WALLEYE AND GOLDEYE FISHERIES INVESTIGATIONS IN THE PEACE-ATHABASCA DELTA--1975

by

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ABSTRACT

The following report presents the results of investigations of walleye and goldeye in the Peace-Athabasca Delta in 1975. The report is divided into four sections that concern the following topics:

1) walleye in the Richardson Lake-Lake Athabasca system;
2) goldeye in the Lake Claire-Mamawi Lake system;
3) field observations of the completed Little Rapids weir on Rivière des Rochers; and
4) assessment of field trials of the feasibility of marking fish with acrylic dye.

Spawning success, movement, distribution, age structure, and several other biological characteristics of walleye and goldeye in the Peace-Athabasca Delta are discussed. The results of fisheries investigations in 1975 were generally incomplete because of the late initiation (mid-July) of the field work, and must therefore be interpreted carefully.

ACKNOWLEDGEMENTS

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Dr. S.B. Smith and T.D. Wright critically reviewed earlier versions of the manuscript.

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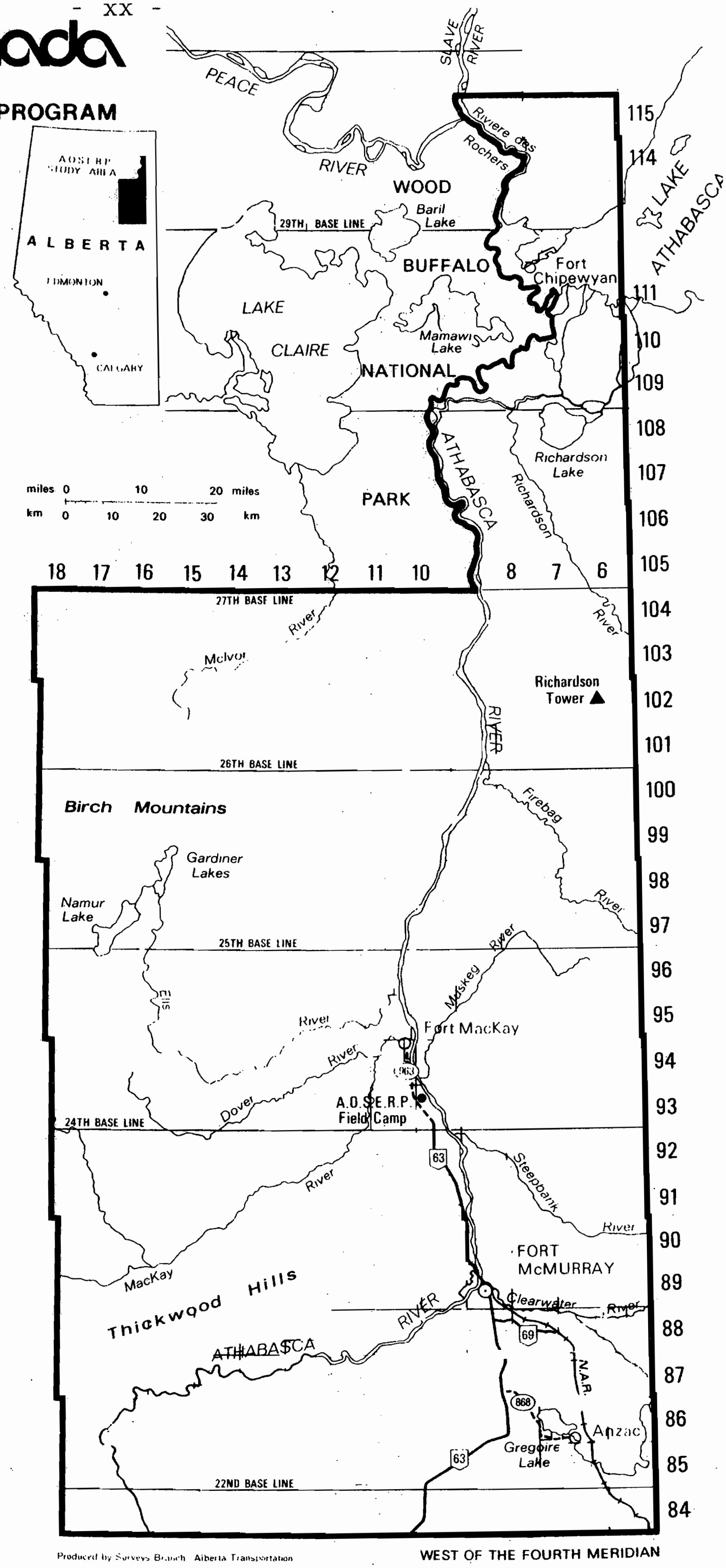

FIGURE 1.
AOSERP study area location.

PART I. WALLEYE INVESTIGATIONS

By

B.S. Ott and A.D. Sekerak

INTRODUCTION

This report presents results of field investigations of walleye (*Stizostedion vitreum vitreum* [Mitchill]) conducted in 1975 in the Peace-Athabasca Delta. These investigations were part of a continuing effort to identify effects on walleye of the changes in water levels in the Delta that were caused by the upstream operation of the Bennett Dam. Since the closure of the Bennett Dam on the Peace River in 1968, water regimes in the Delta have been greatly modified. This modification has been due primarily to unnatural moderation of spring high-water levels on the Peace River (Bidgood 1973).

Fernet (1971) briefly referred to numbers of walleye fry in the Delta, and Atton (1971) surveyed walleye in some Saskatchewan streams on the south side of Lake Athabasca. Knowledge of the life history and population dynamics of walleye in the Delta comes principally from the works of Bidgood (1968, 1971, 1973) and Dietz (1973). These studies provided evidence that Richardson Lake is a major spawning ground for walleye and that spawning in Richardson Lake provides most of the annual recruitment to the Lake Athabasca walleye population. In fact, although all areas in the Delta have not been surveyed (e.g. the north shore of Lake Athabasca), no other region in the Delta has been identified as a major walleye spawning area.

Much of Richardson Lake and its outlet stream, Jackfish Creek, freeze to the bottom during winter. A walleye spawning migration from Lake Athabasca to Big Point Channel (Figure 1), in the Athabasca River, occurs during March. Due to ice thickness and lack of ice-free water, walleye cannot enter Richardson Lake until flood water from the Athabasca River flows into Richardson Lake *via* Jackfish Creek. These flood waters normally lift the ice in late April, or soon thereafter, and the spawning migration proceeds into Richardson Lake. It is possible that unusually low water levels during the spring could cause conditions that would prevent or delay walleye from spawning in Richardson Lake.

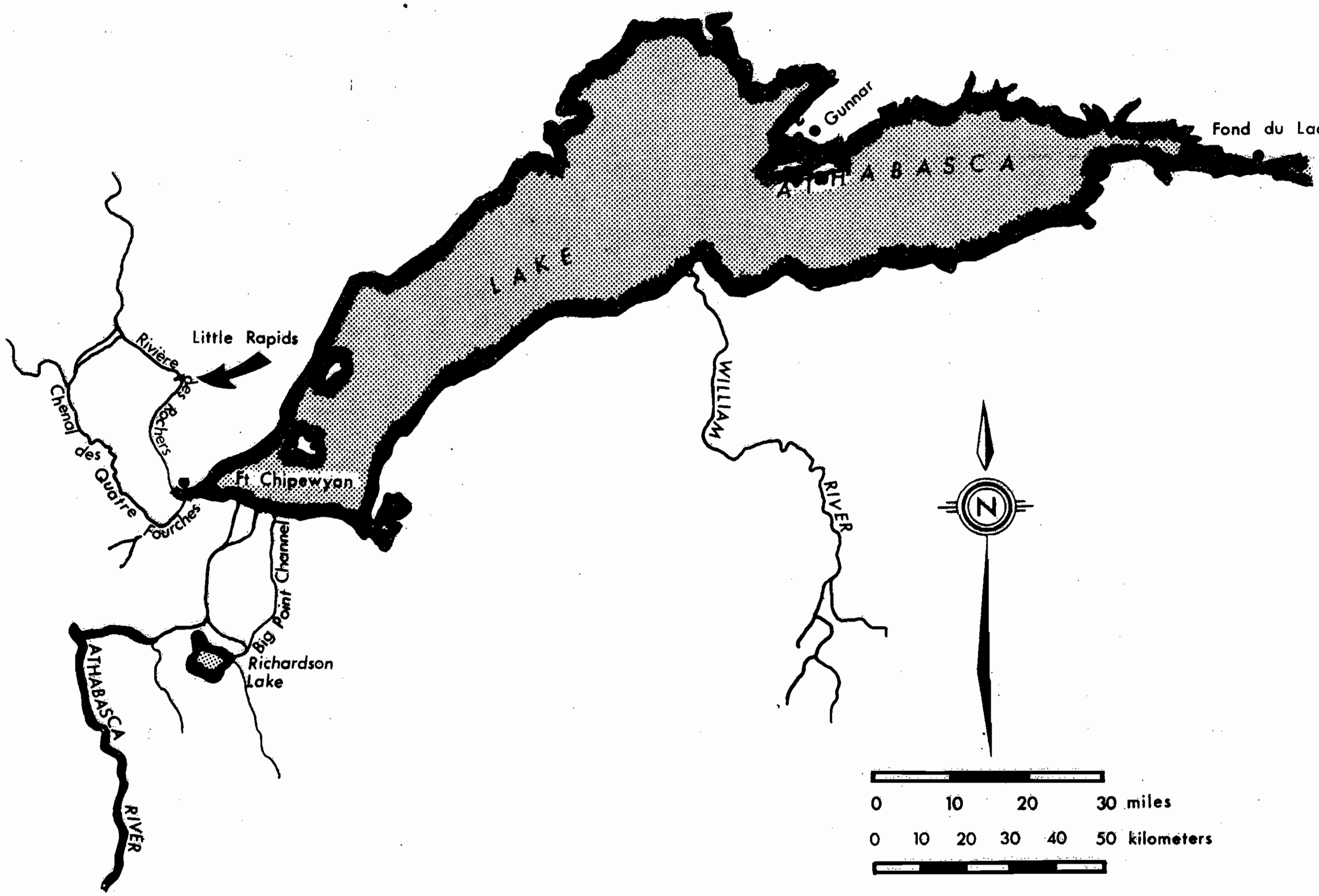

FIGURE 2. Project Study Area.

In view of present information, it appears that Richardson Lake is critical to the propagation of walleye in Lake Athabasca and that the spawning activities of this species could be seriously disrupted by unusually low water during the spring.

Primary objectives of this study were:

1) to delimit fry production in Richardson Lake in 1975; and
2) to obtain the current age structure of the Lake Athabasca walleye population.

Secondary objectives were to obtain weight-length, age-length relationships and to determine sex ratios for Lake Athabasca walleye.

METHODS

Hydrology

Data on water levels were obtained from the Alberta Department of the Environment. Data on ice break-up in Lake Athabasca and Jackfish Creek were obtained from residents of Fort Chipewyan and Jackfish.

Direction of flow in Jackfish Creek was noted daily, and surface current velocity was measured (approximately) through use of the chip method.

Trawling

Walleye fry were collected through use of trawl nets similar to those used by Donald and Kooyman (1974) but with 1 m^2 mouths. The frames were constructed of 1.9 cm-diameter aluminum tubing; the bags were 2.4 m in length and were made of plastic window screening with a mesh size of 2 mm.

Two trawls were towed simultaneously on either side of a skiff; the mouths of these trawls were 90 to 95% submerged. The speed of the tows was 30 m/min in water with no current. The duration of each tow was 2, 10, or 20 minutes. After 21 July, towing time was increased from 2 to 10 minutes; this increase greatly decreased net handling time and allowed more time to be spent in fishing. Increased net clogging was not apparent when towing time was increased. Except in mid-lake or shallow water areas, tows were conducted approximately 7 m from shore.

Sample locations in Richardson Lake and Jackfish Creek are shown in Figures 2 and 3. Twenty-one trawls (sites 44 to 81), each 20 minutes in length, were conducted in Richardson Lake on 22 and 23 July (Figure 2). Trawling was not possible in the northwest portion of Richardson Lake due to its shallowness and to the presence of large masses of rooted aquatic vegetation. Occasionally, vegetation

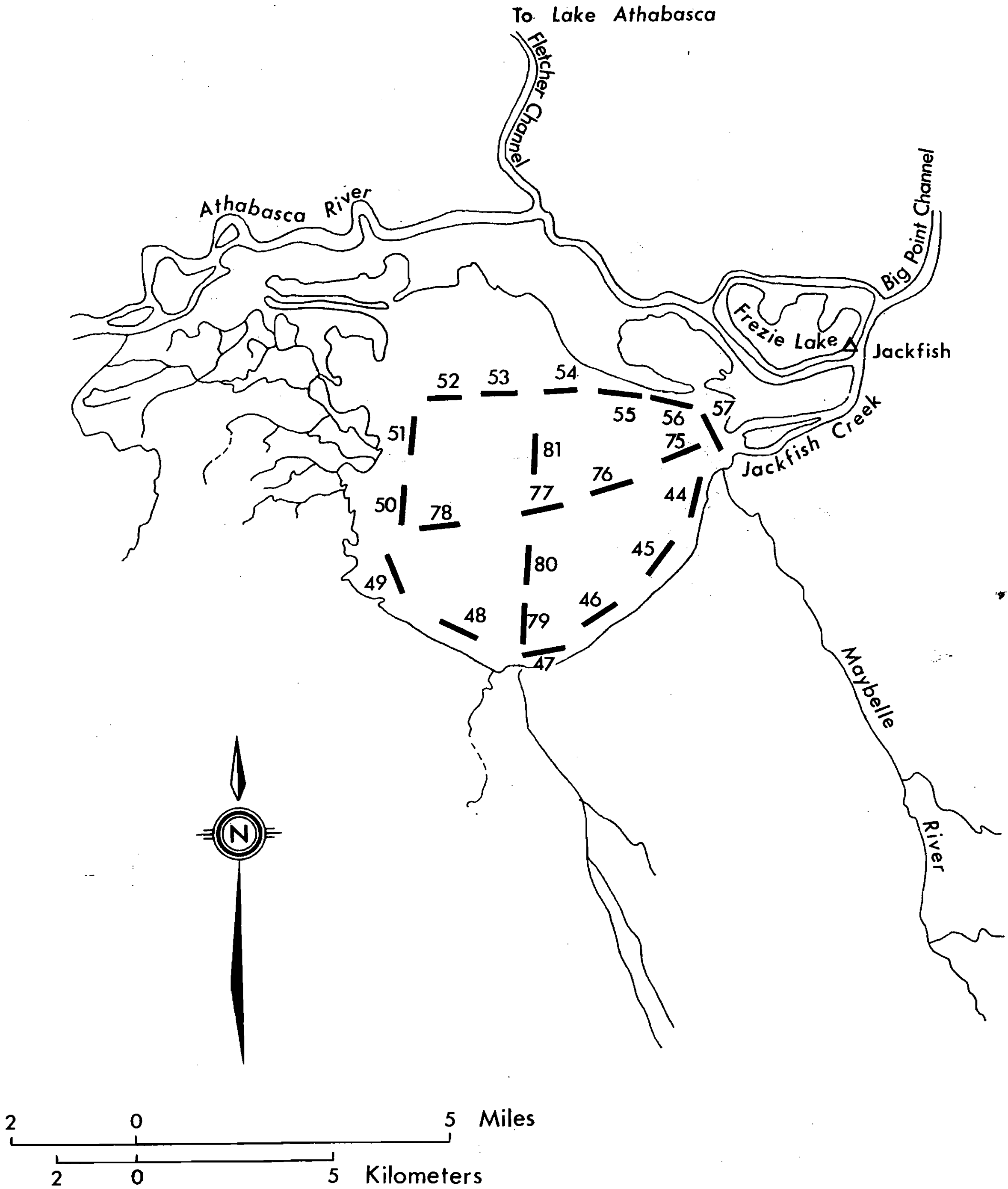

FIGURE 3. Trawl Locations (44-57; 75-81) in Richardson Lake.

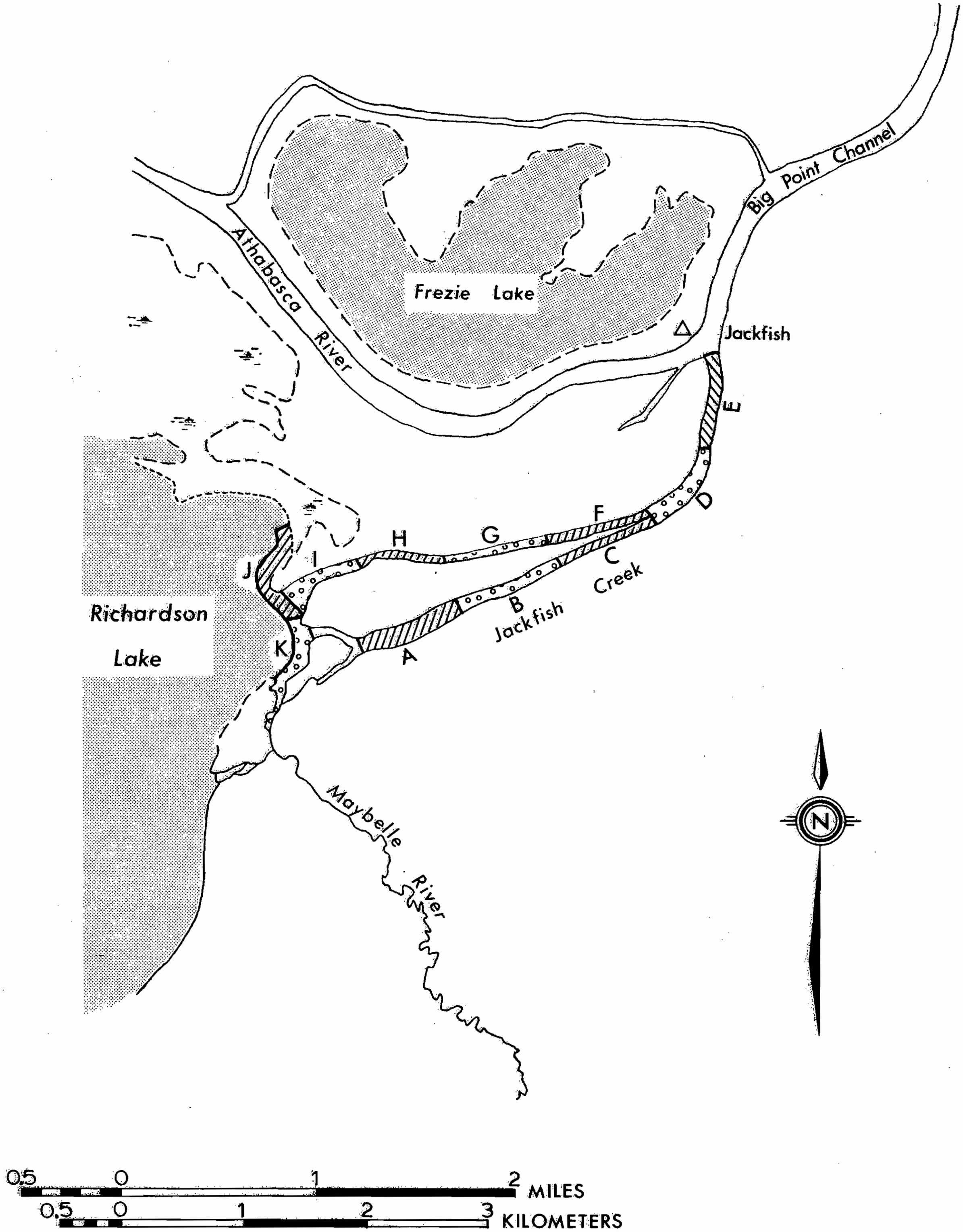

FIGURE 4. Trawl Locations in Jackfish Creek (A-I) and Adjacent Areas in Richardson Lake (J, K).

caught in the propeller of the out-board motor and slowed towing speed considerably. It is possible that fewer numbers of fry would have been caught during tows conducted under such conditions (cf. Noble 1970).

Jackfish Creek was divided into nine trawling sections, A to I; a contiguous area of Richardson Lake was divided into two sections, J, K (Figure 3). From 18 July to 11 August (with the exceptions of 19, 24, 25, and 26 July and 2 August), trawling was conducted four times daily in stream sections D and E and twice daily in the remaining sections. One ten minute trawl generally traversed each section; however, due to changes in current direction and velocity, some trawls were not confined to one section or did not traverse an entire section. A total of 353 trawls were conducted in Jackfish Creek.

Gillnetting

From 12 August to 9 September, walleye specimens (total of 408) were obtained from the Alberta portion of Lake Athabasca through use of gillnetting. Two types of nets were used: (1) a monofilament gang series composed of 10 panels, each 50 ft long by 8 ft deep, in stretched mesh sizes of 3/4, 1, 1 1/2, 2, 2 1/2, 3, 3 1/2, 4, 4 1/2, and 5 inch; (2) a braided nylon gang series composed of four panels, each 150 ft by 8 ft deep, in stretched mesh sizes of 1 1/2, 2 1/2, 3 1/2, and 4 inches. Sets (Figure 4) were placed 50 to 200 m from shore in depths of approximately 1.5 m; occasionally sets were placed in deeper waters to a maximum of 4.6 m. Nets were left overnight and were normally tended the following day unless storms prevented retrieval. The following data pertinent to specimens of walleye, except fry, were recorded: length, weight, and sex; a scale sample was obtained from the body surface posterior to the insertion of the pectoral fin. Scales were not collected from fry, and sex determination of these as well as some reproductively spent individuals was not attempted.

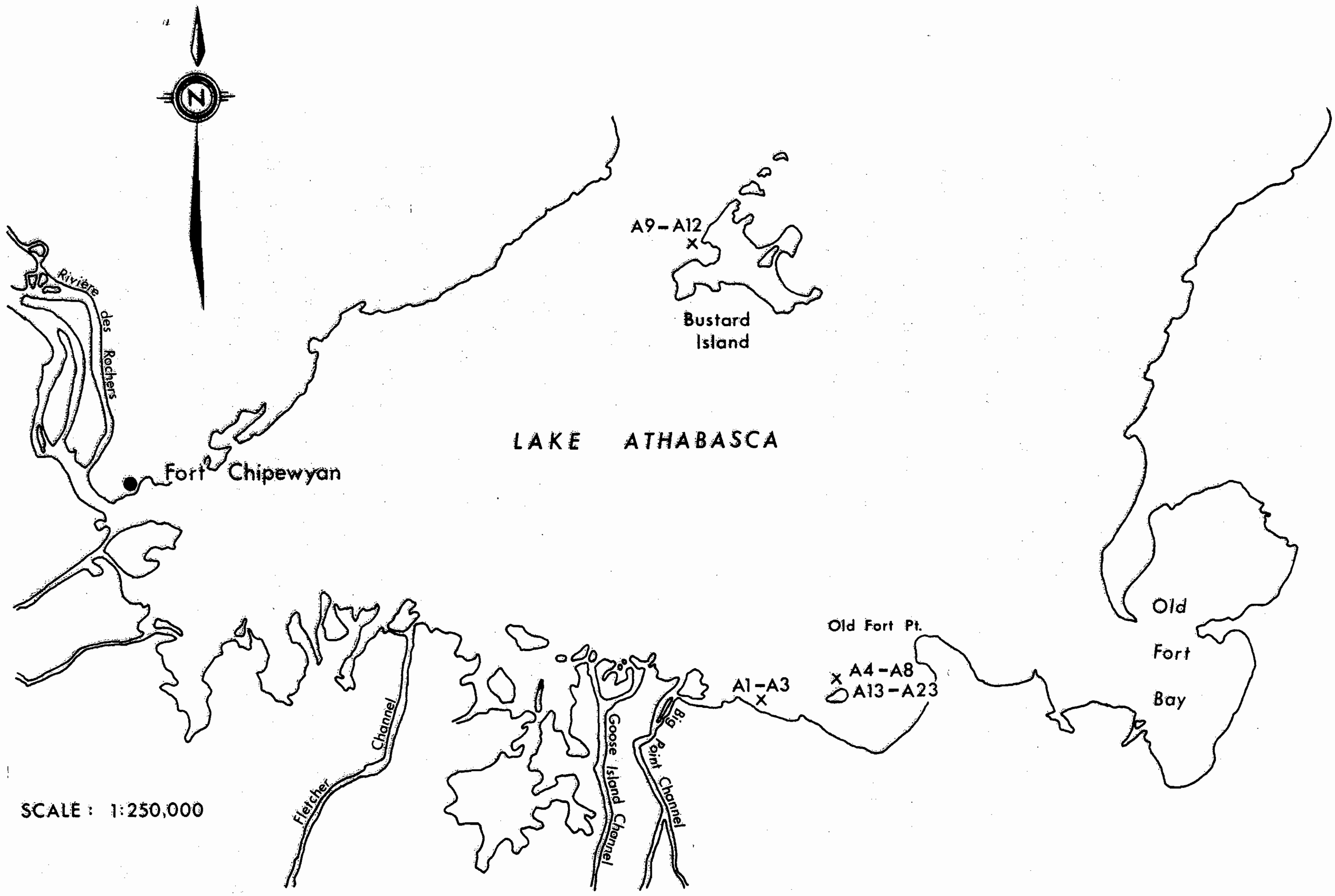

FIGURE 5. Location of Gillnet Sets in Lake Athabasca, August 1975.

In addition to the walleye collected through use of the above-described techniques, 695 walleye were obtained from the commercial fishery at Gunnar, Saskatchewan, between 2 and 10 September. Commercial fishermen exclusively used 4 1/2 inch stretched mesh braided nylon gillnets. The exact locations of catches are not known, but commercial fishing operations were centered around Gunnar and Fond du Lac. Scales were obtained from these walleye, and the lengths and weights of all these specimens were recorded. However, it was possible to record the sexes of only a portion (171 specimens) of these walleye.

In the laboratory, age determinations were aided through scale impressions made on acetate slides. The process consisted of placing scales on acetate slides, covering the slides with acetone, and sandwiching the acetate slides between glass slides until dry. Dry scales were then removed and the acetate slides labelled and stored for age determinations. Ages were determined independently by David Staines and Hugh Bain on the basis of scale impressions on the acetate slides. Differences between age determinations made by readers were resolved (when necessary) through reference to further readings.

Sex ratios within age classes that contained 10 or more specimens were tested for differences from a 50:50 ratio through the use of the chi-square test.

Deposition of Data

The report contains summaries of data collected on walleye during this study. Raw data has been tabularized and submitted to the chairman of the Peace-Athabasca Delta Monitoring Committee.

RESULTS

Hydrology

In 1975, break-up of ice on Jackfish Creek occurred on 29 April; the Alberta end of Lake Athabasca was ice free on 5 May. During break-up, there was no blockage of Jackfish Creek by ice or debris which might have prevented walleye from entering Richardson Lake.

Table 1 shows the water levels on the section of the Athabasca River upstream from Jackfish Creek and at the north outlet channel of Richardson Lake. The Athabasca River was monitored from February to September and Richardson Lake from May to September.

Water levels in the north outlet of Richardson Lake were fairly constant from 27 May to 24 June. From 24 June to 5 July, the water level at this outlet rose 3.61 feet (1.10 m). From the high recorded on 5 July, the water level at this location slowly decreased for the remainder of the month; thereafter, more rapid decrease was noted. The lowest water level of the summer at this location was recorded on 20 August.

Direction of flow in Jackfish Creek was eastward (out of Richardson Lake) on 18 and 19 July and westward (into Richardson Lake) from 21 to 22 July. No current was observed on 25 July. From 27 July to 11 August, the current was again eastward. Thus, during the study period water flowed into Richardson Lake only from 21 to 24 July. The period of outward flow (27 July to 11 August) lowered the water level in Jackfish Creek by at least 1.75 feet (0.51 m); current velocities varied between 5 and 30 cm/sec. A corresponding decrease in the water level of Richardson Lake was observed but not measured.

Abundance of Walleye Fry in Richardson Lake and Jackfish Creek

On 22 and 23 July, an average of 0.095 walleye fry/min (Table 2) were captured during trawls in Richardson Lake. Fry were most numerous along the southeast shore, where 0.90 and 0.55/min

TABLE 1. Water Levels as Recorded by the Alberta Department of the Environment on the Athabasca River at the Mouth of Jackfish Creek and at the North Outlet of Richardson Lake, for 1975. Levels are in feet above mean sea level.*

ATHABASCA RIVER ABOVE JACKFISH CREEK

DAY	MONTH: FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1		687.39	687.73	693.51	689.03	690.22		
2		687.36	687.78		689.05	690.72		
3		687.35	687.75		689.08	691.28		
4		687.34	687.75		689.02	692.05		
5		687.33	687.75		688.91	692.18	690.69	
6		687.33	687.74		688.80			
7			687.74		688.78			
8			687.75		688.77			
9			687.75		688.86	692.25		
10			687.75		688.92			
11			687.74		689.12	692.07		
12			687.72		689.38			
13		687.63	687.72		689.41			
14		687.63	687.75		698.59			
15		687.65	687.82	689.73	689.58			
16		687.64		690.04	689.49			690.59
17		687.65		690.05	689.40			
18	687.43	687.66		690.03	689.33			
19	687.47	687.65		689.97	689.21			
20	687.46	687.66		689.83	689.31			
21	687.46	687.68		689.66	689.48	693.00		
22	687.45	687.68		689.72	689.46			
23	687.44	687.68		689.54	689.34			
24	687.43	687.68		689.46	689.32			
25	687.42	687.68		689.49	689.23			
26	687.42	687.68		689.33	689.25			
27	687.42	687.67		689.13	689.71			
28	687.40	687.69		689.96	689.63			
29	------	687.70		689.05	689.69	691.69		
30	------	687.73		689.11	689.81			
31	------	687.73	------	689.07	------			------

NORTH OUTLET, RICHARDSON LAKE

DAY	MONTH: MAY	JUNE	JULY	AUGUST	SEPTEMBER
1					
2					690.09
3					
4					
5			692.93	690.17	
6					
7					
8					
9			692.32		
10		688.54			
11				690.13	
12					
13					
14					
15					
16					690.60
17					
18					
19					
20				689.14	
21			692.01		
22					
23					
24		689.32			
25					
26					
27	689.18				
28					
29			691.88		
30					
31		------			------

* Figures not verified.

TABLE 2. Catch Rate for Walleye Fry in Richardson Lake Survey Trawls, 22 and 23 July. Trawl numbers correspond to those in Figure 2.

TRAWL NUMBER	NUMBER OF FRY PER MINUTE
44	0.9
45	0.55
46	0.10
47	0.10
48	0.05
49	0.05
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
75	0.1
76	0.05
77	0.05
78	0
79	0.01
80	0
81	0

were captured during tows 44 and 45, respectively. During tows conducted in the remainder of the lake, a low average catch of 0.027 fry/min was obtained.

With the exception of two tows, trawl-catch rates in Richardson Lake were extremely low on 22 and 23 July compared to catches in Jackfish Creek. Possible explanations for these low catch rates are that by 22 July few fry were still in Richardson Lake, that fry were widely dispersed, and that fry were not vulnerable to the fishing technique. The higher catch rates near the mouth of Jackfish Creek suggest that fry were concentrating in this area before proceeding down Jackfish Creek and that fry are sometimes vulnerable to trawling in a lake environment.

By gillnetting, Dietz (1973) found that when walleye fry attained a length of 40 to 80 mm (after mid-July) they occurred predominantly near the bottom of the lake during daylight hours. This behavioural characteristic of such fry would greatly reduce catch rates, especially in deep portions of a lake. However, depths of more than 1.5 m are rare in Richardson Lake.

From 18 to 31 July, trawling (N = 209) in Jackfish Creek and in a contiguous area of Richardson Lake (see Figure 3) yielded an average catch rate of 0.73 fry/min. From 1 August to 11 August, when trawling was terminated, the average catch rate was 0.03 fry/min (N = 144). As shown in Figure 5, the catch rate 'peaked' on 23 July and then declined steadily until 31 July. Fry were not abundant in Jackfish Creek thereafter.

A crude approximation of the number of fry migrating out of Richardson Lake *via* Jackfish Creek can be obtained by assuming

1) trawl catch rates are valid and yield a realistic estimate of fry abundance
2) trawl catch rates would be similar at night
3) fry are equally dispersed throughout the stream channel (i.e. they have no preference for mid-channel or near-shore habitats)

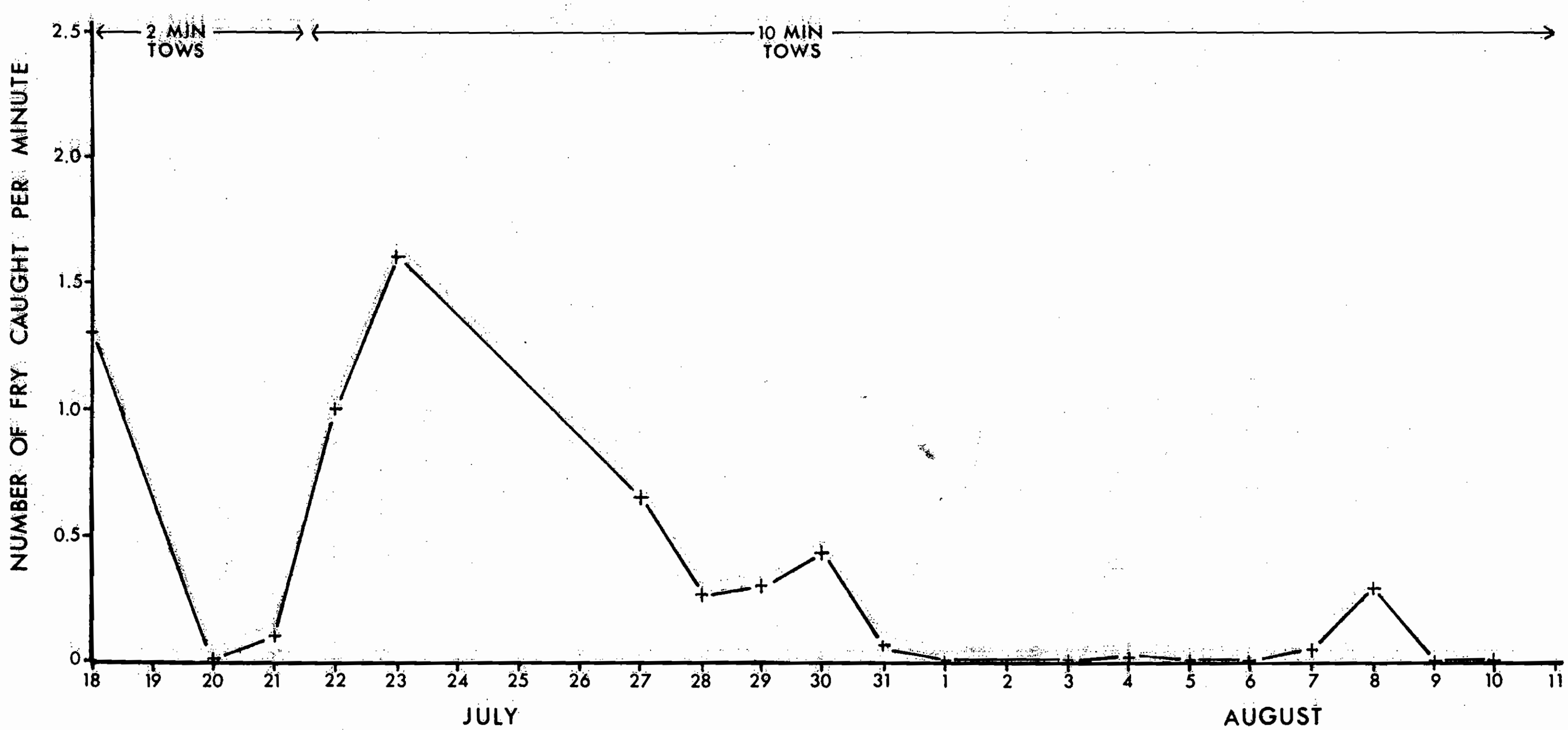

FIGURE 6. Average Catch Rate of Walleye Fry in Jackfish Creek, 18 July to 11 August 1975. Data were not obtained on 23-26 July and 2 August.

4) captured fry are not recaptured and are not subject to recapture (i.e. migration through Jackfish Creek is completed in 24 hours)
5) average depth of Jackfish Creek is 1.0 m
6) average width (including both the western branches) of Jackfish Creek is 100 m.

Only the latter assumption is based on realistic estimates.

During the period 18 July to 31 July, fry were captured at an average rate of 0.73 fry/min or 1052 fry/day. Trawls sampled 2.0 m of the stream channel which was a total of approximately 100 m wide; therefore, 1052 x 50 = 52,600 fry/day were distributed throughout Jackfish Creek. For the time period under consideration, it is estimated that 736,400 fry (52,600 fry x 14 days) migrated out of Richardson Lake. The 95% confidence limits place the estimated number of walleye fry between 400,000 and 1,000,000 because of the high standard error (0.74). If fry migration commenced on 15 June and continued (at a rate of 52,600 fry/day) until 31 July a total of 2,472,200 fry migrated. It must be re-emphasized that all figures are relative estimates. We have no data on absolute numbers of fry.

Movements of Walleye Fry

Data in Figure 5 show that the abundance of walleye fry within different sections of Jackfish Creek fluctuated during the study period; that is, relatively discrete 'schools' of fry possibly migrated through Jackfish Creek at different times.

Because the complete length of Jackfish Creek was trawled on each day during which samples were taken, it is possible to compare catch rates in different sections (Figure 3) of the stream on a particular day and on succeeding days. Figures 6A, B, C and D consist of such comparisons. Figure 6A shows that the highest catch rates on 21, 22, and 23 July were obtained in successive 'downstream' (eastward) sections of Jackfish Creek. These data can be interpreted as a 'school' of fry that were migrating out of Richardson Lake to

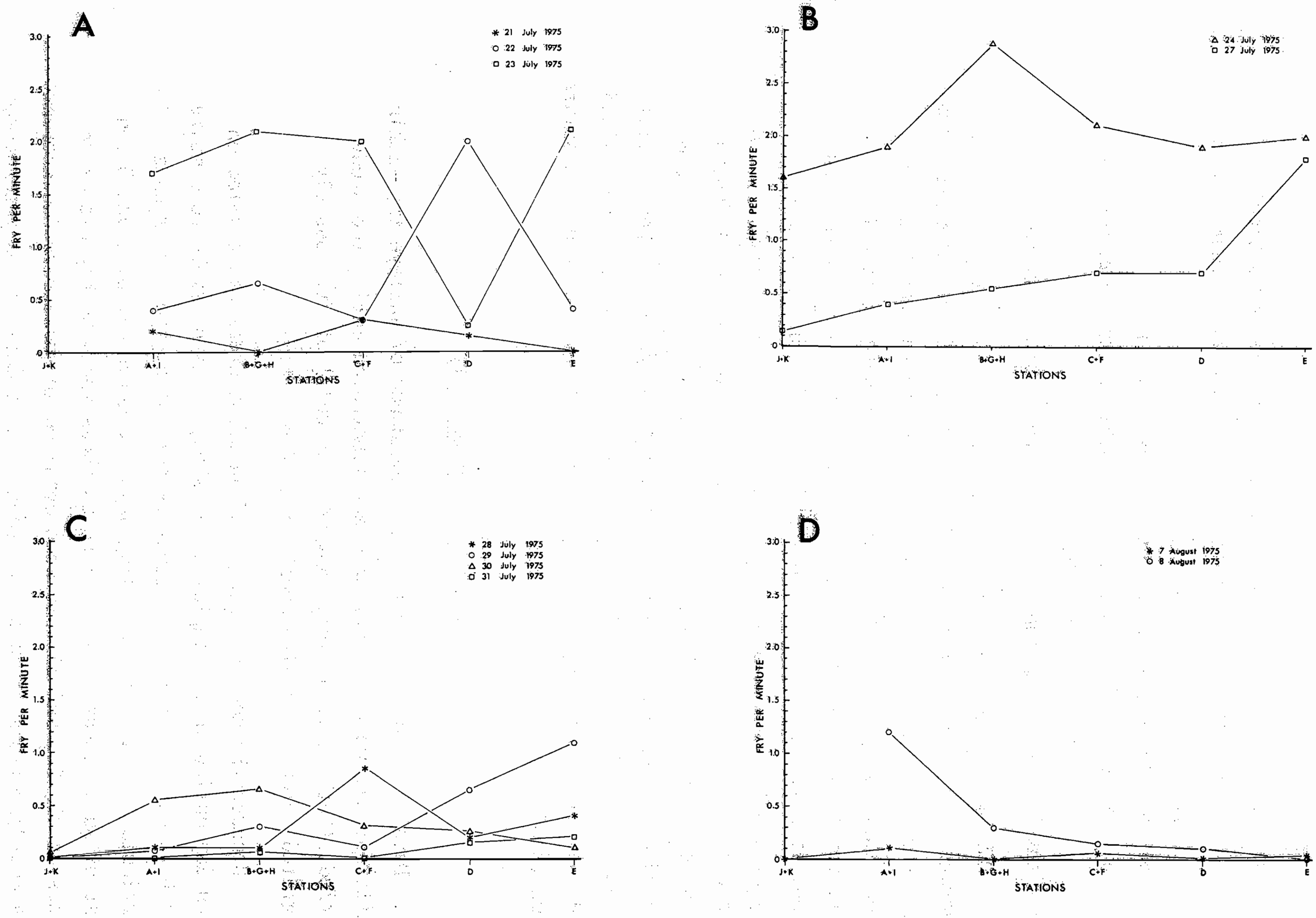

FIGURE 7. Average Catch Rate in Portions of Jackfish Creek in Different Time Periods. A. 21-23 July: B. 24, 27 July; C. 28-31 July; D. 7, 8 August.

the Athabasca River. On 23 July, high catch rates were also obtained in western sections of Jackfish Creek, and on 24 July even higher catch rates were obtained in this section of this creek (Figure 6A, 6B). By 27 July, few fry were caught in the western sections of this stream, but high catch rates were still obtained in the easternmost section. These data suggest that another 'school' of fry migrated out of Richardson Lake from 23 to 27 July. Catch rates from 28 to 31 July (Figure 6C) were relatively constant in comparison to such rates during previous days and do not lend themselves to interpretation; however, the two highest catch rates (obtained in stream sections C and F on 28 July and in stream section E on 29 July) were again sequential in time and indicated eastward movement. Catch rates during August (Figure 6D) do not show any pattern.

It must be emphasized that the above interpretations of Figure 6 are speculative. Due to large variation in catch rates and lack of replicate samples, precise interpretation is not possible. However, it is clear that catch rates are not uniform throughout Jackfish Creek; they vary with location and time. Given the assumption that no sampling errors were introduced by the sampling technique, evident trends suggest that the migration of walleye fry out of Richardson Lake occurs in a series of wavelike movements.

Biological Characteristics of Walleye in Lake Athabasca

Sex

Table 3 lists the chi-square sex comparisons. As shown in the table, males in Alberta were significantly more abundant in age class 5 and males in Saskatchewan were more common in 4 and 5. When catches were combined, males were more numerous than females in age classes 4 and 5; females in Alberta were significantly more numerous in age class 7, females in Saskatchewan were more numerous in age class 8, and females in the total sample more numerous in age class 9. When age classes 7 through 11 were combined, females were more numerous than males in all but the Alberta sample.

TABLE 3. Male-female Ratios for Lake Athabasca Walleye, 1975. Chi-square values and five percent significance are shown.

ALBERTA					SASKATCHEWAN					TOTAL				
AGE	NUMBER OF MALES	NUMBER OF FEMALES	χ^2	SIGNIFICANCE (5%)	AGE	NUMBER OF MALES	NUMBER OF FEMALES	χ^2	SIGNIFICANCE (5%)	AGE	NUMBER OF MALES	NUMBER OF FEMALES	χ^2	SIGNIFICANCE (5%)
0	--	--			0	--	--			0	--	--		
1	--	--			1	--	--			1	--	--		
2	2	2			2	--	--			2	2	2	0	
3	5	9	1.24	-	3	--	--			3	5	9	1.24	-
4	26	22	0.34	-	4	13	3	10.26	+	4	39	25	3.22	+
5	28	13	6.33	+	5	11	4	4.18	+	5	39	17	10.22	+
6	6	7	0.08	-	6	10	14	0.69	-	6	16	21	0.69	-
7	3	7	1.90	+	7	10	7	0.55	-	7	13	14	0.04	-
8	1	0			8	7	12	1.41	+	8	8	12	0.83	-
9	2	1			9	1	8			9	3	9	5.44	+
10	0	1			10	0	1			10	0	2		
11	--	--			11	0	1			11	0	1		
7-11	6	9	0.63	-	7-11	18	29	2.72	+	7-11	24	38	3.33	+

Bidgood (1971) also found that males of 4 and 5 years of age were more numerous than females in Lake Athabasca. However, in many walleye populations females apparently outnumber males in older age classes (Scott and Crossman 1973).

Weight-Length Relationship

The relationship between weight and fork length of walleye from Lake Athabasca is shown in Figure 7. The usual curvilinear relationship (Everhart *et al.* 1975) is evident. The correlation coefficient is 0.93.

As the high correlation coefficient reflects, weight can be predicted accurately from fork length. Through use of 95% confidence limits, weights of specimens with fork lengths from 30 to 50 cm can be predicted to within ±20 gm of the mean weight of their 5 cm fork length interval. That weights of specimens with fork lengths greater than 50 cm cannot be predicted as accurately is possibly due in part to lack of data, as found by Bidgood (1971) and in the present study. However, Figure 7 shows that specimens with fork lengths between 50 and 60 cm varied in weight from 1025 to 2525 g. These data indicate that variation in weight may be greater in larger (possibly older) walleye.

Age Structure

As stated previously, walleye scale impressions were aged independently by two readers. Table 4 lists the percent agreement between these two age interpretations. Because of the large number of checks and false annuli on scales from old walleye, complete agreement between readers decreased markedly with increased age of the specimens. Despite the low extent of complete agreement between readers (40.7% on all readings), the magnitude of error was small because 84.9% and 96.2% of all readings agreed to within ±1 or ±2 years, respectively.

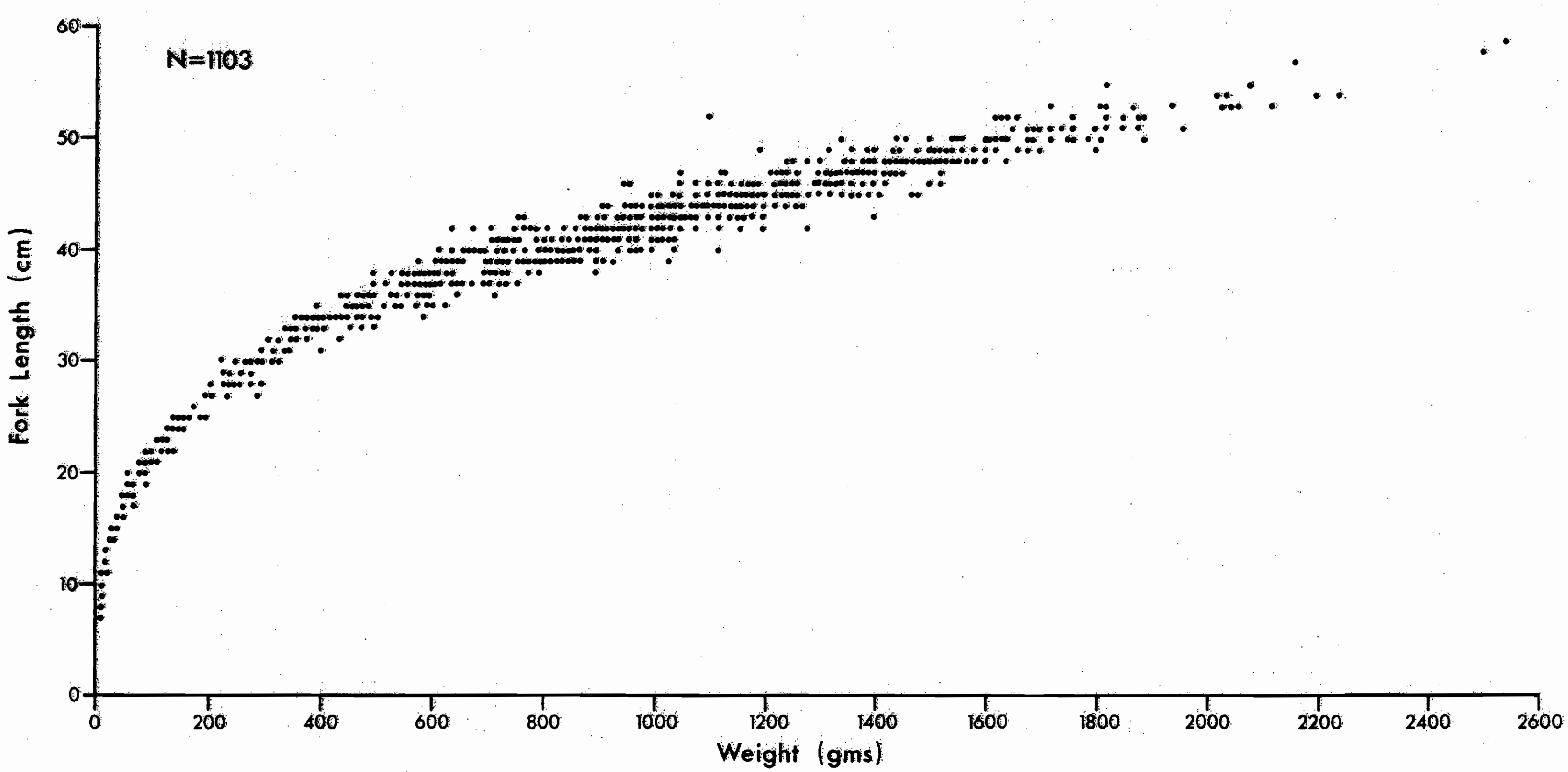

FIGURE 8. Weight-Fork Length Relationship for Lake Athabasca Walleye.

TABLE 4. Percent Agreement Between Two Agings of Walleye.

ALBERTA			SASKATCHEWAN			TOTAL		
NUMBER	AGE	% AGREEMENT	NUMBER	AGE	% AGREEMENT	NUMBER	AGE	% AGREEMENT
103	0	-	-	-	-	103	0	-
42	1	83.3	-	-	-	42	1	83.3
39	2	64.1	1	2	0	40	2	62.5
42	3	47.6	14	3	57.1	56	3	50.0
80	4	55.0	115	4	46.9	195	4	50.3
64	5	37.0	190	5	40.0	254	5	39.4
17	6	29.4	185	6	31.4	202	6	31.2
14	7	28.6	108	7	27.8	122	7	27.9
2	8	0	54	8	31.5	56	8	30.3
4	9	25.0	22	9	18.2	26	9	19.2
1	10	0	5	10	0	6	10	0
			1	11	0	1	11	0

The present age estimates are similar to those of Bidgood (1973) but differ from those of Dietz (1973). It is thought that the latter author overestimated ages by at least 1 year in young age classes and by a greater degree in older (4+) classes. For this reason age data gathered during this study are not compared with such data in Dietz's study. Use of Bidgood's age estimates and those from this study indicates that the growth rate of Lake Athabasca walleye is similar to that of walleye from Lake Winnipeg and Lac La Ronge (Scott and Crossman 1973, p. 771). Use of Dietz's age estimates indicates that walleye in Lake Athabasca grow more slowly than those in the other two lakes mentioned above (see Figure 9).

Figure 8 presents age-frequency histograms for walleye from Lake Athabasca. Due to the different fishing methods that were employed, walleye obtained from the Alberta and Saskatchewan portions of Lake Athabasca are not comparable. Other than fry, 4 year olds were most numerous in Alberta. In contrast, 5 and 6 year olds constituted over 50% of the commercial catch in Saskatchewan.

The large mesh size of the nets used in Saskatchewan possibly eliminated walleye younger than 4 years from the catch (Regier *et al.* 1969, p. 75). Due to the range of mesh sizes used in Alberta, Figure 8A yields an approximation of the age structure of walleye present in the Alberta portion of the lake during late August and early September. It is possible, however, that data in this figure are not representative of the age structure of the entire walleye population because during midsummer adult walleye appear to migrate to the deeper portion of the Saskatchewan section of Lake Athabasca (Bidgood 1971). Large numbers of older walleye were possibly absent from the Alberta section of this lake when gillnetting was conducted.

A single population of walleye is thought to exist in Lake Athabasca. Because data were obtained from a substantial number of specimens (N = 1103) during 1975, Figure 8C possibly reflects an adequate representation of age structure of walleye in Lake Athabasca--excluding walleye 3 years old and younger. Nearly 60% of

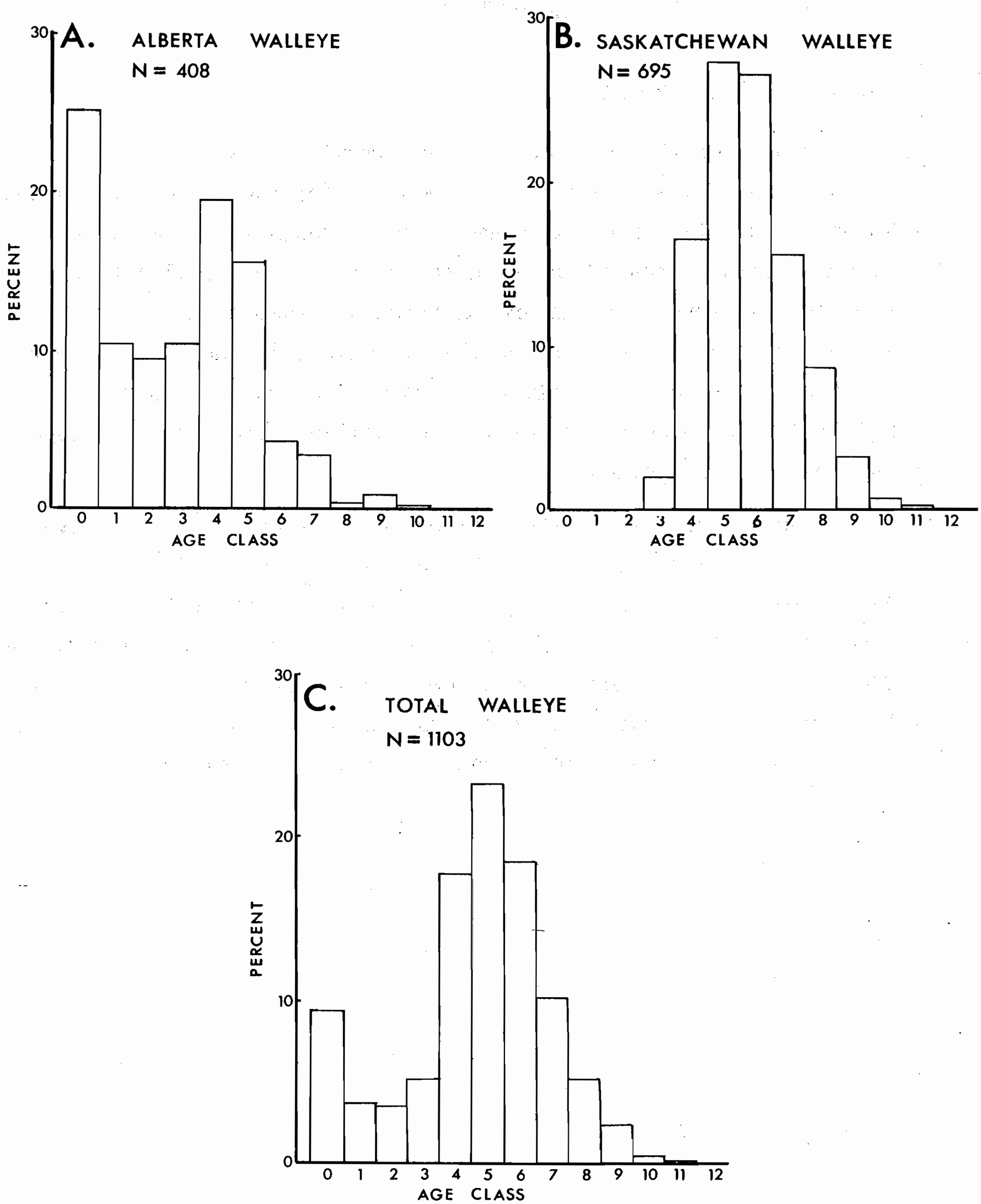

FIGURE 9. Age Class Structure for Lake Athabasca Walleye.

the total catch consisted of specimens that were 4 to 6 years of age. Abundance decreases sharply in older age classes, and walleye older than 11 years were not captured in 1975.

Age-Length Relationship

Because of the low number of specimens that were collected in old (7+) age classes, sexes were combined for the following analysis. The mean fork length of each age class is shown in Table 5, and Figure 9 illustrates the age-length relationships of 1103 Lake Athabasca walleye (Alberta and Saskatchewan samples combined). It is not known why mean fork lengths of walleye in the 2 and 3 year old age classes are slightly below values needed to produce a uniformly smooth curve, since younger walleye were caught throughout the sampling period.

Figure 9 also shows the age-length relationships of walleye collected by Dietz (1973) in 1972 and by Bidgood (1973) in 1971. The latter author's results closely approximate those of the present study. The results of Dietz (1973) show a substantially slower growth rate; as previously mentioned, this growth rate is thought to be an artifact due to over estimation of age by 1 year in 2 and 3 year age classes and by more than 1 year in 4 and 4+ year age classes.

TABLE 5. Age-Fork Length Relationships for Lake Athabasca Walleye, 1975.

AGE	ALBERTA				SASKATCHEWAN				TOTAL			
	NUMBER FISH	% TOTAL CATCH	MEAN FORK LENGTH (cm) + STANDARD ERROR	FORK LENGTH RANGE (cm)	NUMBER FISH	% TOTAL CATCH	MEAN FORK LENGTH (cm) + STANDARD ERROR	FORK LENGTH RANGE (cm)	NUMBER FISH	% TOTAL CATCH	MEAN FORK LENGTH (cm) + STANDARD ERROR	FORK LENGTH RANGE (cm)
0	103	25.25	10.73±2.82	7.0-19.0	0				103	9.34	10.73±2.82	7.0-19.0
1	42	10.29	19.30±2.69	16.0-25.5	0				42	3.81	19.30±2.69	16.0-25.5
2	39	9.56	23.72±2.47	18.0-29.0	1	0.14	31.0	-	40	3.63	24.00±2.69	18.0-31.0
3	42	10.29	29.08±3.12	23.0-36.0	14	2.01	33.00±4.52	27.0-44.0	56	5.08	30.40±3.74	23.0-44.0
4	80	19.61	36.09±2.84	30.0-42.0	115	16.55	38.56±2.51	32.0-44.0	195	17.68	37.70±3.03	30.0-44.0
5	64	15.69	39.13±2.96	30.0-47.0	190	27.34	42.22±2.53	35.0-49.0	254	23.03	41.50±2.94	30.0-49.0
6	17	4.17	41.00±3.06	33.0-46.0	185	26.62	44.93±2.32	40.0-50.0	202	18.31	44.60±2.73	33.0-50.0
7	14	3.43	45.00±2.95	39.0-49.0	108	15.54	47.21±2.19	42.0-51.0	122	11.06	47.70±2.50	39.0-51.0
8	2	0.49	50.50±2.12	49.0-52.0	54	7.77	49.69±2.47	45.0-54.0	56	5.08	49.60±2.47	45.0-54.0
9	4	0.98	51.75±4.03	46.0-55.0	22	3.17	50.76±2.59	45.0-57.0	26	2.36	51.00±2.76	46.0-57.0
10	1	0.25	58.00	-	5	0.72	48.00±4.30	43.0-54.0	6	0.54	52.50±4.43	43.0-58.0
11	0				1	0.14	50.00	-	1	0.09	50.00	-

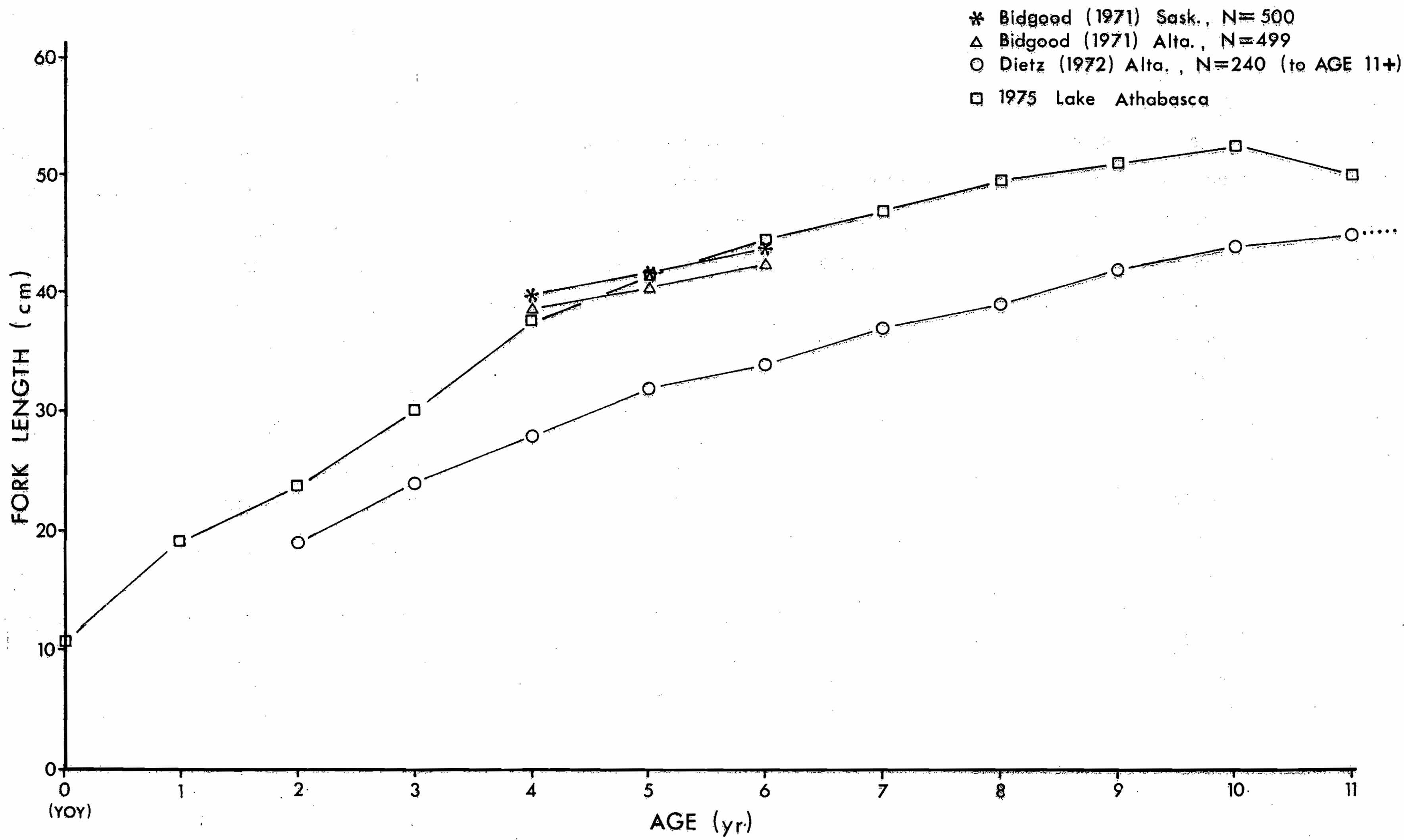

FIGURE 10. Age-Fork Length Relationships for Three Lake Athabasca Walleye Studies, 1971, 1972 and 1975.

DISCUSSION

Walleye Spawning Success - 1975

On the basis of the results of this study, it is evident that some walleye spawned successfully in Richardson Lake in 1975. Hydrological data show that water levels in the Athabasca River and Richardson Lake were not unusually low in 1975. In addition, no barriers that could have prevented ripe walleye from entering Richardson Lake to spawn were observed in Jackfish Creek during break-up.

No data were obtained on the magnitude of the spawning run in 1975. Also, Figure 5 indicates that walleye fry had initiated migration out of Richardson Lake before field studies commenced on 18 July. Without estimates of the number of spawners and the number of fry that survived and participated in the migration out of Richardson Lake, it is not possible to evaluate in absolute terms the success of walleye spawning in 1975. It is only possible to point out that some walleye spawned and that some fry were produced in 1975. No previous estimates of the number of fry that have migrated out of Richardson Lake have been made; therefore, year-to-year comparisons of these fry are not possible. The estimate of 2.5 million fry in 1975 is extremely tenuous because it was necessary to estimate several unknown factors in order to calculate this figure.

Insight into the problem of estimation of total numbers of fry out-migrating and a perspective may be gained by consideration of the following. Bidgood (1973) estimated that the Richardson Lake spawning population consisted of from 500,000 to 1,000,000 individuals in 1971, and Dietz (1973) found that ripe females from Richardson Lake contained an average of 57,572 eggs. Given the assumptions of a sex ratio of 70:30 (male to female), and a mortality rate of 99% (Scott and Crossman 1973) to the time of migration, it is possible that between 86 million and 172 million walleye could be produced from 150,000 to 300,000 ripe females annually. The estimate (based on data gathered during this study) of 2.5 million fry in Jackfish Creek in 1975 is low by a factor of 34 in comparison to the lower estimate of potential number of fry.

It is apparent

1) that fewer than 250,000 females spawned in Richardson Lake in 1975, or
2) that egg-fry mortality was higher than 99%, or
3) that 2.5 million is an underestimate of the number of fry that migrated through Jackfish Creek in 1975.

Any one or a combination of the above possibilities could be correct. The above calculations are extremely speculative and cannot be scientifically defended. These calculations do, however, provide an estimate (or a starting point) to be refined in future years.

High catches of fry were obtained in Jackfish Creek irrespective of current direction in the stream; therefore, out-migration does not appear to be dependent upon current direction. It may be significant that current reversed and started draining Richardson Lake on 27 July. Because the water level in the Athabasca River dropped markedly in August, it is assumed that the above-mentioned reversal marked the beginning of summer drainage of Richardson Lake. Catch rates in Jackfish Creek (Figure 5) decreased markedly from 23 July to 11 August, and it appeared that by the time summer drainage of Richardson Lake commenced fry out-migration was near completion.

Data obtained in 1975 indicate that fry possibly migrate from Richardson Lake in a series of relatively individual schools. Despite large, seemingly random variations in catch rates, patterns in abundance of fry can be correlated with time and location in Jackfish Creek. If the above hypothesis is correct, it is extremely important to monitor fry migration from its commencement to its termination. Monitoring of part of the migration during an identical time period of each year is unlikely to produce precise estimates. Because annual environmental variations may affect the timing of fry movements, there is no assurance that results obtained during a short time period of a particular year would be comparable to results obtained during similar periods of other years.

Age Structure

Figure 10 indicates that the age structure of walleye in Lake Athabasca has changed significantly from 1971 to 1975. During 1971, over 60% of the commercially caught walleye in Lake Athabasca were 5 years of age (produced in 1966). As shown in Figure 8 and 10, this year class does not appear as a strong 9-year-old class in 1975. Natural mortality and probably (much more importantly) commercial fishing has depleted this stock to less than 3% of the population. During 1976, this age class will contribute insignificant numbers to the fishery. The importance of this year class is now virtually eliminated.

Of special interest to this study are the year classes spawned in 1968 to 1971, when the water levels of the Peace-Athabasca Delta were low. At the present time these specimens are in the 4 to 7 year-old age classes. As shown in Figures 8A, B and C, each of these year classes contributes significantly to the adult population in Lake Athabasca (or at least to the commercial catch). Thus, despite years of extremely low water, large enough numbers of fry were produced between 1968 and 1971, to now constitute over 80% of the adult population and contribute significantly to the commercial fishery.

During the period 1968 to 1971, complete spawning failure of walleye did not occur. However, it is again not possible to establish how successful walleye spawning was from 1968 to 1971 because the abundance of fry during this time was not estimated. It is not, therefore, possible to absolutely determine whether or not the low water years of this period were detrimental to walleye production.

Differences in the age structures of the walleye population in 1971 and in 1975 may correlate with changes in commercial fishing

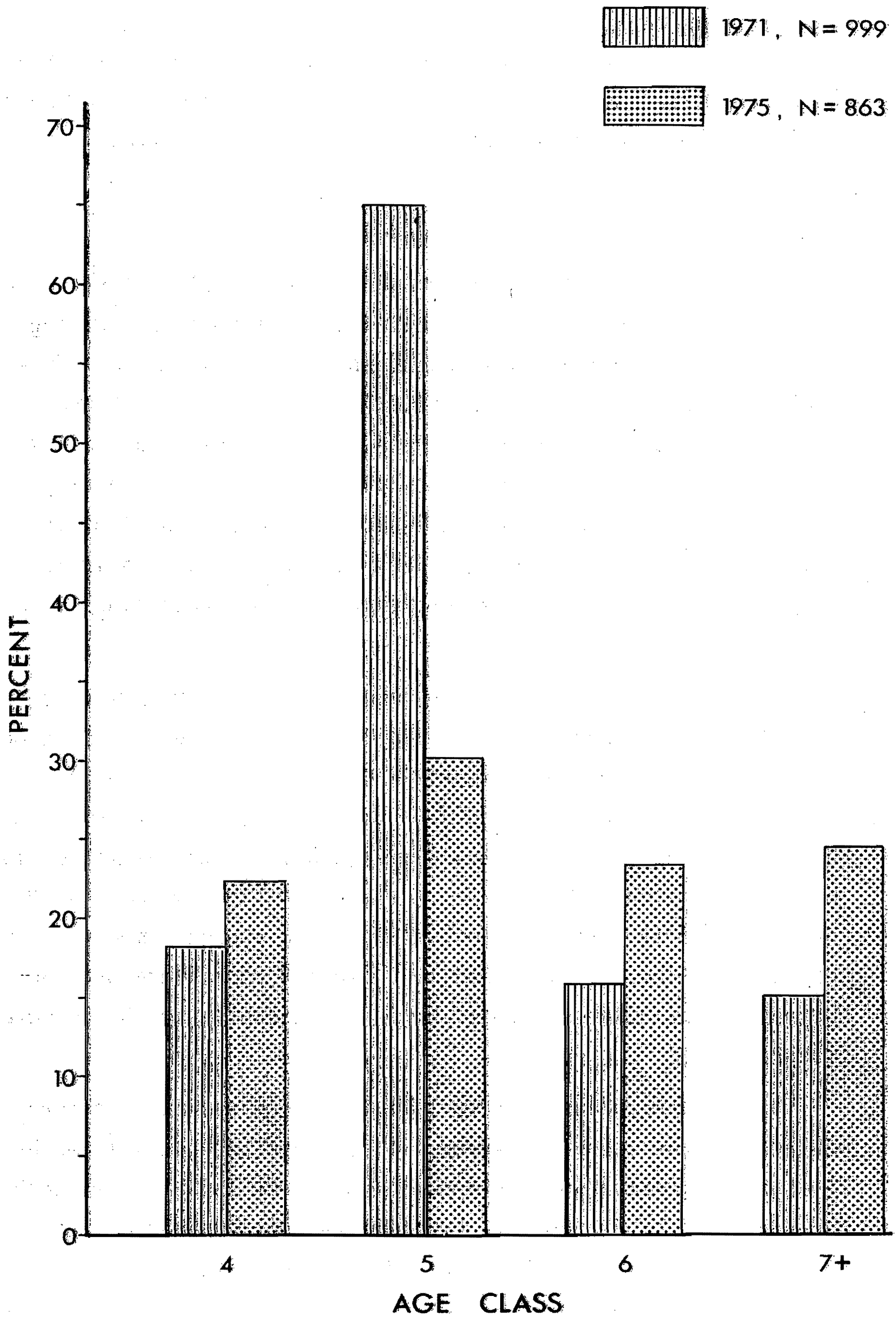

FIGURE 11 Age Structure of Lake Athabasca-Walleye for 1971 and 1975.

harvests (Table 6). The age structure of the population in 1971 suggests that the population had been heavily fished and that individuals were harvested shortly after they had reached a commercial size (at 4 to 5 years of age).

Commercial fishing in Richardson Lake was terminated in 1967, and the harvest in Lake Athabasca from 1967 to 1972 was approximately half of that from 1963 to 1966. Also, relatively small catches have been taken during 1973 and 1974. Decreased commercial catches from 1967 to 1974 and especially the termination of fishing on the spawning grounds in Richardson Lake should have resulted in increased recruitment to the walleye population. Walleye produced in 1971, 1970, and 1969 formed most of the commercial catch in 1975; each age class was well represented in this catch. Substantially greater numbers of walleye 7 years and older are now surviving than were in 1971. These data indicate that the walleye population has changed favourably in age structure from 1971 to 1975 probably as a result of decreased commercial fishing. (A larger proportion of older females yields a potentially greater population fecundity [Scott and Crossman 1973].)

It must be stated that the above discussion applies only to the age structure of the population expressed as percentages of catches. Total number of walleye in the population of any year is unknown. Favourable changes in age structure of the population may not reflect larger numbers of walleye in the population. It does, however, appear that a greater number of older walleye are now present in the system and that the population (as a whole) has a greater reproductive potential than in 1971.

Interpretation of walleye capture data must consider fishing methods used. Such consideration is especially important when specimens obtained for population age structure analysis are collected with gillnets. Peaks of selectivity of nets from 2 to 5-inch stretched mesh are pronounced (Regier *et al.* 1969, p. 75), but if test gangs (which contain progressively larger mesh sizes from 2 to 5-inch) are used, the sample of fish obtained is likely to

TABLE 6. Commercial Catch (pounds) of Walleye in Delta Waters 1963-1975.* Table modified from Bidgood (1973). Alberta poundage figures 1972-1975 supplied by Mr. Charles Scott and Saskatchewan poundage for the same period by Mr. V.R. Espinosa.

YEAR	ALBERTA FISHERY		SASKATCHEWAN FISHERY	TOTAL
	RICHARDSON LAKE	LAKE ATHABASCA	LAKE ATHABASCA	
1963	207,291	117,294	31,009	355,594
1964	137,672	214,769	31,642	384,083
1965	116,790	128,849	35,546	281,185
1966	60,147	135,590	14,851	210,588
1967	Closed	133,902	29,571	163,473
1968		212,424	62,039	274,463
1969		94,513	37,290	131,803
1970		37,652	135,994	173,646
1971		53,365	92,139	145,504
1972		97,700	78,203	175,903
1973		63,642	12,953	76,595
1974		54,742	3,401	58,143
1975		18,747	5,204	23,951

* 1975 values are incomplete

reflect the true age structure of a portion of the population. Use of such a gang would (theoretically) permit equal sampling across a population varying from 25 to 60 cm in total length (i.e. 3 to 12 year old walleye in Lake Athabasca).

Test gangs containing 3/4 to 5-inch stretched mesh were used to obtain walleye from the Alberta portion of Lake Athabasca. Gross differences in the age structure of catches from Alberta and Saskatchewan, where 4 1/2-inch mesh nets were used, are evident (Figures 8A and B). Combination of the two catches (Figure 8C) yields another estimate of the age structure of Lake Athabasca walleye. It is believed that Figure 8C yields a reliable approximation of the true age structure of walleye of 4 and possibly 3 years of age and older. However, younger age classes are underestimated. Therefore, due to the necessity of obtaining substantial numbers of walleye from the commercial fishery, it is not possible (1) to estimate the relative abundance of young age classes or (2) (most importantly) to correlate abundance of young age classes to success of spawning in 1972 to 1974. Due to natural mortality, strong year classes would be most easily identified in their early years, when they are most abundant.

SUMMARY

Walleye Spawning and Fry Production

Water levels were not unusually low in the Athabasca River or in Richardson Lake in 1975. Break-up of Jackfish Creek occurred on 29 April and walleye successfully spawned in Richardson Lake. An estimate of 2,500,000 fry produced in 1975 was obtained by extrapolating trawl catch rates through time and space. This number is at best a crude approximation. Some data were obtained which suggested that fry migration through Jackfish Creek occurred in a series of 'wavelike' movements.

Walleye in Lake Athabasca

Data in 1975 strongly indicate that the age structure of walleye 3 to 4 years of age and older has changed from that in 1971. Walleye 6 years and older are now substantially more abundant in commercial catches. The change in age structure of the population may be attributed to cessation of commercial fishing on the spawning grounds in Richardson Lake and reduced commercial catches in recent years. Because of the increased numbers of older walleye the population may have a higher reproductive potential than it did in 1971-72. No data have been obtained on absolute abundance of any year class and it is therefore not possible to state with any assurance that increased relative numbers of older walleye reflect increases in absolute abundance.

PART II. GOLDEYE INVESTIGATIONS

By

J. Kristensen and A.D. Sekerak

INTRODUCTION

Since the completion of the Bennett Dam on the Peace River in 1968, low water levels below this dam have been recorded (Peace-Athabasca Delta Project Group 1973a). The results of numerous ecological studies in the Peace-Athabasca Delta indicate that low water levels may be detrimental to certain faunal components of this delta (Peace-Athabasca Delta Project Group 1973b). An attempt was made to increase water levels in the Mamawi-Claire Lakes system through construction of a dam on the west channel of Quatre Fourches in the fall of 1971. In early September 1975, a submerged weir was completed at Little Rapids, on Rivière des Rochers, in an attempt to hold back water flowing out of Lake Athabasca and parts of the Peace-Athabasca Delta. Upon completion of the Little Rapids weir, the Quatre Fourches structure was removed. Construction is presently underway on a third structure on Revillon Coupé.

Results of past studies (Kennedy and Sprules 1967; Fernet 1971; Kooyman 1972; and Donald and Kooyman 1974) indicate that goldeye (*Hiodon alosoides*) migrate into waters of the Peace-Athabasca Delta, in spring, spawn and migrate back to the Peace River during summer and autumn. These studies have strongly suggested that the Chenal des Quatre Fourches is a major spring migratory route for adult and juvenile goldeye and a major summer and autumn migratory route for adult, juvenile, and fry of this species. Concern has arisen that water level control structures may block goldeye migration routes.

The major objectives of this study were the following:

1) to determine the age structure of the goldeye population in the Claire-Mamawi system; and
2) to estimate the spawning success of goldeye in this system.

A secondary objective was to collect information concerning seasonal movements of goldeye. Of tertiary importance was the examination of all collections for previously tagged goldeye.

PROJECT STUDY AREA

Goldeye investigations were conducted in the section of the Peace-Athabasca Delta in Wood Buffalo National Park, Alberta (Figure 1). More specifically, samples were obtained from Lake Claire, Prairie River, Mamawi Lake, Chenal des Quatre Fourches and associated channels, and Rivière des Rochers.

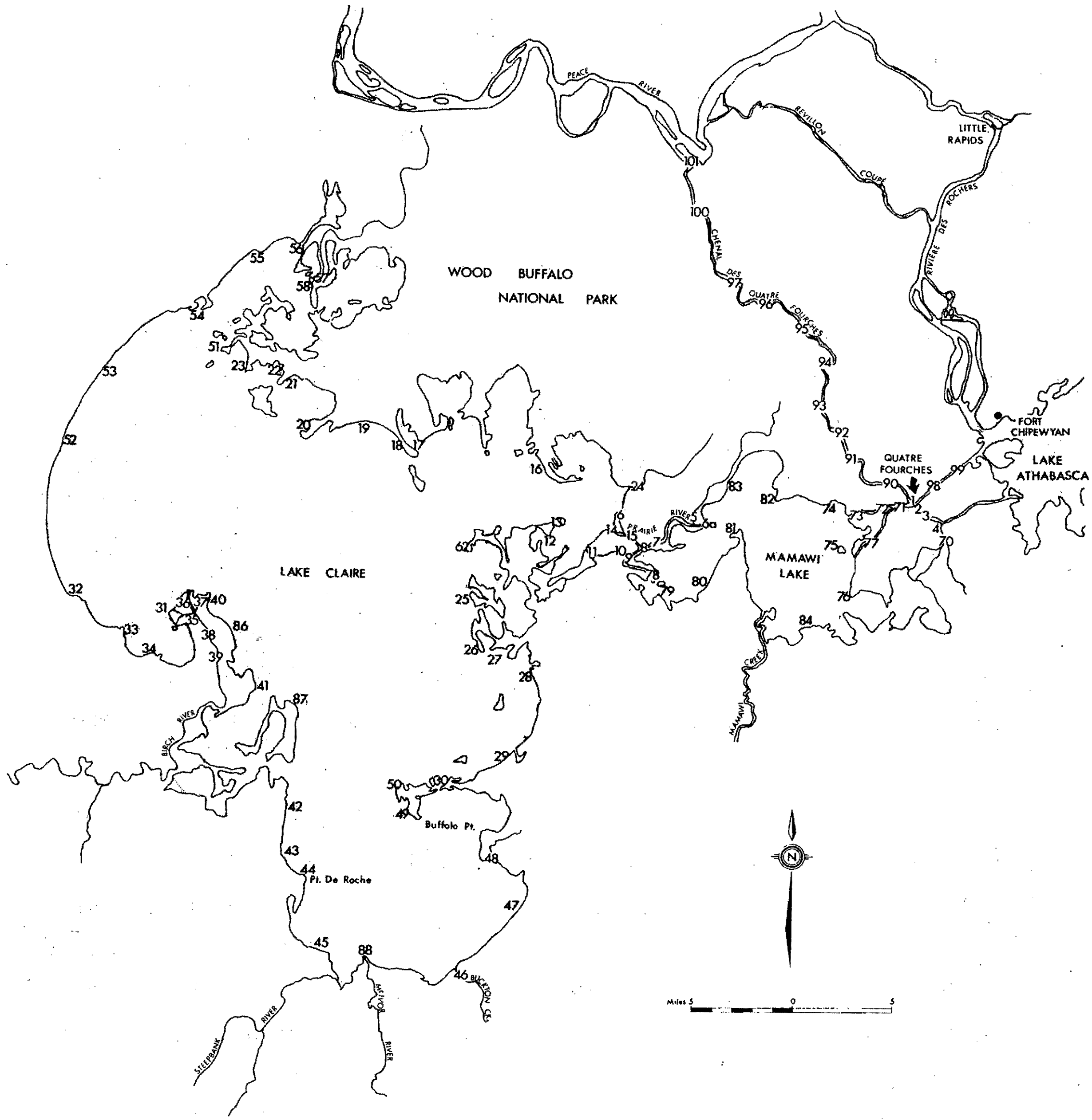

FIGURE 1. Project Study Area, 1975. Numbers Indicate Locations of Goldeye Fry Collections in August, September, and October.

METHODS

Hydrology

Hydrological data referred to in this report were obtained from the Technical Services Division, Alberta Environment, Fort Chipewyan Branch.

Trawl Sampling Techniques

The trawl nets and trawling methods used during this study were similar to those described in Part I, with the exceptions that trawl nets with 83-cm square mouths were used and that trawls were conducted for two minutes in all cases. In rivers, trawling was conducted in water between 1.0 to 1.5 m in depth and from 3 to 6 m from shore. In lakes, trawling was conducted in water between 1.0 to 1.5 m in depth and as close to shore as possible; these distances were recorded. During July and August, trawling was conducted from a 20-foot skiff powered by a 25 horsepower engine and during September and October from a 20-foot scow powered by a 20 horsepower engine.

Trawling for goldeye fry (fish hatched in 1975) was conducted from 29 July to 31 August and from 26 September to 22 October 1975. From 29 July to 5 August, samples were collected at 197 sites along the shoreline of Mamawi Lake and along continuous sections of shorelines of the west channels of Quatre Fourches and of part of Chenal des Quatre Fourches (Figure 2). The only areas not sampled during this period were the bays of Mamawi Lake which were too shallow for boat passage. During the remainder of August and during September and October, 479 trawls were conducted at sites that are numbered in Figure 1. Most of these sites were also sampled during studies conducted in 1972, and 1973 (Donald and Kooyman 1974). In numerous instances it was not possible to conduct trawls at sites that had been sampled in 1972 and 1973 because water levels during 1975 were lower than during these previous years.

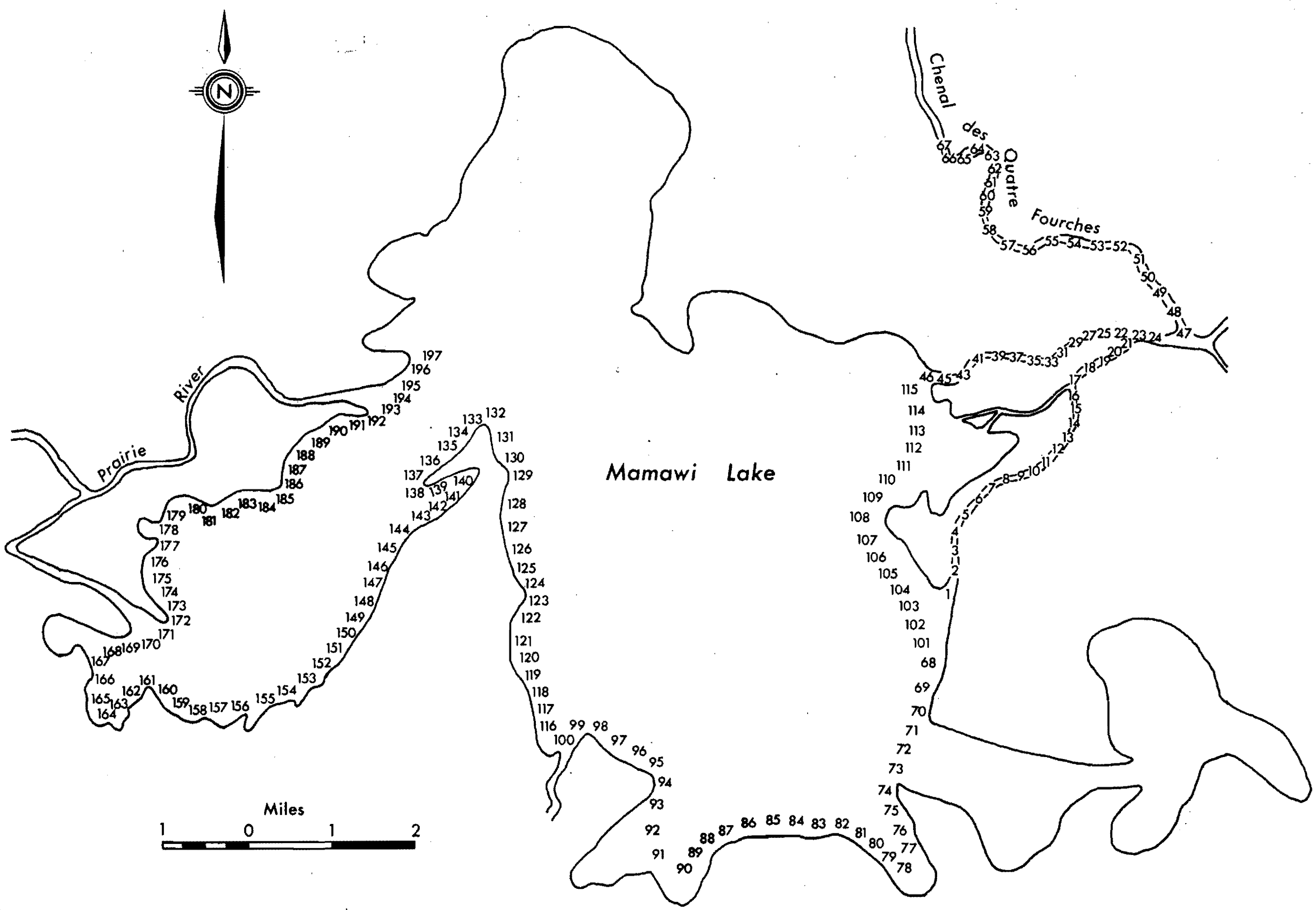

FIGURE 2. Sites Where Goldeye Fry were Sampled 29 July to 5 August 1975. Due to Lack of Space, Only Every Second Site Between 25 and 45 is Shown.

The number of species and the numbers of individuals of each species caught in all tows were recorded. Other than goldeye, only fish three or more centimeters in total length were counted. Goldeye fry were retained in formalin; most other species caught in tows were released after they had been counted.

Vegetation associations along shorelines adjacent to sampling sites were recorded (usually only to a broad taxonomic level).

Gillnet Sampling Techniques

Figure 3 shows the sites at which gillnetting for juvenile and mature goldeye was conducted from 19 July to 30 July and from 1 October to 23 October 1975. Fish from 1 to 5 years of age were classed as juveniles and fish 6 years or older were classed as mature. A monofilament survey gang net consisting of 50-foot lengths of 3½, 1½, 4, 2½, 1, 4½, 2, 3, and 3/4-inch stretched mesh nets (fished in respective order) was used during July. One 50-yard, 2½-inch stretched mesh braided nylon net was used during July and October. Nets were set perpendicular to and within approximately 300 m of shore. Gillnetting sites were chosen on the basis of information obtained from D. Donald (pers. comm. 1975) and local fishermen.

The numbers of individuals of all species caught in gillnets were recorded, and during eight of the nine collections made with the test gang net in July the numbers of individuals of all species caught were recorded in relation to mesh size.

The fork and total lengths, weight, and sex of all goldeye except fry were recorded. The sexes of large goldeye were determined on the basis of the sexually dimorphic shape of the anal fin. The sexes of smaller goldeye were validated through inspection of the gonads. All fish collected were examined for tags, scars left by lost tags, and fin clipping.

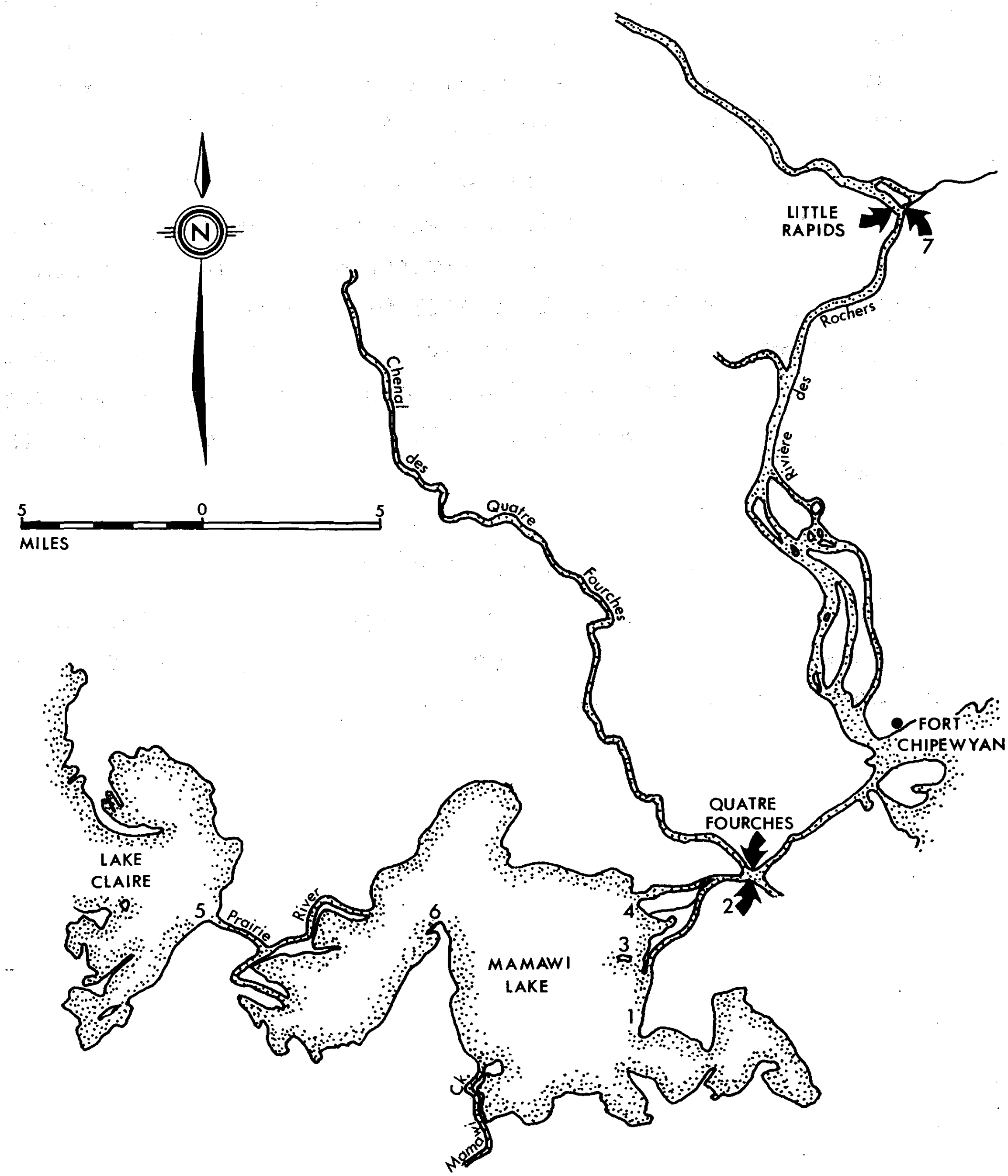

FIGURE 3. Locations (1 to 7) of Gillnet Sets, 1975.

Scales were removed from the area immediately ventral to the origin of the dorsal fin on the left side of all juvenile and mature goldeye collected in July and October. In the field, one sample of scales from each fish was sealed in a scale envelope, and another sample was mounted between two glass slides and labelled.

In the laboratory, mounted scales taken from juvenile and mature goldeye collected during July were aged independently by a technician and the senior author; ages were determined according to standard criteria (Chugunova 1963; Glenn 1975) for identification of annuli. In most cases, a minimum of three scales per fish was read to ensure that age was not based on malformed scales. When readers disagreed on age, they re-read and discussed the scales in question until they reached agreement.

Deposition of Data

Raw data pertinent to goldeye and other species caught during 1975 have been tabulated and deposited with the chairman of the Peace-Athabasca Delta Monitoring Committee.

RESULTS

Hydrology

Various hydrological parameters could affect the abundance and distribution of goldeye in the Peace-Athabasca Delta. A discussion of the effects of hydrological conditions upon goldeye movements in the Delta is given by Donald and Kooyman (1974). Briefly, during the winter, water from the Claire-Mamawi system flows slowly to the Peace River through Chenal des Quatre Fourches. During spring, the direction of current flow changes for a short period, approximately when break-up occurs; this altered current flows into the Delta. Shortly following break-up, the current direction again changes and flows out of the Delta and back to the Peace River. The main migration of goldeye in spring has occurred both with and against the current in different years (Donald and Kooyman 1974). During summer, movement of goldeye out of the Claire-Mamawi system is normally downstream. Current flow changes abruptly, however, for short periods of time when high winds create seiches in a direction opposite to the natural flow.

Table 1 summarizes 1975 water conditions in the Claire-Mamawi system. Water levels during 1975 were higher than those from 1968 to 1971 but lower than those during 1960 and 1972 (Peace-Athabasca Delta Project Group 1973a).

Goldeye Fry

Sampling

Results of intensive trawling conducted from 29 July to 5 August 1975 are given in Table 2. One of the purposes of these trawls was to determine whether catch rates at a few selected sites (Figure 1) were representative of those obtained by sampling entire shorelines.

TABLE 1. Summary of Hydrological Conditions in the Claire-Mamawi System During May to October, 1975.† Levels are in feet above mean sea level. Discharge is in cubic feet per second.

STATION NUMBER 33 - QUATRE FOURCHES

DATE	WATER TEMPERATURE(°C)	MEAN GAUGE HEIGHT(FT)	DISCHARGE(C.F.S.)
7 May	2	685.72	7860
5 June	-	685.54	3430
19 June	-	685.58	4140
4 July	20	685.67	1992
15 July	21	686.53	7370
1 August	-	686.74	10380
12 August	18	686.28	9280
25 August	14	686.42	10800
8 September	12	685.82	8810
22 September	8	686.40	10110
8 October	4	686.40	9170
21 October	3	685.92	9750

STATION NUMBER 46 - PRAIRIE RIVER NEAR LAKE CLAIRE

DATE	WATER TEMPERATURE(°C)	MEAN GAUGE HEIGHT(FT)	DISCHARGE(C.F.S.)
22 May	-	687.13	7360
13 June	-	686.93	4320
26 June	20	687.14	6690
8 July	21	687.54	6550
23 July	20	687.73	7690
7 August	17	687.63	8230
13 August	16	686.69	2160
15 September	9	687.50	6850
2 October	-	687.48	7090
16 October	-	687.25	5280

†Data obtained from Technical Services Division, Alberta Environment. Upon report completion date, the figures were unverified.

TABLE 2. Number of Goldeye Fry Collected in the Peace-Athabasca Delta 29 July to 5 August 1975.

LOCATION	NO. OF TRAWLS	MEAN NO. OF GOLDEYE CAUGHT PER TRAWL	STANDARD DEVIATION
Chenal des Quatre Fourches	21	0.19	0.68
West Channel of Quatre Fourches	46	0.13	0.54
Mamawi Lake			
1. West bay	65	0.14	0.43
2. South bay	44	0.02	0.15
3. East shore	21	0.05	0.22

The mean catch rate of intensive trawls conducted in Mamawi Lake was 0.08 fry per trawl (N = 130); this rate did not significantly differ (P > .05) from the mean catch rate (0.2 fry per trawl [Table 3]) of trawling at selected sites (N = 10) at approximately the same time. A modified Students' t test, which considers unequal sample sizes and unequal variances, was used to test for significance. On the basis of this statistical result it would appear that representative samples can be obtained at a few selected sites and that those results can be extrapolated. However, it is possible that the Students' t test is not entirely appropriate because variability in catch rates is large and produces extremely wide confidence limits. These preliminary field tests and analyses have not solved problems in the technique of sampling fry; therefore, data based on trawl catches must be interpreted with caution.

Distribution

Between 29 July and 5 August, 197 trawls were conducted in Mamawi Lake and in surrounding areas (Figure 2). As shown in Table 2, within Mamawi Lake high catches were obtained only in the west bay. From 6 August to 22 October, catch rates were also higher in the west bay than the rest of Mamawi Lake. These findings lend partial support to the results of Kooyman (1972) who recorded goldeye fry within Mamawi Lake only in the west bay.

Tables 3 to 7 show the mean numbers of goldeye fry collected at sampling sites (Figure 1) throughout the Claire-Mamawi system from 6 August to 22 October 1975. During this study, the greatest number of fry was collected in Lake Claire. Catch per trawl was normally higher along the north and west shores than along the south and east shores of this lake (Table 4). Fry collections taken in past years (Donald and Kooyman 1974) also indicate high catches along the north and west shores of Lake Claire. If the sampling yield of trawling provides a reliable basis for an estimate of the number of fish, then goldeye fry appear to manifest some degree of area preference within Lake Claire.

TABLE 3. Number of Goldeye Fry Collected from Sampling Sites at Mamawi Lake, August to October, 1975.

SAMPLING DATE	NO. OF SAMPLING SITES	MEAN NO. OF GOLDEYE CAUGHT PER TRAWL	STANDARD DEVIATION
8 August	10	0.20	0.42
17 August	10	0.10	0.32
25 August	10	0.20	0.63
2-4 October	10	0.00	0.00
7-8 October	10	0.20	0.42
15 October	10	0.50	0.97
21 October	10	0.20	0.42

TABLE 4. Number of Goldeye Fry Collected from Sampling Sites at Lake Claire, August to October, 1975.†

SAMPLING DATE	NORTH SHORE			WEST SHORE			SOUTH AND EAST SHORES		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
10-18 August	15	0.80	1.01	17	2.29	3.44	17	1.53	1.66
20-30 August	15	3.27	4.93	11	2.73	4.38	17	0.53	0.94
27 September-4 October	15	0.80	0.94	13	0.38	0.65	17	0.41	0.51

† N = Number of Sampling Sites, $\bar{X}$ = Mean Number of Goldeye Caught Per Trawl, and S = Standard Deviation.

TABLE 5. Number of Goldeye Fry Collected from Sampling Sites at Prairie River, August to October, 1975.

SAMPLING DATE	NO. OF SAMPLING SITES	MEAN NO. OF GOLDEYE CAUGHT PER TRAWL	STANDARD DEVIATION
8-11 August	9	2.44	5.34
17-20 August	9	0.78	1.64
24-25 August	8	2.75	5.82
29 September- 4 October	9	0.11	0.33
7 October	9	0.33	0.50
11 October	9	0.33	0.71
15 October	9	0.22	0.44
21 October	9	0.44	0.88

TABLE 6. Number of Goldeye Fry Collected from Sampling Sites at Chenal des Quatre Fourches, August to October, 1975.

SAMPLING DATE	NO. OF SAMPLING SITES	MEAN NO. OF GOLDEYE CAUGHT PER TRAWL	STANDARD DEVIATION
7 August	8	0.00	0.00
13 August	10	0.10	0.32
28 August	10	0.00	0.00
1 October	10	0.30	0.48
3 October	10	0.10	0.32
6 October	10	0.00	0.00
9 October	10	0.30	0.48
14 October	10	0.20	0.42
18 October	10	0.60	0.84
22 October	10	0.40	0.70

TABLE 7. Number of Goldeye Fry Collected from Sampling Sites at Quatre Fourches (East, West, and South Channels), August to October, 1975.

SAMPLING DATE	NO. OF SAMPLING SITES	MEAN NO. OF GOLDEYE CAUGHT PER TRAWL	STANDARD DEVIATION
6-7 August	9	0.00	0.00
13-15 August	10	0.00	0.00
21 August	11	0.27	0.90
26 September	11	0.18	0.40
3 October	11	0.00	0.00
6 October	11	0.00	0.00
10 October	11	0.09	0.30
17 October	11	0.18	0.40
22 October	11	0.00	0.00

The mean numbers of goldeye fry caught per trawl in Prairie River (Table 5) were similar to those caught per trawl in Lake Claire in 1975 but were lower than means caught in the same area in 1971 to 1973. On the basis of the relatively high numbers of fry that were collected in Prairie River and Lake Claire during August 1975, it is possible that goldeye prefer these two areas as spawning grounds. (It has been suggested that goldeye fry remain close to the area where they are hatched until they migrate out of the Delta [Donald and Kooyman 1974].)

Few goldeye fry were collected during August in Chenal des Quatre Fourches (Table 6) or in the east, west, and south channels of Quatre Fourches (Table 7). In comparison, Donald and Kooyman (1974) obtained variable but usually higher catches of fry in Chenal des Quatre Fourches and the west channel of Quatre Fourches.

Fry Movement

Because determination of seasonal fry movements was not a primary objective of this study, few data pertinent to such determination were obtained. The only potential indication of seasonal movement consists of the decreasing catch rates along the west and perhaps the north shores of Lake Claire (Tables 3 to 7). Slightly higher catches were obtained later in the season in Mamawi Lake and in Chenal des Quatre Fourches. These data are in agreement with those of Donald and Kooyman (1974), which indicate a movement of fry out of the Delta, through Mamawi Lake and Chenal des Quatre Fourches, to the Peace River where they are thought to overwinter.

Abundance of Goldeye Fry in the Claire-Mamawi System

Abundance of goldeye fry in the study area during 1975 was estimated through use of the method used by Fernet (1971). This method assumes that only water within 600 to 700 m of shoreline is used by goldeye fry and that catch rates are representative of total fry numbers. The following estimated calculations, which do not consider volume of water, must be made before fry numbers can be estimated. The average linear distance covered by one trawl net was 233 m. Diameter of trawl nets was 0.83 m, and two trawl nets sampled an average surface area of 387 m^2 during one two-minute tow. Fry numbers can then be estimated through use of the following formulae (Fernet 1971):

1) $$\text{possible number of sample tows} = \frac{\text{calculated surface area}}{\text{surface area in one tow}}$$

2) fry number estimate = possible number of sample tows X mean number of fry per tow

As shown in Table 8, the estimated number of fry in Lake Claire is much greater than in other regions of the study area. This estimate follows both from the larger size of Lake Claire and from the higher catch rates in this waterbody. For the following reasons, it is thought that estimates are minimal:

1) Lake volume was not considered.
2) Mean catch rates were based on catches throughout the summer and fall rather than on those during early summer, when fry should be most numerous.
3) Fry were assumed to be completely absent in waters beyond 600 to 700 m from shore.

Factors Potentially Affecting Abundance and Distribution of Goldeye Fry

Several factors--such as water temperatures, turbidity, currents, and weather--that may affect the abundance and distribution of juvenile and mature goldeye have been discussed in the pertinent literature. Factors that possibly affect abundance and distribution of goldeye *fry* have not to date been extensively researched.

Abundance of goldeye fry in relation to distance from shore is illustrated in Figure 4. Although based on a relatively small sample size there is an indication that higher numbers of goldeye fry do not occur at great distances from shore. Donald and Kooyman

TABLE 8. Population Estimates for Goldeye Fry in the Claire-Mamawi System, 1975.

WATERBODY	CALCULATED SURFACE* AREA WITHIN 600-700 M OF SHORE (M^2)	POSSIBLE NO. OF SAMPLE TOWS	MEAN CATCH** RATE	TOTAL ESTIMATED NO. OF FRY
Lake Claire	146,858,438	379,479	1.42	538,860
Prairie River	812,500	2,099	0.93	1,953
Mamawi Lake	15,725,000	40,633	0.20	8,127

* From Fernet (1971) and modified to include only areas within 600 to 700 m of shore.

** Calculated from total number of trawls.

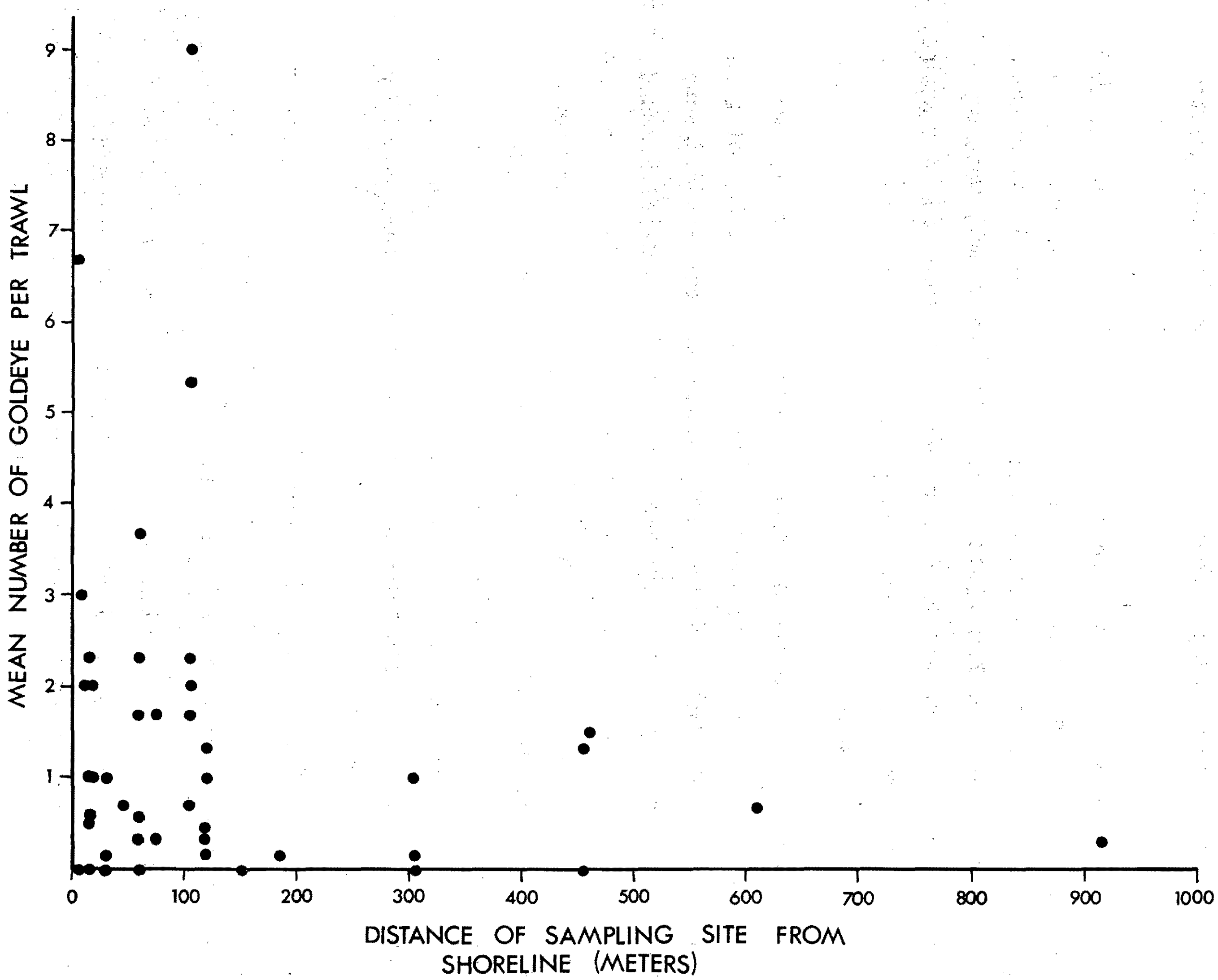

FIGURE 4. Number of Goldeye Fry Collected From Lake Claire and Mamawi Lake in Relation to Distance of Sampling Site from Shoreline. Only Those Sampling Sites Located Along *Lake* Shorelines Are Included.

(1974) found a strong inverse correlation between number of fry collected and distance from shore in Lake Claire. These data indicate that the inshore trawling technique used during this study and previous studies ensures that the areas that fry most prefer are sampled.

Table 9 shows the mean number of goldeye fry collected in relation to types of shoreline vegetation. Catches were especially high (3.67 fry per trawl) where ragwort (*Senecio* spp.) was present. Relatively smaller catches (1.44 to 1.11 fry per trawl) were obtained in areas (associations 2 to 6) where combinations of ragwort, grasses (many species), willow (*Salix* spp.), and sedge (*Scirpus validus*) were present.

Catches near the remaining plant associations (7 to 17) were less than half of those near associations 1 to 6. Catches of goldeye fry were consistently low in areas where horsetail (*Equisetum* spp.) grew along the shore. However, horsetail was usually found along narrow creeks with relatively clear water, and it is possible that fish are better able to avoid the trawl nets in water where visibility is greater. In addition, goldeye prefer turbid water to clear water (Paetz and Nelson 1970). These preliminary observations suggest that the habitat preferences of goldeye fry are related to shoreline vegetation or to other factors that possibly control vegetation type.

Additional flora listed in Table 9 include the following: balsam poplar (*Populus balsamifera*), smartweed (*Polygonum* sp.), red osier (*Cornus stolonifera*), and river alder (*Alnus tenuifolia*).

Interspecific interaction may also be a factor that determines distribution and abundance of goldeye fry. If competition with other species occurs, goldeye may avoid areas in which competitive species are distributed. To test this hypothesis, the relationship between mean number of goldeye fry and number of other species caught per trawl at sampling sites is plotted in Figure 5. The following species other than goldeye are included:

TABLE 9. Number of Goldeye Fry Collected in the Peace-Athabasca Delta, August to October 1975, in Relation to Shoreline Vegetation at Sampling Sites.†

ASSOCIATION NUMBER	SHORELINE VEGETATION ASSOCIATION[1]	N	$\overline{X}$	S
1	Ragwort	3	3.67	5.51
2	Grasses - ragwort	16	1.44	2.73
3	Ragwort - grasses	12	1.42	1.51
4	Willow - grasses	58	1.41	3.19
5	Grasses - willow	29	1.41	3.38
6	Grasses - sedge	9	1.11	1.54
7	Willow - ragwort	19	0.42	0.69
8	Grasses	48	0.42	1.32
9	Willow	95	0.41	1.80
10	Balsam poplar	21	0.38	0.97
11	Sedge	45	0.36	0.74
12	Smartweed - ragwort	3	0.33	0.58
13	Horsetail - willow	18	0.33	0.77
14	Red osier - willow	10	0.30	0.67
15	Alder - red osier or alder-willow	22	0.27	0.55
16	Willow - horsetail	52	0.12	0.38
17	Horsetail	18	0.00	0.00

† N = number of trawls, $\overline{X}$ = mean number of goldeye fry collected per trawl, S = standard deviation.

[1] The most abundant or the most abundant plus second most abundant taxonomic groups are listed.

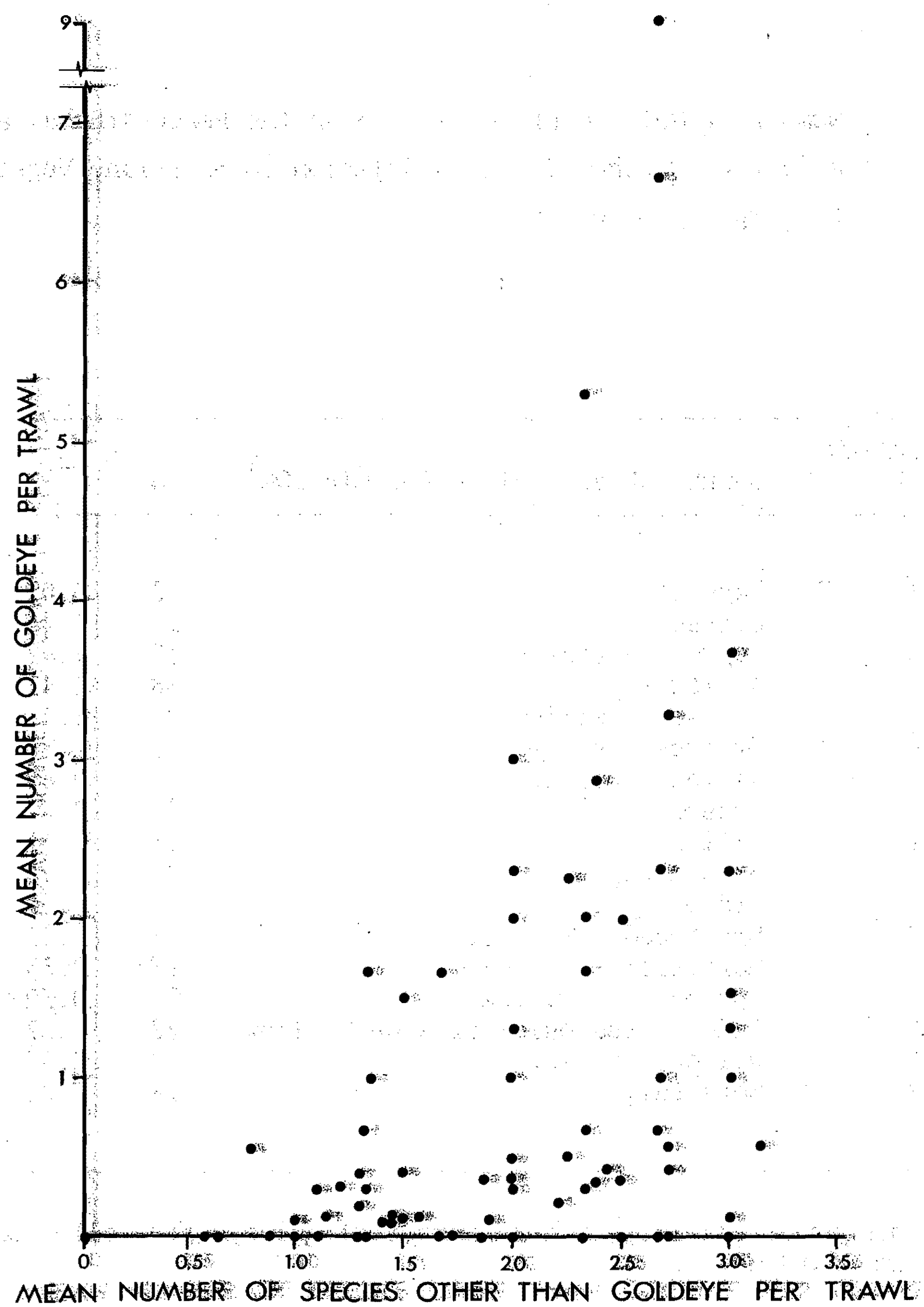

FIGURE 5. Number of Goldeye Fry Collected in the Claire-Mamawi System in Relation to Number of Other Species Collected at Sampling Sites.

spottail shiner (*Notropis hudsonius*), emerald shiner (*Notropis atherinoides*), flathead chub (*Platygobio gracilis*), trout-perch (*Percopsis omiscomaycus*), ninespine stickleback (*Pungitius pungitius*), and fry of lake whitefish (*Coregonus clupeaformis*), northern pike (*Esox lucius*), sucker (*Catostomus catostomus* or *C. commersoni*), and walleye (*Stizostedion vitreum*). On the basis of data presented in Figure 5, it appears that goldeye fry do not avoid areas where increased numbers of other species occur; in fact, the highest counts of goldeye fry were obtained in areas where relatively high numbers of other species were also present. The occurrence pattern suggests that some resource is in common demand and/or that some habitat type is preferred by many small species and young of larger species.

Presently available data indicates the following:

1) that shorelines are preferred habitats of goldeye fry;
2) that vegetation type or a factor controlling vegetation type influences fry distribution along shorelines; and
3) that goldeye fry inhabit areas that also contain a relatively greater number of other fish species.

Abundance and Distribution of Juvenile and Mature Goldeye

A list of juvenile and mature goldeye caught in gillnets in 1975 appears in Table 10. Although relatively small numbers of fish collections were made and although collections were very spaced temporally, catch per unit effort at sites 1 and 2 in Mamawi Lake and at Quatre Fourches, respectively (Figure 3) suggest that large numbers of goldeye occurred in these parts of the Delta near the end of July. In 1972 and 1973 high catches of goldeye per unit effort were also obtained in the same areas during late July and early August (Donald and Kooyman 1974). This time period corresponds with the summer migration of all age groups out of the Claire-Mamawi system (Donald and Kooyman 1974).

TABLE 10. Gillnet Catches of Goldeye in the Peace-Athabasca Delta, July to October 1975.†

SAMPLE SITE NUMBER [1]	DATE OF SET	NO. OF HOURS OF SET	NO. OF GOLDEYE CAUGHT	NO. OF GOLDEYE PER 50 YDS OF NET PER HOUR
1[2]	23 July	4.00	14	3.5
	24 July (a.m.)	2.75	49	17.8
	24 July (p.m.)	4.92	42	8.5
	2 October	5.67	8	1.4
2	25 July	1.00	4	4.0
	30 July	1.92	184	95.8
	1 October	7.42	38	5.1
	10 October	5.08	11	2.2
	14 October	7.08	8	1.1
3	27 July (a.m.)	5.25	27	5.1
	27 July (p.m.)	3.50	20	5.7
4	28 July (a.m.)	4.50	33	7.3
	28 July (p.m.)	5.75	12	2.1
5	7 October	4.67	1	0.2
6	11 October	5.42	0	0.0
7	19 October	4.92	133	27.0
	23 October	2.42	47	19.4

† Only fish caught in 2-, 2½-, or 3-inch mesh (extension measure) nets are included.

[1] See Figure 3.

[2] One set made at sample site 1 is not included because record was not kept of the number of fish caught per mesh size.

As was the case during past studies, catch per unit effort during autumn in the Mamawi-Quatre Fourches region was extremely low in 1975; this level suggests that by autumn most goldeye have migrated out of the Claire-Mamawi system.

During October, catch per unit effort was high immediately upstream from the Little Rapids weir (site 7, Table 10). These catch levels are difficult to interpret because the presence of the weir possibly hindered goldeye from crossing the structure and caused fish to congregate at the site. In 1975 and in previous years (Donald and Kooyman 1974), catch per unit effort was low during the same time of year in other parts of the Delta. On 23 October, most goldeye (81%) entered the gillnet from the east, which suggests that a downstream movement toward the weir was in progress. The large number of goldeye that were gillnetted at Little Rapids suggests that Rivière des Rochers is a more important migratory route for goldeye in and out of the Delta than is suggested by Donald and Kooyman (1974).

Gillnet Selectivity

In an attempt to equally sample goldeye of all sizes, a survey gang gillnet was used during nine of 10 sets in July. Data in Table 11 indicate that the majority of goldeye were caught in nets of 1½-to 3½-inch mesh size. In 1975, many goldeye were caught in nets only by their teeth; therefore the size of fish caught in a net is not completely dependent upon mesh size (as can be the case with other species which are caught primarily by their gills). However, nets of mesh size smaller than 1½-inch and larger than 3½-inch caught only approximately 3% of the total catch. Had there been a greater proportion of mature goldeye in the 1975 population, it is probable that the 4- and 4½-inch mesh nets would have been more successful.

TABLE 11. Number of Goldeye Collected in the Claire-Mamawi System, 1975, Using a Survey Gang Net.†

MESH SIZE (INCHES)[1]	DATE								PERCENT OF TOTAL[2]
	23 JULY	24 JULY (a.m.)	24 JULY (p.m.)	25 JULY	27 JULY (a.m.)	27 JULY (p.m.)	28 JULY (a.m.)	28 JULY (p.m.)	
3/4	0	0	1	0	1	0	0	0	1
1	0	0	1	0	0	0	1	0	1
1 1/2	3	13	5	1	3	4	2	4	14
2	6	33	18	3	17	10	14	5	41
2 1/2	5	10	16	1	4	4	13	3	22
3	3	6	8	0	6	6	6	4	15
3 1/2	3	3	2	2	0	0	2	3	6
4	1	0	1	0	0	0	0	0	1
4 1/2	0	0	0	0	0	0	0	1	0

† One fish collection is not included because record was not kept of the number of fish caught per mesh size.

[1] Extension Measure.

[2] Because percentages are rounded off, they don't add up to 100.

Recovery of Marked Goldeye

Goldeye in the Peace-Athabasca Delta were marked with coloured flag tags, numbered spaghetti tags, and/or through fin clipping in 1972, 1973, and 1974 (Donald and Kooyman 1973 and 1974; D. Donald pers. comm. 1975).

All fish collected during this study were examined closely for tags or clipped fins. No tags were recovered; nor were any scars from lost tags noted. Several goldeye possessed what appeared to be malformed dorsal or anal fins--not to be confused with the more straight-edged fins clipped for marking purposes.

Although no marked goldeye were recovered during this study, one was caught on 3 August 1975 at the Quatre Fourches junction by a local fisherman. Unfortunately, this fish had been cleaned and hung to dry, and an orange flag tag had been thrown away. Examination of the partial carcass of this fish indicated that it was an adult female approximately 500 to 600 grams in weight. A scar from the removed tag was also noted on the left side of the carcass. This fish was probably tagged in 1973 (D. Donald pers. comm. 1975).

Biological Characteristics of Juvenile and Mature Goldeye

Age Structure

Scales from 507 goldeye collected in July were aged. Complete agreement between scale readers occurred on 89.7% ($^{455}/507$) of the scale samples. After disagreed-upon scales had been re-read, the extent of agreement was 97.4% ($^{499}/507$). Eight scale samples were discussed in detail until the two readers reached agreement. Approximately one-half of the incorrectly-aged scale samples were misinterpreted by each reader. (One reader consistently counted one more annulus than the other reader.) In most cases, misinterpretations were results of overlooked criteria used in determining ages, particularly looking for checks and marginal annuli (Chugunova 1963). As pointed out by Godfrey and Worlund (1968), useful criteria in interpretation of scales could be formulated if readers compared the processes by which they assigned ages to individual scales.

The age frequency of goldeye caught during July is presented in Table 12. Approximately 85% of the total catch consisted of 4-year olds. This cohort comprised 81% of the female catch and 91% of the male catch. Fish older than 4 years comprised less than 3% of the catch. Only one 9-year old was captured, and 7 and 8-year olds were completely absent from the catch.

Sex

Females significantly (at the 95% level) outnumbered males in year-classes 2 and 4 (Table 12). When classes were combined, females were significantly (at the 95% level) more numerous than males. Because 85% of the 1975 catch consisted of 4-year old goldeye, results of sex-ratio analysis are not considered to be reliably applicable to other age groups. Donald and Kooyman (1974) found that in 1973 male and female goldeye were equally represented in the year-class hatched in 1971. In 1975, 58% ($^{250}/431$) of the same year-class was composed of females.

Weight-Length Relationship

The weight-length relationship of goldeye collected during July 1975 is illustrated in Figure 6. No differences in the weight-length relationship of males or females were noted when these factors were plotted in a manner similar to that shown in Figure 6. From the shape of the curve in Figure 6, it is evident that the fork length and weight of young goldeye increase at similar rates. At 2 and 3 years of age (see Figures 7 and 9), weight begins to increase at a greater rate than fork length. The correlation coefficient for the weight-length relationship of male and female goldeye combined is approximately 0.93. This high value supports the near-linear relationship shown in Figure 6.

TABLE 12. Age Frequency and Sex Ratio of Goldeye Gillnetted from Sampling Sites at Mamawi Lake and Quatre Fourches in July, 1975. Chi-square Values and 95% Significance Levels are Shown.

AGE	NO. OF FEMALES	NO. OF MALES	χ^2	DIFFERENT (95%)[1]	TOTAL	% OF TOTAL[2]
1	2	0			2	<1
2	35	9	15.36	+	44	9
3	12	6	2.00	-	18	4
4	250	181	11.34	+	431	85
5	5	2			7	1
6	2	2			4	1
7	0	0			0	0
8	0	0			0	0
9	1	0			1	<1

[1]Statistical analysis was conducted with only those cohorts where sample size was greater than 10.

[2]Percentages are rounded off.

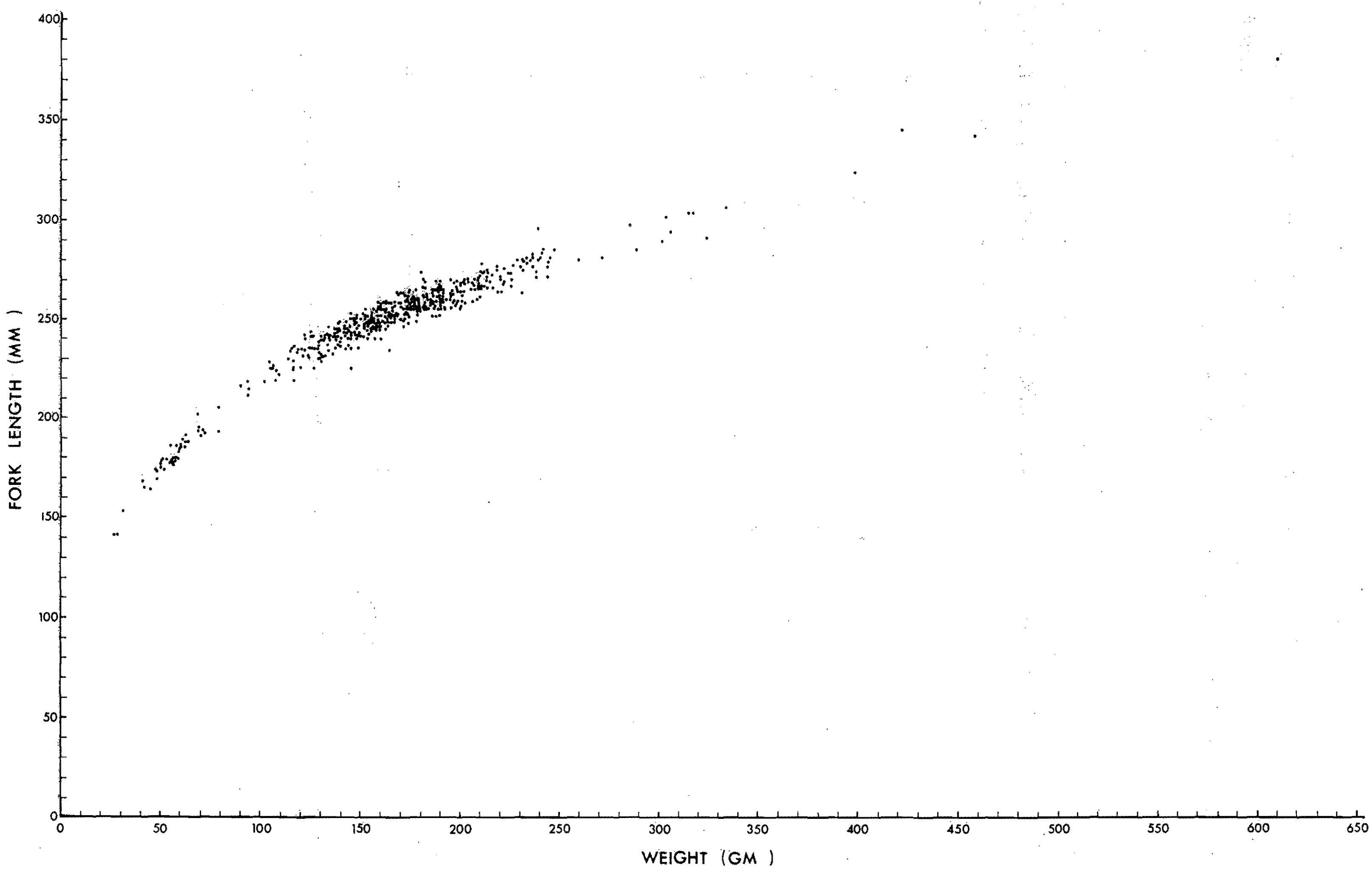

FIGURE 6. Weight-Length Relationship of Goldeye (Sexes Combined) Gillnetted in the Claire-Mamawi System, July 1975. Only Points That Would Have Fallen on Top of Other Points are Excluded.

Age-Length Relationship

The age-length relationships of male, female, and total goldeye captured during July 1975 are shown in Figure 7. A decreased growth rate is evident for 4 and 5-year old fish. Figure 8 compares the age-length relationships of goldeye caught in the Peace-Athabasca Delta from 1947 to 1948 (Kennedy and Sprules 1967), during 1973 (Donald and Kooyman 1974), and during 1975. Growth rates during 1975 were apparently higher than those during 1947 and 1948, but it appears that a decreased growth rate has occurred in age classes 4 and 5 since 1973. Because the majority of goldeye (excluding fry) in the 1975 sample were 4-year olds (85%), it is possible that this decreased growth rate is significant. In part, the apparent decrease in growth may be an artifact produced by collection of the 1975 fish sample during early and mid-summer. It is also possible that competition among goldeye hatched in 1971 and similarly-sized fish has increased with time as they have become larger.

Age-Weight Relationship

The age-weight relationship of goldeye collected in the Claire-Mamawi system during 1975 is shown in Figure 9. This figure indicates that by 1975 the rate of weight increase had decreased in 4 and 5-year old goldeye. This trend may not be as pronounced as it appears in Figure 9 because of the small sample sizes for 5 and 6-year olds (Table 12); however, these data correspond to those presented in the previous section to the extent that 4 and 5-year old goldeye are not as heavy nor as long as were fish of the same age in 1973 (Figure 8).

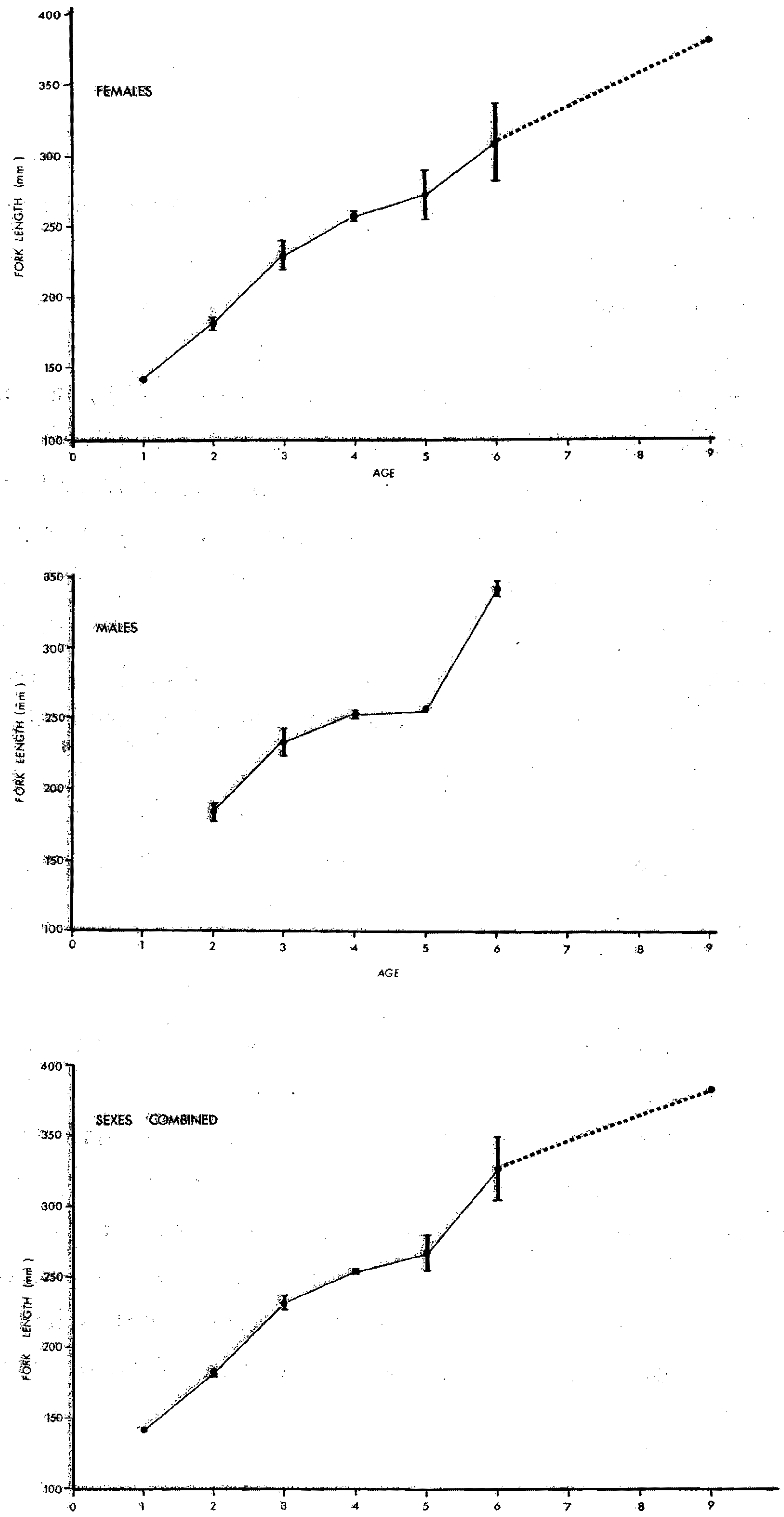

FIGURE 7. Age-Length Relationship of Goldeye Gillnetted in the Claire-Mamawi System, July 1975. Means and 95% Confidence Intervals are Shown, When Possible.

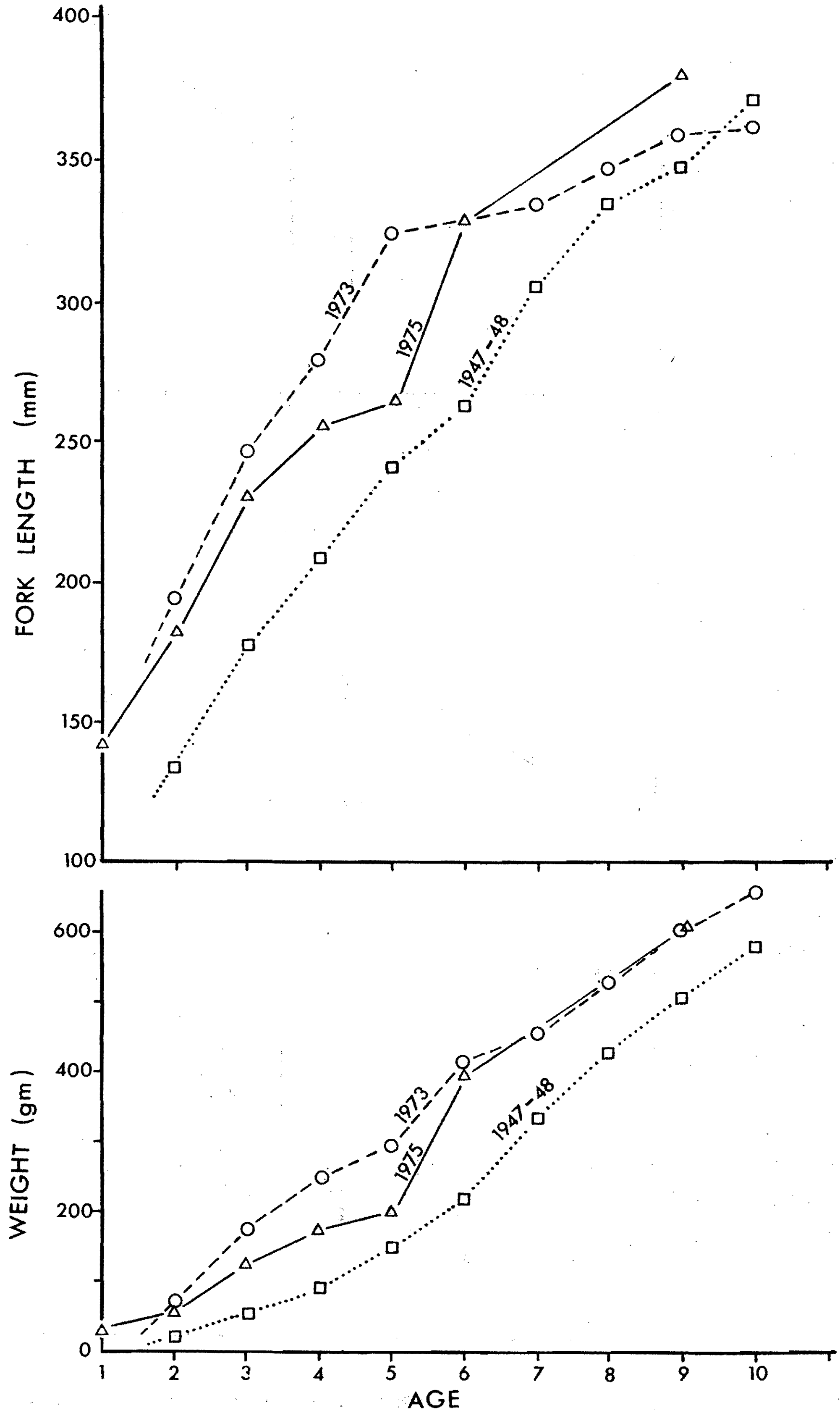

FIGURE 8. Age-Length and Age-Weight Relationships of Goldeye in the Peace-Athabasca Delta, 1947-48, 1973 and 1975.

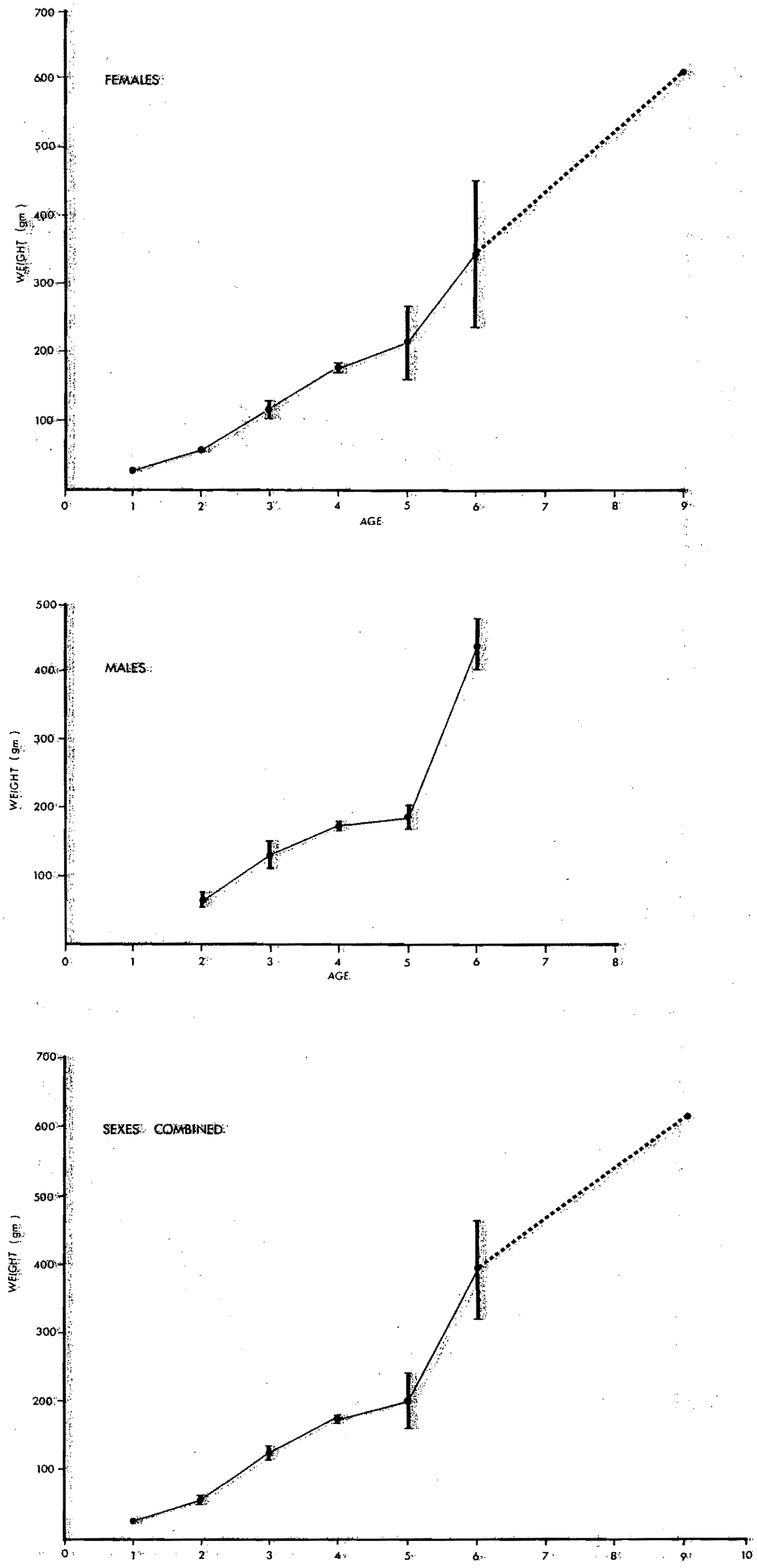

FIGURE 9. Age-Weight Relationship of Goldeye Gillnetted in the Claire-Mamawi System, July 1975. Means and 95% Confidence Intervals are Shown, When Possible.

DISCUSSION

Hydrological Effects on Goldeye

On the basis of incomplete data (see Table 10) it is estimated that the peak movement of goldeye out of the Claire-Mamawi system through Quatre Fourches in 1975 occurred between 24 and 30 July, when the water temperature was approximately 20°C, the water level was approximately 686.74 ft (209.32 m), and the rate of discharge was approximately 10,380 c.f.s. at Quatre Fourches.

Average water levels were markedly lower (more than 1.0 ft in Lake Claire and Mamawi Lake) during 1971 (Peace-Athabasca Delta Project Group 1973a) than during 1975. That the spawning success of goldeye--based on the estimated number of goldeye fry (see Table 13) and the large proportion of 4-year olds in the 1975 fish collections--was much higher in 1971 than in 1975, suggests that low water levels do not necessarily negatively affect spawning in this species.

Goldeye Spawning Success - 1975

The number of goldeye fry in the Claire-Mamawi system was partially dependent upon the size of the spawning population that entered the Delta in 1975. During the early spring of 1975, very few mature fish were gillnetted (D. Donald pers. comm. 1975). Gillnet catches during late July 1975 suggest a very small spawning population; in fact, less than 1% ($^{5}/507$) of the catch during this month consisted of mature individuals (6 years or older). During this same period (late July) in 1972 and 1973, peak catches of mature goldeye were obtained (Donald and Kooyman 1974). These data suggest a cause-effect relationship between a small spawning population of goldeye that entered the Claire-Mamawi system in 1975 and the relatively low numbers of fry of this species that were captured.

Table 13 lists estimated numbers of goldeye fry produced in 1971 and in 1975. These estimates suggest that recruitment to the population was approximately five times greater in 1971 than in 1975.

Age Structure

Data obtained during 1975 support the results of previous studies (Kooyman 1972; Donald and Kooyman 1974) that indicate that the 1971 year-class of goldeye in the Claire-Mamawi system is extremely successful. Eighty-five percent of the catch in 1975 was composed of 4-year olds. As Donald and Kooyman (1974) point out, several factors possibly contributed to the success of the 1971 year class. In 1971, the previously strong year-class of 1964 entered the spawning population as 7-year old fish. This segment of the spawning population produced the now abundant 4-year old age class.

Successful reproduction, however, is not necessarily guaranteed by a large spawning population. Two previously successful year-classes entered the spawning population in 1972 as 7 and 8-year old fish, but the 1972 year-class was relatively unsuccessful.

There are two additional factors that were possibly of advantage to goldeye hatched in 1971 (Donald and Kooyman 1974). Mature goldeye migrated into the Delta earlier in 1971 than in 1972 and 1973, and spawning in 1971 was therefore completed about a week earlier than during the two following years. Also, that the stomachs of goldeye fry contained more food in 1971 than in 1972 and 1973 perhaps indicates more plentiful food sources during that year. Success of the 1971 year-class was possibly enhanced by the increased length of the growing season in combination with the abundant food supply in 1971.

Given the assumption that goldeye in the Claire-Mamawi system mature at approximately 7 (Kennedy and Sprules 1967) or possibly

TABLE 13. Estimated Numbers of Goldeye Fry in 1971 and 1975.

WATERBODY	1971*	1975
Lake Claire	2,800,000	538,860
Prairie River	18,000	1,953
Mamawi Lake	21,000	8,127

* From Kooyman (1972) and modified to include only surface area within 600 to 700 m of shore.

6 (Donald and Kooyman 1974) years of age, there should be a large number of fish entering the spawning population of this system in 1977 and 1978.

Age classes above the 4-year old class were very poorly represented in the 1975 population (Table 12). That the 1967 to 1970 year-classes were also poorly represented in previous studies (Donald and Kooyman 1974) indicates possibly weak 1960-63 year-classes. In 1971, 1972, and 1973, the 1964 and 1965 year-classes were strongly represented. It should be remembered that strong 1964 and 1965 year-classes probably contributed to a successful 1971 year-class. However, no 10 or 11-year olds (1964 and 1965 year-classes, respectively) were collected during 1975, and only one goldeye older than 7 years of age was collected in 1975.

Older fish (10 to 13-year olds) were well represented in Lake Claire in 1947 and 1948 (Kennedy and Sprules 1967). Eight-year olds comprised the dominant year-class in Lake Claire in 1954 (Schultz 1955). The extremely low number of older goldeye now present in the Delta has been attributed to commercial fishing (Donald and Kooyman 1974). Figure 10 presents catch curves that represent goldeye populations in three areas: Lake Texoma (Oklahoma), Saskatchewan Delta, and Lake Claire. Catch curves of goldeye collected during 1947 to 1948 and during 1975 from Lake Claire compare a relatively unexploited population (1947-48) with one that has been heavily fished (1975). Despite the termination in 1966 of commercial fishing for goldeye in the Peace-Athabasca Delta, the population had not recovered by 1975; that is, the 1975 population lacked the natural age composition evident in the 1947 and 1948 populations. The catch curve plotted for goldeye collected in the Saskatchewan Delta from 1945 to 1947 is intermediate between the catch curves of goldeye taken from Lake Claire in 1947 and 1948 and in 1975; this position of the Saskatchewan Delta catch curve suggests that fishing in the Saskatchewan Delta was not as intense as it was in Lake Claire. The catch curve plotted for the virtually unfished population of goldeye from

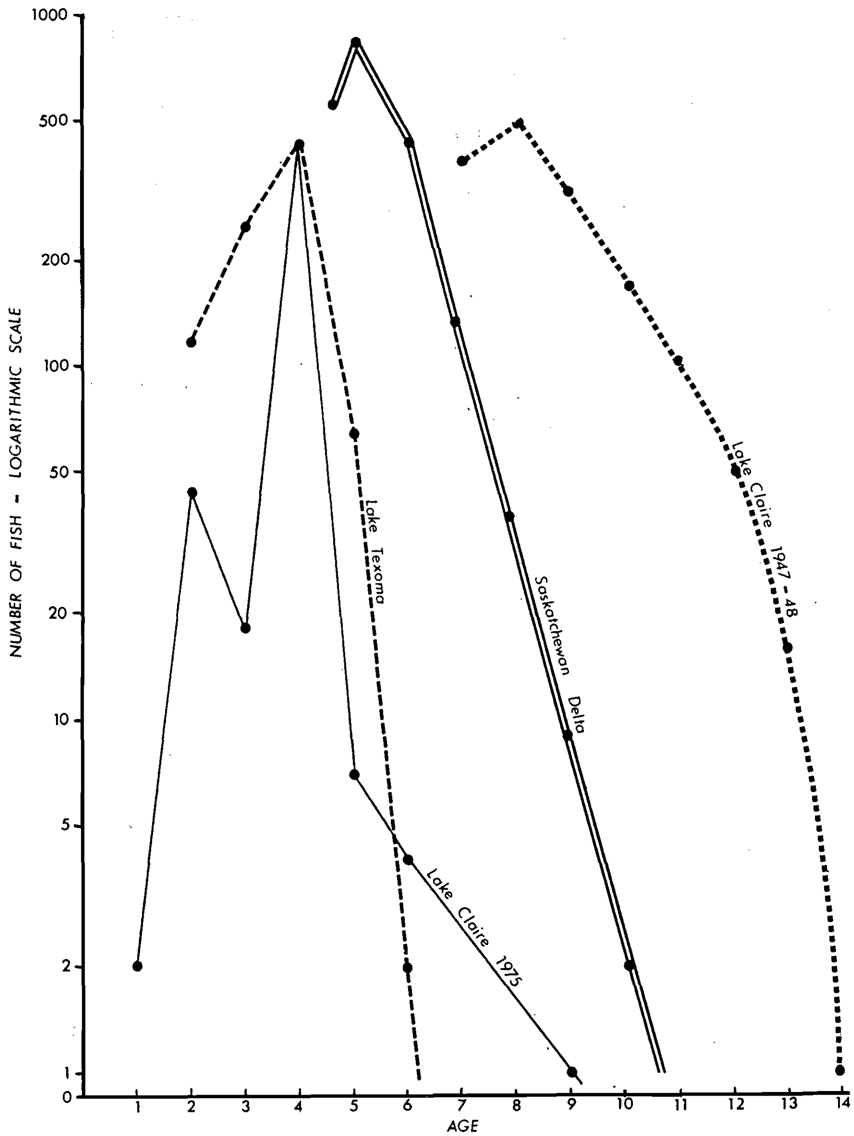

FIGURE 10. Goldeye Catch Curves Based on Data from TABLE 12 and Published Data from Kennedy and Sprules, 1967.

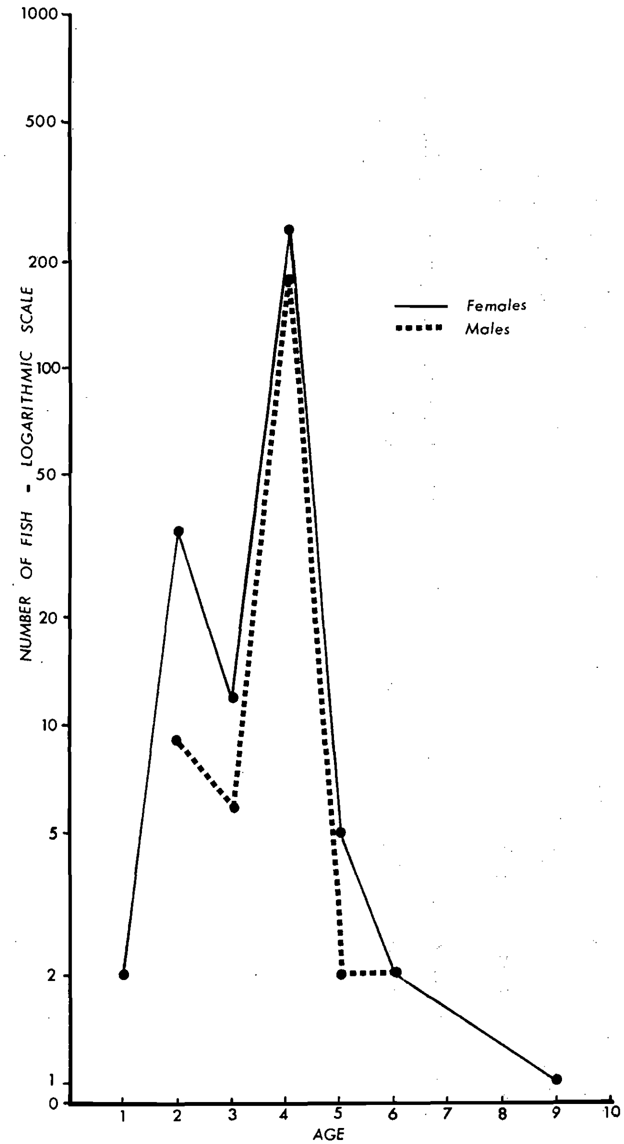

FIGURE 11. Goldeye Catch Curves Based on Data from TABLE 12.

Lake Texoma is similar to that for goldeye taken from Lake Claire during 1975. Kennedy and Sprules (1967) attributed the absence of goldeye older than 7 years to higher mortality rates in populations in southern latitudes.

The comparison between catch curves for female and male goldeye collected during 1975 is illustrated in Figure 11.

SUMMARY

The major results and conclusions of this study are the following:

1) Recruitment to the 1975 goldeye population in the Peace-Athabasca Delta was estimated to have been approximately 550,000 fry (approximately one-fifth of the recruitment in 1971).
2) It was not possible to absolutely assess the spawning success of goldeye in the study area in 1975 because the number of spawners was unknown. In relative terms, spawning in 1975 appeared to be less successful than that in 1972 and 1973.
3) That eighty-five percent of the goldeye population (excluding fry) consisted of fish that were 4 years of age reflects the large number of fry that were produced in 1971.
4) It is probable that the number of spawners in the goldeye population of the study area will be greatly increased in 1977 and 1978, when the 1971 year-class will reach sexual maturity.
5) In 1975, 4 and 5-year old goldeye were not as large in terms of length and weight as were goldeye of similar age groups in 1973. Possible causes of this lower growth are decreased food supply and increased intensity of competition with increased size of goldeye. (It must be remembered that 4-year old goldeye formed most of the 1975 population; hence, large numbers of similarly-sized fish were present.)
6) Preliminary field work suggests that the distribution of goldeye fry is correlated with type of shoreline vegetation or with a factor that controls type of shoreline vegetation.

PART III. INSPECTION OF THE LITTLE RAPIDS WEIR SITE

By

J. Kristensen

INTRODUCTION

In early September 1975, construction of a submerged weir was completed at Little Rapids, on Rivière des Rochers; the purpose of this weir is to hold back water flowing out of Lake Athabasca and parts of the Peace-Athabasca Delta. (For a detailed description of the weir, see Peace-Athabasca Delta Project Group 1973a.) Because it is possible that such structures negatively affect the normal movements of fish, construction should include designs of adequate passageways for fish.

Ground inspections of the above-mentioned weir site were conducted 22 September, 24 September, and 16 October 1975. One aerial inspection of the site was conducted from a Cessna 185 12 October 1975. The major objective of these inspections was to derive procedures to be used in future studies that will attempt to determine whether fish can successfully move across the weir and/or fishway.

RESULTS AND DISCUSSION

During ground inspections, several approximate measurements were taken of the fishway. These measurements are listed in Table 1. On the basis of data gathered during ground and aerial inspection, several sites close to and on both sides of the weir and fishway have been mapped as being suitable for setting of gillnets (Figure 1). Nets cannot be set too close to the weir or fishway because of strong turbulence.

The dam constructed across the Flett bypass channel (Figure 1) was also inspected. Water in this channel can flow through the rock-fill dam, but fish cannot pass through this structure. Studies of fish movement at Little Rapids are presently in the planning stages, and it may be necessary to travel back and forth between the north and south sides of the weir. A track and hand-operable winch for hauling boats have been constructed across the Flett bypass channel dam. Approximately three-quarters of an hour and 2000 revolutions of the winch were required to haul a 20-foot scow one way across the dam. Unless a different system is constructed, it is recommended that two vessels--one for each side of the weir--be utilized in any future studies at the weir site.

Information collected during inspections of the weir site, together with a collection of photographs taken during inspection, should aid the planning of future research at this site. Recommendations (based on the above-given information) for studies of fish movement across the weir and fishway have been outlined in separate unpublished reports.

A reconnaissance of the Little Rapids weir was also conducted by Drs. S.B. Smith and B.R. Hammond on 1 October 1975; their manuscript report (1975) adequately describes physical conditions and possible fisheries problems at the weir and the fish channel. We concur with the above authors in that:

TABLE 1. Measurements of the Fishway at Little Rapids.

The following approximate measurements were made of the fishway at Little Rapids on Rivière des Rochers 16 October 1975:

1) Length of fishway: 210 m.

2) Width of fishway:
   (i) 4.3 m at the upstream end.
   (ii) 5.2 m at the downstream end.
   (iii) 14.6 m at the widest point.
   (iv) 3.0 m at the narrowest point.

3) Depth of fishway:
   (i) Varies from 0.9 to 1.8 m.
   (ii) 1.2 m at the upstream end.
   (iii) 0.9 m at the downstream end.

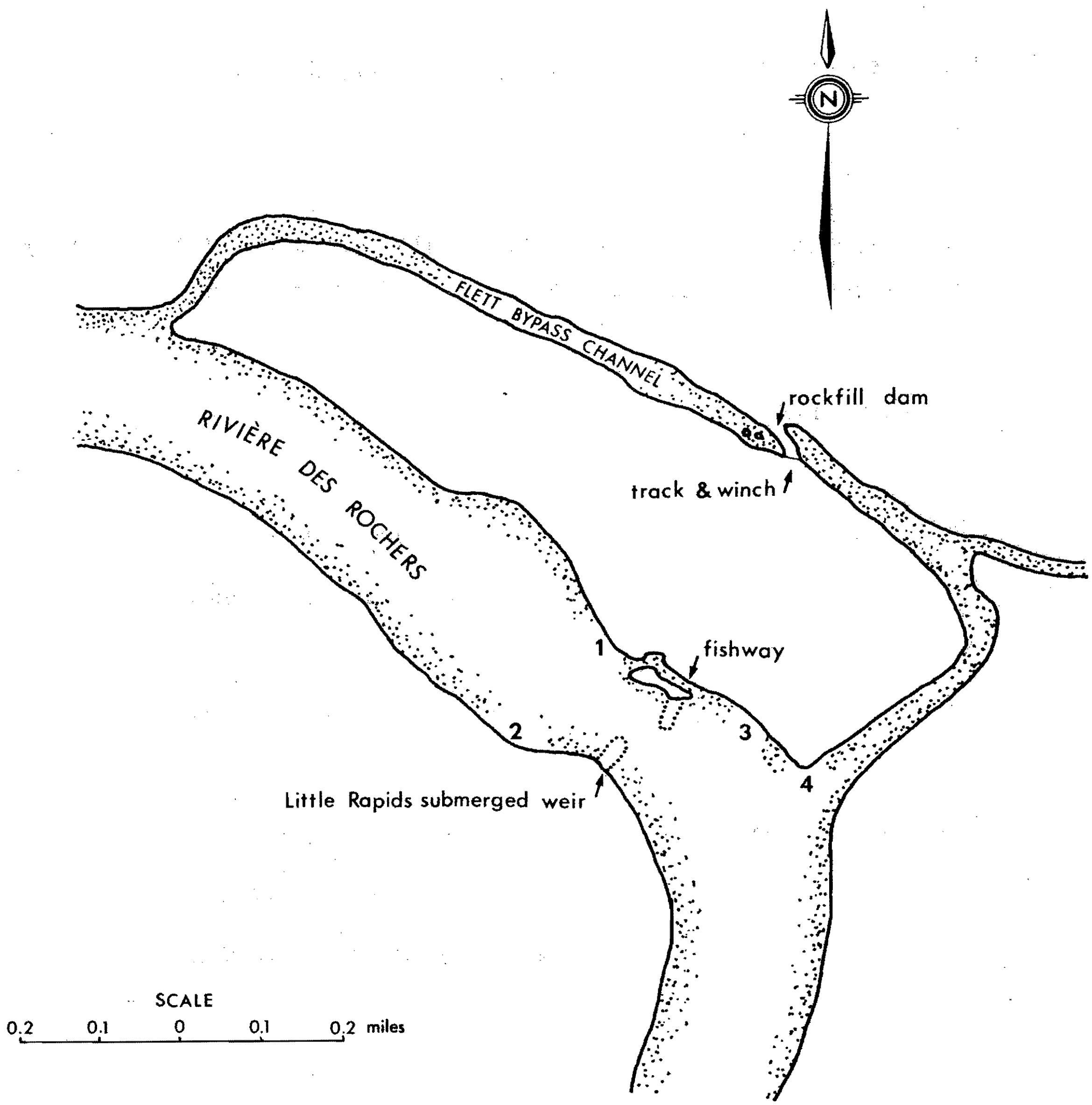

FIGURE 1. Little Rapids Weir Site Showing Suitable (Numbered) Locations for Setting Gillnets. Current Flow is Northwest.

1) Current velocity across the weir could hinder upstream movement of fish.
2) Current velocity within the fishway appears even greater than that across the weir, and passage of fish through this channel could be difficult.
3) The downstream mouth of the fishway appears to be located so far downstream of the weir that fish will probably have difficulty locating the fishway.

PART IV. FIELD TRIALS OF ACRYLIC DYE FISH MARKING TECHNIQUE

By

J. Kristensen and B.S. Ott

INTRODUCTION

Some research concerning marking of fish with injected dyes has recently been conducted (Kelly 1967; Smith 1970; and Lotrich and Meredith 1974). Although these studies have not been able to determine how long various dyes last, use of injected dyes has proven to be economical, rapid and relatively easy. The 1975 investigations of walleye and goldeye in the Peace-Athabasca Delta included tests intended to assess the feasibility of marking fish in the field with acrylic dye.

METHODS

Basically, the dye marking technique involves injection of a dye subcutaneously in the desired anatomical location of the fish with a needle of appropriate size. (For a more detailed description of this technique see Kelly [1967] or Fernet [unpublished manuscript report].) It is important that the dye be injected in an area where it will be easily visible to the observer, yet not render the fish susceptible to increased predation. Also, an appropriate dye colour that will produce an easily recognizable mark must be used. Care must be taken not to use colours that will blend with natural fish colours or with blood caused by hemorrhaging incurred by gillnetting. Results of experimentation will produce shapes and sizes of marks that will be applicable to the objectives of specific investigations.

MARKING OF WALLEYE

A total of 38 walleye were marked during sets made on 3, 5, 7, 14, and 16 September 1975 in the portion of Lake Athabasca in the vicinity of Fort Chipewyan. Gillnets that were used varied in mesh size from 1- to 4½-inch.

The actual marking procedure took from 10 to 15 seconds per fish; with further practice, the time required for this procedure could be reduced.

Most walleye were injected on the operculum; a few were injected on the lower jaw with "phthalocyanine blue" acrylic dye (brand name, "Liquitex"). A 1-to-20 dilution of dye in water produced an easily recognizable mark. One and one-half-inch (20G) needles were found to be most satisfactory for fish greater than 25 cm long; 5/8-inch (25G) needles were found to be best for fish less than 25 cm long.

Injection was accomplished more easily on the operculum than on the lower jaw, but because skin pigmentation on the lower jaw is lighter, the dye was more visible on the latter location. The dye appeared as a circle approximately 2 cm in diameter on the operculum and as thin lines running along the lower jaw.

MARKING OF GOLDEYE

On 23 October 1975, 47 goldeye were gillnetted immediately above the recently constructed weir at Little Rapids. A 50-yard, 2½-inch mesh gillnet was set for a total of 2 hours and 25 minutes. The net was checked three times at half-hour to one-hour intervals. A total of 52 minutes was spent removing fish from the net. Care was taken to minimize injury and scale loss. Previous to marking, fish that had been removed from the net were retained in tubs full of water. After they had been marked, fish were placed in retaining tubs, where their activity was observed briefly in order to ensure that no noticeable injury had been incurred. Fish were then carefully released. A total of 31 minutes was spent injecting fish with dye, observing their subsequent activity, and releasing them. Approximately 15 seconds were spent injecting each fish; at this rate, it would be possible to mark over 200 fish per hour. Only one fish was observed to die after having been released; this individual had been severely injured by a northern pike while in the gillnet.

Goldeye were injected at the origin of the anal fin with "phthalocyanine blue" acrylic dye. The origin of the dorsal fin was also found to be a suitable injection site. Approximately 3 c.c. of 1-to-20 dilution dye were used to mark 47 goldeye. A 3 c.c. plastic syringe with a 20G 1½-inch shank needle was used to inject the dye. Other needle sizes were tested but were found less suitable.

The dye appeared as a thin line along the entire basal length of the fin. In a few cases, the dye did not flow along the base but, rather, produced a round, thumb tack-size mark at the origin of the anal fin.

MARKING OF OTHER SPECIES

Between 30 and 40 northern pike and lake whitefish, respectively, that were caught incidental to walleye and goldeye were also marked. The most suitable injection site on northern pike was the base of either pelvic fin, where a blue patch (1 cm diameter) was formed. Due to problems encountered in handling of pike, a greater amount of time was spent marking fish of this species.

Injected blue dye was easily visible anywhere on the ventral surface of lake whitefish but was most visible at the base of the adipose fin. Blue dye is noticeable almost anywhere on lake whitefish where marking is practicable due to the light colour of this species.

Preliminary testing suggests that marking of walleye and goldeye subcutaneously with acrylic dye is relatively quick and simple and that such marking would be an efficient technique to use in future studies of walleye and goldeye movement. Other species can also be marked through use of this method. The permanence of the mark on the above-mentioned species is unknown.

GLOSSARY OF TAXONOMIC NAMES

The following glossary presents the taxonomic names and their English-language equivalents used in this report. Scientific and common nomenclature of fish are according to Scott and Crossman, Freshwater Fishes of Canada, 1973, and the naming of flora follows Moss, Flora of Alberta, 1959.

Fish

Catostomus catostomus - longnose sucker
Catostomus commersoni - white sucker
Coregonus clupeaformis - lake whitefish
Esox lucius - northern pike
Hiodon alosoides - goldeye
Notropis atherinoides - emerald shiner
Notropis hudsonius - spottail shiner
Percopsis omiscomaycus - trout-perch
Platygobio gracilis - flathead chub
Pungitius pungitius - ninespine stickleback
Stizostedion vitreum - walleye

Flora

Alnus tenuifolia - river alder
Cornus stolonifera - red osier
Equisetum spp. - horsetail
Polygonum sp. - smartweed
Populus balsamifera - balsam poplar
Salix spp. - willow
Scirpus validus - sedge (common great bulrush)
Senecio spp. - ragwort

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