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The Commercial Feasibility of Rearing Pompano, *Trachinotus carolinus* (Linnaeus), in Cages

THEODORE ISAAC JOGUES SMITH

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Theodore Isaac Jogues Smith

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PREFACE

The Sea Grant Colleges Program was created in 1966 to stimulate research, instruction, and extension of knowledge of marine resources of the United States. In 1969 the Sea Grant Program was established at the University of Miami.

The outstanding success of the Land Grant Colleges Program, which in 100 years has brought the United States to its current superior position in agricultural production, was the basis for the Sea Grant concept. This concept has three objectives: to promote excellence in education and training, research, and information services in the University's disciplines that relate to the sea. The successful accomplishment of these objectives will result in material contributions to marine oriented industries and will, in addition, protect and preserve the environment for the enjoyment of all people.

With these objectives, this series of Sea Grant Technical Bulletins is intended to convey useful research information to the marine communities interested in resource development quickly, without the delay involved in formal publication.

While the responsibility for administration of the Sea Grant Program rests with the Department of Commerce, the responsibility for financing the program is shared equally by federal, industrial and University of Miami contributions. The study, The Commercial Feasibility of Rearing Pompano, *Trachinotus carolinus* (Linnaeus), in Cages, is published as a part of the Sea Grant Program. Graduate research support was provided through a fellowship from Giffen Industries and an Assistantship from the University of Miami Sea Grant Program.

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ABSTRACT

Much time, effort and money have been spent in attempts to raise the Florida pompano, *Trachinotus carolinus* (Linnaeus). Success has been limited. This species commands the highest retail price of all fishes landed in the southern United States and consumer demand is great. Also, pompano are suitable for aquaculture since growth in captivity is rapid and they can endure a wide range of environmental conditions. Based on these considerations a study was conceived to rear pompano in 1 m^3 aluminum cages (6.4 mm mesh) at five stocking densities: 100, 250, 400, 650 and 900 fish per cubic meter.

The growth rates suggest that marketable fish (454 g) are obtainable within 47-51 weeks, starting with a 7 g fish. Growth and yield per fish stocked were significantly higher at the lower stocking densities. However, the highest total yields (113 and 116 kg/m^3) were obtained at the highest stocking density. Probably, such yields are below the maximum carrying capacity of the cages and greater yields are likely. Mean mortality was lowest (16%) at stocking density 100 and highest at stocking density 650. Overall mortality was 21%, half of which was attributable to dietary inadequacy. Feed costs to raise 1 kg of pompano were lowest ($1.70) at stocking density 100 and increased to $2.17 at stocking density 900. Some economic aspects of pompano-rearing in cages were considered and it was shown that the greatest profit ($160/cage) occurred at the highest stocking density.

Although monogenetic trematodes and some body abrasions were noted, no significant disease or parasitic infestations occurred. Major problems during the study were associated with heavy cage fouling and poor water quality.

Finally, it was demonstrated that pompano released after cage-conditioning would remain and feed in the area of conditioning, suggesting the possibility of culturing this species without the use of confining structures.

INTRODUCTION

In recent years much interest and activity has centered around the possibility of commercially rearing the Florida pompano, *Trachinotus carolinus* (Linnaeus). This carangid receives the highest retail price of all fin-fishes landed in Florida and demand exceeds the supply. Pompano (the term pompano will refer to the Florida pompano throughout this paper) are tolerant of a wide range of environmental conditions, can be handled with little or no mortality and readily adjust to man-made confinements. They grow rapidly and reach marketable size within one year. For these reasons, pompano are suitable for aquaculture, and one can look forward to an expanding pompano-farming industry.

The University of Miami has been actively involved in developing pompano farming as a viable industry, both through its research programs and its consultations with companies involved with pompano-rearing (Idyll *et al*., 1968, 1969). Objectives of this project were to assess the suitability of cages for raising pompano and to measure growth and mortality at stocking densities that would be likely in a commercial operation. This paper presents the results of the above investigation and, on the basis of data collected and observations made, discusses the problems and future of pompano farming as a potential industry.

Progress in pompano research has been encouraging and should help provide a strong foundation for successful farming ventures. Much of the available scientific knowledge concerning the ecology, biology and farming potential of pompano has been published only recently. The taxonomy, occurrence, spawning and food habits of Florida east coast pompano were investigated by Fields (1962). Additional ecological information, including Florida west coast pompano, was given by Finucane (1969a). Parasites and diseases and the environmental parameters associated with the occurrence of juvenile pompano were included. Seasonal occurrence, growth, length-weight relationships and food habits of juvenile pompano in Louisiana were reported by Bellinger and Avault (1970, 1971). Food preferences, growth rates, longevity, spawning movements and migration, and environmental tolerances were summarized by Berry and Iversen (1967). Their paper also discussed the commercial and sport fisheries, early farming attempts and preliminary recommendations on pompano farming, as did Iversen (1968). A recent comprehensive review of pompano biology, ecology and environmental tolerances was provided by Kumpf (1972). Iversen and Berry (1969) described a palatability test in which wild and cultured pompano were shown to be comparable to each other and superior to related species (e.g. permit, *Trachinotus falcatus*). They also included data on the collection of fry along beaches of the east coast of Florida and on growth of pompano in captivity. Work on artificial spawning and diets was carried out by Finucane (1969b, 1970a,b and 1971) in floating pens and a fenced 6-acre embayment. A description of a commercial pompano farm, basic considerations of pompano-rearing and research on environmental tolerances were given by Moe, Lewis and Ingle (1968). Finally, a patent was awarded to Groves (1970) for a system of free-circulating ponds open at both ends to tidal flow, for raising pompano and other estuarine fishes.

Many early attempts to farm pompano were carried out in pond-type arrangements, with the corresponding problems of population estimation, predator and competitor control, periodic low-oxygen kills and harvesting. Several research organizations and commercial farmers now utilize more intensive stocking systems, such as tanks and "silos," in which large numbers of fish are raised in a minimum of space. Such systems require less space, and allow complete harvesting, easier detection and treatment of parasites and diseases and easier sampling and population estimation. However, they require large volumes of water and high flow rates and, accordingly, high electrical power demands. Also, elaborate back-up life support systems are usually necessary. Both pond and tank systems require coastal land, for which demand and price are high.

Studies on rearing fresh-water fishes have utilized a culture system that reduces the high initial cost of setting up a fish farm and eliminates many shortcomings of pond-type systems. Various forms of cage culture have been practiced in the Far East for several decades (Vaas and Sachlan, 1957; Hickling, 1962; Hora and Pillay, 1962; Kuronuma, 1968 and Swingle et al., 1970). However, the western world has only begun to adapt cage culture methods within the last decade. A wide variety of fishes, both fresh-water and marine, are being tested in cages, including salmonids in Canada (Seguin, 1970), Scotland (Phillips, personal communication) and the United States (Mahnken, Novotnyn and Joiner, 1970; Collins, 1972; Ledbetter, 1972; and Swingle, in press). Other species cultured in cages in the United States include *Tilapia aurea* (Pagan, 1969, 1970), striped bass, *Morone saxatilis* (Swingle, in press), striped mullet, *Mugil cephalus* (Swingle and Tatum, 1971) and, particularly, channel catfish, *Ictalurus punctatus* (Lewis, 1969, 1970; Schmittou, 1969 and Collins, 1970). The results of these studies have been encouraging and several companies are presently attempting to rear salmonids and ictalurids in cages on a commercial scale.

Preliminary work by this author in 1970 involved raising pompano in .079 ha ($\frac{1}{4}$-acre) ponds, 20-ton rectangular cement tanks and 1 m^3 cages, with the latter proving to be the most efficient and versatile system. Floating cages provide ease of observation and inspection for growth and diseases. Cages give quick access to the fish, whereas in ponds or tanks sampling is often difficult. Cage-harvesting is complete and only requires that the cages be lifted and emptied. In pond-harvesting by seining, fish may evade the net and an incomplete harvest may result; also, harvesting is often time-consuming and laborious. If harvesting involves draining the tanks or ponds, predation by birds or an oxygen or temperature kill may occur as the water level is lowered, especially if draining is slow. Other advantages are that cages provide better predator and competitor control and an efficient system for managing crop size by varying stocking density and number of cages. Also, since water flow occurs naturally as a consequence of wind, currents and the fishes' movement, there is less electrical power demand than when circulation must be provided.

Cages can be used in areas such as large salt-water impoundments and power plant cooling canals, which are presently unsuitable for fish farming because predator-competitor control, harvesting, population estimation and disease control are difficult, if not impossible. Furthermore, recent passage of a Florida aquaculture law (Florida State Legislature, 1969) encourages use of this technique since the water column can now be leased for aquaculture (Marifarms, Inc., 1972). Some states have made the placement of cages in fresh-water lakes illegal, although Arkansas encourages their use and requires that 5% of the total fish production be released to provide sport fishing for the public (Mathis, 1970). Perhaps a similar arrangement can be worked out for marine waters if it can be shown that such releases benefit sport fisheries.

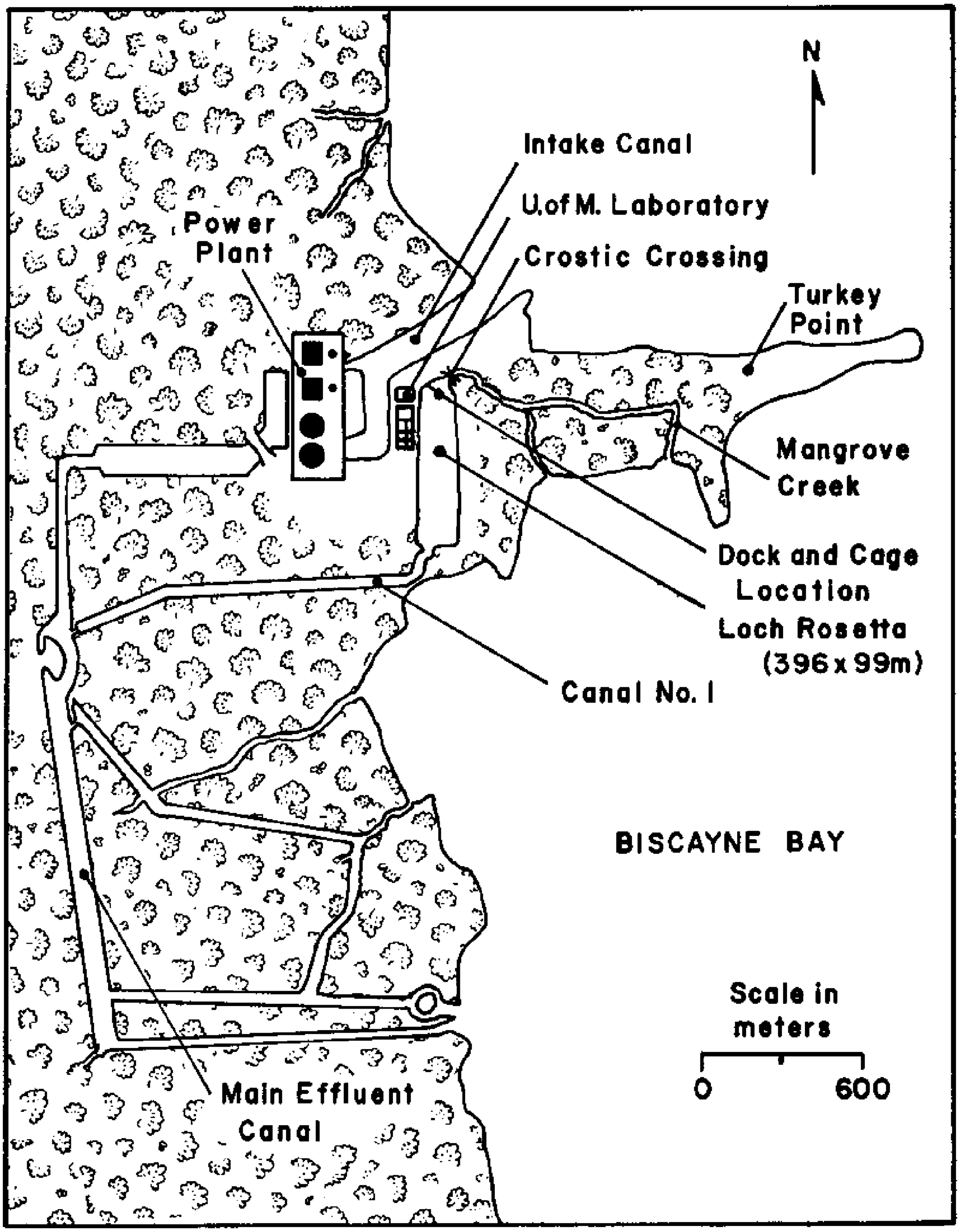
One stumbling block to development of commercial pompano culture is that pompano are thermophilic. Research has shown that pompano stop feeding and go into shock below 12.2^{o} C (54^{o} F) and die at about 10^{o} C (50^{o} F) (Finucane, 1969a and Moe et al., 1968). Thus, to be successful, a farm must regulate its temperature or be located in an area where the lower lethal temperature is not encountered. The former alternative is expensive, and areas in the United States that are suitable for year-round culture are extremely limited. Another option is to use heated effluent from a fossil-fuel power plant. The demand for electricity is increasing at an unprecedented rate, hence the construction of power-generating plants, and the opportunities for their use as fish farms grow accordingly. However, the use of effluents from nuclear power plants for such purposes is prohibited. Rearing fishes in systems receiving thermal additions from power stations is being investigated worldwide; Germany (Steffens, 1969), Russia (Gribanov, Korneev and Korneeva, 1968), Japan (Yang, 1970), United Kingdom (Nash, 1968, 1969 and Shelbourne, 1970) and in the United States (Tilton and Kelley, 1971 and Anonymous, 1972a). Reviews of thermal aquaculture have been written by Gaucher (1970) and Yee (1972).

Because Miami waters occasionally reach the lower lethal temperature for pompano and since thermal effluents were available, this experiment was located in an area receiving some heated waters from a power plant. Thus, low temperature problems were avoided and otherwise wasted heat energy was used to produce usuable fish protein. A cage culture experiment employing 4,600 juvenile pompano was set up to test the commercial feasibility of such a system. The cages were stocked with beach-seined pompano fry from the Florida east coast at densities from 100 to 900 fish per cubic meter. Data on growth, mortality, food conversion and yields were obtained, as well as observations made on problems associated with the use of cages. Also, some economic aspects of cage culture were considered.

MATERIALS AND METHODS

This research began on 26 August 1970 with the cages located in an area receiving some heated effluent from a power plant. The commercially-available 1 m^3 aluminum-frame cages were 0.9 x 0.9 x 1.2 m long (3 x 3 x 4 ft) and had 6.4 mm (.25 in) woven aluminum wire mesh. Each aluminum cage cover contained a 22.9 cm wide by 30.5 cm deep by 45.7 cm long (9 x 12 x 18 in) feeding ring in the center. Styrofoam floats attached to the inside of each cage provided the necessary flotation. The cages were secured alongside a dock which was located in Loch Rosetta (Figure 1). This man-made lake received some heated water from the Florida Power and Light Company's Turkey Point generating station and is adjacent to the University of Miami's aquaculture facilities (Figure 1). Loch Rosetta is 396 m (1,300 ft) long by 99 m (325 ft) wide with an

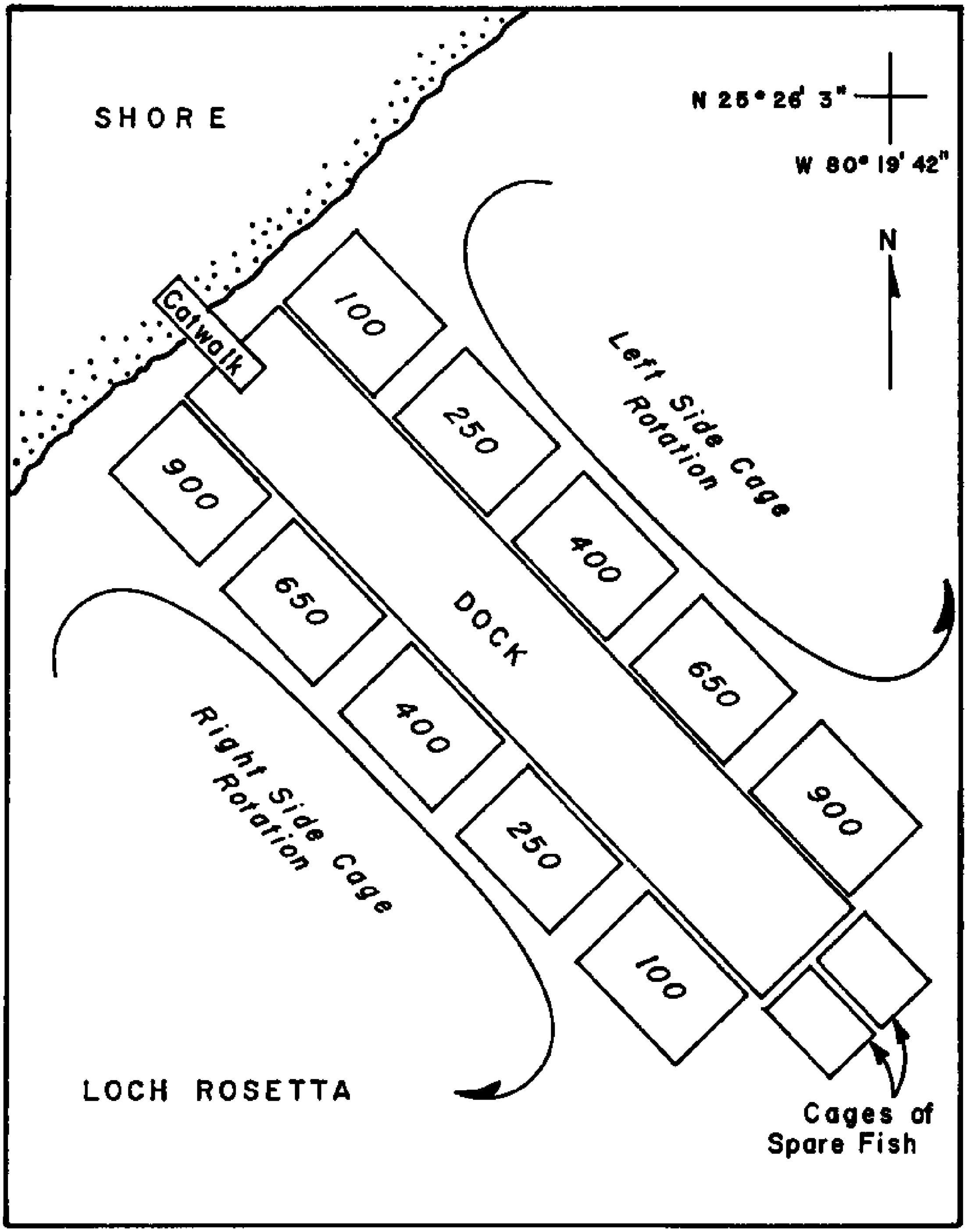
Figure 1. Map of Turkey Point Generating Plant showing location of study area.


N
Intake Canal
U.of M. Laboratory
Crostic Crossing
Power Plant
Turkey Point
Mangrove Creek
Dock and Cage Location
Loch Rosetta (396 x 99m)
Canal No. 1
BISCAYNE BAY
Scale in meters
0
600
Main Effluent Canal

average depth of 9 m (30 ft). It received heated water through the south end and had a tidal exchange in the north end through Crostic Crossing which is about 3.8 m (12.5 ft) wide and 1.4 m (4.5 ft) deep. Two 1.5 m (5 ft)-wide wooden docks with styrofoam blocks for flotation were used during the experiment. The first was 7.9 m (26 ft) long and permitted a cage spacing of 35.6 cm (14 in). After six months a 9.1 m (30 ft) dock was substituted for the first dock and it permitted a 61 cm (24 in) spacing between cages. Water depth beneath the dock varied from 1.7 m (5.5 ft) at the shallow end to 7.6 m (25 ft) at the deep end.

Juvenile pompano, collected by seining along the beaches of eastern Florida, were used in this study to test five stocking densities: 100, 250, 400, 650 and 900 fish per cubic meter. Each density was run in duplicate on opposite sides of the dock (Figure 2). The fish were sampled at two-week intervals at the beginning of the experiment; later, these intervals were extended to three, four and finally five-week sampling periods. During each sampling all fish were netted from their cages and counted by hand into a large tank of water; while being counted, the pompano were visually inspected for parasites and diseases. The fish were then netted into buckets and a total weight obtained on a scale with a 5 kg capacity in 1 g gradations. As the fish grew, it became necessary to use a scale having a 27 kg (60 lb) capacity in 45 g (.1 lb) gradations. After weighing, the fish were returned to clean cages. Pompano

Figure 2. Initial arrangement of cages showing stocking densities and rotational scheme.


SHORE
N 25° 26' 3"
W 80° 19' 42"
N
Catwalk
100
250
400
650
900
Left Side Cage Rotation
DOCK
900
650
400
250
100
Right Side Cage Rotation
LOCH ROSETTA
Cages of Spare Fish

killed or lost during sampling were replaced by fish of similar size obtained from two cages containing surplus stock, placed at the end of the dock. Two hundred of these fish were used to replace fish that died as a result of low oxygen due to heavy fouling in one of the 650 stocking density cages on 24 December 1970. These 200 deaths were not included in the mortality data.

Since cage positioning could have influenced the results, all cages were rotated one position each week on their side of the dock in order to reduce the effects of any non-homogeneity in environmental parameters such as current flow. Figure 2 shows the experimental design and rotational scheme.

A combination of dry, pelleted trout feed (Glencoe Mills) with a squid or fish supplement was used during the experiment. At the start, a #4 crumble (40% protein) was used and the size was increased until a 6.4 mm (.25 in) pellet (40% protein) was fed at the end of the study. In addition, from the eighth week to the twenty-ninth week, squid was fed one day per week. Starting on the thirtieth week when a nutritional deficiency was detected, a fish supplement was used instead of the squid because it was felt that fish would provide a more nutritionally-balanced supplement and was less expensive than squid. Chopped fish was obtained from a filleting house and consisted primarily of fish wastes: bones, skin, entrails and heads. Both the fish and squid were ground in an electric food grinder using cutting plates with 5 mm (.2 in) to 12 mm (.5 in) holes. Specially-ordered trout feed containing double the normal amounts of vitamins and minerals was used beginning on 27 April.

From preliminary studies, 6.3% was considered to be a sufficient, but not excessive, feeding rate. The pompano were sampled and weighed about every four weeks and the amount of feed adjusted to an initial rate of 6.3% body weight (all percentages hereafter will refer to body weight). The amount of feed remained constant for the cage throughout each sampling period. However, since the fish were growing, the feeding rate (percentage feed per pound of body weight) was actually decreasing until, by the end of the period, it might be only 4.0%. The mean feeding rate for the first seven weeks was 5.5%. From the eighth through the twenty-ninth week, squid was fed at a mean rate of 21.3%. During the period of nutritional recovery (from the thirtieth through the thirty-fourth week), ground fish was fed at a mean rate of 6.2% in addition to 2% pellets. After the recovery period, the mean feeding rate of ground fish was decreased to 5.4% and the mean rate of trout feed was increased to 3.8% because of financial and labor considerations. This mixture was fed until the end of the investigation.

Pompano were fed three times daily on weekdays, at 9:00 A.M., 12:30 P.M. and 4:00 P.M., and usually twice daily on weekends, at 10:00 A.M. and 3:00 P.M. Since a sinking trout pellet was used, care was needed to prevent pellets from falling out the bottoms of the cages. Slow feeding reduced such losses.

Food conversions were based on dry weight of feed to wet weight of fish. To obtain dry weights of ground squid and fish, five food samples were taken from feed prepared for the pompano. These samples were placed in an oven at 93 ^{o}C (200 ^{o}F) and weighed daily until a constant weight was obtained. The moisture content of the squid ranged from 82.8% to 84.6% with a mean moisture content of 83.5%. The fish samples ranged from 64.4% to 70.6% moisture content with a mean of 66.7%. The dry trout feed contained 8-10% moisture which was included in the calculation of the feed conversions.

The actual food conversion figures were based on weight changes in mean size of fish during a sampling period in relation to mean amount of food distributed to each fish during that period. By basing food conversions on changes in mean individual weights, it was possible to reduce the effects of mortality on food conversions by assuming that all fish that died during a sampling period died at midpoint in the period. Food which they would have consumed during the last half of the period was then allocated to the live fish and included in the calculation of food conversions. Thus, this method should give a realistic evaluation of the food conversions, if all food which entered the cages was available to and eaten by the pompano. Although no stomach analyses were performed, the amount of additional feeding from natural foods in the cages was probably insignificant; small crabs, shrimps and tube worms were found untouched in the cages during cleaning.

Because of fouling and accumulated debris, it was necessary to clean the cages. Several techniques were used for cleaning. Initially, the cages were brushed while in the water, but this method was not satisfactory. Scraping and brushing the cages after removal from the water was better. Later, a high-pressure water sprayer delivering 35.2 kg/cm^2 (500 psi) was used on the cages. This sprayer removed most fouling except for barnacles, oysters and most algal holdfasts. After several days of sun-drying, a second spraying removed most of the holdfasts. If the drying procedure was not used, up to 50% clogging occurred a few days after the cages were placed back in the water, mostly due to the settling out of detritus onto the algal holdfasts.

Temperature and salinity data were recorded daily at 9:00 A.M. and oxygen determinations also were made towards the end of the study. A mercury thermometer with 1^{o} gradations was used for temperature measurements, and salinity was obtained with an American Optical Company refractometer. Dissolved-oxygen levels were determined with a Yellow Springs Instrument Company oxygen meter. When the oxygen meter was used, temperature was obtained with this instrument. Temperature, salinity and oxygen determinations for

Loch Rosetta were taken from the south end of the dock with the pompano cages at a depth of 61 cm (2 ft). Data on ambient conditions were recorded from the intake canal (Figure 1).

Towards the end of spring, dissolved-oxygen became critically low (Table 1). After the scheduled 26 May sampling, several partial oxygen kills occurred and the experiment was terminated. All data contained in this paper were collected through the 26 May sampling period, except for the final individual length and weight data which were obtained on 11, 12 June and used to calculate the length-weight relationships and condition factor.

RESULTS

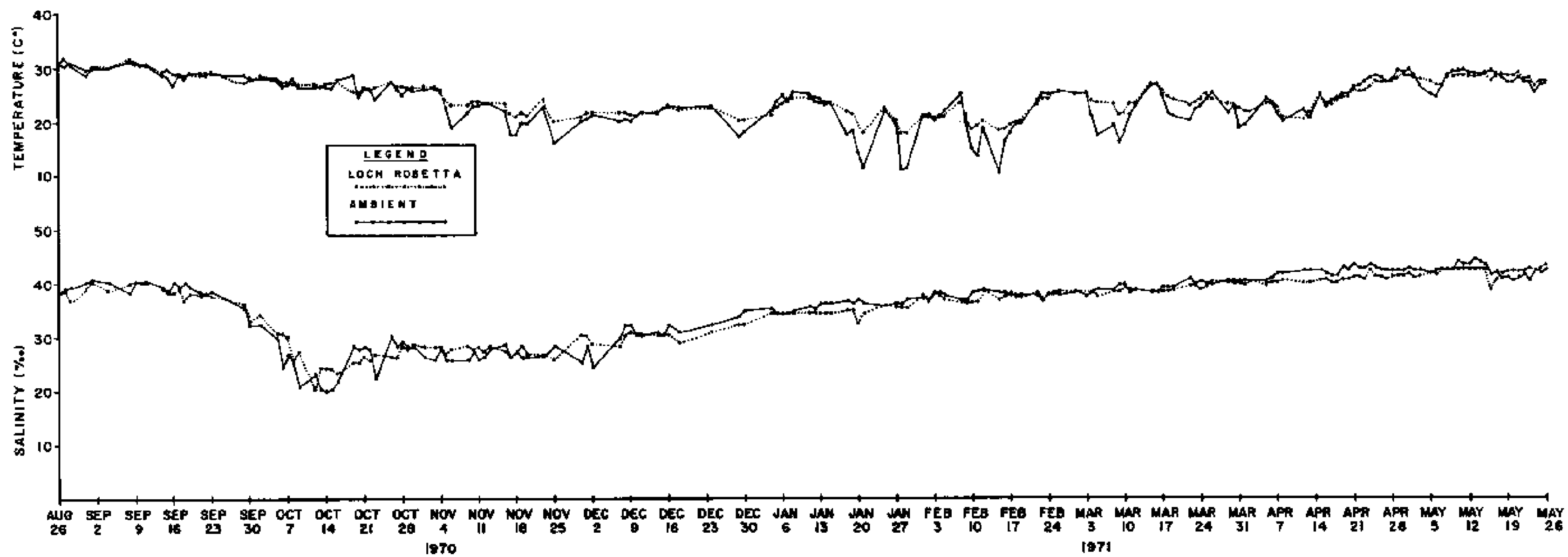
Temperature, Salinity and Oxygen Data

Temperature and salinity in Loch Rosetta generally fluctuated in the same direction as the ambient water of Biscayne Bay (intake canal) (Figure 3). However, several times from 21 January to 15 February 1971 the ambient temperature of the intake canal water dropped sharply to about $10^{\circ}C$, the lethal temperature for pompano. Due to the depth of Loch Rosetta and the addition of heated effluent at the south end, only small temperature changes occurred in the region of the cages. However, there was a low temperature kill of surplus pompano (not part of the experiment) being held in the ambient water of the intake canal. The dampening effect of Loch Rosetta on the temperature

Table 1.--Dissolved oxygen levels in area of cages in Loch Rosetta

Date	Dissolved Oxygen (ppm)	
	Loch Rosetta	Saturation
5/21/71	6.0	6.3
5/24	5.6	6.6
5/25	6.3	6.5
5/26	7.3	6.4
5/27	7.5	6.6
5/29	9.8	6.4
5/30	7.9	6.4
6/1	6.7	6.6
6/2	6.6	6.3
6/3	7.2	6.3
6/4	7.1	6.3
6/5	7.6	6.4
6/6	7.5	6.3
6/7	6.0	6.3
6/8	5.8	6.3
6/9	3.3	6.4
6/10	2.9	6.4
6/11	2.8	6.4
6/12	2.6	6.4

Figure 3. Comparison of ambient water temperatures and salinities (intake canal) with those occurring in the caged pompano area of Loch Rosetta.



TEMPERATURE (C°)
SALINITY (‰)
40
30
20
10
50
40
30
20
10
LEGEND
LOCH ROBETTA
AMBIENT
AUG 26
SEP 2
SEP 9
SEP 16
SEP 23
SEP 30
OCT 7
OCT 14
OCT 21
OCT 28
NOV 4
NOV 11
NOV 18
NOV 25
DEC 2
DEC 9
DEC 16
DEC 23
DEC 30
JAN 6
JAN 13
JAN 20
JAN 27
FEB 3
FEB 10
FEB 17
FEB 24
MAR 3
MAR 10
MAR 17
MAR 24
MAR 31
APR 7
APR 14
APR 21
APR 28
MAY 5
MAY 12
MAY 19
MAY 26
1970
1971

regime permitted growing of pompano throughout the year.

Dissolved oxygen in Loch Rosetta reached critically low levels several times in late spring (Table 1). During the last few weeks of the experiment, oxygen levels as low as 2.3 ppm were recorded in the cages during early morning hours and the experimental fish were observed lying on the bottoms of the cages. The reduced oxygen was attributed in part to the influx of poorly-oxygenated water from shallow water over adjacent grass beds which entered Loch Rosetta near the fish cages through the long, narrow mangrove-lined creek passing under Crostic Crossing (Figure 1). Two weeks after the last sampling period the pompano did suffer a partial oxygen kill in all cages, whereas there was no evidence that any of the wild fishes in Loch Rosetta succumbed.

Cage Fouling

Fouling and accumulated debris reduced the water circulation through the cages and was one of the most serious problems encountered in the experiment. The circulation pattern of Loch Rosetta, in combination with prevailing southeast winds, deposited *Rhizophora mangle* branches, leaves, roots and seeds; *Thalassia testudinium* and *Syringodium filiforme* blades, *Sargassum sp.* and other debris against the cages. Usually, this debris had to be removed daily. Bryozoans, oysters, polychaetes, algae and barnacles readily colonized the cage surfaces and their weight tended to slowly sink the cages. Most fouling of the 6.4 mm mesh was caused by algae, especially the red alga, Ceramium sp. Also, large amounts of suspended detritus stuck to the algae and settled out on the cages.

Diseases and Parasites

No epizootics occurred during the study. Juvenile pompano collected from the beaches had some obvious external parasites, Argulus sp. and an isopod, but these were lost as the fish were transported by truck from the beaches where they were collected or during the holding period prior to the experiment. About twelve weeks into the study, moderate numbers of monogenetic trematodes, probably Bicotylophora trachinoti (MacCallum, 1921) Price, 1936, were observed on the gills. These parasites were killed by placing the fish in a tank of 250 ppm formalin for 35 minutes. A similar treatment was administered during the time of nutritional trouble to remove the few monogenetic trematodes that were present.

Some dorsal abrasions were noted and attributed to pompano bumping the cages during their aggressive feeding behavior. As the fish grew, they became more active during feeding and in many cases knocked the aluminum screening out of the feeding rings. As a result, fish were injured on the sharp edges of the feeding ring frames as well as on calcareous fouling organisms. Removal of the feeding rings eliminated the occurrence of dorsal abrasions. Some lip abrasions appeared during the last few weeks of the experiment. These were apparently due to the fish moving along the screening facing the incoming water during periods of oxygen stress.

Mortality

Although differences in total mortalities among the various densities seemed probable, none were statistically detectable. An analysis of variance run on the mortality rates detected no difference ($Pr \geq .05$) by side of dock nor by stocking density (Table 2). The mortalities throughout the experiment at the different stocking densities are shown in Figure 4. The total mortalities by density and side of dock are summarized in Table 3. Thus, mortality is not a function of stocking density.

Differences in sampling period mortalities could exist, even though total mortalities were similar. Non-parametric statistics were used to analyze the data, since sampling periods were not of equal duration. Friedman's analysis of variance indicated no detectable differences ($Pr \geq .05$) in mortalities among stocking densities nor by side of dock.

Since there were no detectable differences, all cages were combined and the mortalities under various conditions examined. To do this, the number of fish dying during a period was divided by the number of days in the period to give the number of deaths per day during a particular period (Table 4). Under normal conditions a mean of 1.5 fish per day could be expected to die, whereas under conditions of stress or nutritional problems the rate could be 6.9 times the normal mortality.

Table 2.--Analysis of variance on mortality rates on 26 May 1971

Source of variance	Degrees of freedom	Mean square	F value
Stocking Density	4	23.73	1.83 ns
Side of Dock	1	20.42	1.57 ns
Residual	4	12.97	
Total	9		

Figure 4. Mortality of caged pompano at each stocking density from 26 August 1970 to 26 May 1971. Each point represents the mean of the two cages for each density.

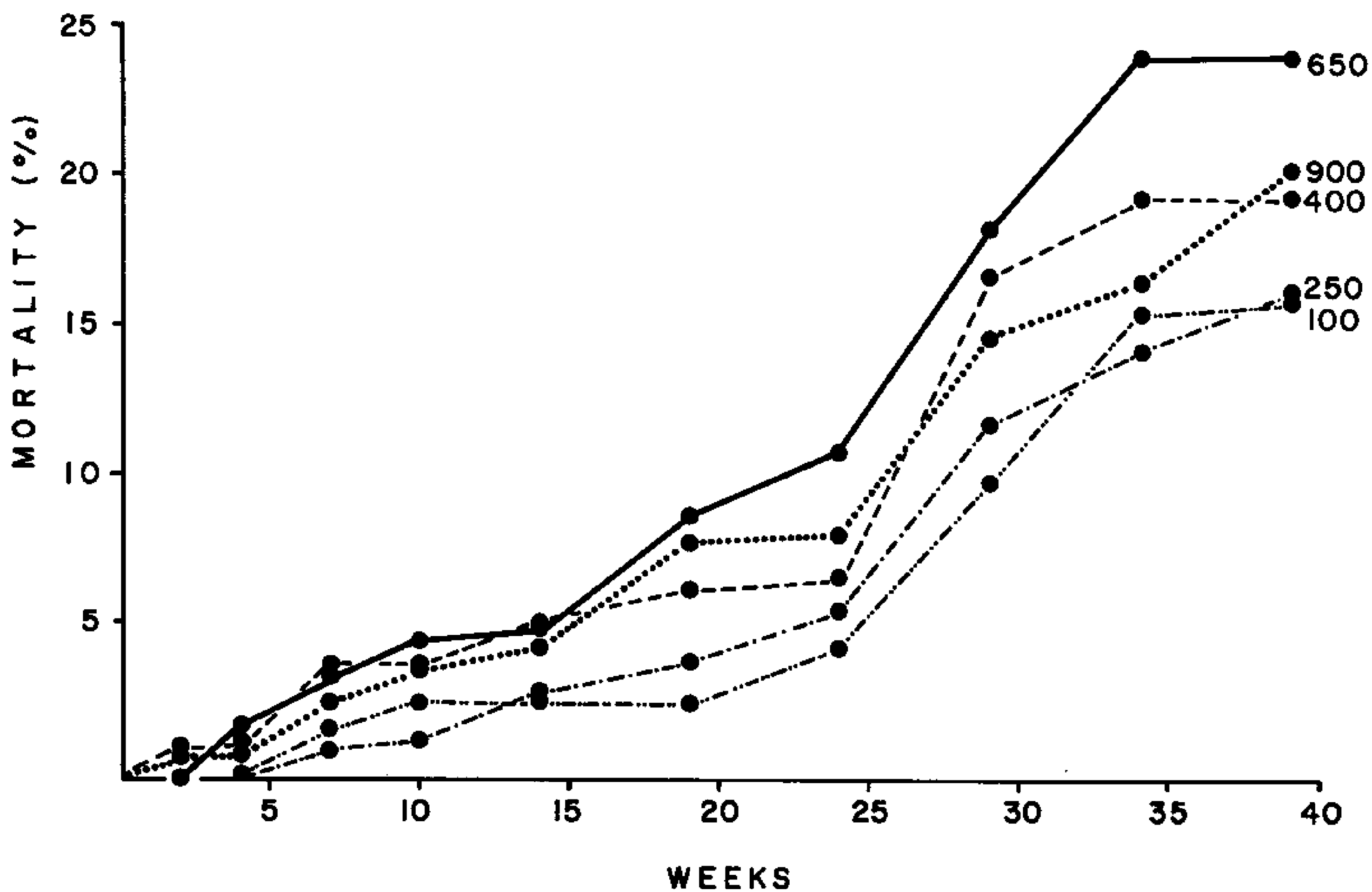

MORTALITY (%)
25
20
15
10
5
5
10
15
20
25
30
35
40
WEEKS
650
900
400
250
100

Table 3.--Percent mortality of caged pompano by stocking density and side of dock (26 August 1970-26 May 1971

Side of Dock	Stocking Density				
	100	250	400	650	900
Left	12.0	12.0	21.0	23.9	20.3
Right	20.0	20.4	18.0	24.9	20.2
Mean	16.0	16.2	19.5	24.4	20.3

Table 4.--Mortality and mean food conversions of caged pompano (26 August 1970-26 May 1971

Sampling Period	Duration (weeks)	Mortality in Mean # Deaths/Day	Diet	Mean Food Conversions[1]	Conditions
1	2	1.2	trout feed	3.71 (2.91-4.94)[2]	normal
2	2	1.7	" "	4.07 (2.17-7.18)	"
3	3	4.1	" "	7.55 (6.37-8.91)	wrong size trout feed
4	3	1.7	trout feed & squid	3.91 (3.27-4.56)	normal
5	4	1.4	"	2.98 (2.78-3.23)	"
6	5	3.6	"	5.25 (3.95-6.58)	cages badly fouled
7	5	1.3	"	2.97 (2.77-3.26)	normal
8	5	10.4	"	5.24 (4.09-5.96)	nutritional deficiency
9	5	4.0	trout feed & fish	4.61 (3.62-5.09)	nutritional recovery
10	5	2.2	"	5.14 (4.44-6.95)	oxygen stress

[1] Mean was obtained by averaging all ten cages.

[2] Range of food conversions.

Total mortality for the experiment was 20.7% or 951 fish. Of this total, 505 fish (53%) died during the period of nutritional problems. The nutritional problem developed about 1 March and peaked within a two-week interval with more than 100 fish dying in a two-day period. The fish first became sluggish and some would not feed. They were examined externally and dissected, but no parasites or bacterial infections were found. However, the blood was anemic (Carl Sindermann, personal communication) and the livers were pale and fatty. Fish was immediately added to the diet and mortality declined markedly over the next four weeks.

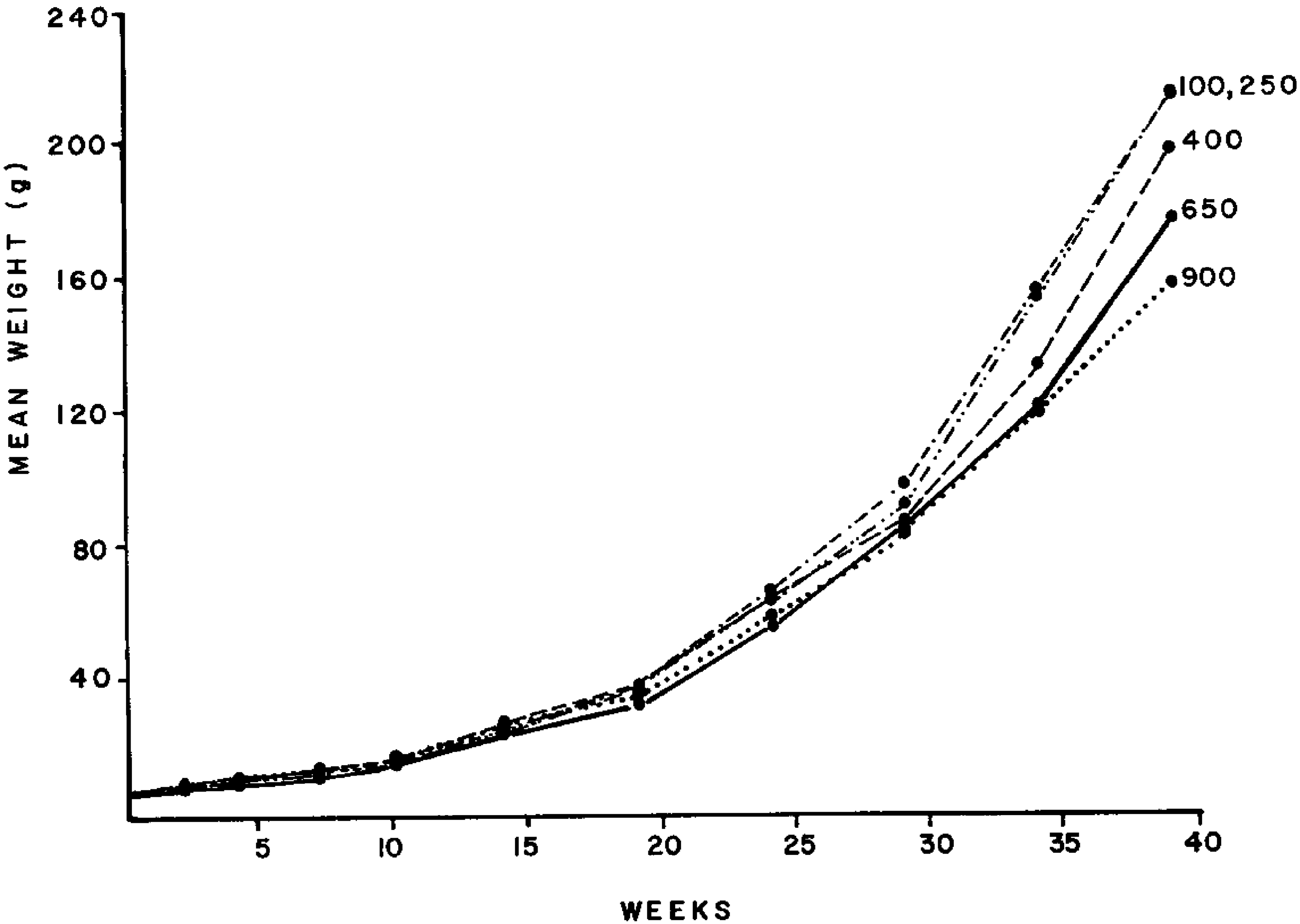
Food Conversion

Food conversion is influenced by many factors, including diet and size of fish. Therefore, the conversions obtained are not strictly comparable among different sampling periods. However, the overall mean for each period was calculated, as well as the range of values from the ten cages (Table 4). No differences were apparent for the various stocking densities, but it may be significant that when mean food conversion was high, so was mortality (Table 4).

Growth and Yield in Weight

Growth was similar in all cages for the first 30 weeks, after which the growth curves diverged (Figure 5). Variances within stocking densities were similar, except for density 100. Therefore, density 100 was excluded from

Figure 5. Mean weight of caged pompano at each stocking density from 26 August 1970 to 26 May 1971. Each point represents the mean of the individual fish weights of the two cages for each density.


MEAN WEIGHT (g)
240
200
160
120
80
40
5
10
15
20
25
30
35
40
WEEKS
100,250
400
650
900

further statistical analyses. An analysis of variance run on the other four final mean individual fish weights failed to detect a difference ($Pr \geq .05$) by side of dock, although a difference ($Pr \leq .005$) was found among densities (Table 5). Mean weights at different stocking densities were compared with the Student-Newman-Keuls multiple-range test and statistically significant differences ($Pr \leq .01$) were found among all densities.

Least square regressions were fitted to the growth data for each cage density and an analysis of variance was run on the slopes. No difference ($Pr \geq .05$) was detected by side of dock nor among the stocking densities (Table 6). The mean growth regressions by stocking density are shown in Table 7.

Total yields among the stocking densities were quite different, and yields per fish stocked were also dissimilar in most cases. Analysis of variance run on the yields per fish stocked found a difference ($Pr \leq .005$) by stocking density but not by side of dock ($Pr \geq .05$). The Student-Newman-Keuls multiple-range test detected no differences ($Pr \geq .05$) between densities 100 and 250, 250 and 400, and 650 and 900. All other comparisons were significantly different ($Pr \leq .05$). Total yields, yields per fish stocked and mean individual weights on 26 May 1970 are shown in Table 8. Also, Figure 6 shows the yields throughout the experiment. To obtain actual yield at a given time, multiply yield per fish stocked by stocking density; e.g. the

Table 5.--Analysis of variance on mean individual weights on 26 May 1971

Source of variance	Degrees of freedom	Mean square	F value
Stocking Density	3	1,089.85	104.59***
Side of Dock	1	16.38	1.57 ns
Residual	4	10.42	
Total	8		

***Significant at .005 level of probability.

Table 6.--Analysis of variance on growth rates

Source of variance	Degrees of freedom	Mean square	F value
Stocking Density	4	.00000575	5.17 ns
Side of Dock	1	.00000003	.03 ns
Residual	4	.00000111	
Total	9		

Table 7.--Mean growth rates of caged pompano at five stocking densities

Stocking Density	Regression Equation
100	log weight[1] = .8304 + .0389 time[2]
250	log weight = .8620 + .0384 time
400	log weight = .9028 + .0363 time
650	log weight = .8459 + .0366 time
900	log weight = .8956 + .0347 time

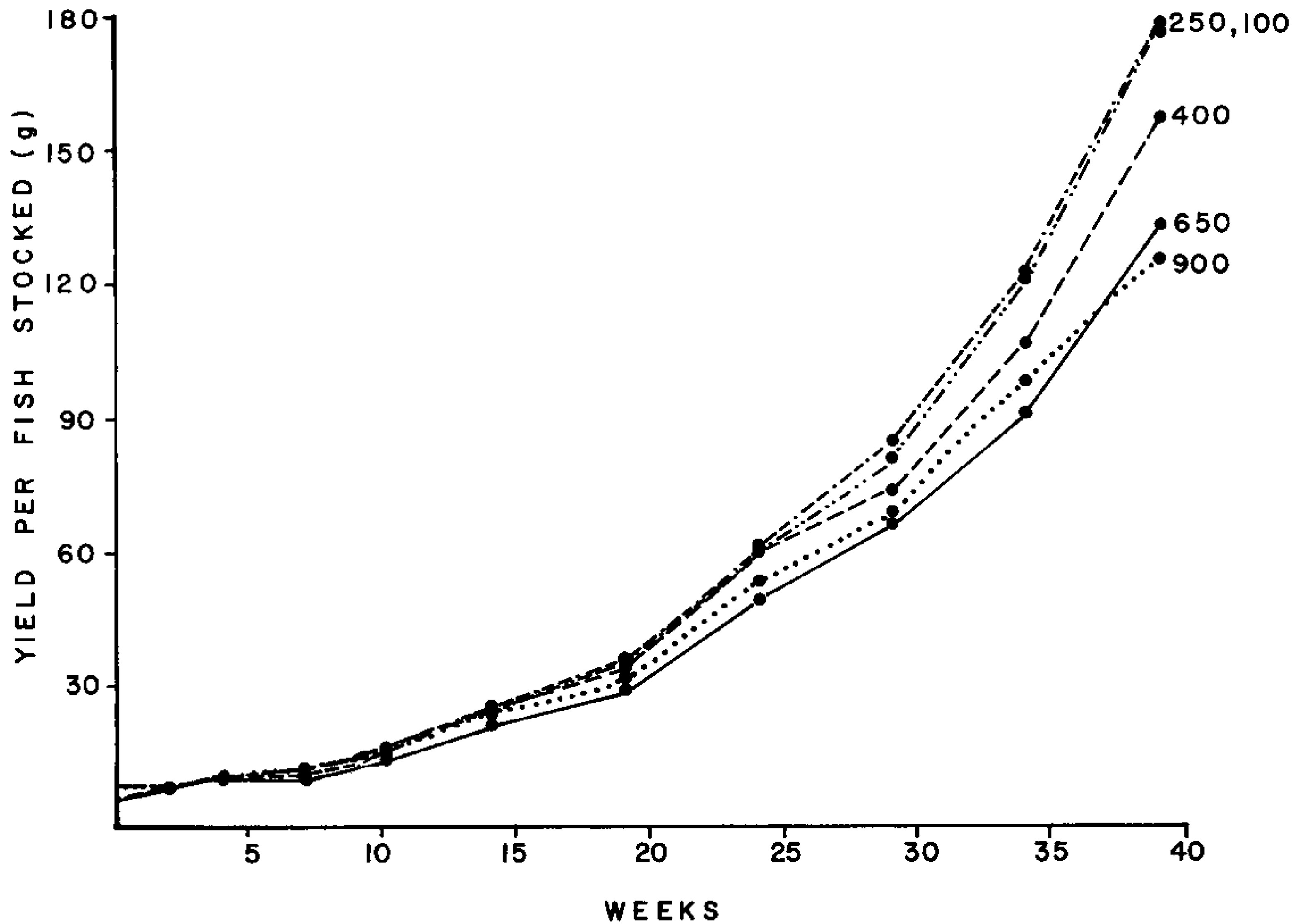
[1] Weight in grams.

[2] Time in weeks.

Table 8.--Yield, yield per fish stocked and mean size of caged pompano by side of dock and stocking density (26 August 1970-26 May 1971)

Stocking Density	Yield (in grams) by Side of Dock		Yield Per Fish Stocked (in grams) by Side of Dock		Mean Size (in grams) by Side of Dock	
	Left	Right	Left	Right	Left	Right
100	17,252.	18,501.	172.52	185.01	196.04	231.26
250	46,535.	42,903.	186.14	171.61	211.52	215.59
400	63,124.	64,032.	157.81	160.08	199.76	195.22
650	86,242.	88,898.	132.68	136.77	174.22	182.17
900	113,119.	116,129.	125.68	129.03	157.77	161.74

Figure 6. Yield per pompano stocked at each stocking density from 26 August 1970 to 26 May 1971. Each point represents the mean of the two cages for each density.


YIELD PER FISH STOCKED (g)
180
150
120
90
60
30
5
10
15
20
25
30
35
40
WEEKS
250,100
400
650
900

yield at stocking density 100 on week 30 equals 90 g x 100 fish = 9,000 g.

Length-Weight Relationships and Condition Factor

At the termination of the experiment there were differences in length-weight relationships among the different stocking densities. Samples of about 100 fish per cage were measured in fork length to the nearest millimeter and weighed to the nearest tenth of a gram. These data were transformed into common logarithms and an analysis of covariance run (Le Cren, 1951). No difference ($Pr \geq .05$) was detected by side of dock; therefore, the samples were combined by stocking density. No difference ($Pr \geq .05$) was detected among the regression slopes, but a highly significant difference ($Pr \leq .01$) was detected among the adjusted means (a measure of condition) (Table 9). The Student-Newman-Keuls multiple-range test found differences ($Pr \leq .01$) in all density combinations except 100, 250 and 400. Thus, stocking density did influence the relative "robustness" or condition factor of the fish. Fish stocked in lower density cages were heavier for a given length than those kept in higher density cages. The length-weight relationships are shown in Table 10.

Economics: Feed Costs and Time-To-Market

The cost of feed to raise 1 kg of pompano (mean size range of fish 158-231 g) was calculated. The price basis was: trout pellets - 20.9¢/kg, whole squid - 40.9¢/kg and chopped fish - 22.1¢/kg. The calculated costs are based

Table 9.--Analysis of covariance on the length-weight relationships

Source of variance	Degrees of freedom	Sum of Squares and Products x^2	xy	y^2	Deviations about Regression: Degrees of freedom	Mean square	F value
Stocking Density	4	0.1791	0.6405	2.3146	4	.00350	
Residual	959	2.3152	6.7488	20.7600	954	.00113	
Total	963						
Comparison of slopes							3.10 ns
Difference for testing among adjusted means					4	.02313	20.30**

**Significant at .01 level of probability.

Table 10.--Length[1]-weight[2] relationships of caged pompano at five stocking densities[3]

Stocking Density	Regression Equation
100	log weight = -4.7059 + 3.0323 log length
250	log weight = -4.3590 + 2.8815 log length
400	log weight = -4.2222 + 2.8212 log length
650	log weight = -4.4771 + 2.9263 log length
900	log weight = -4.4892 + 2.9266 log length

[1] Fork length in millimeters, range 123-253 mm.

[2] Weight in grams, range 42-371 g.

[3] Data pooled by stocking density.

on total amount of food fed and include losses due to fish mortality, pellets falling through the cages, food particles too small to be eaten by the fish and poor feeding response during the period of nutritional deficiency. The mean feed costs to rear 1 kg of pompano are, in order of increasing stocking density, $1.70, $1.76, $1.85, $1.90 and $2.16 (Table 11).

An analysis of variance run on the feed costs failed to detect a difference by side of dock, although there was a significant difference ($Pr \leq .05$) by density. The Student-Newman-Keuls test found no differences ($Pr \geq .05$) among densities 100, 250, 400 and 650, although all were different ($Pr \leq .05$) from density 900. Statistically, feed costs to raise 1 kg of pompano were similar in the four lower stocking densities; however, there was a definite trend: as stocking density increased, so did feed costs.

Generally, the estimated time-to-market for pompano varied according to stocking density. Assuming that growth rates remained the same, times to reach a marketable size of 454 g can be derived from the least square regressions fitted to the growth data. The variance within density 100 was non-homogeneous with respect to the other stocking densities; therefore, density 100 was excluded from further statistical analyses. Analysis of variance run on the other four densities found no difference ($Pr \geq .05$) by side of dock, although a difference ($Pr \leq .005$) was found among stocking densities. The Student-Newman-Keuls test

Table 11.--Calculated feed costs (in dollars) to raise 1 kg of pompano in cages by stocking density and side of dock

Stocking Density	Side of Dock		
	Left	Right	Mean
100	1.76	1.64	1.70
250	1.70	1.85	1.77
400	1.85	1.86	1.86
650	1.88	1.89	1.89
900	2.16	2.18	2.17

found differences ($Pr \leq .01$) among the four densities. Thus, stocking density did influence estimated time-to-market: as stocking density increased, so did marketing time. Table 12 shows that the times varied from a low of 46.8 weeks at density 250 to a high of 50.8 weeks at the highest stocking density. Therefore, starting with a 7 g pompano, it should be possible to raise a 454 g fish within a year.

DISCUSSION AND SUMMARY

There are many important details to be considered in the successful large-scale farming of pompano. At present, the farmer must rely on the vagaries of nature for his source of "seed" stock. Not only is seining for pompano along the beaches sometimes unrewarding, but it restricts the supply of stock to those periods of natural spawning. Furthermore, although seining is permitted in some states, Florida prohibits the taking of juvenile pompano for commercial purposes and other states may eventually do likewise. Also, the high cost of catching and transporting fry to a farm is a material consideration.

Several research organizations and corporations engaged in aquaculture recently have been able to artificially mature and spawn adult pompano and rear the larvae through the critical stages. Also, the National Marine Fisheries Services laboratory at St. Petersburg Beach, Florida, has worked on spawning with some success (Finucane, 1970b) and early in 1972 the Florida Department of

Table 12.--Estimated time (weeks) to raise marketable pompano (454 g) in cages by stocking density and side of dock

Stocking Density	Side of Dock		
	Left	Right	Mean
100	48.1	45.8	47.0
250	46.9	46.7	46.8
400	48.2	48.6	48.4
650	49.6	49.5	49.6
900	50.6	50.9	50.8

Natural Resources announced they had successfully matured, spawned and reared larvae up to 69 hours (Anonymous, 1972b). However, few have been able to rear the laboratory-spawned larvae without high mortality. Presently, there are no supplies of commercially-reared juvenile pompano available to the commercial grower. Hopefully, within the next few years the mass-culture of larval pompano will be achieved.

Cage design is an important consideration for a commercial venture. Although rectangular aluminum cages with 6.4 mm mesh were used, they are not recommended for future work. They were used in this study because they were commercially available; however, they are not durable enough to take harsh environmental conditions that exist in certain coastal zones. The aluminum frame can be easily damaged and the aluminum mesh can be ripped open by large fish predators. A vinyl-coated wire cylindrical cage as proposed by Swingle (1971) and modified by Swingle et al. (1971) would be more durable and less expensive to build. Cylindrical cages also eliminate the dead corners not utilized by pompano because of their milling schooling behavior. A cage design which permits changes in mesh size as fish grow would be an improvement because larger mesh size would permit increased water exchange and reduce fouling. Cages should be covered to prevent predation by birds and mammals. Also, covered cages should improve growth and survival and food utilization since pompano are less nervous and excitable in covered cages.

Cage fouling may be reduced or eliminated through the use of omnivorous grazers, different cage design and careful site selection. Schools of striped mullet were observed daily as they grazed along the cages. They did not seem to do an effective job on the 6.4 mm mesh, although Swingle et al. (1971) reported that mullet reared with pompano in cages having 12.8 mm (.5 in) mesh satisfactorily controlled fouling organisms. He attributed part of their success to the larger mesh. Another possible method for reducing the fouling that occurred in the corners along the frames is the use of a cylindrical cage design such as Swingle's (1971), Swingle et al. (1971) or that proposed by Caillouet (1972). In Caillouet's design, the cage can be rotated on its horizontal axis as needed to prevent the establishment of fouling organisms, or if cleaning is necessary it can be done without removal of the fish. Also, the design permits easy sorting and harvesting by simply placing a baffle inside and rotating the cage. In sorting, the baffle consists of a series of grading bars which permit smaller fish to swim through. In harvesting, the baffle consists of a solid plate which fish accumulate against as the cage is rotated. Also, proper site selection can reduce the amount of fouling organisms and totally eliminate certain types of fouling such as floating debris.

Although I had no serious problems with either diseases or parasites, these can become serious problems for a commercial operation. Parasites on wild pompano have been observed by Linton (1905, 1940) and Overstreet and Brown (1970) have described a digenetic trematode found in pompano. Several authors, including Iversen et al. (1969), Brown (1971), Monroe (1971), Swingle et al. (1971) and Williams (1972) have recorded disease and parasite problems associated with cultured pompano.

Few of the chemicals suggested for the control of diseases and parasites are approved by the Food and Drug Administration for use on fishes raised for human consumption. This situation is especially true for marine species such as pompano. Although Swingle et al. (1971) has studied the toxicity levels to pompano of Dylox and Birdsong and Avault (1971) have determined the toxicity levels of acriflavin, copper sulfate, formalin and potassium permanganate, none of these legally can be used. Only salt, glacial acetic acid and sulfamerazine are approved for use on all food-fishes and terramycin is restricted to use on salmon, trout and catfish.

The use of reduced salinities may help control parasites. In preliminary aquaria studies done in 1970, monogenetic trematodes, causing gill infestations on pompano, were effectively controlled by reducing salinity. Kumpf (1972) also found that salinity extremes had a controlling effect on the number of parasites infecting pompano. Since pompano can tolerate very low salinities (Moe et al., 1968; Allen and Avault, 1970; Nelson and Neely, n. d. and Kumpf, 1972), it is possible that this method can provide some control in a large-scale operation.

The utilization of cages interrupts the life cycles of those parasites with indirect life cycles, because the intermediate hosts are not normally found in the cages. Also, since cages are not in contact with the bottom, parasites requiring bottom substrate for part of their life cycles cannot easily reinfest caged fish, particularly if water depth is great. Swingle *et al.* (1971) and Williams (1972) discussed the parasitic infestation of pompano before and after culture in cages. Generally, digeneans, leeches, copepods, isopods and blood flagellates were reduced or absent in post-culture samples, although immature cestodes and *Trichodina* increased. In comparison with pond and tank culture of pompano, my findings of reduced parasite problems associated with cage culture are similar to those found for other species raised in cages, such as *Tilapia aurea* (Pagan, 1969) and channel catfish (Collins, 1970; Hatcher, 1970 and Smith, 1970). However, susceptibility of caged fishes to bacterial infections may be increased (Hatcher, 1970 and Smith, 1970).

The lack of a nutritionally complete pelleted ration is still a major obstacle to profitable pompano farming. My study re-emphasizes this fact. Diets of codfish, shrimp meal and trout feed have been shown to be nutritionally inadequate (Finucane, 1969b, 1970c). Tatum (in press) examined the feasibility of using ground fish and a soybean mixture and obtained poor growth and survival.

He also used trout chow with no nutritional problems, but the lack of dietary problems was probably due to the shortness of the study which may not have allowed time for acute symptoms to develop. At present, it seems that trout feed supplemented with ground fish is suitable for growing pompano, but use of this diet does not necessarily insure optimum growth.

Mortality during the experiment was considerably less than that experienced in other studies. In 12.2 m-diameter cylindrical outdoor tanks at Seaquarium, Miami, Florida, mortality was as high as 40% (Iversen et al., 1969). Finucane (1969b, 1970b,c) experienced mortalities up to 95% in his salt water enclosure and floating pen studies. These high mortalities were primarily a result of inadequate diet and low temperatures. Loss of fish due to inadequate diet can be minimized by routinely having the fish analyzed histologically and bio-chemically, and adjusting the diet accordingly. Some symptoms of nutritional problems are discussed by Halver (1970).

Although I started with 7 g fish, mortality was low and I did not encounter high mortality of juvenile pompano under 10 g as reported by Swingle et al. (1971) and Tatum (in press). I concur with Iversen et al. (1969) that a mortality of 10% should be the upper limit experienced by a properly equipped and managed pompano farm. This 10% includes mortality during transportation and that attendant to the rearing to market size of beach-caught fry.

An analysis of the regression lines for the length-weight relationships among the various stocking densities showed them to be statistically significant. When plotted, these regression lines indicate that the highest condition factor was obtained at the lowest stocking density, while the poorest condition factor occurred at the highest density. Comparison with tank-reared pompano at Seaquarium (Iversen *et al*., 1969) show that the cage-reared pompano have a slightly lower condition factor. The length-weight relationships of the lower stocking densities are similar to those of the St. Augustine pond-reared fish and the length-weight relationship at the highest stocking density is similar to that of the St. Augustine wild fish (Moe *et al*., 1968). Thus, these data suggest that it is possible to regulate the condition factor in cage-reared pompano by manipulating stocking density.

The optimum stocking density was not determined, although yields as high as 116.1 kg/m^3 (255.5 lb) were obtained. No apparent differences were found between stocking densities 100 and 250. There were, however, differences in mean size among the other stocking densities and in some cases among yields per fish stocked. No difference was detectable with respect to mortality. The decrease in growth rate in the highest stocking density may be a reflection of overstocking or of increased sensitivity to environmental conditions. I believe that it was due primarily to the latter cause, and that higher yields can be obtained.

Projected growth of pompano in cages suggests that market-size fish can be raised within one year. Some pompano grew to 454 g within ten months, but mean size was much smaller and overall growth rates were slower than those reported in other studies. Initial growth corresponds to that obtained by Tatum (in press) on a ground fish and soybean diet and is much slower than that obtained on the trout diet. The initial slow growth may reflect the effects of repeated sorting of the fish prior to the experiment and necessary handling involved in weighing, counting and measuring the fish as they were stocked into the cages. Also, in the early part of the experiment sampling periods were short and may have disturbed the fish. Furthermore, the cages were only 35.6 cm apart and cage cleaning was inefficient. The growth rates of pompano above 40 g in size increased but were still less than those obtained by Iversen et al. (1969) and Swingle (in press). Probably, most of the difference was due to poor water circulation because of small cage mesh and closeness of cages. Studies of caged channel catfish have shown that 6.4 mm mesh is significantly inferior to 12.8 mm mesh in terms of yield, mean weight per fish and survival (Schmittou, 1969). Also, it should be remembered that this study was conducted during the cooler months of the year (26 August to 26 May); and that water quality was poor during parts of the study. Thus, the growth rates obtained are probably less than those which can be achieved in a commercial operation.

Although the present marketable size of pompano is about 454 g, it may be more economical for cultured fish to be marketed at a smaller size. It has been suggested by recent attempts to raise pompano that peak growth is attained around 230-280 g (8-10 oz), after which growth seems to slow down markedly (Ray Lewis and John Christopher, personal communications). If this is the case, it would be more economical to harvest the fish at this size. Several restaurants have indicated that they will have little trouble in selling these "pan-size" pompano.

Financial considerations are basic to the establishment of a profitable fish farming operation. Therefore, some economic aspects of this study were considered in order to estimate the economic feasibility of a cage culture system for rearing pompano (Table 13). Cost projections for different stocking densities include: cages, labor, feed and fingerlings. All costs and yields are based on the ten-month study period. No attempt is made to estimate other expenses such as the cost of leasing the water column, on-shore installations, equipment and supplies, and marketing costs, because of their highly variable nature.

The cages used in the study were of poor quality construction and are no longer commercially available. Therefore, the cage costs are derived from cages designed by Wayne Swingle (1971), Alabama Department of Conservation,

Table 13.--Some economic estimations for raising pompano in cages at five stocking densities

Stocking Density	Rearing Costs for 10 Months (in dollars)					Yield (in dollars)	Profit (in dollars)
	Cages	Labor	Feed	Fingerlings	Total		
100	2.79	31.25	30.42	7.00	71.46	78.82	7.36
250	2.79	31.25	79.17	17.50	130.71	197.17	66.46
400	2.79	31.25	117.99	28.00	180.03	280.32	100.29
650	2.79	31.25	165.00	45.50	244.54	386.11	141.57
900	2.79	31.25	248.27	63.00	345.31	505.40	160.09

for rearing pompano and other marine species. Since Swingle's cages are only three-quarters the size of those used in my study, their cost is multiplied by 1.34 to give the estimated cost for a one cubic meter cage. The life expectancy of these cages is about ten years, giving a 10-month cost of $2.79 per cage.

The labor required to care for a cage is based partly on my experience and partly on that experienced in a 1,000-cage commercial catfish operation (Paul Barrett, personal communication). It assumes an efficient system of several hundred cages with fully-utilized manpower. A floating feed to minimize waste can be delivered to the cages by demand feeders or by boat. It is estimated that two men can completely care for about 400 cages daily. Based on a seven-day work week, their combined salaries total about $15,000 yearly or $31.25 per cage for ten months. This assumes that the time it takes to feed different densities of fish is about the same, a reasonable assumption if a floating feed is employed.

The cost of feed to raise pompano at the different densities is taken directly from my data. It includes mortality and feed wastes as mentioned previously. The price basis of the feeds was also given earlier.

The cost of pompano fingerlings for stocking into the cages is hypothetical, as none are commercially available at the present. However, when available, a price of 7¢ each seems reasonable, based on catfish fingerling prices.

The price of marketable pompano has steadily increased over the years and is presently at a new high. A survey of local retail outlets in Miami yielded a price range of about $2.49 to $2.99 per 454 g for pompano "in the round," with a mean price of $2.75. The present ex-vessel price is about $1.75 per 454 g. Thus, a farm selling-price of $2.00 wholesale appears reasonable since cultured fishes usually receive a higher price than wild-caught fishes because of superior quality. In fact, a higher price might be obtainable if these cultured fish are sold directly to restaurants and are available during those times of the year when natural supplies are low.

The yields of pompano at the different stocking densities were taken from my data (Table 8). However, we are dealing with a total yield in weight; few individual pompano were of marketable size.

From Table 13 it can be seen that as stocking density increases, so does the profit. Since these calculations are based on small experimental cages, use of larger cages can aid materially in increasing the profit by increasing yields without significantly changing labor costs. Also, there is some evidence that fish grow faster in larger cages, even though stocking density remains constant (Paul Barrett, personal communication). Additional savings are possible by stocking cages by weight rather than by number of fish. As the total weight of fish in the cage approaches the maximum carrying capacity for rapid growth, more cages can be added as needed, permitting efficient utilization of cages.

The cost of rearing pompano is partially dependent on their efficiency of food utilization. Food conversions and costs obtained in this study are somewhat high and are comparable to those obtained by Swingle (in press). Since a sinking trout pellet was used, there were losses through the cages which increased the calculated food costs, as did similar losses from the ground squid and fish. The feed conversions obtained by Tatum (in press) using trout feed are more encouraging, with an overall value of 3.8 and some as low as 1.6. Probably, food conversions of 2.0-3.0 can be obtained using a fish-supplemented trout feed diet.

An interesting aspect of the cage culture study was the accumulation of large numbers of wild fishes around the cages. Snappers, primarily grey snappers (Lutjanus griseus), stayed in the area of the cages and ate pellets that fell through the cages. A population of several hundred remained throughout the experiment. Less numerous were the striped mullet which regularly grazed on the cages. Although a resident population of about 30-50 occurred, at times their numbers reached close to 1,000. These mullet actively sucked the pellets out of the cages and tended to keep the pompano from feeding on food falling to the bottoms of the cages. Several large snook, Centropomus unidecimalis, of about 9 kg (20 lbs) regularly stayed under the dock and on occasion were observed feeding on the mullet. Also, several medium-size great barracudas, Sphyraena barracuda, were seen in the area of the cages. Although these wild fishes could be caught by hook and line, a more efficient harvest method can be devised to provide additional income for the cage culturist, assuming there are no legal constraints. Perhaps conditioning them to feed in open-sided cages which can be quickly closed might work. In any case, these wild fishes can certainly provide recreational fishing, if not supplemental income.

The possibility of rearing pompano without the use of confining structures was suggested by this research. Prior to the study, it was noted that small pompano which escaped would stay around the caged fish until eliminated by predation. Therefore, at the termination of the study, approximately 2,000 160-230 g pompano were released and two cages containing about 150 fish each were retained. The released fish stayed in the vicinity of the dock and were fed daily along with the caged fish. During this period, visual estimates during feeding periods suggested that most of the pompano had remained in the area. After three months the remaining caged fish were removed and feeding of the released pompano ceased. Although not being fed, these free pompano remained near the dock for another month. At this time it was estimated that about 300-500 pompano remained, and these fish were very thin. Thus, it seems that they had become heavily dependent on the pelleted food and would stay in an unconfined area after they had been conditioned. Similar behavior was observed in pompano released into the Atlantic Ocean off Plantation Key, Florida (John Christopher, personal communication). This finding suggests the possibility of developing a technique for conditioning pompano to come to feeding stations where they can later be harvested for market.

In summary, the data obtained from this study are encouraging. It was demonstrated that pompano can be raised successfully in cages at high densities with fewer difficulties than with other rearing techniques. Also, cages provide a flexible system of fish culture in terms of management and low initial investment. I believe that considerable improvement is likely with the use of proper cages, careful site selection and the use of automatic or demand feeders and an improved floating pellet. The possibility of supplemental income from wild fishes associated with a cage system was suggested as was the feasibility of rearing pompano without the use of confining barriers. Yields on the latter type of system exposed to natural mortality and straying await determination.

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VITA

Theodore Isaac Jogues Smith was born in Brooklyn, New York, on January 13, 1945. His parents were Theodore Graham Smith and Madeline Sonsire Smith. He received his elementary education at Saint Mary Magdalene Parochial School, Springfield Gardens, New York, and his secondary education at Saint Dominic's Parochial High School, Oyster Bay, New York. In September 1962, he enrolled in Nassau Community College, Garden City, New York, and graduated with an Associate in Arts degree in biology in June 1964. In September 1964, he entered the School of Agriculture, Cornell University, Ithaca, New York, and in August 1966, he received his B. S. degree in marine ecology.

He was admitted to the graduate school of C. W. Post College of Long Island University, Greenvale, New York, in September 1966. He was awarded the degree of Master of Science in marine science in October 1968.

He entered the graduate school of the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Florida, in September 1968, and was granted the degree of Doctor of Philosophy in marine sciences in January 1973.

He was married to Karen Lydia Clendinnen of Coram, New York, in March 1968. They have no children.

Permanent Address: 11445 Quail Roost Drive
South Miami Heights, Florida