LAKE SUPERIOR STATE UNIVERSITY'S CENTER FOR FRESHWATER RESEARCH AND EDUCATION FISH HATCHERY

2019 ANNUAL REPORT

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LAKE SUPERIOR STATE UNIVERSITY

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ACKNOWLEDGMENTS

We are extremely grateful to Cloverland Electric Cooperative for providing space within their facility and electricity, which are essential to our hatchery operations. We are also appreciative of Lighthouse.net and Packerland Broadband for graciously providing broadband internet service for broadcasting our fishcam (https://www.lssu.edu/cfre/cfre-fishcam/). The Michigan Department of Natural Resources supplies the feed necessary to sustain our hatchery operation, funds all disease testing, and provides expertise and additional supplies as needed. We also acknowledge numerous student employees and volunteers that contribute to the success of the Center for Freshwater Research and Education Fish Hatchery.

HATCHERY OPERATIONS

Sub-adult Rearing

A total of 30,574 age-0 Atlantic Salmon *Salmo salar* moved into fry raceways in late February 2018 survived until the time of early feeding and were reared in filtered and heated water until June 2018. About 20,871 fry survived through mid-June of 2018, at which time they were transferred into large raceways and were reared in ambient river water. On average, these fish grew about 132 mm in total length during March-December 2018 (Table 1).

Table 1. Biweekly rearing data of age-0 Atlantic Salmon reared (in heated water) in 2018 (lot: P-ATS-LL-W-17-SM-LS-LS). The starting number of eyed eggs was 32,261, starting number of sac-fry was 30,783 and the starting number of swim-ups was 29,766 placed in the raceways.

Mid date of biweekly summary	Ending # of fish	Mean temp (°C)	Mean length (mm)	Mean biomass (kg)	TUGR (mm/°C)	FCR	Biweekly mortality (%)	Avg. density (kg/m^3)	Flow (L/min)
20-Mar	29,511	9.83	25.68	4.77357	0.00974	3.32	0.86	4.64	35.23
3-Apr	26,899	9.51	28.44	6.17857	0.03140	1.29	8.85	5.43	61
17-Apr	23,622	9.00	32.73	8.55067	0.03494	1.17	12.18	7.54	61
1-May	21,890	8.87	37.24	11.50953	0.03713	1.05	7.33	10.19	81.3
15-May	21,177	9.83	41.96	15.77959	0.03510	1.01	3.26	9.25	118
29-May	20,965	11.00	46.90	21.80889	0.03266	0.973	1.00	12.79	118
12-Jun	20,898	10.62	53.50	32.41828	0.05482	0.682	0.320	19.02	118
26-Jun	20,871	10.42	58.39	42.78421	0.01124	3.38	0.129	6.07	244
10-Jul	20,798	13.90	63.14	54.04962	0.04034	0.930	0.349	5.11	549
4-Jul	20,784	17.17	73.12	84.55333	0.05039	0.807	0.067	5.98	733.5
7-Aug	20,703	18.58	86.35	141.1443	0.05518	0.908	0.390	9.98	977.1
21-Aug	20,544	19.39	100.93	228.1247	0.05459	0.890	0.768	8.18	1936
4-Sep	20,406	18.74	114.91	339.3281	0.05008	1.21	0.67	11.19	1936
18-Sep	20,194	16.89	126.27	451.6376	0.04048	1.33	1.04	14.89	2022
2-Oct	20,052	13.07	133.08	527.7271	0.02214	2.5	0.070	17.39	2022
16-Oct	20,013	10.06	141.6	634.8281	0.09233	0.700	0.190	13.78	3076
30-Oct	19,996	7.56	149.42	750.9474	0.02483	2.50	0.085	23.74	2108
13-Nov	19,990	6.66	153.82	820.6705	0.06614	0.920	0.030	25.95	2108
27-Nov	19,988	3.76	158.4	899.0299	0.05707	0.918	0.010	28.43	2108

Stocking & Disease Testing

A total of 19,894 age-1 Atlantic Salmon were reared at Lake Superior State University's Center for Freshwater Research and Education (CFRE) Fish Hatchery and stocked into the St. Marys River, Chippewa County, Michigan, on 11 June 2019 (Table 2). These fish were our 33rd stocking in the St. Marys River from our hatchery. The fish (lot P-ATS-LL-W-17-SM-LS-LS) were stocked directly into the river at 22:30 at a water temperature of 8.3 C. Each fish received a RP (right pectoral) clip and averaged 171 mm in total length and 50.4 g in weight or 19.8/kg. In the spring of 2019, 60 of these age-1 fish were tested for the presence of *Aeromonas salmonicida*, Bacterial Kidney Disease (BKD), Infectious Hematopoietic Necrosis Virus, Infectious Pancreatic Necrosis Virus, Viral Hemorrhagic Septicemia Virus, and *Yersinia ruckeri* by Michigan State University (MSU) personnel prior to stocking. All fish tested negative for pathogens, except four, in which one had medium and three had low antigen concentrations of BKD (Appendix 1). Our fish may have had low antigen concentrations of BKD for two reasons. One, we had problems with parasites in the early rearing cycle, to the point of losing fish. A leak in the intake side of the pump line increased the total saturation of gasses to a level that caused stress, likely weakening the immune response of our fish to the parasites and resulting in mortality. Second, the canal level dropped below safe levels for ambient water flow during the summer months, so our incoming flow was compensated by running a back-up pump during this time. The pump water was not degassed before going into the raceways, and it increased the percent saturation of gasses to levels high enough to weaken the immune response of our fish.

Survival of the 2017 lot of Atlantic Salmon, from eyed-eggs until stock-out at age 1, was just over 67%, which has been dropping the past few years. Survival rates have been about 80% since 2008 when the water filtration system was first installed, but have declined in the past few years. The 67% survival rate to age 1 is troublesome and may, at least in part, have been caused by external flavobacteriosis and flagellated protozoan parasites (*Ichthyobodo or Crypobid*).

The relatively poor survival rate of the 2017 lot of fish was surprising because of the extra steps taken to prevent health problems. We installed six additional filters, doubling the number of filtration vessels from six to twelve and allowing us to filter the water down to 10 micron for most of the winter months. Then, in the summer of 2017 most of the water supply lines were disinfected along with all rearing containers.

Atlantic Salmon from the MI DNR Platte River State Fish Hatchery were delivered on 9 May 2019 and placed into an acclimation area within the first tailrace tunnel of the hydroplant. This acclimation area was created by placing a blocker net on the downstream end of the first tailrace tunnel. These Atlantic Salmon were held and fed for 34 days and released at 21:30 on 11 June 2019 by removing the blocker net. Personnel from the Platte River State Fish Hatchery conducted a fish quality assessment prior to release.

Prior to use in 2019, repairs were made to the acclimation area. Personnel from Cloverland Electric Hydroplant repaired holes in the tailrace chamber's wall, but high water levels limited repair work. Additional repairs will be made to the tailrace chamber wall once the water level recedes. The blocker net was repaired by the MI DNR personnel from the Gaylord field office, and placed a double net wall on it. This repair worked, but a small hole on the side of the net facing the chamber was found when it was removed from the water and about 20 dead fish were within this double net wall. Another issue with the acclimation area was the incidental trapping of a Double-crested Cormorant *Phalacrocorax auratus*, which likely happened when the blocker net was placed over the opening. The bird was noticed a week after the fish were

placed in the acclimation area, and it was removed by lowering the top of the net until it flew out.

Table 2. Number and mean total length of age-1 Atlantic Salmon stocked during 1987-2019. Stocking typically occurred between mid-May and mid-June of each year.

Year	# stocked	Mean total length
1987	19,000	189
1988	12,751	196
1989	19,966	170
1990	31,702	131
1991	8,367	127
1992	8,048	179
1993	47,716	191
1994	20,350	174
1995	29,060	185
1996	33,756	183
1997	43,373	150
1998	41,721	142
1999	49,818	181
2000	46,220	179
2001	35,909	172
2002	29,313	154
2003	54,743	180
2004	24,811	211*
2005	29,665	201*
2006	38,032	186
2007	20,437	178
2008	29,373	186
2009	28,400	185
2010	26,301	184
2011	31,100	200
2012	35,230	189
2013	35,000	196
2014	40,908	181
2015	29,880	164
2016	36,790	183
2017	28,983	177
2018	34,937	169
2019	19,894	171

*Fish were held until August because they were treated for BKD and furunculosis

Broodstock Collection, Disease Testing, Gamete Collection, and Egg Treatments

Personnel from the CFRE Fish Hatchery, with help from volunteers, collected returning adult Atlantic Salmon for broodstock from 24 October to 12 November 2018. Fish were captured from the St. Marys River at the east end of the Cloverland Hydroelectric Plant using a gill net that covered the opening of the third inactive turbine going west (east of the first active turbine) The gill net used was 15.2 m (50 ft) long, 3.4 m (10 ft) high, with a 10.2 cm (4 in) stretch mesh. The net was continuously observed until a fish became entangled in the net, at which time the net was lifted and the fish was immediately removed. Upon removal, each fish was identified to species, measured for length and weight, and examined to determine sex, maturity (ripe or unripe), presence of fin clips, tags, and most were checked for Sea Lamprey (*Petromyzon marinus*) scars. After examination, Atlantic Salmon were retained for subsequent gamete collection in one of two raceways, separated by sex, whereas all other species were released. Netting continued until at least 160 individuals of each sex were collected. Data were recorded from all fish, including those that were not needed and subsequently released.

The net was fished for five days between October 24th and November 12th for an average of 1.79 hr/d (Table 3). A total of 356 Atlantic Salmon were collected; 13 on 24 October, 11 on 30 October, 151 on 31 October, 117 on 1 November, and 64 on 12 November. The catch rate of Atlantic Salmon was about 40 fish/hr (Table 4). The 207 males measured averaged 67.82 cm in total length and 2.76 kg in weight, whereas the 149 females sampled averaged 61.59 cm in total length and 2.65 kg in weight.

Of the 356 Atlantic Salmon caught in 2018, 256 (72%) were reared at LSSU and 100 (28%) were reared by the MI DNR (based on observed fin clips). The ages of fish reared at LSSU ranged from 1-5 years, but the majority (53%) were age 2 (Table 5). The average Fulton's condition factor *K* for all fish was 1.056 in 2018 and there was no discernable trend since record-keeping began in 1990 (Figure 1). Data on individual Atlantic Salmon used as broodstock are presented in Appendix 2.

All 356 Atlantic Salmon were examined for Sea Lamprey scars, of which about 31% had at least one Sea Lamprey scar (Figure 2). Type B scars were the most common among fish that had scars (about 56.6%; Table 6).

Table 3. Dates and times netting was conducted for Atlantic Salmon broodstock during fall 2018.

Date	Time set	Time pulled	Hours netted	# of fish caught	Water temperature(°C)	
24-Oct-18	3:30 PM	4:04 PM	0.57	13		8.27
30-Oct-18	1:15 PM	1:45 PM	0.50	11		7.43
31-Oct-18	2:10 PM	5:02 PM	2.87	151		7.60
1-Nov-18	8:02 AM	10:57 AM	2.92	117		7.63
12-Nov-18	2:26 PM	4:32 PM	2.10	64		5.23
	Total		8.95	356	Average	7.23

Table 4. Summary of Atlantic Salmon gill netting from 1990-1994 and 1998-2018.

Year	# of fish	Mean hrs/d	# of d	Area of net (m^2)	mean # per fish/hr	Mean # fish/d
1990	46	----	23	47	----	2.00
1991	65	6.50	23	47	0.43	2.83
1992	19	6.70	28	58	0.10	0.68
1993	11	2.50	18	56	0.24	0.61
1994	18	2.60	23	65	0.31	0.78
1998	87	2.60	17	47	1.98	5.12
1999	49	3.00	26	56	0.63	1.88
2000	105	2.80	18	47	2.00	5.83
2001	116	2.50	13	47	3.61	8.92
2002	104	2.70	13	56	2.94	8.00
2003	158	2.80	9	56	6.36	17.56
2004	196	3.10	14	56	4.50	14.00
2005	210	4.11	6	56	8.52	35.00
2006	111	2.71	6	56	6.83	18.50
2007	276	2.62	6	56	17.52	46.00
2008	172	2.79	4	47	15.40	43.00
2009	140	4.50	3	47	10.37	47.00
2010	212	4.78	3	47	14.78	70.67
2011	240	4.23	4	47	14.19	42.40
2012	313	1.99	6	47	26.21	52.17
2013	378	3.46	4	47	27.35	94.49
2014	225	2.90	2	47	38.79	112.50
2015	348	4.43	3	47	26.19	116.00
2016	315	3.31	4	47	23.77	78.75
2017	625	2.77	5	47	45.06	125.00
2018	356	1.79	5	47	39.78	71.20

Table 5. Age of Atlantic Salmon collected in Fall 2018.

Age	Fin clip	# of males	# of females	Total # of fish
2	LP	114	67	181
3	RV	28	35	63
4	RP	0	4	4
5	LV	3	3	6
Unknown	AD	60	40	100
Unknown	No clip	2	0	2
	Total	207	149	356

Table 6. Classification of Sea Lamprey scars observed on Atlantic Salmon in fall 2018. The scars are based off of the 356 fish caught and 109 of them had scars (31%) for an average of 1.3 scars per fish.

Species	Sex	Scar type	Scar stage	# scars	percent
Atlantic Salmon	Male	A	I	2	1.4
		A	II	4	2.8
		A	III	3	2.1
		A	IV	15	10.5
		Total		24	16.8
		B	I	2	1.4
		B	II	0	0.0
		B	III	6	4.2
		B	IV	22	15.4
		Total		30	21.0
	Female	A	I	2	1.4
		A	II	4	2.8
		A	III	2	1.4
		A	IV	30	21.0
		Total		38	26.6
		B	I	11	7.7
		B	II	3	2.1
		B	III	6	4.2
		B	IV	31	21.7
		Total		51	35.7
		Grand Total-A		62	43.4
		Grand Total-B		81	56.6

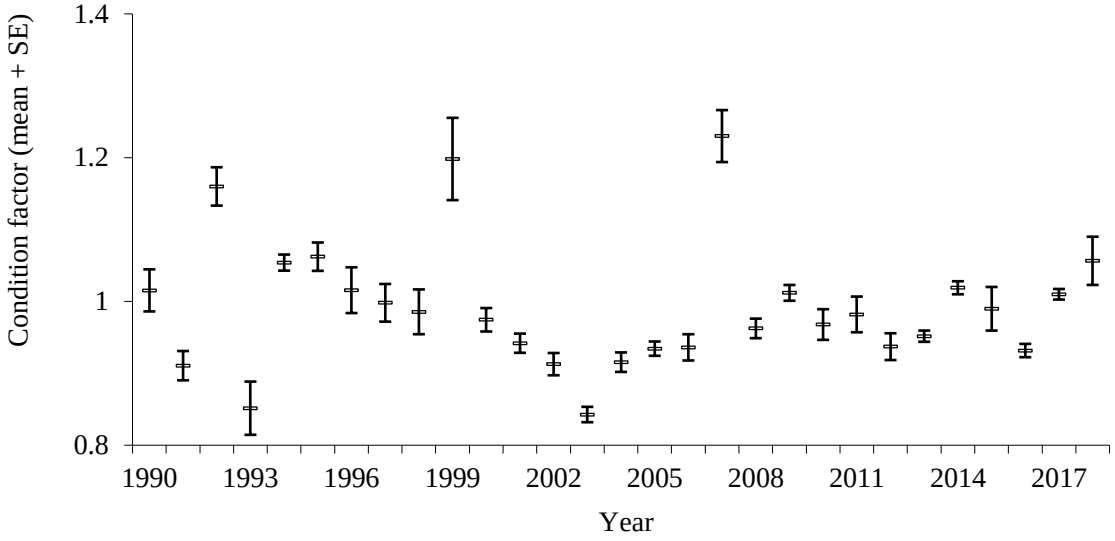

Figure 1. Annual mean (±SE) Fulton's condition factor *K* for Atlantic Salmon netted during 1990-2018

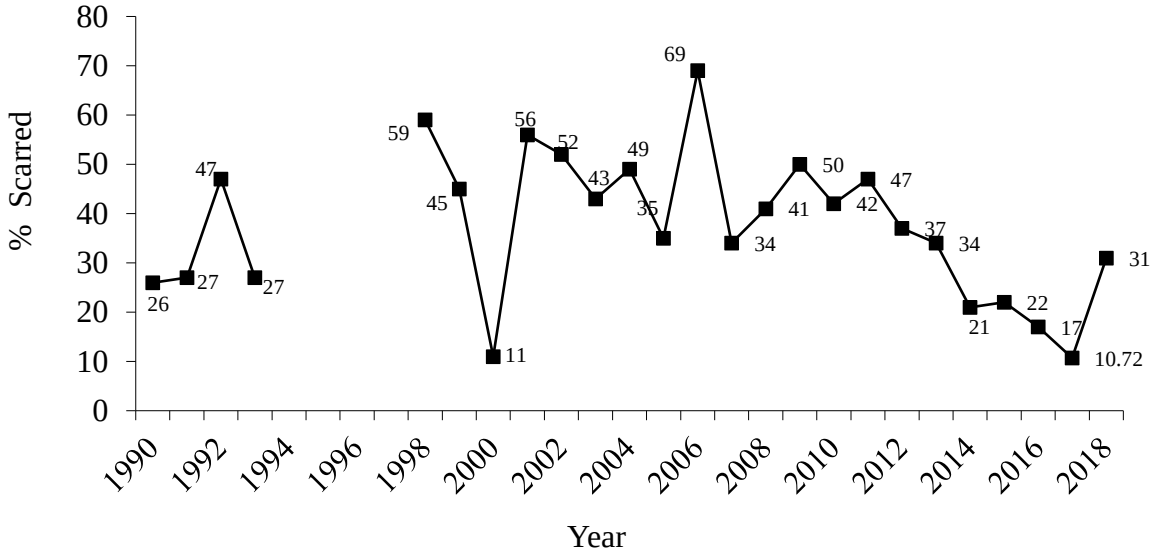

Figure 2. Percent of Atlantic Salmon broodstock that had at least one lamprey scar during 1990-1993 and 1998-2018.

Fish were held in raceways for at least nine days prior to gamete collection, which occurred on 8, 13, 15, 16, and 19 of November 2018. A 1 female: 1 male crossing scheme and the dry method were used during artificial spawning of 143 pairs of Atlantic Salmon. Fertilized eggs from 86 pairs were isolated in buckets until testing was completed for BKD by LSSU's CFRE Fish Hatchery staff (usually done within 24 hours of collecting). After tests for BKD came back negative (Appendix 1), fertilized eggs were mixed together according to the date of collection and placed into egg trays. Personnel from the MI DNR Platte River State Fish Hatchery came to help with egg take on 8 and 13 November 2018. We took eggs from 143 fish; 57 were not tested for BKD and the MI DNR took the majority of these eggs. We kept approximately 500 eggs from each pair that were not tested for BKD. On 16 November, five fish were spawned and not tested for BKD for a student's senior thesis project in which we took the surplus eggs or sac-fry after the study was complete.

Personnel from MSU arrived on 20 November 2018 to do a fish health inspection on 60 adult fish for the presence of *Aeromonas salmonicida*, BKD, Infectious Hematopoietic Necrosis Virus, Infectious Pancreatic Necrosis Virus, *Myxobolus cerebralis*, Viral Hemorrhagic Septicemia Virus, and *Yersinia ruckeri* on 60 adult fish that had been previously tested and resulted negative for BKD by LSSU. Personnel from MSU also tested the gametes, kidney, and spleen tissue from these 60 broodstock fish for BKD, Infectious Hematopoietic Necrosis Virus, Infectious Pancreatic Necrosis Virus, *Aeromonas salmonicida*, *Oncorhynchus masu* Virus, and Viral Hemorrhagic Septicemia Virus; gametes of one fish tested positive (low antigen concentrations) for BKD and 14 tested positive (low antigen concentrations) in body tissues (Appendix 1).

A total of 490,808 Atlantic Salmon eggs were collected in 2018 (Table 7). All fertilized eggs were treated according to MI DNR protocols, which included saline baths, erythromycin treatment, and disinfection in iodine. Dosages for each treatment are described in Appendix 3. On 8 and 13 November 2018, MI DNR took 216,086 and 46,878 green eggs for a total of 262,964. Then, on 4 January 2019, about 23,439 eyed eggs were transported by MI DNR personnel to the Platte River State Fish Hatchery, and 135,000 to Harrietta Hatchery.

Our Atlantic Salmon eggs were given thiamine treatments during the water hardening stage for the second year, instead of post-hatch as was done prior to 2016. The thiamine treatments were conducted at the same time as our erythromycin bath, with both solutions present in the same bath. Thiamine baths were at a concentration of 20.4 g of 98% buffered thiamine per 20 L of filtered river water (thiamine provided by MI DNR). Our fish showed no signs of thiamine deficiency once the sac fry stage was reached, so no additional thiamine baths were conducted.

Table 7. Summary data of egg collection efforts in 2018.

Date	# of pairs	Mean # of eggs/fish	# of eggs retained by LSSU	# of eggs retained by MI DNR	Total # of eggs
8-Nov-18	71	3543	35,500	216,086	251,586
13-Nov-18	43	3631	100,851	46,878	156,166
15-Nov-18	16	3826	61,228	-	61,228
16-Nov-18	5	3117	15,586*	-	15,586
19-Nov-18	8	3652	25,142	-	29,223
Totals	143	3593	238,307	262,964	513,789

*Eggs used for undergraduate research

Table 8. Eggs taken by MI DNR

Transfer date	Total L of green eggs	Eggs per L	Total # of green eggs	Total L eyed eggs	Total # of eyed eggs
*11/8/2018	26	8,311	216,086	22.5	186,998
*11/13/2018	6	7,813	46,878	5.8	45,315
**1/4/2019	NA	7,813	NA	3	23,439
Total	32		262,964	28.3	255,752
**1/4/2019	NA	NA			135,000
Grand Total					390,752

*11/8 and 11/13 Michigan DNR personal came up from Platte River State Fish Hatchery to assist in egg take and took these eggs back with them

** 1/4 Harrietta personal came and picked up eggs for themselves and for Platte River.

Use of Atlantic Salmon for Education and Research

During 2019, a total of 381 Atlantic Salmon of various life stages were used and sacrificed for education, research, and MI DNR activities (Table 8). Adult broodstock were only sacrificed for a fish health inspection conducted by MSU. Fish of various size categories, ranging from sac-fry to yearlings, were used to support education and research at LSSU.

Table 9. Summary data of Atlantic Salmon used and sacrificed for education, research, and MI DNR activities during Feb 2018-April 2019.

Date	Number	Size category	Use
14-Feb-18	125	Sac-fry	Dr. Evans- class*
29-Mar-18	13	Yearlings	Fish Culture used for dissecting*
4-Apr-18	20	Yearlings	Platte river DNR Quality Assessment killed their fish*
29-June-18	100	Fingerlings	Senior project
7-July-18	10	Fingerlings	Frog fest community event
21-Sept-18	42	Fingerlings	Nash senior project
25-Oct-18	18	Fingerlings	Nash senior project
15-Jan-19	5	Yearlings	Dr. Li- class
21-Jan-19	3	Yearlings	Dr. Li- class
23-Jan-19	60	Sac-fry	Dr. Evans- class
5-Feb-19	60	Sac-fry	Dr. Evans- class
11-Feb-19	3	Yearlings	Dr. Li- class
26-Feb-19	65	Yearlings	Health inspection
11-April-19	15	Yearlings	Fish Culture class

*These are fish that were not included in the 2018 Annual Report

APPENDICES

Appendix 1. Results of fish health inspection of age-1 Atlantic Salmon from lot P-ATS-LL-W-16-SM-LS-LS conducted by Michigan State University.

FISH HEALTH INSPECTION REPORT CONTINUED. REPORT NUMBER:

Species	Designation	AAHL #	Age	Number in Lot	Obtained as Eggs (E) or Fish (F) From:	Pathogens Inspected for and Results							
						As	*Yr*	*Rs*	VHS	IHN	IPN	*Om* V.	WD

SUPPLEMENTAL INSPECTION INFORMATION

Date	Species	Lot #	Findings

Pathogen Abbreviations

IHN	Infectious Hematopoietic Necrosis Virus	IPN	Infectious Pancreatic Necrosis Virus
VHS	Viral Hemorrhagic Septicemia Virus	*As*	(BF) *Aeromonas salmonicida* (furunculosis)
Rs	(BK) *Renibacterium salmoninarum* (BKD)	WD	*Myxobolus cerebralis* (whirling disease)
Yr	*Yersinia ruckeri* (ERM)	X	Various (see remarks box)
Y	Various (see remarks box)	Z	Various (see remarks box)

Species Abbreviations

ATS	Atlantic Salmon	BKT	Brook Trout	BNT	Brown Trout	CHS	Chinook Salmon
COS	Coho Salmon	FCS	Fall Chinook Salmon	LAT	Lake Trout	Mixed	Mixed species
OSA	Other Salmonids	RBT	Rainbow Trout	SPL	Splake (Brook x Lake)	STN	Sturgeon
STT	Steelhead Trout						

[1]For juv. hatchery fish give age in months; for feral and adult hatchery fish use symbols e=eggs or fry; f=fingerlings; y=yearlings; b=older fish.
[2]See list of pathogen and spp. abbreviations (pg 2).
cc: Gary Whelan

FISH HEALTH INSPECTION REPORT--FISHERIES DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
Fish Health Inspection Report

AAHL Number: 181120-1-BI-LSSU

This report is not evidence of future disease status. To determine current status, contact Fish Health Official below.

Name and Location of Fish Source:	Owner/Manager:	Inspection Date(s): Fall 2018	Type of Water Supply:
Lake Superior State University Sault Ste. Marie, MI	Roger Greil	This: 11/20/18 Prior: 11/14/17	Stream Origin of Fish Examined:
		Classification: B-BK, BF	Hatchery Type of Fish Examined: Salmonid

Species[2]	Designation	AAHL #	Age[1]	Number in Lot	Obtained as Eggs (E) or Fish (F) From:	Pathogens[2] Inspected for and Results[a]							
						As	*Yr*	*Rs*[b]	VHS	IHN	IPN	*Om* V.[c]	WD
ATS	Feral Fall Atlantic Salmon Spawners* (kidney & spleen samples)	181120-1-BI-LSSU	b	n/a	Wild	60 (0)	60 (0)	60 (14: 14L)	60 (0)	60 (0)	60 (0)	NR[d]	60 (0)
ATS	Feral Fall Atlantic Salmon Spawners (ovarian fluid/milt samples)	181120-1-BI-LSSU	b	n/a	Wild	NR	NR	60 (1: 1L)	60 (0)	60 (0)	60 (0)	60 (0)	NR

Remarks/Recommendations:

a: Laboratory assays were conducted in accordance with the guidelines of the Great Lakes Fishery Commission - Great Lakes Fish Health Committee (GLFC-GLFHC), the American Fisheries Society - Fish Health Section (AFS-FHS), and the World Organization for Animal Health (OIE).
b: The presence of *Renibacterium salmoninarum* was tested with quantitative QELISA, which is more sensitive than the direct fluorescent antibody technique, H=high, M=medium, L=low antigen concentrations.
c: *Onchorhynchus mons* virus testing is done on ovarian fluid samples only as per GLFC recommendations.
d: NR=Test not required.

* Infectious salmon anemia virus was not detected in ATS tissues tested by real-time Reverse Transcriptase PCR (rRT-PCR).

Address/Phone of Contracted Fish Health Official:
Aquatic Animal Health Laboratory
College of Agriculture & Natural Resources
College of Veterinary Medicine
Michigan State University
1129 Farm Lane, Room 340G
Food Safety & Toxicology Building
East Lansing, MI 48824
PHONE: 517/884-2024; FAX: 517/432-2310

Signature of Contracted Fish Health Official

Thomas P. Loch, MS, Ph.D.

[1]For juv. hatchery fish give age in months; for feral and adult hatchery fish use symbols e=eggs or fry; f=fingerlings; y=yearlings; b=older fish.
[2]See list of pathogen and spp. abbreviations (pg 2).
cc: Gary Whelan

Appendix 2. Data on individual Atlantic Salmon used for gamete collection in 2018. Note: 000-099 and 000A-020A are females, 100-199 and 100A-120A are males, and fin tissue samples were collected from each fish. 128

Date	ID Number	Fin Clip	Age	Total Length (cm)	Weight (kg)
8-Nov-18	000-18	LP	2	76	
	100-18	LP	2	60.2	
	001-18	RV	3	57.1	
	101-18	LP	2	58.1	
	002-18	AD		68.2	
	102-18	RV	3	72.1	
	003-18	RV	3	67.6	
	103-18	LP	2	56	
	004-18	RV	3	64	
	104-18	AD		72.7	
	005-18	RV	3	67.5	
	105-18	AD		68.5	
	006-18	AD		66	
	106-18	LP	2	58	
	007-18	LP	2	52	
	107-18	LP	2	56	
	008-18	RV	3	67	
	108-18	LP	2	53	
	009-18	RV	3	57	
	109-18	LP	2	61	
	010-18	RV	3	66	
	110-18	LP	2	58	
	011-18	LP	2	55	
	111-18	RV	3	72	
	012-18	RV	3	67	
	112-18	AD		73	
	013-18	RV	3	62	
	113-18	LP	2	56	
	014-18	RP	4	72.5	
	114-18	LP	2	56	
	015-18	LP	2	58	
	115-18	LP	2	63	
	016-18	RV	3	61	
	116-18	LP	2	59.5	
	017-18	LP	2	56	
	117-18	LP	2	59	
	018-18	LP	2	56	

118-18	AD		73
019-18	LP	2	55
119-18			75
020-18	RV	3	72
120-18	LP	2	61.5
021-18	LP	2	57
121-18	AD		80
022-18	LP	2	53
122-18	AD		76
023-18	LP	2	53
123-18	LP	2	60
024-18	LP	2	58
124-18	LP	2	63.5
025-18	LP	2	54.5
125-18	LP	2	61.5
026-18	AD		67
126-18	LP	2	56.5
027-18	LP	2	52.5
127-18	AD		73
028-18	LP	2	54.5
128-18	AD		71
029-18	LP	2	53
129-18	LP	2	64.5
030-18	LP	2	56.5
130-18	AD		75
031-18	LP	2	53
131-18	LP	2	50.7
032-18	RV	3	67
132-18	AD		61
033-18	LP	2	53
133-18	LP	2	62
034-18	LP	2	50.5
134-18	RV	3	71
035-18	RV	3	61
135-18	RV	3	71
036-18	LP	2	57.5
136-18	RV	3	80
037-18	LP	2	59.6
137-18	AD		74
038-18	LP	2	55
138-18	LP	2	69.6
039-18	AD		65.7
139-18	LP	2	68

040-18	LP	2	47.5
140-18	RP	4	61.5
041-18	LP	2	57
141-18	LP	2	60.5
042-18	LP	2	57.4
142-18	AD		63
043-18	LP	2	50.5
134-18	LP	2	63
044-18	LP	2	58.9
144-18	LP	2	61
045-18	AD		67.5
145-18	LP	2	57
046-18	AD		57.4
146-18	AD		76
047-18	LP	2	59.6
147-18	LP	2	62.5
048-18	RV	3	71.5
148-18	LP	2	56.5
049-18	LP	2	47
149-18	AD		76.5
050-18	LP	2	54
150-18	LP	2	64
051-18	RV	3	64
151-18	LP	2	58
052-18	LP	2	56
152-18	LP	2	60
053-18	LP	2	55
153-18	LV	5	72
054-18	LP	2	55.5
154-18	AD		61
055-18	AD		59
155-18	LP	2	59
056-18	RV	3	65
156-18	LP	2	65
057-18	AD		69.5
157-18	AD		72
058-18	LP	2	39.3
158-18	LP	2	58.5
059-18	AD		72
159-18	LP	2	59
060-18	AD		72
160-18	AD		70
061-18	LP	2	55

	161-18	LP	2	61	
	062-18	LP	2	57	
	162-18	LP	2	55.5	
	063-18	AD		65.5	
	163-18	LP	2	62	
	064-18	RV	3	67.5	
	164-18	LP	2	58.5	
	065-18	AD		70.5	
	165-18	LP	2	63	
	066-18	LP	2	56.5	
	166-18	LP	2	64	
	067-18	LP	2	56.5	
	167-18	LP	2	46	
	068-18	AD		67	
	168-18	LP	2	63	
	069-18	AD		65	
	169-18	LP	2	58	
	070-18	LP	2	56.5	
	170-18	RV	3	73	
13-Nov-18	071-18	LP	2	58.1	2.32
	171-18	AD		76.1	4.04
	072-18	LP	2	55	1.93
	172-18	LP	2	61	2.03
	073-18	LP	2	61.4	2.4
	173-18	LP	2	60.6	2.28
	074-18	LP	2	57.5	2.01
	174-18	AD		67.2	2.51
	075-18	LP	2	58	1.89
	175-18	RV	3	77.2	3.99
	076-18	RV	3	63.2	3.15
	176-18	RV	3	70.8	2.96
	077-18	LP	2	55.8	1.64
	177-18	AD		76.6	4.32
	078-18	RV	3	74.5	5.61
	178-18	RV	3	73.1	3.72
	079-18	RV	3	65.4	3.26
	179-18	AD		67	5.57
	080-18	RV	3	61.6	2.53
	180-18	AD		75.5	4.06
	081-18	LP	2	66.1	2.098
	181-18	LP	2	55.5	1.58
	082-18	AD		72.2	3.5
	182-18	LP	2	65.1	2.37

083-18	RV	3	67.4	1.23
183-18	LP	2	59.4	1.7
084-18	AD		66.6	2.69
184-18	LP	2	60.5	2.15
085-18	LP	2	53	1.78
185-18	LP	2	61.4	1.94
086-18	AD		70.7	3.48
186-18	AD		71	3.26
087-18	AD		70	3.53
187-18	AD		75	3.26
088-18	AD		61	2.26
188-18	LP	2	58	2
089-18	RV	3	66.5	2.61
189-18	LP	2	61.5	2.15
090-18			70	4.08
190-18	LP	2	61.6	2.26
091-18	LP	2	54.5	1.49
191-18	LP	2	58.3	1.88
092-18	LP	2	54	1.81
192-18	RV	3	72	3.73
093-18	RV	3	67.6	3.43
193-18	LP	2	56.5	1.81
094-18	LP	2	58	2.03
194-18	RV	3	72	3.51
095-18	RV	3	69	3.95
195-18	AD		75.9	5
096-18	LP	2	56.6	1.99
196-18	LP	2	57.5	1.77
097-18	LP	2	51.6	1.57
197-18	RP	4	72.2	3.72
098-18	LP	2	54.8	1.81
198-98	LP	2	59.5	1.97
099-18	LP	2	54.5	1.66
199-18	LP	2	60.5	2.12
000-A-18	LV	1	63.4	3.2
100-A-18	LP	2	55.5	1.61
001-A-18	LP	2	57.2	
101-A-18	AD		72.4	
002-A-18	AD		66.4	
102-A-18	LV	1	71	
003-A-18	LV	1	65.2	
103-A-18	LP	2	53.5	
004-A-18	AD		53.4	

	104-A-18	LP	2	53.2	
	005-A-18	AD		68.7	
	105-A-18	LP	2	54.8	
	006-A-18	RV	2	70	
	106-A-18	LP	2	58.2	
	007-A-18	LP	2	55.2	
	107-A-18	LP	2	61.7	
	008-A-18	LP	2	56.8	
	108-A-18	LP	2	54.5	
	009-A-18	RP	4	73	
	109-A-18	AD		70.2	
	010-A-18	AD		66.2	
	110-A-18	LV	1	57	
	011-A-18	RV	3	65.3	
	111-A-18	LP	2	55	
	012-A-18	LP	2	53.3	
	112-A-18	LP	2	56.5	
	013-A-18	AD		74.5	
	113-A-18	AD		72.5	
15-Nov-18	014-A-18	RV	3	66.2	3.45
	114-A-18	LP	2	55.1	1.71
	015-A-18	RV	3	68.0	3.12
	115-A-18	LP	2	48.0	1.12
	016-A-18	AD		65.3	3.4
	116-A-18	AD		72.0	3.41
	017-A-18	LP	2	57.5	2.91
	117-A-18	AD		74.5	3.4
	018-A-18	RV	3	70.5	3.6
	118-A-18	LP	2	60.7	1.9
	019-A-18	AD		72.0	3.95
	119-A-18	LP	2	61.5	1.96
	020-A-18	AD		70.9	3.46
	120-A-18	LP	2	64.5	1.9
	021-A-18	LP	2	55.5	1.74
	121-A-18	LP	2	63.5	2.2
	022-A-18	RV	3	70.5	4.44
	122-A-18	LP	2	63.3	2.18
	023-A-18	AD		62.0	2.45
	123-A-18	LP	2	62.0	2.04
	024-A-18	AD		61.1	2.78
	124-A-18	AD		71.0	3.3
	025-A-18	-		44.0	1.07
	125-A-18	RV	3	74.0	3.4

	026-A-18	AD		66.3	2.62
	126-A-18	LP	2	58.0	1.38
	027-A-18	LP	2	56.0	1.72
	127-A-18	LP	2	60.4	1.85
	028-A-18	AD		71.2	3.98
	128-A-18	AD		73.1	3.88
	029-A-18	LP	2	56.5	1.84
	129-A-18	AD		75.5	3.8
16-Nov-18	030-A-18	RV	3	65.8	3.06
	130-A-18	RV	3	69.9	2.88
	031-A-18	AD		72.0	3.66
	131-A-18	AD		71.5	3.45
	032-A-18	AD		66.9	3.37
	132-A-18	RV	3	72.5	3.9
	033-A-18	AD		69.0	2.99
	133-A-18	RV	3	70.2	3.44
	034-A-18	AD		68.7	3.1
	134-A-18	RV	3	70.9	3.39
19-Nov-18	035-A-18	AD		72.3	3.67
	135-A-18	LP	2	59.0	1.76
	036-A-18	LP	2	55.3	1.9
	136-A-18	AD		72.0	2.4
	037-A-18	LP	2	57.3	2.36
	137-A-18	LP	2	62.5	2.35
	038-A-18	RV	3	70.0	3.34
	138-A-18	LP	2	58.2	
	039-A-18	LP	2	51.1	1.42
	139-A-18	LP	2	53.0	
	040-A-18	AD		70.1	3.92
	140-A-18	LP	2	61.5	
	041-A-18	LP	2	54.0	1.44
	141-A-18	AD		71.0	
	042-A-18	RV	3	59.8	2.47
	142-A-18	LP	2	56.1	

Appendix 3. Dosages for treatments of Atlantic Salmon eggs.

Saline Bath
0.75% needed
0.75/100 = 0.0075
0.0075*20L = 0.15 mL or g
0.15*1,000 = 150 g needed for 20 L of H_2O

Erythromycin Treatment
2 ppm (mg/L) needed
2 mg/L*20 = 400,000 mg
400,000/0.23 = 1,739,130 (23% active)
1,739,130/10,000 = 173.9
173.9/1,000 (to get to g) = 0.174g per 20 L of H_2O

Iodine Treatment
1% active
1% free iodine to get 100 ppm (mg/L) dilute 100 times
20 L = 20,000 mL
20 L*1,000 mL = 20,000 mL
20,000 mL/100 = 2,000 mL
2,000 mL*50 = 100,000 mL
100,000 / 1,000 (to mL) = 100 mL of Iodine needed for 20 L of H_2O

Thiamine Treatment
1,000 ppm (mg/L) needed
20.4 g of 98% active, buffered thiamine added per 20 L of H_2O