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Abstract.–During the early 1980s Fisheries Division embarked on a program to establish a limited trophy fishery for landlocked Atlantic salmon *Salmo salar*. In order to maintain such a program, Gull Lake in Barry and Kalamazoo Counties was selected as the primary broodstock lake. Broodstock landlocked Atlantic salmon were collected from Gull Lake during 1991-96. Gametes from mature salmon were first collected from Gull Lake in 1988. Salmon were collected during the same week each year in November. Sufficient numbers of broodstock salmon were collected each year except 1994, 1995, and 1996 in order to maintain the desired level of statewide program needs. Population estimates of age 2 and 3 salmon during the fall of 1991 were estimated at nearly 6.5 adults per acre. Fall returns of salmon to netting were variable. It was apparent that our stocking rate of 12 yearlings per acre was excessive based on a drastic reduction in growth rates. The switch to stocking fall fingerlings to avoid hatchery mortalities (due primarily to bacterial gill disease) was a complete failure, most likely due to predation. Fall fingerlings were also stocked at 12-13 per acre. It is recommended that future stocking rates for yearling landlocked Atlantic salmon be 1-2 per acre for sport fisheries, and 2-4 per acre annually for broodstock water. Because salmon are easy to catch, bag limits should remain low (1 per day in season).

Introduction

In 1873, one of the first official acts of the newly established Michigan Fish Commission was stocking 21,250 anadromous Atlantic salmon *Salmo salar* into a number of lakes and streams throughout Lower Michigan. Landlocked-strain Atlantic salmon from Sebec Lake in Maine were first stocked into Dowagiac Creek, Cass County, in 1874 (Jerome 1875). A total of about 775,000 Atlantic salmon were stocked in Michigan waters between 1873 and 1932, but no self-sustaining populations were established (Latta 1974). More recent attempts to introduce Atlantic salmon began in 1972, when an anadromous strain was planted in the Boyne and Au Sable rivers.

Although the state's modern landlocked Atlantic salmon program began in 1974 at Gull Lake, Kalamazoo County, salmonids have been stocked since 1965 (Table 1). This lake was chosen for a broodstock program because of its excellent water quality, proximity to Wolf Lake State Fish Hatchery, and the presence of Michigan State University's Kellogg Biological Station on the lake. Gull Lake in the late 1980s was one of five Michigan lakes that contained landlocked-strain Atlantic salmon, hereafter, referred to as salmon.

From 1974-78, stocking of salmon was erratic (Table 1). Other Division responsibilities and a lack of hatchery space due to remodeling interrupted the stocking program in 1979.

During the early 1980s, Fisheries Division decided that a broodstock lake for salmon was needed. Gull Lake was selected because of its proven performance with salmon in the 1970s. Strong public support for the program also existed. Gull Lake was stocked with spring yearlings from 1986 to 1990 and fall fingerlings from 1990 to 1992. Returns from these stockings were monitored and ripe fish collected from 1988 to 1996. Results of the first 3 years of the program are covered in a previous technical report by Dexter (1991a). This paper presents the results of the final six years of salmon broodstock collection efforts at Gull Lake, but data for the whole period are included in relevant tables and figures to provide a more complete picture of the results.

Study Site

Gull Lake is a 2,030-acre lake located in Barry and Kalamazoo counties. Classified as mesotrophic (perhaps slightly oligotrophic), Gull Lake has provided an excellent two-story fishery for decades.

The lake contains populations of bluegill *Lepomis macrochirus*, yellow perch *Perca flavescens*, rock bass *Ambloplites rupestris*, smallmouth bass *Micropterus dolomieu*, and largemouth bass *Micropterus salmoides* (Dexter 1996). Lake trout *Salvelinus namaycush* have also been stocked successfully and rainbow trout *Oncorhynchus mykiss* are currently being stocked. There is also an on-going effort to re-establish rainbow smelt (Table 1).

The lake's deepest depression (110 feet) is located almost directly in the middle of the lake, and another depression (108 feet) is located in the north end (Figure 1). The shoal areas of Gull Lake compose approximately 30% of the total surface area.

The water quality of Gull Lake is excellent. Secchi disc readings in May 1989 were as deep as 40 feet. In August 1993, the thermocline was between 30 and 38 feet and dissolved oxygen levels remained above 5 ppm to a depth of 43 feet. Water temperatures ranged from 77^{O} F at the surface to 48^{O} F at 70 feet. The alkalinity ranged from 133-168 ppm (moderately hard) and pH readings were alkaline (8.7). Water quality parameters have changed little over the years, except for generally increased dissolved oxygen and greater water clarity. These two parameters have improved because of improved wastewater treatment. A wastewater treatment plant was built and began operating in the early 1980s. Zebra mussels also were found for the first time in 1994 and the presence of these mussels will likely lead to a further increase in water clarity.

Several tributaries flow into Gull Lake, although all are quite small. The largest is Prairieville Creek, located at the north end of the lake. This designated trout stream flows at about 5- 10 ft^3/s and is the main tributary that salmon utilize for spawning (Dexter 1991b).

Methods

To develop Gull Lake as an Atlantic salmon broodstock source, spring yearling and fall fingerling salmon were planted in Prairieville Creek, or at its mouth, annually from 1986-92 (Table 1). Most of these fish were marked with an identifying fin clip (Table 2). The stocking goal was 12 fish per surface acre (yearling or spring fingerling).

Each year from 1988 to 1993, immediately after salmon were observed in Prairieville Creek, a blocking weir made of pipe was installed near the mouth in order to prevent salmon from leaving the lake and migrating upstream where they would be inaccessible. For the period from 1991 through 1996 covered by this report, mature salmon were collected between 4 November and 11 November using standard 6'x3'x1.5" mesh trap nets at the north end of the Lake (Figure 1). The same index sites were fished each year. Traps were lifted each day until gamete and data needs were met, or until catch was very low. Salmon used for gamete collection were transferred from Gull Lake by hatchery truck to Wolf Lake State Fish Hatchery, about 25 miles away. Salmon were held in a separate spawning building until ripe. All gamete collections occurred between 12 and 23 November.

Salmon total lengths were recorded to 0.1 inches each year and weights were measured to 0.1 pounds in 1991, 1995, and 1996, although only females were caught in the latter two years. A length-weight regression for salmon was previously established from 1989 and 1990 Gull Lake data (Dexter 1991a). All salmon captured and released received either a fin clip or jaw tag in order to identify recaptures. Salmon ages were determined primarily by fin clips. Age was determined from scales for fish that had confusing clips or were unclipped, and scales from some fish were assessed for spawning checks to identify the amount of repeat spawning (1991 only).

Most salmon collected in 1991 and 1992 were jaw tagged with circular strip monel fish tags (Salt Lake Stamp Company, Utah, Tag # FC3, FC4, and FC5). Tagging fish enabled population estimation, an evaluation of angler catch, and determination of individual growth and spawning patterns. Population estimates were calculated using the Chapman modification of the Peterson formula (Lockwood and Schneider 2000) with both trap netting data and independent ice fishing data. This formula is applied with the following assumptions: that mortality rate of marked fish is the same as that for unmarked fish, that emigration of marked fish is similar to unmarked fish, the marks are retained on the fish, that marked fish are captured at the same rate as unmarked fish, and that all fish are randomly distributed.

Length comparisons by year and within gender were made by ANOVA with post hoc comparisons using the Bonferroni technique. Comparison of gender size at age by year was made using t-test with Bonferroni adjustment to P value (Miller 1981).

Results

Broodstock Collections-1991

Mature salmon were observed ascending Prairieville Creek on 25 October. The blocking weir was installed 26 October. One trap net was set in each of 6 standard locations plus one new location on 7 November (Figure 1). In 18 net lifts a total of 787 salmon were collected (44/lift Figure 2). Salmon ranged from 7.3 to 22.7 inches total length (TL) (Figure 3). Just over 60% of all salmon collected were age 2. Age 3 salmon accounted for 39%, and the remaining few were young-of-the-year (YOY) and age 1 (Table 3). The average TL of age 2 male salmon (Table 4) was significantly smaller than any year of collection ($p<0.001$). Age 3 males were the smallest recorded since the inception of broodstock collecting in 1988 ($p<0.0001$). There was no difference in size of age 2 mature males and females ($p=0.032$). However, age 3 mature salmon of both sexes were significantly different in size ($p<0.0001$). Mature males, mature females, and immature salmon were similar in size. The return of age 2 salmon represented a minimum of 1.89% of the 1990 planting of yearling fish (Table 6). Many more fish could have been netted, but collection was stopped on 10 November due to a shortage of jaw tags.

One hundred ninety five mature females and 80 mature males were transported to Wolf Lake State Fish Hatchery on 8 November. At the time of capture, 46% of the females were ripe. Fish were spawned on 12 November at which time 90% of the females were ripe. The total number of eggs collected was 263,307. The average number of eggs per female was 1,504, the lowest average to date from Gull Lake (Table 7). Thirty adults were sacrificed for fish health inspection, and the remainders were measured, jaw tagged, and released back to Gull Lake. A total of 702 salmon were jaw tagged. Three of these died, and were recovered and subtracted from the total tagged fish available.

Broodstock Collections-1992

Mature salmon were observed in Prairieville Creek on 26 October. The blocking weir was installed on 27 October and trap nets were set in the standardized netting locations on 9 November. A total of 1,096 salmon were collected in 3 days of netting (61/lift, Figure 2). Salmon ranged from 14.6-22.4 inches TL (Figure 3). Of all salmon collected, 70.2% were age 3. Age 4 salmon accounted for 26.2% of the catch, and age 1 and age 2 fish accounted for only 3.6 % (Table 3). Age 3 salmon were markedly smaller in 1992 compared to 1991 ($p<0.0001$, Tables 4 and 5). Mature male salmon at both age 3 and 4 were larger than mature females of the same age ($p<0.0001$). The return of age 3 salmon represented a minimum of 3.07% of the 1990 stocking of yearling fish. Age 4 salmon provided a 1.21% return from time of stocking to netting (Table 6).

Two hundred and eight mature females and 75 mature males were transported to Wolf Lake State Fish Hatchery on 9 November. At the time of capture, only 2% of the females were ripe. Salmon were spawned on 17 November at which time 93% of the females were ripe. The total number of eggs collected was 283,910 and the average number of eggs per female was 1,502, similar to 1991 (Table 7). Thirty fish were sacrificed for fish health inspection. Eight salmon tagged in 1991 died from fungus prior to 17 November. The remaining broodstock were measured, jaw tagged if needed, and released back to Gull Lake on 18 November. Fungus had developed on many of the fish by this date and 18 of the released fish died and were recovered within 2 weeks of the release date. These 26 recovered tags were subtracted from the total tagged fish available. A total of 997 salmon were jaw tagged through the collection efforts and released back to Gull Lake.

Broodstock Collections-1993

Mature salmon were observed entering Prairieville Creek the last week of October. The blocking weir was installed on 27 October and trap nets were set in the standardized netting locations on 8 November. A total of 175 salmon were captured in 3 days of netting (10/lift, Figure 2). Salmon ranged from 14.5 to 25.5 inches TL (Figure 3) and age 2 salmon were the most prevalent age group collected (37.2%). These fish represented 1991 stocked fall fingerlings. Mature females at age 3 were larger than those collected in 1992, but not 1991 ($p<0.0001$, Table 5). Age 4 salmon accounted for 35.9% of the total catch (Table 3). Females in this age group were not significantly larger than those collected in 1992 ($p<0.0001$). Length at age for both sexes increased compared to 1992 except for age 4 males ($p=0.259$, Tables 4 and 5) and females in a post hoc comparison ($p<0.0001$). A comparison of mature males vs. females at age showed that only age 2 fish were significantly different in size ($p<0.0001$). The returns based on stocking levels of ages 2 and 4 salmon to collection date were 0.002% for each year class (Table 6).

Ninety mature females and 55 mature males were transported to Wolf Lake State Fish Hatchery on 8 and 9 November. At the time of capture, only 5% of the females were ripe. Seventy-eight females were spawned, yielding 142,049 eggs. The average number of eggs per female was 1,821 (Table 7). A total of 33 salmon were sacrificed for fish health inspection. The remaining fish were not tagged but were returned to Gull Lake.

Broodstock Collections-1994

Recruitment of salmon in Gull Lake through stocking efforts had been sufficiently low in prior years that we expected to obtain fewer than 50 salmon during normal netting operations. The blocking weir in Prairieville Creek was not used in 1994 but six trap nets were set at the standardized locations on 7 November. A total of 36 salmon were captured in 3 days of netting (2/lift, Figure 2). Salmon ranged from 14.0 to 28.1 inches TL (Figure 3). Age 3 salmon were the most abundant at 58.3% of the catch (Table 3). Ages 1, 3, 4, 5 and 6 were collected. Age groups 5 and 6 were stocked as yearlings, and age groups 3 and 4 were stocked as fall fingerlings. One age 1 salmon was a naturalized fish. Length at age increased dramatically compared to the 1993 catch ($p<0.0001$, Tables 4 and 5). Returns of all age groups from stocking to netting were less than 1/1000 of a percent (Table 6).

Twenty-seven mature female salmon and seven male salmon were transported to Wolf Lake State Fish Hatchery for spawning. At the time of capture only 14% of the females were ripe. Egg collections were made from 24 females on 16 and 17 November, yielding 57,250 eggs. The average number of eggs per female was 2,385 (Table 7).

Only two of the thirty-six salmon captured were jaw tagged (from 1992). No fish were sacrificed for fish health inspections. Because the number of eggs collected was too small to meet program needs, the eyed eggs were shipped to Lake Superior State University (LSSU) for rearing.

Broodstock Collections-1995

Six trap nets were set at the standardized netting locations on 6 November. A total of 27 salmon were captured in four days of netting (1/lift, Figure 2). Salmon ranged in size from 19.6 to 27.0 inches TL (Figure 3). Age groups 2, 3, and 4 were identified (although not all fish were scale sampled).

Fourteen females and eight males were transported to Wolf Lake State Fish Hatchery. At the time of capture, two of the females (16%) were ripe. Nine female salmon were spawned on 9 November. The total number of eggs collected was about 25,000 and the average number of eggs per female was 2,777 (Table 7). No fish were sacrificed for health inspections. Eyed eggs were again shipped to LSSU for rearing.

Broodstock Collections-1996

This was the last year of broodstock collection efforts. Six trap nets were set at the standardized netting locations on 4 November. A total of 13 salmon were collected in 2 days of netting (1/lift, Figure 2). No salmon were collected on the second day. Salmon ranged from 23.4 to 28.0 inches TL (Figure 3). Of the nine female salmon aged, six were age 3 (1992-year class), two were age 4 (1991-year class) and one was age 5 (Table 5). Only one of the 13 fish had a fin clip. The remainders were males that could not be aged because of scale resorption.

All of the fish were transported to Wolf Lake State Fish Hatchery. None of the females were ripe at the time of capture. Salmon were spawned on 13 November and 28,890 eggs were collected from 9 females. The average number of eggs per female was 3,210 (Table 7). No fish were sacrificed for fish health inspections. All of the eggs were shipped to LSSU on 24 December.

Population Estimates

Using the data from Gull Lake salmon tagged in November 1991, I computed two different population estimates (age 2 and 3 combined) for the late fall period of 1991. The first estimate was calculated using data collected from five ice anglers who caught 550 salmon during January and February 1992 (Table 10). The estimated size of the age 2 and 3 salmon population was 16,051 with a lower 95% confidence limit of 10737 and an upper confidence limit of 23,897.

The second estimate was calculated using 1991 tag returns collected during broodstock netting in November 1992. The estimated population size was 13,445 age 2 and 3 salmon (lower 95% confidence limit of 10,497 and an upper limit of 17,868). Age 1 and 2 salmon collected in 1992 were removed from the estimate, as were tagged fish that were harvested by anglers.

Tagged Salmon Recaptures

Some marked salmon were captured and/or handled more than once by either anglers or fisheries personnel. Anglers caught 18 tagged salmon at least twice. Four of these 18 were also spawned at the hatchery prior to being caught. Four of the eighteen were caught three times, and two were caught four times. Most recaptures by anglers came during the ice-fishing season. One salmon was caught twice in the same day and two salmon were captured on two consecutive days. One salmon was caught on three consecutive days in a row, and one salmon was caught four times in one month.

Anglers captured 30 of the 245 salmon tagged and returned to Gull Lake after spawning at Wolf Lake State Fish Hatchery in 1991 and captured 29 of the 251 tagged salmon returned after spawning in 1992. Of the 15 tagged salmon collected for broodstock purposes in fall 1993, 10 had been caught and released by anglers prior to broodstock collection.

Two salmon spawned in 1992 had also been spawned in 1991. Four salmon that were spawned in 1993 were spawned in 1991 and three were spawned in 1992. One fish spawned in 1994 had been spawned in 1992, and one was spawned each year as a tagged fish (1992, 1993, and 1994) and caught by an angler ice fishing in 1993.

The growth rates and maturity of 18 individual salmon were followed from data collected during gamete collections. Information returned by anglers regarding the size of fish caught was not used due to the good probability that length was estimated. A total of four age 2 males and four age 2 females were followed (Table 11). Immature 2-year-old males that became mature at age three grew 0.5 inches more than immature 2-year-old females that became mature at age 3. Two-year-old immature females that remained immature at age 3 grew faster than those females that matured at age 3.

Of six age 3 females that were tracked, two that were immature became mature at age 4 or 5 and their growth rates were about one inch per year after tagging. One age 3 mature female failed to spawn at age 4, but another did produce eggs at age 4 (Table 11). Of all mature males, all were mature at subsequent captures. Males in general grew faster than females. Only one age IV female (mature) was tracked, and it was mature also at age VII, having only grown 1.9 inches in that 3 year period.

Discussion

Sufficient numbers of broodstock salmon were collected each year except for 1994, 1995, and 1996 to maintain the desired level of statewide program needs for salmon. These needs changed after 1992 when the stocking program at Gull Lake was discontinued. Statewide needs decreased dramatically because only the St. Mary’s River stocking remained through 1995.

Fall returns of stocked salmon from Gull Lake to Prairieville Creek were quite variable from 1991-96. This was due to high survival and stockpiling of adults, followed by natural mortality coupled with cessation of stocking. When comparing the Gull Lake stocking rates to stocked salmon lakes in the East Coast region, ours were very high, even for a broodstock lake. Salmon lakes in Maine are typically stocked with spring yearlings (as we did through 1990) but only up to 2 fish per acre (Warner and Havey 1985). This is considered a maintenance stocking level in Maine, and this rate is used even when predation and/or competition is intense. Many East Coast (broodstock) lakes also have very restrictive fishing regulations or no fishing at all.

Based on the results of our netting, it is quite apparent that our stocking rate of 12 yearlings per acre was excessive (Figure 2). The population of adult salmon in Gull Lake exploded to 6-8 per acre by 1992. This stockpiling of salmon led to the serious decline in growth rates observed in 1991 and 1992, as compared to the early years of the program (Dexter 1991a) and the mid -1990s (Tables 4 and 5).

Perhaps the most interesting aspect of the high survival rates in Gull Lake is the fact that these fish were prone to fungal infections and bacterial gill disease when in the hatchery, requiring frequent treatment (Table 12). Several times the Hatchery Manager at Wolf Lake State Fish Hatchery commented that the fish were not worth stocking (Jim Copeland, Wolf Lake State Fish Hatchery, personal communication).

At Wolf Lake State Fish Hatchery rearing typically occurred in one linear raceway at very high densities (fall fingerlings-304 pounds per 35 cubic feet), much higher than those used in East Coast hatcheries (Hosmer et al. 1979). This was probably the major reason why various infections and diseases spread rapidly among the salmon at this facility. The rearing program at Wolf Lake ended in 1994 and was shifted to Thompson Hatchery and Lake Superior State University in the Upper Peninsula.

In an effort to minimize the time fish spent in the hatchery, and thus hatchery mortality, a decision to stock salmon as fall fingerlings was instituted in 1991. As a result, stocking rates increased only slightly from 12 to 13.5 per acre, but returns declined to 0.04% of yearlings in the first year, and thereafter no fall fingerlings were recovered in subsequent years (Table 6). It is apparent from the data that: 1) diseased (and perceived as poor quality) spring yearling salmon survived well in Gull Lake, and 2) fall fingerling salmon performed miserably in Gull Lake, and their stocking was followed by the eventual collapse of the population. In fact by 1996 most of the salmon collected were determined to be natural fish that came from Prairieville Creek. I suggest the failure of fall fingerling stocking occurred because these fish were unable to compete in Gull Lake due to the excessive number of cool and warmwater fish species that would prey on them.

Regulating the salmon population was very difficult because of fluctuating populations and the dual goal of both protecting broodstock, and promoting a trophy fishery (Dexter 1991a). Because the salmon proved to be such fast growing fish, and they were easy to catch (especially through the ice), fishery size limits were changed 3 times from 1986 to 1994. In 1986 the size limit was raised from 10 inches to 18 inches. In 1991 the size limit was raised again to 25 inches, and in 1994 it was lowered to 20 inches. Bag limits were reduced in 1991 from 5 to 1 fish. The effects of these changes were increased survival of stocked fish, confusion among the anglers, and a high level of concern from the anglers about the impact of the large number of salmon on other Gull Lake sport fish.

It is important to note the consistency in the time of maturation of salmon in each year. Salmon schooled at the mouth of the inlet stream, prior to ascending the stream, on 25 and 26 October in each year from 1991 to 1993. Adults (females) also matured in practically the same week each year.

Weather patterns were variable among years. In 1992 summer air temperatures were extremely cool and subsequent years were the warmest on record. Therefore, I believe that their maturation and schooling behavior is triggered by photoperiod. This is important for other salmon fisheries that may in the future be developed for broodstock purposes.

Management Implications

The short salmon program at Gull Lake was successful in many ways. The primary objective of establishing a productive source of broodstock was achieved. The secondary objective of establishing a valuable fishery was also achieved.

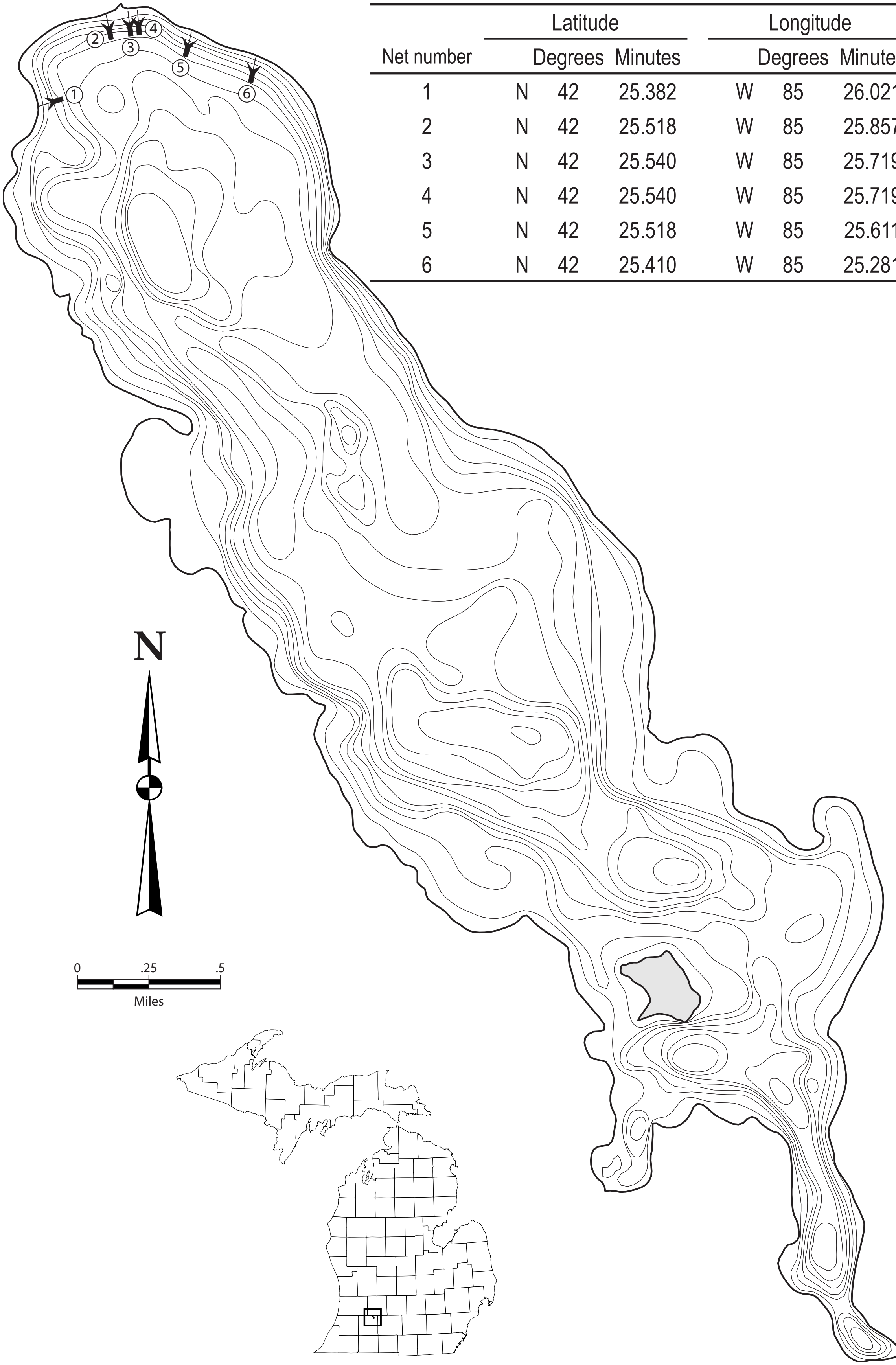
The program also yielded some interesting results that will be valuable in guiding future efforts to establish Atlantic salmon broodstock lakes. First, it became obvious that the stocking rate of yearling salmon in Gull Lake was much too high. Unfortunately, this was not realized until it was too late (when growth seriously declined). Furthermore, East Coast salmon managers predicted that our stockings of fall fingerling salmon would fail and they were correct.

Fishing regulations were quite inadequate at first, and were adjusted within the first year to better protect future broodstock. We did go too far however. Raising the size limit to 25 inches was too large, thereby making the fishery practically catch and release. This angered many of the local anglers, as the salmon were very easy to catch but too small to harvest.

Based upon the number of eggs produced per female, current state needs for salmon, and existing regulations, it is recommend that future stocking rates for yearling landlocked Atlantic salmon be 1-2 per acre for sport fisheries and 2-4 per acre annually for broodstock waters. Because salmon are easy to catch, bag limits should remain low as they are now (1 per day in season). Size limits can be set at less than 20 inches, while still affording salmon the chance to mature and the angler to catch a fish that they can keep.

Acknowledgements

I would like to thank the Plainwell Fisheries staff and the Wolf Lake State Fisheries staff for their dedication and perseverance in conducting this program. I also want to recognize the assistance of Roger Lockwood and Michelle Kolozsvary for their contribution to the statistical analysis of the data.



Net number	Latitude			Longitude		
		Degrees	Minutes		Degrees	Minutes
1	N	42	25.382	W	85	26.021
2	N	42	25.518	W	85	25.857
3	N	42	25.540	W	85	25.719
4	N	42	25.540	W	85	25.719
5	N	42	25.518	W	85	25.611
6	N	42	25.410	W	85	25.281

Figure 1.–Gull Lake showing salmon netting locations.

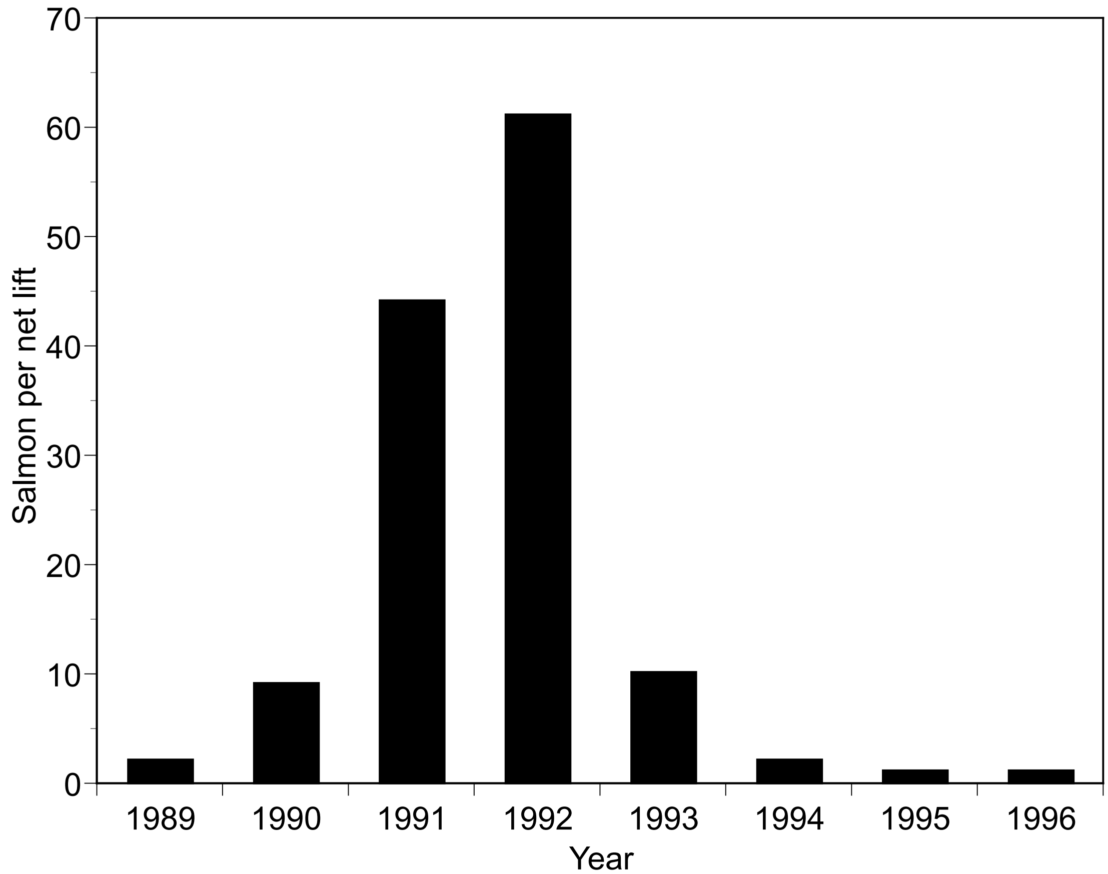


Figure 2.–Catch per net lift for Gull Lake Atlantic salmon. Data from 1989-90 are from Dexter (1991a).

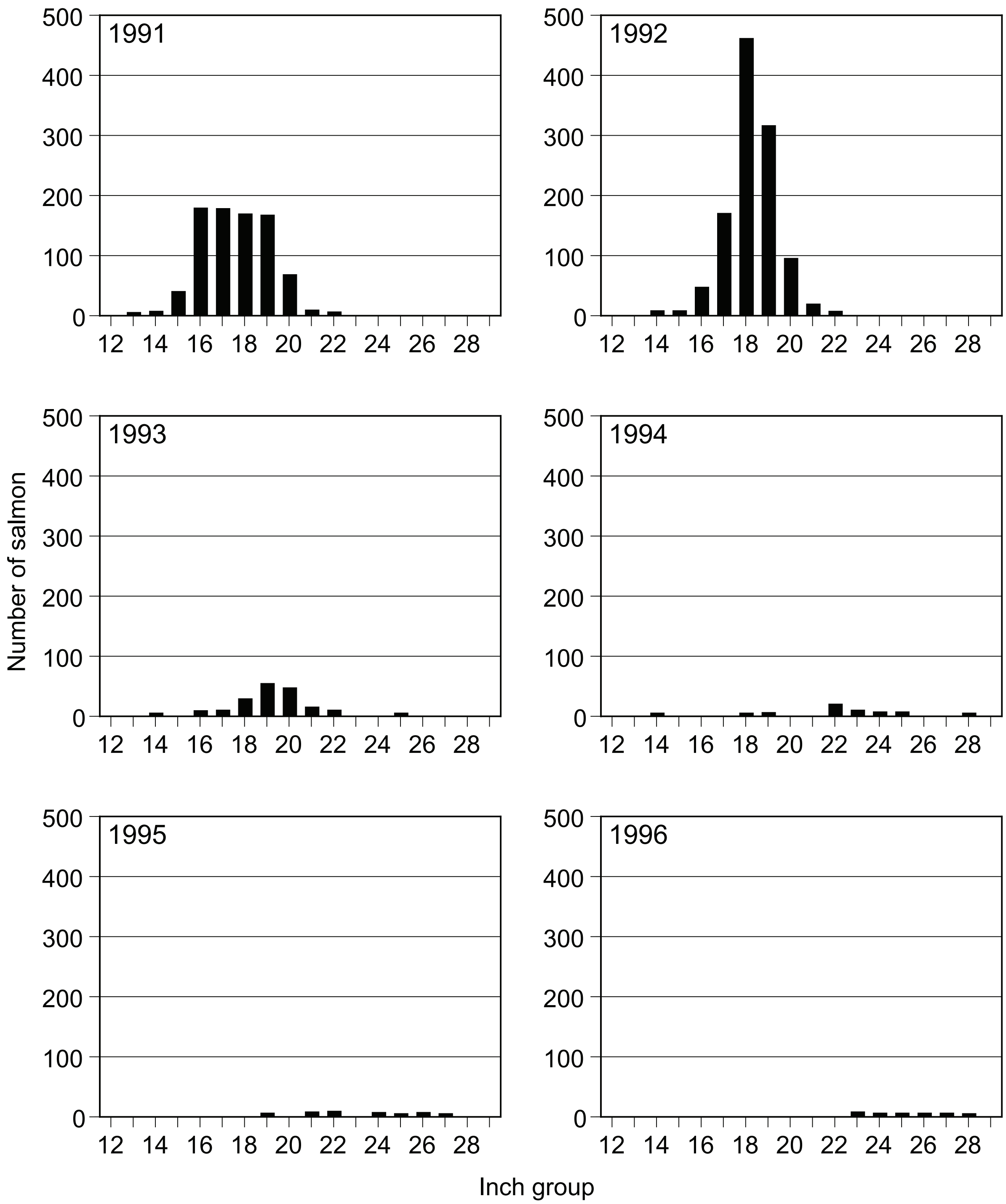


Figure 3.–Length frequency of most Atlantic salmon collected for broodstock from Gull Lake, Kalamazoo County, 1991-96.

Table 1.–Stocking history of salmonids and rainbow smelt in Gull Lake from 1965 to 1996. Age of fish stocked: ff = fall fingerlings, sy = spring yearlings, A = adults, GE = green eggs.

Year	Species							
	Lake Trout		Rainbow Trout		Atlantic Salmon		Rainbow Smelt	
1965	-		15,000	ff	-		-	
1966	157	A	4,000	ff	-		-	
1967	-		-		-		-	
1968	-		8,000	sy	-		-	
1969	-		8,000	ff	-		-	
1970	8,100	sy	8,000	ff	-		-	
1971	-		12,000	sy	-		-	
1972	4,525	sy	10,070	sy	-		-	
1973	-		14,000	sy	-		-	
1974	10,000	sy	14,000	sy	28,558 37	sy A	-	
1975	10,000	sy	-		11,366	sy	-	
1976	10,000	sy	-		29,905	sy	-	
1977	10,000	sy	-		280 A		-	
1978	10,000	sy	22,023	sy	324 A		-	
1979	13,700	sy	30,000	sy	-		-	
1980	15,000	sy	30,000	sy	-		-	
1981	-		22,000	sy	-		-	
1982	10,000	sy	25,000	sy	-		-	
1983	-		30,000	sy	-		-	
1984	194	A	19,000	sy	-		-	
1985	-		29,900	sy	-		-	
1986	-		-		25,356	sy	-	
1987	-		-		23,632	sy	-	
1988	-		6,018	sy	11,956	sy	-	
1989	-		5,300	sy	23,688	sy	-	
1989	-		+25,000	ff	-		-	
1990	-		6,000	sy	25,103	sy	-	
1990	-		-		29,949	ff	-	
1991	-		20,209 1,833	sy ff	26,869	ff	13,179	A
1992	-		26,400	sy	26,871	ff	500,000	GE
1993	-		21,600	sy	-		1,000,000 + 44,320	fry A
1994	-		30,000	sy	-		-	
1995	-		27,154	sy	-		47,610	A
1996	4,000	sy	24,985	sy	-		-	

Table 2.–Fin clip combinations for salmon stocked in Gull Lake, 1986-1992. Fin clips: AD = adipose, RP = right pectoral, RV = right ventral, LP = left pectoral, LV = left ventral. All salmon are spring yearlings unless noted as fall fingerlings (ff).

Year	Number Stocked	Fin Clip
1986	21,356	AD
	2,000	RP
	2,000	RV
1987	11,966	RV + AD
	11,966	LV
1988	11,956	RV
1989	12,438	RP
	11,250	None
1990	25,103	None
	29,949 ff	LP
1991	26,869 ff	LV
1992	26,871 ff	AD

Table 3.–Percent age composition of mature salmon collected from Gull Lake, 1988 through 1996. Data prior to 1991 are from Dexter (1991a).

	Year								
Age	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	–	–	–	<0.1	–	–	–	–	–
1	–	6.5	6.5	<0.1	0.6	0.6	–	–	–
2	11.8	1.1	90.8	60.5	3.0	37.2	67.7	50.0	–
3	88.2	68.8	–	39.4	70.2	19.2	5.9	25.0	75.0
4	–	23.6	1.6	–	26.2	35.9	23.5	25.0	25.0
5	–	–	1.1	–	–	7.1	2.9	–	–
6	–	–	–	–	–	–	–	–	–

Table 4.–Average lengths and weights of male salmon collected from Gull Lake in the fall, 1991-1996. Data are from aged or clipped fish only.

		Mature			Immature		
Year	Age	Number	Mean Length (Inches)	Mean Weight (Pounds)	Number	Mean Length (Inches)	Mean Weight (Pounds)
1991	1	0	–	–	0	–	–
	2	175	17.2	1.5	16	17.2	–
	3	111	19.8	2.4	0	–	–
1992	1	7	14.6	–	0	–	–
	2	32	17.7	–	0	–	–
	3	289	18.5	–	2	19.3	–
	4	84	20.5	–	1	19.8	–
1993	1	0	–	–	1	14.5	
	2	28	20.4	–	0	–	–
	3	11	20.4	–	1	20.4	–
	4	24	20.2	–	0	–	–
	5	6	20.9	–	0	–	–
1994	1	0	–	–	1	14.0	–
	2	0	–	–	0	–	–
	3	3	26.4	–	0	–	–
	4	0	–	–	0	–	–
	5	4	23.2	–	0	–	–
1995			no data			no data	
1996			no data			no data	

Table 5.–Average lengths and weights of female salmon collected from Gull Lake in the fall of 1991 -1996. Information is from aged or clipped fin only.

		Mature			Immature		
Year	Age	Number	Mean Length (Inches)	Mean Weight (Pounds)	Number	Mean Length (Inches)	Mean Weight (Pounds)
1991	1	0	–	–	0	–	–
	2	180	17.8	1.4	109	17.0	1.3
	3	187	19.0	2.4	11	19.3	2.1
1992	1	0	–	–	0	–	–
	2	0	–	–	0	–	–
	3	460	18.2	–	19	18.8	–
	4	192	19.0	–	10	19.6	–
1993	1	0	–	–	0	–	–
	2	28	18.7	–	1	18.1	–
	3	18	19.6	–	0	–	–
	4	31	19.5	–	1	20.8	–
	5	5	20.7	–	0	–	–
1994	1	0	–	–	0	–	–
	2	0	–	–	0	–	–
	3	20	23.0	–	0	–	–
	4	2	22.1	–	0	–	–
	5	4	22.4	–	0	–	–
	6	1	19.6	–	0	–	–
1995	1	0	–	–	0	–	–
	2	2	20.8	3.7	0	–	–
	3	1	22.7	4.1	0	–	–
	4	4	25.7	7.9	0	–	–
1996	1	0	–	–	0	–	–
	2	0	–	–	0	–	–
	3	6	24.9	6.1	0	–	–
	4	2	25.4	7.0	0	–	–
	5	1	26.7	7.7	0	–	–

Table 6.–Percentage return of salmon in each year class in relation to number stocked over nine years of broodstock collections from Gull Lake. Year class refers to the year eggs were obtained, not hatched. For example, salmon stocked as yearlings in 1991 were of the 1989-year class. Data from 1985-1990 year classes are from Dexter (1991a).

	Year class									
Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1			0	0.26	0.21	0.003	0.26	0.0004		
2		0.25	0.02	1.08	1.89	0.10	0.002	0		
3	0.70	0.30	0	1.30	3.07	0.001	0.0008			
4	0.13	0.01	0	1.21	0.002	0.00008				
5	0.001	0	0	0.005	0.0005					
6			0.00004	0.00008						

Table 7.–Average number of eggs produced by female Atlantic salmon, 1988 -1996. Data from 1988-1990 are from Dexter (1991a).

Year	Number of Eggs per Female	Age majority
1988	2,500	3
1989	2,611	3
1990	1,725	2
1991	1,504	3, 2
1992	1,502	3, 4
1993	1,820	4, 2, 3
1994	2,385	3
1995	2,777	Unknown
1996	3,210	3, 4

Table 8.–Average length (inches) of mature salmon from 1988-1996. Data prior to 1991 are from Dexter (1991a).

	1988	1989	1990	1991	1992	1993	1994	1995	1996
Males	23.2	24.2	17.6	18.2	18.9	20.5	24.6	22.6	25.7
Females	22.0	23.3	17.2	18.4	18.4	19.6	22.7	23.4	25.2

Table 9.–Average percent maturity by age for female and male salmon collected during egg-take operations at Gull Lake 1989-1996. The number in parentheses indicates the total number of fish evaluated. Data from 1989 and 1990 are from Dexter (1991).

	Percent mature at age (Years)				
Sex	1	2	3	4	5
Female	0 (60)	73 (449)	96 (762)	89 (263)	100 (11)
Male	42 (41)	98 (374)	92 (445)	96 (118)	100 (10)

Table 10.–Population estimates of age 2 and 3 salmon in late fall 1991. Estimate 1 is from recapture efforts by ice angling. Estimate 2 is from recapture efforts by trap netting during fall 1992.

	Estimate 1	Estimate 2
Marked fish available	669	664
Unmarked fish captured in second “run”	528	1,057
Marked fish recaptured in second “run”	22	54
Chapman-Petersen estimate	16,051	13,445
95% Confidence Limits	10,737-23-897	10,497-17,868

Table 11.–Sex, age, maturity, and average growth upon subsequent recaptures of tagged salmon from Gull Lake.

Sex	Age/Maturity at Initial Capture	N	3	4	5	6	7	Average Growth (Inches/year)
Female	2 I	20	M	-	-	-	-	1.37
Female	2 I	2	I	-	-	-	-	1.90
Female	2 M	5	M	-	-	-	-	0.74
Female	2 M	1	-	M	-	-	-	2.50
Male	2 I	10	M					1.86
Male	2 I	1	-	M	-	-	-	3.70
Male	2 M	2	M	-	-	-	-	1.55
Male	2 M	3	-	M	-	-	-	2.00
Female	3 I	1	-	M	-	-	-	0.90
Female	3 I	1	-	-	M	-	-	2.20
Female	3 M	7	-	M	-	-	-	0.87
Female	3 M	4	-	I	-	-	-	0.95
Female	3 M	6	-	-	M	-	-	3.00
Female	3 M	1	-	-	-	M	-	1.40
Male	3 I	1	-	-	M	-	-	2.10
Male	3 M	2	-	M	-	-	-	0.55
Male	3 M	1	-	-	M	-	-	0
Female	4 M	1	-	-	-	-	M	1.90

Table 12.–List of salmon lots, diagnosed diseases, and prescribed treatments by date, 1991-1994, Wolf Lake State Fish Hatchery.

Year	Lot Number and Date	Diagnoses and treatment
1991	P-ATS-W-91-GL-WL	
	3/3-4, 3/9-22/92	BGD[1], treated with Purina 4X & CH-T[2]
	4/7-9, 25-27/92	Fungus, treated with Formalin
	5/2-4/92	BGD, treated with CH-T
	8/10-14, 28-30/92	Fungus, treated with Formalin
1991	P-ATS-PB-D-91-CO-NY-WL	
	1/27, 28, & 31/92	BGD, treated with CH-T
	2/2, 5, 13, 19/92	BGD, treated with CH-T
	3/14, 16, 19, 22/92	BGD, treated with CH-T
	4/28 – 29/92	BGD, treated with CH-T
1992	P-ATS-W-92-GL-WL	
	3/17/93	BGD, treated with CH-T
1992	P-ATS-PB-D-92-CO-NY-WL	BGD, treated with CH-T
	2/22/93	
1993	P-ATS-W-93-GL-WL	
	3/24 & 4/6/94	BGD, treated with CH-T
	7/19 & 21/94	BGD, treated with CH-T
	9/1-2/94	BGD, treated with CH-T
	12/5, 7, 8/94	BGD, treated with CH-T
	12/24-25/94	Fungus, treated with CH-T & Formalin
	1/17, 19, 27/95	Fungus, treated with Formalin
	02/09/95	Fungus, treated with Formalin
1993	P-ATS-PB-D-93-CO-NY-WL	No disease data found
1994	P-ATS-W-94-GL-WL	Eyed Eggs shipped to LSSU 1-3-95
1994	P-ATS-PB-D-94-CO-NY-WL	
	3/8 – 9/95	BGD, treated with CH-T
	4/20/95	BGD, treated with CH-T
		Fry shipped to LSSU 6-6-95

[1]BGD = Bacterial Gill disease
[2]CH-T= Chloramine-T

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