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VERTEBRATE AQUACULTURE RESEARCH UNDER THE SEA GRANT PROGRAM AT SKIDAWAY INSTITUTE OF OCEANOGRAPHY DURING 1971

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The research discussed in this report involves the examination of various vertebrate species as to their suitability for aquaculture in Georgia coastal waters. This research was funded by the Sea Grant Office of the National Oceanic and Atmospheric Administration under Grant 1-36009. Funding was obtained for this project on 1 May 1971 and this report covers research activities for the period 1 May through 31 December 1971.

FACILITIES

During the first year of this sea grant project, two types of facilities were to be constructed. The first of these was a temporary metal building approximately 25 by 100 feet in dimension which was completed late in the summer 1971. This building houses a small laboratory, fiberglass rearing tanks and aquaria. The laboratory is used for feed preparation, storage and water quality analyses.

The second part of the facility involves the construction of a series of small ponds adjacent to the Skidaway River. Negotiations are presently underway for construction of the ponds which will be used during the second year of study.

The metal building presently houses 36 1-meter diameter by 1-meter deep fiberglass culture tanks and 20 fiberglass aquaria maintained at a volume of 50 liters each. Both the fiberglass tanks and aquaria are operated utilizing a flow-through water system.

Water is pumped directly from the Skidaway River into a gravel filter which removes most of the suspended material. Water is then pumped directly to the aquaculture facility. Water may be run into the tanks at either ambient river temperature or it may first pass through a large fuel oil heater which can be adjusted to heat the water from its coldest ambient winter temperature to approximately 30°C. Water enters the tanks and aquaria through constant volume flow regulators. The tanks drain via Venturi drain systems into troughs recessed in the floor of the building. The water then passes into a drainage ditch and returns to the Skidaway River. The aquaria are also fitted with constant flow regulators. Outflowing water is passed through a series of pipes and into the floor drain system.

The water passing through the flow regulators enters the tanks under sufficient pressure to maintain the oxygen level in the water above 6 parts per million (ppm) provided that tanks are not overstocked. In case of water failure, an AC/DC air compressor provides supplemental aeration via air stones in each tank.

SAMPLING

The initial goal of this project was to demonstrate the feasibility of rearing commercially valuable flounders of the family Bothidae under aquaculture conditions. To accomplish this goal it was decided that juvenile flounders be obtained by otter trawling. During May, 1971, several trawls were made in Wassaw Sound, Georgia with two 35-foot diameter otter trawls from a commercial shrimp boat. Several flounders of the genus Paralichthys and approximately 300 oscellated flounders (Ancyclopsetta quadrocellata) were obtained. These fish were stored outdoors in fiberglass tanks since the indoor facility had not been built at that time. The fish were subsequently lost due to bird predation and failures of the water system.

Ancyclopsetta quadrocellata appeared in the otter trawl catches associated with another sampling project beginning in November, 1970 and apparently disappeared from Georgia coastal waters after May, 1971. Our catch records appear to agree with other catch records from the state for this species (Dahlberg and Odum 1970). Flounders of the genus Paralichthys occurred throughout the year; however, never in great numbers. Most of the Paralichthys flounders obtained were Paralichthys lethostigma with the second most prevalent species being Paralichthys dentatus.

During the calendar year 1971 an excess of 200 trawl stations were made in the estuarine waters of the coast of Georgia using otter trawls varying from 20 to 55 feet in diameter at the mouth. On no occasion did flounders of the genera Paralichthys or Ancyclopsetta dominate the catches and in many cases these fish were absent from the catches. Etropus crassosutus often dominated individual catches and was regularly of suitable stocking size (ca. 40-50 mm standard length). Unfortunately, this fish does not reach a commercial size.

Following completion of the indoor aquaculture facility, a two-day cruise was undertaken on the R/V Kit Jones, a 65-foot trawler, which is maintained and operated by the University of Georgia Marine Laboratory at Sapelo Island. During the two day period, 7 through 8 October, 1971, sixteen otter trawls each of approximately 25 to 30 minutes duration were made with a 55-foot diameter net. Approximately 70 flounders of the genus Paralichthys were obtained. These fish were subsequently transported to the Skidaway Institute of Oceanography. About 50% of the fish died within two weeks following capture due to injuries incurred either during trawling or transportation. A second sampling cruise on the R/V Kit Jones was undertaken on 20 December 1971 yielding about 30 Paralichthys. Other sampling trips on other boats failed to yield more than a very few Paralichthys or Ancyclopsetta.

In addition, the flounders captured on all cruises averaged upwards of 100 grams whereas fish of much smaller size were sought. At no time during the year were small flounders captured in quantity.

Due to the relative unavailability of flounders, other fish species were examined as to their potential for aquaculture. To date these include the Rock Sea Bass, Centropristes philadelphicus and the Spotted Sea Trout, Cynoscion nebulosus. Centropristes philadelphicus were obtained by both rod and reel and by trawling. Cynoscion nebulosus were sometimes obtained in the otter trawl; however, they were usually severely damaged and did not survive following capture in the net. The fish which were eventually stocked in the tanks for evaluation of feeding behavior were obtained by rod and reel.

EXPERIMENTAL

Flounder Experiments

Paralichthys were stocked on 17 October, 1971 at low density in several 1-meter diameter fiberglass tanks (Table 1). The fish were weighed individually at the time of stocking and at bi-weekly intervals through 9 December 1971. Water quality data including temperature, salinity and pH were obtained during much of the experimental period (Figure 1).

Temperature was maintained by use of the oil fueled heater and after the heater was put into operation late in October, 1971. Temperature was generally in the range 20 to 25°C. Salinity ranged generally between 20 and 25 parts per thousand (ppt) while pH showed a narrow range of 7.7 to 7.9. Occasional oxygen determinations were made by means of the Winkler titration method. At no time was the oxygen concentration found to be below 7 ppm in any tank. Mortality over the experimental period varied between 0 and one fish per tank (Table 1).

The fish were fed twice daily at 3% of body weight on number 5 Purina floating trout chow pellets. These pellets are approximately 5 mm in diameter. Prior to the initiation of the experiment, the fish were offered the same feed ad libitum over a period of several days. Previous investigations on Ancyclopsetta quadrocellata (Stickney, White, and Miller 1972) and Paralichthys (R.R. Stickney, unpublished data) indicated that these fish will eat floating pelleted diets although a period of starvation appears necessary prior to acceptance of pelleted food by the fish.

Growth data for Paralichthys flounders are presented in Tables 1 and 2. From Table 1 it is apparent that the smaller fish more readily accepted the pelleted diet as indicated by their subsequent growth.

Feeding activity was observed in each of the tanks; however, the smaller fish (especially groups 5, 6 and 7) appeared to more completely consume their feed than did the larger fish. Group 1 was also composed of small fish but these failed to develop a well established feeding pattern. Paralichthys in nature are carnivores and feed almost exclusively on living prey. It seems apparent from the data in Table 1 that these fish can be more readily trained to accept non-living pelleted feed when obtained at a small size. The average size of the smallest group investigated was somewhat larger than we would have preferred, thus, it is not presently known if smaller fish can be adapted to feed on pellets.

Surface feeding has several advantages including the fact that the workers can determine how much of the feed is consumed and the waste does not accumulate on the bottom of the tank where it can rot and foul the water. The incoming water is often too turbid for easy visualization of the fish so feeding activity is also more readily observed when floating pellets are used.

That the growth rate of Paralichthys is not particularly rapid is apparent from the data in Tables 1 and 2. Food conversion ratios (gram feed/gram weight gain) of less than 2.0 may be considered fairly good for fish.

It is apparent from the fishing efforts of 1971 that sufficient numbers of Paralichthys cannot be readily obtained through trawling.

It may be possible to obtain Ancyclopsetta quadrocellata in quantity during restricted periods of the year, but the fact that Ancyclopsetta quadrocellata disappears from the Georgia coastal environment during the summer months may be an indication of temperature limitations which could restrict attempts at aquaculture. In either or both cases, the ultimate usefulness of flounders in aquaculture will probably depend upon either spawning the fish in captivity or collecting postlarvae from nature in quantity. Field stripping of flounders has been accomplished off New England (Smith and Fahay 1970). Larval flounders are available along much of the east coast of the United States and are abundant as far south as North Carolina during the winter (Williams and Deubler 1968); however, there have been no published reports as to their availability off the Georgia coast. Future plans include the capture of postlarval Paralichthys from North Carolina and attempts at rearing them in the present aquaculture facility.

Centropristes philadelphicus

The Rock Sea Bass (Centropristes philadelphicus) reaches a maximum size of approximately 500 grams and is not as highly regarded as its close relative, the Blackfish, (Centropristes straitus).

Two groups of Centropristes philadelphicus, one made up of relatively small fish and the other of subadults, were examined (Table 3). The fish were fed twice daily at 3% of body weight a diet of Purina floating trout chow pellets. These fish were individually weighed at the initiation of the experiment and weighed bi-weekly thereafter. Temperature, salinity and pH determinations for Centropristes philadelphicus are presented in Figure 1. Centropristes philadelphicus proved to be an aggressive feeder following about a week to 10 day period of acclimation to pelleted food. They did not; however, always consume the whole of their 3% daily feeding. In spite of their active feeding behavior, a pattern of rather slow growth was obtained (Table 3). This may have been related to the rather high apparent metabolic rate of the animals.

Even through the growth rate of Centropristes philadelphicus was low, we were encouraged by the fact that these fish did adapt rapidly to the pelleted diet. The Blackfish, Centropristes striatus, is common on the continental shelf off Georgia and will be investigated for its aquaculture potential in light of the results obtained with Centropristes philadelphicus. Centropristes striatus can be captured in sufficient quantity by rod and reel or trapping and is available throughout the year.

Cynoscion nebulosus

The Spotted Sea Trout, Cynoscion nebulosus, is a popular sport fish of the Georgia coast along with its relative the Weakfish, Cynoscion regalis. Cynoscion nebulosus occurs mainly in the winter while Cynoscion regalis is common during the warmer months in Georgia. Several tanks were stocked at low density with Cynoscion nebulosus for a one month period (Table 4). Three tanks were maintained at ambient river water temperature (cold water) and one tank was furnished with heated water. The temperature regime in the heated and unheated tanks as well as the salinity regime of the experimental tanks are presented in Figure 2. The fish were weighed and fed as described for the species previously discussed. The fish were not observed to eat in any of the tanks although the experiment was run for approximately one month. Fish in all tanks lost weight during the experimental period. Cynoscion nebulosus, as is the case for the other species of fish examined to date, is a carnivore. The fish used in this experiment were of a small adult size and were apparently unable to adapt their feeding habits to the artificial diets. Sinking pellets were also tried during the period of the experiment without success. Further experiments will be run in the future using Cynoscion nebulosus and/or Cynoscion regalis of smaller size to ascertain whether or not it is possible to adapt these fish to pelleted diets.

Sea Turtles

During October, 1971, hatching Green Sea Turtles (Chelonia mydas) and Loggerhead Sea Turtles (Caretta caretta) were were obtained from the Florida Board of Natural Resources Laboratory in Jensen Beach, Florida. Approximately 100 Green and 60 Loggerhead Sea Turtles were made available to our laboratory. These animals were fed ad libitum for several weeks on both pelleted Purina trout chow and ground fish diets. Subsequently, groups of turtles of each species in duplicate aquaria were placed on diets of either (1) floating Purina trout chow pellets, (2) half Purina floating trout chow pellets and half ground fish, (3) ground fish or (4) ground crab scrap diets. These experiments were still in progress at the conclusion of calendar 1971 and the results are being prepared for separate publication.

FUTURE STUDIES

During calendar 1972, attempts will be made to obtain postlarval flounders for rearing to market size in tanks. In addition, attempts will be made to evaluate the aquaculture potential of other finfish which are available in the Georgia coastal area including Centropristes striatus, Cynoscion nebulosus, Cynoscion regalis and Pomatomus saltatrix. Cynoscion nebulosus begins its spawning season during the first quarter of the year and attempts will be made to obtain gravid fish for laboratory spawning.

Upon completion of the outdoor ponds, the turtles obtained during 1971 will be transferred to the pond environment and investigations involving the availability of natural foods and requirements for supplemental feed, as well as continued growth evaluation, will be undertaken. Additional hatchlings of Green Sea Turtles have been tentatively promised as being available to us in October 1972 from the Florida Board of Natural Resources. Loggerhead Sea Turtle eggs are available in Georgia during the summer months. The thrust of the turtle experiments is two fold. Green Sea Turtles which once commonly occurred along the Goergia coast have for all practical purposes been eliminated. Loggerhead Sea Turtles, while still present, are threatened by commercial shrimp fishermen in that the turtles are often captured and drowned in the fish nets. Rearing sea turtles in captivity may result in the reestablishment of the Green Sea Turtle and supplement the recruitment of Loggerheads. Secondarily, but of no less importance, is the determination of the aquaculture potential of these animals. The Green Sea Turtle is highly valued as a gourmet food item and the Loggerhead is also edible and considered excellent food by many people. Both of these should bring high prices in the market place.

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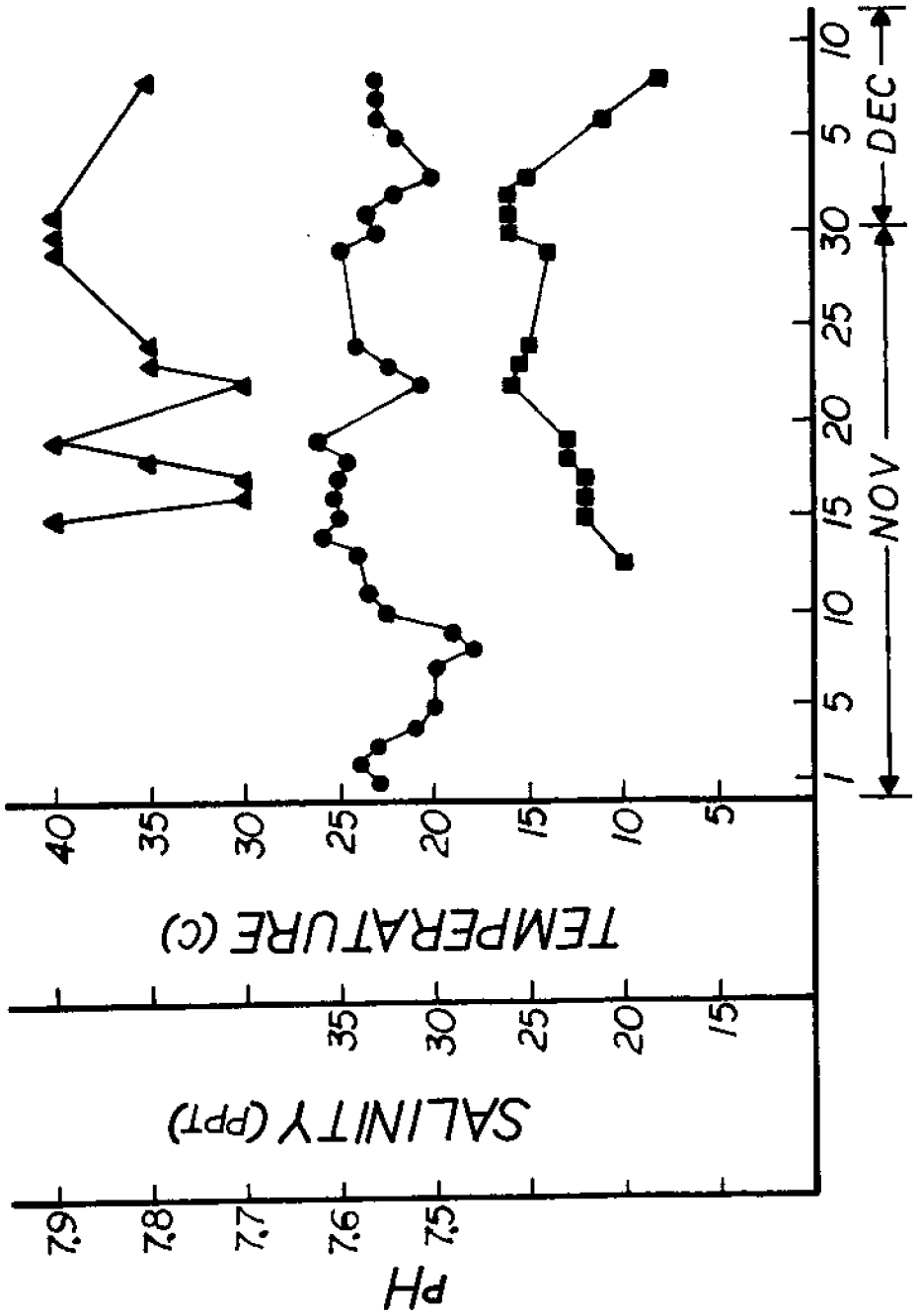
Figure 1. Temperature, salinity and pH of water in 1-meter diameter fiberglass tanks housing Paralichthys species during November and December, 1971. (● = temperature (C), ■ = salinity (ppt), ▲ = pH).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7.5
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TEMPERATURE (C)
40
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30
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1
5
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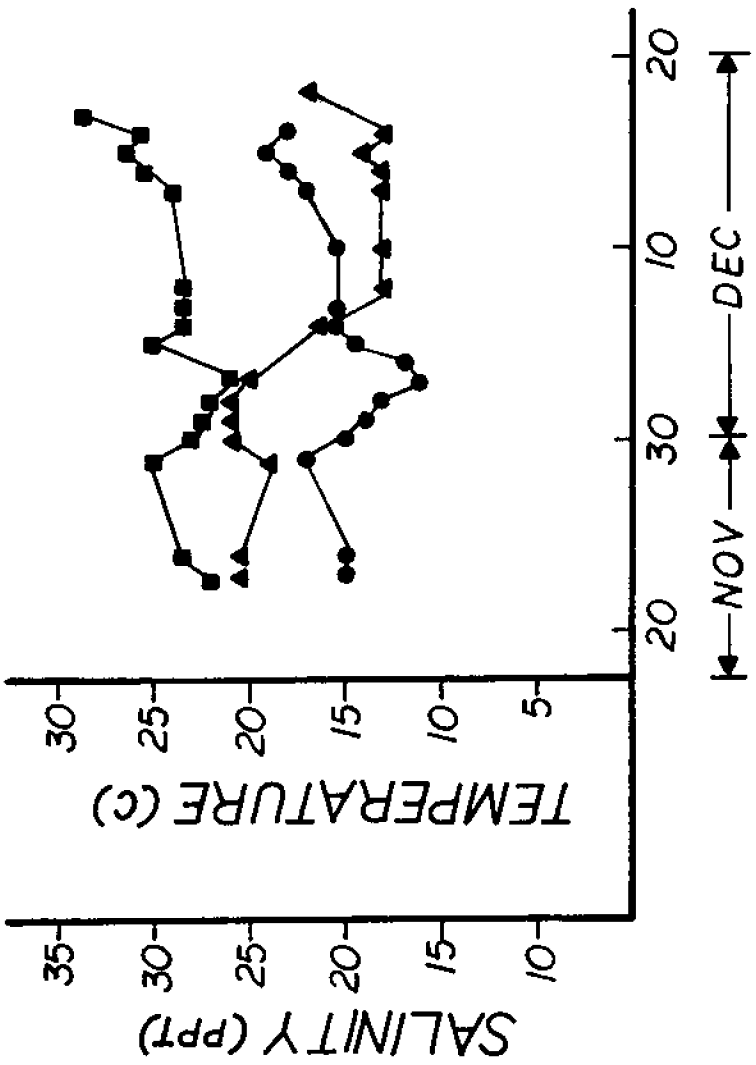
Figure 2. Temperature and salinity of water in 1-meter diameter fiberglass tanks housing Cynoscion nebulosus during November and December, 1971 [● = temperature of ambient incoming water (tanks 1, 3, 4), ■ = temperature of heated water (Tank 2), ▲ = salinity].


SALINITY (PPT)
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TEMPERATURE (C)
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TABLE 1

Growth of Paralichthys spp. fed commercial feed in 1-meter diameter fiberglass tanks at low density stocking for the period 17 October through 9 December 1971.

Sample Number	Number Stocked	Mortality (number)	Initial Average wt. (g)	Final Average wt. (g)	Percentage Average Gain
1	6	1	57.6	45.2	-21.5
2	6	1	153.4	157.5	2.67
3	4	0	163.4	164.3	0.55
4	3	0	261.7	229.3	-12.4
5	5	1	38.8	75.3	90.5
6	3	1	41.5	77.8	87.5
7	4	0	52.3	106.3	103.3
8	3	0	116.7	97.3	-16.6
9	2	0	134.0	159.5	19.0

TABLE 2

Growth of selected groups of Paralichthys spp. on commercial fish pellets in 1-meter diameter fiberglass tanks. (Group numbers correspond with those in Table 1).

Group Number	Time Period (1971)	Initial Average wt. (g)	Final Average wt. (g)	Percentage Weight Increase	Food Conversion Ratio
5	17 Oct- 1 Nov	38.8	43.3	11.1	3.9
	1 Nov-15 Nov	43.3	55.5	28.2	1.5
	15 Nov-29 Nov	55.5	74.1	41.8	2.1
	29 Nov- 9 Dec	74.1	75.3	1.5	21.7
	17 Oct- 9 Dec	38.8	75.3	90.5	-
6	17 Oct- 1 Nov	41.5	45.2	8.9	4.4
	1 Nov-15 Nov	45.2	57.1	26.3	1.6
	15 Nov-29 Nov	57.1	79.5		4.5
	29 Nov- 9 Dec	79.5	77.8	-2.1	-
	17 Oct- 9 Dec	41.5	77.8	87.5	-
7	17 Oct- 1 Nov	52.3	59.9	14.5	3.1
	1 Nov-15 Nov	59.9	79.8	33.2	1.3
	15 Nov-29 Nov	79.8	102.1	27.9	2.3
	29 Nov- 9 Dec	102.1	106.3	4.1	8.2
	17 Oct- 9 Dec	52.3	106.3	103.3	-
9	17 Oct- 1 Nov	134.0	141.0	5.2	-
	1 Nov-15 Nov	141.0	157.0	11.4	3.7
	15 Nov-29 Nov	157.0	160.4	2.2	29.2
	29 Nov- 9 Dec	160.4	159.5	-0.6	-
	17 Oct- 9 Dec	134	159.5	19.0	-

TABLE 3

Growth of Centropristes philadelphicus fed commercial fish pellets in 1-meter diameter fiberglass tanks

Group Number	Time Period (1971)	Initial Average wt. (g)	Final Average wt. (g)	Percentage Weight Change
1[a]	10 Oct-25 Oct	35.2	33.9	-3.7
	25 Oct-10 Nov	33.9	39.2	15.6
	10 Nov-24 Nov	39.2	42.1	7.4
	24 Nov- 6 Dec	42.1	42.0	-0.2
	6 Dec-20 Dec	42.0	42.2	0.5
	1 Oct-20 Dec	35.2	42.2	19.9
2[b]	17 Oct-25 Oct	110.8	116.7	5.3
	25 Oct-10 Nov	116.7	113.9	-2.4
	10 Nov-24 Nov	113.9	128.4	12.7
	24 Nov- 6 Dec	128.4	126.0	-1.9
	6 Dec-20 Dec	126.0	132.9	5.5
	17 Oct-20 Dec	110.8	132.9	20.0

[a]-Number stocked = 18, Mortality = 1

[b]-Number stocked = 3, Mortality = 0

TABLE 4

Growth of Cynoscion nebulosus on commercial fish pellets in 1-meter diameter fiberglass tanks from 23 Nov 71 through 20 Dec 72

Group Number	Number Stocked[a]	Initial Average wt. (g)	Final Average wt. (g)	Percentage Weight Change
1	5	160.2	147.2	-8.8
2[b]	5	165.6	146.5	-13.0
3	6	273.9	262.9	-4.2
4	4	165.1	153.4	-7.1

[a]No mortalities occurred in any tank during the period of the experiment.

[b]Warm water group. All others at ambient river temperature.