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ATLANTIC SALMON REARING IN MICHIGAN

Brood Stock Rearing

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SUMMARY

Two and three year old Atlantic salmon, obtained from Quebec, Canada, in May of 1972, were maintained for brood stock at Michigan's Wolf Lake State Fish Hatchery. No ripe females were found in the fall of 1972, but in the fall of 1973, 20 percent of the females of the oldest group were sexually mature and produced a total of 51,889 eggs. An incubation temperature of 46°F resulted in improved eye-up, hatch-off and early fry survival when compared with eggs incubated in 51°F water. Overall fry survival, as of March 1, 1974, was 73 percent.

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INTRODUCTION

On May 5, 1972, 500 three year old and 875 two year old Atlantic salmon were delivered by fish transport trucks to the Wolf Lake Fish Hatchery near Kalamazoo, Michigan. These fish were part of a shipment of 20,000 two year old smolts, which were purchased from the Domtar Salmon Center on the Madeleine River in Quebec, Canada. The trip lasted approximately 48 hours. All fish arrived in good condition with only one three year old fish dead on arrival.

METHODS

Each year class was placed in a 14" x 90" section of a four section flow-through raceway series. The series received 600 g.p.m. of 51°F spring water. Here they were maintained until March 14, 1973, when they were transferred to an earthen pond, approximately 0.25 acres in size. They were fin clipped for future identification.

During their stay in the raceways, the salmon were started on Oregon moist pellets, but due to the small size (1/8") pellets, were soon switched to a dry (3/8") pelleted diet. The federal production diet, PR-6, fortified with a double vitamin pre-mix package, was used.

The growth rate of the fish while in the raceway from May 1972 through December 1972 was excellent. Three year olds gained an average length of .79" per month, the two year olds gained .94" per month. Conversion through the period ranged from 1.89 to 2.95. Feeding levels were determined by observation, the fish receiving all they chose to eat. After the salmon were transferred to the earthen pond, feeding was continued with this diet, but soon there was observed a reluctance of the salmon to feed. Pellets were no longer accepted during April and most of May. Concern about the cessation of feeding resulted in attempts to feed pieces of frozen fish (lake trout and ciscoes). Some feeding activity was resumed but the lack of fresh or frozen fish forced an end to this feeding method. In further attempts to at least have the salmon take in some feed, live fathead minnows were offered. They were readily taken; but, again due to a lack of such forage, another food source was needed. Several hundred two to three inch brown trout fingerlings were placed in the pond. Some were immediately taken by the salmon, but after a few days the trout were completely ignored as a food source. From here on there was peaceful co-existence between the trout and the salmon. Fortunately by the end of May pellets were taken readily again and feeding was done twice daily. We presume that the salmon ceased their feeding due to smolting.

The earthen pond, oval to round in shape, has a mean depth of two feet, with a maximum depth of five to six feet near the outlet structure. The pond was supplied continuously with 200 g.p.m. 51°F well water, and augmented with 100 g.p.m. spring water run-off. This water would reach a temperature of 70°F during hot weather periods. During heavy rains the spring water was diverted away from the pond to prevent siltation.

As the season progressed 90 to 95 percent of the pond bottom became covered with rooted vegetation while up to 50 percent of the surface was covered with algal mats. Surface water temperatures reached 70"F, but subsurface temperatures near the outlet never exceeded 68°F at a depth of two feet.

At all times the salmon were able to locate relatively cool water (less than 71°F). Most of the time there was a concentration of 50 to 100 salmon at the well water intake. However, the fish would cruise the entire pond and it appeared that there was territorial behavior. Salmon were observed in specific locations near certain weeds, chasing away approaching fish.

In order to protect against poaching by means of conventional angler gear (this problem had occurred several times), a woven wire fence was placed around the inner pond six feet from shore. The large, square mesh fencing allowed the fish to pass through this fence without any interference. After the obstruction to the fishermen had been installed, the salmon cruised the outer rim between shore and fence in a clockwise direction. They continued this for about two weeks.

On October 24, 1973, the fish were removed from the pond, inventoried, and returned to the concrete raceway in anticipation of the egg take operation. The earthen pond was unmanageable for a spawn taking operation.

Table I indicates the length, weight, conversion and survival data for the salmon from May 1972 through January 1974.

MORTALITIES AND DISEASES

Losses of Atlantic salmon were not excessive. Shortly after arrival of the fish, on May 18, 90 fish were made available to the fish pathology laboratory for a disease inspection.

The three year olds (1968 fish) were positive for furunculosis and IPN. The two year olds (1969 fish) did not show positive for any of the diseases checked.

Smolting and furunculosis were the most likely causes of the high mortality observed from May 1972 through August of 1972.

Fungus developed as a problem and control was attempted with formalin at a concentration of 1:4000 constant flow for one hour. The treatment was unsuccessful so Malachite green was applied at one ppm constant flow for one hour. However, not until furunculosis was controlled with terramycin and Furoxone during July and August were we able to successfully treat the fungus.

Because of the threat of a reoccurrence of a furunculosis outbreak, it was decided to initiate a prophylactic treatment using Furoxone. On October 3, 1972, Furoxone was administered with pellets. The drug was mixed with the pellets at a ratio of 1:4000 by weight. This practice of prophylactic treatment continued until January 15, 1974.

SEXUAL MATURITY AND EGG PRODUCTION

On November 10, 1972, approximately sixty of the oldest fish were checked for sexual maturity. Some of the males were ripe but only one female was found to be partially ripe. On November 24, 1972, all of the older fish were examined. No ripe females were found and none were determined to be sexually mature. Of the 319 fish checked, 75 males were found to be ripe. The younger group of salmon were not checked for maturity, but it was suspected that some of the males were ripe. On October 24, 1973, the salmon were taken from the earthen pond and returned to the raceway. In the harvesting process, 20 fish succumbed. Once back in the raceway, the fish could be checked and handled with relative ease.

On October 29, the first egg take took place. A total of 23,684 eggs were collected from 19 females. The fish were hand spawned, two females per pan with four males providing the sperm. The eggs were hardened in a five gallon pail for one hour before being placed into the jar incubator.

Other egg takes occurred on the following dates:

a)	November 1, 1973	9,216 eggs	(9 females)
b)	November 7, 1973	16,640 eggs	(14 females)
c)	November 13, 1973	2,816 eggs	(3 females)
d)	November 20, 1973	bad eggs	(3 females)

Table II represents the data on egg take, incubation and hatching.

The constant temperature 51°F spring water used for the incubation battery at this hatchery was chilled to 46°F for most of the eggs. However, of each lot a small portion was incubated at 51°F. Observations by Roger Dexter (personal communication) indicated that an incubation temperature of over 50°F may produce poorer hatching success as well as higher post-hatching mortalities. Since the temperature of the spring water at the Wolf Lake Hatchery is right at this point (50°-51°F) we believed it to be of value to further test this possible critical point by incubating a portion of the

eggs at 51°F. Poor quality eggs were maintained separately (lots 1-B; 2-B; and 4). Lot 5 was disposed of because no apparent viable eggs were present. The designation "buckshot" was given to those eggs that were glassy and hard in appearance. All eggs were incubated in standard, six quart hatching jars, each receiving about 0.5 g.p.m. of flow.

The fry, after hatching, were placed into rectangular concrete rearing tanks (3' x 25' x 2.5' depth). Lots were now combined for practical reasons.

Tank #3 received lots 3 and 4 or 12,334 fry.
Tank #4 received lots 1-A; 1-B; 2-A and 2-B, or a total of 8,818 fry.
Tank #5 received lots 1 and 3-A or 11,873 fry.
Tank #6 received lot 2 or 6,463 fry.

All fish in the tanks received 51°F spring water.

RESULTS

The female Atlantic salmon brood stock did not sexually mature until they were five years old, and then only 20 percent produced eggs. The average production per female was slightly over 1,000 eggs. The quality of the eggs was beyond expectation. Average eye-up was 78.94 percent, hatch-off 76.10 percent. Table II presents the data per individual lot. Poor quality eggs (bloody and buckshot conditions) were kept separately through hatching. When excluded from the total average eye-up results, we see an increase in eye-up to 83.10 percent.

A further difference in eye-up, hatch-off and early fry losses was observed between lots incubated in 46°F and those incubated in 51°F water. T-tests indicated no significant differences at the 95 percent level except for the fry survival, but skimpy data requires cautious interpretation.

Table III illustrates these values. On January 29, 1974, while all fry were feeding, lots were further combined for practical purposes. Tank #6 was combined with Tank #3 (lot numbers 2, 3 and 4) and Tank #5 was combined with Tank #4 (lot numbers 1; 1-A; 1-B; 2-A; 2-B; 3 and 4). As of March 1, 1974, 28,800 Atlantic salmon fingerlings or 73 percent of the hatched fry have survived, and appear to be in a normal state of health.

DISCUSSION

Success with maintaining Atlantic salmon brood stock at the fresh water Wolf Lake Fish Hatchery has been quite good. Although difficulties with feeding arose, they were "weathered through" without undue losses, and are now viewed as a cyclic phenomena coinciding with a spring smoltification process. Losses, associated with

furunculosis, were curtailed and later on controlled through therapeutic medication with terramycin and Furoxone followed by a continuation of administering Furoxone at a prophylactic level.

The transfer of the brood stock from the raceway environment with its more or less constant temperature of 51°-53°F, to the earthen pond with a much wider temperature regime (51°-70°F), was probably important to successful egg development. The salmon occupied this pond the entire summer and when transferred in October, moved from a pond temperature of around 55°F, to the raceway with a temperature of 51°F.

The present brood stock, along with additional future brood stock, will again be transferred to the earthen pond sometime by April, and be maintained there until spawning season approaches.

The high success with the eggs and fry can be attributed to the excellent condition of the brood stock (high water quality and proper nutrition), ideal quality water during incubation, including favorable temperatures (46°F), as well as the excellent fish cultural attention provided by the Wolf Lake Hatchery staff.

We hope to be able to repeat this performance with the brood stock and eggs next fall (1974) when an expected egg take of 250,000 green eggs moves us significantly towards a management goal of 250,000 smolts annually.

At this time no significant changes in procedures are recommended.

TABLE I

Atlantic Salmon Brood Stock - Growth Rate, Conversions and Losses (May '72 - Feb. '74)

	1969 Salmon Stock						1968 Salmon Stock					
Date	No. of Fish	Wt. in Pounds	Mortality for Period	Food Fed in Pounds	Conversion	Length in Inches	No. of Fish	Wt. in Pounds	Mortality for Period	Food Fed in Pounds	Conversion	Length in Inches
5-5-72	875	87.5	--	--	--	6.27	518	--	--	--	--	--
5-31-72	753	--	122*	66	--	--	428	--	90*	90	--	--
6-30-72	588	--	39	87	--	--	399	199	29	139	--	10.7
7-31-72	554	--	34	93	--	--	382	--	17	154	--	--
8-31-72	498	199	56	156	2.42	9.95	354	354	28	181	2.95	13.5
9-30-72	494	--	4	163	--	--	353	--	1	192	--	--
10-31-72	494	380	0	179	1.89	12.4	349	499	4	209	2.66	15.2
11-30-72	482	--	0	163	--	--	314**	--	8	162	--	--
12-31-72	482	482	0	155	2.94	13.5	308	616	6	155	2.23	17.0
1-31-73	482	--	0	155	--	--	307	--	1	155	--	--
2-28-73	482	--	0	146	--	--	306	--	1	146	--	--
3-14-73	450	--	32$^{\Delta}$	47	--	--	281	--		47	--	--
Period of 3-14-73	450	--	--	--	--	--	281	--	25$^{\Delta}$	--	--	--
+ 10-24-73	388	--	62$^{\Delta\Delta}$	--	--	--	242	--	39$^{\Delta\Delta}$	--	--	---
2-1-74	372	620	16	--	--	--	188	484	54^{x}	--	--	--

* Total of 90 fish sacrificed for disease inspection.
** Inventory by hand counting.
Δ Unaccountable loss during raceway period (poaching?).
$\Delta\Delta$ Unaccountable loss during stay in brood stock pond.
x 33 males disposed of and post-spawning mortality of 21 females.

TABLE II

Incubation and Hatching Data of Atlantic Salmon

Date of Egg Take	Lot Designation	Incubation Temp. °F	Number of Eggs	Days to First Visible Eyes	Percent Eyed Eggs	Percent Loss of Eyed Eggs	Percent Loss at Hatching	Percent Hatch-off	Number of Days to Hatching
October 29, 1973 19 females	1	46	12,960	32	88.42	1.45	0.08	86.88	58-61
	1-A	51	9,720	23	85.92	5.31	1.11	79.50	42-44
	1-B*	51	1,031	23	22.60	9.12	1.65	11.83	42-43
November 1, 1973 9 females	2	46	7,168	32	92.23	2.01	--	90.16	61-62
	2-A	51	1,080	23	86.30	3.33	1.76	81.20	42-45
	2-B**	51	879	23	11.72	.91	.34	10.47	43-44
November 7, 1973 14 females	3	46	15,616	32	78.78	1.40	.01	77.27	61-62
	3-A	51	1,000	23	67.50	5.7	.50	61.30	44-46
November 13, 1973 3 females	4Δ	46	2,435	32	13.38	2.05	.37	10.97	58-59x
November 20, 1973 3 females	5ΔΔ	--	Rejected "Buckshot"	--	--	--	--	--	--
Average & Totals	--	--	51,889	--	78.94	--	--	76.10	--

* - Eggs bloody
** - Eggs "buckshot"
Δ - Eggs of 3 females (2 of poor quality)

ΔΔ - 3 females, all "buckshot" - rejected
x - moved this lot to 51°F on December 27, 1973

TABLE III

Comparison of eye-up, hatch-off and early fry losses of
Atlantic salmon eggs incubated in 46°F and 51°F temperatures

Lot Designation	Incubation Temperature	Percent Eye-up	Difference 46°-51°	Percent Hatch-off	Difference 46°-51°	Fry Losses: Lot Designation	Fry Losses: Incubation Temperature	Fry Losses: Percent Loss Over First 21 Days
Lot #1	46°	88.4	2.5	86.9	7.4	Lots 1-A, 1-B, 2, 2-A	51°	23.1
Lot #1-A	51°	85.9		79.5				
Lot #2	46°	92.2	5.9	90.2	9.0	Lots 1 and 3-A	46°	10.4
Lot #2-A	51°	86.3		81.2				
Lot #3	46°	78.8	11.3	77.3	16.0	Lots 2	46°	10.1
Lot #3-A	51°	67.5		61.3				
						Lots 3 and 4	46°	15.6*

* This group contains lot 4 which includes 2 poor quality females (see Table II).

A statistical analysis, using T-test, showed no significant difference in eye-up and hatch-off at the 95 percent level, however, the difference was significant at the 95 percent level for fry survival. Limited data, however, required cautious interpretation. Experiment will be repeated with larger samples in the 1974-75 season.