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A STUDY OF LAKE ONTARIO — ST. LAWRENCE RIVER SMALLMOUTH BASS

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ABSTRACT

A study of smallmouth bass of the eastern Lake Ontario-Thousand Islands region was carried on during 1944-50. Tagging of 4,408 wild, adult bass at 10 principal localities was undertaken to determine if populations were homogeneous. Studies of age, growth and reproduction of the bass from different localities were made. Metal strap tags used on the dorsal fin and maxillary during 1944-45 gave recoveries of only 2.0 per cent and 9.1 per cent, respectively. During 1946-50 round, metal strap tags, applied to the lower jaw, were used on a total of 2,853 fish. This method gave 612 recoveries (21.5 per cent). Angling recoveries were used as an index to the catch of bass on various grounds during different months of the fishing season. Despite a relatively heavy take of bass on some grounds during June there was no evidence that the early fishing affected the population adversely. Heaviest returns, generally, were in August. Distinct populations of bass were recognized using migrations and growth as the main criteria for separation. Four to 6 years are required in this area for bass to reach the legal length of 10 inches. The oldest bass found were 14 years old. Considerable variation in spawning time was found to be a characteristic of bass in this region. Late May to early June spawning occurred in tributary streams and in some of the warmer bays while late June-July spawning occurred among the fish influenced by the cold water of Lake Ontario.

Fishing grounds of the eastern Lake Ontario-Thousand Islands region are the largest and probably most productive for smallmouth bass in the State. A long-term study of the bass in this region was begun in 1944. Tagging of wild, adult bass was undertaken in order to determine the nature and extent of their movements and to find out if populations are homogeneous or possibly need management of a local, specific type. Studies of age and growth of the bass obtained from different localities were made and the natural reproduction of bass in the region was investigated. In addition, consideration was given to certain specific problems such as the effect of

the June fishing on the maintenance of the bass fishing on the different grounds.

PROCEDURE

During the years 1944-1950, bass totaling 4,408 were tagged. These fish were obtained by means of small trap nets operated in depths of 5 to 20 feet of water. The majority of the fish were netted during the first two weeks of June although in 1945-46 some bass were tagged during the last week of May. The general area where tagging was done extends from Henderson Bay to and down the St. Lawrence River as far as Eel Bay (Figure 1). Tagging was carried on at the following localities on the St. Lawrence River: the foot of Eel Bay, Linda Island, Dodge Bay, Sunnybank, and the head of Carleton Island. In Lake Ontario the principal localities were: Wilson Bay, East Charity Shoal, North Shoal off Galloo Island, and the foot of Stony Island. The Chaumont Bay bass were tagged at Three Mile Bay and off Point Peninsula.

All bass were tagged and released at the locality of capture with the exception of 313 specimens which were tagged on July 20, 1944 after being used as breeders by the Federal hatchery at Cape Vincent. Records for the hatchery-held fish are used in this study only in the calculation of the percentages of recovery according to the method of tagging.

Various data were recorded for fish to be tagged, as well as for tagged fish when recaptured. All measurements of the fish were made in total length. Since some of the specimens were obtained during the early part of the spawning period it was possible to secure data as to their sex. Many of the males were ripe. While relatively few females were ripe, the enlarged abdomen and appearance of the vent made sex recognition possible. Scales for the study of age and growth were taken from all fish at the time of tagging and again if they were recaptured in project netting during subsequent years. Age was determined by counting the number of annuli (winter marks) on the scales. On the basis of scale examinations the last annulus was considered to be marginal on all scales obtained during the tagging work, January 1 being taken as the transition date into the next age group.

The tagging program was given considerable publicity and help in obtaining returns by local newspapers, fish and game clubs, guides, resort owners, commercial fishermen, Department game protectors, the Federal hatchery at Cape Vincent, the Department of Fisheries

of the Province of Ontario, Queens University, fish and game clubs in Kingston (Ontario), and many interested sportsmen.

FINDINGS

The fact that an appreciable amount of the bass fishing by non-resident anglers is done with the aid of guides in this territory helped considerably in obtaining reports of the tagged fish caught by this group. It is known that some of the tags taken by anglers were not reported but it is believed that at least 50 per cent of the tagged fish caught were reported and probably the return was much higher in some localities.

METHODS OF TAGGING AND PERCENTAGES OF RECAPTURE

A relatively small amount of information was available at the time this study was begun as to the most successful methods of tagging bass. Snyder (1932) marked bass with aluminum tags fastened to the upper portion of the gill cover. He released 150 tagged bass in Lake Ontario near Cape Vincent in early July 1931 and reported a recovery of 19 fish (12.7 per cent) by angling during the summer of 1931 and the forepart of the following fishing season. However, he mentioned that the tags had practically worn through the gill covers of the fish caught the second season.

During the early years of this study experiments were carried on with metal strap tags (Salt Lake, size 3) applied to the dorsal fin and also around the maxillary bone. In the year 1944 a total of 587 fish received tags on the front of the second dorsal fin. From this group only 12 recoveries (2.0 per cent) were made during the year of tagging and none has been reported in subsequent years. The maxillary method was used on 1,039 fish during the years 1944-1946. This tagged stock gave an angling return of 9.1 per cent, the bulk of the tags (94.7 per cent) being recovered during the year of tagging while the second and third fishing seasons yielded 4.2 and 1.1 per cent of the returns, respectively. An additional 2.8 per cent of the maxillary tags were recovered in project netting. It was observed during the netting operations of June 1946 and 1947 that 38 bass had obviously lost their maxillary tags. The tag had finally worn through the maxillary bone. It should be mentioned that the actual number of fish tagged by the dorsal and maxillary methods was 71 fish less than the total of 1,626 reported above due to the fact that 71 fish received tags on both the dorsal fin and maxillary.

In view of the poor results with the dorsal and maxillary tags

TABLE 1. RECOVERY BY ANGLING OF BASS TAGGED ON LOWER JAW ACCORDING TO LOCALITY AND YEAR OF TAGGING*

Locality	Year tagged	Number tagged	Recoveries		Number of recoveries in various fishing seasons after tagging§					
			Number	Per cent	1st	2nd	3rd	4th	5th	6th
East Charity Shoal	1949	416	55	13.2						
	1950	169	24	14.2						
Sub-total		585	79	13.5	30	20	26	3	..	..
North Shoal	1950	189	37	19.6	20	12	5	..	..	..
Stony Island	1950	111	32	28.8	17	14	1	..	..	..
Six Town Point	1950	18	8	44.4	5	..	3	..	..	..
Wilson Bay	1946	60	11	18.3						
	1947	513	98	19.1						
	1948	58	15	25.9						
Sub-total		631	124	19.7	69	25	18	6	5	1
Eel Bay	1948	399	98	24.6						
	1949	194	41	21.1						
Sub-total		593	139	23.4	92	29	8	7	3	..
Linda Island	1946	101	24	23.8						
	1947	140	45	32.1						
	1948	40	6	15.0						
Sub-total		281	75	26.7	30	24	16	5	..	..
Dodge Bay	1946	98	31	31.6						
	1947	133	31	23.3						
	1948	40	9	22.5						
Sub-total		271	71	26.2	32	25	8	5	1	..
Carleton Island	1946	11	3	27.3						
	1947	82	24	29.3						
Sub-total		93	27	29.0	8	12	4	1	2	..
Sunnybank	1946	5	2	40.0						
	1947	76	18	23.7						
Sub-total		81	20	24.7	14	4	2	..	..	..
Total		2,853	612	21.5	317	165	91	27	11	1

* Includes recoveries through 1952 season.

§ Only total figures given for each locality because of relatively low numbers involved.

a round metal strap tag (Salt Lake, length straightened $2\frac{1}{4}$ inches) was tried on the lower jaw, beginning during the 1946 season. Good results were obtained with this tag without appreciable harm to the jaw bone of the fish and thus the method was continued for the remainder of the study.

The lower jaw method was used on a total of 2,853 fish. By the end of the year 1952 this group had given an angling return of 612 tags (21.5 per cent). Percentages of the total number of returns according to recovery in subsequent fishing seasons were in the following order: first (year of tagging), 51.8 per cent; second, 26.9 per cent; third, 14.9 per cent; fourth, 4.4 per cent; fifth, 1.8 per cent, and sixth, 0.2 per cent. Netting operations gave 107 additional returns (3.8 per cent). The percentages of recovery of the jaw tagged bass according to locality and year of tagging are given in Table 1.

Since all bass were tagged prior to June 16, the opening date for bass fishing in the area, the fish were subjected to a complete season of fishing during each year of tagging. Some localities gave a rather high percentage of recovery considering the small numbers of fish tagged there. This may indicate a high fishing intensity on relatively small local groups of bass. On the other hand, at Charity Shoals which is known to have a heavy fishing pressure, the percentages of recovery were the lowest for the whole region. This may show that the bass population at Charity was large or it may be that appreciable numbers of the tagged fish were lost to natural mortality. Most of the bass tagged at Charity were in the older age groups (Table 3).

The angling recaptures of tagged bass according to month taken for the different tagging localities are summarized in Table 2. The returns are expressed in percentages of the total number of recoveries for each locality. It is believed that these returns serve as an index to the catch of bass on various grounds during June as well as in other months of the fishing season. Heaviest returns in June were from fish tagged at East Charity Shoal. The bulk of these returns came from the locality of tagging. An appreciable number of the fish tagged at Eel Bay were also taken in June (30.8 per cent of the recaptures). Most of these fish were caught in Eel Bay. Lowest June returns were from fish tagged at Stony Island and for the St. Lawrence River localities between Carleton and Linda Islands. August returns were high for all localities except North Shoal and East Charity Shoal.

TABLE 2. RECOVERY BY ANGLING OF ALL TAGGED BASS ACCORDING TO MONTH TAKEN AND LOCALITY OF TAGGING (1944-52)*

Locality	Total recoveries§	June 16-30	July 1-15	July 16-31	Aug. 1-31	Sept. 1-30	Oct. 1-31	Nov. 1-30
East Charity Shoal....	78 (1)	61.5	2.5	9.0	16.7	9.0	...	1.3
North Shoal.....	37	24.3	27.0	5.4	18.9	18.9	5.4	...
Stony Island.....	32	6.2	18.8	18.8	37.5	15.6	...	3.1
Six Town Point.....	7 (1)	...	...	...	71.4	28.6	...	...
Wilson Bay.....	166 (21)	10.8	10.8	16.3	47.6	13.9	0.6	...
St. Lawrence River (Sunnybank, Dodge Bay, Carleton and Linda Islands).....	166 (39)	9.0	16.9	15.1	43.9	14.5	0.6	...
Eel Bay.....	130 (9)	30.8	6.2	8.5	40.0	11.5	3.0	...
Chaumont Bay (Three Mile Bay, Point Peninsula)....	17 (2)	11.8	11.8	5.8	41.2	29.4	...	...
Total.....	633 (73)	21.2	11.7	12.5	39.2	13.9	1.2	0.3

* Expressed as percentages of the total number of recoveries for each locality.
 § Additional recoveries not used here due to undetermined dates taken are shown in parentheses.

BASS MIGRATIONS

Movements of the bass tagged at East Charity Shoal, based upon 79 recaptures, are shown in Figure 1. Sixty fish were caught within a 1-mile radius of the point of release. Movements to shoals or island areas in the open lake (Duck Islands, Amherst Island, False Duck Islands, Grenadier Island, Allan Otty Shoal, and Big Bar Shoal) were made by 13 fish. Migrations to bays at the head of Wolfe Island were made by three individuals. Only two of the Charity tagged fish were reported caught from the St. Lawrence River, one at the head of Howe Island and the other between Fisher's Landing and Round Island. It is doubtful if the Charity bass leave the open lake and move into the river in sufficient numbers to contribute to the fishing there. The longest migration that was recorded was made by a Charity bass which was recaptured at the black buoy at the entrance to Sodus Bay which is located on the south shore of Lake Ontario in Wayne County. It is possible that this migration was influenced by strong currents in the lake during storms.

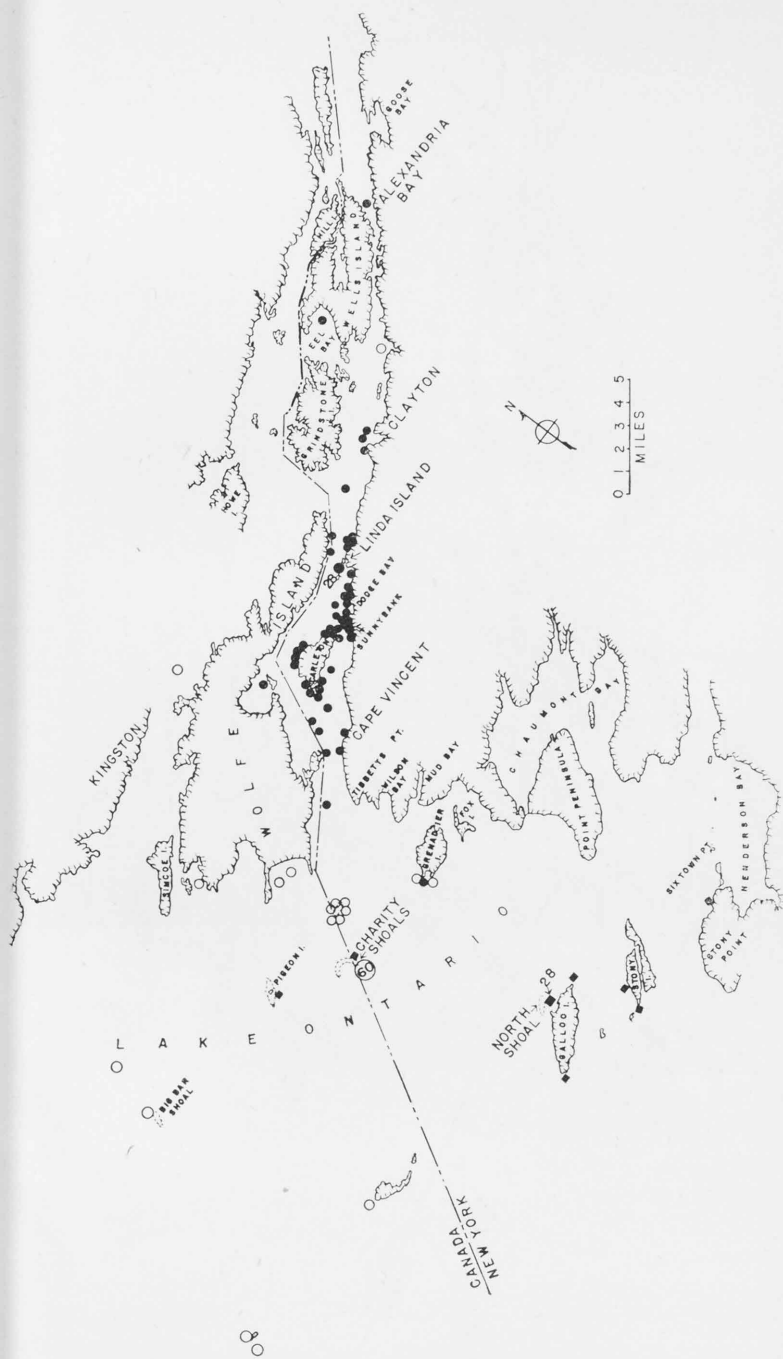


FIGURE 1. Chart of the Lake Ontario-Thousand Islands region showing distribution of recaptures of bass tagged at Linda Island (solid circles), East Charity Shoal (plain circles), and North Shoal (solid squares). Each circle or square represents one recovery unless a greater number is indicated.



FIGURE 2. Distribution of recaptures of bass tagged at Dodge Bay (solid circles), foot of Stony Island (plain circles).



FIGURE 3. Distribution of recaptures of bass tagged at Three Mile Bay (solid circles) and Wilson Bay (plain circles). Each circle represents one recapture unless a greater number is indicated.

Of the bass tagged at the North Shoal off Galloo Island, 3 recaptures were made within the Galloo-Stony Island area (Figure 1). One fish traveled to Pigeon Island, another was recorded off Stony Point, and a third was caught at East Charity Shoal. The locality of recapture was not determined for two returns.

The distribution of recaptures of bass tagged at the foot of Stony Island is shown in Figure 2. A total of 23 returns came from the Galloo-Stony Island area. One fish moved into the St. Lawrence River and was caught in Eel Bay. Movement to inshore areas was as follows: vicinity of Point Peninsula, three fish; Association Island, two fish; Stony Point, one fish; Lime Barrel Shoal, one fish. For one individual, the locality of recapture was undetermined.

A small number of bass were tagged off Six Town Point which lies at the entrance to Henderson Bay. Seven returns showed movements within the Henderson Bay region while one fish traveled to the foot of Stony Island (Figure 2).

For bass tagged by the dorsal and maxillary methods at Three Mile Bay the 11 returns are shown in Figure 3. Although all of these recoveries were made within Chaumont Bay the general trend of their movements was toward Lake Ontario. It is believed that bass do move into Chaumont Bay from the open lake at spawning time.

During the period 1944-1952 migration data from 173 recaptures of bass tagged at Wilson Bay were obtained. This return included maxillary tagged fish as well as the jaw tagged individuals on which data are given in Table 1. An additional 14 returns were not usable here because they lacked the locality of recapture. About 35 per cent of the recaptures of the Wilson Bay fish were made less than 1 mile from the foot of the bay where the tagging was done, while an additional 29 per cent represents recaptures in the St. Lawrence River (Figure 3). It appears that the Wilson Bay fish contribute more to the fishing in the river than any of the other groups of bass which were tagged at localities in or adjoining Lake Ontario. While the majority of the bass were taken at distances less than 5 miles down the river, one fish was reported at Alexandria Bay—a migration of about 30 miles. A southward migration to the vicinity of Mud Bay, Fox and Grenadier Islands was shown by about 25 per cent of the recaptures. It is possible that the run of fairly large bass that appear at times on the shoals at the head of Grenadier Island during early July is from the Wilson Bay population. The remaining 11 per cent represented fish which had moved across the international boundary.

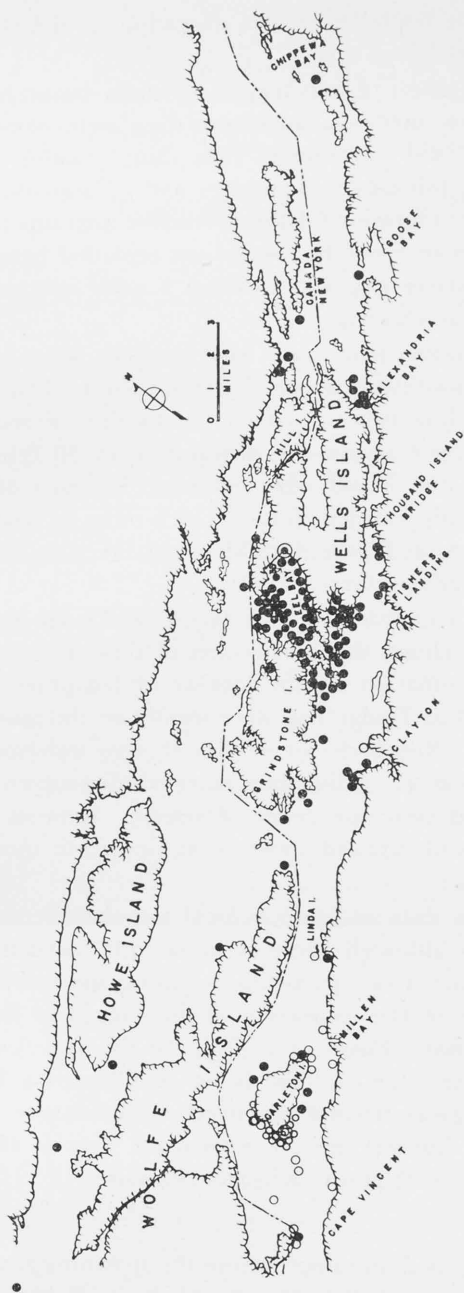


FIGURE 4. Chart of St. Lawrence River showing distribution of recaptures of bass tagged at Eel Bay (solid circles) and Carleton Island (plain circles). Each circle represents one recovery unless a greater number is indicated.

to the head of Wolfe Island as well as migrations to the Duck Islands and the Galloo-Stony Island area.

Of the 81 recaptures of bass tagged at Linda Island by the maxillary and lower jaw methods, migration data were obtained on 76 fish (Figure 1). Local movements (less than 1 mile) were made by 28 fish, while 11 fish moved downriver and 37 individuals traveled upriver toward Lake Ontario. Of the downriver migrants five traveled distances of 5 miles or more but none was recorded below Eel Bay. While 17 of the upriver migrants traveled 5 miles or more, only one fish was taken in Lake Ontario.

Both the maxillary and lower jaw methods were used on the bass tagged at the southwest tip of Carleton Island. This group gave 33 recoveries including two for which the locality of recapture was not reported. Figure 4 shows the distribution of 30 returns. Local movements around the island were exhibited by most of these fish. Only three individuals traveled distances of 5 miles or more including one fish (not shown on Figure 4) which was taken in Lake Ontario at the head of Grenadier Island.

A total of 71 recaptures of bass tagged at Dodge Bay has been reported. Figure 2 shows the distribution of these returns except for 11 that lacked information on the locality of recapture. It appears that the fish tagged at Dodge Bay were mostly on the move, probably to spawning areas. Recoveries of 47 fish showed movements toward Lake Ontario, while 11 individuals traveled downriver. Only two fish were recovered near the point of release. Returns on the fish tagged off Sunnybank showed movements similar to those from the Dodge Bay locality.

The migration data indicate a local population of bass in the region of Eel Bay although there is apparently some intermingling with bass from other areas, particularly during the spawning season. About 50 per cent of the recaptures of fish tagged at Eel Bay were taken within Eel Bay (Figure 4). Only 10 fish traveled downriver appreciable distances, the farthest being to Chippewa Bay. Movements upriver to areas beyond the head of Grindstone Island were shown by 12 fish. Longest upriver movements were to Horne's Dock (opposite Cape Vincent) and to Kingston, Ontario.

GROWTH

Growth data based on samples from the spawning runs at Charity Shoals, Wilson Bay, and Eel Bay are given in Tables 3 to 5 and Figure 5. Data from these localities are given in detail because of

TABLE 3. AGE-LENGTH RELATIONSHIP ACCORDING TO SEX AND AGE OF 201 BASS FROM COMBINED SAMPLES COLLECTED AT EAST CHARITY SHOAL IN 1949 AND 1950

Length in inches	Age group and sex																		Total											
	IV		V		VI		VII		VIII		IX		X		XI		XII		XIII		XIV									
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F								
10.0 to 10.9.....	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..			
11.0 to 11.9.....	..	..	..	..	2	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	5	2	7	..		
12.0 to 12.9.....	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	7	1	..	..	..	..	..	..	..	10	7	17	..	
13.0 to 13.9.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	3	..	..	..	..	..	..	..	..	..	24	36	60	..
14.0 to 14.9.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	35	41	76	..
15.0 to 15.9.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17	19	36	..
16.0 to 16.9.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	3	4	..
Total specimens...	1	..	..	..	2	1	1	..	..	..	..	..	..	2	4	1	45	53	37	46	3	4	..	..	1	93	108	201	..
Average length Each sex.....	10.5	11.6	11.8	11.6	13.1	13.2	11.9	13.8	13.7	14.4	14.6	14.2	15.6	15.6	13.9	14.2	XXX	..
Sexes combined	10.5	11.6	11.6	11.6	13.1	13.1	13.0	13.0	13.7	14.5	14.5	15.0	15.0	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	14.2	14.1	14.1	..
Per cent male.....	100	67	100	100	0	80	80	46	46	45	45	43	43	0	45	43	43	0	0	0	46	46	46

TABLE 4. AGE-LENGTH RELATIONSHIP ACCORDING TO SEX AND AGE OF 520 BASS FROM COMBINED SAMPLES COLLECTED AT WILSON BAY IN 1947 AND 1948

Length in inches	Age group and sex														Total							
	IV		V		VII		VIII		IX		X		XI		XII		XIII		Total			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F				
10.0 to 10.9.....	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..	4
11.0 to 11.9.....	3	..	7	..	1	2	2	1	1	..	..	..	..	..	..	..	..	..	24	6	30
12.0 to 12.9.....	5	..	9	2	7	5	11	3	5	..	..	..	..	..	..	..	..	..	67	17	84
13.0 to 13.9.....	..	..	2	..	18	5	22	24	19	1	..	..	..	..	..	..	..	..	83	53	136
14.0 to 14.9.....	..	..	..	..	3	3	6	34	17	40	38	5	8	..	..	..	..	..	85	69	154
15.0 to 15.9.....	..	..	..	..	..	5	2	11	4	21	16	5	9	2	..	..	..	..	42	34	76
16.0 to 16.9.....	..	..	..	..	..	..	3	2	4	5	5	5	5	1	1	1	..	..	14	14	28
17.0 to 17.9.....	..	..	..	..	..	1	..	1	..	..	3	1	1	1	1	..	..	..	4	4	8
Total specimens...	10	..	20	2	62	10	32	19	83	53	95	84	19	23	1	4	1	1	1	323	197	520
Average length Each sex.....	11.7	..	11.9	12.4	12.6	13.0	13.7	14.0	14.1	14.3	14.4	15.7	15.3	16.3	16.1	16.8	17.0	..	16.6	13.7	14.2	XXX
Sexes combined..	11.7	..	11.9	12.7	13.7	14.0	14.4	15.5	16.1	16.9	16.6	16.9	16.6	16.6	16.6	16.6	16.6	16.6	16.6	13.9	13.9	13.9
Per cent male.....	100	..	91	86	63	61	53	45	20	50	0	62	62	62	62	62	62	62	62	62	62	62

TABLE 5. AGE-LENGTH RELATIONSHIP ACCORDING TO SEX AND AGE OF 301 BASS FROM SAMPLES COLLECTED AT WILSON BAY IN 1948

the large number of fish taken in the samples and because the samples are considered to be representative of different types of habitat. Charity Shoals is located in the open lake, Wilson Bay is inshore on the lake, and Eel Bay is well down the river.

The growth curves in Figure 5 indicate that separate and distinct populations of bass may exist in these localities, each having its own

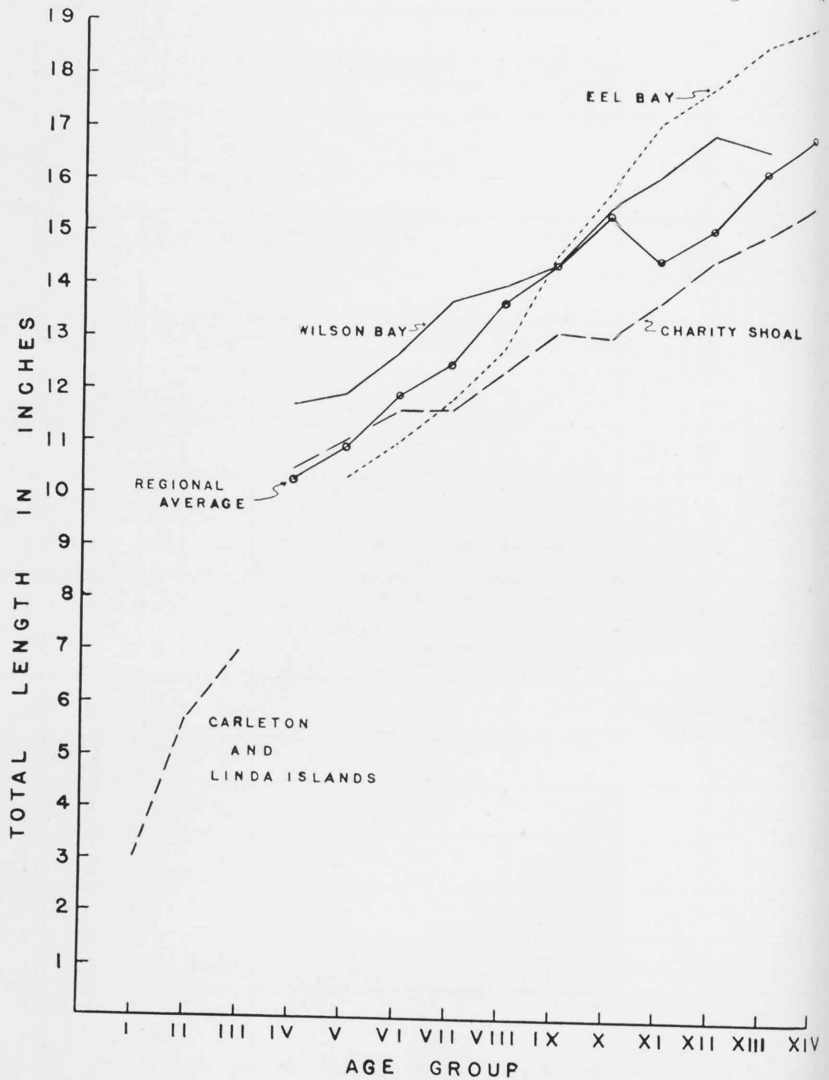


Figure 5. Average total length for the various age groups of bass. The upper four curves are based on Table 7. The lower curve for young bass is based on data from immature specimens taken by angling.

growth-rate characteristics. The slower growth of the Charity Shoals bass may be due to the cooler water temperatures which prevail in the open lake, a less abundant food supply than inshore, or a combination of these conditions. Eel Bay has a reputation for producing many small bass. It also has an abundance of other species of small size such as yellow perch, rock bass and sunfish, all of which may result in such severe competition for the types of food utilized by the small bass that the early growth of the bass is retarded. However, the Eel Bay bass eventually catch up and surpass in size bass of the same age in the other two localities. In general, the older bass of the open lake do not attain the size reached by inshore and river bass of the same age.

On the average, it requires 4 to 6 years in the region under study for a bass to reach the legal length of 10 inches. This growth rate is considerably slower than that found in many inland waters in New York State, particularly further south where the growing season is longer. Also, the general abundance of rock bass and yellow perch probably further reduces the growth of the small bass through competition for food. In reading the scales it was noted that the second and third annuli often occurred very close together, indicating unusually poor growth in the third year of life, a period when the bass were at a size at which they might be expected to suffer most from competition with the rock bass and perch. Greeley (1940) says "The relatively poor growth of juvenile bass is explainable by assuming intense competition conditions. Observations indicate that these fish are often found in conditions of heavy fish population. One area, the 'gas buoy' shoals off Galloo Island, had small bass so abundant in late July that they might very well have been expected to limit each other's food supply. Many other grounds, particularly shore areas, have relatively fewer small bass but have an abundance of rock bass, sunfish, perch and other fish which compete with small bass."

There was little difference in rate of growth between the sexes. Table 6 demonstrates this particularly well for a sample of bass of age group IV. In the Eel Bay samples (Table 5) it appears that the females in the younger age groups averaged slightly greater in length than the males, but this was possibly due to the larger females of these age groups maturing and entering the spawning runs first.

Both sexes have been combined in Table 7 which gives a comparison of the growth rates found in the various localities where netting was done. The data on the Chaumont Bay bass indicate that in general the bass in this area grow somewhat faster than those in the other areas sampled. This may be due to the removal of competitive

TABLE 6. LENGTH-FREQUENCY DISTRIBUTION OF SMALLMOUTH BASS OF AGE GROUP IV, ACCORDING TO SEX, TAKEN IN GILL NETS SET NORTH-EAST OF STONY ISLAND ON AUGUST 19-20, 1943

Length in millimeters	Number male	Number female	Sexes combined
220—229	2	...	2
230—239	1	1	2
240—249	1	4	5
250—259	4	6	10
260—269	7	9	16
270—279	6	8	14
280—289	5	2	7
290—299	2	2	4
300—309	1	1	2
Average length In millimeters	268	267	267
In inches	10.6	10.5	10.5
Number specimens	29	33	62

fish by the commercial fishery which operates in the Chaumont Bay area. The samples obtained from the off-shore areas in Lake Ontario showed that the Stony Island fish grew faster than the North Shoal and Charity Shoal bass. Rates of growth of the bass from Wilson Bay, Carleton Island, Sunnysbank, and Dodge Bay were similar.

SEX RATIO

In the samples taken from the spawning runs there was a tendency for males to be distinctly predominant among the younger fish and for females to be slightly predominant among the older fish, while the sexes were about equally represented among the fish of intermediate age and size. Tables 4 and 5 illustrate this general tendency. Several factors may have influenced the sex ratio in the samples. Among these are: (1) the original sex ratio at hatching; (2) the age at which each sex matures; (3) differential rate of mortality due to natural causes.

No data were obtained in this study as to the sex ratio at time of hatching, which is believed to be 50-50. However, information was

TABLE 7. COMPARISON OF THE AVERAGE TOTAL LENGTH (INCHES) OF BASS FROM DIFFERENT LOCALITIES IN THE LAKE ONTARIO-ST. LAWRENCE RIVER REGION ACCORDING TO AGE (SEXES COMBINED)*

Locality	Year	Age group											
		IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
East Charity Shoal	1949-50	10.5 (1)	.....	11.6 (3)	11.6 (1)	.....	13.1 (2)	13.0 (5)	13.7 (98)	14.5 (83)	15.0 (7)	15.6 (1)
North Shoal.....	1950	10.0 (1)	.....	11.7 (11)	12.4 (11)	12.9 (8)	13.2 (6)	14.2 (11)	14.5 (49)	15.1 (72)	16.0 (9)	16.3 (1)
Stony Island.....	1950	10.2 (9)	11.2 (7)	11.8 (29)	12.5 (22)	13.4 (11)	12.9 (3)	15.1 (2)	15.1 (8)	15.6 (8)	16.9 (1)	.....
Wilson Bay.....	1947-48	11.7 (10)	11.9 (22)	12.7 (72)	13.7 (51)	14.0 (136)	14.4 (179)	15.5 (42)	16.1 (5)	16.9 (2)	16.6 (1)	.....
Carleton Island...	1947	9.7 (7)	11.0 (18)	12.1 (13)	12.4 (3)	13.8 (18)	14.7 (19)	16.9 (1)	16.6 (1)	.....	18.1 (2)	.....
Sunnybank.....	1947	9.6 (1)	11.3 (21)	12.2 (15)	13.1 (6)	14.3 (19)	15.3 (7)	.....	.....	.....	.....	.....
Dodge Bay.....	1947-48	10.4 (10)	10.7 (39)	11.9 (46)	13.2 (32)	13.6 (23)	14.8 (19)	15.7 (5)	.....	.....	.....	.....
Linda Island.....	1947-48	8.1 (6)	9.9 (21)	11.3 (26)	12.0 (22)	13.2 (34)	14.4 (19)	15.8 (15)	16.8 (5)	17.5 (3)	.....	.....
Eel Bay.....	1948	.....	10.3 (15)	11.0 (76)	11.8 (106)	12.8 (47)	14.6 (39)	15.8 (19)	17.1 (16)	17.8 (10)	18.6 (2)	19.0 (1)
Chaumont Bay...	1945	11.1 (4)	11.8 (9)	13.4 (30)	14.3 (3)	15.6 (12)	16.5 (3)	16.6 (2)	17.8 (1)	.....	.....	.....
All localities.....	.....	10.3 (49)	10.9 (152)	11.9 (321)	12.5 (257)	13.7 (308)	14.4 (296)	15.4 (102)	14.5 (183)	15.1 (178)	16.2 (22)	16.9 (3)

* The number of specimens upon which each average is based is shown in parentheses.

obtained on a group of relatively young bass which were taken on August 19-20, 1943 in 60 to 80 feet of water by means of gill nets ranging in mesh size from 1½ to 5 inches. The nets were set in an area northwest of Bass Island and northeast of Stony Island, a locality which is roughly 12 miles south of Wilson Bay. The composition of the catch is shown in Table 8. These data have been presented because the sample was taken late enough in the summer so that the sex ratio should not have been influenced by spawning behavior and because there was little or no selectivity due to gear. Both mature and immature specimens of each sex occurred in this sample, and although the number of fish taken was small, it seems reasonable to assume that the sample was representative of age group IV, at least. It appears that the two sexes occurred in about equal numbers when in their fifth year of life.

TABLE 8. NUMBER OF SMALLMOUTH BASS, ACCORDING TO AGE AND SEX, TAKEN IN GILL NETS SET NORTHEAST OF STONY ISLAND ON AUGUST 19-20, 1943

Age group	Number			Per cent	
	Male	Female	Total	Male	Female
III	1	2	3	33	67
IV	29	33	62	47	53
V	10	7	17	59	41
Total	40	42	82	49	51

The second factor, the age at which each sex matures, is important in explaining the high percentage of males among the younger fish. The male bass mature at an earlier age than the females. Since the spawning run consists primarily of mature fish, these younger males enter the run while females of the same age which have not matured are normally absent from the run. As the females mature they in turn enter the run. If the original sex ratio of young bass was 50-50, then this ratio again should be reached in the spawning run when all the fish have matured. In both the Wilson Bay and Eel Bay samples the 50-50 ratio was reached when the fish were about 8 or 9 years old.

The third factor, differential rate of mortality due to natural causes, probably has an influence on the sex ratio found among older

bass. The presence of an increasing percentage of females as a given age class becomes older has been noted by other workers. Hile (1941) concluded that the inherent viability of the male fish was less than that of the female and was the cause of such an increasing relative abundance of females among the rock bass of Nebish Lake in Wisconsin. The fact that male smallmouth bass mature about 2 years earlier than the females should be considered as a factor tending to shorten the average life span of the male bass.

TABLE 9. NUMBER AND PERCENTAGE OF BASS, ACCORDING TO SEX, TAKEN AT VARIOUS LOCALITIES (1946-50)

Locality	Number			Per cent	
	Male	Female	Total	Male	Female
East Charity Shoal..	272	328	600	45	55
North Shoal.....	67	106	173	39	61
Stony Island.....	58	59	117	50	50
Wilson Bay.....	424	277	701	60	40
Six Town Point.....	5	13	18	28	72
Three Mile Bay....	18	15	33	55	45
Carleton Island.....	51	34	85	60	40
Sunnybank.....	47	24	71	66	34
Dodge Bay.....	106	70	176	60	40
Linda Island.....	144	109	253	57	43
Eel Bay.....	313	184	497	63	37
Total.....	1,505	1,219	2,724	55	45

The numbers and percentages of males and females taken in various localities are given in Table 9. The overall predominance of males in the samples is due to the generally greater abundance of bass of the younger age groups. In the exceptions, such as Charity Shoals and North Shoal, where the females outnumbered the males, the population was composed largely of old fish.

MATURITY AND LONGEVITY

Male bass begin to reach maturity at the end of the fourth year of life. Age group IV was the youngest group of mature males to

appear in the samples from the spawning runs, and a few ripe males of this age were taken in nearly every locality, although much larger groups of males were taken in ages beyond IV. The data do not reveal the youngest age group at which all of the males had reached maturity because immature fish were not represented in the spawning run samples in proportion to their true numbers in the whole population. However, it is likely that nearly all of the males are ready to spawn by the time they are 6 years old. The smallest ripe male was taken at Linda Island and measured $7\frac{3}{4}$ inches in length, but very few males mature at less than 10 inches, and possibly some are still immature at 12 inches.

Female bass begin to reach maturity at the end of the fifth year of life, but spawning females of this age are rare. They first begin to appear in numbers in age group VI and apparently do not all mature until about 8 or 9 years of age, the age at which both sexes were equally abundant in the spawning runs. The smallest ripe female was taken at Eel Bay and measured $10\frac{1}{8}$ inches in length, but relatively few mature at less than 12 inches, and possibly some are still immature at 14 inches.

The oldest bass taken were three female fish which were 14 years old. These fish were taken at Charity Shoal, Eel Bay, and North Shoal. Relatively few fish were taken in age group XIII, but in some localities a considerable number of fish had reached an age of 12 years. For example, in the sample of 177 fish taken at Charity Shoal in 1950 there were 83 fish in age group XII or approximately 47 per cent of the sample. Probably many of these fish were destined to be removed from the fishery by natural mortality due to old age rather than by being caught by anglers. It is interesting to note that some males lived just about as long as the females even though females were more numerous among the older age groups.

NATURAL REPRODUCTION

There is considerable variation in the spawning time of the bass in this region. Relatively early spawning (latter part of May or early June) is characteristic of the bass which ascend the streams, spawn near the creek mouths or enter the shallow waters of some of the bays. But it is certain that some bass do not spawn until the latter part of June or well into July, particularly those fish influenced by the cold water of Lake Ontario. Water temperature is considered to be an important factor controlling the spawning time of bass. Hubbs and

Bailey (1938) state that smallmouth bass spawning occurs at water temperatures of 59° to 65°F.

Stony Creek, which enters Lake Ontario just south of Stony Point, is an example of an early stream-spawning area. However, there are few such streams in the region and further study would be necessary to determine their role in the maintenance of bass fishing.

Millen Bay (Figure 4) is typical of some of the early bay-spawning grounds. Observations were made on 16 bass nests in this bay during the period June 15-30, 1948. Ten nests were located along the protected west shore on June 15. The nests were hollowed-out, circular excavations (1½ to 2½ feet in diameter) on a gravel bottom at depths ranging from 1½ to 3 feet of water. They were located at distances of 10 to 30 feet out from shore. On June 15 water temperatures varied from 63° to 70°F. and during the following week an additional six nests were established. Guarding male bass were seen on 13 of the 16 nests at least once. Eggs were observed on all but two nests. The first fry appeared among the gravel of one nest on June 23 while the first black fry rose off the bottom on June 25. Seven of the 16 nests (44 per cent) hatched fry. Nine of the nests were abandoned and became covered with silt or overgrown with filamentous algae before the fry hatched. Possibly some of the guarding male bass were removed by angling.

An appreciable amount of spawning activity apparently occurs in the region of Eel Bay during the first two weeks of June. In the years 1948 and 1949 water temperatures in Eel Bay varied from 61° to 65°F. while 40 per cent of a total of 184 female bass netted were ripe. One group of advanced fry was observed in the bay on June 22, 1948.

In most years, water temperatures in the open lake would run much less than 60°F. during the first two weeks of June. Water temperatures at Charity Shoals on June 2 and 6, 1949 were 54° and 53°F., respectively, and all female bass examined during tagging operations were hard. Although no observations were made on spawning activities at Charity Shoals it is reported by commercial fishermen that bass do spawn there. Examinations of bass netted during the first two weeks of June from Wilson Bay and the off-shore localities in Lake Ontario showed that most of the females were hard. Of a total of 746 gravid females examined only six fish (0.8 per cent) were ripe.

A wide search was made during the period June 15-28, 1948 for evidence of bass spawning. The following areas in the St. Lawrence River, all containing suitable gravel bottom for spawning, were

inspected: Dodge Bay, the bay at Cedar Point State Park, a small bay just west of Burnham Point, Carleton Island, Sand Bay, Linda Island, Beadle Bay, and the territory around Bluff, Murray, Picton, and Grindstone Islands. Only four bass nests were found during this survey. They were located as follows: one nest in the bay at Cedar Point State Park, one nest along the east shore of Beadle Bay, and two nests along the north shore of Grindstone Island. Additional areas adjacent to Lake Ontario were checked. They were: Wilson Bay, Mud Bay, Point Peninsula, and Three Mile Bay. However, no evidence of bass spawning was observed in these areas during the June survey. There are several possible explanations for the small amount of spawning activity observed in the areas mentioned above.

1. The period between June 15 and June 28 was too early for the bulk of the inshore populations to be at the peak of spawning activity.
2. There was an extensive spawning period, i.e., only a few fish spawned at one time.
3. The majority of bass spawned in deeper water where the nests could not be observed.
4. Spawning was scattered over a large expanse of shoreline. Reports from guides indicate a greater extent of suitable spawning area on the Canadian side of the river. This area was not investigated during this study.

To determine the success of bass spawning in the region, surveys of young bass were conducted in September 1948 and August 1949. During September 1948 young-of-the-year bass were taken by angling with artificial flies in the vicinity of Carleton Island and Linda Island. These small fish were caught where water depths ranged from 15 to 20 feet. None was found in shallow water close to shore. During August 1949 young bass, $1\frac{1}{2}$ to $2\frac{1}{8}$ inches in length, were seined in the vicinity of Linda Island, Dodge Bay, and Carleton Island. However, none was taken in Sand Bay, Beadle Bay, Poplar Tree Bay, Point Peninsula, Wilson Bay, Eel Bay, or the bay at the mouth of Fox Creek.

As may be seen from Table 10 there appear to have been dominant year classes in the bass from Wilson Bay. Young bass produced in the years 1938 and 1939 comprised 65 to 75 per cent of all the bass netted from this area in the years 1945, 1947, and 1948. These dominant year groups reflect differences in the success of spawning or survival of the young fish in different years and stages of development

TABLE 10. Y
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Year class	Age group	
	I	II
1943	II	
1942	III	
1941	IV	
1940	V	
1939	VI	
1938	VII	
1937	VIII	
1936	IX	
1935	X	
1934	XI	
1933	XII	
1932	XIII	
Total		

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TABLE 10. YEAR-CLASS FREQUENCY DISTRIBUTION OF WILSON BAY BASS ACCORDING TO SAMPLES OBTAINED IN THE YEARS 1945, 1947 AND 1948

Year class	Year of recovery								
	1945		1947		1948		1945	1947	1948
	Age group	Number	Age group	Number	Age group	Number	Percentage of sample	Percentage of sample	Percentage of sample
1943	II	...	IV	10	V	2	....	2.1	2.6
1942	III	...	V	20	VI	1	....	4.1	1.3
1941	IV	3	VI	73	VII	16	0.8	15.1	21.0
1940	V	13	VII	41	VIII	3	3.7	8.5	4.0
1939	VI	115	VIII	139	IX	18	32.5	28.8	23.7
1938	VII	154	IX	176	X	31	43.5	36.5	40.8
1937	VIII	40	X	21	XI	3	11.3	4.3	4.0
1936	IX	12	XI	3	XII	2	3.4	0.6	2.6
1935	X	13	XII	...	XIII	..	3.7	....	....
1934	XI	3	XIII	...	XIV	..	0.8	....	....
1933	XII	...	XIV	...	XV	..	....	....	....
1932	XIII	1	XV	...	XVI	..	0.3	....	....
Total		354		483		76	100.0	100.0	100.0

CONCLUSIONS

In future bass management in the Lake Ontario-St. Lawrence River region consideration should be given to the fact that the bass population as a whole is not homogeneous but is composed of a number of local populations. The main criteria used to distinguish local groups of bass were rate of growth and migration. Distinct bass populations can be recognized for Eel Bay, Wilson Bay, Charity Shoals, Chaumont Bay and the Galloo-Stony Island area. It appears that the river bass in the Carleton-Linda Island area are for the most part one population although there probably are small local groups around both of these islands.

It appears that the bass of the inshore area of the lake in proximity to the head of the St. Lawrence River, i.e., such areas as Wilson

Bay, contribute appreciably to fishing in the St. Lawrence River above Clayton.

Despite a heavy take of bass at Charity Shoals during June there is no evidence to show that this fishing adversely affects the abundance of this bass population. This conclusion is supported by the fact that the older age groups of bass were strongly represented in the samples studied. If some of these bass were not harvested during June it is probable that more would be lost to natural mortality. This conclusion may also be applied to North Shoal. In the other areas, with the exception of Eel Bay, the June catch is relatively small. Of the Eel Bay bass, however, there appears to be an appreciable amount of spawning before the June 16 opening date for bass fishing.

If in subsequent years a change in condition warrants additional protection to the bass during June such concentration areas as Eel Bay, Wilson Bay, Charity Shoals, and North Shoal could be given special consideration.

In the St. Lawrence River and to some extent in the open lake competition of the bass with other species, particularly rock bass, appears to be an important limiting factor.

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