Canadian Technical Report of

Fisheries and Aquatic Sciences 1407

December 1985

AN ANALYSIS OF THE 1984 WALLEYE, *Stizostedion vitreum vitreum* (Mitchill), RUN AT CREAN LAKE IN PRINCE ALBERT NATIONAL PARK, SASKATCHEWAN WITH REFERENCE TO THE IMPACT OF SPAWN-TAKING

by

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This is the 190th Technical Report

from the Western Region, Winnipeg

Cat. no. Fs 97-6/1407E ISSN 0706-6457

Correct citation for this publication is:

Mathias, J.A., J.A. Babaluk, and K.D. Rowes. 1985. An analysis of the 1984 walleye, *Stizostedion vitreum vitreum* (Mitchill), run at Crean Lake in Prince Albert National Park, Saskatchewan with reference to the impact of spawn-taking. Can. Tech. Rep. Fish. Aquat. Sci. 1407: iv + 34 p.

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ABSTRACT

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The Canada Department of Fisheries and Oceans has identified Crean Lake, Prince Albert National Park, Saskatchewan as the only known Canadian site where it is feasible to obtain walleye, Stizostedion vitreum vitreum (Mitchill), eggs containing the distinctive genetic marker required for the department's stocking programs. The persistence of the distinctive malate dehydrogenase alleles in the Crean Lake population was confirmed by examining 102 fish. The unique gene frequency has remained unchanged since 1971.

In 1984, 974 migrating walleye were intercepted and 71 females were spawned to produce approximately 3.36 million eggs. A sample of 336 walleye were measured, tagged, and released. Ages were determined. The migration of walleye, as well as that of several associated species: cisco, Coregonus artedii Lesueur; lake whitefish, Coregonus clupeaformis (Mitchill); yellow perch, Perca flavescens (Mitchill); northern pike, Esox lucius Linnaeus; and white sucker, Catostomus commersoni (Lacépède) was described.

The Crean Lake walleye population was examined for evidence of any negative impact arising from nine years of intensive spawn-taking between 1967-1975. It was concluded that there was no evidence that the previous spawn-taking had depressed the strength of particular year-classes or that it had resulted in an unexpected, small 1984 walleye migration; there was no relationship between the number of eggs laid between 1967 and 1975 and the strength of resulting year-classes; and the incidence of disease in Crean Lake walleye had not increased from 1975 levels.

The "health" of the Crean Lake walleye stock appeared good as shown by several strong age-classes composing the spawning population; moderate growth rates of males and females; and the large average size and age of the fish which suggested a low level of exploitation.

Key words: age composition; diseases; genetic tag; growth; migrations; spawning run; water temperature; impact.

RESUME

Mathias, J.A., J.A. Babaluk, and K.D. Rowes. 1985. An analysis of the 1984 walleye, Stizostedion vitreum vitreum (Mitchill), run at Crean Lake in Prince Albert National Park, Saskatchewan with reference to the impact of spawn-taking. Can. Tech. Rep. Fish. Aquat. Sci. 1407: iv + 34 p.

Le ministère fédéral des Pêches et Océans a établi que le lac Crean, situé dans le Parc national Prince-Albert, en Saskatchewan, constituait le seul endroit au Canada où l'on pouvait procéder à la cueillette d'oeufs de doré, Stizostedion vitreum vitreum (Mitchill), qui renfermaient le marqueur génétique requis par les programmes d'accroissement de population du Ministère. On a confirmé la persistance d'un allèle de déshydrogénase de malate distinct dans la population du lac Crean grâce à l'examen de 102 individus. La fréquence génétique unique de ces poissons est demeuré inchangée depuis 1971.

On a intercepté en 1984, 974 dorés en migration et fécondé 71 femelles afin de produire environ 3,36 millions d'oeufs. Un échantillonnage de 336 dorés a été mesuré, étiqueté et relâché. On a établi l'âge et décrit la migration des dorés et de quelques autres espèces apparentées: cisco de lac, Coregonus artedii Lesieur; grand corégone, Coregonus clupeaformis (Mitchill); grand brochet, Esox lucius Linné; meunier noir, Catostomus commersoni (Lacépède).

On a examiné la population de dorés du lac Crean afin de déceler toute trace de retombées négatives de neuf années de cueillette intensive d'oeufs, entre 1967 et 1975. On arriva à la conclusion qu'il n'y avait aucune répercussion négative des cueillettes d'oeufs précédentes sur l'importance numérique des individus d'une année de fécondation particulière; cela n'avait donné en outre lieu à aucune petite migration inattendue de dorés en 1984. Il n'y avait aucun rapport entre le nombre des oeufs produits entre 1967 et 1975 et le nombre des individus nés ultérieurement. De plus, le taux de maladie n'avait pas crû depuis 1975.

La "santé" de la population de dorés du lac Crean a semblé bonne, comme l'ont démontré plusieurs classes d'âge saines composant la population reproductrice, les taux de croissance modérés des mâles et des femelles, et les grandes dimensions moyennes et l'âge des poissons étudiés, ce qui semblait dénoter un faible taux d'exploitation.

Mots-clés: distribution par âge; maladies; biopolymorphisme; croissance; migrations; migrations reproductrices; température de l'eau.

INTRODUCTION

The Fisheries Rehabilitation Research Project is a new research and development program of the Canadian Department of Fisheries and Oceans. Its objectives are to evaluate techniques for the rehabilitation of depleted stocks of walleye, Stizostedion vitreum vitreum (Mitchill). A number of techniques, such as stocking larval walleye, stocking juvenile fish, and rehabilitating stream spawning habitats, will be tested at Dauphin Lake, Manitoba (51°17'N, 99°48'W). It is anticipated that the results of this research will be transferable to other lakes in Canada where walleye stocks are depleted.

One of the first questions to be answered is: "how effective is larval stocking for rebuilding walleye populations?". Governments in Canada and the United States have spent millions of dollars to produce walleye fry for stocking, yet the usefulness of the technique is still open to considerable debate (Laarman 1978).

The success of larval walleye stocking can be evaluated only if the stocked fish can be distinguished from naturally produced fish. Genetically distinct fish, found in Crean Lake, Prince Albert National Park, Saskatchewan (54°05'N, 106°09'W) (Fig. 1) offer the only solution to this problem at the present time, because the small size of larval walleye precludes marking them artificially. Three forms of the enzyme malate dehydrogenase can be found in walleye muscle tissue (Clayton et al. 1971, 1973). A single fish can contain two of the three forms at most, so that six combinations (or MDH phenotypes) are possible. The phenotypes of walleyes from Crean Lake are generally quite distinct from the phenotypes of walleyes from other parts of western Canada (Clayton et al. 1974).

In order to evaluate walleye stocking techniques, it was proposed that 50 million walleye fry, originating from Crean Lake, be stocked into Dauphin Lake each year for four years. The primary objective of the Fisheries Rehabilitation Research Project in 1984 therefore, was to procure 70 million walleye eggs from Crean Lake. (It was assumed that about 70% of these eggs would hatch, yielding approximately 50 million fry.)

A second objective, associated with the collecting of walleye eggs, was to confirm that the unique gene frequency found by Clayton et al. (1974) was still present and unchanged in the Crean Lake walleye population in 1984.

Crean Lake falls under the management jurisdiction of Parks Canada. A 1979 policy developed by Parks Canada defines activities which are compatible with natural resource management, as those which are non-manipulative. Of equal concern are activities which have adverse effects upon park resources, operations, management, or visitor use. Therefore, a third objective of this study was to examine the Crean Lake walleye stock for evidence of adverse impact caused by massive spawn-taking by the Saskatchewan Department of Parks and Renewable Resources and the Canadian Wildlife Service between 1967 and 1975. If the average annual removal of 54 million eggs in those years had had an adverse effect on population size, a depression of the relative strength of the year-classes of fish produced between 1967 and 1975 might be expected.

A fourth objective of the study was to assess the "health" of the present spawning stock of walleye in terms of age distribution, growth rates, mortality rates, and disease status. This is closely related to the issue of environmental impact.

Finally, this study sought, as a fifth objective, to provide a detailed description of a natural phenomenon (the spawning migration) which could potentially be of use to Parks Canada in an interpretative context for the public.

MATERIALS AND METHODS

Crean Lake is situated in Prince Albert National Park in central Saskatchewan (Fig. 1). It receives water from the Hanging Heart chain of lakes and drains into Montreal Lake (54°20'N, 105°40'W) to the east.

Fish comprising the Crean Lake spawning migration are presumably resident in Crean Lake during the winter, but migrate through the Crean Lake - Hanging Heart Lake channel (Fig. 1) in the early spring. The channel is shallow (1-2 m in depth) and water flow in it is highly variable, both in velocity and direction. Approximately one half way along its length, a narrows in the channel, provided a good location for a fish trap.

The configuration of the fishing structure is shown in Fig. 2. A wooden walkway and platforms for tending the fish trap, spawning fish, and hardening the eggs were suspended from wooden fence posts driven into the channel bottom. Female walleye were held in a 5.5 m x 5.5 m net pen and males were held in a 3.1 m x 3.1 m net pen. The fish trap was a pound net with a 3.0 m x 3.0 m cage. Smaller pens (1.0 m x 1.0 m) were used to hold fish prior to measuring, tagging, and release. Trap leads (12.7 mm bar mesh) extended from the trap to both shorelines and were anchored to the stream bottom by rocks and vertical wooden stakes. A Weksler recording thermometer measured water temperatures 0.5 m from the stream bottom, and observations were made on the direction of water flow.

A net barrier was installed across the channel on April 17 to prevent fish from migrating during trap construction. The barrier was removed on April 20, and the fish trap remained operational for the following three weeks, from April 20 to May 11.

Fish caught in the trap were removed, identified, and counted three times per day; at 0900 h, 1400 h and 2000 h. Walleye were sexed on the basis of body size or the type of sexual product expelled upon squeezing the abdomen. Females were scored as green, ripe, or spent by squeezing the abdomen and noting whether eggs were present but not extruded, were extruded, or were not present, respectively. Each walleye was scored also for the presence of dermal sarcoma, lymphocystis, or epidermal hyperplasia. Non-diseased female walleye which were green or ripe were placed into the large holding pen for later spawning as were non-diseased males. Diseased fish were held in a small holding pen until they could be measured and released.

Approximately 35% of the walleye caught were sampled for fork length (mm), round weight (g), and sex. The second spine of the first dorsal fin was removed for age determination. Ages were determined as described by Campbell and Babaluk (1979). The fish were marked with yellow Floy (spaghetti) tags bearing a four digit numerical code unique to each fish. A complete description of these fish is given in Appendix 1.

Eggs were fertilized in the following manner: sperm from one male were stripped into a large stainless steel mixing bowl, containing a small amount of water. All the eggs from one female were then stripped into the bowl followed by the sperm from another male. The eggs and sperm were then stirred with a large goose feather. This procedure was continued until six females were expended, and ended with addition of sperm. Water was added to almost fill the bowl and stirring was continued for approximately two minutes. Water in the spawning bowl was replaced by clean water several times until the eggs were clean. The eggs were then transferred to a large tub of water and were continually stirred with periodic water changes, until eggs were no longer adhesive (approximately one hour). The partially hardened eggs were then placed in wood-framed, screened boxes and immersed in the channel to complete hardening.

Tissue samples of approximately 2 g were taken from 72 live fish using biopsy needles as described by Uthe (1971). These samples were analysed for the frequency of alleles for supernatant malate dehydrogenase according to the methods of Clayton et al. (1971). All fish undergoing this treatment or any other form of measurement were anesthetized with M.S. 222 (m-aminobenzoic acid ethyl ester methane sulphonate, Kent Chemicals, Vancouver). Anesthetized fish were held in pens until fully recovered; then released.

RESULTS AND DISCUSSION

ENVIRONMENTAL CONDITIONS AND WALLEYE SPAWNING MIGRATION

The Crean Lake walleye migration was intercepted and spawn was taken for nine consecutive years between 1967 and 1975 by the staff of the Province of Saskatchewan Fort Qu'Appelle Fish Hatchery and the Canadian Wildlife Service. Information about the migrations is presented in Appendix 2. These historical data allow construction of a time versus water temperature "window" (Fig. 3) which encompasses the 95% confidence limits for the dates and temperatures which were associated with the start and finish of the walleye migrations in those years. The inner window of Fig. 3 shows the mean dates and temperatures of the walleye migrations. Also plotted are the daily maximum and minimum temperatures measured during the 1984 spawning expedition.

During the period 1967-75, the average temperature at the beginning of the walleye migration was 6.9°C on April 27, and the lower (95% confidence) limit was 5.8°C on April 25. In 1984, these temperatures were reached for a short period almost a week earlier, on April 18. These conditions presumably caused walleye to begin moving upstream, since the trap caught 24 fish on April 20, the first day of operation (Fig. 4). The migration at that time was not large, however, because a net barrier to prevent fish movement had been in place since April 17. If a large number of fish had tried to move upstream between April 17 and 20 the barrier would have prevented them until it was removed on April 20, and then we would have observed a larger number of fish in the trap. Night searches with a spotlight in front of the barrier, between April 17 and 20, showed that very few fish were active.

From April 20 to 23 water temperatures fell, and the migration remained low and constant at about 25 walleye per day. When water temperatures began to rise again on April 24, the run doubled to about 50 fish per day (Fig. 4). The gradual increase in the number of walleye migrating until May 5 was caused largely by an increase in the number of males and immature fish (Fig. 5A). In contrast, the rate at which females moved into the trap was relatively constant and low (Fig. 5B). During the course of the migration the percentage of females gradually decreased from approximately 50% at the beginning to approximately 20% at the end (Fig. 6). This pattern is quite different from Bodaly's (1980) observations of walleyes at Southern Indian Lake, Manitoba. In two streams during 1977 he observed that the male:female ratio was 3:1 and 14:1 as the runs started, and rose to 18:1 and 52:1 just prior to the peak of the runs. It then approached 1:1 in both streams near the end of the runs. We can offer no explanation for the difference in pattern between our results and Bodaly's.

Water flow at the fish trap was highly variable, both in velocity and direction and was not related to the number of fish migrating. On 17 out of 21 days, the flow direction reversed at least once during the day, and the distribution of flow-direction was about equally divided between the two directions over the study period. Both the velocity and direction were strongly influenced by wind. During a north wind, the normal flow from Heart Lake to Crean Lake was reversed. Flow velocities in the channel ranged from 0.0 - 1.5 $cm \cdot s^{-1}$.

Females captured before April 27 were green (not ready to spawn but gravid). After that, ripe (ready to spawn) females began to enter the trap in small numbers until May 9 (Fig. 5B). Although green females continued to migrate throughout the entire study period, the presence of spent females after April 28, and the decline in the numbers of green and ripe females after May 5 (Fig. 5B) indicated that walleye had begun to spawn in Crean Lake.

The large walleye migrations of previous years (average = 7 768 fish, Appendix 2) did not materialize in 1984. The total number of walleye caught was only 974. There were anomalous warm temperatures prior to April 17 (Fig. 3). This could have caused the fish to migrate up the Crean-Heart lakes channel prior to installation of the net barrier. An alternative explanation for the small walleye migration is that early warm temperatures followed by low temperatures caused the run to abort. This is suggested by the fact that many walleye migrations normally used for spawn-taking in Manitoba were, also, unusually small or failed to materialize in 1984 (B. Schaldemose, Manitoba Department of Natural Resources, Winnipeg, personal communication). Derback (1947) observed that a reversal of the normal warming trend in a tributary stream of Heming Lake, Manitoba slowed the walleye run considerably. Bodaly (1980) concluded that the migration of stream spawning walleyes at Southern Indian Lake, Manitoba was triggered by temperatures of about 5°C, and made repeated observations of slowing or stoppage of the walleye run in response to reversals in the warming trend.

SPAWN-TAKING ACTIVITIES

As female walleye arrived in the trap, they were held in net pens until a quantity sufficient for mass spawning was obtained (Table 1). Fish from the holding pens were spawned on April 29 and May 6. Fish spawned at other times were taken directly from the fish trap.

Holding female walleye in the net pens did not result in their complete ripening. Of 165 females accumulated in the pen from April 20 to May 6, about 76% were still green on May 6 while approximately 14% were ripe and approximately 10% had released eggs in the pen. In future spawn-taking programs it is recommended that only females approaching the 'ripe' state be held in holding pens. In these females the ovaries are clearly swollen, but also quite soft. Females in which the ovaries are swollen but hard should be allowed to pass upstream to ripen and spawn.

A total of 71 females were spawned during the operation, with an estimated egg production of 3.36 million eggs.

FISH MIGRATION IN THE CREAN-HEART LAKES CHANNEL

Five other species of fish were moving from Crean Lake to Heart Lake at the same time as walleye: white sucker, _Catostomus commersoni_ (Lacépède); northern pike, _Esox lucius_ Linnaeus; cisco, _Coregonus artedii_ Lesueur; lake whitefish, _Coregonus clupeaformis_ (Mitchill); and yellow perch, _Perca flavescens_ (Mitchill). Cisco and whitefish are fall spawners, so their movements were not related to spawning activity and showed little discernible pattern (Fig. 7 and 8A, respectively). Of the spring spawning species, yellow perch exhibited the strongest peak movement (Fig. 8B), with strong migrations on April 30 and May 1 when day water temperatures reached 8.0°C in the channel.

Northern pike were already moving strongly on the first day of trap operation (Fig. 8C), and their rate of migration declined gradually over the study period from approximately 225 fish per day to less than 50 fish per day. The total number of pike captured was 2 375 fish, about 25% higher than the 1967-75 average of 1 880 fish.

Relatively few white sucker (624) migrated through the channel, while the trap was operational. The greater part of the migration occurred before May 1 (Fig. 8D).

Walleye migration is nocturnal. Over 95% of walleye captured had entered the trap between 2000 h and 0900 h (Fig. 9A). Of the other species, white sucker (Fig. 9A), northern pike (Fig. 9B), and lake whitefish (Fig. 9A) also exhibited mainly nocturnal movement, but less strongly than walleye. Cisco (Fig. 9B) showed little preference in time of day for their movements, while yellow perch, a major prey of walleye and northern pike, made approximately 90% of their migration during the day.

CONFIRMATION OF GENE FREQUENCY STRUCTURE

The frequency of alleles for malate dehydrogenase (MDH), which was found in Crean Lake walleye in 1971-72 (Clayton et al. 1974), was observed to be unchanged in 1984. Table 2 shows the percent of walleye with each MDH phenotype and the frequency of the alleles in the population. The frequency of the same alleles in the walleye population of Dauphin Lake are shown for comparison (Table 2). It can be seen that fish with the phenotypes b_1,b_1 and b_1,b_3 can be identified as originating from Crean Lake with a high degree of certainty. Fish with phenotypes b_2b_2 and b_2b_3 originate from Dauphin Lake fish, and fish with the b_1b_2 or b_3b_3 phenotypes cannot be distinguished as to their lake of origin. The latter would comprise about 16% of fish in a population of equal numbers of Crean and Dauphin Lake fish.

INCIDENCE OF DISEASE IN CREAN LAKE WALLEYE

The incidence of skin tumours in the 1984 Crean Lake walleye spawning population was 10.4% (n = 974 fish). This was similar to the 11.0% incidence found in the same population in 1975 by Yamamoto et al. (1976). In 1984 the overall incidence was 5.5% in males and 20.2% in females, similar to the 1975 incidence of 6.0% and 15.0%, respectively (Yamamoto et al. 1976). However, in contrast to 1975 findings that skin tumour incidence was highest in small fish (20.0%); less in medium size fish (9.0%); and least in large fish (0.0%), we found that tumour incidence increased with fish age (Fig. 10); from 0.0% in 5 to 8 year old fish, to about 20.0% in fish older than 13 years. The 5 and 6 year old fish which were 20.0% infected in 1975 still showed that same infection rate as 14 and 15 year old fish in 1984.

During the course of the walleye migration in 1984, the incidence of tumours dropped from 35.0% at the beginning of the run to nearly 0.0% at the end (Fig. 11A-females; Fig. 11B-males).

This was partly because older fish made up a higher proportion in the early part of the migration.

The relative proportion of tumour types in the entire walleye migration was 6.2% walleye dermal sarcoma, 3.3% hyperplasia, and 0.9% lymphocystis (n = 974). While these proportions were relatively constant for males (2.0%, 2.8% and 0.7%, respectively), females showed a much higher proportion of dermal sarcoma (14.7% dermal sarcoma, 4.2% hyperplasia, and 1.3% lymphocystis; n = 307).

POTENTIAL IMPACT OF SPAWN-TAKING

A negative impact of spawn-taking upon a walleye spawning migration could be identified if those year-classes representing the years of spawn-taking were under represented in the age distribution of the adult population. Figure 12 shows that the year-classes of walleye which were produced during the 1967-75 spawn-taking at Crean Lake include both the strongest and the weakest year-classes. From 1972 to 1975, year-classes were strong despite spawn-taking. From 1967 to 1971, year-classes were weak. This weakness could be evidence for the impact of spawn removal, only if it could be shown that these years would normally have given rise to strong year-classes. Observations on other lakes suggest the opposite. In two unexploited Manitoba lakes at a similar latitude as Crean Lake, where the populations contain individual fish old enough to include the spawn-taking years at Crean Lake, the year-classes of 1967 and 1968 in Home Lake (54°53'N, 101°03'W) (Fig. 13A) and 1967, 1968, and 1969 in Wapun Lake (54°51°N, 101°12°W) (Fig. 13B) were "naturally" weak. It could be argued that year-classes of 1970 and 1971 in Crean Lake were depresed relative to those in Home and Wapun lakes, but the balance of the evidence over the other seven years of spawn-taking does not lend support to the hypothesis that spawn-taking has depressed year-classes at Crean Lake.

Another way to approach the question of the effect of spawn removal upon year-class strength is to examine the underlying assumption that year-class strength is directly proportional to the number of eggs spawned. The data from previous spawn-taking at Crean Lake (Appendix 2) permit an evaluation of this assumption.

An estimate of the annual number of eggs spawned naturally by female walleye in the Crean Lake migration, after spawn-taking, is given in Table 3. When the number of eggs spawned is correlated with the corresponding year-class strength, given on the ordinate of Fig. 12, the correlation coefficient (r = 0.18) is not statistically significant at the 0.05 probability level. This suggests, that between 23 and 150 million eggs, there is no relation between the number of eggs spawned and year-class strength. Forney (1976) also found no correlation between these variables in a 10 year study of a walleye population in Oneida Lake, New York. Other factors, notably percent survival at the egg, larval, and juvenile stages of the fish life history were more important in determining year-class strength. Smith and Krefting (1954) also found no correlation between the size of the brood stock and the resulting year-class in the Red Lakes, Minnesota. In many cases, environmental factors, such as high spring water levels (Chevalier 1977; Carlander and Payne 1977) and mean daily temperature rise during spawning and incubation (Busch et al. 1975) are important in controlling year-class strength in walleyes.

A third approach to the question of impact is to make use of the fact that the size of the white sucker migration between 1967 and 1975 was directly proportional to the size of the walleye migration (Fig. 14, correlation coefficient (r) = 0.83, p = 0.05, data from Appendix 2) represents a depression caused by egg removal in 1967-75. If that were so, little similarity between the size of the walleye and sucker migrations in 1984 would be expected because the sucker population was not impacted by spawn removal. In fact, the migration of both species was small. For example, the above correlation predicts a sucker migration of 548 fish, very close to the actual number of 624 fish. This suggests that the small migration of walleye in 1984 was caused by factors other than spawn removal; factors which affected the sucker population to a similar extent.

CHARACTERISTICS OF THE CREAN LAKE WALLEYE SPAWNING POPULATION

The characteristics which describe the Crean Lake spawning population in 1984 are those of an unexploited walleye population. There are two broad size-classes of fish: those with a modal length of 49.5 cm and those with a modal length of 33.5 cm (Fig. 15A). The larger size group is more abundant and is made up by about 67.0% females (Fig. 15B) and 33.0% males (Fig. 15C). The smaller size group consists of a preponderance of males. The relatively large size of fish in Crean Lake, as well as the presence of many old fish suggests a low level of exploitation.

The fork length-round weight relationship is shown in Fig. 16 for all fish. A linear relationship between the logarithm of fish fork length and the logarithm of fish round weight is described by the equation:

$$\log_{10} \text{Weight} = -5.02 + 3.03 \log_{10} \text{Length}; \quad r^2 = 0.99; \quad n = 375$$

This relationship was not significantly different for females or males alone, so that the above equation may be applied to all walleye in the migration.

The growth rate of Crean Lake spawners can be approximated by plotting the average fork length of fish against age (Fig. 17A and 17B). Females grow considerably faster than males after sexual maturity at 6+ years of age, reaching their maximum size of 55.0 cm or 1.92 kg at about 16+ years of age. Males take about the same length of time (ca. from 6 - 16 yr to reach a smaller maximum size of about 49.0 cm or 1.35 kg. The difference between males and females in average maximum weight is about 0.57 kg. The growth curves for males and females diverge at about 6+ years of age suggesting that growth up to the age of sexual maturity is the same for both sexes.

It was not possible to calculate mortality rates for the Crean Lake walleye spawning population because the fish had not been previously marked. However, in 1984, a total of 336 fish were tagged so that mortality estimates can be made if the migration is examined in the future.

ACKNOWLEDGMENTS

The authors would like to thank G. Curry, K. Dey, P. Komonko, O. Nielsen, R. Olson, and P. Schaap for technical assistance in the field. D. Tretiak analyzed tissue samples for MDH, and S. Main analyzed data. D. Allen, J. Dickinson, and C. Millard arranged the logistics of our stay at Prince Albert National Park. W. Whiting and J. Marchinko provided information of previous spawn taking at Crean Lake. G. Decterow typed the manuscript.

The authors thank O. Nielsen, R.A. Bodaly, and J. Clayton for their suggestions and critical review of the manuscript.

REFERENCES

BAILEY, G.S., and A.C. WILSON. 1968. Homologies between isoenzymes of fishes and those of higher vertebrates: evidence for multiple H_4 lactate dehydrogenases in trout. J. Biol. Chem. 243: 5843-5853.

BAILEY, G.S., A.C. WILSON, J.E. HALVER, and C.L. JOHNSON. 1970. Multiple forms of supernatant malate dehydrogenase in salmonid fishes: biochemical, immunological and genetic studies. J. Biol. Chem. 245: 5927-5940.

BODALY, R.A. 1980. Pre- and post-spawning movements of walleye, Stizostedion vitreum, in Southern Indian Lake, Manitoba. Can. Tech. Rep. Fish. Aquat. Sci. 931: v + 30 p.

BUSCH, W.-D.N., R.L. SCHOLL, and W.L. HARTMAN. 1975. Environmental factors affecting the strength of walleye (Stizostedion vitreum vitreum) year-classes in western Lake Erie, 1960-70. J. Fish. Res. Board Can. 32: 1733-1743.

CAMPBELL, J.S., and J.A. BABALUK. 1979. Age determination of walleye, Stizostedion vitreum vitreum (Mitchill), based on the examination of eight different structures. Can. Fish. Mar. Serv. Tech. Rep. 849: iv + 23 p.

CARLANDER, K.D., and P.M. PAYNE. 1977. Year-class abundance, population and production of walleye (Stizostedion vitreum vitreum) in Clear Lake, Iowa, 1948-74, with varied fry stocking rates. J. Fish. Res. Board Can. 34: 1792-1797.

CHEVALIER, J.R. 1977. Changes in walleye (Stizostedion vitreum vitreum) population in Rainy Lake and factors in abundance, 1924-75. J. Fish. Res. Board Can. 34: 1696-1702.

CLAYTON, J.W., R.E.K. HARRIS, and D.N. TRETIAK. 1973. Identification of supernatant and mitochondrial isozymes of malate dehydrogenase on electropherograms applied to the taxonomic discrimination of walleye (Stizostedion vitreum vitreum), sauger (S. canadense), and suspected interspecific hybrid fishes. J. Fish. Res. Board Can. 30: 927-938.

CLAYTON, J.W., R.E.K. HARRIS, and D.N. TRETIAK. 1974. Geographical distribution of alleles for supernatant malate dehydrogenase in walleye (Stizostedion vitreum vitreum) populations from western Canada. J. Fish. Res. Board Can. 31: 342-345.

CLAYTON, J.W., D.N. TRETIAK, and A.H. KOOYMAN. 1971. Genetics of multiple malate dehydrogenase isoenzymes in skeletal muscle of walleye (Stizostedion vitreum vitreum). J. Fish. Res. Board Can. 28: 1005-1008.

DERBACK, B. 1947. The adverse effects of cold weather upon the successful reproduction of pickerel, Stizostedion vitreum, at Heming Lake, Manitoba, in 1947. Can. Fish. Cult. 2:22-23.

FORNEY, J.L. 1976. Year-class formation in the walleye (Stizostedion vitreum vitreum) population of Oneida Lake, New York, 1966-73. J. Fish. Res. Board Can. 33: 783-792.

LAARMAN, P.W. 1978. Case histories of stocking walleyes in inland lakes, impoundments, and the Great Lakes - 100 years with walleyes, p. 254-260. In R.L. Kendall (ed.) Selected coolwater fishes of North America. Am. Fish. Soc. Spec. Publ. 11.

SMITH, L.L., Jr, and L.W. KREFTING. 1954. Fluctuations in production and abundance of commercial species in the Red Lakes, Minnesota, with special reference to changes in the walleye population. Trans. Am. Fish. Soc. 83: 131-160.

UTHE, J.F. 1971. A simple field technique for obtaining small samples of muscle from living fish. J. Fish. Res. Board Can. 28: 1203-1204.

YAMAMOTO, T., R.D. MacDONALD, D.C. GILLESPIE, and R.K. KELLY. 1976. Viruses associated with lymphocystis disease and dermal sarcoma of walleye (Stizostedion vitreum vitreum). J. Fish. Res. Board Can. 33: 2408-2419.

Table 1. Number of walleye caught in fish trap and held in holding pens in Crean-Heart lakes channel, 1984. Numbers do not include immature fish.

Date		Females			Males	
	Caught	Released	Held	Caught	Released	Held
April 20	14	0	14	10	0	10
21	17	0	31	16	0	26
22	16	0	47	11	1	36
23	14	37[a]	24	11	0	47
24	25	0	49	44	0	91
25	13	0	62	36	0	127
26	17	0	79	32	0	159
27	11	0	90	40	0	199
28	21	2	109	6	0	205
29	15	31[b]	93	22	6	221
30	15	3	105	38	0	259
May 1	19	7[b]	117	25	9	275
2	30	3[b]	144	37	2	310
3	18	0	162	38	0	348
4	13	6[b]	169	40	5	383
5	22	8[b]	183	59	1	441
6	8	24[b]	167	10	23	428
7	12	44[c]	135	4	0	432
8	10	0	145	3	0	435
9	5	11[b]	139	4	12	427
10	9	0	148	2	0	429
11	9	157	0	1	430	0

a = walleye tagged and released.
b = walleye spawned or spent and released.
c = walleye spent and released.

Table 2. Percent occurrence of malate dehydrogenase (MDH) phenotypes[a] and allele gene frequencies for walleye from Crean Lake, Saskatchewan and Dauphin Lake, Manitoba.

Lake	Year	N	% of fish with BB MDH phenotype						allele frequencies		
			1,1	1,2	1,3	2,2	2,3	3,3	B-1	B-2	B-3
Crean	1971	72	40.3	0.0	44.4	0.0	0.0	15.3	0.625	0.000	0.375
Crean	1972	345	35.1	1.7	49.9	0.0	0.0	13.3	0.609	0.008	0.383
Crean	1984	102	42.1	1.0	45.1	0.0	0.0	11.8	0.652	0.005	0.343
Dauphin	1983	109	0.0	4.6	0.9	51.4	28.4	14.7	0.028	0.679	0.293

[a] These alleles and phenotypes were originally designed c^n and CC by Clayton et al. (1971), but further interpretation of the data by Clayton et al. (1973) strongly suggests that these are indeed b and BB supernatant MDH alleles and phenotypes as originally described by Bailey and Wilson (1968) and Bailey et al. (1970). (J.W. Clayton, Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, personal communication.)

Table 3. Estimates of numbers of eggs spawned naturally by walleye in the Crean-Heart lakes spawning migration, 1967-1975.

Year	A No. Females in Migration	B No. Females Spawned	C Ave. No. Eggs Per Female[a] ($x10^3$)	D No. Females Escaped[b]	E No Eggs Naturally Spawned[c] ($x10^6$)
1967	1047	644	78.1	403	23.6
1968	2365	596	88.9	1769	117.9
1969	1190	732	95.9	458	32.9
1970	1663	812	87.5	851	55.8
1971	2593	793	95.2	1800	128.5
1972	6484	1048	61.3	5436	249.7
1973	4609	656	48.3	3953	143.2
1974	3041	612	59.2	2429	107.8
1975	2053	446	63.0	1607	75.9

a = ounces eggs collected x 3500 eggs per ounce (W. Whiting, Saskatchewan Department of Parks and Renewable Resources, Fort Qu'Appelle, personal communication).

b = column A - column B.

c = column C x column D x 0.75 (The 75% factor adjusts for females that do not spawn, or that contain fewer than the average number of eggs).

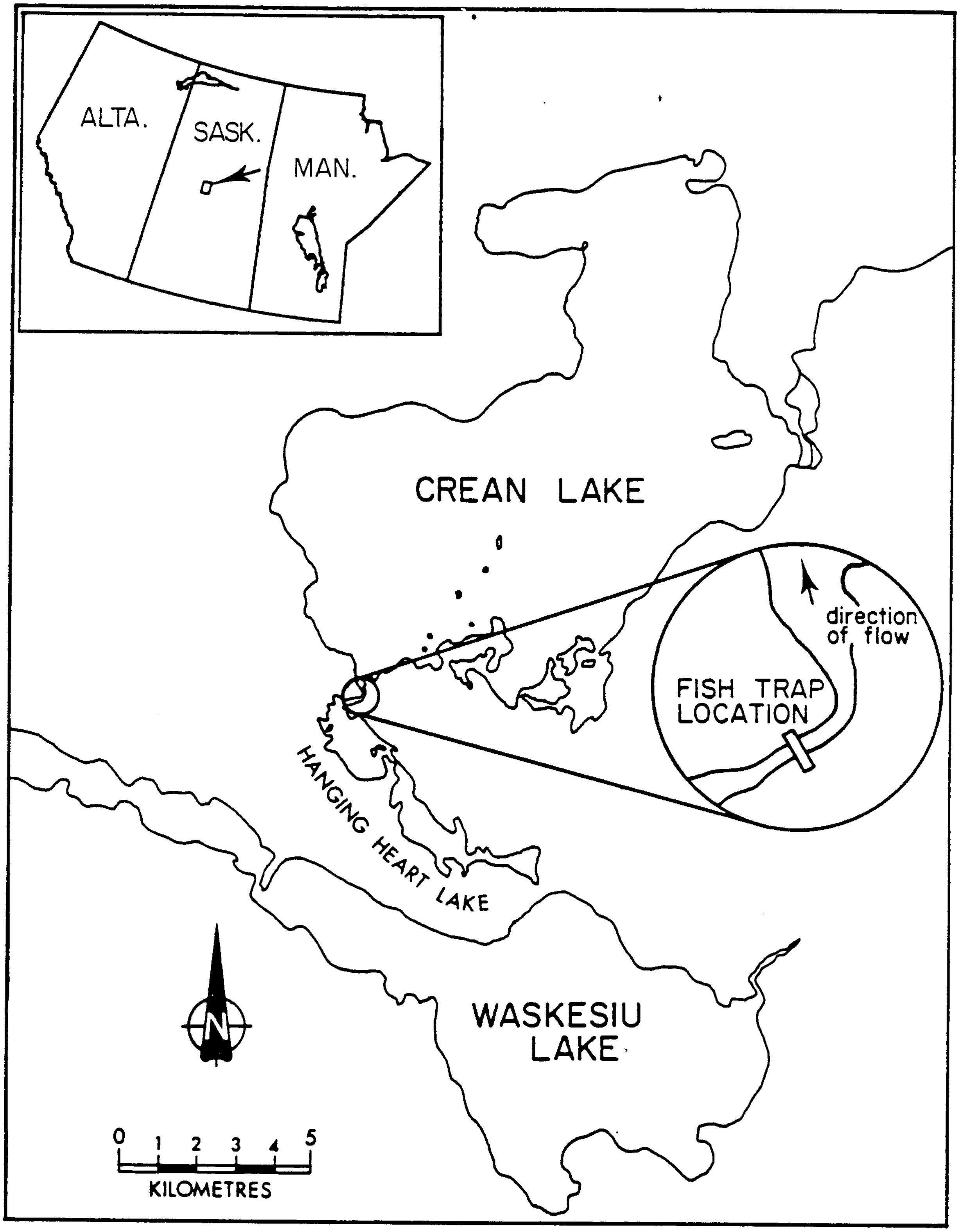

Fig. 1. Map of Crean Lake, Prince Albert National Park (inset) showing fish trap location.

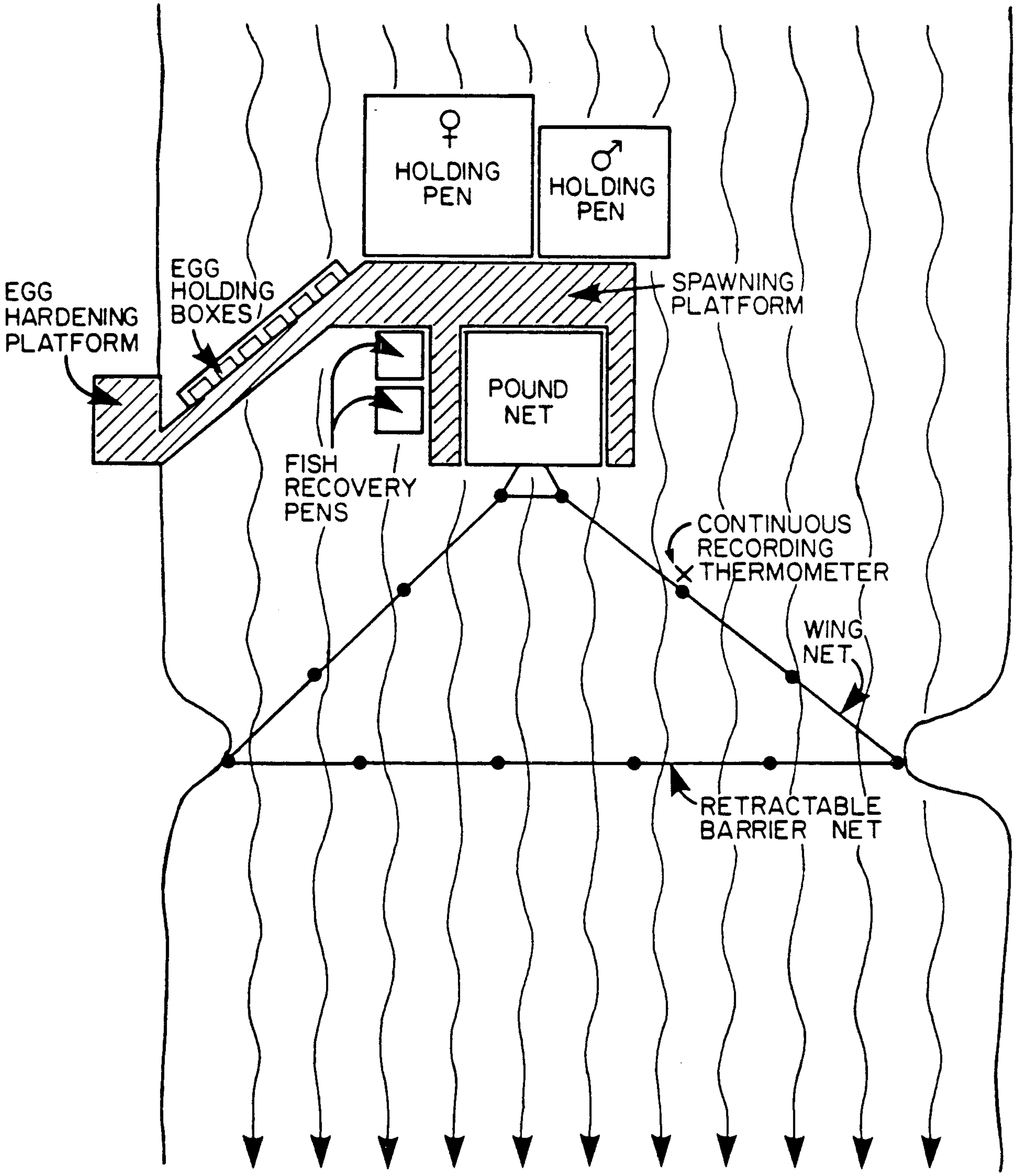

Fig. 2. Schematic drawing of fish trap (not to scale).

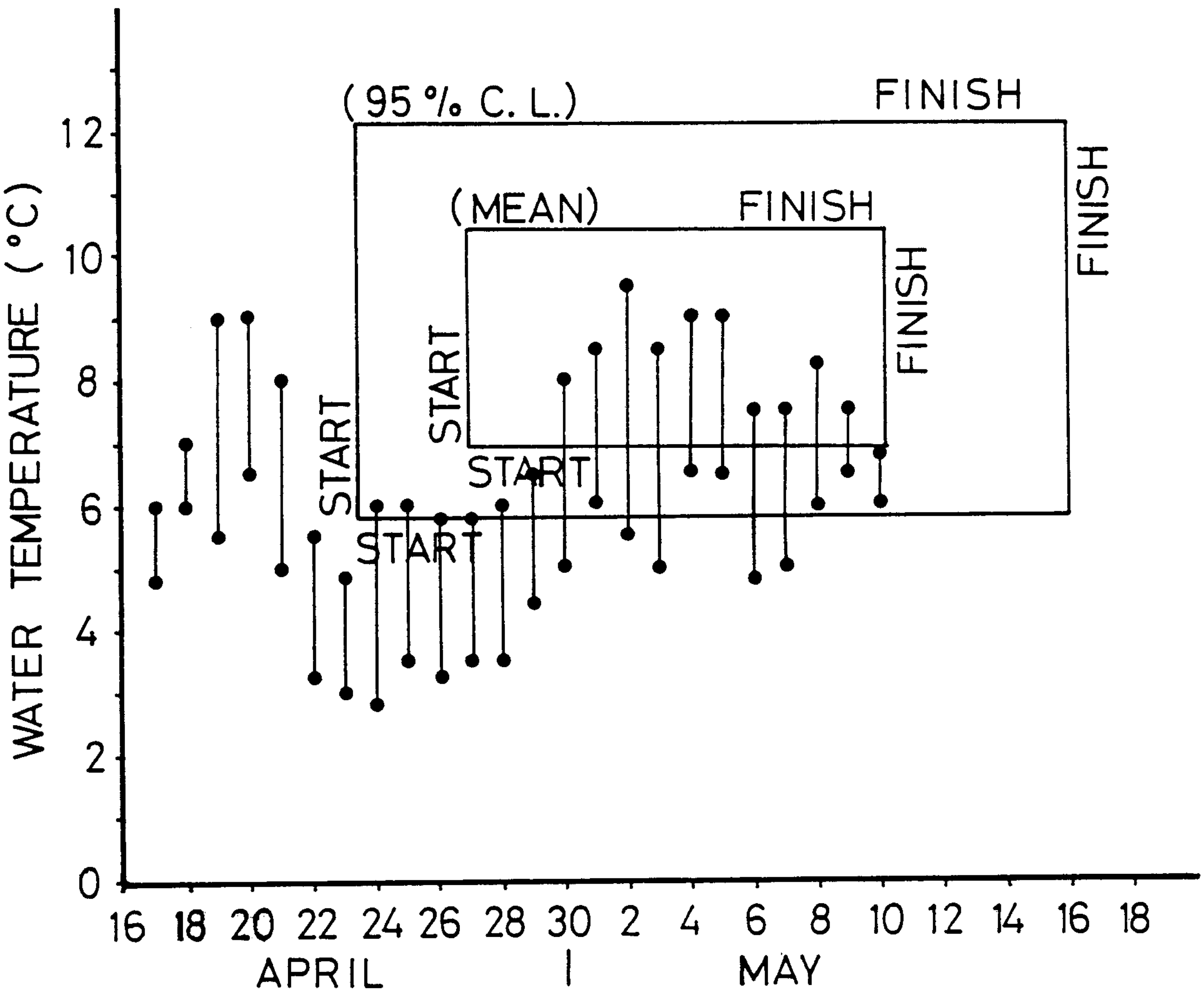

Fig. 3. Daily maximum and minimum water temperatures in the Crean-Heart lakes channel, 1984, in relation to the mean water temperatures and dates (inner rectangle) at which the walleye migration started and finished between 1967 and 1975. Outer rectangle indicates:

- the temperatures at which 95% of the 1967-1975 walleye runs started (bottom) and finished (top).
- the dates on which 95% of the 1967-1975 walleye runs started (left side) and finished (right side).

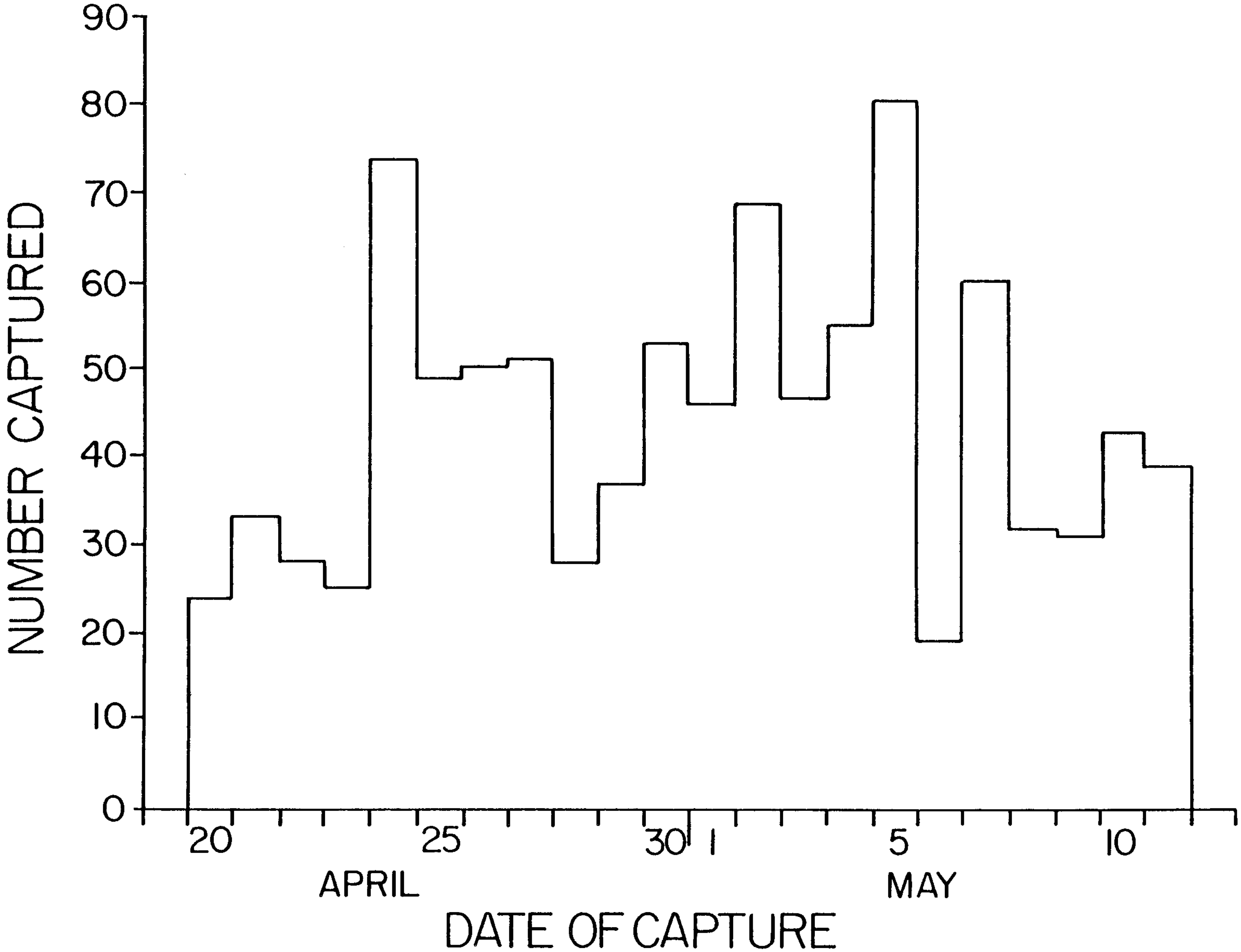

Fig. 4. Numbers of walleye (both sexes) in the Crean Lake spawning migration, 1984.

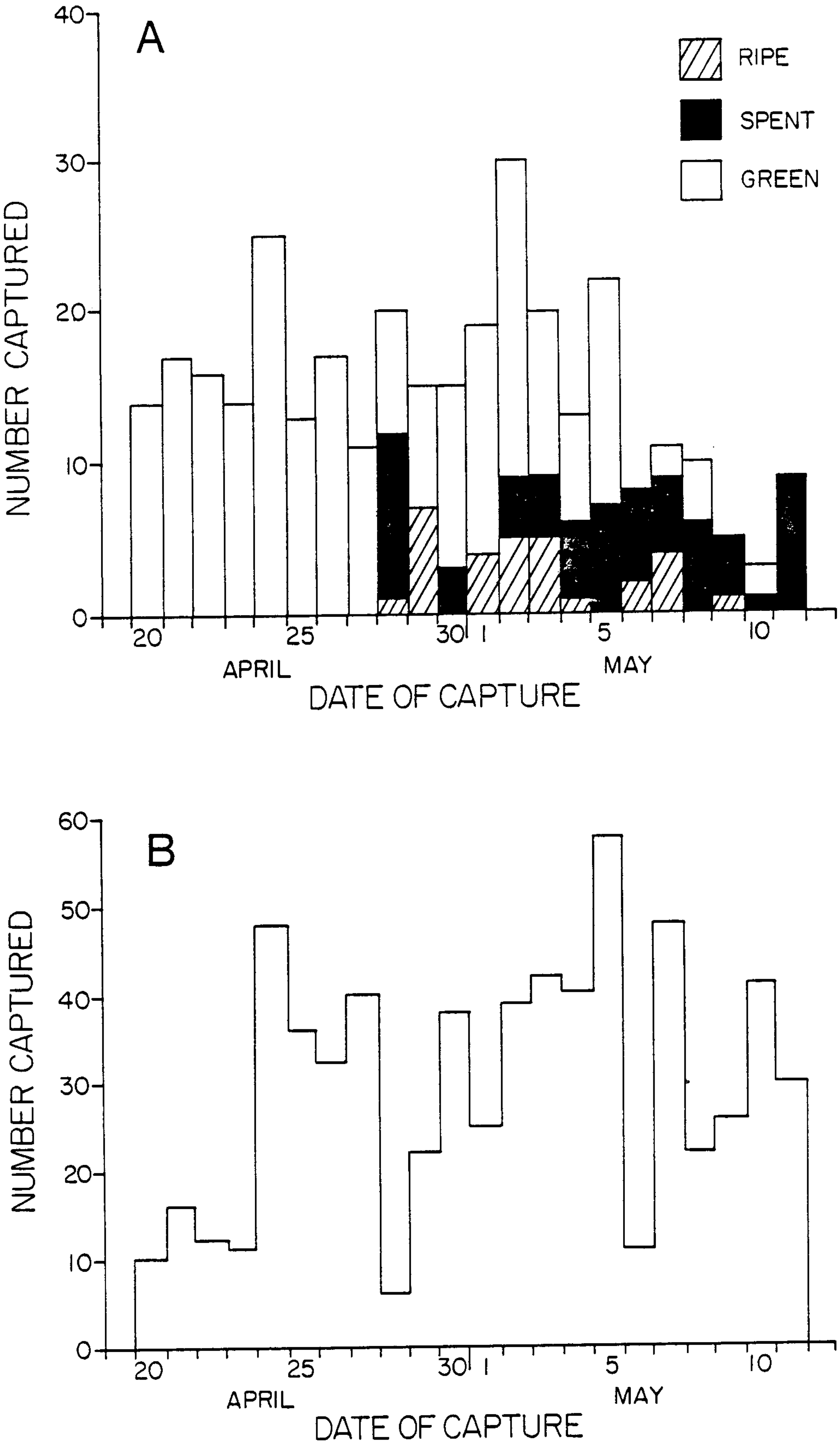

Fig. 5. Numbers of walleye in the Crean Lake spawning migration, 1984. A, Females, B. Males, indicating numbers of ripe, spent and green fish.

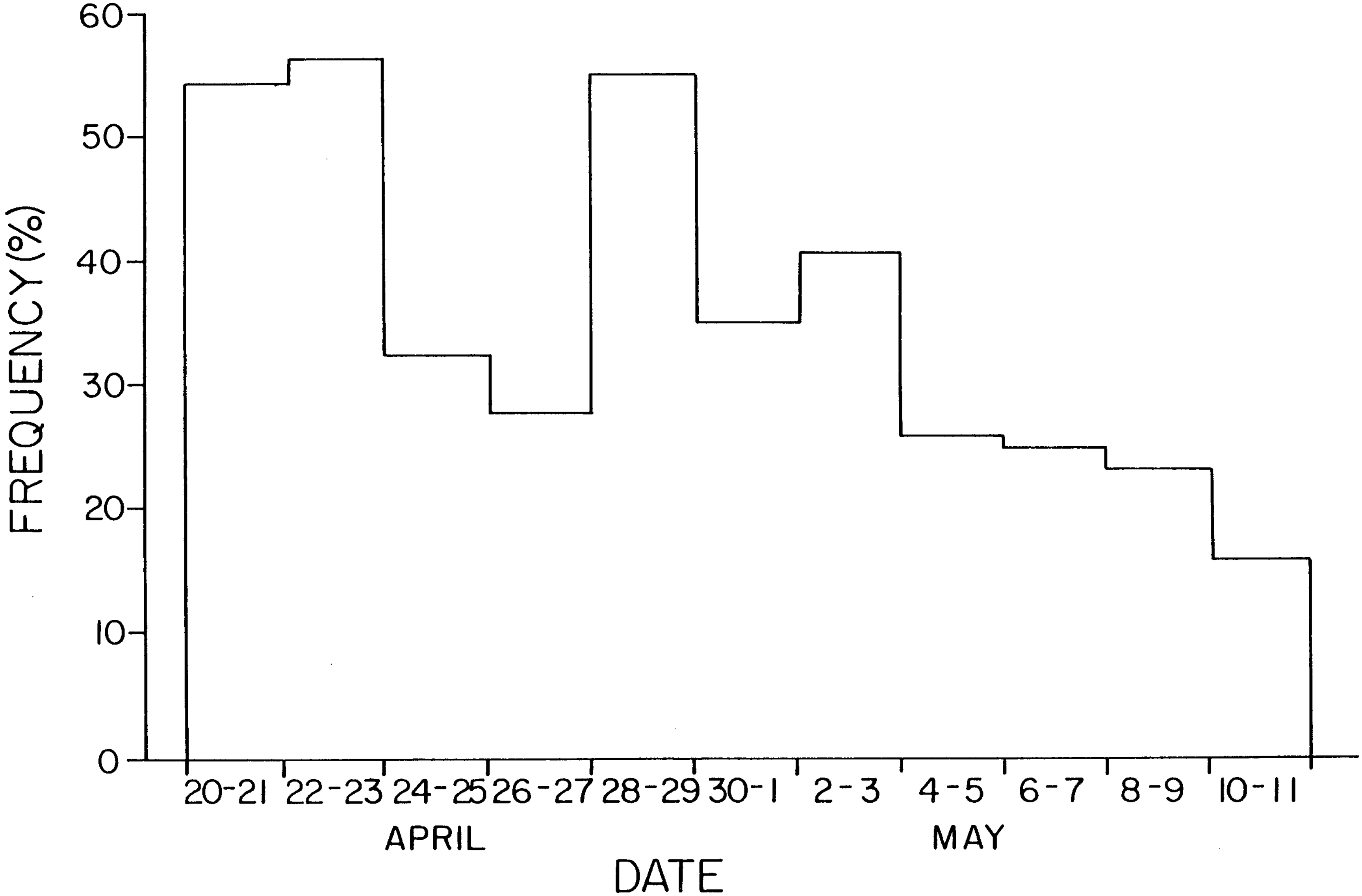

Fig. 6. Percent frequency of female walleye in the Crean Lake spawning migration, 1984.

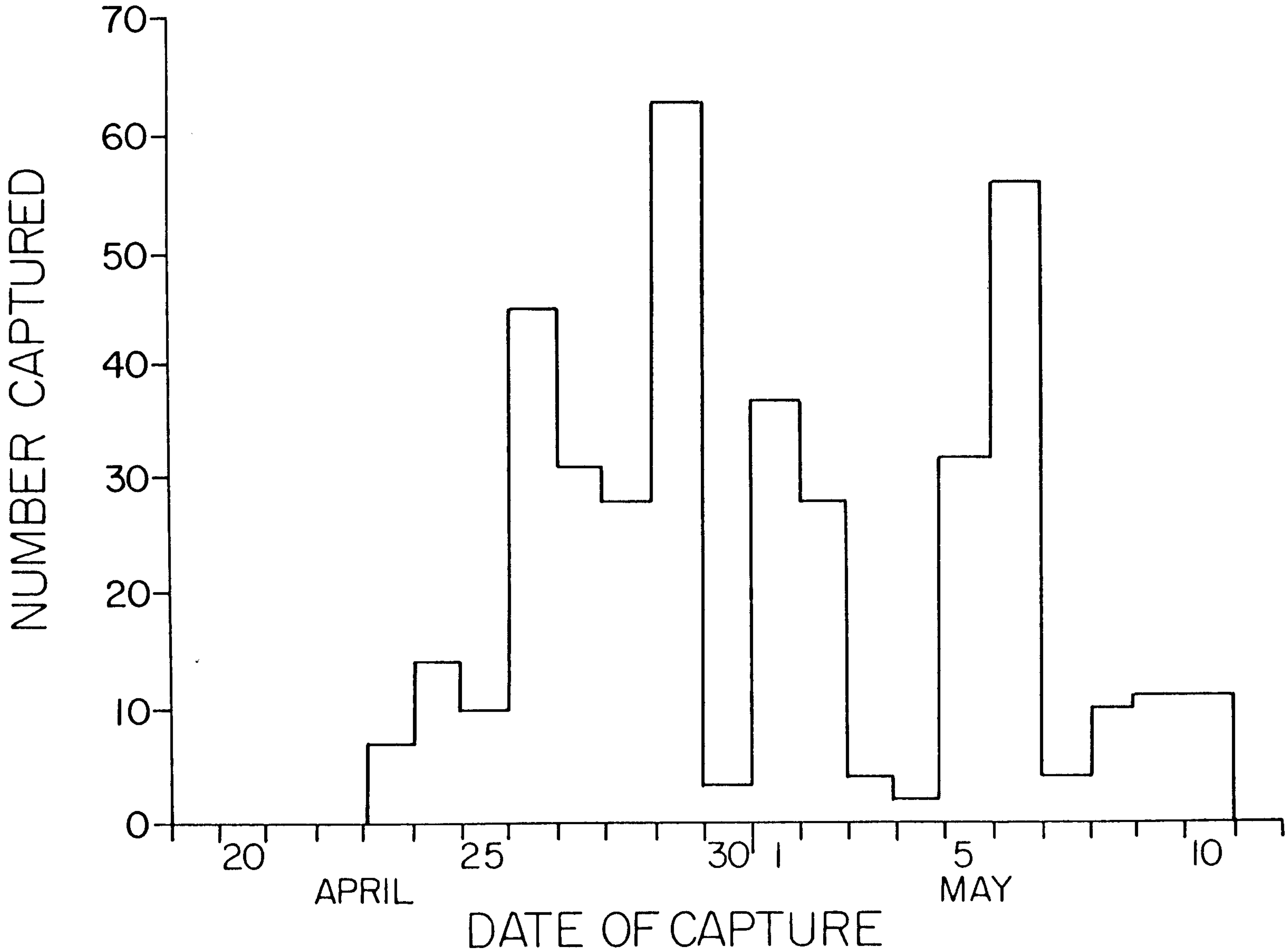

Fig. 7. Numbers of cisco migrating through the Crean-Heart lakes channel, 1984.

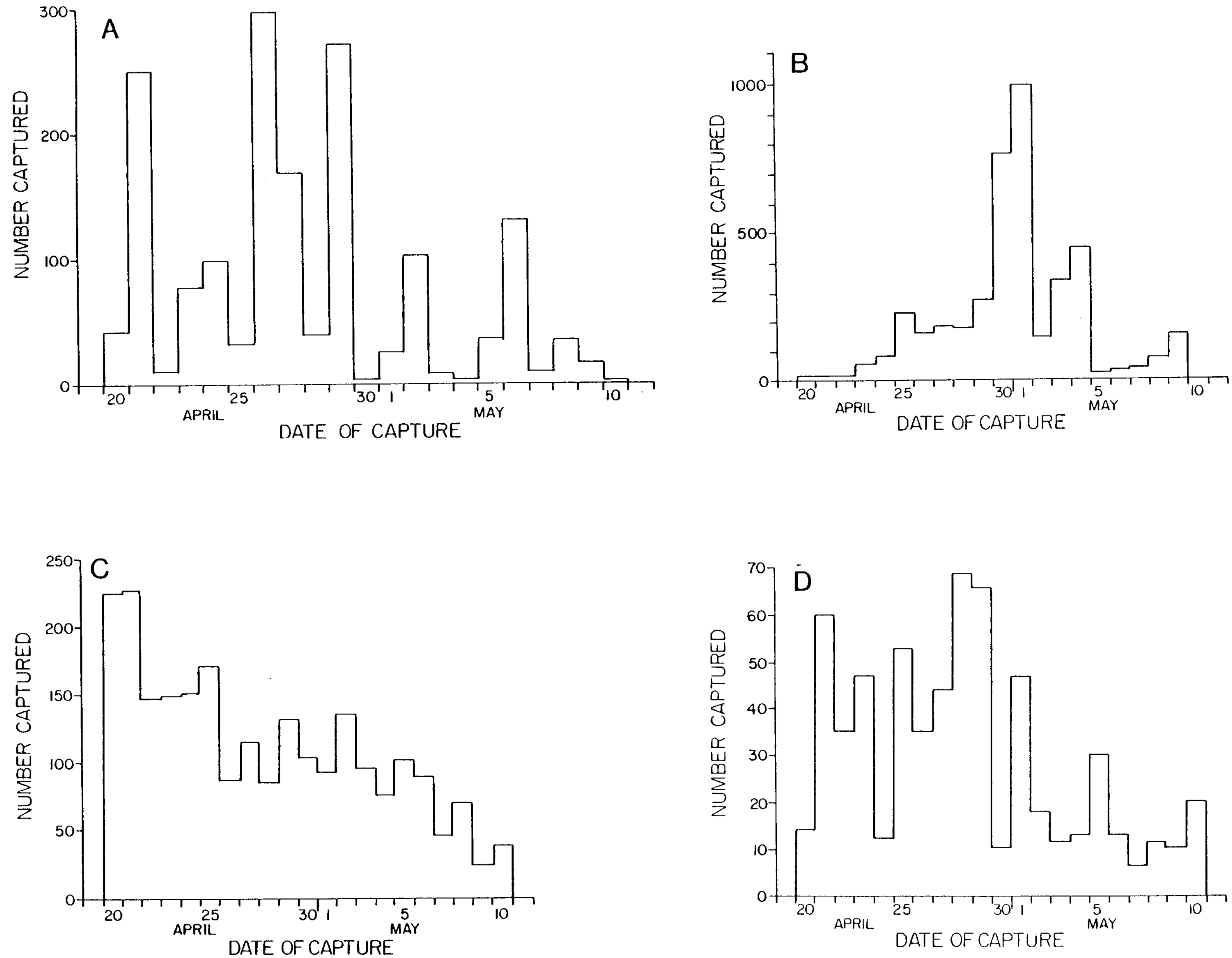

Fig. 8. Numbers of fish migrating through the Crean-Heart lakes channel, 1984. A, lake whitefish. B, yellow perch. C, northern pike. D, white sucker.

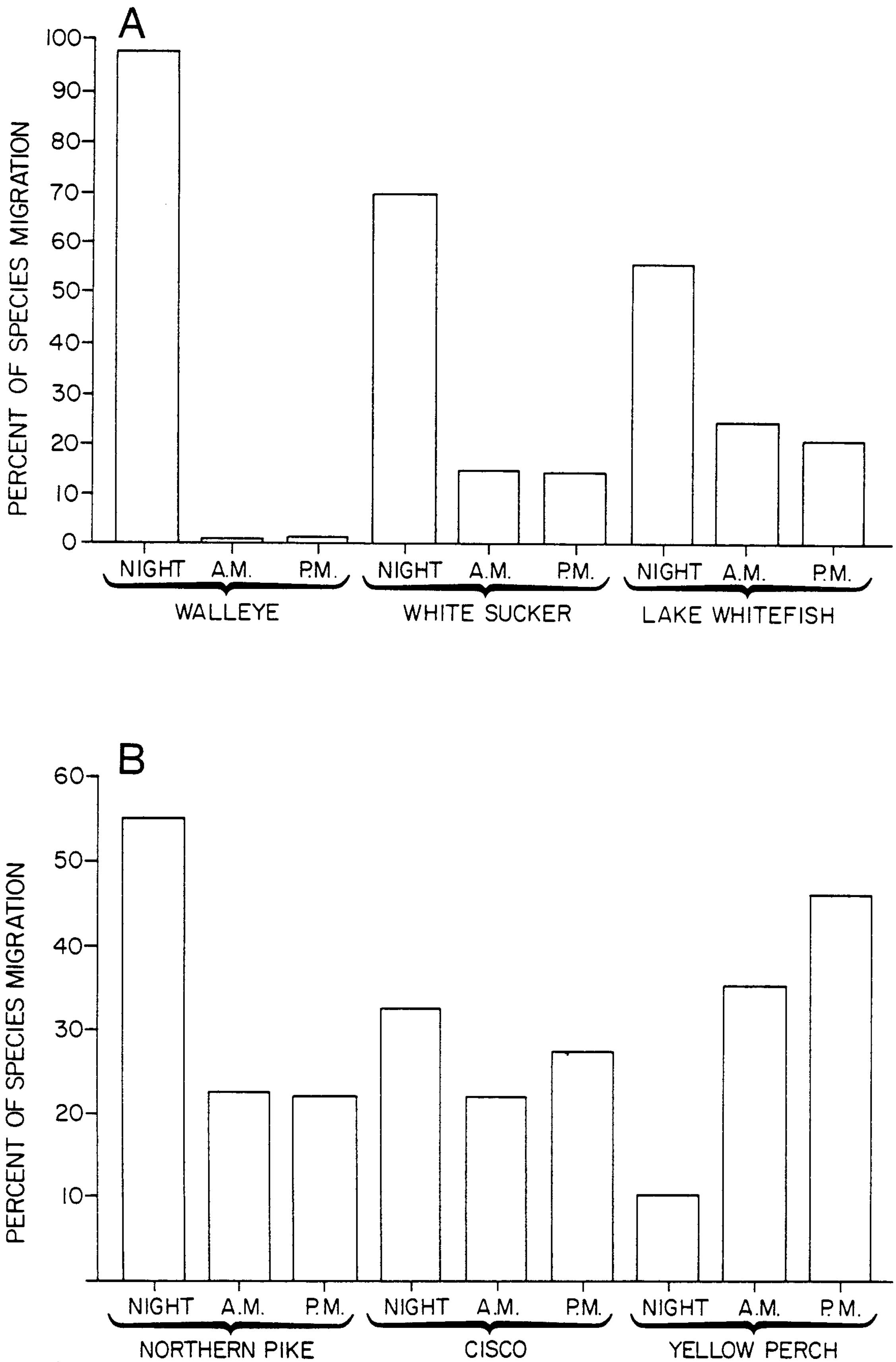

Fig. 9. Percent frequency of each species migrating at night; in the morning; and in the afternoon for: A, walleye, white sucker, and lake whitefish, and B, northern pike, cisco, and yellow perch.

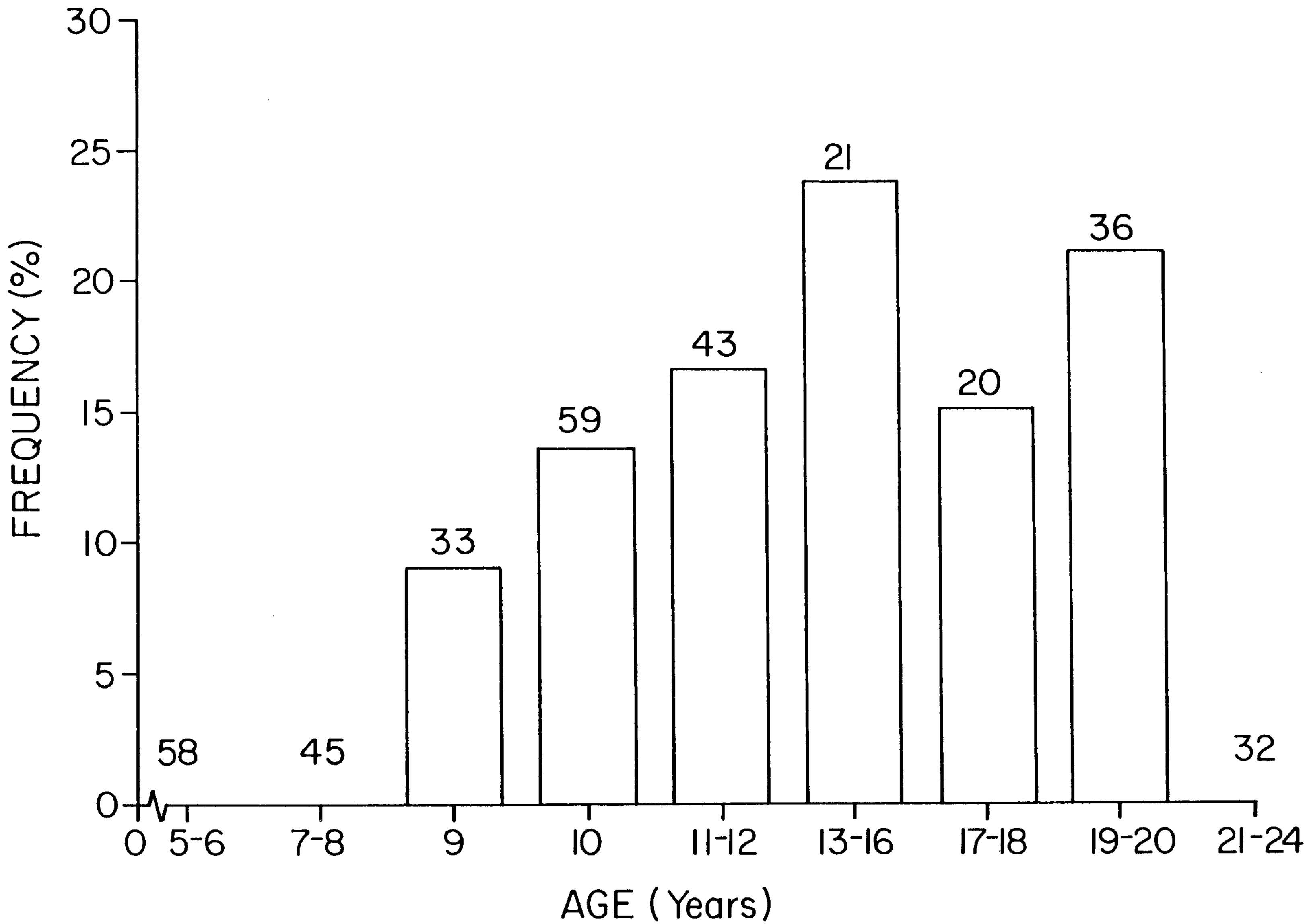

Fig. 10. Percent frequency of disease in spawning walleye, Crean Lake, 1984. Number refers to sample size.

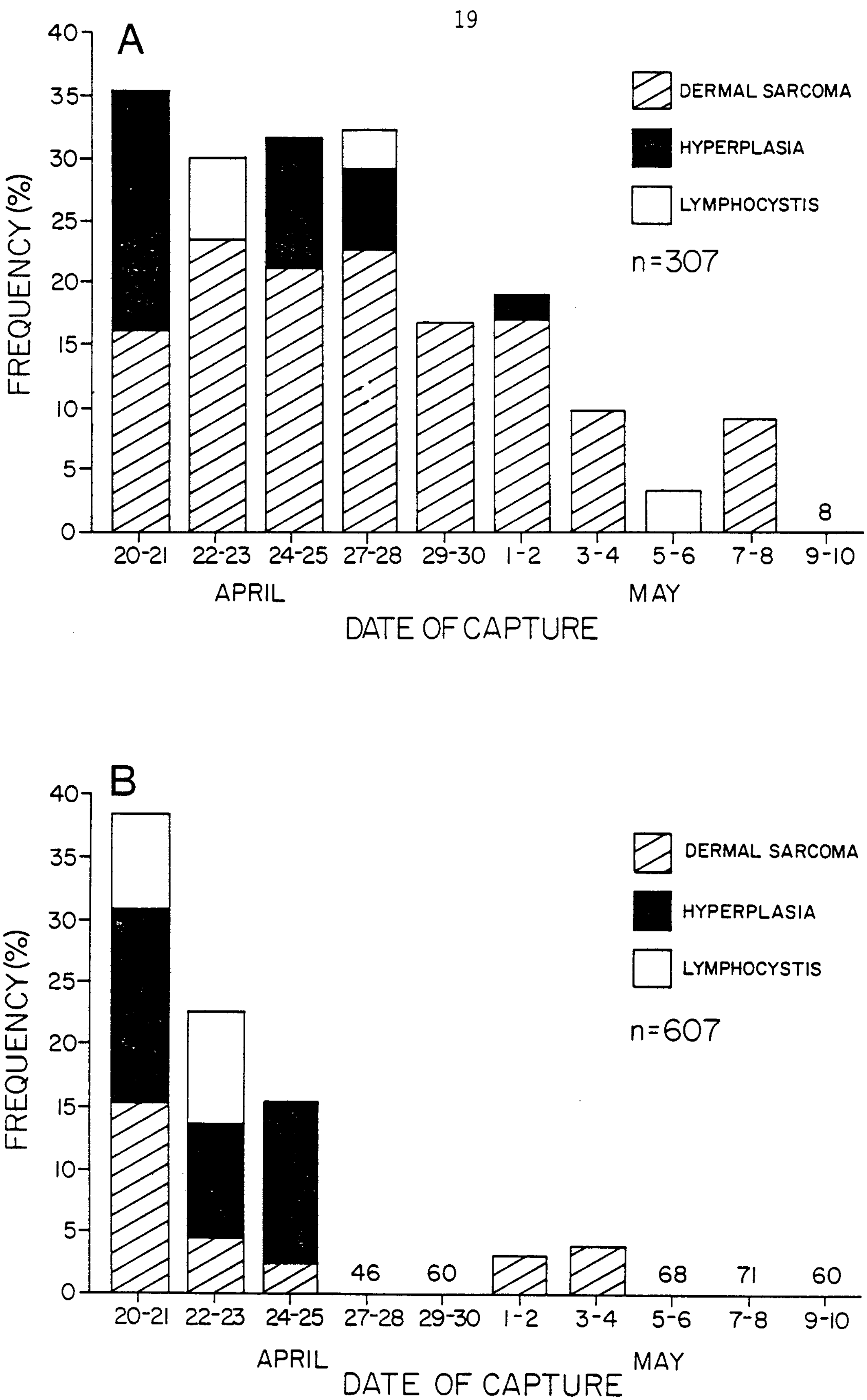

Fig. 11. Percent frequency of dermal sarcoma, hyperplasia, and lymphocystis disease in walleyes in Crean Lake spawning migration, 1984. A, females, B, males. Incomplete data of 26 April not included. Number refers to sample size.

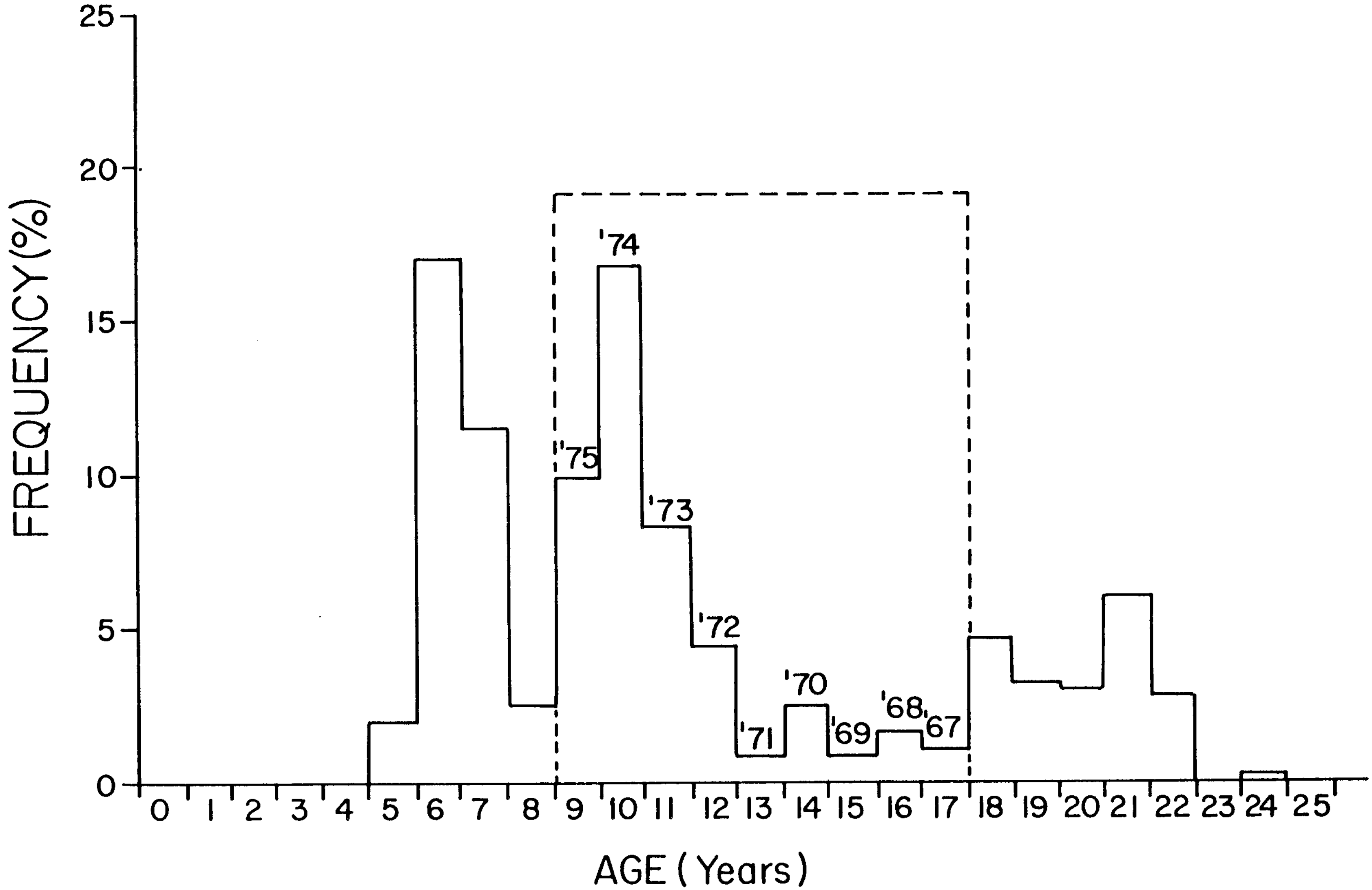

Fig. 12. Age frequency distribution of walleye from Crean-Heart lakes spawning migration, 1984. Numbers inside rectangle indicate the year in which fish were spawned.

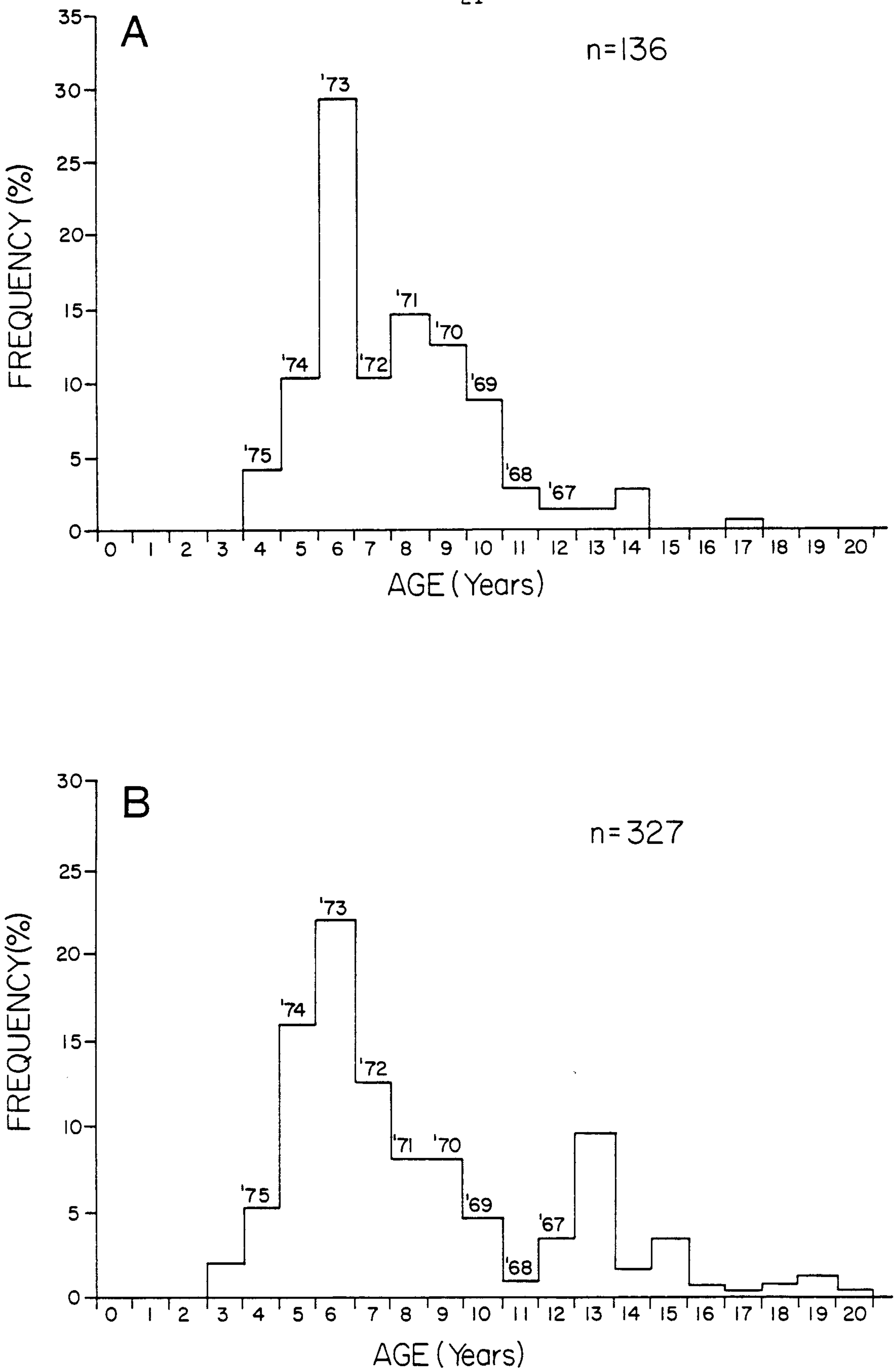

Fig. 13. Age frequency distribution of walleye from A, Home Lake, Manitoba, 1979, and B, Wapun Lake, Manitoba, 1979. Numbers at the top of bars indicate the year in which fish were spawned.

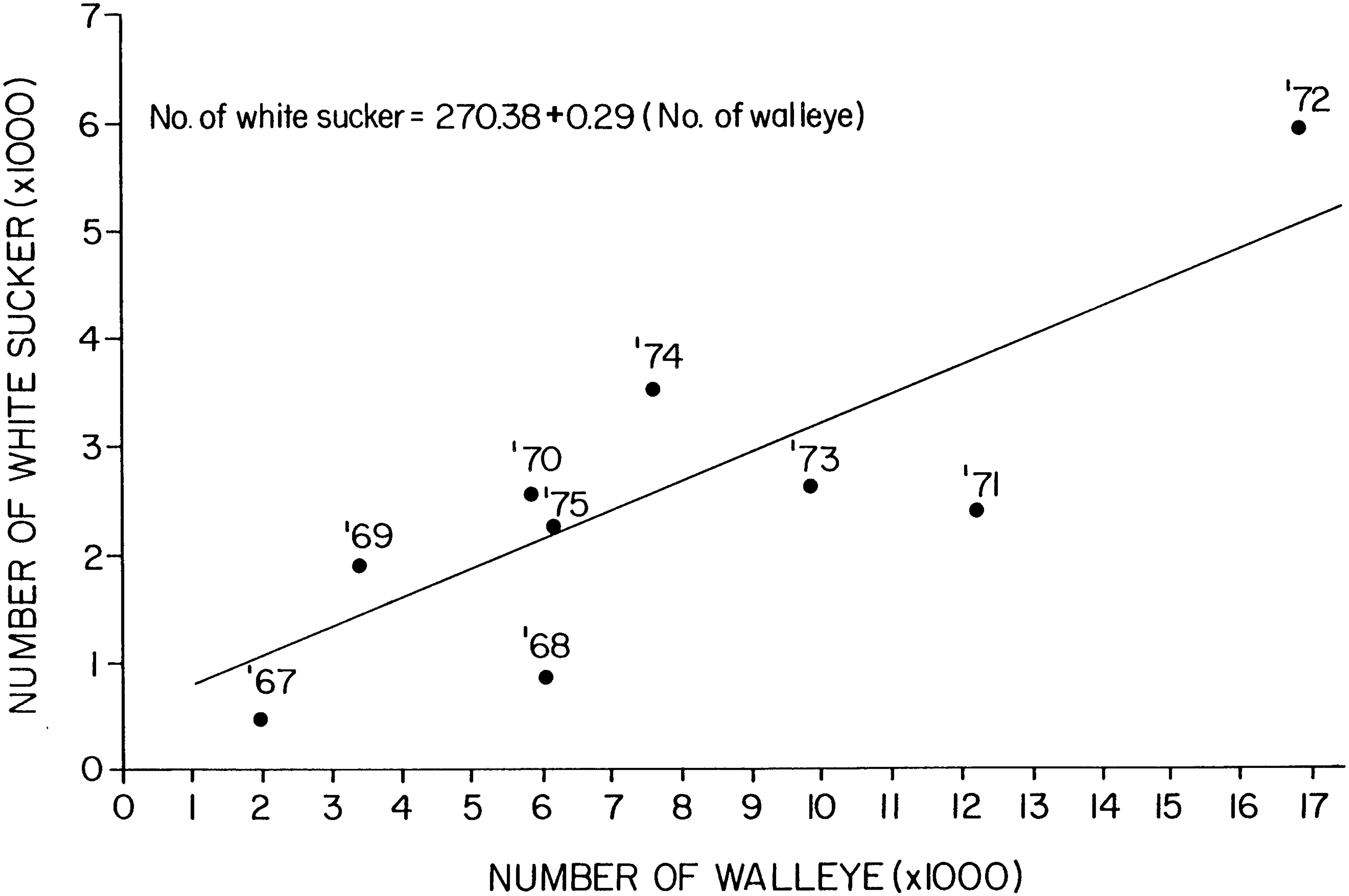

Fig. 14. Relationship between the numbers of white sucker and walleye in Crean Lake spawning migrations, 1967-1975.

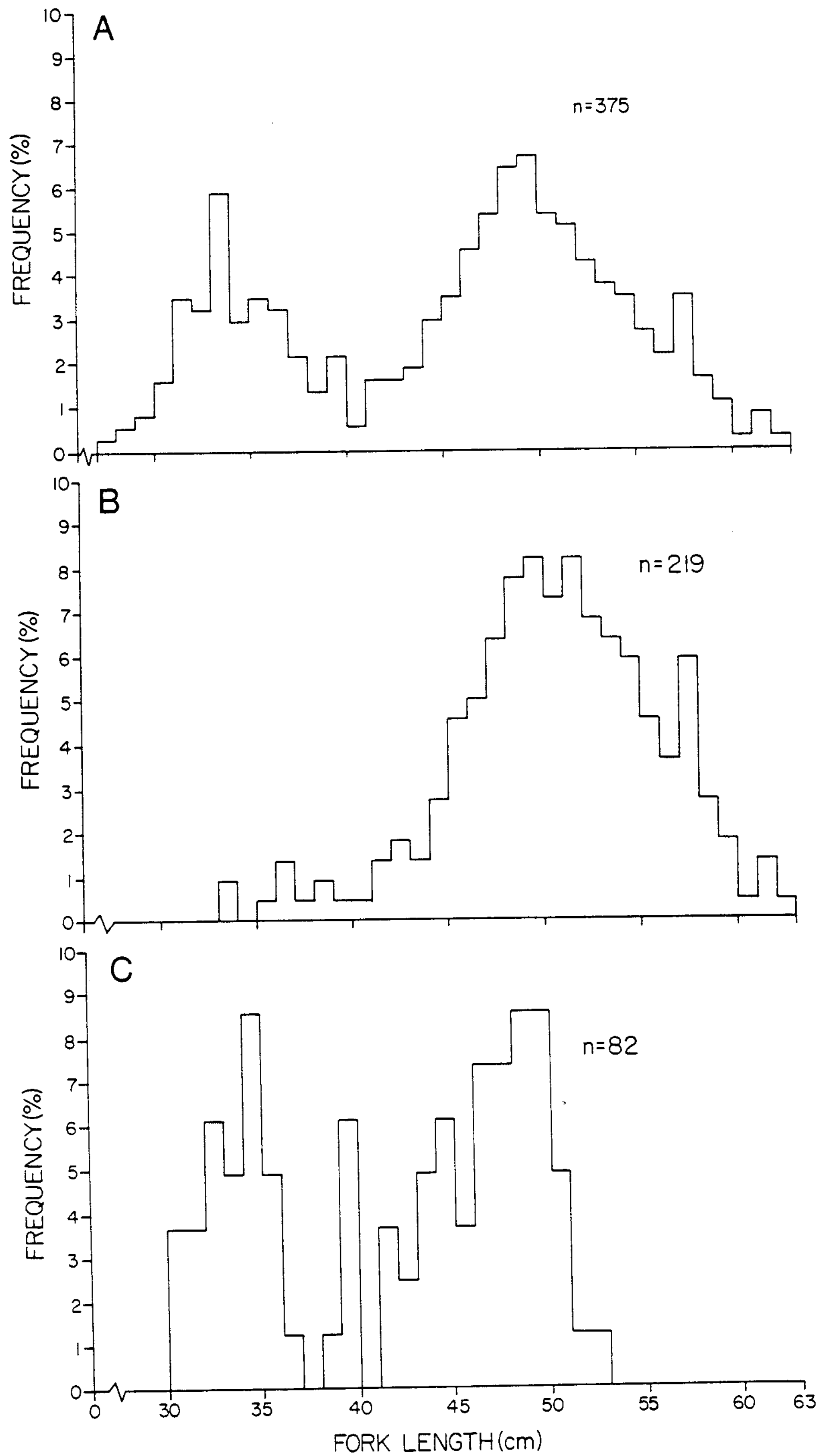

Fig. 15. Length frequency distribution of (A) all walleye; (B) female walleye; and (C) male walleye from the Crean Lake spawning migration, 1984.

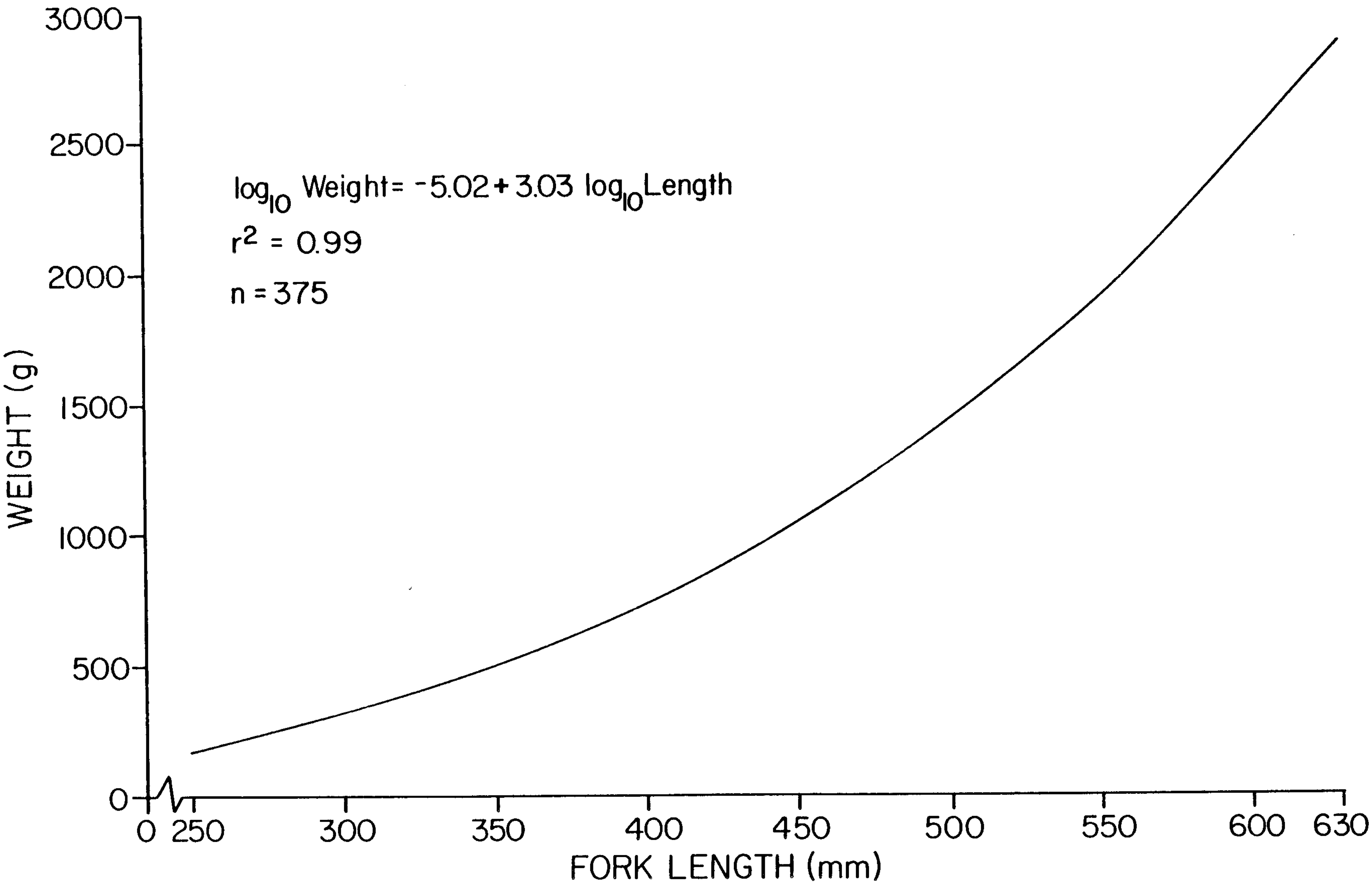

Fig. 16. Relationship between round weight and fork length for walleye from the Crean Lake spawning migration, 1984.

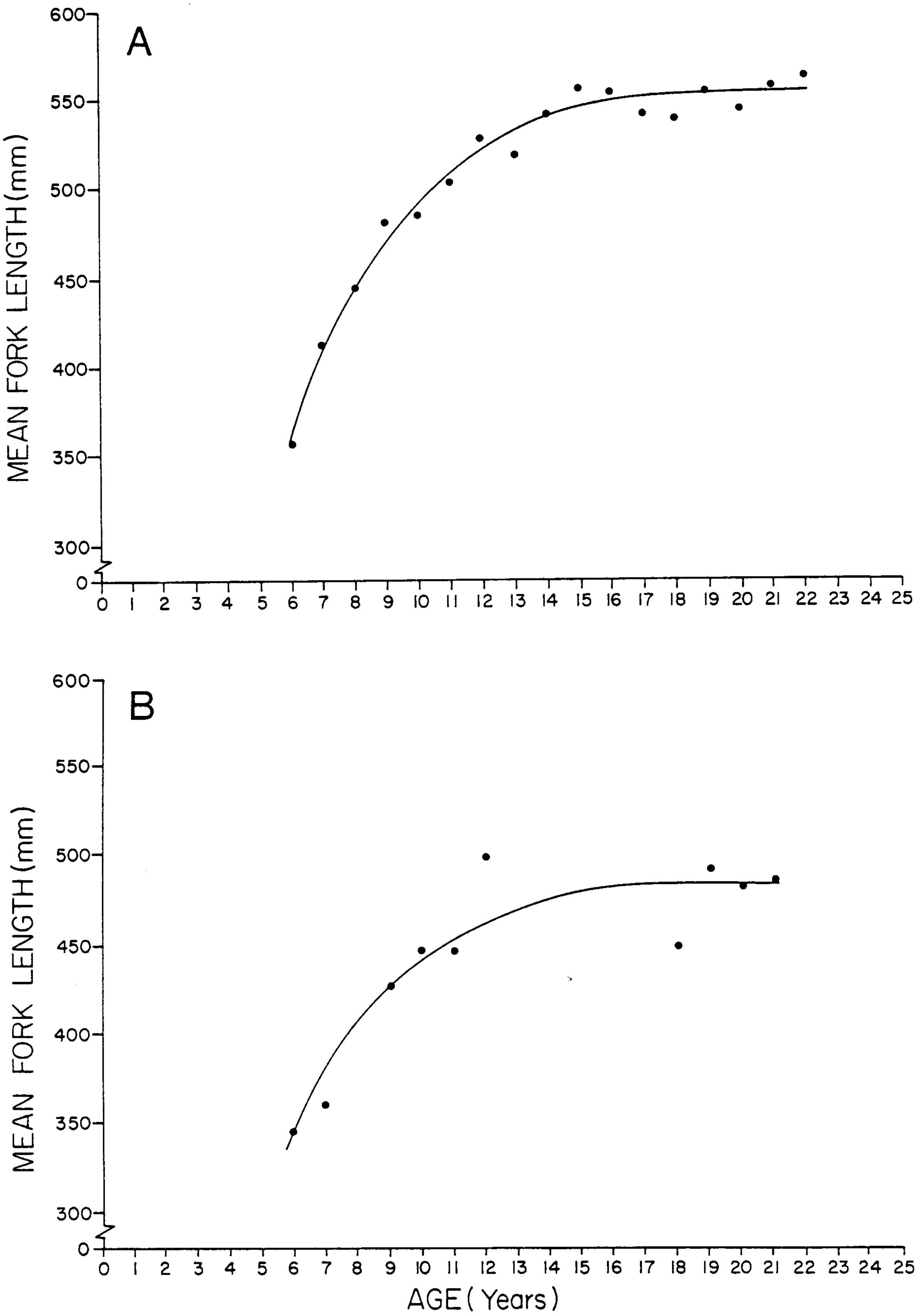

Fig. 17. Relationship between mean fork length and age for (A) female walleye and (B) male walleye from the Crean Lake spawning migration, 1984.

Appendix 1. Tag numbers, fork length, weight, sex, age, and disease status for walleye tagged in Crean-Heart lakes channel, April-May, 1984.

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases[a]
1	6026		531	1 800	F	18	
2	6027		551	2 480	F	21	
3	6028		567	2 640	F	14	
4	6029		504	1 520	F	12	W.D.S.
5	6030		524	1 740	F	19	Hyper.
6	6031		579	2 360	F	22	
7	6032		479	1 290	F	8	
8	6033		552	2 350	F	22	
9	6034		520	1 950	F	20	
10	6035		531	2 020	F	21	
11	6036		568	2 260	F	18	
12	6037		530	1 950	F	11	
13	6038		487	1 400	F	10	
14	6039		518	1 500	F		
15	6040		544	2 100	F	21	
16	6041		574	2 340	F	16	
17	6042		494	1 390	F	9	Lympho.
18	6043		483	1 200	F	14	
19	6044		555	2 130	F	19	
20	6045		485	1 340	F	10	
21	6046	6047	459	1 250	F	8	
22	6048		533	1 860	F	10	
23	6049		581	2 620	F	19	
24	6050		441	1 040	F	9	
25	6076		507	1 650	F	16	
26	6077		504	1 790	F	10	W.D.S.
27	6078		577	2 460	F	14	W.D.S.
28	6079		470	1 240	F	9	
29	6080		520	1 910	F	14	Lympho.
30	6081		497	1 440	F	10	W.D.S.
31	6082		577	2 350	F	15	W.D.S.
32	6083		505	1 680	F	10	W.D.S.
33	6084		556	2 030	F	21	
34	6085		546	2 060	F	20	
35	6086		516	1 560	F	12	
36	6087		503	1 580	F	11	
37	6088		476	1 390	F	10	W.D.S.
38	6089		572	2 190	F	21	
39	6090		496	1 710	F	11	
40	6094		464	1 200	F	10	
41	6095		488	1 480	F	13	
42	6096	6097	542	1 920	F	21	

[a] W.D.S., - walleye dermal sarcoma; Hyper., - hyperplasia; lympho., - lymphocystis

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
43	6099		532	1 880	F	18	Hyper.
44	6100		623	3 060	F	22	
45	6093		513	1 640	F	11	
46	6098		508	1 820	F	16	
47	6092		495	1 490	F	10	
48	6091		548	2 110	F	22	
49	6101		581	2 400	F	21	
50	6102		524	1 980	F	13	
51	6103		482	1 500	F	10	
52	6104		581	2 680	F	16	
53	6105		577	2 390	F	24	
54	6106		502	1 630	F	12	W.D.S.
55	6107		501	1 690	F	12	
56	6108		567	2 160	F	14	
57	6109		542	2 000	F	11	
58	6110		505	1 580	M		Hyper.
59	6115		495	1 560	M	21	
60	6116		371	570		6	
61	6117		386	710	M	6	W.D.S.
62	6118	6119	353	470	M	6	
63	6121		460	1 250	F	9	
64	6122		436	1 020	F	9	
65	6123		448	1 040	M	15	
66	6124		467	1 260	M	18	Hyper.
67	6125		484	1 450	M	20	Hyper.
68	6113		461	1 090	M	10	
69	6112		376	660		5	
70	6114		336	490		6	
71	6126		392	670	M	6	
72	6127		495	1 520	M	17	Hyper.
73	6128		405	840		7	
74	6129		574	1 840	F	19	
75	6111		550	2 280	F	22	
76	6130		545	1 940	F	21	
77	6131		575	2 100	F	16	
78	6132		615	2 420	F	19	
79	6134		522	1 480	F	10	
80	6136		575	2 240	F	9	
81	6137		522	1 880	F	19	W.D.S.
82	6138		520	1 860	F	18	
83	6135		572	2 160	F	12	Hyper.
84	6139		365	1 080	F	8	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
85	6140		518	1 520	F	17	
86	6141		448	1 060	F	10	
87	6142		456	1 060	F	8	
88	6143		494	1 380	M	21	
89	6144		499	1 480	M	19	
90	6145		540	1 700	F	19	
91	6146		480	1 300	F	9	
92	6147		575	2 400	F	16	
93	6148		578	2 120	F	20	
94	6149		495	1 540	F	9	
95	6150		582	2 000	F	17	
96	6151		490	1 160	F	9	
97	6152		595	2 300	F	21	
98	6153		465	1 240	M	11	
99	6154		534	1 700	F	15	
100	6157	6158	470	1 240	M	18	
101	6160		493	1 640	F	10	
102	6161		466	1 140	F	8	
103	6169		488	1 260	F	11	
104	6156		450	1 140	M	10	
105	6155		510	1 520	F	18	
106	6162		520	1 470	F	11	
107	6163		598	2 010	F	21	
108	6164		465	1 070	M		
109	6165	6177	513	1 390	F	10	
110	6166		512	1 560	F	11	
111	6168		446	930	M	10	
112	6167		308	300	M		
113	6169	6178	619	2 510	F	21	
114	6170		356	465	M	6	
115	6171		467	1 110	M	21	
116	6173		471	1 140	M	21	
117	6174	6176	473	1 140	M	19	
118	6175		489	1 185	M	12	
119	6172		498	1 480	M	18	
120	6179		314	330	M	5	
121	6180		459	1 240	F	8	
122	6181		494	1 470	F	11	
123	6182		494	1 320	F	10	
124	6183		392	650	M	6	
125	6184		392	650	M	9	
126	6185		489	1 160	F	10	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
127	6186		460	1 230	F	9	
128	6187		487	1 200	F	10	
129	6188		453	940	F	10	
130	6189		529	1 440	F	11	
131	6190		453	1 140	F	10	
132	6191		423	1 200	F	9	
133	6192		476	1 180	F	10	
134	6193		596	1 415	F	9	
135	6194		420	830	M	10	
136	6195		518	1 470	F	10	
137	6196		477	1 255	F	10	
138	6197		477	960	M	10	
139	6198		514	1 430	F	10	
140	6199		498	1 290	F	10	
141	6200		496	1 335	F	9	
142	6201		480	1 220	F	9	
143	6202		504	1 370	F	9	
144	6203		522	1 620	F	10	
145	6204		484	1 220	F	11	
146	6205		460	1 090	F	10	
147	6206		421	840	M	18	
148	6207		577	1 960	F	9	W.D.S.
149	6208		553	2 070	F	22	
150	6209		542	1 680	F	13	
151	6210		491	1 410	M	18	
152	6211		524	1 450	F	12	
153	6212		531	1 610	F	11	
154	6213		424	830	F	8	
155	6214		534	1 660	F	10	
156	6215		560	1 980	F	19	W.D.S.
157	6216		411	800	M	8	
158	6217		487	1 440	M	18	
159	6218		565	2 300	F	21	
160	6219		512	1 680	F	19	
161	6220		546	1 830	F	21	
162	6221		553	1 890	F	18	
163	6222		447	990	F	9	
164	6223		434	1 000	M	10	
165	6224		386	690		7	
166	6225		439	950	F	10	
167	6226		356	520	M	6	
168	6227		495	1 190	F	11	
169	6228		614	2 620	F	18	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
170	6229		518	1 380	F	11	
171	6230		546	1 740	F	12	W.D.S.
172	6231		515	1 480	M	20	
173	6232		314	360	M	6	
174	6233		530	1 440	F	18	
175	6234		467	1 160	M	10	
176	6235		514	1 465	F	11	W.D.S.
177	6236		556	1 850	F	12	
178	6237		550	1 890	F	12	
179	6238		457	1 120	M	9	
180	6239		564	2 185	F	21	
181	6240		546	1 930	F	22	
182	6241		531	1 550	F	12	W.D.S.
183	6242		396	740		8	
184	6243		472	1 270	F	9	
185	6244		498	1 300	F	9	
186	6245		532	1 530	F	10	
187	6246		508	1 450	F	9	
188	6247		453	990	F	9	
189	6248		461	1 075	F	11	
190	6249		518	1 480	F	12	
191	6250		538	1 860	F	14	
192	6251		448	1 060	M	9	
193	6252		505	1 370	F	12	
194	6253		333	410	M	6	
195	6254		523	1 510	F	17	
196	6255		313	350		6	
197	6256		585	2 340	F	21	
198	6257		512	1 600	F	11	
199	6258		362	460		5	
200	6259		441	990	M	9	
201	6260		533	1 650	F	12	
202	6261		594	2 360	F	22	
203	6262		486	1 220	F	10	
204	6263		490	1 260	F	9	
205	6264		472	1 110	M	20	
206	6265		524	1 660	M	12	
207	6266		523	1 610	F	11	
208	6267		360	555		7	
209	6268		461	1 100	F	10	
210	6269		414	890	F	10	
211	6270		512	1 430	F	10	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
212	6271		483	1 255	F	10	
213	6272		498	1 315	F	11	
214	6273		560	1 760	F	20	
215	6274		474	1 080	F	11	
216	6275		478	1 140	F	10	W.D.S.
217	6276		474	1 120	F	11	
218	6277		606	2 270	F	22	
219	6278		447	880	F	10	
220	6279		456	950	F	9	
221	6280		486	1 190	F		
222	6281		509	1 490	F	9	
223	6282		507	1 480	F	11	W.D.S.
224	6283		429	950	F	7	
225	6284		585	2 240	F	14	W.D.S.
226	6285		538	1 680	F		
227	6286		334	420		6	
228	6287		338	450		6	
229	6288		473	1 380	F	22	
230	6289		502	1 250	F	9	
231	6290		507	1 450	F	10	W.D.S.
232	6291		318	350		5	
233	6292		320	340		6	
234	6293		290	360		6	
235	6294		316	340		6	
236	6295		332	440		7	
237	6296		315	340		6	
238	6297		341	440		7	
239	6298		316	320		6	
240	6299		317	340		6	
241	6300		307	320		6	
242	6301	6302	362	430		7	
243	6303		338	410		6	
244	6304		375	620		7	
245	6305		472	1 040	F	10	
246	6306		544	1 670	F	14	W.D.S.
247	6307		450	990	F	9	W.D.S.
248	6308		460	1 170	F	9	
249	6311		366	450		5	
250	6312		332	430		6	
251	6313		337	420		6	
252	6314		333	410		6	
253	6315		339	460		6	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
254	6316	6317	336	470		7	
255	6318		311	360		7	
256	6319		363	430		7	
257	6320		270	295		6	
258	6321		506	1 420	M	19	
259	6322	6323	463	1 060	F	21	
260	6324		363	590		6	
261	6325		349	490		6	
262	6309		348	490		6	
263	6310		359	540		6	
264	6326		281	240		5	
265	6327	6328	307	310		6	
266	6329		333	410		6	
267	6330	6332	325	360		7	
268	6331		316	350		6	
269	6333		299	310		6	
270	6334		350	490		7	
271	6335		324	390		7	
272	6336		316	350		6	
273	6337		327	360		7	
274	6338		352	510		7	
275	6339		364	490		7	
276	6340		352	510		7	
277	6341		324	410		5	
278	6342		293	310		7	
279	6344		284	210		6	
280	6343		338	450		6	
281	6345		516	1 480	F	10	W.D.S.
282	6346		372	555		7	
283	6347		379	620		7	
284	6348		545	1 850	F	11	
285	6349		525	1 650	F	11	
286	6350		371	570		7	
287	6351		351	510		7	
288	6352		351	490		7	
289	6353		330	400		7	
290	6354		464	1 150	F	10	
291	6355		481	1 110	F	10	
292	6356		335	430		7	
293	6357		343	460		6	
294	6358		514	1 550	F	11	W.D.S.
295	6359		358	560		6	

Appendix 1. continued

No.	Tag No.	Secondary Tag No.	Fork Length (mm)	Weight (g)	Sex	Age (yr+)	Diseases
296	6360		362	580		6	
297	6361		308	310		6	
298	6362		439	920		10	W.D.S.
299	6363		381	640	F	6	
300	6364		321	390		6	
301	6365		372	640		7	
302	6366		311	320		7	
303	6367		321	380		6	
304	6368		358	460		6	
305	6369		337	430		6	
306	6370		448	1 000	F	9	
307	6371		474	1 270	F	10	
308	6372		489	1 390	F	10	
309	6373		494	1 270	F	14	
310	6374		474	1 280	F	11	
311	6375		478	1 090	F	10	
312	6376		494	1 300	M	20	
313	6377		439	1 010	M	18	
314	6378		507	1 600	M	21	
315	6379		330	350		6	
316	6380		342	410	M	7	
317	6381		331	400	M	7	
318	6382		394	660	M	7	
319	6383		412	820	M	10	
320	6384		328	390	M	6	
321	6385		335	380	M	6	
322	6386		433	880	M	10	
323	6387		339	420	M	6	
324	6388		346	480	M	7	
325	6389		495	1 230	F	10	
326	6390		456	1 040	F	10	
327	6391		418	710	F	7	
328	6392		404	710	F	7	
329	6393		398	720		7	
330	6394		465	1 170	F	9	
331	6395		485	1 370	F	10	
332	6396		420	810	F	11	
333	6397		450	970	F	9	
334	6398		447	1 050	F	10	
335	6399		494	1 370	F	18	
336	6400		503	1 480	M	10	

Appendix 2. Duration of spawning migration, waters temperatures, and numbers of walleye and white sucker, Crean-Heart lakes channel, 1967-1975.

Year	Duration of Migration*	Water temperature during Migration Start (°C)	Finish (°C)	Numbers of Walleye	Numbers of White Sucker
1967	May 2 - May 18	7.2	10.0	1 950	482
1968	Apr. 24 - May 10	7.8	8.9	6 026	855
1969	Apr. 22 - Apr. 30	6.1	10.0	3 369	1 880
1970	Apr. 27 - May 10	6.1	10.0	5 868	2 532
1971	Apr. 28 - May 8	6.1	13.3	12 225	2 390
1972	Apr. 29 - May 13	8.7	11.7	16 848	5 928
1973	Apr. 26 - May 13	6.7	9.4	9 872	2 614
1974	Apr. 26 - May 11	6.1	8.9	7 590	3 512
1975	Apr. 29 - May 9	7.4	11.1	6 165	2 237

* duration of migration estimated from annual reports submitted by Saskatchewan Department of Parks and Renewable Resources to Parks Canada.