length range
1971												
7-21		2		211.0	234.0	468					2.455	192-230
9-3	44	2	100.0	246.5 (35.5)	385.5 (151.5)	771	1.755	0.8	3.4	64.7	2.532	239-256
10-8	35	2	100.0	262.5 (16.0)	487.5 (102.0)	975	5.352	0.5	2.9	26.4	2.699	254-271
11-17	40	2	100.0	277.0 (14.5)	527.0 (39.5)	1054	**	0.4	1.0	8.1	2.483	270-284
12-8	21	2	100.0	277.5 (0.5)	534.0 (7.0)	1068	**	0.0	0.3	1.3	2.498	272-283
1972												
2-4	48	2	100.0	280.0 (2.5)	631.5 (97.5)	1263	***	0.0	2.0	18.2	2.882	270-290
3-10	35	2	100.0	288.5 (8.5)	670.0 (38.5)	1340	***	0.2	1.1	6.0	2.782	277-300
Overall	233		100.0	(77.5)	(436.0)			0.3	1.9	186.3		

*Increment in parenthesis
**Cage contained other species of fish, therefore food conversion for black drum could not be calculated
***Fish were not fed

Survival.--Survival of black drum was excellent. The survival of the two black drum for the 233-day culture period was 100% (Table 46, page 140).

Feeding and food conversion.--No surface feeding activity of the black drum was observed during the study.

Food conversions for the periods from 21 July to 3 September 1971, and for 3 September to 8 October 1971 were 1.755 and 5.352, respectively (Table 46, page 140). After 8 October and until 8 December 1971 the black drum were in a cage containing other species of fish, and food conversions could not be calculated. After 8 December 1971 black drum were not fed.

Length-weight relationship and condition.--The calculated length-weight relationship of black drum cultured during this study was based on 14 length-weight observations and can be described by the formula:

$$\text{Log } W = -4.98107 + 3.16465 \text{ Log } L$$

where W = weight in grams, and L = standard length in millimeters. The size range was 192 to 300 mm. The correlation coefficient (r) and the mean square deviation from regression ($s^2_{y.x}$) were 0.98269 and 0.00096, respectively. The sums, sums of squares, and sum of cross products used in calculating the black drum length-weight

regression equation are:

$$\sum X = 33.85387$$

$$\sum X^2 = 81.89563$$

$$\sum Y = 37.40067$$

$$\sum Y^2 = 100.25155$$

$$\sum XY = 90.54251$$

where X = log standard length, and Y = log weight.

Mean condition increased from 21 July to 8 October 1971, and then dropped for the 11 November and 8 December 1971 sampling dates (Table 46, page 140). Average condition increased in February and then decreased slightly in March 1972. The maximum average condition of black drum was calculated on 4 February 1972. The final mean condition value was higher than the initial value.

Growth.--Black drum attained a final average length and weight of about 288 mm and 670 g within 233 days from stocking (Table 46, page 140; Fig. 25). Average length and weight increased about 78 mm and 436 g, and represented an absolute growth rate in length and weight of 0.3 mm/day (9.0 mm/month) and 1.9 g/day (57.0 g/month). The relative growth in average weight was 186.3%. Absolute and relative growth decreased from 21 July to 8 December 1971. A slight increase in growth was recorded from 8 December 1971 to

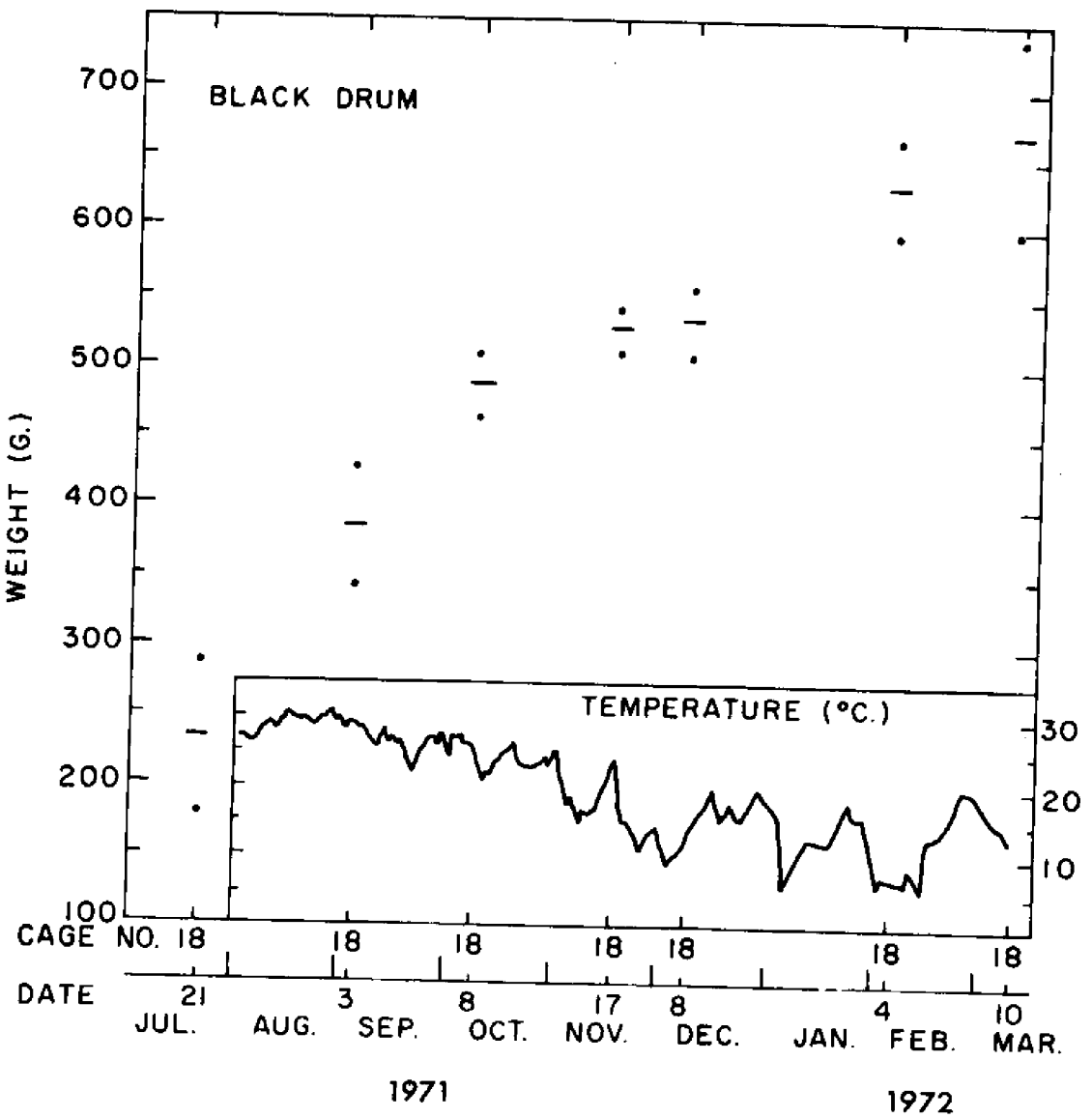

FIGURE 25.--Changes in weight of black drum in cage 18. Observed weights are individually plotted and mean weights are designated by the horizontal bar. Water temperatures (C) recorded at intake canal station 2 are represented by the solid line.

4 February 1972, and thereafter decreased. A maximum length of 300 mm and 740 g was recorded.

Organoleptic Evaluation

Mean scores and standard deviations of the organoleptic evaluation of the cultured fish by the 12-member taste panel are presented in Table 47. Pompano received the highest mean scores for flavor, mouthfeel and overall satisfaction, but scored lowest in the appearance evaluation. Croaker ranked highest in the appearance category, but were second in the flavor, mouthfeel and overall satisfaction evaluation. Pinfish were ranked second in the appearance category, but received the lowest mean scores for flavor, mouthfeel and overall satisfaction. The analysis of variance for the appearance, flavor, mouthfeel, and overall satisfaction evaluation of the fish are summarized in Tables 48, 49, 50, and 51, respectively. Mean scores for the three species of fish for each of the evaluation categories were not significantly different. In all analyses of variance there was a significant difference among judges.

The percent of judges who considered the fish products acceptable (i.e., scored 5 or above in the 8-point hedonic scale) is presented in Table 52. Croaker , pinfish and pompano were all rated

TABLE 47.--Mean scores of the organoleptic evaluation of fish.*

Species	Scores for the attributes evaluated**							
	Appearance		Flavor		Mouthfeel		Overall satisfaction	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Croaker	5.6	1.1	5.6	1.3	5.7	1.4	5.8	1.3
Pinfish	5.5	1.2	5.6	1.5	5.5	1.5	5.5	1.4
Pompano	5.4	1.0	6.0	1.2	5.9	1.5	5.9	1.2

*Mean scores based on an 8-point hedonic scale (extreme like = 8, extreme dislike = 1) judged by a 12-member taste panel, with each species of fish judged twice. One judge did not rate the products for overall satisfaction, therefore overall satisfaction mean scores are based on ratings of 11 judges.

**Mean scores for appearance, flavor, mouthfeel and overall satisfaction were not significantly different for the three species of fish at 0.01.

TABLE 48.--Analysis of variance of taste panel scores for appearance of croaker, pinfish, and pompano.

Source	d.f.	SS	MS	F
Total	71	85.986		
Treatment	35	61.486	1.756	
Species (S)	2	0.361	0.181	0.239
Judges (J)	11	44.486	4.044	5.349**
S x J	22	16.639	0.756	
Duplicate determinations	36	24.500	0.681	

**Significant at 0.01

TABLE 49.--Analysis of variance of taste panel scores for flavor of croaker, pinfish, and pompano.

Source	d.f.	SS	MS	F
Total	71	124.444		
Treatment	35	76.444	2.184	
Species (S)	2	2.027	1.014	0.905
Judges (J)	11	49.777	4.525	4.040**
S x J	22	24.640	1.120	
Duplicate determinations	36	48.000	1.333	

**Significant at 0.01

TABLE 50.--Analysis of variance of taste panel scores for mouthfeel of croaker, pinfish, and pompano.

Source	d.f.	SS	MS	F
Total	71	153.278		
Treatment	35	126.972	3.626	
Species (S)	2	1.361	0.681	0.288
Judges (J)	11	73.611	6.692	2.831*
S x J	22	52.000	2.364	
Duplicate determinations	36	23.306	0.731	

*Significant at 0.05

TABLE 51.--Analysis of variance of taste panel scores for overall satisfaction of croaker, pinfish, and pompano.

Source	d.f.	SS	MS	F
Total	65	110.621		
Treatment	32	70.121	2.191	
Species (S)	2	2.030	1.015	0.967
Judges (J)	10	47.121	4.712	4.491**
S x J	20	20.970	1.049	
Duplicate determinations	33	40.500	1.227	

**Significance at 0.01

TABLE 52.--Frequency of scores expressing acceptability of the fish.*

Species	Percent of judges rated the product acceptable**			
	Appearance	Flavor	Mouthfeel	Overall satisfaction
Croaker	83	71	75	77
Pinfish	83	71	75	73
Pompano	83	92	79	91

*Acceptable score was 5 and above in an 8-point hedonic scale.

**Total number of judges on the taste panel was 12, however one judge did not rate the products for overall satisfaction, therefore overall satisfaction percentages are based on ratings of 11 judges.

acceptable for appearance by 83% of the judges. Croaker and pinfish were both liked by 71% and 75% of the judges for flavor and mouthfeel, respectively. Pompano was acceptable to 92% for flavor and 79% for mouthfeel. For overall satisfaction, 91% liked pompano, 77% rated croaker acceptable, and 73% liked pinfish.

Cage Related Observations

After approximately 1 year in the water, most cages were in good condition and would be suitable for a second year's culture use after removal of the barnacle growth from the cage frame and painting with Lagotex Black. Excluding barnacles on the cage frame, fouling of intake cage wire was minimal and did not prevent the free flow of water through a cage. The wire mesh of intake cages containing pinfish were less fouled (almost free of fouling) than the other cages. However, discharge cages became extremely fouled shortly after their placement in the canal and resulted in decreased water circulation through a cage.

The wire baskets of several cages in the discharge canal broke open. Breakage occurred on the side of the cage directly opposed to the water current. This appeared to be the result of a combination of heavy fouling of the wire mesh and the higher water velocity in the

discharge canal. As fouling progressed to the point of occluding the wire mesh, the force of the water flowing against the wire probably created mechanical stresses greater than the wire material could withstand and breakage occurred. These breaks occurred in cages at or near the center of the discharge canal where higher water velocities were recorded.

When first placed in the discharge, cages at or near the center of the canal tended to rise above the water surface (Fig. 26). The wire mesh of the cage provided enough resistance against the flow of water so that as the flow increased to a certain velocity cages would lift above the water surface. Cages were often lifted about 1 to 1.5 ft and would remain elevated until the water velocity decreased. Increasing the length of rope connecting the cage to the discharge platform slightly reduced the lifting effect.

When cages were in the discharge canal for about 1 or 2 months, a reverse of the situation described above was observed. Cages were by this time extremely fouled and as a result were considerably heavier. As the flow of water increased to a certain velocity, cages would begin to tilt away from the direction of the water flow (i.e., towards the discharge structure). As cages continued to tilt, water would begin to flow across the cage top, and force the cage beneath the water surface (Fig. 27). Cages were often observed almost

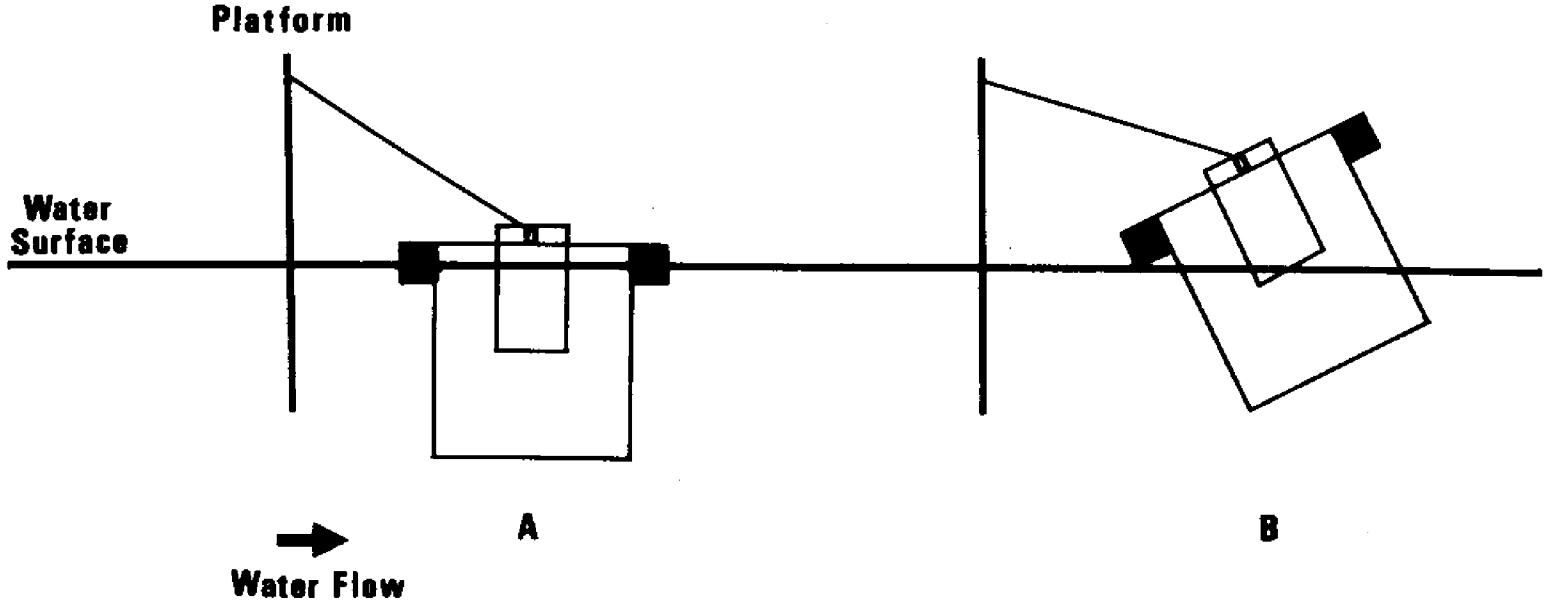

FIGURE 26.--Floating positions of unfouled cages in the discharge canal. (A) Cage in normal floating position; (B) Cage raised above water surface during high water flow.

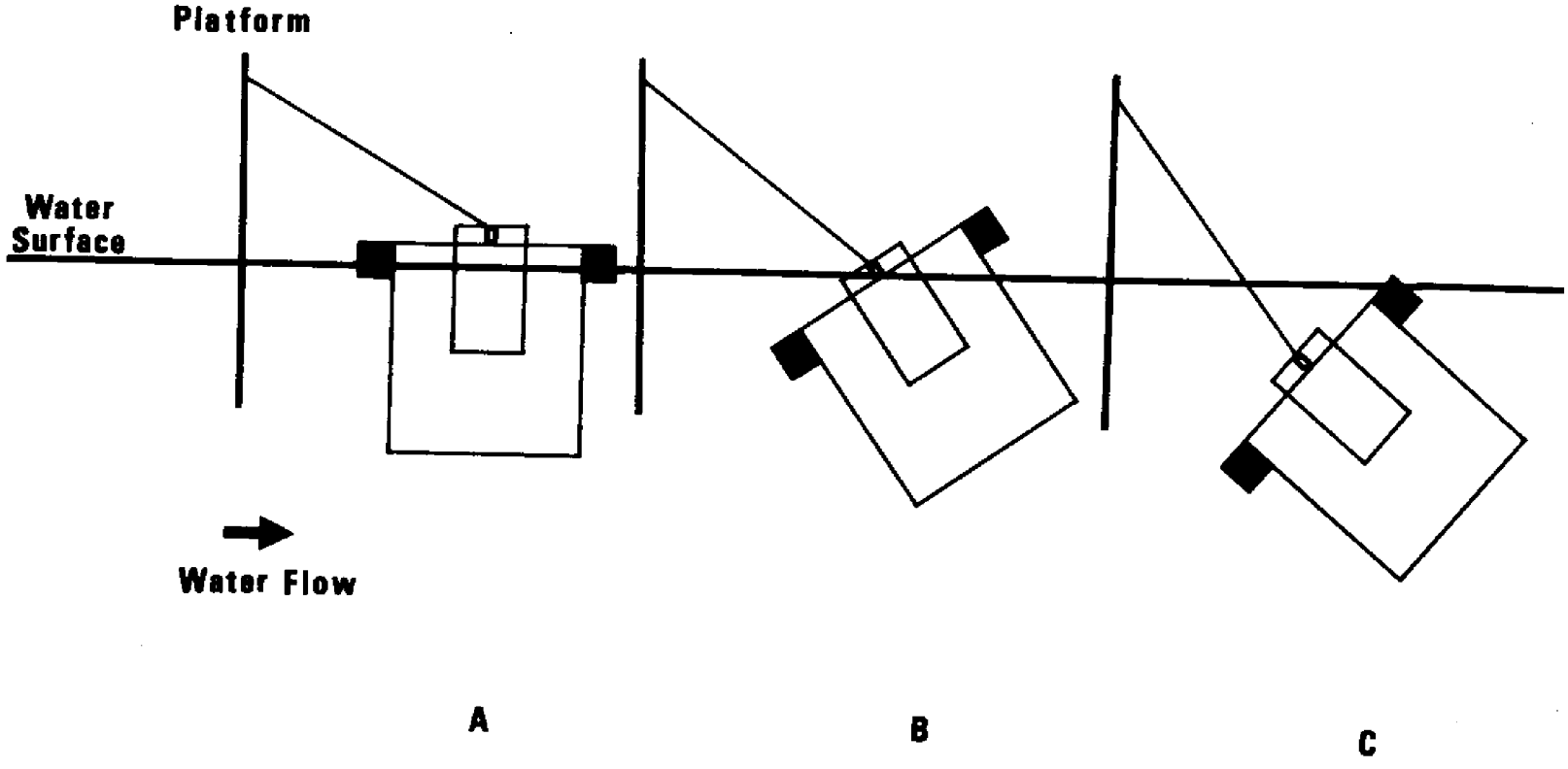

FIGURE 27.--Floating positions of fouled cages in the discharge canal. (A) Cage in normal floating position; (B) Cage just beginning to sink; and (C) Almost completely submerged during high water flow.

totally submerged. Cages would float back to the surface when the water velocity decreased. Cage sinking, rather than rising was probably due to the increased weight of cages from fouling.

Lagotex Black No. 599 provided fair protection for the metal cage materials against the corrosive action of sea water. After about 1 year in the water, some corrosion of the wire mesh of cages was evident but was not critical.

Some fish, especially pinfish, received minor mouth injuries (cuts and abrasions) during periods of hyper-activity (e.g., during sampling) apparently by swimming head-on into the welded wire.

The styrofoam flotation blocks were somewhat damaged as a result of excavation and burrowing by various organisms (possibly by crabs of the family Xanthidae).

Pompano that were observed swimming near the surface within discharge cages appeared to experience some difficulty in trying to maintain positions within the cage. The fish would attempt swimming against the water current, but would be repeatedly pushed back against the side of the cage after apparently becoming fatigued.

DISCUSSION

Survival

Among other factors, good survival is necessary if commercial cage culture of marine fishes is to succeed. Compared to an arbitrarily assumed minimum acceptable survival value of 70%, the overall survival of croaker, pinfish, pompano, white mullet, spot, and black drum cultured during this study in the intake canal was on the average acceptable.

Some comparative survival data for pompano cultured in cages, and croaker cultured in ponds was available. Theodore Smith, School of Atmospheric and Marine Sciences, University of Miami, has recorded acceptable survival of pompano stocked in rectangular cages at densities of 100, 250, 400, 650, and 900 fish per m^3 (personal communication). The overall mean survival of pompano cultured for 9 months was 79.3% and ranged from 75.1% to 88.0%. Swingle and Tatum (1971) reported a low overall mean survival of 40.7% for pompano stocked in cylindrical cages at densities of 51, 150, and 300 fish per yd^3. They state that their low survival was the result of initial mortality probably caused by low feeding rates and only one feeding per day.

Avault et al. (1969) conducted a 2-year study of croaker cultured in 12 brackish-water ponds in southwest Louisiana. At the end of the first culture year, survival of croaker stocked at a rate of 1000 fish per acre in six 0.1-acre ponds was very low, with only 24 fish recovered from a single pond. Inadequate supervision and possible cold-induced mortalities were suggested as an explanation for the poor survival. Somewhat better results were obtained during the second culture year. Average survival of croaker stocked in replicate ponds at rates of 500, 1000, and 2000 fish per acre was 47.0%, 74.5%, and 41.5%, respectively.

Although preliminary results appear promising, further study is needed to determine whether acceptable survival can be consistently attained when cages are stocked at densities appropriate for commercial culture operations (greater than 100 fish per m^3).

The overall survival of pigfish, Gulf kingfish, and silver perch during this study was less than that considered acceptable for commercial fish culture operations.

With the exception of pinfish, survival of caged-fish in the discharge canal was extremely poor. An almost complete mortality of croaker and pompano in the discharge canal occurred shortly after their transfer from the intake. The cause of the observed mortality

can only be suggested. However, good circumstantial evidence seems to implicate gas-bubble disease (GBD).

Dead croaker and pompano that were removed from the discharge canal cages showed pronounced exophthalmos, a feature that has been frequently observed as an external symptom of GBD (Beiningen and Ebel, 1970; DeMont and Miller, in press; Marsh and Gorham, 1905). Considering the occurrence of exophthalmos in the croaker and pompano, the rupturing of the croaker abdomens, and the confirmed diagnosis of GBD in the discharge pinfish, it is believed that GBD was the cause of the mortality of croaker and pompano located in the discharge canal. The fact that at a later date, pinfish survived in the discharge canal may have been due to lower gas saturation levels and/or greater species resistance to GBD. There is no positive evidence (i.e., gas analysis) indicating the existence of gas supersaturation of the discharge water at the time of the observed mortality of croaker and pompano for no water analyses were performed.

Gas-bubble disease in fish may result when they are exposed to an environment that is supersaturated with dissolved gases. Gasious supersaturation of water can be caused by phytoplankton blooms (Renfro, 1963; Woodbury, 1942), increasing the temperature and/or decreasing the pressure of gas saturated water without allowing equilibration (DeMont and Miller, in press), the falling of water into

plunge basins below dam spillways (Beiningen and Ebel, 1970; Ebel, 1969; Harvey and Cooper, 1962), and/or the drawing in of air at water pump intakes, leaky pipelines, or similar situations and then subjecting the water to increased pressure (Harvey and Smith, 1961; Marsh and Gorham, 1905). In supersaturated water, the blood of a fish becomes supersaturated, and excess gas is liberated in the form of bubbles after a pressure decrease or temperature increase (Renfro, 1963). Death due to gas embolism may eventually result. Gas-bubble disease has caused fish mortalities (Beiningen and Ebel, 1970; Ebel, 1969; DeMont and Miller, in press; Marsh and Gorham, 1905).

From some of the above reported causes of gas supersaturation of water, it is easy to see how intake water passing through an electric generating station can become supersaturated with gases. DeMont and Miller (in press) reported the first incidence of GBD in fish in heated effluent at a steam-generating station in North Carolina. They stated that the highest incidence of GBD occurred during the winter months. Dr. John Kelley, Department of Wildlife and Fisheries Sciences, Texas A&M University, has stated that during the winter of 1971 catfish in cages located in the heated discharge canal of the Trinidad Power Generating Station, Trinidad, Texas, developed GBD (personal communication).

It is important to note that the problem of GBD in this study, as well as those mentioned above, was observed primarily during the winter months. This is also the time of year that the use of thermal effluents to extend the growing season of fish would be most desired. As a result, GBD may become a problem associated with the future utilization of thermal effluents in the culture of fish. Investigations directed at the GBD problem are needed to determine its extent and seasonality, and to devise various methods of alleviation.

Food Conversion

Croaker had the best overall food conversion rates. Although these overall food conversions were acceptable, they still did not approach the desired food conversions of 1.0 to 1.9 that are usually attained in present commercial culture of catfish in cages. Overall food conversions of pompano were comparable to those reported by Finucane (1970a), Ted Smith, School of Marine and Atmospheric Sciences, University of Miami (personal communication), and Swingle and Tatum (1971), and although somewhat high, they might be acceptable for commercial culture operations because of the high retail market price of pompano. Food conversions for the remaining species cultured were inefficient and would not be acceptable for

commercial culture operations. No published food-conversion data for species other than pompano were found.

Food conversion became generally less efficient as fish size increased. This was probably the result of overfeeding. Relatively efficient food conversions (less than one and up to about three) were recorded for pompano, croaker, pinfish, white mullet, and black drum during some phase of the study, and evidently the feeding rate was appropriate at these times. More efficient overall food conversions might have been attained if feeding rates were reduced as the fish grew larger, and as feeding activity decreased. It is apparent that more study is needed on the amount of food that should be fed to various species of fish in cages at different developmental stages and temperatures.

Feeding Behavior and Cage Design

The purpose of feeding rings is to contain feed within a cage without interfering with the exchange of water into and out of the cage. There are at least three general types of feeding enclosures used in cages. These are the feeding ring or tube (Schmittou, 1969), the peripheral feeding ring (Swingle, 1971), and the submerged feeding tray (Armbrester, 1970).

The feeding ring which was used during this study is a rectangular or circular feeding enclosure of limited surface feeding area that extends into the cage interior and is usually attached to the center of the cage top. Feeding rings are generally used with floating feeds.

The peripheral feeding ring is attached to the top inside perimeter of a cage and allows the utilization of the entire cage surface area for surface feeding. Peripheral feeding rings do not extend as far below the water's surface (usually less than 8 inches) as do feeding tubes, because water flow into and out of the cage would be adversely affected. Peripheral feeding rings are also used with floating feeds.

Submerged feeding trays are located within the cage interior, and are designed to retain sinking feed while allowing the fish unobstructed access to the food.

The choice of feeding enclosure designs is usually based on the type of supplemental feed used during culture (i.e., floating or sinking), and the feeding behavior exhibited by the cultured fish.

The feeding behavior of pompano differed from that of the other species observed feeding (i.e., croaker, pinfish, pigfish, and Gulf kingfish), in that pompano congregated at the surface within the feeding ring, and usually remained there, eating continuously, until

all the food was consumed. The other species would swim up within the feeding ring, ingest some food, and immediately return back down. During the latter type of feeding behavior, water currents that pulled the pelleted feed several inches under water were created within the feeding ring. The feeding activity of pompano did not create these water currents; therefore there was no need for a feeding enclosure to extend 20 inches into the cage interior to insure feed retention. The peripheral feeding ring would be a more appropriate design for the culture of pompano in cages.

Since pompano congregated and usually remained at the surface during feeding, available surface feeding area is of importance. The peripheral feeding ring would greatly increase the surface area that could be utilized during feeding, and should reduce competition between fish for available feeding space. During this study, smaller pompano were often seen swimming along the inside perimeter of a cage, while larger fish actively fed within the feeding ring. This apparent lack of interest in feeding may have been the result of inadequate surface feeding area, which allowed the larger and more aggressive fish in the cage to monopolize the available surface feeding space. As a result, smaller pompano probably could not compete for feeding space and refrained from feeding. John Ogle, Department of Wildlife and Fisheries Sciences, Texas A&M University, compared

the acceptability of several cage designs for the culture of pompano (unpublished manuscript). He noted that pompano of poorest final condition, as well as the only emaciated pompano observed during his investigation, were from cages identical to those used during this study (equipped with feeding rings). He concluded that the poor condition of these pompano was the result of the limited surface feeding area available within the feeding rings.

Since the feeding activity of croaker, pinfish, pigfish, and Gulf kingfish did create water currents that pulled the pelleted feed several inches under water, a feeding enclosure that extends well into the cage interior is needed to retain the feed within the cage. Therefore, the feeding rings used during this study were adequate.

However, the observed surface feeding activity of the above species was brief and not consistent from day to day. This may have been the result of low stocking densities. Perhaps sufficient natural food was available within the cage so that the fish were not hunger-stressed and forced to seek supplemental feed. Regardless, evidence did suggest, at least for some croaker and pinfish, that subsurface feeding activity occurred. This is probably true of the other species cultured that were not observed feeding during the study. If this is the case, then installation of submerged feeding trays and the use of

sinking feed may be a more appropriate feeding structure for the culture of these species. Armbrester (1970) has used submerged feeding trays to culture tilapia (Tilapia aurea) in cages.

During this study, three pompano were found dead on cage tops. One of the fish had a puncture wound on the side of the abdomen. These mortalities could have been caused by fish jumping out of the feeding rings during vigorous feeding activity. It is more likely that these mortalities were the result of predation by large birds. Large perching birds were often seen standing or walking about on the tops of cages while searching for food. As previously stated, pompano responded consistently to the cage-tapping stimulus. It is believed that sufficient noise to initiate a feeding response of pompano was probably created as the birds moved about on the cage, and as a result these pompano were the victims of the feeding activity of the birds. A feeding ring cover should be installed to prevent the occurrence of either of the above suggested explanations for the observed mortality.

Organoleptic Evaluation

On a mean score basis, croaker, pinfish, and pompano were rated acceptable. Mean scores for the three species of fish for each of the evaluation categories were not significantly different. This

result was of interest since it was expected that pompano would be rated significantly higher, especially in terms of flavor, than croaker and pinfish. Pompano is generally considered as one of the most delicious of marine fishes and is highly desired (Allen and Avault, 1970; Berry and Iversen, 1967; Finucane, 1970b; Iversen and Berry, 1968; Moe et al., 1967; Pew, 1954).

The fact that pompano were not rated significantly higher than croaker and pinfish may have been due to culturing of the fish. Culturing a fish may improve or reduce its quality. Compared to wild fish, the quality of pompano cultured during this study may have been reduced. Diet (supplemental feeding) could have affected fish quality.

Cobb (1971) has reviewed some of the literature on how specific chemical substances can contribute to the flavor of fish. If these various substances are lacking in the diet, a poorer quality fish is produced. If the supplemental feed used during this study lacked one or more specific chemical substances that impart the highly desired flavor in wild pompano, a poorer flavored pompano would have been produced. In a palatability comparison, Iversen and Berry (1968) implied that wild and cultured adult pompano were alike. The mean flavor scores for wild and cultured pompano were the same, however, mean scores for cultured pompano in the texture, appearance, and

aroma evaluation categories were lower than those for wild pompano. Their cultured pompano were fed a mixture of ground whole fish and commercial trout feed. The inclusion of ground whole fish in the diet could have supplied the chemical substances required to produce good flavor in pompano, and as a result, wild and cultured pompano were rated the same in terms of flavor.

Compared to wild fish, the quality of pompano cultured during this study may have remained unchanged, while the quality of croaker and pinfish may have been improved. This possible change in fish quality may have been the result of diet and/or containment within a cage. Supplemental feeding of croaker and pinfish with trout chow may have increased the quality of the fish. It is also possible that containment within a floating cage, especially for croaker, could have improved fish quality by preventing bottom feeding. The flavor of fish can resemble the material on which the fish feed (Cobb, 1971). If the bottom material on which the fish feed has a foul or bad odor, then the flavor of the fish feeding on such material could be adversely affected. Preventing the ingestion of such material could improve fish flavor. Dr. John Kelley (personal communication) stated that catfish raised in cages appear to be better flavored than catfish raised in ponds where they can feed on the bottom.

If the flavor of fish is reduced as a result of culture (i.e., inadequate diet), the possibility of tailoring the flavor of the fish just prior to harvest exists (Cobb, 1971). Once the chemical substances that contribute to the desired flavor in various high-priced fish species (e.g., pompano) have been identified, it may be possible to "flavor" fish prior to harvesting by adding these desired substances to the fish's diet. Thus, the flavor of cultured fish could be greatly improved. Likewise, it may also be possible to improve the flavor of less desirable fish. Through supplemental flavoring, the flavor of less desired species, which may also be easier to culture, could possibly be made to resemble that of species of better flavor, and thus bring a higher retail price. Ray Monroe (in Cobb, 1971) has indicated that mullet raised with pompano develop a flavor very similar to that of pompano.

It is apparent that more research is needed on the proper diets required to raise good quality fish. It is recommended that future fish culture research include organoleptic evaluations between cultured and wild fish to determine whether fish quality is being adversely or beneficially affected.

Cage Related Observations

With proper maintenance, the cages used during this study could be used in salt water for at least 2 to 3 years before major repair work (i.e., replacing wire baskets affected by corrosion) would be required. Limited use of metal construction materials subject to corrosion is recommended. Further research is needed to test the suitability of vinyl coated wire and plastics for cage construction materials, with special emphasis placed on material longevity and cage weight.

As a result of fouling after 1 year's use, cages from this study increased in weight by about two-fold. This weight increase as well as the damage to some of the flotation material affected the floating level of the cages somewhat. Such cage weight increases could also exert considerable stress on mooring systems.

The damage to cages located in the discharge canal, as well as the problems encountered in trying to maintain a cage in a normal floating position were the result of the high discharge water velocities. Placement of cages in flowing water with velocities greater than about 0.4 m/sec is not recommended because of the excessive lateral pressure exerted on the cages and mooring systems.

Pinfish were very efficient at keeping the wire mesh of cages free from fouling. Swingle (1970) and Swingle and Tatum (1971) have used striped mullet to control fouling of their cages, but remarked that growth of their mullet was poor. Some pinfish cultured during this study grew to sizes that might be acceptable for commercial sale (from about 230 g to 390 g) and could provide an additional retail crop if a market can be established. Quality of these pinfish was comparable to that of pompano and croaker cultured in cages. Pinfish may, therefore, be a more appropriate species for biologically controlling fouling of cages in the marine environment. Study should be directed towards determining the compatability of pinfish in confinement with more desirable culture species (e.g., pompano).

Length-Weight Relationship

For lengths greater than 120 mm, pinfish were heaviest among the fish cultured during this study (Fig. 28). Although length-weight regression lines for silver perch, spot, and black drum were calculated, they are not presented in Figure 28 because it was felt that the number of length-weight observations that were used in the calculation of the lines was inadequate to describe accurately the length-weight relationship of these species cultured in cages. Differences in the length-weight relationship of the species cultured

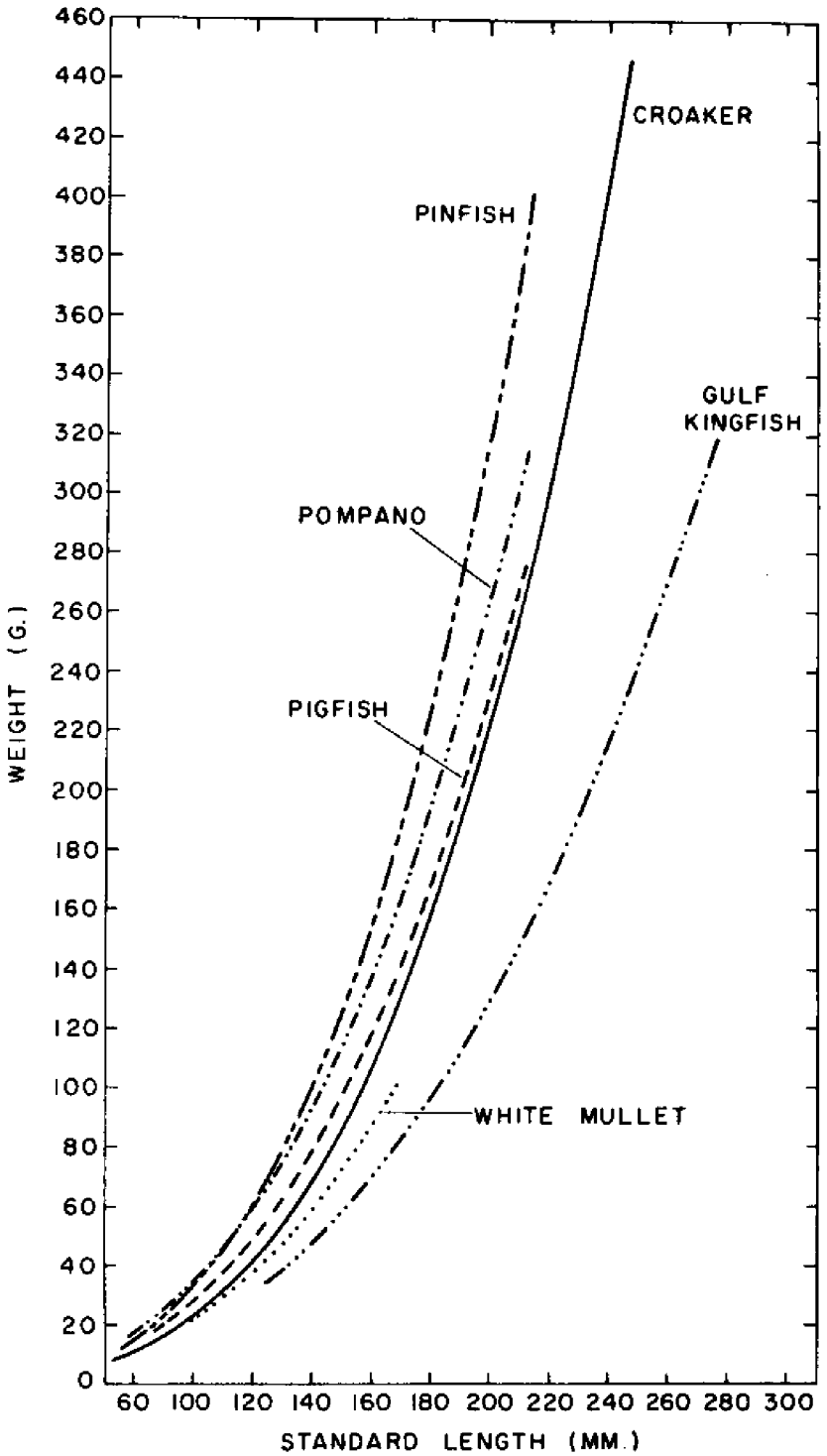

FIGURE 28.--Comparison of the length-weight relationship of croaker, pinfish, pompano, white mullet, pigfish, and Gulf kingfish cultured in cages.

are related to the body form of the fish. For a specific length, weight decreased as body form changed from compressed (greater body depth, e.g., pompano) to fusiform or torpedo shaped (e.g., mullet).

The length-weight relationships of croaker, pinfish, and pompano were compared to those found in the literature. For standard lengths greater than 150 mm, croaker cultured in cages in this study were heavier than those collected from the Mississippi-Louisiana coasts (Dawson, 1965) and Galveston Bay (Parker, 1971), as well as croaker cultured in brackish water ponds in southwest Louisiana (Avault et al.). These weight differences may be partially explained by the different size ranges used in fitting the regression equations and by nutritional differences. Croaker cultured in cages during this study may have attained heavier weights per unit length than those reported above, because they did not have to expend as much energy searching for food (they were supplementally fed) as would the fish occurring naturally. The croaker of Avault et al. were cultured in ponds, but they were not supplementally fed.

The length-weight relationship of pompano cultured in cages from this study was similar to that reported by Iversen and Berry (1968) for pompano raised in tanks at Miami Seaquarium, Florida. These authors

stated that condition of their pompano was better than that of pompano raised in ponds at St. Augustine, Florida.

A comparison of the length-weight relationship of pinfish cultured in cages during this study to those reported by Caldwell (1957) and Cameron (1969) for pinfish from natural environments indicated that cultured pinfish were heavier per unit length. The differences in weights may be partially explained by different size ranges used in fitting the regression lines (size ranges were not indicated by either author) but is more likely the result of nutritional differences. Since they were supplementally fed, pinfish in cages would not have to expend as much energy searching for food as would the fish occurring naturally, and as a result could utilize more food for increasing body weight.

Growth

Fish in the intake canal grew little if at all after water temperatures dropped below about 20 C (from about November 1971 through February 1972). This general cessation of fish growth shows the desirability for utilization of thermal discharges during these colder periods hopefully to extend the growing season of fish. Unfortunately, this possibility was not thoroughly investigated as a result of discharge fish mortality.

After an approximate 90-day comparative culture period, the average weight of pinfish in the discharge canal was significantly higher ($P = 0.01$) than that of pinfish in the intake canal. During approximately the same time period, pinfish in the intake canal increased in average weight by only 5 g, while those in the discharge increased by about 22 g.

Although only preliminary data was obtained, the use of heated discharges to extend the growing season of fish during periods of below optimum water temperatures looks promising and warrants further study. It is hoped that as a result of some of the observations recorded during this study (e.g., the occurrence of GBD in discharge fish), precautionary measures can be taken prior to other fish culture research that will allow the attainment of more conclusive data demonstrating the effect of thermal discharges on fish growth in cages.

Since the feeding of fish other than pompano was infrequently or never observed, attempts to determine whether supplemental feeding affected the growth in weight of croaker, pinfish, and white mullet were needed. The effect of supplemental feeding on the average weight attained by croaker depended upon the initial size of the fish at the beginning of the feeding tests. Considering first the initially large fish (average length of about 181 mm), supplemental feeding

did not affect the final weight attained. However, supplemental feeding did affect the final mean weight attained by initially small croaker (average length about 151 mm). The average weight attained by small croaker receiving supplemental feed was statistically higher than the average weight attained by croaker that were not fed. Supplemental feeding affected the final average weight attained by pinfish. The final average weights of pinfish receiving supplemental feed were statistically higher than the final average weights of pinfish that were not fed. The final average weights attained by white mullet were not affected by supplemental feeding. The pinfish and white mullet tested were of relatively small size. However, these experiments were done during a period when water temperatures were usually below 20 C and as a result the fish did not eat or grow as much at such temperatures.

Evidently, when supplemental feeding did not affect the final mean weights attained by the fish, little or no subsurface ingestion of the feed occurred. It is not known why the supplemental food was not utilized. However, two possible explanations for croaker are a change in food habits and a differential effect of low water temperature on fish of different sizes.

After summarizing the works of various authors, Darnell (1958) concluded that croaker pass through four overlapping but recognizable

food stages as they develop into adults. These food stages, in order of succession, are zooplankton, micro-benthos, detritus, and larger animals. Croaker less than 74 mm specialize on the first two stages, while intermediate size fish (75 to 150 mm) and adult fish (greater than 150 mm) feed on detritus and larger animals, respectively.

It is therefore possible that the supplemental feed offered during this study was acceptable as a food item to only the initially small sized croaker. The larger croaker were presumably in a different food stage, and did not accept the feed.

Older croaker are more sensitive to cold than are younger fish (Hildebrand and Cable, 1930; Schwartz, 1964). The feeding activity and the amount of food required for maintenance of large croaker (older) are probably reduced when water temperatures are low. Therefore, with less food ingested, large croaker that received supplemental feed were not able to utilize fully the additional food that was offered. Large croaker that were not supplementally fed were able to obtain sufficient quantity of natural food within the cage to support gains in weight similar to those of large fed croaker. Since smaller (younger) croaker are less sensitive to cold than are the larger and older fish, feeding activity and the amount of food required for maintenance were not as greatly affected. Therefore, small croaker that were provided with supplemental feed were able

to utilize the additional food and attain a greater average weight than small croaker that were not fed. Natural food was not available in sufficient quantity to meet the needs of the unfed small croaker, and as a result they did not grow as much in weight.

Avault et al. (1969) concluded that croaker cultured in ponds do not accept artificial feed. They discontinued the supplemental feeding of croaker in brackish water ponds after they could find no evidence (by stomach analysis) that the croaker were utilizing the feed. However, the croaker used for stomach analysis were harvested from one of their culture ponds in December 1966, and although no information as to the size of these fish was given, one can assume (based on the results of their culture of croaker in 1968) that these fish were of relatively large size. Similar to this study, their small croaker may have also utilized the artificial feed that they provided.

Some effect of density on the growth in mean weight of pompano was observed. During the period from 3 September to 7 October 1971 and at about one-fourth the density, the relative growth in mean weight of pompano in cage 17 was about two and one-half times greater than the relative growth in mean weight of pompano in cages 12 and 13. The greater increase in weight for pompano at the lower density (cage 17) was probably the result of reduced competition for

available food and surface feeding area. Moe et al. (1968) have shown that increasing the density of pompano fry in confined areas can restrict growth.

Pompano in cages 12 and 13 did not attain as high an average weight as did pompano in cages 20 to 24. This was of interest since there was a difference in the early treatment history of these two groups of fish. All pompano were collected during approximately the same time period off West Beach, Galveston, Texas. Some pompano (those eventually stocked in cages 12 and 13) were transported directly to the intake canal. The remaining fish were transferred to holding facilities at the East Lagoon National Marine Fisheries Service Field Laboratory, Galveston, Texas. The pompano that remained at the East Lagoon Laboratory were utilized by John Ogle (student, Texas A&M University) in a special problems course directed by Dr. David V. Aldrich (Texas A&M Marine Laboratory, Galveston, Texas) to determine the effect of cage design on the survival and growth of pompano. After completion of that project, the pompano were transported to Bacliff and stocked in cages 20 to 24 in the intake canal for the present study.

Differences during the initial confinement of the two groups of fish primarily included a difference in the amount of feed fed, and the salinity of the water. Pompano in cages at the East Lagoon Lab

were fed at a higher percentage rate (20% of body weight) twice per day and were in water of about 8 ppt higher salinity (about 30 ppt) than were pompano in cages in the intake canal (fed at 3% of the total weight of fish in a cage once per day; salinity was about 22 ppt). The differences in the average weights attained by the two groups of fish are possibly related to the amount of feed fed and not to salinity differences. Pompano are usually found in water with a salinity of about 29 ppt or higher (Finucane, 1969a). However, Moe et al. (1968) have demonstrated that pompano can tolerate extreme salinity depressions (salinities as low as 1.27 ppt). Allen and Avault (1970) did not find a correlation between salinity level and survival or growth of juvenile pompano maintained in large aquaria at salinities of 5, 10, 15, and 23 ppt. They concluded that salinity level would probably not limit the culture of pompano in Louisiana. Moe et al. (1968) have also suggested that growth of pompano may actually be greater at low salinities since less metabolic energy would be expended in excreting salts from the body.

To evaluate the growth of cultured fish, comparisons between reported natural growth and growth during culture were made. However, this required the determination of the age of each fish species cultured so that the growth of fish of similar ages could be compared. The ages assigned to fish cultured in cages during this study are not

entirely correct since many cages contained apparent mixed age groupings. This was the result of not sorting the fish for size at the start of the experiments. All fish were utilized for culture tests since some difficulty was experienced in procuring stock. For meaningful comparisons, only those cages containing fish of essentially a single age group were used. These were cages containing croaker, pinfish, pompano, white mullet, spot, and black drum.

At the termination of the culture experiments, croaker in cages 1, 2, 5, 6, and 7 were essentially 1 year of age. The mean size attained was greater than that reported for fish of the same age in nature by Hansen (1970), Hildebrand and Cable (1930), Parker (1971), Pearson (1929), Suttkus (1955), and Welsh and Breder (1923). Size of croaker from this study were comparable to those cultured in brackish water ponds in Louisiana (Avault et al., 1969).

Pinfish in cages 15, 16, 17, 18, 26, and 30, and in cages 3 and 9 were about 1 and 2 years of age, respectively, at the end of the experiments. Cultured pinfish of both age groups attained larger sizes than have been found in nature for fish of these ages by Caldwell (1957) and Hansen (1970).

At the end of experiments, pompano were 6 months to 1 year of age. Growth in weight of pompano from this study (except pompano in cages 12 and 13) was comparable to growth during culture reported

by Berry and Iversen (1967), Finucane (1969b, 1970a, b), and Swingle and Tatum (1971). Growth in weight for cultured pompano appears to average about 30 g/month.

White mullet were primarily young-of-the-year, and attained an average size comparable to that reported for natural growth by Anderson (1957).

Spot and black drum were about 2 years of age at the end of culture. Cultured spot attained a mean size greater than that reported for 2-year-old fish from Texas (Pearson, 1929) and New Jersey (Welsh and Breder, 1923), but were of comparable size to those from Chesapeake Bay (Pacheco, 1957). Black drum cultured in cages attained a mean size similar to that reported for 2-year-old fish in Texas (Pearson, 1929; Simmons and Breuer, 1962). Better growth of cultured fish is most likely the result of a greater availability of food (supplementally fed).

Without the use of thermal effluents to extend the growing season, it does not appear possible to grow on the upper Texas Coast any of the fish tested during the study from juvenile to marketable size (generally considered 1 pound) in cages in less than 1 year. If thermal effluents are used, the average weights of croaker, pompano, and older pinfish may approach marketable size in 1 year's culture. With the exception of pompano, current markets for some of these

fish would not justify the additional expenditure that would be required for their maintenance for a year. However, favorable publicity and advertising may improve the marketing outlook, so research on these species (e.g., croaker and pinfish) should continue.

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APPENDIX

APPENDIX TABLE 1.--Surface temperature values (C) for stations sampled from 3 August 1971 to 25 March 1972.

Date	Stations					
	1	2	3	4	5	6
1971						
8-3	27.0	27.0	27.0	-	-	-
8-5	26.0	26.0	25.5	-	-	-
8-6	27.0	27.0	27.0	-	-	-
8-8	28.0	28.0	28.0	-	-	-
8-9	28.5	28.5	28.5	-	-	-
8-10	28.5	28.5	28.5	-	-	-
8-11	29.0	28.5	28.5	-	-	-
8-12	28.5	28.5	28.5	-	-	-
8-13	29.5	29.5	29.5	-	-	-
8-14	29.5	29.5	29.5	-	-	-
8-16	30.5	30.5	30.5	-	-	-
8-18	29.5	29.5	29.5	-	-	-
8-19	29.5	29.5	29.5	-	-	-
8-20	29.5	29.5	29.5	-	-	-
8-21	30.0	30.0	30.0	-	-	-
8-23	28.5	28.5	28.5	-	-	-
8-24	29.0	29.0	29.0	-	-	-
8-25	30.0	30.0	30.0	-	-	-
8-26	29.5	29.5	29.5	-	-	-
8-27	30.5	30.5	31.0	-	-	-
8-28	31.0	30.8	31.0	-	-	-
8-30	29.0	29.3	29.0	-	-	-
8-31	29.8	29.5	29.5	-	-	-
9-1	27.8	27.5	27.5	-	-	-
9-2	29.0	29.3	29.0	-	-	-
9-4	29.0	29.0	28.9	-	-	-
9-6	28.0	28.0	28.0	-	-	-
9-7	28.2	28.2	28.2	-	-	-
9-8	27.5	27.2	27.0	-	-	-
9-9	26.2	26.2	26.2	-	-	-
9-11	25.5	25.5	25.5	-	-	-
9-13	28.5	28.4	28.9	-	-	-
9-14	26.0	26.0	26.1	-	-	-
9-15	27.0	27.0	27.0	-	-	-
9-17	25.8	25.2	25.5	-	-	-

APPENDIX TABLE 1.--Continued

Date	Stations					
	1	2	3	4	5	6
9-18	26.2	26.2	26.2	-	-	-
9-20	23.1	23.1	23.1	-	-	-
9-21	21.2	21.5	21.5	-	-	-
9-22	23.2	23.0	23.1	-	-	-
9-23	25.0	24.8	24.8	-	-	-
9-24	25.7	25.6	25.6	-	-	-
9-25	26.8	26.8	26.6	-	-	-
9-27	27.4	27.4	27.5	-	-	-
9-28	26.0	25.9	26.1	-	-	-
9-29	27.8	27.8	27.8	-	-	-
9-30	27.2	27.2	27.2	-	-	-
10-1	24.9	24.5	24.9	-	-	-
10-2	27.0	27.0	27.0	-	-	-
10-4	27.1	27.1	27.1	-	-	-
10-5	27.2	27.2	27.2	-	-	-
10-6	26.0	25.8	25.8	-	-	-
10-7	26.1	26.1	26.1	-	-	-
10-8	25.9	25.7	25.7	-	-	-
10-9	25.3	25.2	25.2	-	-	-
10-11	21.0	21.0	21.0	-	-	-
10-12	22.1	22.1	22.1	-	-	-
10-13	21.6	21.9	21.9	-	-	-
10-14	22.8	22.4	22.2	-	-	-
10-15	23.7	23.6	23.7	-	-	-
10-16	24.2	24.2	24.2	-	-	-
10-18	25.2	25.2	25.2	-	-	-
10-19	26.5	26.5	26.2	-	-	-
10-20	26.0	26.0	26.0	-	-	-
10-21	24.5	24.5	24.5	-	-	-
10-22	23.2	23.2	23.2	-	-	-
10-23	23.2	23.2	23.2	-	-	-
10-25	23.1	23.1	23.1	-	-	-
10-26	23.1	23.2	23.5	-	-	-
10-28	23.5	23.5	23.6	-	-	-
10-29	23.8	23.8	23.8	-	-	-
10-30	23.5	23.5	23.5	-	-	-
11-1	26.0	26.0	26.0	-	-	-
11-3	23.0	23.0	23.0	-	-	-

APPENDIX TABLE 1.--Continued

Date	Stations					
	1	2	3	4	5	6
11-4	18.0	18.0	18.0	-	-	-
11-5	18.0	18.0	18.0	-	-	-
11-6	19.0	19.0	19.0	26.2	25.2	25.2
11-8	15.0	15.0	15.0	23.0	23.0	22.0
11-9	17.1	17.1	17.0	26.2	24.9	23.6
11-10	16.0	16.1	16.1	23.8	24.0	24.5
11-11	16.1	16.0	16.1	24.7	25.1	24.6
11-12	17.1	16.9	17.1	-	-	-
11-13	18.8	18.4	18.4	27.2	26.0	25.0
11-15	21.0	21.0	20.9	30.0	29.8	30.0
11-16	21.1	20.9	21.0	31.0	30.0	29.0
11-17	23.5	23.5	23.5	32.8	32.0	32.0
11-18	24.9	24.8	24.2	32.5	31.5	30.0
11-19	17.0	16.9	16.8	-	-	-
11-20	15.0	15.0	15.0	-	-	-
11-22	15.0	14.9	14.9	23.6	23.1	23.1
11-25	11.0	11.0	11.0	18.0	18.0	18.0
11-26	12.1	12.5	12.2	20.8	20.5	20.5
11-27	13.2	13.5	13.4	20.8	20.5	20.2
11-30	14.8	14.8	14.7	22.3	22.0	21.6
12-3	8.9	8.9	8.7	16.1	16.9	17.1
12-8	12.0	12.0	12.0	21.9	22.0	21.9
12-10	-	17.7	17.7	24.0	-	23.4
12-13	-	17.1	17.0	25.0	-	25.0
12-16	-	20.4	20.4	25.1	-	23.9
12-17	-	19.9	19.9	27.3	-	27.1
12-18	-	14.3	14.2	20.8	-	20.6
12-20	-	16.6	16.5	24.0	-	23.6
12-21	-	17.7	17.7	24.0	-	23.3
12-22	-	16.6	16.6	21.0	-	21.0
12-23	-	16.1	16.2	21.2	-	20.1
12-24	-	15.8	15.8	23.1	-	22.2
12-27	-	18.1	18.1	26.2	-	26.5
12-28	-	19.5	19.0	27.0	-	27.0
12-29	-	19.9	19.7	27.8	-	27.8

APPENDIX TABLE 1.--Continued

Date	Stations					
	1	2	3	4	5	6
1972						
1-4	-	15.4	15.6	26.1	-	25.8
1-5	-	5.5	5.6	14.9	-	15.0
1-7	-	8.0	7.8	14.8	-	14.8
1-12	-	13.0	13.7	21.0	-	20.4
1-15	-	9.0	9.1	17.3	-	17.8
1-19	-	12.3	12.1	17.0	-	16.4
1-21	-	15.0	15.1	21.9	-	23.9
1-24	-	18.2	17.8	26.3	-	26.0
1-25	-	16.5	16.2	25.9	-	25.0
1-27	-	15.5	15.7	25.1	-	24.8
1-28	-	16.5	16.5	26.0	-	25.2
2-1	-	6.2	6.2	15.0	-	14.6
2-2	-	7.9	7.4	16.5	-	16.0
2-4	-	7.3	7.0	15.9	-	15.5
2-8	-	7.0	7.0	15.3	-	15.1
2-9	-	6.8	6.7	14.9	-	8.3
2-10	-	9.0	8.5	18.0	-	16.6
2-14	-	6.0	6.0	18.2	-	19.5
2-15	-	13.0	13.0	20.0	-	21.0
2-18	-	13.0	12.9	23.0	-	22.8
2-22	-	15.8	15.8	20.3	-	19.6
2-25	-	20.0	19.8	29.2	-	28.9
2-28	-	19.9	19.5	29.8	-	27.9
3-3	-	17.2	17.2	26.2	-	25.7
3-6	-	15.0	15.0	-	-	-
3-7	-	15.0	14.9	25.8	-	26.1
3-10	-	13.1	12.9	23.2	-	21.9
3-13	-	12.5	11.8	29.0	-	23.0
3-20	-	19.9	19.9	28.5	-	28.3
3-25	-	21.2	22.0	29.5	-	28.3

APPENDIX TABLE 2.--Surface salinity values (ppt) for stations sampled from 3 August 1971 to 25 March 1972.

Date	Stations					
	1	2	3	4	5	6
1971						
8-3	19.8	19.8	19.8	-	-	-
8-5	22.5	22.5	22.5	-	-	-
8-6	21.0	21.0	21.0	-	-	-
8-8	21.0	21.0	21.0	-	-	-
8-9	23.0	23.0	23.0	-	-	-
8-10	20.2	20.2	20.2	-	-	-
8-11	20.3	20.2	20.2	-	-	-
8-12	20.2	20.2	20.2	-	-	-
8-13	22.3	22.3	22.3	-	-	-
8-14	23.0	23.0	23.0	-	-	-
8-16	22.5	22.5	22.5	-	-	-
8-18	21.8	21.8	21.8	-	-	-
8-19	21.8	21.8	21.8	-	-	-
8-20	22.5	22.5	22.5	-	-	-
8-21	22.5	22.5	22.5	-	-	-
8-23	23.0	23.0	23.0	-	-	-
8-24	23.5	23.5	23.5	-	-	-
8-25	23.0	23.0	23.0	-	-	-
8-26	23.1	23.1	23.1	-	-	-
8-27	22.5	22.5	22.5	-	-	-
8-28	22.5	22.5	22.5	-	-	-
8-30	23.0	23.0	23.0	-	-	-
8-31	23.0	23.0	23.0	-	-	-
9-1	23.5	23.5	23.5	-	-	-
9-2	23.5	23.5	23.5	-	-	-
9-4	23.5	23.5	23.5	-	-	-
9-6	21.5	21.5	21.5	-	-	-
9-7	22.8	22.8	22.8	-	-	-
9-8	23.0	23.1	23.2	-	-	-
9-9	21.5	21.5	21.5	-	-	-
9-10	12.5	-	-	-	-	-
9-11	2.6	2.6	2.6	-	-	-
9-13	5.8	5.8	5.0	-	-	-
9-14	11.0	11.0	11.0	-	-	-

APPENDIX TABLE 2.--Continued

Date	Stations					
	1	2	3	4	5	6
9-15	17.0	17.0	17.0	-	-	-
9-16	16.8	16.8	16.8	-	-	-
9-17	17.2	17.2	17.2	-	-	-
9-18	19.1	19.1	19.1	-	-	-
9-20	11.0	11.0	10.0	-	-	-
9-21	13.8	13.8	13.8	-	-	-
9-22	16.6	16.6	16.6	-	-	-
9-23	17.2	17.2	17.2	-	-	-
9-24	18.0	18.0	18.0	-	-	-
9-25	18.0	18.0	18.0	-	-	-
9-27	18.4	18.4	18.4	-	-	-
9-28	18.8	18.8	18.0	-	-	-
9-29	19.5	19.5	19.5	-	-	-
9-30	19.7	19.7	19.7	-	-	-
10-1	20.6	20.6	20.6	-	-	-
10-2	20.4	20.4	20.4	-	-	-
10-4	18.5	18.5	18.5	-	-	-
10-5	17.0	17.0	17.0	-	-	-
10-6	16.5	16.5	16.5	-	-	-
10-7	17.5	17.5	17.5	-	-	-
10-8	18.1	18.1	18.1	-	-	-
10-9	18.0	18.0	18.0	-	-	-
10-11	18.5	18.5	18.5	-	-	-
10-12	18.5	18.5	18.5	-	-	-
10-13	19.1	19.1	19.1	-	-	-
10-14	19.0	19.0	19.0	-	-	-
10-15	18.1	18.1	18.1	-	-	-
10-16	18.5	18.5	18.5	-	-	-
10-18	19.2	19.2	19.2	-	-	-
10-19	18.0	18.0	18.0	-	-	-
10-20	19.5	19.5	19.5	-	-	-
10-21	18.8	18.8	18.8	-	-	-
10-22	19.5	19.5	19.5	-	-	-
10-23	19.5	19.5	19.5	-	-	-
10-25	20.3	20.3	20.3	-	-	-
10-26	20.3	20.3	20.3	-	-	-
10-28	19.1	19.1	19.1	-	-	-

APPENDIX TABLE 2.--Continued

Date	Stations					
	1	2	3	4	5	6
10-29	19.5	19.5	19.5	-	-	-
10-30	19.2	19.2	19.2	-	-	-
11-1	20.0	20.0	20.0	-	-	-
11-3	21.7	21.7	21.7	-	-	-
11-4	21.4	22.0	22.0	-	-	-
11-5	21.1	21.1	21.6	-	-	-
11-6	21.4	21.4	21.4	21.4	21.4	21.4
11-8	22.5	22.5	22.5	22.5	22.5	22.5
11-9	20.0	20.4	20.4	20.6	20.6	20.6
11-10	21.4	21.4	21.4	21.4	21.4	21.4
11-11	20.4	20.4	20.4	21.4	21.4	21.4
11-12	18.8	20.0	20.0	-	-	-
11-13	16.3	16.3	17.2	18.6	18.8	18.8
11-15	17.2	17.2	17.2	18.8	18.8	18.8
11-16	19.5	19.5	19.5	16.5	16.7	17.1
11-17	19.0	19.0	19.0	17.0	17.3	17.3
11-18	16.5	16.5	16.5	15.5	15.6	16.2
11-19	22.2	22.2	22.2	-	-	-
11-20	23.6	23.6	23.6	-	-	-
11-22	21.9	21.9	21.9	19.0	19.5	19.5
11-25	20.0	20.4	20.4	20.0	20.0	20.0
11-26	21.4	21.4	21.4	21.4	21.4	21.4
11-27	20.4	20.4	20.4	20.4	20.4	20.4
11-30	20.0	20.0	20.0	20.4	20.4	20.4
12-3	19.2	20.0	20.0	19.2	20.0	20.0
12-8	17.5	17.5	17.5	15.6	15.6	15.6
12-10	-	-	-	15.6	-	15.8
12-13	-	-	-	12.5	-	12.5
12-16	-	-	-	13.0	-	13.4
12-17	-	-	-	14.2	-	14.2
12-18	-	-	-	16.0	-	16.0
12-20	-	-	-	15.0	-	15.0
12-21	-	-	-	14.3	-	14.3
12-22	-	-	-	14.3	-	14.3
12-23	-	-	-	15.0	-	15.5
12-24	-	14.9	14.9	15.0	-	15.4
12-27	-	14.3	14.3	13.0	-	13.0
12-28	-	13.0	13.0	12.2	-	12.2

APPENDIX TABLE 2.--Continued

Date	Stations					
	1	2	3	4	5	6
12-29	-	12.5	12.5	12.0	-	12.0
1972						
1-4	-	10.1	10.1	9.8	-	9.8
1-5	-	6.6	6.6	5.7	-	5.7
1-7	-	9.5	9.5	10.8	-	10.1
1-12	-	6.8	6.8	6.8	-	6.8
1-15	-	10.1	10.1	9.7	-	9.3
1-19	-	10.1	10.1	8.8	-	9.8
1-21	-	9.5	9.5	8.5	-	8.3
1-24	-	9.5	9.5	9.0	-	9.0
1-25	-	10.6	10.6	9.8	-	10.0
1-27	-	10.0	10.0	10.8	-	10.8
1-28	-	11.5	11.5	10.3	-	10.8
2-1	-	8.2	8.2	8.0	-	8.0
2-2	-	5.2	5.2	6.3	-	6.3
2-4	-	6.2	6.2	6.3	-	6.2
2-8	-	9.6	9.6	9.5	-	9.5
2-9	-	9.0	9.0	8.7	-	10.1
2-10	-	10.2	10.2	9.3	-	9.4
2-14	-	7.2	7.2	6.7	-	6.3
2-15	-	8.2	8.2	8.3	-	8.1
2-18	-	9.2	9.2	8.3	-	8.3
2-22	-	10.2	10.2	10.4	-	10.4
2-25	-	10.6	10.6	10.6	-	10.6
2-28	-	14.2	14.2	13.3	-	13.3
3-3	-	14.0	14.0	14.0	-	14.0
3-6	-	11.8	11.8	-	-	-
3-7	-	14.2	14.2	14.2	-	14.2
3-10	-	16.5	16.5	14.5	-	14.5
3-13	-	18.0	18.0	18.0	-	18.0
3-20	-	14.0	14.0	13.2	-	13.2
3-25	-	15.0	15.0	-	-	-

APPENDIX TABLE 3.--Surface dissolved oxygen values (ppm) for stations sampled from 3 August 1971 to 25 March 1972.

Date	Stations					
	1	2	3	4	5	6
1971						
8-3	4.0	4.5	4.5	-	-	-
8-5	4.0	4.3	4.4	-	-	-
8-6	5.7	5.7	5.7	-	-	-
8-8	6.5	6.5	6.8	-	-	-
8-9	5.5	5.2	5.2	-	-	-
8-10	6.3	6.5	6.4	-	-	-
8-11	5.5	-	-	-	-	-
8-12	4.0	4.0	4.0	-	-	-
8-13	5.8	5.8	6.0	-	-	-
8-18	5.5	5.5	5.5	-	-	-
8-19	5.5	6.0	5.8	-	-	-
8-20	6.6	6.0	6.0	-	-	-
8-21	5.5	5.5	6.0	-	-	-
8-23	4.5	5.1	5.4	-	-	-
8-24	4.5	4.5	5.0	-	-	-
8-25	6.0	6.0	6.0	-	-	-
8-26	6.0	7.0	6.5	-	-	-
8-27	5.9	5.9	6.4	-	-	-
8-30	6.0	6.0	5.9	-	-	-
9-1	5.6	5.1	5.4	-	-	-
9-2	5.4	5.6	5.6	-	-	-
9-4	5.5	5.8	5.6	-	-	-
9-6	5.5	4.6	5.0	-	-	-
9-7	5.2	5.4	5.6	-	-	-
9-8	5.8	5.8	6.0	-	-	-
9-9	10.0	9.7	12.5	-	-	-
9-11	4.8	4.9	4.9	-	-	-
9-13	5.8	5.6	5.8	-	-	-
9-14	5.8	6.1	6.1	-	-	-
9-15	7.0	6.2	6.3	-	-	-
9-17	6.9	6.6	6.8	-	-	-
9-18	5.8	6.1	6.2	-	-	-
9-20	6.8	7.4	7.4	-	-	-
9-21	5.6	5.5	5.6	-	-	-

APPENDIX TABLE 3.--Continued

Date	Stations					
	1	2	3	4	5	6
9-22	6.4	6.4	6.5	-	-	-
9-23	7.0	7.0	6.8	-	-	-
9-24	6.4	6.7	6.8	-	-	-
9-25	8.7	9.3	9.2	-	-	-
9-27	7.6	7.6	7.4	-	-	-
9-28	5.5	5.7	5.7	-	-	-
9-29	6.7	7.5	7.6	-	-	-
9-30	6.2	6.8	6.2	-	-	-
10-1	10.6	10.2	10.0	-	-	-
10-2	7.4	7.6	7.6	-	-	-
10-4	7.5	7.6	7.7	-	-	-
10-5	7.6	8.4	8.4	-	-	-
10-6	7.8	7.7	7.9	-	-	-
10-7	7.0	7.6	7.9	-	-	-
10-8	7.5	7.9	8.3	-	-	-
10-9	6.5	7.3	7.5	-	-	-
10-11	8.4	8.4	8.2	-	-	-
10-12	8.0	8.2	8.2	-	-	-
10-13	8.0	8.1	7.8	-	-	-
10-14	8.5	8.7	8.9	-	-	-
10-15	8.4	8.4	8.5	-	-	-
10-16	7.5	7.5	7.2	-	-	-
10-18	8.5	8.6	9.7	-	-	-
10-19	6.5	6.9	6.5	-	-	-
10-20	7.6	7.9	7.8	-	-	-
10-21	7.3	7.0	7.4	-	-	-
10-22	8.6	9.0	9.0	-	-	-
10-23	8.2	8.4	8.4	-	-	-
10-25	8.5	8.6	8.9	-	-	-
10-26	8.2	8.2	8.4	-	-	-
10-28	7.6	7.6	7.4	-	-	-
10-29	7.4	7.2	6.8	-	-	-
10-30	7.9	7.5	6.9	-	-	-
11-3	5.7	6.1	5.9	-	-	-
11-4	6.3	6.4	6.4	-	-	-
11-5	7.4	7.4	7.5	-	-	-
11-6	8.1	8.3	8.4	7.4	7.2	7.2

APPENDIX TABLE 3.--Continued

Date	Stations					
	1	2	3	4	5	6
11-8	7.9	7.4	7.3	5.7	5.7	5.8
11-9	8.6	8.4	9.8	6.4	6.4	6.3
11-22	8.2	8.1	8.6	6.8	7.2	7.2
11-25	8.7	8.4	8.4	6.8	6.6	6.3
11-26	7.4	6.8	6.8	6.3	6.2	6.0
11-27	8.2	8.0	8.0	6.9	6.7	6.7
11-30	8.7	8.6	8.6	7.4	7.2	6.9
12-10	-	-	-	6.8	-	7.4
12-13	-	-	-	8.4	-	8.8
12-13	-	-	-	8.4	-	8.8
12-16	-	-	-	7.6	-	7.0
12-17	-	-	-	9.4	-	9.5
12-18	-	-	-	9.8	-	9.8
12-20	-	-	-	10.2	-	9.6
12-21	-	-	-	10.4	-	10.2
12-22	-	-	-	10.5	-	12.0
12-23	-	-	-	9.3	-	9.2
12-24	-	8.7	8.2	6.8	-	7.6
12-27	-	8.4	7.9	6.4	-	7.0
12-28	-	10.4	10.2	8.1	-	8.5
12-29	-	15.1	12.5	5.7	-	4.7
1972						
1-4	-	8.4	8.3	8.0	-	7.3
1-5	-	8.6	8.6	8.3	-	8.1
1-7	-	10.2	10.3	10.2	-	10.0
1-12	-	11.5	15.0	15.7	-	15.6
1-15	-	12.0	12.0	14.9	-	13.2
1-19	-	7.8	7.6	6.1	-	6.2
1-21	-	13.7	15.6	17.0	-	17.0
1-24	-	12.0	12.7	12.6	-	12.7
1-25	-	7.0	7.4	7.2	-	6.9
1-27	-	9.0	8.3	8.2	-	7.9
1-28	-	9.7	10.5	10.3	-	9.7
2-1	-	11.5	12.5	12.4	-	11.7
2-2	-	12.0	18.5	13.6	-	13.6

APPENDIX TABLE 3.--Continued

Date	Stations					
	1	2	3	4	5	6
2-4	-	10.2	10.6	12.2	-	12.1
2-8	-	12.6	12.4	13.0	-	12.2
2-9	-	11.7	13.0	14.9	-	15.2
2-10	-	10.5	13.5	13.4	-	14.3
2-14	-	15.5	17.5	11.7	-	11.7
2-15	-	15.2	15.0	12.8	-	13.3
2-18	-	10.0	9.6	6.3	-	6.4
2-22	-	7.5	7.3	8.4	-	7.5
2-25	-	7.5	7.5	5.9	-	5.8
2-28	-	6.4	9.8	4.3	-	4.6
3-3	-	7.9	7.7	7.4	-	7.2
3-6	-	7.9	8.0	-	-	-
3-7	-	8.0	8.0	5.9	-	5.9
3-10	-	8.1	7.6	6.1	-	6.0
3-13	-	8.8	9.0	5.1	-	6.4
3-20	-	7.4	7.9	7.4	-	7.3
3-25	-	6.3	6.0	4.9	-	5.5

APPENDIX TABLE 4.--Surface pH values for stations sampled from 3 August 1971 to 25 March 1972.

Date	Stations					
	1	2	3	4	5	6
1971						
8-3	7.30	7.30	7.10	-	-	-
8-5	8.35	8.25	8.25	-	-	-
8-6	8.00	8.00	7.80	-	-	-
8-8	7.60	7.60	7.70	-	-	-
8-9	8.65	8.65	8.70	-	-	-
8-10	8.78	8.72	8.71	-	-	-
8-11	7.15	7.08	7.05	-	-	-
8-12	7.90	7.40	7.50	-	-	-
8-13	8.60	8.65	8.70	-	-	-
8-14	8.68	8.68	8.68	-	-	-
8-16	8.80	8.70	8.75	-	-	-
8-18	8.75	8.73	8.80	-	-	-
8-19	8.78	8.75	8.85	-	-	-
8-20	8.81	8.80	8.82	-	-	-
8-21	8.81	8.75	8.85	-	-	-
8-23	8.77	8.70	8.69	-	-	-
8-24	8.68	8.62	8.68	-	-	-
8-25	8.71	8.73	8.79	-	-	-
8-26	8.74	8.79	8.79	-	-	-
8-27	8.80	8.81	8.80	-	-	-
8-28	8.81	8.80	8.81	-	-	-
8-30	8.78	8.78	8.85	-	-	-
8-31	8.79	8.79	8.80	-	-	-
9-1	8.77	8.76	8.70	-	-	-
9-2	8.78	8.78	8.84	-	-	-
9-4	8.80	8.78	8.83	-	-	-
9-6	8.56	8.69	8.63	-	-	-
9-7	8.70	8.69	8.67	-	-	-
9-8	8.68	8.64	8.60	-	-	-
9-9	8.63	8.61	8.61	-	-	-
9-11	8.10	8.00	8.20	-	-	-
9-13	8.25	8.00	8.25	-	-	-
9-14	8.44	8.35	8.52	-	-	-
9-15	8.71	8.64	8.68	-	-	-

APPENDIX TABLE 4.--Continued

Date	Stations					
	1	2	3	4	5	6
9-16	8.60	8.60	8.59	-	-	-
9-17	8.63	8.68	8.65	-	-	-
9-18	8.65	8.68	8.65	-	-	-
9-20	8.58	8.58	8.50	-	-	-
9-21	8.60	8.60	8.59	-	-	-
9-22	8.55	8.60	8.59	-	-	-
9-23	8.55	8.72	8.65	-	-	-
9-24	8.68	8.68	8.64	-	-	-
9-25	8.74	8.81	8.73	-	-	-
9-27	8.71	8.67	8.68	-	-	-
9-28	8.68	8.68	8.71	-	-	-
9-29	8.78	8.74	8.69	-	-	-
9-30	8.76	8.71	8.75	-	-	-
10-1	8.67	8.70	8.71	-	-	-
10-2	8.63	8.59	8.65	-	-	-
10-4	8.59	8.61	8.57	-	-	-
10-5	8.50	8.60	8.51	-	-	-
10-6	8.49	8.52	8.48	-	-	-
10-7	8.60	8.58	8.62	-	-	-
10-8	8.55	8.62	8.62	-	-	-
10-9	8.65	8.63	8.68	-	-	-
10-11	8.51	8.63	8.59	-	-	-
10-12	8.65	8.67	8.65	-	-	-
10-13	8.55	8.65	8.62	-	-	-
10-14	8.63	8.70	8.68	-	-	-
10-15	8.69	8.60	8.71	-	-	-
10-16	8.62	8.66	8.62	-	-	-
10-18	8.49	8.58	8.57	-	-	-
10-19	8.60	8.70	8.60	-	-	-
10-20	8.58	8.58	8.64	-	-	-
10-21	8.53	8.70	8.58	-	-	-
10-22	8.50	8.50	8.55	-	-	-
10-23	8.60	8.59	8.66	-	-	-
10-25	8.61	8.68	8.68	-	-	-
10-26	8.60	8.66	8.63	-	-	-
10-28	8.65	8.63	8.61	-	-	-
10-29	8.69	8.68	8.67	-	-	-

APPENDIX TABLE 4.--Continued

Date	Stations					
	1	2	3	4	5	6
10-30	8.61	8.62	8.62	-	-	-
11-1	8.68	8.68	8.60	-	-	-
11-3	8.45	8.55	8.60	-	-	-
11-4	8.58	8.60	8.48	-	-	-
11-5	8.62	8.59	8.66			
11-6	8.59	8.73	8.71	8.61	8.69	8.66
11-8	8.45	8.60	8.69	8.62	8.65	8.71
11-9	8.65	8.60	8.69	8.62	8.62	8.62
11-10	8.65	8.64	8.60	8.55	8.65	8.63
11-11	8.68	8.64	8.65	8.67	8.72	8.63
11-12	8.65	8.69	8.60	-	-	-
11-13	8.60	8.68	8.56	8.60	8.63	8.62
11-15	8.60	8.63	8.57	8.48	8.60	8.58
11-16	8.52	8.55	8.55	8.52	8.60	8.60
11-17	8.60	8.63	8.58	8.66	8.64	8.60
11-18	8.53	8.55	8.56	8.55	8.62	8.60
11-19	8.57	8.55	8.55	-	-	-
11-20	8.73	8.51	8.58	-	-	-
11-22	8.55	8.60	8.50	8.63	8.60	8.67
11-25	8.60	8.60	8.58	8.75	8.52	8.59
11-26	8.60	8.43	8.48	8.51	8.42	8.43
11-27	8.57	8.61	8.60	8.61	8.66	8.65
11-30	8.62	8.63	8.68	8.68	8.60	8.65
12-3	8.58	8.60	8.55	8.50	8.56	8.60
12-8	8.64	8.68	8.65	8.72	8.69	8.64
12-10	-	-	-	8.68	-	8.61
12-13	-	-	-	8.72	-	8.68
12-16	-	-	-	8.74	-	8.67
12-17	-	-	-	8.82	-	8.85
12-18	-	-	-	8.68	-	8.78
12-20	-	-	-	8.68	-	8.68
12-21	-	-	-	8.78	-	8.80
12-22	-	-	-	8.86	-	8.84
12-23	-	-	-	8.76	-	8.78
12-24	-	8.71	8.68	8.69	-	8.72
12-27	-	8.83	8.82	8.85	-	8.86
12-28	-	9.05	8.98	8.92	-	9.04

APPENDIX TABLE 4.--Continued

Date	Stations					
	1	2	3	4	5	6
12-29	-	9.10	9.08	9.14	-	9.20
1972						
1-4	-	8.73	8.71	8.68	-	8.70
1-5	-	6.79	6.78	8.55	-	8.61
1-7	-	8.60	8.66	8.65	-	8.73
1-12	-	8.72	8.61	8.73	-	8.76
1-15	-	8.80	8.80	8.75	-	8.82
1-19	-	8.85	8.88	8.90	-	8.91
1-21	-	8.90	8.88	8.85	-	8.89
1-24	-	8.85	8.81	8.75	-	8.85
1-25	-	8.75	8.70	8.31	-	8.42
1-27	-	8.73	8.71	8.70	-	8.74
1-28	-	8.66	8.69	8.61	-	8.72
2-1	-	8.46	8.49	8.50	-	8.50
2-2	-	8.40	8.40	8.57	-	8.53
2-4	-	8.51	8.48	8.60	-	8.54
2-8	-	8.56	8.58	8.51	-	8.52
2-9	-	8.59	8.60	8.60	-	8.61
2-10	-	8.68	8.72	8.75	-	8.77
2-14	-	8.89	8.82	8.93	-	8.88
2-15	-	8.95	9.00	8.99	-	9.05
2-18	-	8.72	8.82	8.82	-	8.90
2-22	-	8.85	8.86	8.69	-	8.86
2-25	-	8.73	8.80	8.70	-	8.76
2-28	-	8.69	8.71	8.60	-	8.63
3-3	-	8.52	8.52	8.60	-	8.59
3-6	-	8.56	8.62	-	-	-
3-7	-	8.52	8.59	8.60	-	8.58
3-10	-	8.49	8.43	8.51	-	8.49
3-13	-	8.49	8.51	8.49	-	8.51
3-20	-	8.45	8.56	8.58	-	8.53
3-25	-	8.52	8.59	8.53	-	8.56

APPENDIX TABLE 5.--Water velocity values (m/sec) for stations sampled from 31 August 1971 to 25 March 1972.

Date	Stations					
	1	2	3	4	5	6
1971						
8-31	.326	.270	.209	-	-	-
9-1	.246	.283	.300	-	-	-
9-4	.147	.300	.373	-	-	-
9-6	.073	.288	.250	-	-	-
9-7	.130	.307	.340	-	-	-
9-8	.097	.250	.304	-	-	-
9-11	.000	.259	.366	-	-	-
9-13	.000	.214	.545	-	-	-
9-20	.002	.373	.345	-	-	-
9-21	.095	.261	.269	-	-	-
9-22	.080	.247	.280	-	-	-
9-23	.207	.357	.538	-	-	-
9-24	.047	.247	.238	-	-	-
9-25	.066	.430	.321	-	-	-
9-27	.150	.280	.278	-	-	-
9-29	.233	.328	.340	-	-	-
9-30	.171	.269	.278	-	-	-
10-1	.090	.326	.369	-	-	-
10-2	.035	.330	.316	-	-	-
10-4	.007	.152	.192	-	-	-
10-5	.000	.407	.302	-	-	-
10-6	.002	.304	.309	-	-	-
10-7	.076	.259	.269	-	-	-
10-8	.026	.278	.259	-	-	-
10-9	.045	.230	.254	-	-	-
10-11	.023	.123	.276	-	-	-
10-13	.033	.292	.290	-	-	-
10-14	.042	.269	.264	-	-	-
10-15	.071	.304	.328	-	-	-
10-16	.164	.352	.304	-	-	-
10-18	.116	.369	.330	-	-	-
10-19	.121	.397	.269	-	-	-
10-20	.026	.283	.271	-	-	-
10-21	.109	.292	.264	-	-	-

APPENDIX TABLE 5.--Continued

Date	Stations					
	1	2	3	4	5	6
10-22	.052	.269	.250	-	-	-
10-23	.045	.228	.221	-	-	-
10-25	.116	.388	.292	-	-	-
10-26	.085	.395	.280	-	-	-
10-28	.111	.369	.302	-	-	-
10-29	.097	.319	.257	-	-	-
10-30	.057	.259	.285	-	-	-
11-1	.119	.273	.302	-	-	-
11-3	.102	.304	.195	-	-	-
11-4	.069	.254	.390	-	-	-
11-5	.071	.204	.223	-	-	-
11-6	.035	.273	.254	.628	.773	.466
11-8	.009	.364	.271	.659	.754	.473
11-9	.085	.259	.238	.564	.838	.369
11-10	.016	.250	.278	.602	.681	.326
11-11	.045	.230	.238	.581	.681	.338
11-12	.028	.307	.264	-	-	-
11-13	.088	.340	.261	.826	.842	.490
11-15	.045	.321	.030	.604	.752	.469
11-16	.047	.373	.209	.600	.728	.409
11-17	.021	.328	.233	.526	.726	.350
11-18	.004	.211	.147	.419	.742	.380
11-19	.021	.207	.152	-	-	-
11-20	.026	.188	.159	-	-	-
11-22	.066	.247	.195	.404	.561	.280
11-25	.004	.221	.161	.395	.547	.438
11-26	.033	.161	.080	.380	.516	.347
11-27	.040	.195	.173	.364	.573	.350
11-30	.071	.242	.271	.400	.547	.314
12-3	.128	.323	.228	.152	.500	.352
12-8	.069	.221	.188	.188	.421	.271
12-10	-	-	-	.402	-	.342
12-13	-	-	-	.342	-	.261
12-16	-	-	-	.326	-	.252
12-17	-	-	-	.335	-	.219
12-18	-	-	-	.397	-	.395
12-20	-	-	-	.352	-	.326

APPENDIX TABLE 5.--Continued

Date	Stations					
	1	2	3	4	5	6
12-21	-	-	-	.359	-	.319
12-22	-	-	-	.476	-	.347
12-23	-	-	-	.276	-	.204
12-24	-	.223	.197	.361	-	.280
12-27	-	.323	.195	.428	-	.283
12-28	-	.292	.192	.445	-	.309
12-29	-	.211	.080	.421	-	.288
1972						
1-4	-	.252	.169	.326	-	.266
1-5	-	.230	.150	.342	-	.228
1-7	-	.314	.207	.478	-	.261
1-12	-	.345	.119	.369	-	.240
1-15	-	.278	.242	.457	-	.207
1-19	-	.311	.295	.709	-	.488
1-21	-	.216	.257	.754	-	.483
1-24	-	.292	.269	.678	-	.473
1-25	-	.176	.054	.461	-	.271
1-27	-	.133	.109	.490	-	.395
1-28	-	.033	.095	.366	-	.290
2-1	-	.014	.123	.357	-	.219
2-2	-	.095	.228	.478	-	.295
2-4	-	.069	.102	.469	-	.288
2-8	-	.023	.038	.433	-	.204
2-9	-	.223	.200	.647	-	.052
2-10	-	.100	.100	.452	-	.252
2-14	-	.119	.252	.566	-	.311
2-15	-	.104	.176	.509	-	.080
2-18	-	.104	.173	.404	-	.338
2-22	-	.238	.223	.661	-	.442
2-25	-	.119	.152	.447	-	.357
2-28	-	.057	.116	.376	-	.342
3-3	-	.023	.014	.390	-	.319
3-6	-	.071	.061	-	-	-
3-7	-	.014	.109	.538	-	.323
3-10	-	.102	.073	.480	-	.304

APPENDIX TABLE 5.--Continued

Date	Stations					
	1	2	3	4	5	6
3-13	-	.219	.133	.747	-	.428
3-20	-	.085	.052	.509	-	.390
3-25	-	.014	.009	.088	-	.047

APPENDIX TABLE 6.--Standard lengths and total lengths in millimeters used for computing the standard length-total length conversion equation for *Micropogon undulatus* caught in Galveston Bay, March-May 1972.

Standard length	Total length	Standard length	Total length	Standard length	Total length
89	113	66	85	53	69
75	96	63	81	62	81
85	110	80	100	62	80
89	114	82	104	67	86
76	100	80	100	61	79
80	103	73	93	58	76
84	106	72	90	73	93
87	116	65	84	58	77
91	115	60	79	69	89
80	106	57	75	56	73
85	111	59	77	62	81
78	102	63	83	69	78
89	116	72	92	64	83
82	104	70	90	65	83
85	105	80	100	54	70
80	105	60	79	69	90
79	103	65	84	55	72
92	119	66	88	64	82
85	108	75	98	93	118
82	104	65	84	84	108
80	103	61	80	88	113
82	105	55	73	89	113
55	72	70	90	88	114
90	114	61	80	85	109
94	116	78	98	84	109
92	116	65	84	80	105
87	109	60	79	88	112
67	85	54	70	75	98
95	119	62	80	91	116
62	80	61	80	48	62
60	76	45	58	65	83
44	58	45	58	51	65
57	75	48	60	44	57
42	56	43	56	28	35

APPENDIX TABLE 6.--Continued

Standard length	Total length	Standard length	Total length	Standard length	Total length
52	67	48	62	39	51
47	61	40	51	42	55
55	70	41	53	34	44
49	63	39	50	47	61
39	51	47	60	58	76
46	60	39	49	40	51
42	56	46	58	66	85
42	55	44	57	45	57
44	58	54	69	40	51
52	67	43	55	47	59
50	64	48	61	44	57
42	54	48	62	45	58
40	52	45	58	34	45
69	89	41	54	40	51
43	55	48	64	40	51
52	68	66	84	36	47
36	46	51	65	39	51
44	57	51	65	57	72
42	55	46	60	60	77
44	57	47	62	46	56
41	54	49	64	57	73
37	45	43	55	41	53
42	55	34	44	34	44
57	74	38	49	58	78
49	64	40	51	37	48
52	67	130	162	112	145
47	60	106	131	131	166
49	63	144	180	151	190
46	61	119	144	130	163
50	65	115	146	121	150
56	70	114	145	126	157
41	52	125	157	142	175
48	60	110	133	110	141
45	59	135	167	159	199
42	53	131	167	127	160
110	140	115	146	145	180

APPENDIX TABLE 6.--Continued

Standard length	Total length	Standard length	Total length	Standard length	Total length
140	173	155	192	145	184
158	194	137	170	127	161
145	182	145	172	130	164
147	185	135	169	142	175
140	175	136	165	134	169
120	152	130	163	120	151
134	168	117	145	138	172
142	177	130	152	136	170
135	169	129	160	139	175
138	171	139	174	120	151
152	189	143	176	128	162
145	180	152	188	103	131
122	154	152	188	106	132
120	153	110	139	105	135
135	170	144	177		
103	132	138	173		
136	170	136	171		
102	129	139	171		
185	229	168	204		
218	260	172	208		
219	258	170	209		
230	276	186	223		
198	240	205	248		
185	223	215	262		
204	245	192	235		
255	299	199	238		
186	230				
168	204				
203	249				
215	262				
200	237				
193	236				
255	305				
181	222				
192	234				

APPENDIX TABLE 6.--Continued

Standard length	Total length	Standard length	Total length	Standard length	Total length
185	225				
187	229				
178	218				
205	245				
205	248				
180	215				
193	235				
209	254				
226	270				
178	222				
199	238				
193	238				

APPENDIX TABLE 7.--Standard length in millimeters and weight in grams recorded for croaker in cage 1 from 21 July to 29 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	100	19	100	22	165	93
	92	21	99	24	112	35
	165	95	112	38	185	133
	118	41	85	15	75	21
	100	23	94	23	102	23
	99	31	85	17	100	22
	125	35	116	36	111	30
	112	28	97	21	131	58
	133	58				
9-15-71	173	158	160	108	178	172
	170	134	150	93	153	96
	144	74	148	79	158	104
	193	168	160	94	155	96
	149	82	160	116	162	111
	160	114	160	108	155	98
	185	140	147	84	150	100
	158	102	179	138		
10- 6-71	168	108	156	104	159	108
	185	208	183	174	180	197
	181	158	162	120	174	146
	158	102	163	124	197	195
	161	114	170	134	152	88
	170	135	172	149	173	145
	197	210	170	140	172	136
11-11-71	174	140	176	154	190	197
	168	138	170	144	186	192
	165	120	190	193	200	220
	194	195	178	161	175	132
	211	264	185	168	190	222
	185	178	188	192	168	132
	161	114	181	175	185	219

APPENDIX TABLE 7.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11-29-71	176	142	186	183	190	190
	168	135	189	213	190	195
	168	131	212	250	185	212
	200	216	176	154	178	166
	175	128	188	175	193	188
	192	193	185	163	177	150
	166	116	172	146	163	114

APPENDIX TABLE 8.--Standard length in millimeters and weight in grams recorded for croaker in cage 2 from 21 July to 29 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	106	24	97	21	80	14
	90	18	94	20	101	24
	90	17	94	22	100	22
	92	16	89	14	94	18
	96	23	84	15	101	25
	102	27	82	18	119	41
	96	18	124	44	168	89
	87	17	105	28	149	74
	75	19				
9- 8-71	162	118	148	94	157	112
	149	91	147	70	149	89
	166	125	167	131	144	77
	190	161	141	82	152	91
	142	67	160	115	168	116
	150	84	137	80	158	115
	139	72	152	90	155	96
10- 6-71	165	120	164	118	173	157
	177	174	198	184	176	160
	178	174	171	127	164	116
	155	109	177	141	167	132
	170	128	153	104	174	136
	167	139	178	176	160	116
	165	119	165	130		
11-11-71	178	160	166	132	184	158
	185	196	185	164	185	196
	181	159	163	126	173	153
	205	220	185	150	178	143
	187	202	184	171	176	144
	180	172	183	175	184	162
	177	144	188	192		

APPENDIX TABLE 8.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11-29-71	185	194	185	156	190	168
	186	188	175	140	189	198
	167	126	175	148	185	158
	185	170	180	144	184	152
	186	192	176	144	206	212
	180	171	165	124	185	175
	180	160	182	156		

APPENDIX TABLE 9.--Standard length in millimeters and weight in grams recorded for pinfish in cage 3 from 21 July to 27 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	170	170	172	182	164	184
	163	146	175	177	140	93
	149	110	156	125	155	103
	148	102	146	107	144	104
	150	118	157	127	156	143
	159	153	129	74	142	90
	153	144	139	140	127	125
	160	134	132	75	173	180
	75	16				
9- 8-71	189	243	179	223	178	206
	165	170	170	186	162	164
	193	288	173	213	176	222
	182	204	176	208	179	216
	176	220	163	176	178	254
	178	228	186	268	170	199
	172	218	127	80	171	195
	163	169	165	174		
10- 8-71	202	320	184	245	170	195
	174	224	181	231	180	243
	174	208	188	272	182	234
	176	206	187	264	183	242
	185	266	183	231	188	266
	172	202	184	248	168	186
	170	197	187	236	182	273
	140	114	176	222		
11-13-71	192	276	190	296	195	305
	188	284	184	265	182	230
	191	286	202	340	185	239
	160	165	214	390	192	275
	195	260	190	290	195	290
	185	258	191	326	196	301

APPENDIX TABLE 9.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	185	278	180	238	193	268
	182	254	177	224		
11-27-71	178	212	185	242	192	261
	180	212	195	264	195	291
	191	306	189	274	194	246
	184	221	191	259	191	272
	200	316	189	266	212	323
	190	268	195	292	190	177
	185	268	184	242	185	252
	180	214	163	167		

APPENDIX TABLE 10.--Standard length in millimeters and weight in grams recorded for silver perch in cage 4 from 21 July to 17 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	158	74	158	91	172	142
	154	79	165	101	158	93
	155	98	120	38	163	113
	143	60				
9- 8-71	156	64	156	70	126	47
	163	87				
10- 6-71	158	66	155	72	165	91
	131	58				
11-17-71	160	70	132	58	155	74
	155	96				

APPENDIX TABLE 11.--Standard length in millimeters and weight in grams recorded for croaker in cage 5 from 21 July to 29 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	108	29	115	32	103	24
	102	24	104	32	95	18
	111	28	128	46	115	28
	105	26	99	21	98	21
	99	22	89	16	86	14
	110	30	94	16	86	14
	110	30	94	16	120	34
	93	18	184	138	104	24
	92	18	104	23	127	35
	156	33				
9- 8-71	160	114	153	95	162	118
	194	180	156	108	161	116
	159	100	158	104	160	115
	164	122	155	102	148	85
	155	100	146	80	142	76
	165	129	147	98	148	74
	140	72	148	90	156	104
	153	104	150	98		
10- 6-71	176	181	163	142	172	156
	177	168	171	142	169	145
	175	157	150	84	201	225
	165	136	163	123	172	157
	170	149	176	150	170	124
	181	160	171	135	162	114
	177	160	171	147	161	119
	174	142	160	121		
11-11-71	166	112	205	260	185	234
	190	210	185	179	183	180
	185	184	177	160	200	219
	183	192	184	204	179	160
	177	173	194	192	191	228
	190	196	177	184	173	149

APPENDIX TABLE 11.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	165	140	178	154	187	198
	196	211	186	152		
11-29-71	176	170	180	152	172	144
	186	176	183	200	187	192
	192	204	187	174	187	191
	187	180	203	220	203	252
	191	192	197	211	186	175
	184	232	193	223	163	136
	194	190	175	159	177	178
	179	154	164	114		

APPENDIX TABLE 12.--Standard length in millimeters and weight in grams recorded for croaker in cage 6 from 21 July to 11 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	99	21	92	18	95	18
	135	30	182	120	102	23
	96	20	90	16	159	83
	97	18	117	22	116	20
	99	15	118	84	89	20
	111	23	89	15	117	31
	115	33	100	18	140	58
	129	44	104	22	101	19
	100	18				
9- 8-71	162	114	206	226	153	88
	149	94	134	66	154	102
	146	96	146	91	162	122
	137	62	138	69	153	108
	156	95	164	119	193	204
	178	149	153	83	140	80
	160	121	150	94	153	106
	158	104	167	128	152	91
10- 6-71	161	107	174	167	166	114
	185	186	170	125	203	266
	175	158	163	114	165	134
	172	154	173	140	155	121
	163	126	177	150	215	283
	162	128	171	132	157	100
	178	167	155	100	177	161
	183	167	161	97	166	132
11-11-71	169	130	160	124	182	176
	185	186	168	134	190	184
	180	162	176	142	170	116

APPENDIX TABLE 12.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	179	186	192	200	173	154
	186	167	208	270	174	141
	185	164	220	300	180	152
	165	115	192	209	183	143
	188	174	175	142	172	143

APPENDIX TABLE 13.--Standard length in millimeters and weight in grams recorded for croaker in cage 7 from 21 July to 11 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	99	22	102	22	102	26
	86	15	116	33	113	32
	85	15	133	46	128	40
	117	30	83	13	120	28
	94	14	73	18	163	82
	112	30	96	20	90	20
	120	40	94	22	92	22
	96	20	87	18	111	26
	96	21				
9- 8-71	146	78	172	141	197	202
	154	94	165	128	143	78
	162	119	152	99	161	122
	154	106	143	86	150	95
	141	90	155	99	143	84
	155	103	141	92	148	82
	155	120	147	88	141	75
	146	80	165	133	164	110
10- 6-71	180	170	178	153	159	121
	156	103	209	271	160	107
	161	122	158	104	183	162
	152	120	172	152	177	156
	157	112	170	129	172	155
	161	117	170	150	168	151
	163	140	161	119	169	126
	165	155				
11-11-71	177	160	172	138	167	120
	180	174	164	137	168	121
	178	136	169	140	172	174
	189	174	177	150	197	214
	180	176	175	174	172	126
	220	335	165	150	182	170
	184	177				

APPENDIX TABLE 14.--Standard length in millimeters and weight in grams recorded for pigfish in cage 8 from 21 July to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	165	127	153	94	162	115
	172	130	193	174	143	77
	175	131	159	100	146	82
	146	85	182	140	159	92
	190	156	185	142	162	102
	152	84	151	86	169	103
	157	88	166	108	170	125
	182	134	163	101	146	72
	154	78				
9- 8-71	187	177	178	166	178	198
	162	124	195	227	173	150
	165	150	155	108	151	108
	175	158	175	166	166	139
	162	129	160	126	190	210
	195	220	165	136	152	119
	157	122	183	200	176	166
10- 6-71	175	161	184	212	201	240
	200	226	181	190	159	112
	170	158	173	158	194	226
	187	186	183	187	173	162
	183	184	190	206	167	136
	155	125	185	188	167	146
11-11-71	198	234	180	182	206	255
	177	169	209	288	206	263
	183	194	196	266	190	220
	179	189	168	164	192	218
	190	210	185	202	192	218
	188	214	200	240		
12- 8-71	200	235	192	226	207	260
	188	216	211	298	191	228

APPENDIX TABLE 14.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	169	162	206	268	187	218
	200	250	184	188	195	223
	182	191	184	200	197	272
	187	205	180	175		

APPENDIX TABLE 15.--Standard length in millimeters and weight in grams recorded for pinfish in cage 9 from 21 July to 27 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	142	82	114	52	152	102
	162	132	157	120	142	90
	135	78	146	87	122	75
	148	105	137	87	117	59
	88	22	145	99	123	59
	150	116	127	58	108	44
	107	48	134	77	145	100
	117	55	112	52		
9- 3-71	165	164	171	168	152	140
	169	163	158	164	133	86
	162	161	173	186	181	228
	163	174	177	202	166	161
	148	121	155	136	147	115
	144	115	158	162	163	164
	139	100	167	167	158	136
	146	115	157	146	137	95
10- 8-71	172	200	180	230	151	150
	157	174	180	212	168	199
	150	136	160	164	185	269
	163	192	169	216	162	174
	167	206	165	179	157	155
	165	204	170	200	166	173
	183	240	177	212	173	197
	145	116	161	164	151	146
11-13-71	178	260	193	277	173	204
	184	248	170	190	178	208
	171	222	196	282	176	246
	164	185	194	314	178	224
	178	264	176	226	190	244
	171	200	166	197	187	248
	168	204	178	255	185	226
	159	150	173	210	160	168

APPENDIX TABLE 15.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11-27-71	160	149	190	234	188	236
	173	194	193	300	183	218
	168	190	184	240	177	240
	174	202	170	184	165	188
	191	264	178	196	179	250
	165	178	171	210	178	246
	178	220	195	272	177	248
	175	215	172	188		

APPENDIX TABLE 16.--Standard length in millimeters and weight in grams recorded for pigfish in cage 10 from 21 July to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	186	143	187	146	154	90
	183	140	187	144	180	130
	147	79	135	60	88	26
	85	18	92	22		
9- 8-71	163	142	132	79	190	208
	187	211	186	208	192	241
	155	128	118	57	130	81
10- 6-71	190	219	198	225	197	234
	202	261	132	72		
11-17-71	199	254	202	245	206	283
	199	230				
12- 8-71	201	250	201	236	202	268
	207	290				

APPENDIX TABLE 17.--Standard length in millimeters and weight in grams recorded for croaker in cage 11 from 21 July to 11 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	105	21	108	28	117	33
	97	22	106	23	95	26
	93	18	135	50	109	27
	100	20	186	137	152	77
	168	104	197	164		
9- 3-71	223	286	202	179	170	112
	168	111	152	88	183	151
	179	130	151	89	145	77
	138	63	150	80	158	91
	207	211				
10- 8-71	217	300	235	366	191	196
	190	190	167	114	177	148
	160	110	172	152	219	250
	192	192	180	147	166	128
	166	124				
11-11-71	180	164	225	354	198	234
	234	318	191	192	247	463
	211	262	180	143	185	184
	178	163	181	159	202	244
	192	178				

APPENDIX TABLE 18.--Standard length in millimeters and weight in grams recorded for pompano in cage 12 from 21 July to 27 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	100	31	105	40	120	55
	103	36	94	27	89	28
	89	26	100	26	113	40
	120	55	78	17	95	28
	130	60	99	35	108	41
	82	20	94	32	137	81
	112	50	94	31	128	65
	112	44	122	57	115	50
	111	40				
9- 3-71	133	72	158	132	149	103
	132	78	138	82	131	68
	78	34	141	92	135	79
	148	108	153	117	139	92
	127	62	148	102	153	120
	134	81	135	86	134	82
10- 7-71	135	87	140	98	125	70
	167	182	147	121	141	102
	145	98	172	186	135	86
	136	94	122	64	148	110
	133	92	131	76	135	80
	142	96	153	124	146	114
10-22-71	184	224	128	63	148	102
	147	92	160	131	138	86
	148	106	154	112	149	108
	162	140	144	95	188	215
	144	102	135	72	170	154
	137	78	148	106	146	98
11- 5-71	174	176	152	107	146	88
	144	92	128	63	136	74
	155	120	149	99	145	95

APPENDIX TABLE 18.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	195	243	192	246	150	106
	137	80	162	128	146	102
	169	160	150	101	134	71
11-27-71	170	164	193	250	178	191
	161	128	150	99	145	191
	140	78	150	100	158	129
	148	80	135	72	137	73
	145	96	150	94	155	100
	145	86	129	60		

APPENDIX TABLE 19.--Standard length in millimeters and weight in grams recorded for pompano in cage 13 from 21 July to 5 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	120	50	103	38	107	40
	125	60	97	35	104	40
	117	53	107	40	139	81
	93	30	87	24	112	50
	85	26	132	74	84	24
	108	42	99	30	99	32
	117	58	105	36	98	34
	120	55	92	29	109	40
	87	28				
9- 3-71	138	86	146	109	133	79
	145	111	132	81	131	74
	128	71	141	98	146	92
	153	124	141	90	138	88
	133	77	117	56	110	40
	120	59				
10- 7-71	160	151	141	102	140	96
	171	182	141	84	131	78
	137	89	133	80	143	100
	132	86	141	107	150	116
	118	63	116	56	140	100
	120	63	167	174	163	156
10-22-71	183	202	175	177	125	64
	184	214	145	86	146	99
	138	86	129	71	150	108
	146	102	135	76	140	94
	158	135	156	130	142	90
	173	179	125	64	150	103
11- 5-71	178	195	193	240	158	123
	149	82	125	60	180	194

APPENDIX TABLE 19.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	127	59	148	95	129	67
	193	235	148	97	136	73
	150	106	145	86	143	90
	150	99	166	150	140	84

APPENDIX TABLE 20.--Standard length in millimeters and weight in grams recorded for Gulf kingfish in cage 14 from 21 July to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	172	95	143	49	210	147
	215	136	220	160	261	278
	206	140	232	178	247	220
	181	100	195	120	217	171
	227	176	228	173	175	82
	200	112	252	252	259	260
	277	326	258	263	125	34
	159	64	203	129	170	80
	175	94				
9- 3-71	260	220	178	78	183	104
	190	133	262	277	231	192
	201	111				
10- 8-71	264	300	190	123	255	226
	227	185	172	78	190	138
11-17-71	275	361	197	154	186	116
	201	157	238	224		
12- 8-71	241	226	203	154	188	118
	200	153	276	340		

APPENDIX TABLE 21.--Standard length in millimeters and weight in grams recorded for pinfish in cage 15 from 8 October 1971 to 10 March 1972.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	100	31	102	30	112	44
	127	66	115	48	102	38
	99	33	107	40	99	34
	109	46	104	36	102	36
	100	32	101	34	108	44
	118	58	99	34	99	32
	100	36	110	40	110	42
	106	40	107	39	115	52
	105	39				
11-13-71	125	74	135	94	135	92
	125	83	117	65	130	78
	121	68	130	80	119	64
	117	69	123	70	120	70
	125	74	122	68	121	69
	120	70	120	66	122	64
	125	80	124	67	122	72
	122	67	119	61	120	68
	121	68				
12- 8-71	125	70	130	75	131	78
	125	74	138	96	123	61
	131	88	128	74	139	91
	120	65	125	71	120	64
	122	66	121	68	121	61
	135	83	121	64	123	61
	120	66	128	71	125	68
	128	74	125	70	123	68
	126	72				
2- 4-72	136	82	148	101	145	104
	135	75	132	71	133	82
	131	78	140	94	142	105
	132	83	128	71	139	90
	140	92	157	132	139	88

APPENDIX TABLE 21.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	132	70	141	94	135	80
	135	83	134	88	138	92
	135	83	139	95	139	98
	142	102				
3-10-72	160	138	149	106	139	85
	140	99	133	78	151	101
	138	75	139	75	144	98
	138	80	146	104	142	90
	142	94	136	87	137	82
	147	102	145	98	145	102
	140	90	146	98		

APPENDIX TABLE 22.--Standard length in millimeters and weight in grams recorded for spot in cage 16 from 21 July to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	167	109	143	68	168	114
	89	20	177	158	176	146
	170	132				
9- 3-71	188	186	186	180	186	185
	163	117	182	161		
10- 8-71	187	195	190	189	172	144
	190	212	190	213		
11-17-71	197	246	197	241	198	223
	182	176	199	249		
12- 8-71	201	250	202	261	200	270
	200	252	185	176		

APPENDIX TABLE 23.--Standard length in millimeters and weight in grams recorded for pinfish in cage 16 from 8 October to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	109	42	109	42	115	47
	109	40	110	44	113	47
	105	38	110	41	101	32
	107	42	108	39	109	38
	92	28	95	29	41	26
	97	32	155	110	117	44
	107	38	117	52	110	38
	104	35	111	46	98	32
	112	47				
11-13-71	118	56	160	130	124	71
	125	69	112	48	116	64
	124	66	11	52	124	67
	120	62	125	65	120	60
	127	71	110	52	120	67
	122	61	115	54	125	76
	125	70	122	66	113	54
	120	68	125	76	125	71
	117	61				
12- 8-71	124	60	160	123	115	46
	120	55	126	68	123	60
	128	64	113	42	126	68
	123	54	115	46	127	58
	128	68	125	65	128	68
	121	55	121	64	114	46
	119	55	111	46	118	60
	126	65	120	58	125	60
	126	66				

APPENDIX TABLE 24.--Standard length in millimeters and weight in grams recorded for pompano in cage 17 from 21 July to 7 October 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	103	43	97	40	109	46
	95	35	113	48	99	41
	87	26	107	43		
9- 3-71	152	121	129	78	150	116
	136	83				
10- 7-71	153	124	146	114	167	174
	163	156				

APPENDIX TABLE 25.--Standard length in millimeters and weight in grams recorded for pinfish in cage 17 from 8 October to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	110	40	110	43	109	40
	132	75	86	20	105	39
	105	40	100	30	90	24
	100	32	101	34	106	37
	95	27	109	46	110	42
	109	34	102	34	115	52
	110	42	112	50	115	50
	105	40	105	41	114	47
	95	26				
11-13-71	120	58	130	78	120	60
	108	47	118	67	140	96
	123	72	121	64	124	68
	110	50	127	73	123	68
	125	68	127	77	116	58
	127	73	115	58	125	67
	115	57	115	53	120	67
	117	60	120	62	128	75
	117	65				
12- 8-71	121	56	125	60	120	54
	121	60	113	46	142	94
	111	46	130	66	118	50
	120	62	125	61	128	65
	121	54	127	64	120	60
	118	52	120	54	130	74
	116	54	118	56	127	62
	126	60	129	72	125	60
	119	52				

APPENDIX TABLE 26.--Standard length in millimeters and weight in grams recorded for black drum in cage 18 from 21 July 1971 to 10 March 1972.

Sampling date	Length	Weight	Length	Weight	Length	Weight
7-21-71	192	180	230	288		
9- 3-71	256	428	239	343		
10- 8-71	254	464	271	511		
11-17-71	284	543	270	511		
12- 8-71	272	510	283	558		
2- 4-72	290	665	270	598		
3-10-72	300	740	277	600		

APPENDIX TABLE 27.--Standard length in millimeters and weight in grams recorded for pinfish in cage 18 from 8 October to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	110	39	109	38	97	30
	100	34	105	38	101	34
	110	45	117	57	98	32
	112	49	111	42	109	42
	108	40	98	31	105	40
	101	34	104	40	101	36
	115	51	108	42	96	28
	114	44	105	40	101	37
	103	37				
11-13-71	128	72	121	70	120	66
	127	76	129	83	124	78
	124	68	124	78	132	95
	119	68	119	69	122	77
	120	74	121	67	125	80
	126	79	123	74	120	65
	120	74	121	70	118	64
	125	74	125	72	121	71
12- 8-71	126	72	126	67	124	72
	130	79	129	74	119	60
	131	82	125	70	135	94
	127	72	124	74	125	76
	127	67	126	71	122	64
	126	74	123	64	121	68
	131	76	124	66	124	66
	126	80	122	62	122	74

APPENDIX TABLE 28.--Standard length in millimeters and weight in grams recorded for pompano in cage 20 from 12 August to 5 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
8-12-71	130	73	149	112	128	74
	138	86	121	54	137	82
	120	58	142	99	138	96
	150	111	137	80	154	121
	136	67	138	81		
9-15-71	162	143	162	155	167	168
	160	156	152	138	146	114
	153	132	172	188	150	120
	164	156	155	137	140	97
	152	132	170	169		
10- 7-71	185	229	170	173	157	134
	178	204	154	134	172	197
	177	210	166	182	183	214
	176	186	171	181	152	120
	168	160				
10-22-71	175	177	193	236	163	135
	164	134	182	196	188	215
	186	216	164	150	177	205
	181	197	191	232	188	220
	194	252				
11- 5-71	198	256	181	190	200	265
	188	213	191	234	188	230
	168	158	165	131	191	232
	178	172	183	222	168	150
	200	262				

APPENDIX TABLE 29.--Standard length in millimeters and weight in grams recorded for pompano in cage 21 from 12 August to 5 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
8-12-71	133	80	130	70	130	79
	108	36	120	58	121	62
	134	87	127	67	138	88
	132	80	130	77	137	80
	130	76	135	88	121	60
	144	91	129	67	123	76
	128	54	129	56	144	105
	155	117	118	53	142	97
	123	68				
9-15-71	125	76	142	100	163	149
	156	134	155	136	150	130
	136	84	153	133	151	134
	140	99	154	144	165	159
	140	104	160	152	141	108
	167	160	14	104	141	105
	150	127	157	138	148	116
10- 7-71	157	136	155	126	146	112
	172	172	155	133	177	202
	171	176	167	168	179	212
	177	196	171	162	155	137
	138	100	171	174	168	160
	162	150	165	162	161	160
	166	170	161	148		
10-22-71	164	158	192	250	179	184
	172	172	180	200	170	164
	190	224	170	180	177	194
	164	140	175	180	175	192
	182	204	170	168	188	236
	184	212	155	130	148	116
	163	151	181	203		

APPENDIX TABLE 29.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11- 5-71	192	236	198	274	190	236
	194	254	170	170	182	212
	155	130	185	194	178	183
	187	215	169	155	178	180
	174	186	199	252	182	208
	177	184	170	164	187	219
	181	189	158	138		

APPENDIX TABLE 30.--Standard length in millimeters and weight in grams recorded for pompano in cage 22 from 12 August to 27 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
8-12-71	135	85	135	80	133	80
	137	88	137	86	125	71
	120	64	122	60	108	58
	117	56	128	78	110	50
	139	94	157	130	123	64
	138	94	132	86	124	72
	127	65	127	73	114	55
	133	80	118	61	134	80
	130	75				
9-15-71	155	131	149	119	155	133
	151	127	149	124	144	108
	155	126	140	102	150	123
	170	172	140	96	146	117
	150	119	145	106	155	142
	152	130	163	151	140	104
	141	102	157	143	140	108
	138	90	137	96	139	103
10- 7-71	157	138	161	157	154	132
	166	170	162	142	171	166
	162	156	157	156	175	183
	158	152	155	148	161	146
	170	172	160	151	178	187
	162	145	172	178	183	202
	148	116	153	130	167	164
	153	132				
10-22-71	162	142	168	173	168	172
	173	164	179	192	185	197
	167	162	173	169	165	152
	168	160	171	162	170	166
	158	130	161	148	195	239
	180	199	185	211	170	168
	178	190	181	196	178	188
	160	148				

APPENDIX TABLE 30.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11- 5-71	175	175	165	158	182	203
	173	188	174	178	165	165
	178	187	179	202	187	201
	176	192	186	216	165	150
	162	143	178	183	173	178
	182	214	186	219	193	239
	175	187	202	265	169	165
	173	185				
11-27-71	185	204	163	146	194	238
	175	193	180	195	166	166
	176	178	166	163	185	210
	175	180	187	219	175	177
	175	182	202	270	177	190
	185	210	180	186	176	194
	182	217	185	204	165	148
	170	172				

APPENDIX TABLE 31.--Standard length in millimeters and weight in grams recorded for pompano in cage 23 from 12 August to 27 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
8-12-71	133	77	132	72	123	66
	116	53	116	53	135	81
	122	55	113	45	133	77
	135	80	127	72	118	56
	127	72	137	79	137	79
	130	71	126	65	118	52
	142	95	102	38	127	66
	124	61	112	45	119	56
	124	61				
9-15-71	122	70	140	104	150	122
	149	122	146	109	146	112
	157	151	134	90	147	116
	140	104	142	106	145	113
	150	122	146	114	148	116
	156	133	135	93	137	96
	148	118	147	114	140	100
	131	84	140	100		
10- 7-71	152	124	163	151	161	142
	164	154	164	152	165	158
	163	158	160	143	173	185
	163	146	167	158	146	108
	158	140	157	140	162	144
	148	116	155	130	170	164
	162	153	164	151	148	110
	141	112				
10-22-71	167	153	173	168	154	122
	163	146	183	206	181	188
	176	174	153	115	173	165
	169	158	175	173	171	169
	176	177	162	143	172	162
	176	177	173	168	154	119
	168	148	167	155	152	114
	173	174				

APPENDIX TABLE 31.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11- 5-71	187	218	187	204	178	184
	172	167	181	190	170	143
	177	178	175	176	155	126
	179	184	178	184	169	159
	180	191	156	131	180	190
	170	165	154	109	179	186
	169	154	152	110	180	183
	172	164				
11-27-71	180	190	180	186	180	186
	157	132	172	168	180	182
	189	212	156	130	182	195
	178	192	178	182	170	164
	185	222	169	152	172	171
	179	184	154	108	174	174
	180	191	168	141		

APPENDIX TABLE 32.--Standard length in millimeters and weight in grams recorded for pompano in cage 24 from 12 August to 5 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
8-12-71	123	57	104	39	126	61
	128	72	113	48	118	52
	115	48	104	40	109	43
	132	74	143	104	117	49
	103	38	119	59	118	62
	154	120	127	68	123	63
	108	44	104	36	129	69
	123	64	101	38	112	50
	106	40				
9-15-71	148	122	122	68	142	100
	175	186	138	100	145	111
	141	100	130	77	131	79
	162	157	136	92	131	88
	135	99	129	84	133	92
	141	108	146	107	151	120
	130	79	152	127	120	66
	140	98	132	88		
10- 7-71	154	134	147	120	197	252
	157	140	159	146	150	126
	163	156	153	120	147	112
	143	110	147	120	168	168
	152	130	158	133	163	138
	169	165	161	158	151	130
	178	196	140	102	156	128
	143	104				
10-22-71	153	107	158	136	157	125
	150	106	164	138	173	174
	158	133	157	129	164	135
	176	176	170	158	186	215
	160	145	207	274	165	148
	166	162	179	176	155	130
	170	150	172	170	153	119
	155	120				

APPENDIX TABLE 32.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
11- 5-71	178	194	175	180	212	306
	190	234	155	118	162	148
	161	143	167	143	162	145
	175	166	180	184	157	120
	166	155	168	154	173	187
	180	190	165	158	155	124
	157	125	168	151	160	143
	176	187				

APPENDIX TABLE 33.--Standard length in millimeters and weight in grams recorded for white mullet in cage 25 from 9 October to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 9-71	88	16	118	34	147	72
	92	20	130	49	85	16
	99	25	89	14	79	11
	74	10	96	18	92	16
	85	15	123	42	94	20
	95	20	88	16	84	12
	88	15	84	12	91	16
	94	18	87	15	85	13
	79	10				
11-17-71	91	18	93	20	82	14
	88	18	144	63	87	16
	97	20	88	18	95	20
	92	16	100	22	150	70
	168	104	115	37	102	24
	97	22	87	16	102	26
	97	24	81	14	95	20
	92	18	98	23	125	41
	77	12				
12- 8-71	122	39	150	68	143	62
	89	16	116	36	97	18
	95	18	98	20	90	18
	97	20	94	18	87	15
	101	23	80	12	81	14
	98	22	168	101	97	20
	78	12	91	18	91	17
	87	16	92	17	88	16
	100	24				

APPENDIX TABLE 34.--Standard length in millimeters and weight in grams recorded for pinfish in cage 26 from 8 October 1971 to 10 March 1972.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	100	32	105	38	92	26
	97	28	109	40	101	35
	95	28	108	40	103	36
	105	40	98	33	107	40
	102	34	100	35	92	29
	92	26	105	36	103	36
	88	23	100	30	98	32
	95	28	102	38	103	35
	108	42				
11-13-71	112	48	114	54	118	60
	117	54	119	61	115	59
	123	62	121	66	120	62
	119	56	117	57	110	50
	107	47	115	52	111	50
	111	53	118	58	117	66
	117	63	109	52	115	52
	118	63	117	63	116	58
	115	53				
12-24-71	116	47	123	64	125	62
	122	56	120	57	123	62
	124	62	119	52	119	58
	118	55	120	59	119	54
	124	62	124	63	123	62
	118	56	122	60	123	60
	111	48	123	60	122	60
	116	50	125	61	126	60
2- 4-72	122	56	125	64	123	61
	124	59	123	60	126	66
	121	55	124	65	119	56
	123	62	120	56	125	64
	120	58	118	54	116	48
	116	49	119	52	120	57

APPENDIX TABLE 34.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	124	60	122	62	123	62
	125	60	123	63	112	49
3-10-72	125	62	127	66	124	64
	125	64	120	59	126	66
	127	63	126	68	125	56
	119	50	120	51	121	54
	127	68	125	61	129	73
	122	62	126	62	118	58
	127	66	124	76	129	70
	129	76	130	75	126	68

APPENDIX TABLE 35.--Standard length in millimeters and weight in grams recorded for white mullet in cage 27 from 9 October to 8 December 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 9-71	94	18	87	14	85	14
	81	12	86	13	97	19
	86	12	95	18	77	10
	82	11	93	16	79	11
	93	16	87	14	131	52
	87	15	97	20	83	13
	84	15	86	16	95	20
	95	19	82	12	85	13
	85	12				
11-17-71	87	15	148	70	90	16
	103	23	107	28	85	17
	97	19	86	14	95	17
	98	23	87	14	107	27
	90	16	120	36	89	16
	82	14	90	16	85	12
	112	29	97	20	91	16
	90	16	88	17	90	16
	90	18				
12- 8-71	109	26	97	17	100	22
	89	14	113	28	95	18
	98	20	107	24	90	14
	86	12	88	14	90	14
	91	16	80	10	87	14
	97	20	85	12	85	12
	90	14	86	14	89	12
	89	16	149	70	120	40
	90	14				

APPENDIX TABLE 36.--Standard length in millimeters and weight in grams recorded for croaker in cage 28 from 8 October to 29 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	127	42	128	45	123	42
	136	58	150	76	130	54
	130	51	132	54	142	62
	154	80	124	39	123	39
	130	48	127	42	145	74
	136	55	184	134	135	52
	151	72	125	45	130	54
	163	100	135	57	144	65
	131	47				
11-11-71	143	72	144	74	155	91
	153	84	147	71	143	66
	153	100	145	78	189	151
	147	76	159	104	143	70
	139	66	150	87	155	91
	159	100	143	69	174	130
	151	81	142	68	157	90
	140	68	142	69	137	70
	140	66				
11-29-71	159	89	153	87	173	127
	145	72	157	93	149	72
	141	68	146	75	145	64
	153	86	158	100	157	100
	144	70	145	67	186	146
	154	100	139	70	148	75
	159	92	142	65	142	71
	150	76	150	82	147	75
	154	83				

APPENDIX TABLE 37.--Standard length in millimeters and weight in grams recorded for croaker in cage 29 from 8 October to 11 November 1971.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	126	42	164	90	123	40
	138	63	126	44	134	54
	134	52	137	58	132	50
	150	73	121	38	132	48
	127	40	130	46	145	65
	157	85	150	72	132	52
	142	59	126	42	124	46
	140	63	170	117	136	53
	138	59				
11-11-71	160	108	153	87	157	89
	175	148	149	89	157	112
	151	102	160	112	178	160
	165	109	147	95	152	101
	151	98	156	107	147	78
	152	98	156	100	148	78
	149	86	153	98	151	87
	143	77	164	116	168	115
	150	91				

APPENDIX TABLE 38.--Standard length in millimeters and weight in grams recorded for pinfish in cage 30 from 8 October 1971 to 10 March 1972.

Sampling date	Length	Weight	Length	Weight	Length	Weight
10- 8-71	110	44	93	28	98	31
	100	31	109	40	95	28
	106	40	111	42	108	37
	118	54	116	53	112	45
	102	32	110	40	105	36
	92	24	90	26	110	45
	98	28	106	38	104	34
	100	36	115	47	109	43
	105	36				
11-13-71	117	62	131	86	121	66
	129	80	120	70	126	81
	128	79	123	70	122	74
	122	72	121	68	127	75
	120	68	120	74	112	58
	112	58	127	82	122	75
	124	72	115	59	124	73
	118	70	115	63	118	70
	127	77				
12-24-71	136	84	126	71	122	64
	133	83	124	67	127	70
	128	69	123	64	132	74
	127	66	127	68	123	58
	133	78	129	78	132	76
	118	56	120	60	125	67
	124	64	128	70	128	73
	131	80	135	82	125	72
	124	67				
2- 4-72	129	71	125	64	127	66
	130	80	126	70	128	70
	134	79	130	70	134	77
	127	70	136	83	132	81
	119	57	124	61	128	64

APPENDIX TABLE 38.--continued

Sampling date	Length	Weight	Length	Weight	Length	Weight
	124	63	126	66	127	72
	124	68	123	62	128	70
	135	86	134	79	134	77
	124	67				
3-10-72	130	67	131	76	138	85
	127	66	129	68	129	66
	138	80	134	84	129	71
	124	61	134	86	132	73
	128	67	130	72	132	74
	131	78	133	76	126	61
	138	84	127	70	140	88
	137	79	130	78	135	82
	134	78				