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A Comparative Study of Northern Pike (*Esox lucius*) Growth in Two Upper Penninsula Michigan Lakes.

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Abstract

Northern pike (*Esox lucius*) were sampled by trap netting in two small lakes in Gogebic County, Michigan. Morris Lake is shallow, warm, macrophyte dense, and contains a very high density of Northern pike (180 fish/ha). Bay Lake is medium depth, cooler, and larger than Morris Lake allowing for more habitats for different sized Northern pike. Bay Lake also contains a lower density of Northern pike and a sufficient supply of soft-rayed forage fish necessary for "normal" Northern pike growth. Morris Lake is not abundant in this type of forage. The Northern pike in Morris Lake were observed to prefer these soft-rayed fish for prey in gut analysis findings. The high competition for this forage, along with the small area that the Northern pike are confined to in Morris Lake has decreased the growth of this Northern pike population to the point where it is stunted. The low average absolute growth and the low average condition factors of the Northern pike in Morris Lake as compared to Bay Lake support this finding.

Introduction

The Northern pike (*Esox lucius*) is the top predator in all lakes in which it is found. When a Northern pike hatches it first feeds on microcrustaceans, it then moves on to fish larvae and insects, and by the time it is 5 to 6.5 cm in length it primarily feeds on other fish (Carlander, 1969). Both male and female fish mature at age 2, though females generally tend to grow faster and larger (Carlander, 1969). The Northern pike average life span is approximately 7 yrs, and in this time it can grow to a total length (TL) of over a meter and weigh 8 to 10 kg (Becker, 1983). In the past, it has been observed that a very high density of Northern pike in a lake can lead to a decline in their growth rates and a lowering of their condition factors (Kempinger and Carline, 1978). The purpose of this study is to compare and contrast the populations of Northern pike in two different lakes at the University of Notre Dame Environmental Research Center (UNDERC) in Gogebic County, Michigan. The population of Northern pike in Morris Lake

Goetz

was introduced approximately twenty years ago (Goetz, personal communication, 1987). This stocking was not managed or controled. Over the years this population obviously became stunted and natural reproduction was questionable. These Northern pike appeared smaller and unhealthier than other Northern pike to anglers on the property (Goetz, pers. comm., 1987). Since this time the fishing pressure, while still very low, has increased on this lake. In this paper the growth of Northern pike in Morris Lake will be analyzed in comparison to the growth of this species in a hypothetically "normal" lake on the property, Bay Lake. Growth will be determined using weight, length, and age data taken from each population. The total number of Northern pike in Morris Lake will be determined along with their prefered prey in this lake.

Materials and Methods

Samping

The Northern pike were sampled using South Dakota trap nets. The nets were anchored on the shore line and the main frames were set in 1-2 m of water approximately 16 m from shore. The side leaders were set at approximately 45° angles from the main leader, although this angle varied if the net was set in a bay or on a point. During the study the fish bags on the trap nets were emptied of fish every 24 hours and the nets were reset for the next day. In Morris Lake the Northern pike were taken to shore for data collection and the other species of fish trapped were returned to the lake. In Bay Lake the data collection for the Northern pike was completed on the boat and the other species of fish returned to the lake.

Total lengths of the Northern pike were taken using a 75 cm measuring board and a meter stick with the measuring board for fish larger than 75 cm. The weight was taken for each fish using calibrated Pesola spring scales. Three to six scales were taken from an area on the left side of each fish, just below the lateral line and posterior to the operculum (Fig. 1). The scales were taken using Dumont forceps and they were placed in glassine weighing paper and scale packets. The fish in Morris Lake were marked with a paper hole punch on the top fork of the caudal fin for mark-recapture purposes (Fig. 1). These fish were then released from the approximate center of the lake to randomize their distribution. The Northern pike in Bay Lake were anethesized with a 1:1000 ratio of 2-phenoxyethanol to water for ease in handling. Most of the fish became lethargic after about three minutes, but this length of time varied depending on the size of the fish. These fish were allowed to recover in fresh lake water and then were released back into the lake.

Age Determination.

The scales of each fish were temporarily mounted in a drop of water on a glass slide with a cover slip. A Bausch and Lomb scale projector was then used to display the scales on a projection screen for aging. The scales were aged as decribed by Goetz (pers. comm., 1987) and Ricker (1968). Age classes were determined for each fish first without knowing the total length and weight of the fish to insure unbiased judgements. The projected radius of each annulus measured from the focus was recorded along with the total radius of the scale projection (Appendix iii).

Analysis.

Back calculations for total length at the end of each growing season were recorded using each annulus and the total length of each fish as described by Ricker (1968) and Everhart, Eipper, and Youngs (1975)(Appendix iii).

$$l_n = s_n / r \cdot TL$$

l_n= length at annulus "n"

TL= total length of fish

s_n= radius of scale at "n"

r= total scale radius

n= age

These back calculations were then used to calculate the relative growth of each fish during each of its growing seasons as described by Everhart, et al. (1975) (Appendix iii).

$$h = (l_{n+1} \cdot l_n) / l_n$$

h= relative growth

l_n= TL of fish at year "n"

The condition factor was calculated for each fish using their total lengths and weights as described by Ricker (1968) and Everhart, et al.(1975) (Appendix iii).

$$CF = W / TL^3$$

W= wieght in g

TL= total length in cm

The average for each age class for total length, weight, back calculations, relative growths, and

condition factors were calculated and are presented in Appendix iii.

Gut Analysis.

Feeding Northern pike were sampled by hook and line in Morris Lake for gut analysis. When a fish was caught it was killed and its stomach was immediately removed and put in a cooler. The stomachs were kept frozen until they were examined. Prior to examination, the stomachs were thawed out in hot water and then the contents were removed. Any item that was identifiable as forage food was measured, weighed, and recorded. A stomach pump method designed for small bass was tried in the field, but was not successful.

Mark-recapture.

A mark-recapture study was conducted to determine the total population of Northern pike in Morris Lake. The fish were marked during routine data collection and the number of recaptures per daily sample were recorded along with a running count of the total number marked and returned to the lake (Ricker, 1968). This data was analyzed with a computer by James Hodgson (St. Norberts University, Wisconsin)(Appendix ii).

Results

Description of study site.

The study sites were two lakes on the UNDERC property in Gogebic County, MI.. Morris Lake is a small (5.7 ha), late stage mesotrophic to early stage eutrophic lake (Linder, et al., 1983). The lake is very shallow in all areas and becomes very warm in the summer months. The bottom substrate is classified as muck and it is characterized by heavy macrophyte growth in its large littoral zone (~0-17 m from shore). Most of the shore lines gradually slope allowing for easy sampling with a trap net. The water color is very dark resulting in low light penetration.

The trap nets were set in five sites along the shore line (Fig. 2). As many different habitats as possible using the trap nets were covered. The lake was sampled from 6/10/87 to 6/21/87 using four nets for five days and two nets for the last seven days.

Bay Lake is a large (69 ha) lake consisting of many bays and channels. It is an early to middle stage mesotrophic lake with medium depth and cool water (Linder, et al., 1983). The substrate ranges considerably including areas of muck, sand, gravel, rock, and boulder depending upon the location studied. It is characterized by few macrophytes in some of its small littoral zones. In other areas the benthos of the littoral zone is composed of large rocks and fallen trees. The water color is relatively clear. Sampling in this large lake was conduted mainly in the rocky and shallow channels. In two of these channels the main leader of the trap net cut off more than half of the narrow waterway. A total of five sites were sampled in this lake, although two of the sites were abandoned since they did not yield any Northern pike (Fig. 3). The lake was sampled from 6/29/87 to 7/5/87 and 7/11/87 to 7/19/87 using two nets.

Sampling results.

A total of 177 Northern pike were sampled in Morris Lake in eleven days of netting, while 25 total Northern pike were sampled in Bay Lake in fourteen days of netting. Other fish species captured in Morris Lake besides Northern pike were Pumpkinseed (*Lepomis gibbosus*), Yellow perch (*Perca flavescens*), shiners (*Notemigonus sp.*), and two species of turtles; Snapping turtle (*Chelydra serpentina*), and Western Painted turtle (*Chrysemys pictabelli*). Other fish species captured in Bay Lake included Pumpkinseed (*Lepomis gibbosus*), Bluegill (*Lepomis macrochirus*), Rock bass (*Ambloplites rupestris*), Yellow perch (*Perca flavescens*), White sucker (*Catostomus commersoni*), Smallmouth bass (*Micropterus dolomieu*), Largemouth bass (*Micropterus salmoides*), and the species of turtle, Snapping turtle (*Chelydra serpentina*).

The Morris Lake Northern pike ranged between the age classes of 1+to 9+; the predominant classes being 3+, 4+, and 5+, while the Bay Lake Northern pike ranged from 4+to 8+; the

predominant classes being 4+ and 5+ (Table 1, Fig. 4). The overlapping age classes between the two lakes were the 4+to 7+ fish. For a given year class, the average total length and the average weights for all the Bay Lake Northern pike are higher than those in Morris Lake (Table 1, Fig. 5). The higher slope in the total length versus weight regression for the Bay Lake Northern pike indicates that the weights of these fish are much higher in comparison to their total lengths than the data for the Morris Lake Northern pike (Fig. 5). Additional evidence for this is seen in that the condition factors for the Bay Lake Northern pike are also much higher than in all the comparable classes in Morris Lake (Table 2, Fig. 6).

Table 3 shows the back calculated total length of each Northern pike at the end of the first growing season; all the relative growth percentages start from this calculation. The relative growth percentage for each year of the Morris Lake Northern pike is comparable to that of the Bay Lake fish (Table 4). In fact, in the younger fish the percent growth from year one to two is higher in Morris Lake than in Bay Lake. Relative and absolute growth in both lakes were shown to be inversely proportional with each successive growing season indicating that the fish grow more slowly as they increase in age (Fig. 7). The 5+ year class back calculations were chosen to show this trend. The total absolute growth of the Northern pike in Bay Lake is also much greater than that of the Northern pike in Morris Lake (Fig. 8).

The mark-recapture study determined the total population of Northern pike in Morris Lake to be 1027 +/- 828.27 within 95% confidence limits (Appendix ii). The sample collected, 177 Northern pike, was at least 10% of the total population of Northern pike in the lake. The density of Northern pike in Morris Lake was determined to be 180 +/- 145 fish per ha.

A total of 18 Northern pike of various total lengths and weights were analyzed for stomach contents (Table 5). Of this number, 7 (39%) contained vertebral columns of small fish in their stomachs, and 3 of these 7 (43%) were definitely identified as shiners.

Discussion

Year class strengths.

The strong year classes of Northern pike in Morris Lake are the 3+, 4+, and 5+ classes, while the strong year classes of Northern pike in Bay Lake are the 4+ and 5+ classes (Fig. 4). Because of the small size of Morris Lake, the percentage of fish sampled in Morris Lake was much higher than the percentage of fish sampled in Bay Lake making the Morris Lake data more accurate. Strong year classes have been associated with high water levels remaining at least a month after spawning has occured (Carlander, 1969). The close proximity of the two lakes to one another indicates that high water levels in both lakes probably occured at the same time, and this may be the reason that the strong year classes are alike. However, a factor that may render the year class strength data unreliable is the selectivity in the sampling method used (Everhart, et al., 1975). The trap net may have been selective for certain size Northern pike, and thus certain age classes. If this were true, invalid year class strengths would be observed. However, the high number of Northern pike sampled, and the wide distribution in age classes in Morris Lake indicate that the year class strengths given above are valid. The year class strengths from Bay Lake may have been affected by gear selectivity more so since it is a much larger and harder lake to sample. In this lake a large number of Northern pike were not sampled and the age distributions of the fish sampled were in a narrow range; no Northern pike below the 4+ age class were sampled in Bay Lake. Only 11 out of the 177 (6.2%) of the Northern pike sampled in Morris Lake were above the 5+ age class (Table 1). This figure indicates that a high rate of mortality is occuring after the fish reach this stage in their growth. The Northern pike in Morris Lake are reproducing well, growing slowly, and dying at young age. The average life span for a Northern pike is 7 yrs (Becker, 1983).

Growth.

The absolute growth data and the condition factors of the Northern pike in Morris Lake indicate that their growth rates are slower than those of the Northern pike in Bay Lake. However, the relative growth percentage of the Northern pike in the two lakes is comparable (Table 4). The relative growth relationship indicates that the two populations of Northern pike grew the same percent increase per year relative to their intial total length the year before. The only observed difference is that the younger fish in Morris Lake grew more in the 1 to 2 year growing period. In other words, in the age classes of 4+, 5+, 6+, and 7+, the fish are growing the same percentage each successive year, but they have started out at a different total length before the 1 to 2 year growing season. It can be infered from the back calculations that during the 0 to 1 year growing season the Bay Lake fish grew approximately 7 cm more than did the Morris Lake fish (Table 3). The relative growth data indicates that after this 0 to 1 year growth the fish in both Morris Lake and Bay Lake increase by the same percentage in length. However, each fish should be looked at as a three-dimensional volume block instead of a one-dimensional length, since the weight of each fish is also a factor in growth. Thus a 10% section of a large volume block (Bay Lake fish) is much larger than a 10% section of a small volume block (Morris Lake fish)(Fig. 9). Therefore, the absolute growth for all the Bay Lake Northern pike is much higher than that seen in the smaller Morris Lake Northern pike.

The condition factor refers to the "fitness" or "well being" of each individual fish (Ricker, 1968; Everhart, et al., 1975). The averages for each weight class, listed in Table 2, indicate that the Bay Lake Northern pike are much healthier than the Morris Lake Northern pike (Fig. 6) These averages include both sickly, underweight fish and fully-fed, overweight fish. Many of the Northern pike sampled in Morris Lake were fully-fed and over their normal weight because they had eaten smaller fish while in the trap net. This was easily seen by the large bulges in their stomachs when emptied from the trap net. The larger Bay Lake Northern pike

did not seem to show this effect. Therefore, the average condition factors for the Morris Lake Northern pike should be lower than the values listed, which would make these fish even less healthy than presented. The activity of the fish during capture was also support to this. The Morris Lake Northern pike were always lethargic and easy to handle, while the Bay Lake Northern pike were very energetic and much more difficult to handle.

The higher slope in the regression of length versus weight of the Bay Lake Northern pike again demonstrates their increased growth and "fitness" over the Northern pike in Morris Lake (Fig. 5). This regression indicates that a given Northern pike from Bay Lake has a greater weight than a fish of similar total length from Morris Lake.

One factor that was not taken into consideration in this study is the variation in total length and weight due to sexual dimorphism. It is known than female Northern pike grow faster and larger in some lakes than do the males in the same age classes (Carlander, 1969). However, a comparative study such as this should not be affected by this since the samples in both lakes were taken randomly and with the same methods. The only way to sex these fish is to kill them first, and this would have defeated the goals of the study. In addition direct changes in weight due to gonadal development would not be a factor since the study was conducted outside of the Northern pike reproductive season (Goetz, pers. comm., 1987).

The graphs of relative and absolute growth indicate that as a Northern pike gets older its total length per year increases, but its relative growth percentage per year decreases (Fig. 7). When the relative growth percentage for length approaches zero the fish begins to grow much more in weight and less in length. This would make the condition factors for the older fish higher than those for the younger fish, but this is only apparent for the 9+ Northern pike from Morris Lake (Table 3). The other Northern pike in Morris and Bay Lakes may not yet be old enough to show this trend.

Forage fish.

The higher weights per total length and the higher condition factors of the Northern pike from Bay Lake indicate that these Northern pike have sufficient forage fish necessary for proper growth, while the Northern pike in Morris Lake do not. Maximum growth of Northern pike occurs in waters with the correct numbers and the correct sizes of soft-rayed forage fish availible (Engstrom-Heg, et al., 1986; Linder, et al., 1983). In past studies by Engstrom-Heg, et al. (1986) Northern pike were shown to prefer the following forage fish; White suckers, followed by shiners, and lastly Yellow perch were chosen. Soft-rayed fish are easier to swallow and digest than spiney-rayed fish and are thus prefered (Linder, et al., 1983). The gut analysis on Morris Lake indicated that the Northern pike in this study also prefered shiners to Yellow perch. The many large White suckers, and the many very large Golden shiners (~15-20 cm in TL) observered in the trap nets in Bay Lake support the higher growth rates of Northern pike in this lake. In Morris Lake, where there are no White suckers, and the shiners are small and lower in abundance, the Northern pike growth rates are lower.

Population density and structure.

This lower abundance of sufficient forage fish for the Northern pike has led to keen competition in Morris Lake. The high population figure from the mark-recapture study on the Northern pike in Morris Lake helps to support this. The density of Northern pike in Morris Lake (180 fish/ha) is very high. In past studies by Snow (1978), a density of 148 fish/ha was considered high. It appears that the density of Northern pike in Bay Lake is much lower than in Morris Lake. In support of this, even though a population study for the Northern pike in Bay Lake was not conducted, the work effort required to trap the Northern pike (catch per unit effort) on this large lake was much greater.

The population structure in Bay Lake consists of a small number of larger sized Northern pike, while the structure in Morris Lake consists of great numbers of smaller Northern pike.

The Northern pike is an avid predator and each fish needs a certain amount of area in which to live and feed. In Bay Lake this area is large, while in Morris Lake this area is small. Again this supports much higher competition for forgage fish in Morris Lake.

Environment.

The physical environment may also be a limiting factor for Northern pike growth along with the high competition for forage food and space (Linder, et al., 1987). The small size and shallow, warm water in Morris Lake has slowed the growth of the Northern pike because it limits them spatially as well as limiting their resource base (Linder, et al., 1983). This type of environment leads to high competition (above), cannibalism, high reproduction, and in the end stunted, short-lived fish (Linder, et al., 1983). Cannibalism was observed in the Northern pike from the Morris Lake trap nets at least ten times in the form of regurgitated Northern pike. Whether this cannibalism was a result of the way in which the fish were sampled is unknown. However, gut analysis on the Northern pike sampled by hook and line did not show evidence of it. All of the Northern pike in Morris Lake seemed to be short-lived, although no direct mortality was seen. As stated above, only 6.2% of the fish sampled were above the 5+ age class. The high stress from competition along with the warm water in Morris Lake may increase the metabolism of the Northern pike until they literally "burn themselves out" (Linder, et al., 1983).

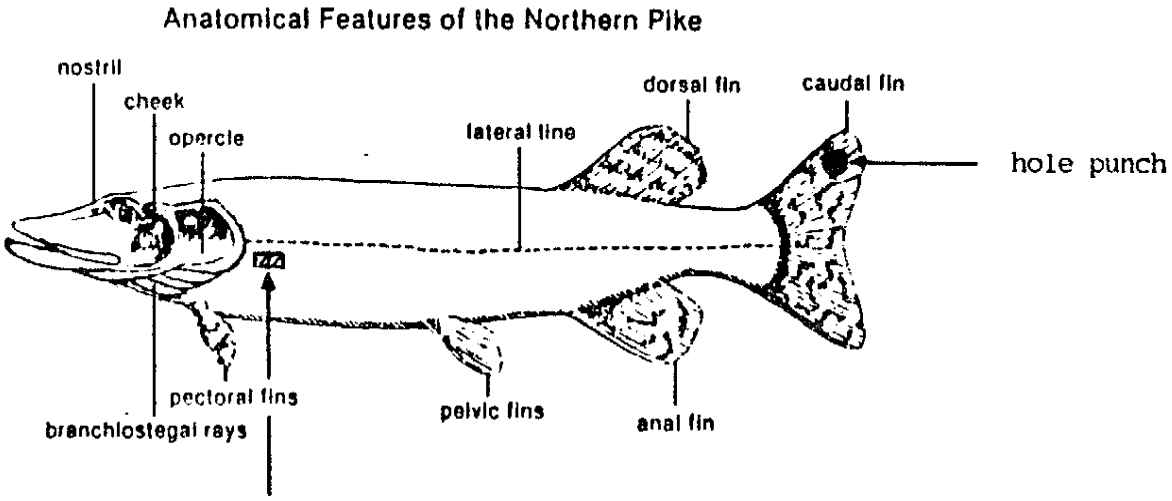
Many of the Northern pike in Morris Lake were also infected with small, round, and black parasites on their scales and skin (Linder, et al., 1983; Snow, 1978). The type of parasite, and whether its cause was from Morris Lake or the fact that the Northern pike were unhealthy is not known. However, many of the Yellow perch in Morris Lake, though very healthy, also were infected.

In contrast to the environment in Morris Lake, Bay Lake is larger, cooler, deeper, and consists of many different habitats in which different sized Northern pike can live and grow.

Small Northern pike are known to inhabit the shallow warm water areas with dense macrophytes (all of Morris Lake), while the larger members of this species prefer the cooler, medium depth areas (Chapman and Mackay, 1984; Linder, et al., 1983). The highest activity, the highest feeding rate, and the highest growth of Northern pike occurs in water in the 4 ° C to 18.4 ° C range (Linder, et al., 1983). During the summer months Morris Lake seems to be well above this range. The many habitats in Bay Lake, along with the lower density of Northern pike, and sufficient forage fish allow these Nothern pike to grow much larger than the Northern pike in Morris Lake. The sampling of smaller Northern pike in Bay Lake would have helped to support this, but unfortunately none were captured. The back calculations from the older Northern pike in Bay Lake will have to stand as the comparison to the younger Northern pike in Morris Lake.

Conclusion.

The results of this study clearly prove that the population of Northern pike in Morris Lake is still stunted. In all respects; mean total length, mean weight, and mean condition factors, these Northern pike are much lower than the hypothetical "normal" population in Bay Lake. It has been shown that Bay Lake has the a more "normal" density of Northern pike, a sufficient forage fish supply, and the many different habitats necessary for "normal" Northern pike growth. On the otherhand, the high density of Northern pike, the lack of sufficient forage fish, and the limited area in Morris Lake do not allow these Northern pike to achieve their "normal" growth potential.



(Linder, et al. 1983)

Figure 1: The area from which scales were taken and the tagging site on the fish.

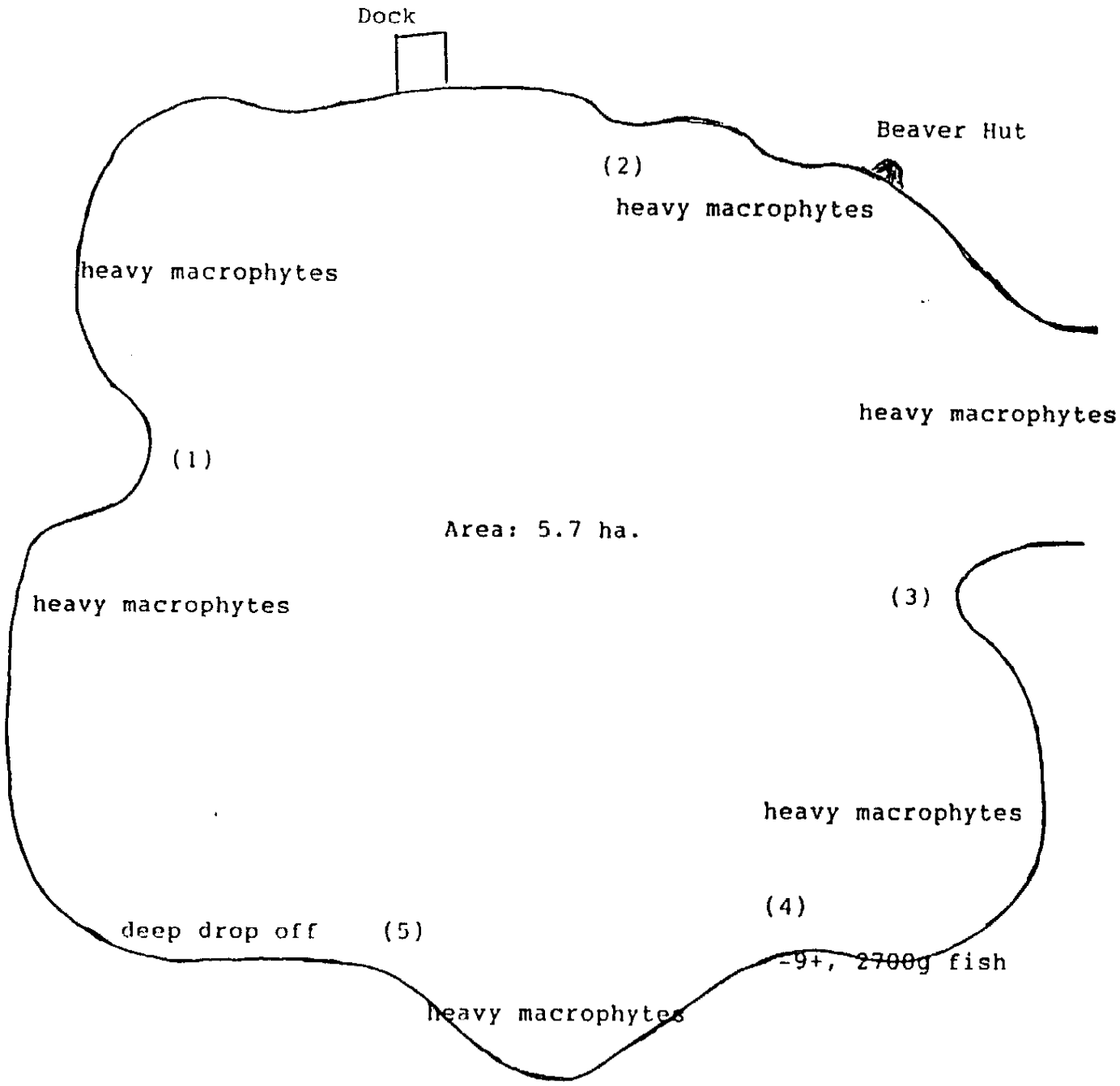


Figure 2: Trap net sites in Morris Lake.
(substrate: muck)

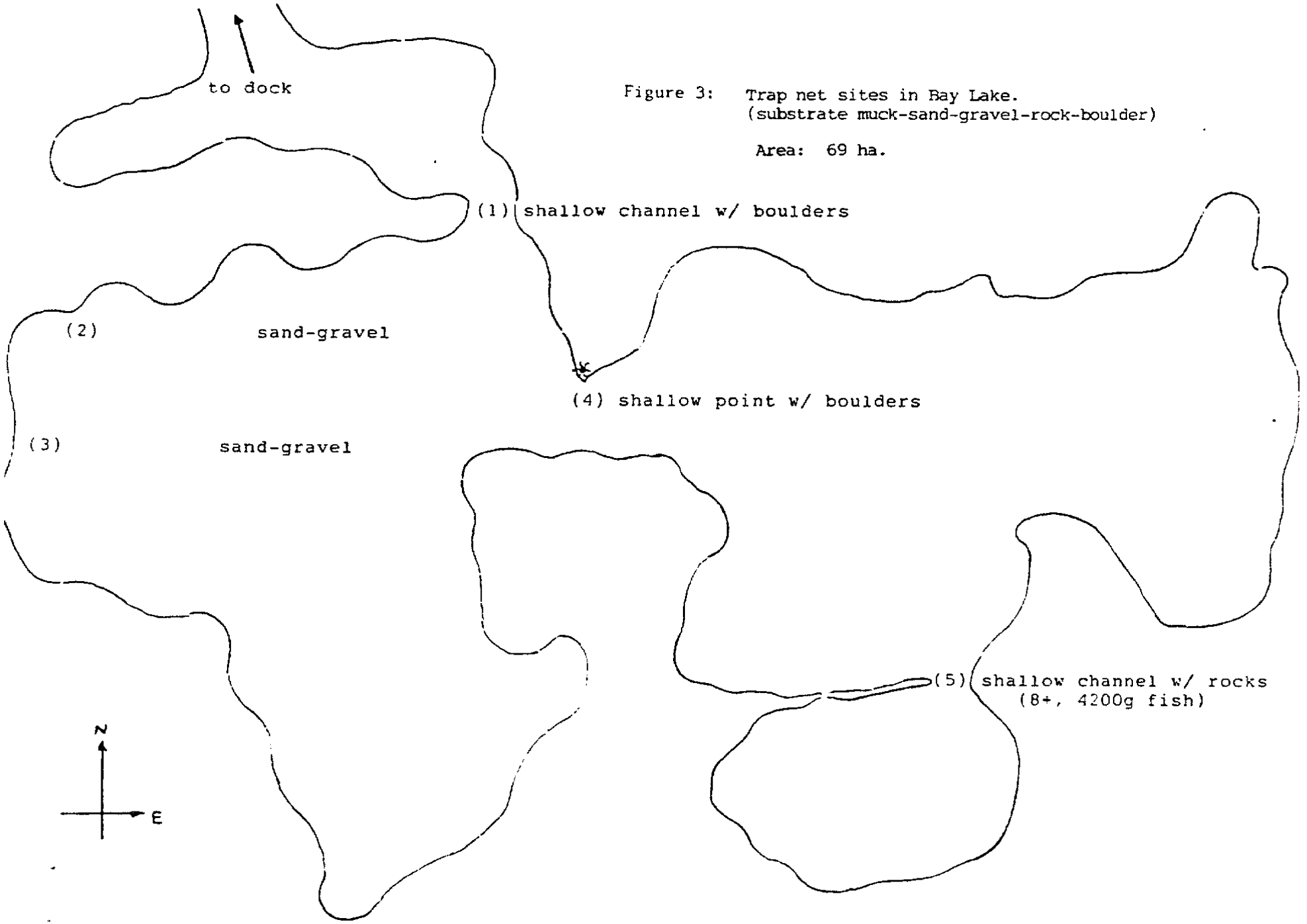


Figure 3: Trap net sites in Bay Lake.
(substrate muck-sand-gravel-rock-boulder)

Area: 69 ha.

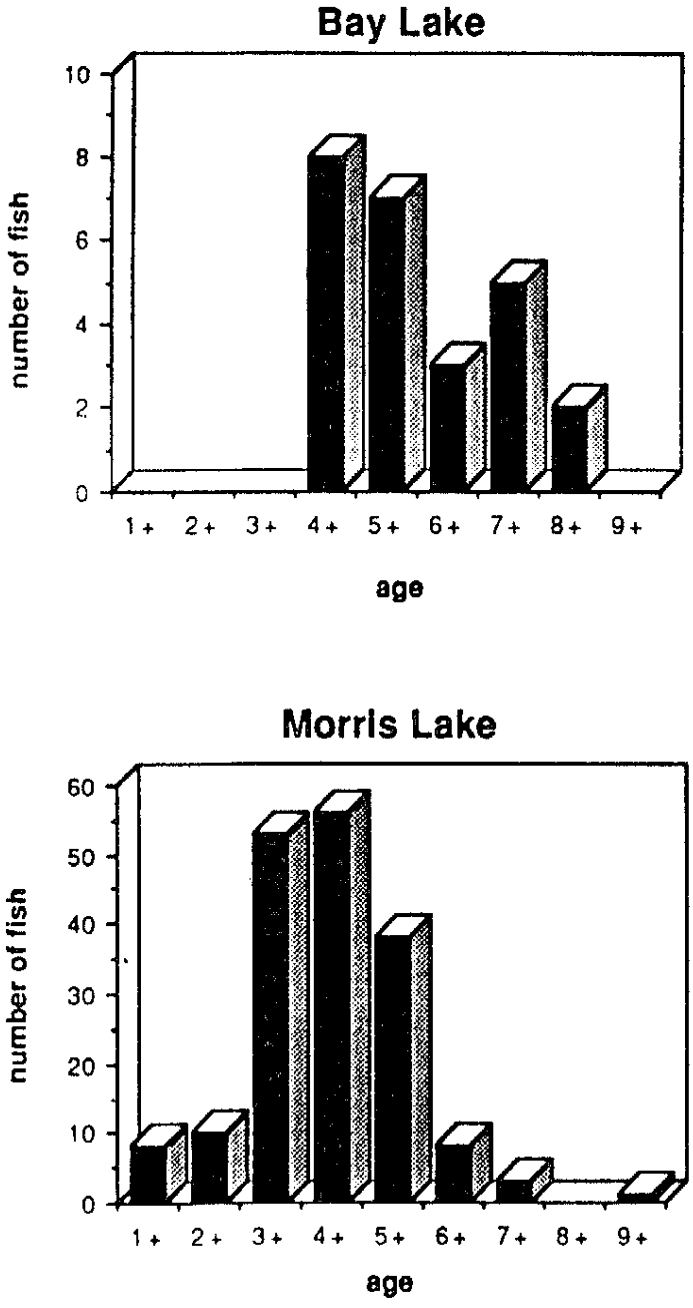


Figure 4: Age class strengths of Northern pike in Bay and Morris Lakes

Table 1: Number of *E. lucius* , average weight, and average total length of each age class in Bay and Morris Lakes

	Bay			Morris		
Age Class	#fish	Avg Wt(g)	Avg TL(cm)	#fish	Avg Wt(g)	Avg TL(cm)
1+	0			8	64.50	22.49
2+	0			10	148.20	30.46
3+	0			53	392.40	41.35
4+	8	1073.13	54.71	56	526.00	45.78
5+	7	1301.43	58.17	38	683.68	50.05
6+	3	2165.00	70.17	8	783.75	52.94
7+	5	2720.00	74.70	3	893.33	56.43
8+	2	3600.00	82.50	0		
9+	0			1	2700.00	73.30
total	25			177		

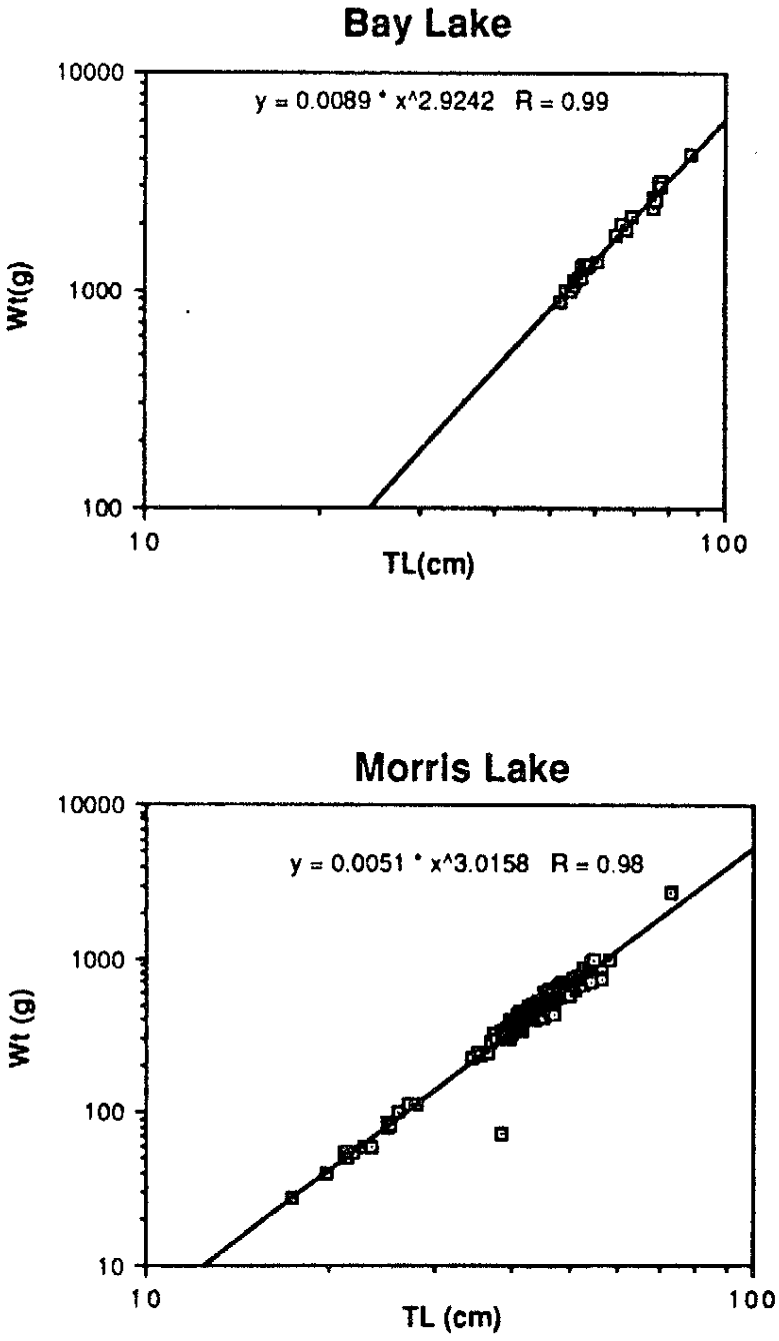


Figure 5: Total length versus weight of E. lucius in Bay and Morris Lakes.

Table 2: Condition Factors of Bay and Morris Lake *E. lucius.*

year	Avg CF(Morris Lake)	Avg CF(Bay Lake)
1+	528.61	
2+	501.08	
3+	552.46	
4+	546.08	651.59
5+	543.53	655.81
6+	527.68	625.77
7+	499.88	649.01
8+		635.71
9+	679.99(single fish)	

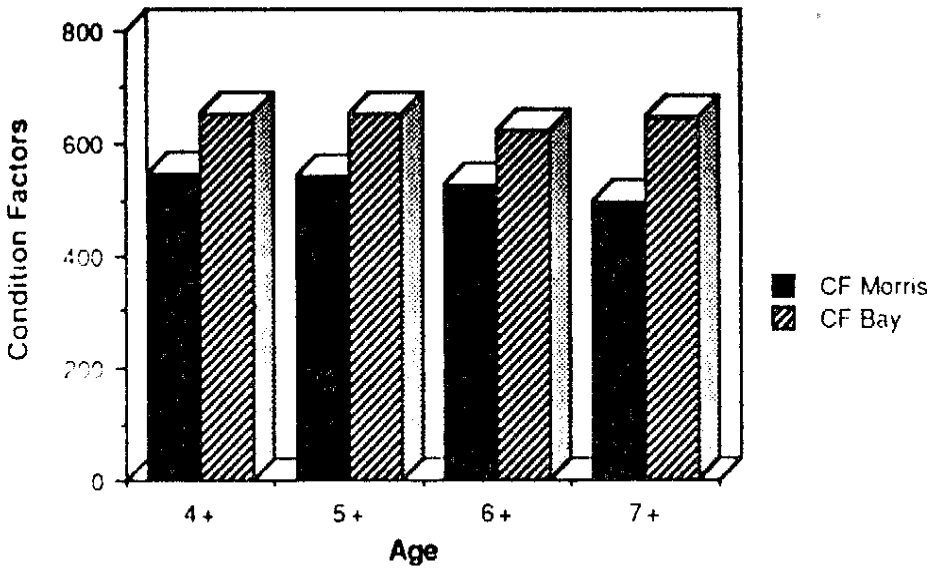


Figure 6: Average Condition Factors for E. lucius in Bay and Morris Lakes.

Table 3: Back calculated TL of Northern pike in Bay and Morris Lakes.

Back Calculated Total Length (cm) at yr 1 (Abs Growth 0-1 yr)

	Morris	Bay
2+	14.56	----
3+	17.76	----
4+	17.91	25.43
5+	18.73	25.35
6+	17.92	25.81
7+	19.40	26.56
8+	-----	26.32
9+	20.14	----

Table 4 : Average Relative Growth of *E. lucius* in Bay and Morris Lakes.

Relative Growth (percentile)

year	yr 1-2	yr 2-3	yr 3-4	yr 4-5	yr 5-6	yr 6-7	yr 7-8	yr 8-9
Morris Lake								
2+	0.65							
3+	0.68	0.26						
4+	0.65	0.29	0.14					
5+	0.60	0.29	0.15	0.09				
6+	0.53	0.32	0.19	0.13	0.05			
7+	0.44	0.36	0.21	0.08	0.05	0.05		
9+	0.50	0.43	0.09	0.11	0.12	0.07	0.06	0.06
Bay Lake								
4+	0.39	0.26	0.15					
5+	0.35	0.24	0.19	0.11				
6+	0.45	0.30	0.23	0.13	0.05			
7+	0.45	0.25	0.21	0.09	0.08	0.05		
8+	0.50	0.10	0.25	0.22	0.11	0.06	0.04	

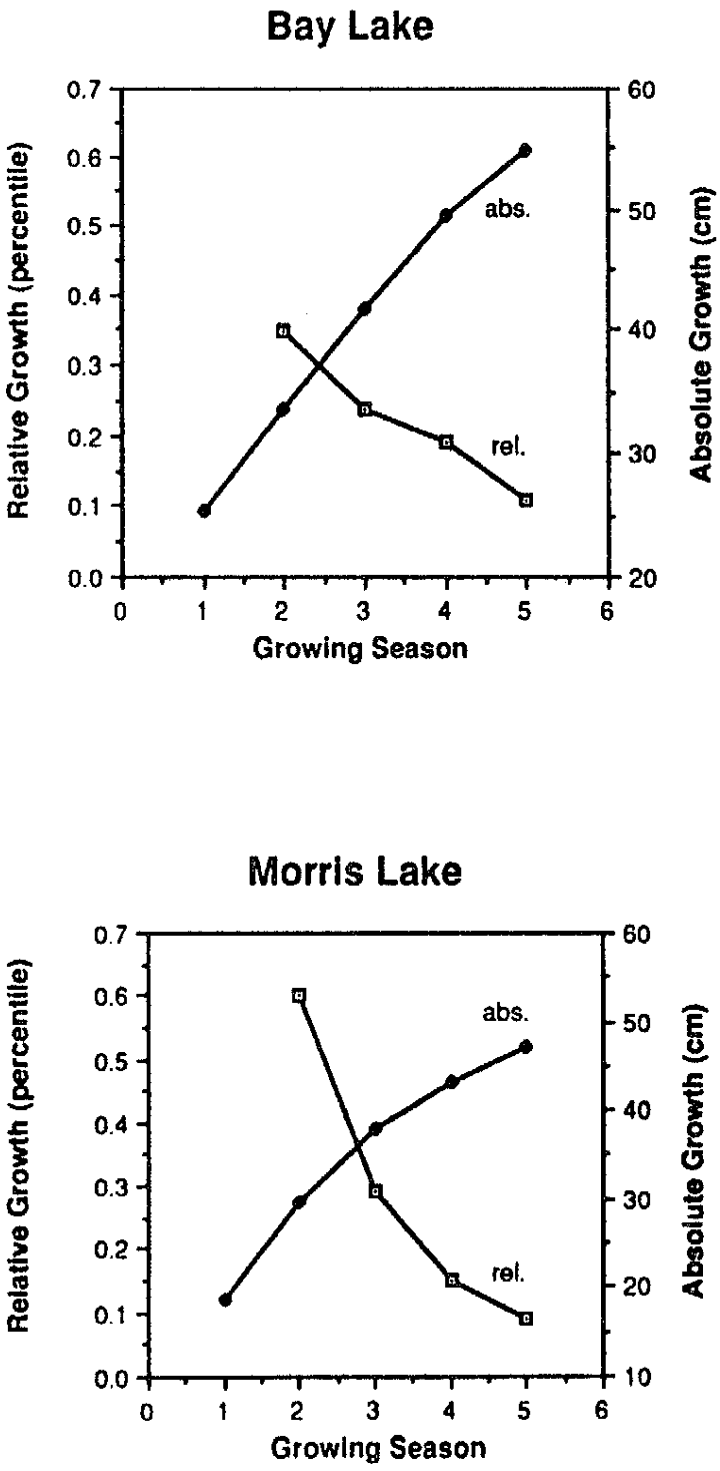
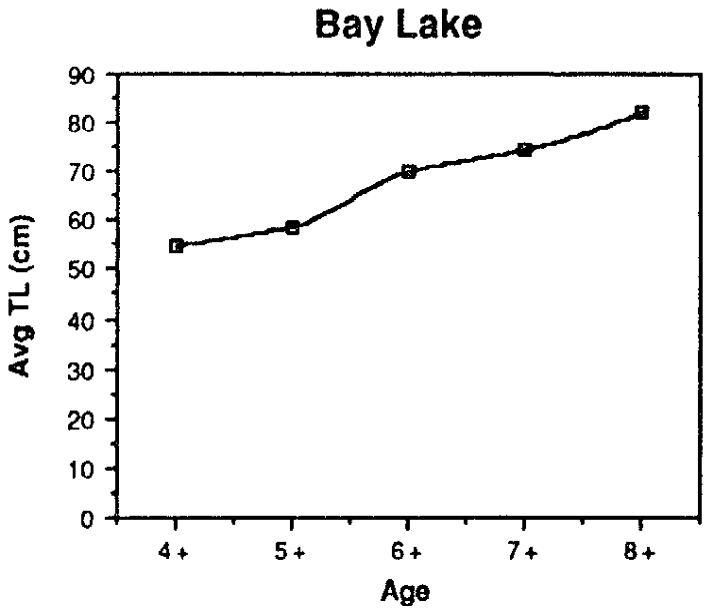


Figure 7: Relative and Absolute Growth of Northern pikein Bay and Morris Lakes.

(5+ fish back calculations)



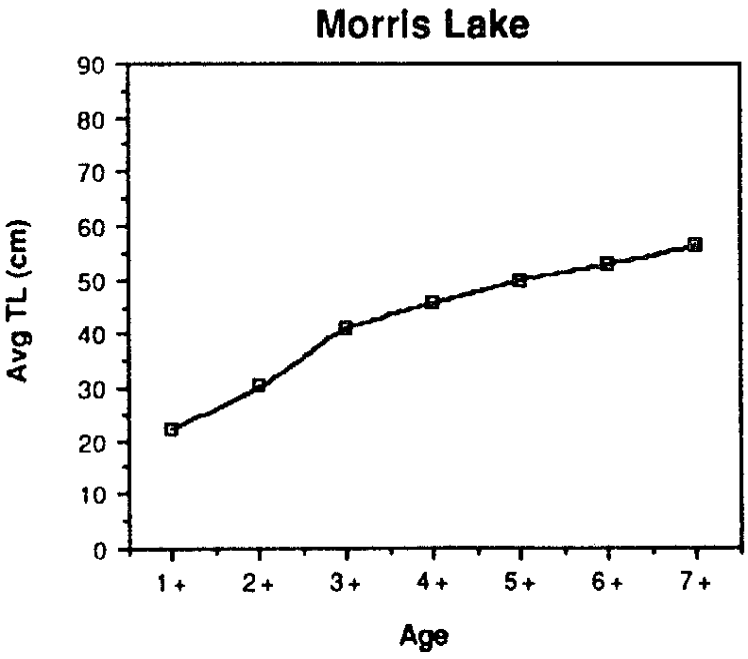
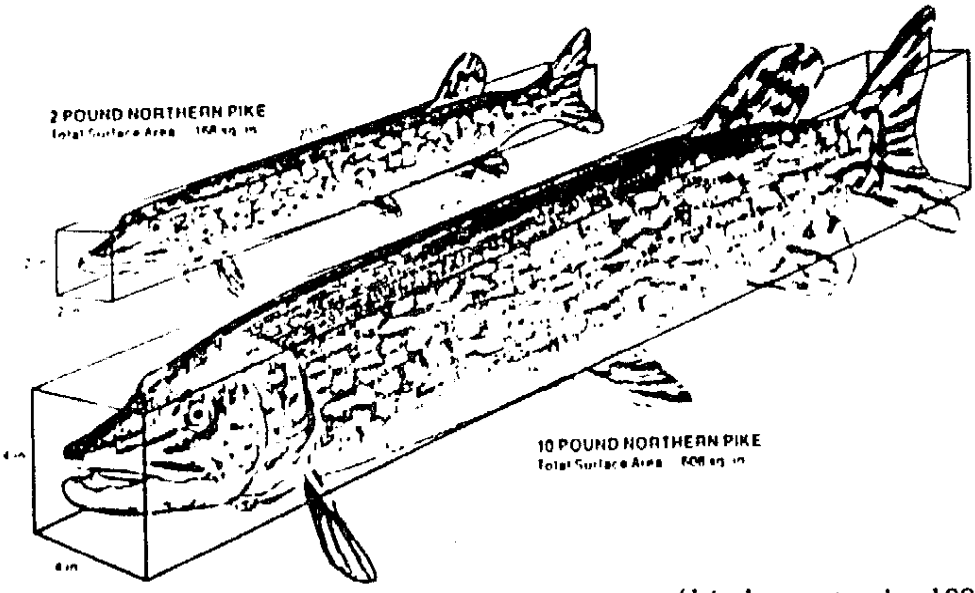


Figure 8: Absolute growth of Northern pike in Bay and Morris Lakes

Table 5: Gut Analysis of *E. lucius* in Morris Lake.

Wt (g)	TL (cm)	Contents of Stomach
--	41	unidentifiable fish vertabrae
400	42.5	0
545	45	type of shiner (~8 cm, 5 g)
515	45.5	0
495	45.6	unidentifiable fish vertabrae (~8 cm)
500	46	0
550	47	0
--	47.5	0
560	48	type of shiner (~8 cm, 5 g)
615	48.6	0
585	48.8	unidentifiable fish vertabrae
650	50.8	0
640	51	0
--	54.5	unidentifiable fish vertabrae
800	55.5	0
--	56.5	0
--	--	type of shiner
--	--	0



(Linder, et al. 1983)

Figure 9: Volume differences between large and small fish.

Acknowledgments

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Appendix i

Ideas for further study of Northern pike at UNDERC.

A. The study above should be extended to Kickapoo Lake. This lake is comparable in size, depth, and vegetation to Morris Lake, but the Northern pike population in this lake seems to be healthier than that of Morris Lake.

B. A temperature and depth profile should be conducted for all three lakes. The temperatures must be taken at all depths and in as many seasons as possible. This temperature profile will allow the researcher to find the cooler areas in the lakes. The larger and older Northern pike are known to prefer these areas (Linder, et al., 1983). A depth profile will allow the researcher to find underwater structures and macrophyte beds in which the Northern pike may live and feed. This type of study could be conducted using a commercial chart recorder ("fish finder").

C. A more complete gut analysis should be conducted. This could be done easily by constructing a stomach pump for large Northern pike. The following reference can be used for this task: Crossman and Hamilton. Env. Biol. Fish. Vol. 3, No. 3, pp. 297-300. 1978.

D. A mark-recapture study should be conducted more extensively and in all three lakes. A few fish should be impounded to study the affects of tagging (paper hole punch), and the time it takes to regenerate the hole.

E. All the raw data should be run through statistical analysis tests to determine significant results.

DATA COLLECTED FOR SCHNABEL POPULATION ESTIMATION

Day (i)	Number in sample ni	Number of recaptures Ri	Number newly marked	Total number previously marked Mi	niMi
1	25	0	25	0	0
2	22	0	22	25	550
3	18	1	17	47	846
4	19	1	18	64	1216
5	13	0	13	82	1066
6	15	0	15	95	1425
7	18	3	15	110	1980
8	10	1	9	125	1250
9	17	3	14	134	2278
10	8	0	8	148	1184
11	10	4	6	156	1560

Morris estn

N = 1027.00 for this set of data

SE = 422.58 for this set of data (standard error)

The size of the sampled population = 1027.00 +- 828.27 ← 95% confidence

$$N = \frac{\Sigma n_i M_i}{\Sigma R_i}$$

Bay Lake Northern pike

	1	2	3	4	5	6	7	8	9	10
1	Date	Age	Wt (g)	TL (cm)		Scale Rad (cm)				
2						to Ann I	to Ann II	to Ann III	to Ann IV	to Ann V
3	7/17/87	4+	1290	57.8	4+ Avg Wt(g)	12	21	26	29	
4	7/12/87	4+	990	54.1	1073.13	15	22	28	31	
5	7/12/87	4+	1050	54.8	4+ Avg TL(cm	12	16	21	24	
6	7/1/87	4+	890	52	54.71	13	17	22	25	
7	6/29/87	4+	975	53		10	14	17	23	
8	6/30/87	4+	1275	56.6		16	20	25	28	
9	7/2/87	4+	1140	56.4		16	20	24	27	
10	7/2/87	4+	975	53		14	19	24	27	
11	7/19/87	5+	1150	56	5+ Avg Wt(g)	13	19	26	29	32
12	7/12/87	5+	1800	65.3	1301.43	13	18	23	30	33
13	7/12/87	5+	1360	60.2	5+ Avg TL(cm	15	20	24	29	31
14	7/12/87	5+	1300	58.2	58.17	15	21	24	27	31
15	7/1/87	5+	1100	55		12	17	20	26	30
16	7/2/87	5+	1300	57		16	20	25	29	32
17	7/5/87	5+	1100	55.5		15	18	23	26	28
18	7/15/87	6+	2575	76	6+ Avg Wt(g)	13	21	25	31	33
19	7/2/87	6+	1920	68	2165.00	12	14	20	27	34
20	7/16/87	6+	2000	66.5	6+ Avg TL(cm	15	22	28	31	33
21	7/13/87	7+	3100	77	70.17	12	18	22	29	32
22	7/13/87	7+	2200	69	7+ Avg Wt(g)	16	21	25	30	31.5
23	7/1/87	7+	3200	77.5	2720	15	21	27	32	35
24	6/30/87	7+	2700	75	7+ Avg TL(cm	16	22	28	33	37
25	6/30/87	7+	2400	75	74.7	12	20	26	30	33
26	7/12/87	8+	4200	87.5	8+ Avg Wt (g)	12	20	23	30	37
27	7/16/87	8+	3000	77.5	3600	15	20	21	25	30
28					8+ Avg TL(cm					
29					82.5					
30										
31										
32										
33										
34										
35										
36										
37										
38										
39										

	11	12	13	14	15	16	17	18
1					Back Calcultations			
2	to Ann VI	to Ann VII	to Ann VIII	to edge of scale	1		2	
3				31	22.37	4+ avg at yr 1	39.15	avg at yr 2
4				33	24.59	25.43	36.07	35.04
5				26	25.29		33.72	
6				27	25.04		32.74	
7				26	20.38		28.54	
8				31	29.21		36.52	
9				30	30.08		37.60	
10				28	26.50		35.96	
11				34.5	21.10	5+ avg at yr 1	30.84	avg at yr 2
12				34.5	24.61	25.35	34.07	33.63
13				33	27.36		36.48	
14				33	26.45		37.04	
15				31	21.29		30.16	
16				34	26.82		33.53	
17				30	27.75		33.30	
18	34.5			36	27.44	6+ avg at yr 1	44.33	avg at yr 2
19	37			38	21.47	25.81	25.05	37.06
20	34			35	28.50		41.80	
21	33	34		36	25.67	7+ avg at yr 1	38.50	avg at yr 2
22	35	37		39	28.31	26.56	37.15	38.27
23	37	39		40	29.06		40.69	
24	40	42		44	27.27		37.50	
25	37	39		40	22.50		37.50	
26	39	40	42	41	25.61	8+ avg at yr 1	42.68	avg at yr 2
27	35	38	39	43	27.03	26.32	36.05	39.36
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								

	19	20	21	22	23	24	25	26
1	Back Calculations							
2	3		4		5		6	
3	48.48	4+ avg at yr 3	54.07	avg at yr 4				
4	45.90	43.98	50.82	50.44				
5	44.26		50.58					
6	42.37		48.15					
7	34.65		46.88					
8	45.65		51.12					
9	45.12		50.76					
10	45.43		51.11					
11	42.20	5+ avg at yr 3	47.07	avg at yr 4	51.94	avg at yr 5		
12	43.53	41.68	56.78	49.60	62.46	54.9		
13	43.78		52.90		56.55			
14	42.33		47.62		54.67			
15	35.48		46.13		53.23			
16	41.91		48.62		53.65			
17	42.55		48.10		51.80			
18	52.78	6+ avg at yr 3	65.44	avg at yr 4	69.67	avg at yr 5	72.83	avg at yr 6
19	35.79	47.26	48.32	57.55	60.84	64.40	66.21	67.88
20	53.20		58.90		62.70		64.60	
21	47.06	7+ avg at yr 3	62.03	avg at yr 4	68.44	avg at yr 5	70.58	avg at yr 6
22	44.23	48.02	53.08	57.92	55.73	63.39	61.92	68.35
23	52.31		62.00		67.81		71.69	
24	47.73		56.25		63.07		68.18	
25	48.75		56.25		61.88		69.38	
26	49.09	8+ avg at yr 3	64.02	avg at yr 4	78.96	avg at yr 5	83.23	avg at yr 6
27	37.85	43.47	45.06	54.54	54.07	66.52	63.08	73.16
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								

	27	28	29	30	31	32	33	34	35
1	Back Calculations			Condition Factor		Relative Growth			
2	7		8			yr 1-2		yr 2-3	
3				668.05	4+ avg CF	0.75	4+ avg	0.24	4+ avg
4				625.24	651.59	0.47	0.39	0.27	0.26
5				638.04		0.33		0.31	
6				632.97		0.31		0.29	
7				654.9		0.4		0.21	
8				703.17		0.25		0.25	
9				635.43		0.25		0.2	
10				654.9		0.36		0.26	
11				654.84	5+ avg CF	0.46	5+ avg	0.37	5+ avg
12				646.45	655.81	0.38	0.35	0.28	0.24
13				623.38		0.33		0.2	
14				659.44		0.4		0.14	
15				661.16		0.42		0.18	
16				701.97		0.25		0.25	
17				643.45		0.2		0.28	
18				586.59	6+ avg CF	0.62	6+ avg	0.19	6+ avg
19				610.62	625.77	0.17	0.42	0.43	0.3
20				680.09		0.47		0.27	
21	72.72	7+ avg at yr 7		679.03	7+ avg CF	0.5	7+ avg	0.22	7+ avg
22	65.46	71.69		669.69	649.01	0.31	0.45	0.19	0.25
23	75.56			687.46		0.4		0.29	
24	71.59			640		0.38		0.27	
25	73.13			568.89		0.67		0.3	
26	85.37	8+ avg at yr 7	89.63	626.94	8+ avg CF	0.67	8+ avg	0.15	8+ avg
27	68.49	76.93	70.29	644.49	635.71	0.33	0.5	0.05	0.1
28		8+ avg at yr 8							
29		79.96							
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									

	36	37	38	39	40	41	42	43	44	45	46
1	Relative	Growth									
2	yr 3-4		yr 4-5		yr 5-6		yr 6-7		yr 7-8		
3	0.12	4+ avg									
4	0.11	0.15									
5	0.14										
6	0.14										
7	0.35										
8	0.12										
9	0.13										
10	0.13										
11	0.12	5+ avg	0.1	5+ avg							
12	0.3	0.19	0.1	0.11							
13	0.21		0.07								
14	0.13		0.15								
15	0.3		0.15								
16	0.16		0.1								
17	0.13		0.08								
18	0.24	6+ avg	0.06	6+ avg	0.05	6+ avg					
19	0.35	0.23	0.26	0.13	0.09	0.05					
20	0.11		0.06		0.03						
21	0.32	7+ avg	0.1	7+ avg	0.03	7+ avg	0.03	7+ avg			
22	0.2	0.21	0.05	0.09	0.11	0.08	0.06	0.05			
23	0.19		0.09		0.06		0.05				
24	0.18		0.12		0.08		0.05				
25	0.15		0.1		0.12		0.05				
26	0.3	8+ avg	0.23	8+ avg	0.05	8+ avg	0.03	8+ avg	0.05	8+ avg	
27	0.19	0.25	0.2	0.22	0.17	0.11	0.09	0.06	0.03	0.04	
28											
29											
30											
31											
32											
33											
34											
35											
36											
37											
38											
39											

Fish Data

Morris Lake Northern pike

Date	Age	Wt (g)	TL (cm)		Scale rad-cm					
					to Ann I	To Ann II	To Ann III	To Ann IV	To Ann V	To Ann VI
6/12/87	1+	28	17.3	1+ Avg Wt(g)	9					
6/14/87	1+	40	19.8	64.50	12					
6/21/87	1+	54	21.3	Avg TL(cm)	13.5					
6/13/87	1+	50	21.5	22.49	11					
6/16/87	1+	55	21.8		9.5					
6/12/87	1+	59	23.4		14.5					
6/14/87	1+	115	27.8		10					
6/14/87	1+	115	27		10					
6/12/87	2+	60	22.8		12.5	17				
6/11/87	2+	79	25	2+ Avg Wt(g)	11.5	19				
6/17/87	2+	87	25	148.2	12.5	16.5				
6/14/87	2+	84	25.3	Avg TL(cm)	9	18.5				
6/12/87	2+	245	35	30.46	11	15				
6/14/87	2+	225	34.5		7	13				
6/14/87	2+	290	37		8	15				
6/12/87	2+	240	35.5		10	17.5				
6/16/87	2+	100	26		8	10.5				
6/12/87	2+	72	38.5		9.5	19				
6/15/87	3+	590	48.5		11.5	16.5	22.5			
6/15/87	3+	450	44	3+ Avg Wt(g)	8.5	14	18			
6/15/87	3+	420	42.3	392.40	8	15	17.5			
6/16/87	3+	457	42.8	Avg TL(cm)	9.5	12.5	16.5			
6/16/87	3+	420	42	41.35	6	12.5	16			
6/16/87	3+	480	46		11	17.5	22			
6/11/87	3+	405	43.8		11	14	17			
6/15/87	3+	475	43.5		8	15	18			
6/12/87	3+	460	43		7.5	16	18			
6/12/87	3+	440	42		10	17	22.5			
6/20/87	3+	350	40.5		9	15	17			
6/20/87	3+	400	42		9.5	14.5	18			
6/20/87	3+	490	44		9	15	18.5			
6/20/87	3+	375	40.5		7.5	13	18.5			
6/12/87	3+	490	43.5		10	18	22			
6/12/87	3+	325	37.2		9	17	19			
6/11/87	3+	460	42.6		9	15	20			
6/12/87	3+	310	38.5		10	16	20			
6/21/87	3+	250	36.5		9.5	13.5	18			
6/12/87	3+	405	39.5		8	18	22.5			

6/12/87	3+	320	39.7		10	18	20			
6/11/87	3+	305	37.7		9	13	19			
6/11/87	3+	340	38.7		9	15	19			
6/15/87	3+	320	39.2		10	16	19			
6/17/87	3+	325	39.8		10	16	19.5			
6/17/87	3+	305	39.5		9	14	17.5			
6/26/87	3+	355	41		9	16.5	21			
6/12/87	3+	375	40.5		10	16	19			
6/12/87	3+	385	41		9	18	22.5			
6/12/87	3+	425	44.8		9	16	20			
6/12/87	3+	390	40.5		10	16	20			
6/12/87	3+	390	40.5		13	17	20			
6/12/87	3+	460	41.3		8	14	17			
6/11/87	3+	350	41.5		11	16	20			
6/14/87	3+	410	41.4		11	16	20			
6/15/87	3+	385	40.2		10	16.5	20.5			
6/14/87	3+	400	41.2		10	17	20			
6/16/87	3+	445	41		9.5	13	18			
6/16/87	3+	360	41.3		9	15	18.5			
6/16/87	3+	360	41.2		9	15	19.5			
6/17/87	3+	325	40		7	13	15			
6/17/87	3+	360	41		10	14	19.5			
6/17/87	3+	360	41.5		8	15	21			
6/17/87	3+	395	41.8		10	15	20			
6/18/87	3+	375	40.5		7	13	18			
6/12/87	3+	355	39.1		9	16	20			
6/18/87	3+	435	42		9	15	19			
6/19/87	3+	350	41		9	18	22			
6/19/87	3+	345	38.5		9	14	18			
6/19/87	3+	340	41		9	13.5	17.5			
6/17/87	3+	435	43.5		9	16	19.5			
6/17/87	3+	415	42.5		11	17	22			
6/17/87	3+	450	44.3		8.5	15.5	20			
6/15/87	4+	710	49.7		7.5	15.5	21	24		
6/15/87	4+	550	47.8	4+ Avg Wt(g	6.5	16.5	21	24.3		
6/15/87	4+	620	51	526	9	15	18	20.5		
6/16/87	4+	540	47.2	Avg TL(cm)	5	11	17.5	20		
6/11/87	4+	550	48	45.78	11	20	23	26		
6/11/87	4+	415	42.1		9	16	21	24		
6/11/87	4+	570	46.5		11	19	24	26		

Fish Data

6/11/87	4+	660	51		8	12	18	21		
6/11/87	4+	540	44.5		9	19	23	24		
6/11/87	4+	420	44.5		8	12	18	21		
6/14/87	4+	560	47		10	19	23	25		
6/14/87	4+	420	44.6		9	13	18	20		
6/14/87	4+	420	45.2		8	13	18	20.5		
6/14/87	4+	570	46		7	12	15	18		
6/14/87	4+	500	44.8		12	19	23	25		
6/14/87	4+	500	45.3		11	14	18	19		
6/14/87	4+	530	45.8		11	19	22	24		
6/12/87	4+	445	47.2		8	13	18	20		
6/12/87	4+	495	46.5		12	17	23.5	25.5		
6/12/87	4+	510	43.2		9	17	19	22		
6/12/87	4+	415	41.2		10	14	18	20.5		
6/12/87	4+	500	44.5		9	17	22	24.5		
6/12/87	4+	550	47.5		11	14	17	19		
6/20/87	4+	480	45.2		10	17	22	25		
6/21/87	4+	495	43.4		10	16	18.5	20		
6/21/87	4+	440	41.8		8	12	14	17		
6/21/87	4+	465	44.8		10	18	21.5	23		
6/21/87	4+	500	42.5		9	15	20	22.2		
6/21/87	4+	460	43.5		7	16	21	23		
6/12/87	4+	615	47.8		10	15	18	20.5		
6/12/87	4+	670	47.3		11	19	22.5	24.5		
6/12/87	4+	560	45.5		10	16	21	22.5		
6/11/87	4+	477	43.2		9	17	21	23		
6/12/87	4+	725	50.8		12	18	23	25		
6/12/87	4+	500	44.5		10	14	19	20.8		
6/11/87	4+	390	41.4		10	14	17	20		
6/11/87	4+	375	41.5		10	13	17	23.5		
6/15/87	4+	415	41.6		9	14	18	21		
6/18/87	4+	510	45.4		9	16	23	25.5		
6/18/87	4+	600	46.5		9.5	14	18.5	20.5		
6/19/87	4+	500	46.5		11.5	15	19	21		
6/19/87	4+	600	48.3		10	15	18	21		
6/19/87	4+	560	47.5		9	16.5	21	23.5		
6/19/87	4+	555	47.6		9	14	18	20		
6/16/87	4+	500	45.5		8	12	17	25		
6/16/87	4+	500	45.5		8	12	16	20.5		
6/16/87	4+	440	46.5		9.5	16	19	21.5		

Fish Data

6/16/87	4+	510	45.3		10.5	14	18	21		
6/16/87	4+	460	44.7		8.5	15	20	22.5		
6/17/87	4+	500	47		8	13	18	20.5		
6/17/87	4+	780	52.5		9.5	16.5	20	23		
6/17/87	4+	660	47.8		9	15	19.5	23.5		
6/17/87	4+	640	46		10	16	21	23		
6/18/87	4+	550	46.8		9	13	17	21		
6/18/87	4+	600	45		10	16.5	20	22.5		
6/18/87	4+	460	44		8	13	16.5	19		
6/17/87	4+	500	45.3		10	16	20.5	24		
6/15/87	5+	890	54		11.5	16	21	24.5	29	
6/11/87	5+	840	54.1	5+ Avg Wt(g)	10	16	22	24	25	
6/11/87	5+	610	48	683.68	12	16	18	21	24	
6/11/87	5+	590	48.1	Avg TL(cm)	10	13	18	22	23	
6/11/87	5+	650	48.6	50.05	11	15	19	22.5	24	
6/11/87	5+	760	51.5		10	15	19	24	27	
6/14/87	5+	610	48.7		9	17	21	23	24	
6/14/87	5+	730	50.5		8	16	20	23	25	
6/14/87	5+	710	54		7	14	20	23	25	
6/14/87	5+	740	52		8	13	19	21	22	
6/20/87	5+	750	53.2		9	14	17	19	20.5	
6/20/87	5+	700	52		8	14	18	18.8	19.5	
6/20/87	5+	700	48.6		11	18	20.5	22	22.5	
6/21/87	5+	700	49.7		10	15	18	22	23	
6/21/87	5+	825	52.8		10	13	19	21	22	
6/12/87	5+	600	47.5		11	16	21	23	24.5	
6/12/87	5+	700	50		9	12	17	20	22	
6/12/87	5+	710	49.7		8	15	20	22	25	
6/11/87	5+	600	46.5		10	14	17	19	20	
6/11/87	5+	650	49.1		10	17	20	21	23	
6/11/87	5+	680	51		9	17	24	26	27	
6/11/87	5+	480	45.8		11	17	21	23	24	
6/26/87	5+	830	54.5		9	14	17	20	22	
6/12/87	5+	750	53		12	17	23	25	26.5	
6/18/87	5+	670	50		9.5	17	20	22.5	25	
6/18/87	5+	580	46.1		10	15	20	25	26.5	
6/19/87	5+	710	50.1		10	15	18	19	21	
6/19/87	5+	620	48		10	13	16	19.5	22	
6/19/87	5+	660	49		7.5	14	17.5	19.5	21.5	
6/19/87	5+	660	47.6		8	13	18	23.5	25	

Fish Data

6/19/87	5+	860	52.5		9	12	16	20	23.5	
6/19/87	5+	720	51		9	14	17	21	23	
6/19/87	5+	690	52.5		9	13	17	20	24	
6/17/87	5+	505	45.7		9	17	19	22	24.5	
6/17/87	5+	600	48.5		9.5	16	19.5	22	24	
6/17/87	5+	650	50		8.5	13.5	20	23	26	
6/17/87	5+	700	50		7	14	18.5	22	25	
6/18/87	5+	550	48		9	16	20	22	23	
6/15/87	6+	580	50		8.5	13	17	22	24	25
6/17/87	6+	800	53		13	18	22	25	27	28
6/21/87	6+	740	53.7	6+ Avg Wt(g)	10	15	19	21	24	25
6/12/87	6+	940	54.3	783.75	7	11	19	23	27	29
6/19/87	6+	690	48	Avg TL(cm)	9	16	20	23	25	26
6/19/87	6+	870	54.5	52.94	9	13	16	19	22.5	24
6/16/87	6+	800	53.5		8	14	18	21	23	24
6/26/87	6+	850	56.5		10	13	17	21	25	27
6/12/87	7+	730	56.5	7+ Avg Wt(g)	11	17	21	25	29	31
6/12/87	7+	980	54.5	893.33	10	14	18	21	22	23
6/21/87	7+	970	58.3	Avg TL(cm)	8	11	17	21.5	22.2	23.2
6/12/87	9+	2700	73.5	56.43	10	15	21.5	23.5	26	29

Fish Data

Scale Rad(cm)				Back Calculations				
To Ann VII	To Ann VIII	To Ann IX	To Edge of scale	(1)		(2)		(3)
			14.3	10.89				
			16	14.85	1+ Avg at yr 1			
			19.3	14.90	14.93			
			17	13.91				
			20	10.36				
			22	15.42				
			14	19.86				
			14	19.29				
			21	13.57	2+ Avg at yr 1	18.46	2+ Avg at yr 2	
			27.5	10.45	14.56	17.27	23.79	
			26.5	11.79		15.57		
			24.5	9.29		19.10		
			17.5	22.00		30.00		
			22	10.98		20.39		
			17.5	16.91		31.71		
			20.5	17.32		30.30		
			12.5	16.64		21.84		
			22	16.63		33.25		
			24.5	22.77	3+ Avg at yr 1	32.66	3+ Avg at yr 2	44.54
			21	17.81	17.76	29.33	29.36	37.71
			20.5	16.51		30.95		36.11
			18	22.59		29.72		39.23
			18	14.00		29.17		37.33
			23.5	21.53		34.26		43.06
			20.5	23.50		29.91		36.32
			21	16.57		31.07		37.29
			21	15.36		32.76		36.86
			23.8	17.65		30.00		39.71
			20	18.23		30.38		34.43
			19.5	20.46		31.23		38.77
			20.5	19.32		32.20		39.71
			20.3	14.96		25.94		36.91
			24.5	17.76		31.96		39.06
			20.3	16.49		31.15		34.82
			22	17.43		29.05		38.73
			21.5	17.91		28.65		35.81
			19.8	17.51		24.89		33.18
			25	12.64		28.44		35.55

			23	17.26		31.07		34.52
			22.5	15.08		21.78		31.84
			21	16.59		27.64		35.01
			21	18.67		29.87		35.47
			21.5	18.51		29.62		36.10
			20.5	17.34		26.98		33.72
			23	16.04		29.41		37.43
			22	18.41		29.45		34.98
			25	14.76		29.52		36.90
			22.6	17.84		31.72		39.65
			23.8	17.02		27.23		34.03
			22	23.93		31.30		36.82
			20.5	16.12		28.20		34.25
			21.8	20.94		30.46		38.07
			21.8	20.89		30.39		37.98
			22.8	17.63		29.09		36.14
			22	18.73		31.84		37.45
			19.8	19.67		26.92		37.27
			20.5	18.13		30.22		37.27
			22	16.85		28.09		36.52
			17	16.47		30.59		35.29
			22	18.64		26.09		36.34
			23	14.43		27.07		37.89
			22	19.00		28.50		38.00
			20.5	13.83		25.68		35.56
			22.5	15.64		27.80		34.76
			23	16.43		27.39		34.70
			24	15.38		30.75		37.58
			20.5	16.90		26.29		33.80
			19.8	18.64		27.95		36.24
			21	18.64		33.14		40.39
			25	18.70		28.90		37.40
			22	17.12		31.21		40.27
			26.5	14.07	4+ Avg at yr 1	29.07	4+ Avg at yr 2	39.38
			27	11.51	17.91	29.21	29.15	37.18
			22	20.86		34.77		41.73
			22	10.73		23.60		37.55
			22.6	23.36		42.48		48.85
			26	14.57		25.91		34.00
			27.5	18.60		32.13		40.58

Fish Data

			23	17.74		26.61		39.91
			25	16.02		33.82		40.94
			23	15.48		23.22		34.83
			26.5	17.74		33.70		40.79
			22.5	17.84		25.77		35.68
			21.5	16.82		27.33		37.84
			20	16.10		27.60		34.50
			27.5	19.55		30.95		37.47
			21.5	23.18		29.50		37.93
			26	19.38		33.47		38.75
			23	16.42		26.68		36.94
			27	20.67		29.28		40.47
			24.5	15.87		29.98		33.50
			22.5	18.31		25.64		32.96
			26.3	15.23		28.76		37.22
			20.5	25.49		32.44		39.39
			27	16.74		28.46		36.83
			21.5	20.19		32.30		37.34
			19	17.60		26.40		30.80
			24.5	18.29		32.91		39.31
			24	15.94		26.56		35.42
			24	12.69		29.00		38.06
			22.8	20.96		31.45		37.74
			26.5	19.63		33.91		40.16
			24	18.96		30.33		39.81
			24.8	15.68		29.61		36.58
			27	22.58		33.87		43.27
			22	20.23		28.32		38.43
			22	18.82		26.35		31.99
			25	16.60		21.58		28.22
			23	16.28		25.32		32.56
			28	14.59		25.94		37.29
			22	20.08		29.59		39.10
			22.2	24.09		31.42		39.80
			23.5	20.55		30.83		37.00
			25	17.10		31.35		39.90
			22	19.47		30.29		38.95
			28	13.00		19.50		27.63
			23	15.83		23.74		31.65
			23	19.21		32.35		38.41

Fish Data

			23.3	20.41		27.22		35.00
			24	15.83		27.94		37.25
			23	16.35		26.57		36.78
			25	19.95		34.65		42.00
			25	17.21		28.68		37.28
			24.5	18.78		30.04		39.43
			23.5	17.92		25.89		33.86
			24	18.75		30.94		37.50
			20.8	16.92		27.50		34.90
			25.2	17.98		28.76		36.85
			31	20.03	5+ Avg at yr 1	27.87	5+ Avg at yr 2	36.58
			26	20.81	18.73	33.29	29.57	45.78
			25	23.04		30.72		34.56
			24.5	19.63		25.52		35.34
			26.8	19.95		27.20		34.46
			29	17.76		26.64		33.74
			26.3	16.67		31.48		38.89
			26	15.54		31.08		38.85
			27	14.00		28.00		40.00
			23	18.09		29.39		42.96
			21.5	22.27		34.64		42.07
			20.5	20.29		35.51		45.66
			23.5	22.75		37.23		42.40
			25	19.88		29.82		35.78
			23.5	22.47		29.21		42.69
			25.8	20.25		29.46		38.66
			23.8	18.91		25.21		35.71
			25.8	15.41		28.90		38.53
			21	22.14		31.00		37.64
			24	20.46		34.78		40.92
			28	16.39		30.96		43.71
			25.6	19.68		30.41		37.57
			24.5	20.02		31.14		37.82
			28	22.71		32.18		43.54
			26	18.27		32.69		38.46
			28	16.46		24.70		32.93
			23.3	21.50		32.25		38.70
			24	20.00		26.00		32.00
			23	15.98		29.83		37.28
			27	14.10		22.92		31.73

Fish Data

			25	18.90		25.20		33.60
			24.5	18.73		29.14		35.39
			26	18.17		26.25		34.33
			25.5	16.13		30.47		34.05
			25	18.43		31.04		37.83
			28.5	14.91		23.68		35.09
			27	12.96		25.93		34.26
			24.2	17.85		31.74		39.67
			27.3	15.57	6+ Avg at yr 1	23.81	6+ Avg at yr 2	31.14
			29.5	23.36	17.92	32.34	27.16	39.53
			27	19.89		29.83		37.79
			30	12.67		19.91		34.39
			27.5	15.71		27.93		34.91
			26	18.87		27.25		33.54
			25	17.12		29.96		38.52
			28	20.18		26.23		34.30
33			35	17.76	7+ Avg at yr 1	27.44	7+ Avg at yr 2	33.90
24			25	21.80	19.40	30.52	27.87	39.24
24			25	18.66		25.65		39.64
31	33	35	36.5	20.14		30.21		43.29

Back Calculations							
	(4)		(5)		(6)		(7)
3+ Avg at yr 3							
36.88							

Fish Data

4+ Avg at yr 3	45.01	4+ Avg at yr4					
37.29	43.02	42.34					
	47.52						
	42.91						
	55.22						
	38.86						
	43.96						

Fish Data

	46.57						
	42.72						
	40.63						
	44.34						
	39.64						
	43.10						
	41.40						
	40.73						
	40.03						
	42.28						
	41.04						
	43.92						
	38.79						
	37.54						
	41.45						
	44.02						
	41.85						
	40.37						
	37.40						
	42.06						
	39.31						
	41.69						
	42.98						
	43.73						
	42.66						
	40.06						
	47.04						
	42.07						
	37.64						
	39.01						
	37.98						
	41.35						
	43.33						
	43.99						
	43.16						
	44.65						
	43.27						
	40.63						
	40.55						
	43.47						

	40.83						
	41.91						
	41.89						
	48.30						
	44.93						
	43.18						
	41.82						
	42.19						
	40.19						
	43.14						
5+ Avg at yr 3	42.68	5+ Avg at yr 4	50.52	5+ Avg at yr 5			
37.87	49.94	43.26	52.02	47.01			
	40.32		46.08				
	43.19		45.16				
	40.80		43.52				
	42.62		47.95				
	42.59		44.44				
	44.67		48.56				
	46.00		50.00				
	47.48		49.74				
	47.01		50.73				
	47.69		49.46				
	45.50		46.53				
	43.74		45.72				
	47.18		49.43				
	42.34		45.11				
	42.02		46.22				
	42.38		48.16				
	42.07		44.29				
	42.96		47.05				
	47.36		49.18				
	41.15		42.94				
	44.49		48.94				
	47.32		50.16				
	43.27		48.08				
	41.16		43.63				
	40.85		45.15				
	39.00		44.00				
	41.54		45.80				
	41.43		44.07				

Fish Data

	42.00		49.35				
	43.71		47.88				
	40.38		48.46				
	39.43		43.91				
	42.68		46.56				
	40.35		45.61				
	40.74		46.30				
	43.64		45.62				
6+ Avg at yr 3	40.29	6+ Avg at yr 4	43.96	6+ Avg at yr 5	45.79	6+ Avg at yr 6	
35.51	44.92	41.99	48.51	47.44	50.31	49.98	
	41.77		47.73		49.72		
	41.63		48.87		52.49		
	40.15		43.64		45.38		
	39.83		47.16		50.31		
	44.94		49.22		51.36		
	42.38		50.45		54.48		
7+ Avg at yr 3	40.36	7+ Avg at yr 4	46.81	7+ Avg at yr 5	50.04	7+ Avg at yr 6	53.27
37.59	45.78	45.43	47.96	48.85	50.14	51.43	52.32
	50.14		51.77		54.10		55.97
	47.32		52.36		58.40		62.42

Fish Data

			Relative	Growth						
	(8)	(9)	yr 1-2		yr 2-3		yr 3-4		yr 4-5	
			0.36	2+ avg						
			0.65	0.65						
			0.32							
			1.06							
			0.36							
			0.86							
			0.87							
			0.75							
			0.31							
			1.00							
			0.43	3+ avg	0.36	3+ avg				
			0.65	0.68	0.29	0.26				
			0.87		0.17					
			0.32		0.32					
			1.08		0.28					
			0.59		0.26					
			0.27		0.21					
			0.87		0.20					
			1.13		0.13					
			0.70		0.32					
			0.67		0.13					
			0.53		0.24					
			0.67		0.23					
			0.73		0.42					
			0.80		0.22					
			0.89		0.12					
			0.67		0.33					
			0.60		0.25					
			0.42		0.33					
			1.25		0.25					

Fish Data

			0.80		0.11					
			0.44		0.46					
			0.67		0.27					
			0.60		0.19					
			0.60		0.22					
			0.56		0.25					
			0.83		0.27					
			0.60		0.19					
			1.00		0.25					
			0.78		0.25					
			0.60		0.25					
			0.31		0.18					
			0.75		0.21					
			0.45		0.25					
			0.45		0.25					
			0.65		0.24					
			0.70		0.18					
			0.37		0.38					
			0.67		0.23					
			0.67		0.30					
			0.86		0.15					
			0.40		0.39					
			0.87		0.40					
			0.50		0.33					
			0.86		0.38					
			0.78		0.25					
			0.67		0.27					
			1.00		0.22					
			0.56		0.29					
			0.50		0.30					
			0.78		0.22					
			0.55		0.29					
			0.82		0.29					
			1.07	4+ avg	0.35	4+ avg	0.14	4+ avg		
			1.54	0.65	0.27	0.29	0.16	0.14		
			0.67		0.20		0.14			
			1.20		0.59		0.14			
			0.82		0.15		0.13			
			0.78		0.31		0.14			
			0.73		0.26		0.08			

Fish Data

			0.50		0.50		0.17			
			1.11		0.21		0.04			
			0.50		0.50		0.17			
			0.90		0.21		0.09			
			0.44		0.38		0.11			
			0.63		0.38		0.14			
			0.71		0.25		0.20			
			0.58		0.21		0.09			
			0.27		0.29		0.06			
			0.73		0.16		0.09			
			0.62		0.38		0.11			
			0.42		0.38		0.09			
			0.89		0.12		0.16			
			0.40		0.29		0.14			
			0.89		0.29		0.11			
			0.27		0.21		0.12			
			0.70		0.29		0.14			
			0.60		0.16		0.08			
			0.50		0.17		0.21			
			0.80		0.19		0.07			
			0.67		0.33		0.11			
			1.29		0.31		0.10			
			0.50		0.20		0.14			
			0.73		0.18		0.09			
			0.60		0.31		0.07			
			0.89		0.24		0.10			
			0.50		0.28		0.09			
			0.40		0.36		0.09			
			0.40		0.21		0.18			
			0.30		0.31		0.38			
			0.56		0.29		0.17			
			0.78		0.44		0.11			
			0.47		0.32		0.11			
			0.30		0.27		0.11			
			0.50		0.20		0.17			
			0.83		0.27		0.12			
			0.56		0.29		0.11			
			0.50		0.42		0.47			
			0.50		0.33		0.28			
			0.68		0.19		0.13			

Fish Data

			0.33		0.29		0.17			
			0.76		0.33		0.13			
			0.62		0.38		0.14			
			0.74		0.21		0.15			
			0.67		0.30		0.21			
			0.60		0.31		0.10			
			0.44		0.31		0.24			
			0.65		0.21		0.13			
			0.62		0.27		0.15			
			0.60		0.28		0.17			
			0.39	5+ avg	0.31	5+ avg	0.17	5+ avg	0.18	5+ avg
			0.60	0.6	0.37	0.29	0.09	0.15	0.04	0.09
			0.33		0.13		0.17		0.14	
			0.30		0.38		0.22		0.05	
			0.36		0.27		0.18		0.07	
			0.50		0.27		0.26		0.13	
			0.89		0.24		0.10		0.04	
			1.00		0.25		0.15		0.09	
			1.00		0.43		0.15		0.09	
			0.63		0.46		0.11		0.05	
			0.56		0.21		0.12		0.08	
			0.75		0.29		0.04		0.04	
			0.64		0.14		0.07		0.02	
			0.50		0.20		0.22		0.05	
			0.30		0.46		0.11		0.05	
			0.45		0.31		0.10		0.07	
			0.33		0.42		0.18		0.10	
			0.88		0.33		0.10		0.14	
			0.40		0.21		0.12		0.05	
			0.70		0.18		0.05		0.10	
			0.89		0.41		0.08		0.04	
			0.55		0.24		0.10		0.04	
			0.56		0.21		0.18		0.10	
			0.42		0.35		0.09		0.06	
			0.79		0.18		0.13		0.11	
			0.50		0.33		0.25		0.06	
			0.50		0.20		0.06		0.11	
			0.30		0.23		0.22		0.13	
			0.87		0.25		0.11		0.10	
			0.63		0.38		0.31		0.06	

Fish Data

			0.33		0.33		0.25		0.18	
			0.56		0.21		0.24		0.10	
			0.44		0.31		0.18		0.20	
			0.89		0.12		0.16		0.11	
			0.68		0.22		0.13		0.09	
			0.59		0.48		0.15		0.13	
			1.00		0.32		0.19		0.14	
			0.78		0.25		0.10		0.05	
			0.53	6+ avg	0.31	6+ avg	0.29	6+ avg	0.09	6+ avg
			0.38	0.53	0.22	0.32	0.14	0.19	0.08	0.13
			0.50		0.27		0.11		0.14	
			0.57		0.73		0.21		0.17	
			0.78		0.25		0.15		0.09	
			0.44		0.23		0.19		0.18	
			0.75		0.29		0.17		0.10	
			0.30		0.31		0.24		0.19	
7+ Avg at yr 7			0.55	7+ avg	0.24	7+ avg	0.19	7+ avg	0.16	7+ avg
53.85			0.40	0.44	0.29	0.36	0.17	0.21	0.05	0.08
			0.38		0.55		0.26		0.03	
	66.45	70.48	0.50		0.43		0.09		0.11	

Fish Data

yr 5-6		yr 6-7	yr 7-8	yr 8-9	Condition Factor			
					540.78	1+ avg CF		
					515.31	528.61		
					558.80			
					503.10			
					530.88			
					460.47			
					535.26			
					584.26			
					506.23	2+ avg CF		
					505.60	501.08		
					556.80			
					518.70			
					571.43			
					547.93			
					572.52			
					536.45			
					568.96			
					126.17			
					517.16	3+ avg CF		
					528.27	552.46		
					554.92			
					582.89			
					566.89			
					493.14			
					481.98			
					577.07			
					578.57			
					593.89			
					526.87			
					539.90			
					575.23			
					564.50			
					595.29			
					631.33			
					595.02			
					543.22			
					514.12			
					657.15			

Fish Data

					511.42			
					569.21			
					586.61			
					531.24			
					515.51			
					494.89			
					515.08			
					564.50			
					558.61			
					472.67			
					587.08			
					587.08			
					652.99			
					489.69			
					577.81			
					592.63			
					571.96			
					645.67			
					511.04			
					514.77			
					507.81			
					522.34			
					503.68			
					540.84			
					564.50			
					593.88			
					587.14			
					507.83			
					604.56			
					493.32			
					528.47			
					540.61			
					517.61			
					578.35	4+ avg CF		
					503.59	546.08		
					467.39			
					513.53			
					497.32			
					556.16			
					566.91			

Fish Data

					497.55			
					612.79			
					476.62			
					539.38			
					473.42			
					454.81			
					585.60			
					556.08			
					537.87			
					551.67			
					423.19			
					492.32			
					632.59			
					593.41			
					567.40			
					513.19			
					519.79			
					605.53			
					602.45			
					517.15			
					651.33			
					558.84			
					563.11			
					633.13			
					594.50			
					591.65			
					553.03			
					567.40			
					549.62			
					524.67			
					576.46			
					545.01			
					596.75			
					497.29			
					532.49			
					522.53			
					514.60			
					530.81			
					530.81			
					437.62			

Fish Data

					548.62			
					515.03			
					481.59			
					539.03			
					604.31			
					657.52			
					536.57			
					658.44			
					540.01			
					537.87			
					565.21	5+ avg CF		
					530.50	543.53		
					551.58			
					530.17			
					566.25			
					556.41			
					528.13			
					566.82			
					450.90			
					526.29			
					498.11			
					497.84			
					609.80			
					570.20			
					560.47			
					559.85			
					560.00			
					578.35			
					596.75			
					549.12			
					512.62			
					499.63			
					512.73			
					503.77			
					536.00			
					592.00 564.61			
					560.62			
					560.99			
					611.96			

Fish Data

					594.32			
					542.78			
					476.84			
					529.11			
					525.93			
					520.00			
					560.00			
					497.32			
0.04	6+ avg				464.00	6+ avg CF		
0.04	0.05				537.36	527.68		
0.04					477.87			
0.07					587.12			
0.04					623.91			
0.07					537.44			
0.04					522.43			
0.08					471.27			
0.07	7+ avg	0.06	7+ avg		404.74	7+ avg CF		
0.05	0.05	0.04	0.05		605.39	499.88		
0.05		0.03			489.52			
0.12		0.07	0.06	0.06	679.99			