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Potential and Success in Spring 1994 of Walleye Spawning in the Salmon River, Tyendinaga Territory, Ontario, Canada

A Thesis Presented to the Faculty of the Department of Biological Sciences of the State University of New York College at Brockport in Partial Fulfillment for the Degree of Master of Science

by

Gordon John Mengel

August 14, 1997

THESIS DEFENSE

Gordon J. Mengel

APPROVED	NOT APPROVED
X	
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✓	

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BIOGRAPHICAL SKETCH

Gordon John Mengel was born [redacted]. He graduated in 1971 from Groton Central High School and in 1976 graduated from the State University of New York, College at Oswego with a Bachelor of Arts (B.A.) in Biology. In the fall of 1992 he enrolled in the M.S. program, Department of Biological Sciences, SUNY College at Brockport.

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"Nia:wen"

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SUMMARY

This study assessed the potential and success of walleye spawning in the lower Salmon River during Spring 1994. It was estimated that between 12,000 and 40,000 adult walleye migrated up the Salmon River from the Bay of Quinte to spawn between 12 April and 11 May 1994. Conditions for spawning and embryo development were nearly optimal with spawning substrate, water temperature, dissolved oxygen, and pH all optimal. However, volume and depth of the river decreased daily from the first day of spawning (14 April) to the end of spawning (May 10). Therefore, walleye eggs deposited in shallow areas, at least 20% of the available spawning area, were at risk of desiccation and, therefore, the overall habitat suitability may have been less than optimal for shallow, near shore areas.

An estimated 1,470,000,000 eggs were spawned in the nearly 9,000 m^2 spawning area below the Shannonville dam. Between 1 May and 5 May, walleye eggs began to hatch and fry descended the Salmon River with the current to the Bay of Quinte. It was estimated that as many as 147,000,000 fry were recruited into the Bay of Quinte and at least 1%, or around 1,470,000, were expected to survive to fingerlings.

Spearing impacted the spawning walleye population by eliminating 3,427 individuals; about 1,180 males and 2,228 females, which were mostly mature

and in a ripe spawning condition, as well as, 19 walleye of undetermined sex. Spearfishing resulted in the removal of as many as 350,000,000 unspawned eggs.

Approximately 1,000,000 walleye eggs were incubated in a community-built, owned and operated hatchery facility. About 85,000 fry were released into the Salmon River or aquaculture ponds.

INTRODUCTION

Eastern Lake Ontario, particularly the Bay of Quinte, is noted as an important walleye fishery (Christie 1973, Savoie 1984) (Figure 1). Walleye (*Stizostedion vitreum vitreum*) provide the Bay of Quinte with a small artisanal fishery (9,055 kg harvested in 1992) and a year around sport fishery (279,381 caught in 1992) (Mathers 1993a, 1993b). Each fall, large walleye migrate from the deep, cool waters of the lake to the shallow nutrient rich waters of the bay (Payne 1963). The Bay of Quinte provides abundant forage for walleye and suitable habitat for over wintering, as noted by an economically important winter walleye fishery (Colby et al. 1991). Each spring, as the ice melts, mature walleye move into shallow shoals and tributaries of the bay to spawn.

The Salmon River is one of four main tributaries to the Bay of Quinte and a site each spring for walleye spawning (Figure 2). Approximately 75 kilometers long, this river originates north of the Bay in the central Ontario counties of Anglesea, Kennebec, and Olden. The watershed is officially recorded as 891 square kilometers and it's average annual discharge is around 10.4 cubic meters per second (personal communication, Napanee Region Conservation Authority 1993). The Salmon River passes through the westernmost extent of Tyendinaga Mohawk territory entering into the Bay of Quinte approximately four kilometers south of the town of Shannonville. Tyendinaga, home for the

Mohawks of the Bay of Quinte, is located in Hastings County in southeastern Ontario, Canada.

Between 12 April and 11 May 1994, a population of walleye spawned in the Salmon River, below the dam at Shannonville. A study was conducted between April and September 1994 that included: monitoring and assessment of habitat suitability for spawning, characterization of the spawning walleye population including a determination of reproductive potential and success, and observations and analysis of stock enhancement potential using a local hatchery. The study site was confined to the lower 4 kilometers of the Salmon River, below the two meter high dam at Shannonville and terminating at the mouth of the river (Figure 3).

There were two main reasons for examining walleye spawning potential and success in the Salmon River. First, available information refers only to the overall abundance of walleye in the Bay of Quinte while contributions of individual tributaries to that production are not considered. This information, based on mark-recapture study and annual harvest data, is provided yearly by the Ontario Ministry of Natural Resources (OMNR) in the Lake Ontario Fisheries Unit's Annual Report. Data generated from this study provided an estimate of walleye spawning and progeny produced in the Salmon River.

Second, this study provided valuable biological and ecological baseline information to facilitate effective, appropriate resource management decisions and future studies by the Mohawks of the Bay of Quinte. Historically, walleye have played an important role in the culture, commerce, and diet of the Tyendinaga Mohawk. Traditionally, each spring, walleye were harvested during their spawning run up the Salmon River. To insure a productive and sustainable resource for the entire community, accurate and up-to-date information as to the status of this resource is essential as recommended by Green and Hill (1992).

Specific objectives of this study were to:

1.) describe and assess walleye spawning potential in the Salmon River based on habitat suitability as defined by specific physical and chemical parameters;

2.) determine and describe population characteristics, including reproductive potential, of walleye spawning in the Salmon River;

3.) estimate walleye fry descending the Salmon River to the Bay of Quinte; and

4.) provide useful information to the Tyendinaga community on hatching manually spawned walleye eggs to produce fry for enhancement of the Bay of Quinte walleye population and for pond culture.

MATERIALS AND METHODS

Site Description

The Salmon River walleye spawning area begins at the foot of the Shannonville dam and extends 260 meters (m) down river to a boat launching area (Figure 4). During the walleye spawning run, the first 100 m of the river below the dam was characterized by medium to large rapids and a very swift current. The river's path cuts through limestone bedrock leaving vertical rock ledge banks. This section of the river averages around 35 m wide (S.D. = 8.5 m, range = 21.5 - 53 m, n = 29) and less than 1 m deep.

From 100 m below the dam to the boat launch the river slows as the stream merges with waters of the Bay of Quinte. Average depth is around 1 m deep and as depth gradually increases, the shoreline has a greater vertical drop from the top of it's rock ledge banks to the river bed. As a result of years of erosion of the exposed bedrock and deposition, the substrate in the spawning area is typically limestone cobble-rubble.

Below the boat launch area and for the next 400 m down river, the Salmon River widens to a mean width of around 200 m. The shoreline on the northwest side of the Salmon River is a flooded wetland. This section of the river ranges in depth from very shallow near the shoreline to 1.0 - 2.0 m deep near the main mid river channel. The bottom of the Salmon River along the northwest side is typically a combination of muck and silt. Stumps and decaying remnants of logs and branches litter the area. The former wetland area is densely populated with submergent aquatic vegetation, predominantly *Myriophylum sp.* and *Potamogeton spp.* Deep areas bordering the main channel of the Salmon River provide adequate cover and may serve as staging areas for spawning adult walleye during daylight hours. According to several older Tyendinaga residents interviewed, no walleye spawning has ever been observed in this area.

The southeastern half of the Salmon River below the boat launch area is impacted more by the flow of the river as it descends from the Shannonville dam. The river on this side is fronted with homes and the shoreline is mostly constructed with bulkhead and rip-rap. For the first 80 to 100 m down river from the boat launch area, the bottom of the Salmon River is typically hard, and lightly covered with loose organic debris. From 100 m to 200 m down river, the bottom is fairly hard, but increasingly littered with materials typical of depositional areas (e.g., sand, bark, twigs, leaves, small shells, etc.) The river depth here averages just less than 2 m. From 200 to 400 m down river, the Salmon River bottom is very soft and composed, chiefly, of combinations of sand, silt, muck, and small organic debris. After about 250 m down river, submerged aquatic vegetation (*Myriophylum sp.* and *Potamogeton spp.*)

becomes more noticeable from the shore to the southeastern edges of the river channel. No walleye spawning has ever been observed in this area.

Organization of Study

A proposal for this study was shared with the Tyendinaga Chief, Band Council, and community members at two meetings held on 9 February and 9 March, 1994 (Annex 1). Additional meetings were held with various community groups and individuals, as well as, representatives of the Ontario Ministry of Natural Resources (OMNR) to address concerns, research background information, and solicit support. Community approval was expressed in the results of a public referendum and official authorization to initiate the study was granted on 7 April by the Tyendinaga Band Council. The OMNR concurred with this decision. Concurrently, all equipment and materials needed to conduct the study were located on site. The study began on 8 April 1994.

An "on-site" presence was maintained at Tyendinaga between 8 April and 3 June. Additional site visits were made on 6, 13, 20 August and 8, 9 September. Community members assisted with collection and recording of data. Community members involved directly in the study included the Tyendinaga "aquaculture team," Tyendinaga "fish wardens," and a local artisanal fisherman (also an elected official to the Tyendinaga Council) (Annex 1). Before and throughout the study, participants received literature and basic training in aquatic ecology, limnology, aquaculture, and fisheries techniques.

Data collection initiated with recording of water quality in the Salmon River during the first week of April and concluded in early September 1994. The most intensive periods of sampling and data collection occurred during the walleye spawning run (14 April to 11 May), walleye egg incubation (18 April to 5 May), egg hatch and fry drift (8 May to 3 June), and analysis of Salmon River's spawning substrate (10, 13, 19 May, 6, 13, 20 August and 8, 9 September).

Data analyses began simultaneously with initiation of the study and continued through March of 1995. Most data analyses and interpretations occurred at the State University of New York, College at Brockport using Microsoft "Word" for wordprocessing, Microsoft "EXCEL" for spreadsheet and graphical presentations and descriptive statistics, and "MyStat" for parametric and nonparametric statistical tests, including one-way and two-way Student's t-tests and Analysis of Variance (ANOVA). For all parametric statistical analyses, an alpha level of significance of $p \leq 0.05$ was used.

Habitat Suitability for Walleye Spawning and Egg Incubation

Reproductive potential of walleye spawning in the Salmon River was assessed in terms of habitat suitable for egg deposition and incubation. McMahon et al. (1984), drawing upon observations of several researchers, identified five habitat variables considered most critical for successful walleye spawning and embryo development. Water temperature, dissolved oxygen, and pH determine water quality. Water level is related to water quantity or discharge and velocity. A spawning habitat index is a measure of the quality and quantity of spawning substrate. Each of the variables identified by McMahon et al. (temperature, dissolved oxygen, pH, water level, and spawning habitat quality) can have a positive or negative impact on walleye egg spawning and embryo development and, therefore, was monitored or determined (Eschmeyer 1950, Johnson 1961, Colby and Smith 1967, Priegel 1970, Smith and Koenst 1975, Koenst and Smith 1976, Anthony and Jorgensen 1977, Spangler et. al. 1977, Balon et. al. 1977, Chevalier 1977, Groen and Schroeder 1978). Each habitat variable was given a Suitability Index (SI) by comparing a value from the Salmon River with a suitability curve for that variable developed by McMahon et al. (1984) (Annex 2).

Water Quality

Temperature, dissolved oxygen, and pH were monitored on the Salmon River between 5 April and 1 June 1994 using standard methods and techniques

(Table 1). All water quality observations were made at a site just above the Shannonville dam (Figure 4). Morning and evening water temperatures and dissolved oxygen levels were recorded on 50 days between 5 April and 3 June 1994; morning or evening temperatures and dissolved oxygen levels were recorded on 4 days. Dissolved oxygen meter readings obtained with a polarographic meter were checked twice weekly by comparison with values obtained using Winkler titrations (APHA 1992). The two means were within 0.2 mg/L O_2 ($n = 16$) and were not significantly different (Student's t-test, $p > 0.05$). The pH was recorded on 17 days between 5 April and 3 June 1994, 3 times per week for the first 4 weeks and once weekly in each of the last 5 weeks.

Water Level, Volume, and Velocity

Water level was observed daily from 8 April at a reference point under the Shannonville bridge on the northwest side of the Salmon River (Figure 4). A mark was made 1 m above river water level on the perpindicular-standing bridge abutment. The height of the reference point above the river surface level and the height of the reference point above the river bottom were recorded in centimeters (cm).

At initiation of spawning (14 April); conclusion of spawning (10 May), indicated by low numbers of speared male walleye and the presence of only green or spent females; and conclusion of egg hatch (1 June), indicated by numbers of captured fry, additional reference marks were used to denote river level. On each date, at points 2 m, 90 m, 140 m, 190 m, and 240 m below the dam, wooden pegs were driven into the shoreline at waters edge. All reference points were located on the northwest shoreline. River level on 1 June was within a few centimeters of the reference pegs marking river level on 10 May, therefore it was assumed that river level and depths on 1 June were not substantially different from river level and depths on 10 May. No further water level measurements were made after 1 June since the walleye hatch had ended.

On 6, 13, 20 August and 8, 9 September 1994, the two sets of reference marks established on 14 April and 10 May were used to determine the overall changes in the Salmon River surface water level and depth between initiation of spawning, conclusion of spawning, and conclusion of egg incubation. Areas with appropriate depth for walleye spawning were determined and quantified using the transect method (Dunham and Collotzi 1975, Duff and Cooper 1976). Transects were made across the Salmon River by suspending a calibrated string between two wooden stakes placed on opposite shores of the river. Using a hand level, string, and calibrated rod, transect stakes were placed between reference pegs at the approximate level of the river on 14 April and 10 May.

The first transect was established 2 m below the dam. Subsequent transects were made every 10 m down river except in two areas. A significant obstacle was located just above the bridge and a transect, only 5 m from the two closest transects, was added. An additional transect, also only 5 m from the two closest transects, was placed under the bridge to provide additional information for river volume calculations. The last transect was located 260 m below the dam, just above the boat launch site.

With a two meter calibrated rod, river depth below the highest reference level (14 April) was determined to the nearest centimeter at every half meter along each transect. Transect data were used to create depth profiles used to define areas of the river with depth greater than 0.3 m and less than 1.5 m, considered suitable for walleye spawning and egg incubation, on 14 April and 10 May.

The degree of change in river level during spawning and embryo development was assessed using definitions provided by Johnson (1961) cited in McMahon et. al. (1984) (Annex 2). An optimal SI of 1.0 (A) is defined as water level that is "rising or normal and stable" with an abundance of shallow shoreline or shoal areas for spawning. An SI of 0.5 (B) is defined as "low" with many spawning areas exposed and never inundated. An SI of 0.2 (C) is defined as "fluctuating" with fluctuations sufficient to alternately expose and flood spawning areas.

Information regarding the daily mean discharge for the Salmon River between 5 April and 1 June 1994 was obtained from the Napanee Water District office in Napanee, Ontario. Daily discharge for the Salmon River was recorded continuously at a gauging station maintained by Water Survey Canada. The station was located approximately 2.25 kilometers (km) up river from the Shannonville dam. There were no permanent feeder streams between the gauging station and the mouth of the Salmon River. It was believed that river flow values above the dam accurately approximated flow below the dam during periods of insignificant run-off.

Equipment for measuring river velocities at various points and times in the Salmon River was not available for this study. Daily velocity for Salmon River water flowing under the Shannonville bridge between 14 April and 5 May was estimated by converting a commonly used equation to calculate discharge (Wetzel and Likens 1991):

$$Q = AV$$

where: Q = discharge (m^3/s)

A = cross sectional area (m^2)

V = velocity (m/s)

The Wetzel and Likens equation was preferred over a similar equation (i.e., Robins and Crawford 1954) because it consistently provided a lower daily estimate of Salmon River velocity. Cross sectional area ($A = WD$) was easily determined under the Shannonville bridge using depth data (D) collected daily from the reference mark established 8 April and the constant distance (W) between two bridge abutments on opposing shorelines.

Delimitation of Spawning Area and Characterization of Spawning Substrate

To determine the lower extent of the Salmon River walleye spawning area, an initial sampling of depth and spawning substrate was conducted on 10, 13, and 19 May 1994. Sampling occurred below the boat launch, down river of areas where walleye were observed spawning between 14 April and 11 May (Figure 5). Sampling was discontinued 400 m down river from the boat launch site where depths greater than 2.0 m and decaying remains of thick aquatic vegetative growth were consistently encountered. The limit of the spawning area was determined by the extent of optimal spawning habitat as defined by water depth (greater than 0.3 m and less than 1.5 m) and substrate quality (soil particles greater than 0.2 cm) (McMahon et al. 1984).

To collect substrate samples and measure depth, a 5.5 m boat, a weighted and calibrated cord, and an Ekman sampler with a 100 cm^2 opening were employed. Ten transects were located from bank-to-bank, one every 40 m down river of the boat launch site. Three depth measurements and 3 individual bottom substrate samples were collected along each bank-to-bank transect across the Salmon River. One depth measurement and substrate sample was taken 25 m from each bank. The third measurement and substrate sample was taken as close to mid river as possible. A total of 30 measurements and samples were collected. Substrate materials were characterized visually according to categories published by the Ontario Ministry of Natural Resources (OMNR) in the "Manual of

Instructions - Aquatic Habitat Inventory Surveys" (Dodge et al. 1981). Additionally, bottom samples were presorted to verify presence or absence of viable eggs. While several samples did contain eggs, no viable eggs were found and, therefore, no eggs were saved for further identification.

Due to high flow and cold conditions in spring, data used to assess the walleye spawning area, from the dam to the boat launch, were collected on 6, 13, 20 August and 8, 9 September 1994. Areas with appropriate substrate for walleye spawning were determined and quantified using the transect method (Dunham and Collotzi 1975, Duff and Cooper 1976). A 100 m string, calibrated in 50 cm units, was employed to measure the length of the Salmon River spawning area. The same calibrated string was used to measure distances across the spawning area at each of 26 transects. Using reference points, river width was determined for 14 April, 10 May, and 1 June. Length and mean width were used to calculate the total area potentially available for walleye spawning on each of those dates.

Spawning substrate quality was determined with a rectangular frame made from 3 cm PVC tubing and measuring 100 cm long by 30 cm wide (3000 cm^2). Two poles rising perpendicular from the substrate sampling frame were used to hold the frame to the river bottom while keeping it directly below the suspended transect string. Percentage of total area within the PVC frame composed of a particular substrate type, as categorized by Dodge et al. (1981), was estimated visually. Substrate quality was estimated, shore-to-shore, meter-by-meter, for the entire length of each of the 26 transects. In depths greater than 80 cm, a mask and snorkel were used to make close-up qualitative and quantitative estimations of substrate type. Areas between each transect were also observed for any significant variance in spawning substrate type.

Percentages of each substrate type were converted to area (cm^2). A substrate index was calculated to assess the quality of the spawning substrate using the formula presented in McMahon et al. (1984):

Substrate Index = 2(% gravel/rubble 2.5 to 15 cm in diameter)
+ (% boulders/bedrock)
+ 0.5(% sand)
+ 0.5(% dense vegetation)
+ 0(% silt/detritus).

The substrate index (maximum = 200) was then used to determine a "spawning habitat index" (McMahon et al. 1984). A spawning habitat index is the proportion of usable spawning area multiplied by the substrate index. The value obtained is compared with the optimal spawning habitat index of greater or equal to 40.

Description of the Spawning Walleye Population

Population Abundance

To describe quantitatively the walleye population spawning below the Shannonville Dam, a mark-recapture study was conducted between 18 April and 11 May 1994. Walleye were captured with hoop nets at the mouth of the Salmon River, sexed, measured, weighed, marked, tagged with external anchor tags, and released (Figure 3). Slightly less than 3 km up the Salmon River, at the walleye spawning area located below the Shannonville dam, walleye were removed with three-pronged spears by Tyendinaga community members. Speared walleye were tallied by Tyendinaga fish wardens, sexed, measured, weighed and examined for tags or marks.

Initially, two 2 m diameter "spring" trap nets were provided by the Ontario Ministry of Natural Resources (OMNR) to capture walleye for tagging. However, the OMNR nets proved inappropriate. Instead, two 1.2 m and two 1.0 m diameter hand assembled "hoop nets" were employed. The four hoop nets were, basically, modified trap nets and were characteristic of nets used by local residents to harvest brown bullhead (*Ameiurus nebulosus*), white perch (*Morone americanus*) and other fishes of commercial value from littoral areas of the Bay of Quinte. Incidental catches of walleye had been noted during walleye spawning using this type of net (Willard Hill, personal communication).

Hoop net "houses" were composed of either 1.0 m or 1.2 m diameter hoops covered with 4.5 cm (edge length) mesh netting. A 15 m or 30 m leader, 1 m or 1.2 m wide, of 5 cm mesh netting was stretched diagonally downstream from each net's mouth and tied to a pole located near shore. Two 1 m long "wings", 1 m or 1.2 m wide, made of 5 cm mesh netting extended out from either side of each net mouth forming a 90 degree angle. Leader and wings were secured with weighted ropes and cement anchors. Nets were kept upright in the current with floats. Nets were set and secured in 1.5 m to 2 m of water by tying a rope from the cod-end of each net to a pole or cement block anchor located up-river of the net. A 5.5 m flat-bottomed steel boat equipped with a 40 hp outboard was initially used to deploy the 4 hoop nets. A second, 5.0 m flat-bottomed steel boat, outfitted with a 15 hp outboard, was used to check and empty all nets.

Capture of spawning walleye migrating up the Salmon River began 18 April, 6 days after walleye had begun to congregate below the Shannonville dam (Table 2). Marking and tagging of walleye for the mark-recapture study terminated on 8 May and all nets were removed from the river on 11 May. With one exception, nets were fished continuously in the spot of initial deployment.

Nets were set on 14 days between 18 April and 8 May. Typically, nets were set and then checked for contents and reset within 24 hours, usually in late morning between 0900 and 1200 hours. Checking nets every 24 hours was not always possible due to unfavorable weather and water conditions, illness, or scheduling problems. Hoop nets were checked after 24 hours (9 times), after 48 hours (4 times) and after 72 hours (1 time).

Each time a hoop net was checked, it was emptied of all fish. All captured walleye were transferred to a holding cage attached to the side of the boat. All other fish captured (by-catch) were identified and enumerated. Fish of economic importance were retained by the boat owner and the rest were returned to the river. No fish mortality was observed in hoop nets between 18 April and 8 May.

After all nets had been emptied and redeployed, individual walleye were removed from the holding cage, examined, marked, tagged and relevant data recorded. Walleye were handled without aid of anesthetics. Fork length (FL), to the nearest 0.5 cm, and weight, to the nearest quarter pound, were determined with a ruled tally board and a 20 pound spring balance. Fork lengths (cm) and weights (g) were measured to facilitate specific analyses. Sex, determined by observing the condition of the ventral area and uro-genital opening and spawning condition (e.g. ripeness), determined by gently stroking the ventral portion of each fish from pelvic fins to the vent and looking for extruded eggs or milt (Richard and Hynes 1986) were also determined for each walleye.

Before being returned to the river, each walleye was tagged with a colored and individually numbered external anchor tag manufactured by Floy, Inc. Floy tags were inserted with a tagging gun into the dorsal musculature of each walleye at the base of the second dorsal fin. All tags were inscribed with the address of the State University of New York at Brockport, New York to assist in identification of each tagged fish as part of this study. Color and number of each anchor tag was recorded for each tagged walleye. As a precaution in case of tag loss, each captured walleye also was marked with a single 6 mm hole in the right pectoral fin using a standard hole punch as described by Wydoski and Emery (1983). All walleye appeared to be in very good condition upon release.

The Tyendinaga spearing season provided opportunities to make observations of individual walleye as well as a means of recapture for the determination of population abundance. For the duration of the study, fish wardens assigned to the Salmon River spawning area observed speared walleye for presence or absence of tags and marks. Wardens obtained descriptive information for speared walleye on 20 of the 28 nights during the spawning run.

To facilitate measurements and quantify observations, each warden was provided a ruled "tally" board (Anderson and Gutreuter 1983). Each examined fish was laid lengthwise on the board, snout flush against a raised end piece, and fork length, to the nearest 0.5 cm, was marked with a pencil in the upper, middle, or lower longitudinal quadrant depending upon sex. At the end of each night all lengths were tallied and recorded by sex.

The total number of walleye speared from the spawning area was estimated from the 1994 Tyendinaga spearing report findings. Using the observed male to female ratio of speared walleye (1 to 1.9, n = 803) it was possible to extrapolate the total number of speared male and female walleye.

To estimate the total population of walleye spawning in the Salmon River from mark-recapture data, the "Schaeffer method for stratified populations" described by Ricker (1975) was chosen. This method of estimating population abundance was employed by Crowe (1955) to estimate abundance of a population of walleye migrating up the Muskegon River (Michigan) to spawn. The Schaeffer computation takes into consideration the movement of individuals from a target population into and out of the sampling area and, therefore, was suitable for estimating abundance of walleye migrating up the Salmon River from the Bay of Quinte to spawn.

The Schaeffer equation is as follows:

$$N = \Sigma N_{ij} = (R_{ij} ((M_i / R_i)(C_j / R_j))) \text{ (Ricker 1975)}$$

where: N = total population

ΣN_{ij} = sum of each portion of the population available for marking in period i and available for recovery in period j

M_i = number of fish marked in the *i* th period of marking

M = ΣM_i, total number of fish marked

C_j = number of fish caught and examined in the *j* th period of recovery

C = ΣC_j, total number of fish examined

R_{ij} = number of fish marked in the *i* th marking period which are recaptured in the *j* th recovery period

R_i = total captures of fish tagged in the *i* th period

R_j = total recaptures during the *j* th period

A "correlated population" method referred to by Bagenal (1978) also was used to estimate abundance of walleye spawning in the Salmon River. This method used an estimate of walleye egg production formulated from the observed fry hatching success. The number of spawning female walleye was then back-calculated using the results of fecundity analysis for female walleye spawning in the Salmon River between 14 April and 11 May 1994. The number of male walleye spawning in the Salmon River at that time was, then, estimated by multiplying the estimated number of females by the male-female ratio observed during the Tyendinaga spearing season.

Population Characteristics

Sex composition of all speared walleye was extrapolated from observed numbers of male, female, and walleye of undetermined sex. Sex composition of walleye caught in hoop nets at the mouth of the river and walleye speared below the dam was compared. Fork lengths of male and female walleye were used for analysis of length frequency by sex; results from the river mouth and spawning area were compared. Length-weight relationships for both male and female walleye were developed using regression analysis. Length-weight relationship and weights of Salmon River walleye were compared with results obtained by Payne (1963) who investigated similar characteristics of walleye caught in the Bay of Quinte each spring between 1959 and 1962. Weights of 1959 - 1962 Bay of Quinte walleye (sexes combined) were calculated by substituting lengths of walleye sampled from the Salmon River into Payne's length-weight regression equation. Total weight of spear harvest was estimated using the length-weight regression equations of male and female walleye. Spawning condition was determined for individual male and female walleye caught at the river mouth and speared from the spawning area and results compared. Relative condition factor (K_r) was calculated for male and female walleye from length and weight data and the following formula attributed by Haynes (1992) to LeCren (1951):

$$K_r = W/aL^n$$

where: K_r = relative condition factor

W = weight (g)

a = an empirically determined constant based on observed weights and lengths

L = fork length (cm)

n = an empirically determined exponent based on observed weights and lengths

and:

$$\log a = \frac{[\sum \log W * \sum (\log L)^2] - \log L * \sum (\log L * \log W)]}{[N * \sum (\log L)^2] - (\sum \log L)^2}$$

$$n = \frac{\sum \log W - N * (\log a)}{\sum \log L}$$

N = number of fish in sample

Age composition of both male and female walleye caught with hoop nets (n = 77) and speared male and female walleye (n = 803) were estimated by the

"Peterson Method" which uses unimodal peaks in fork length frequencies to segregate distinct year classes (Jearld 1983). Mean fork lengths represented by frequency peaks were, then, visually, compared against a length versus age growth curve developed by the Ontario Ministry of Natural Resources for Bay of Quinte walleye (unpublished report 1993) (Figure 6). No scales or otoliths were analyzed.

Fecundity of female walleye per length and per weight was estimated using unruptured ovaries obtained from ten speared walleye. Each female was measured and weighed prior to removal of the paired ovaries. Ovaries were preserved in 10% formalin for eventual analysis (Snyder 1983). Egg number per ovary was determined volumetrically using a technique modified from Bagenal (1978) and Piper et al. (1982). Volume of each ovary was determined by submersion in water and measurement of displacement. Subsamples were cut from each ovary (n = 6), volume measured and total number of eggs in each subsample counted. Egg number in each ovary was then determined by proportion and the result used to determine the number of eggs per centimeter length and per kilogram weight. Fecundity of Salmon River female walleye was, then, compared with fecundity determined by Payne (1963) for 11 female walleye netted from the Bay of Quinte.

Walleye Spawning Success

Shoreline observations of spawning activity were made each day and night between 12 April and 11 May. Quantification of egg deposition was not feasible because of the inherent characteristics of spawned walleye eggs and the dominant spawning substrate (cobble-rubble). Colby et. al. (1979) observed that walleye eggs deposited on rocky bottoms adhered to the rocks for only a short time and ultimately dropped into cracks and crevices. Egg deposition, therefore, was estimated by "back-calculation" using estimated fry production and observed walleye egg hatch rates noted in relevant literature (Johnson 1961, Forney 1975b, Mathias et al. 1992). Additionally, impact of harvest of female walleye on egg deposition in the Salmon River was estimated based on number and length frequencies of females speared, fecundity, and overall spawning condition.

Abundance of walleye fry in the Salmon River was estimated using a fixed drift net (Gale and Mohr 1978, Corbett and Powles 1986, and Franzin and Harbicht 1992). The sampling site was located 1 km upriver from the mouth of the Salmon River (Figure 3). Between 8 May and 3 June, a "double bongo" net with two 50 cm diameter hoops, each with 500 μm nytex mesh icthyoplankton nets having a 1:1.5 diameter to length ratio, was deployed from the side of a 5 m metal boat anchored midstream in the Salmon River. Volumes of samples were measured with a flow meter suspended in the mouth of one of the nets.

Bongo nets were manually lowered to predetermined depths from the side of the anchored boat. Nets were held submerged for 10 minutes, allowing drifting organisms to enter the mouth of the net and collect at the cod-end. The cod-ends of each net had a removable PVC collection tube with 500 μm mesh windows. Once nets were retrieved, sample contents from each collection tube were placed into individually labeled 4 ounce sample jars with approximately 3 ounces of 5% formalin solution for later identification (Snyder 1983).

Sampling for walleye fry occurred about every other night between 6 May and 3 June. Fry were first observed in samples collected 6 May and a standard sampling protocol initiated on 8 May. Samples were collected by making three traverses from shore to shore, east to west, along a 60 m transect across the Salmon River.

Eight duplicate samples were collected from 5 stations located every 10 m along the sampling transect. A single, duplicate sample was taken 0.25 m (from top of net) below the surface at the two shallow water stations nearest the two river banks. Two duplicate samples were taken at each of the three deeper, mid river stations, the first at 0.25 m depth and the second at 1.25 m depth. Approximately 430 m^3 (0.005%) of the Salmon River volume (approximately 9,000,000 m^3) was filtered through collection nets (300 duplicate samples) while nets were submerged (50 hrs).

All sampling of walleye fry was done between dusk and dawn. Each traverse took around 4 hours. Samples could not be collected in the evening of 8 May and the early morning of 9 May due to inclement weather. Samples were not collected on the evening of 11 May and on 12 May due to conflicting responsibilities. By 21 May, due to an increasingly earlier sunrise, no walleye fry were observed in samples taken between 0400 and 0800 hours. No sampling was done, therefore, during morning hours after 27 May.

Walleye sac-fry have been observed to avoid collection efforts at current velocities less than 0.07 m/sec (Houde 1969, Gale and Mohr 1978, and Corbett and Powles 1986). Mean river velocity at the sampling site was estimated on 7 nights between 21 May and 3 June using the "float" method (Cooperider et al. 1986). Estimated velocity values were later compared to estimates of mean velocity calculated from recorded mean discharge values (Wetzel and Likens 1991). Both methods of estimating river velocity showed values consistently greater than 0.07 m/sec and, therefore, collection was unbiased by low velocity.

All Salmon River drift samples were given a preliminary inspection the day following collection at the Tyendinaga ARC hatchery. A Leica 2000 Zoom dissecting microscope was used to verify presence or absence of icthyoplankton and to sort debris from each sample. All icthyoplankton collected between 6 May and 3 June were transported to State University of New York, College at Brockport for further identification and enumeration. Walleye fry were identified using preanal and postanal myomere counts (Hardy 1978), measured to the nearest half millimeter using a dissecting microscope with a 10X ocular micrometer, and enumerated. All other prolarvae were classified by myomere counts, enumerated and the more numerous identified using taxonomic information presented in Auer (1982).

Densities of walleye fry observed each night at the sample site, mean daily discharge and cross-sectional area were used to estimate the total number of walleye fry drifting down the Salmon River to the Bay of Quinte between 8 May and 3 June 1994 (Jude 1992). To estimate walleye fry abundance, several assumptions were considered: (1) each sample collected was representative of walleye fry density at that sampling station and a 10 m section along a transect that extended 5 m on either side of the sampling station, (2) walleye fry were present throughout the water column to a depth of 0.8 times the total depth and no fry were located at lower depths, (3) walleye fry density determined after one or two 10 minute samples was representative of walleye fry density during a 4 hour period, (4) the ratio of walleye fry drifting in the Salmon River was around 1 fry during 12 hours of daylight to 3.8 fry during 12 hours of darkness (Gale and Mohr 1978), and (5) since no significant differences in mean densities of walleye fry were observed at stations where samples were collected at 0.25 m depth and 1.25 m depth (Student's t-test, $p = 0.57$), the two samples could be averaged (Jude 1992). Mean fry densities sampled, therefore, were considered to be fairly representative of fry density in the entire water column at that station.

The Salmon River, at the transect site, had a mean depth of 2.6 +/- 0.4 m (95% C.I., range = 0 - 4.5 m, n = 60) and, therefore, a cross-sectional area of 163 m^2. Due to differences in depth across the transect, each of the five, 10 m wide sampling stations had a different cross-sectional area. Fry densities at each station were "weighted" relative to the their cross-sectional area before being multiplied by the volume of water passing the transect in 24 hours.

An estimate of walleye fry drifting down the Salmon River on days where no sampling occurred was made by averaging the previous and following day's estimates based on sampling results. To account for fry exiting the Salmon River prior to initiation of fry sampling on 8 May, it was necessary to estimate the first possible day of walleye egg hatch. First, the approximate age of fry collected at the sampling site was estimated based on size (TL) and presence or abscence of yolk sac and oil globule (Nelson 1968, Houde 1969, Priegel 1970, Hardy 1978, Colby et. al. 1979, McElman and Balon 1985, Corbett and Powles 1986, Auer and Auer 1987). Water temperature data were then compared with observations on duration of walleye egg incubation at different temperatures made by several investigators including Johnson (1961), Allbaugh and Manz (1964) and Koenst and Smith (1976). The earliest emergence of walleye fry was determined to be the 18th day (1 May) after initiation of spawning, although it more likely occurred around the 22nd day (5 May). An estimate of fry drift down river from the presumed first day of hatching (5 May) to the first day of sampling was calculated by taking an average of the first 3 full days of fry sampling (9 - 10 May, 10 - 11 May and 13 - 14 May) and multiplying by the number of days fry could have drifted prior to initiation of sampling (3).

Potential for Walleye Population Enhancement

Walleye eggs were incubated and hatched at the Aquaculture Resource Center (ARC) hatchery between 18 April and 5 May 1994. The ARC hatchery facility (24.5 m^2) is located next to the Salmon River dam in Shannonville, Ontario. Well water was distributed to the hatchery by a 0.5 hp pump. A head tank (1,030 L capacity) was used to maintain a constant water flow from the well during egg incubation and larval fish rearing. Egg incubation and hatching took place in six, 0.26 m^3 raceways. Maximum maintainable flow with all 6 raceways fully operational was approximately 1.5 liters per minute per raceway.

Water was oxygenated in the hatchery head tank by a continuously functioning 0.25 hp air compressor. Aeration maintained dissolved oxygen above 5.0 mg/L O_2. At initiation of egg incubation, temperature of water drawn from the head tank was 10°C. On 19 April, hatchery personnel installed two 110V room heaters in the hatchery in an attempt to accelerate egg incubation. Water temperature in only one raceway, where eggs were incubated with continuously recirculated water, was impacted; water temperature increased from around 10°C to over 20°C in 24 hours. Water temperature in other raceways where eggs were incubated in "single pass" systems remained relatively unaffected.

Six 5.2 L "Bell" jars were used for incubating walleye eggs in the ARC hatchery. Two Bell jars were initially placed at the head of each of 3 raceways. Each pair of jars was provided with water from a single 12.7 mm diameter PVC inflow pipe. Water flow was regulated with a globe valve and delivered to the bottom of each jar via a "T" section. Water flowed up from the bottom of each jar and kept eggs in constant motion, slightly suspended, and oxygenated while removing debris and metabolites. Overflow from jars was directed into a raceway, passing first through a screened basket that retained eggs and fry. From the start of incubation to hatch, water flow through each of the paired jars was monitored constantly and regulated.

An "experimental" hatching system consisting of twelve, 1 L plastic round bottom bottles was used to hatch walleye eggs in a fourth raceway. A 110V submersible pump was used to continuously recirculate approximately 150 L of water from the raceway back through each of the individual hatching jars at a rate of approximately 2 L per minute. An additional 50 L of make-up water was added to the raceway once (27 April) during egg incubation. Flow to all jars was monitored constantly and adjusted as needed. Oxygen levels were maintained by the air compressor.

Experimental jars were used to make comparisons between fertilization rates and "eye up" rates of walleye eggs obtained from different sources (e.g., Napanee River versus Salmon River) and by different means (e.g., milt and eggs stripped from dip netted males and females versus speared or gill netted males and females). The experimental hatching system was developed to incubate eggs in the same manner and under the same conditions as the Bell jars. Necessary system modifications, however, made the two incubation environments different.

Water quality information recorded daily in the ARC hatchery included water temperature, measured with a standard maximum-minimum thermometer, and dissolved oxygen, measured potentiometrically with a portable dissolved oxygen meter, Model 16046 (Hach) with a Clark-type membrane-covered polarographic probe. Temperature and dissolved oxygen level of water used in the Bell jars was measured inside the head tank. Temperature and dissolved oxygen level of water used in the experimental hatching unit was measured in the raceway.

On 18, 19, and 20 April, male and female adult walleye were caught with dip nets and hand-stripped of milt and eggs to produce fry for pond and Salmon River stocking. All eggs were fertilized using the "dry method" (Piper et al. 1982). Tannic acid was used at 400 ppm for 2 to 4 minutes to decrease adhesiveness of fertilized eggs. Water hardened eggs were transported back to the ARC hatchery and stocked in either 5.2 L Bell jars or 1 L experimental jars (Table 3).

Beginning 21 April, it was no longer possible to observe and, therefore, dip net parental stock during the daylight hours. The availability of speared and gill netted walleye on 23 April provided an opportunity to undertake a relevant investigation to look at the possible viability of gametes obtained from mortally injured parental walleye. Walleye were hand-stripped of eggs and milt within 20 minutes of spearing. Eggs and milt were stripped from gill netted walleye caught during the previous night in the Bay of Quinte near the Salmon River mouth. Although still alive, the condition of the gill netted fish suggested they would not survive if released. All eggs were fertilized by the "dry method" and stocked in experimental jars at the ARC hatchery.

Dead eggs and eggs showing signs of fungal infection were removed from incubation jars daily. Chemical prophylactic use of 1600 ppm formalin for 10 to 15 minutes to control fungus infection of eggs began after official approval for the treatment was received from the Ministry of Health and Welfare (Canada) on 19 April. Bell jars were treated with formalin on 23 April, 29 April and 2 May. Formalin treatment in the experimental hatching system was administered once, on 26 April, to eggs from gill netted and speared walleye. Eggs from dip netted walleye which had already reached the "eyed" stage by 23 April, were not treated with formalin.

RESULTS

Habitat Suitability for Walleye Spawning and Egg Incubation

Water Temperature

Between 5 April and 8 April when the ice began to break up and move down the Salmon River, water temperatures remained below 3°C. After 8 April, morning, afternoon, and daily mean water temperatures rose steadily (Table 4, Figure 7, Annex 3). The first walleye appeared below the Shannonville dam on 12 April, when mean daily water temperature of the Salmon River was around 6.4°C. It was assumed that no spawning took place during the first week water temperature was monitored (5 - 11 April). On 13 April, winds and rain opened up the river by displacing a large ice mass that covered the northern third of Big Bay, including the mouth of the Salmon River. A small number of larger, female walleye were observed with the smaller males below the dam. On 14 April mean daily water temperature of the Salmon River was around 7.6°C and large numbers of both male and female walleye were observed spawning in shallow shoreline areas below the dam. Water temperature continued to increase gradually after 14 April to around 12.9°C at the end of the spawning run on 11 May. By the end of walleye fry hatch, water temperature reached around 18.1°C.

Daily mean temperature during the 8 weeks between 12 April and 3 June 1994 was 11.9 +/- 1.0°C (95% C.I., n = 47) and mean weekly water temperature was around 12.7 +/- 3.0°C (95% C.I., n = 8). Based on an optimal mean weekly water temperature of greater than 11°C and less than 18°C for the period of incubation and hatching of walleye eggs (McMahon et al. 1984), the Suitability Index (SI) for the Salmon River between 12 April and 3 June 1994 was 1.0.

Dissolved Oxygen

From initiation of spawning, during the second week of water quality monitoring, and through egg incubation and egg hatching stages, dissolved oxygen ranged from a maximum of 12.9 mg/L O_2 on 12 April to a minimum of 7.6 mg/L O_2 on 24 May (Table 4, Figure 8, Annex 4). Dissolved oxygen levels were never below optimal (< 6 mg/L O_2), therefore, the SI for dissolved oxygen at the Salmon River spawning area between 5 April and 3 June 1994 was 1.0 (McMahon et al. 1984).

pH

Observed mean pH in the Salmon River between 9 April and 3 June ranged between 7.5 and 8.1 (n = 16 days) (Table 4, Figure 9, Annex 5). A pH within a range of 6.5 to 8.25 is considered optimal for incubation and hatching of walleye eggs (McMahon et al. 1984). The SI for pH was 1.0.

Water Level

The ice pack on the Salmon River broke and dispersed on 8 April. Between 9 April and 14 April, the river level under the Shannonville bridge rose 11 cm above the reference point (Table 5, Figure 10). After 14 April, river level declined almost daily. At the dam reference point, the river level decreased approximately 50 cm between it's peak on 14 April and 10 May. At the bridge reference point, by 21 April, the river had receded to it's 12 April level (date when first mature walleye were observed below the Shannonville bridge) and reached 36 cm below the bridge reference point by 10 May. The river level decreased approximately 30 cm at the reference point 90 m below the dam and around 15 cm at the 140 m, 190 m, and 240 m reference points (Table 6). Salmon River level after 10 May oscillated slightly through 1 June when monitoring ceased.

The upper 90 m section of the Salmon River spawning area, 35% (3,160 m^2) of the total surface area, experienced the greatest change in river level (i.e., depth). On 14 April mean depth in this section was 0.75 +/- 0.20 m (95% C.I., range = 0.40 - 1.20 m, n = 13). On 10 May mean depth for the same section was 0.50 +/- 0.20 m (95% C.I., range = 0.20 - 0.80 m, n = 13). Much of this section of the spawning area exhibited a decrease in depth of 0.30 m or greater and would be considered by Johnson (1961) to have a "low" rating in terms of suitability for spawning and egg incubation. According to McMahon et. al. (1984), this section had an SI of 0.5.

From 90 m below the dam to the boat launch area, nearly two-thirds (5800 m^3) of the spawning area, depth averaged around 1.06 +/- 0.20 m (95% C.I., range = 0.70 - 1.30 m, n = 16) on 14 April. On June 1, the same stretch of river had an average depth of around 0.90 +/- 0.20 m (95% C.I., range = 0.50 - 1.20 m, n = 16), a decrease in depth less than 0.3 m. This section of the river had an SI of 1.0. Additionally, some deeper mid river areas actually became suitable for spawning as depth decreased below 1.5 m.

It was estimated that spawning and egg incubation was, potentially, negatively impacted in about 20% of the spawning area due to a decrease in river depth of 0.3 m or greater (Table 7). A low rating for the entire spawning area was not considered appropriate, only the upper 35% of the spawning area was impacted by lowering water level with little or no impact observed in the lower (65%) spawning area. It was more reasonable to assign an SI that favorably represented the percentage of area (80%) that was not negatively impacted by lowering water level. Therefore, a weighted average of the two SI's (SI = 0.8) was determined to be appropriate.

Discharge

Between 9 April and 20 April, daily mean discharge for the Salmon River ranged from a minimum of 34.8 m^3/s on 12 April to a maximum on 14 April of 42.4 m^3/s with a mean daily discharge of about 38.6 +/- 1.7 m^3/s (95% C.I., n = 12 days) over the entire period (Table 5). Between 21 April and 25 May, mean discharge decreased from around 35.7 m^3/s (21 April) to 10.8 m^3/s (25 May). Heavy spring rains caused the mean daily discharge to increase between 26 May and 1 June from around 12.3 m^3/s (26 May) to 16.1 m^3/s (1 June).

Velocity

Mean river velocity between 8 April and 13 May was 1.3 +/- 0.1 m/s (95% C.I., range = 1.56 - 0.95 m/s, n = 36) (Annex 13). As a result of a decrease in volume after 14 April, the river saw a corresponding decline in velocity at about 0.02 m/s/day (Figure 19). Velocity dropped below 1.0 m/s after 9 May.

Delimitation of Spawning Area

The Salmon River below the boat launch area was not considered optimal for walleye spawning or fry production (Table 8). Mean depth, after 10 May, in the main channel of the river below the boat launch was 198.2 +/- 92.9 cm (95% C.I., range = 100 - 250 cm, n = 30). Depth was considered to have been fairly constant during walleye spawning (unrecorded personal observations). Much of the area below the boat launch was characterized by a soft substrate, typically depositional material characterized by small organic debris, silt and muck. No viable eggs were found in any of the 30 samples collected in this area between 10 and 19 May.

On April 14, between the dam and boat launch (260 m), mean "usable" river width, defined by Eschmeyer (1950), Johnson (1961), and Priegel (1970) as having depth greater than 0.3 m but less than 1.5 m, was estimated to have been around 26.4 +/- 1.2 m (95% C.I., n = 29) (Table 7). The total area suitable for walleye spawning and egg incubation was estimated to have been around 6700 m^2 or 75% of the Salmon River surface area (8900 m^2) on that date. Mean "usable" width of the river on 10 May was estimated to have been 21.3 +/- 2.8 m (95% C.I., n = 29). At both the end of spawning (10 May) and the end of fry hatch (1 June), the total area suitable for egg incubation in this section of the river was estimated to have been around 5400 m^2 or 62% of the river's surface area (8600 m^2) on those dates. By 10 May, the "usable" area for spawning and egg incubation had decreased significantly, by about 20% (Student's t-test, p = 0.03).

Bottom Substrate Quality in the Spawning Area

Composition of substrate in the spawning area was approximately 26% bedrock (2366 m^2), 31% boulder (2821 m^2), 38% rubble (3458 m^2), 4% gravel (364 m^2), and insignificant percentages (<1%, 91 m^2) of silt and detritus (Table 9). The total area surveyed and characterized for substrate quality was around 306 m^2 or roughly 3.4% of the total river surface area estimated for 14 April and representative of the entire spawning area. With the exception of a few bedrock outcroppings, the Salmon River bottom substrate quality was nearly uniform and varied little over the entire nearly 9,000 m^2 spawning area. Most importantly, the percentages of substrate smaller than gravel were insignificant (i.e., detritus, silt) or entirely absent (i.e., muck). Using the formula provided in McMahon et. al. (1984), spawning area substrate composition was transformed into a substrate index of 140 (maximum = 200).

The proportions of usable spawning area between the dam and boat launch on 14 April (75%), 10 May (62%) and 1 June (62%) multiplied by the substrate index (140) provided spawning habitat indices of 105, 92 and 92, respectively, and were optimal (> 40). The SI for habitat index as defined by both suitable depth (< 0.3 m and > 1.5 m) and substrate quality (spawning habitat) was 1.0 and optimal for successful spawning, egg incubation, and egg hatching (Eschmeyer 1950, Johnson 1961).

Overall Spawning Habitat Suitability

The overall Habitat Suitability Index (HSI) for walleye spawning in the Salmon River, according to McMahon et al. (1984), was determined by the minimum value for any component SI. Suitability Indices for mean weekly water temperature, minimum dissolved oxygen, minimal pH, and spawning habitat index were all optimal (1.0) in spring of 1994. Water level was not optimal and an SI was estimated at around 0.8. Therefore, the overall HSI for walleye spawning in the Salmon River was 0.8.

Description of the Spawning Walleye Population

Population Abundance

Hoop Net Capture (Marking Sessions)

Seventy-one walleye were captured in 4 hoop nets deployed at the mouth of the Salmon River during the 20 day marking period between 18 April and 8 May (Table 10). All 71 were marked, tagged and released (Annex 6). All walleye appeared to be unaffected by capture, handling, marking, or tagging.

Spearing Results (Capture Sessions)

The official walleye spearing season at Tyendinaga began on 14 April 1994 and terminated 28 days later on 11 May (Table 11). Tyendinaga fish wardens reported a total of 5,234 walleyes speared within Tyendinaga territory with an estimated 3,427 removed from the Salmon River spawning area. Around 70% of the walleye (2,412) were speared during the first week of the season (344.6 +/- 87.4 speared walleye per day; 95% C.I., n = 7 days) and 18% (622), 8% (275), and 4% (118) of speared walleye were reported on the second, third, and final weeks, respectively. After 11 May no walleye were recorded as speared at the spawning area.

It was not possible to estimate the walleye population using mark-recapture data. No tags or marks were found on any of the 809 (24%) speared walleye sampled during this study or any of the remaining 2,618 speared walleye reported directly to Tyendinaga fish wardens. It is likely that an insufficient number of walleye (n = 71), relative to the total population size, were captured, tagged, and released.

Population Characteristics

Sex Composition

The overall ratio of male to female walleye captured with hoop nets at the mouth of the Salmon River was approximately 1 to 0.5. Of the 71 walleye caught in hoop nets; 49 were male (69%) and 22 were female (31%) (Table 10, Figure 11). Males outnumbered female walleye on 75% of the days hoop nets were checked.

The ratio of male to female walleye obtained from a sample of 809 speared walleye was 1 to 1.9 (Figure 12, Annex 7). Sex composition of 3,427 speared walleye was extrapolated from the sample results. The total number of speared male walleye was estimated to be 1,180 (34.4%) and the total number of speared female walleye was estimated to be 2,228 (65.0%). The sex of 6 (0.6%) walleye could not be determined and their number was estimated at 19.

Speared females outnumbered males on 90% of the days walleye were fished. With one exception, speared male walleye made up 40% or more of walleye speared daily during the first week of spearing. After 20 April, male walleye made up less than 40% of walleye speared daily.

Length

The mean fork length (FL) of 71 walleye caught in hoop nets at the mouth of the Salmon River between 14 April and 13 May was 50.1 +/- 1.6 cm (95% C.I., range = 34.0 - 68.0 cm) (Table 12, Figure 13, Annex 8). The 49 male walleye captured with hoop nets had a mean fork length of 47.9 +/- 1.9 cm (95% C.I., range = 34.0 - 62.0 cm). The 22 female walleye captured with hoop nets had a mean fork length of 55.1 +/- 2.7 cm (95% C.I., range = 46.0 - 68.0 cm). The mean length of male and female walleye captured at the mouth of the Salmon River did not change over time (Table 12, Figure 14). If only days where 2 or more fish were captured (20, 21, 23, 27, 30 April and 2, 3, 4, 5, 8 May) are considered, daily mean fork length for male walleye were not significantly different (ANOVA, $p = 0.22$). Despite the low numbers of females caught, daily mean fork length for female walleye were not significantly different (ANOVA, $p = 0.96$), either.

The mean fork length of 809 speared walleye was 54.3 +/- 0.6 cm (95% C.I., range = 30.0 - 78.0 cm) (Figure 15, Annex 9). The 283 speared male walleye had a mean fork length of 47.9 +/- 0.8 cm (95% C.I., range = 30.0 - 71.0 cm). No significant differences were determined in fork length between male walleye caught in hoop nets and speared (Student's t-test, $p = 0.67$). If only days when 3 or more fish were speared (14, 15, 17, 18, 19, 20, 21, 22, 24, 26 April and 1, 2, and 5 May) are considered, daily mean fork length for male walleye differed significantly over time (ANOVA, $p < 0.01$) (Table 13, Figure 16). However, no obvious trend, increase or decrease in mean fork length for speared male walleye, could be determined over the 20 day sampling period.

The 520 speared female walleye had a mean fork length of 57.8 +/- 0.6 cm (95% C.I., range = 36.0 - 78.0 cm). No significant differences were determined in fork length between female walleye caught in hoop nets and speared (Student's t-test, $p = 0.18$). The mean daily fork length for speared female walleye did differ significantly over time (ANOVA, $p = 0.03$), however. A significant difference (Student's t-test, $p = 0.01$) in mean fork length was noted between female walleye speared during the first 10 days (n = 292 females, mean FL = 58.4 cm) and female walleye speared during the last 10 days (n = 228 females, mean FL = 56.9 cm). Female walleye speared during the last 10 days tended to be smaller in length than females speared during the first 10 days. The 6 speared walleye of undetermined sex had a mean fork length of 55.0 +/- 7.7 cm (95% C.I., range = 45.0 - 65.0 cm). The large variance in length of walleye of undetermined sex most likely indicates that both immature male and female walleye were present during the spawning run.

Weight

Mean weight of all male walleye sampled from the Salmon River was 1.4 +/- 0.09 kg (95% C.I., range = 0.5 - 3.2 kg, n = 118) (Annex 10). The estimated total weight of 1,180 speared male walleye was extrapolated to be around 1,600 kilograms. Mean weight of all sampled female walleye was 2.4 +/- 0.15 kg (95% C.I., range = 0.6 - 4.1 kg, n = 101) (Annex 11). The estimated total weight of 2,228 speared female walleye was extrapolated to be around 5,750 kilograms. Total weight of all walleye reported harvested was estimated at around 7,350 kilograms.

Length-Weight Relationship

Fork length frequencies of 118 male walleye and 101 female walleye sampled from the Salmon River spawning run were significant predictors of weight (r^2 = 0.86 and r^2 = 0.84, respectively) (Figure 17). Fork length frequency of all 219 walleye (sexes combined) was also a significant predictor of weight (r^2 = 0.87). Length-weight regression equations were;

$$\text{male weight (g)} = -2765.823 + 85.99 \times \text{length (cm)},$$

$$\text{female weight (g)} = -4626.664 + 125.43 \times \text{length (cm)},$$

$$\text{and combined weights (g)} = -3856.311 + 109.97 \times \text{length (cm)}.$$

Spawning Condition

Spawning condition between 19 April and 13 May 1994 was determined for 77 walleye caught with hoop nets and 216 speared walleye (Tables 14, 15). Of male walleye captured in hoop nets, 64.8% were ripe, 20.4% green, and 13% spent. Spawning condition of 1 male (1.8%) could not be determined. A similar percentage of speared male walleye were ripe (62.7%), a smaller percentage were green (0%) or spent (3%), and spawning condition of 23 speared males (34.3%)

could not be determined. Of female walleye captured in hoop nets, 69.6% were ripe, 26.1% green, and 0% spent. Spawning condition of 1 female (4.3%) could not be determined. Again, a similar percentage of speared female walleye were ripe (67.8%) and a smaller percentage green (14.1%). A greater percentage were spent (14.8%), as was expected. Spawning condition of 5 speared females (3.3%) could not be determined.

Between 19 April and 3 May, all or most male walleye captured with hoop nets or speared were ripe. After 27 April increasing numbers of green and spent males were observed in hoop nets. Too few speared male walleye were observed after April 27 to note any trends. Male walleye caught in hoop nets on 4 May were mostly green (60%, n = 5) and all male walleye caught on 13 May were spent (100%, n = 5). Between 19 April and 8 May, all or most female walleye captured in hoop nets were ripe. No walleye females captured in hoop nets were were observed to be spent, as was expected. A slight increase in green females was observed after 2 May. On 19, 20, 21, 22, 23, 27 April and 1, 5 May, all or most of speared female walleye were ripe. The most frequent observations of spent females was between 21 April and 23 April and the highest percentage of spent females was observed on 2 May. On 3 May, a majority of speared female walleye observed were green, possibly an indication that mature fish had begun leaving the spawning site.

Relative Condition Factor

Between 14 April and 13 May 1994 (Annex 12) the mean K_r observed for males captured from the Salmon River was 1.04 (s.d. = 0.2, range = 0.68 - 2.27, n = 118). The mean K_r for females during the same time was 1.02 (s.d. = 0.2, range = 0.46 - 1.43, n = 101). A mean K_r of around 1.0 suggests that both male and female walleye spawning in the Salmon River in 1994 were in satisfactory condition and should have had adequate energy reserves to expend for spawning (Haynes 1992).

Age Composition

Based on previous observations of age at maturity of walleye in the Bay of Quinte (Payne 1963) and comparisons of actual length-frequency (Figure 18) with a length-age relationship developed by the OMNR (1993) (Figure 6), it is highly probable that male walleye spawning in the Salmon River were at least 2 years old, a majority were over 3 years old and the average age was around 4.75 years (probable range = 3.5 - 6.5). Female walleye were probably at least 3 years old, a majority were over 4 years old with the average age around 7.0 years (probable range = 5.0 - 9.0).

Fecundity

Female walleye used for the fecundity analysis had a mean fork length of 57.5 +/- 4.3 cm (95% C.I., range = 46.0 - 65.0 cm, n = 10), representative of all female walleyes sampled, and a mean weight of 2.7 +/- 0.7 kg (95% C.I., range = 1.25 - 3.63 kg, n = 10). The overall mean number of eggs per female captured was about 194,127 +/- 63,362 eggs (95% C.I.). The estimated number of eggs per female walleye ranged from approximately 86,408 eggs for a female of 53.0 cm to 345,459 eggs for a female of 65.0 cm (Table 16). The overall mean number of eggs per centimeter of female walleye was about 3,284 +/- 881 eggs (95% C.I., range = 1,630 - 5,453, n = 10) and the mean number of eggs per kilogram was around 72,303 +/- 11,413 eggs (95% C.I., range = 44,771 - 97,647, n = 10).

Positive correlations were noted between both length and egg production (r^2 = 0.72) and weight and egg production (r^2 = 0.68) (Figure 20). Log transformation did not improve r^2 values (r^2 = 0.72 and r^2 = 0.68, respectively). The linear regression equations were:

$$\text{egg production} = -520451.107 + 12427.444 \times \text{length (cm)}$$

and

$$\text{egg production} = -19749.899 + 80223.481 \times \text{weight (kg)}.$$

Walleye Spawning Success

Fry Produced in the Salmon River

A total of 583 walleye fry were caught in dusk-to-dawn samplings between 8 May and 3 June (Table 17). The greatest numbers and densities of walleye fry were observed in samples collected during the darkest hours each night, 0000 to 0400 hours. Walleye fry were identified on 12 of 14 days in samples collected between 0000 and 0400 hours, on 9 of 13 days in samples collected between 2000 and 0000 hours, and on 6 of 11 days in samples collected between 0400 and 0800 hours. Densities (fry per m^3 water sampled) of walleye fry collected from drift at all sampling stations for each of the three time periods sampled differed significantly (ANOVA, $p = 0.01$).

Seventy-three percent (427) of all walleye fry were collected in 110 samples (37.7% of total number of samples) between 0000 and 0400 hours (Figure 21). Volume of the Salmon River sampled during this time was 180.5 m^3 (42.0% of total volume of samples) (Table 18). On average, about 2.4 fry were caught per m^3 sampled, and about 61% of the samples collected had at least one walleye fry. For the 14 nights sampled, mean density of walleye fry was estimated at 9.2 +/- 2.6 fry per m^3 (95% C.I., range = 0.0 - 320.0 fry per m^3, n = 110) (Table 19). The total volume of the Salmon River passing the collection site during sampling was around 3,000,000 m^3 and, therefore, the total number of fry estimated at approximately 28,900,000 (Table 20).

Twenty-one percent (122) of all walleye fry were collected in 88 samples (29.3% of total number of samples) between 0400 and 0800 hours. Volume of the Salmon River sampled during this time was 137.1 m^3 (32.0% of total volume of samples). On an average, about 0.9 fry were caught per m^3 sampled, and about 27% of the samples collected had at least one walleye fry. For all 11 nights sampled, mean density of walleye fry was estimated at 4.9 +/- 0.8 fry per m^3 (95% C.I., range = 0.0 - 97.5 fry per m^3, n = 88). The total volume of the Salmon River passing the collection site during sampling was around 2,400,000 m^3 and, therefore, the total number of fry estimated at approximately 11,700,000.

Six percent (33) of all walleye fry were collected in 102 samples (34.0% of total number of samples) between 2000 and 0000 hours. Volume of the Salmon River sampled during this time was 112.5 m^3 (26.1% of total volume of samples). On an average, about 0.4 fry were caught per m^3 sampled, and about 17.7% of the samples collected had at least one walleye fry. For all 13 nights sampled, mean density of walleye fry was estimated at 0.6 +/- 0.2 fry per m^3 (95% C.I., range = 0.0 - 2.5 fry per m^3, n = 102). The total volume of the Salmon River passing the collection site during sampling was around 3,100,000 m^3 and, therefore, the total number of fry estimated at approximately 1,900,000.

Mean density of walleye fry (fry per m^3) collected from drift at all sampling stations combined during 12 hour sampling periods differed significantly (ANOVA, $p < 0.01$) (Figure 22). The highest densities of walleye fry were observed during the first week of sampling. The greatest number of walleye fry (64) and the highest density of walleye fry (320 per m^3) were observed on the first day of sampling, 8 May. These observations suggest that walleye fry drift commenced prior to initiation of sampling. The last week of sampling produced very few walleye fry and no fry were collected on the last day of sampling (3 June).

Distribution of walleye fry between the 5 sampling stations was not equal (Table 17, Figure 23) nor was it proportional to the volume of water sampled. Thirty-three percent (191) of the total number of walleye fry collected were caught at station 4 in 26.2% (112.5 m^3) of the total volume of water sampled; 25% (149) of fry were collected at station 3 in nearly 35% (150 m^3) of volume sampled; 23% (133) of fry were collected at station 5 in 3.6% (15.5 m^3) of volume sampled; 13% (75) of fry were collected at station 2 in 29% (125.2 m^3) of volume sampled; and, 6% (33) of the fry were collected at station 1 in just over 6% (27.1 m^3) of volume sampled.

Mean density of walleye fry collected between 8 May and 3 June at 5 stations along the sampling transect differed significantly (ANOVA, $p < 0.01$) (Figure 24). Station 5 had a significantly greater density of fry; 18.2 +/- 19.0 fry per m^3 (95%

C.I., n = 38), than station 3; 2.6 +/- 1.4 fry per m^3 (95% C.I., n = 38), and station 2; 0.9 fry +/- 0.6 per m^3 (95% C.I., n = 38). Station 3 had a significantly greater density of fry than station 2 (Student's t-test, $p = 0.01$) No significant differences in fry density were noted (Student's t-test, $p > 0.05$) in walleye fry observed at stations 5 and 1; 3.1 +/- 3.0 fry per m^3 (95% C.I., n = 36), stations 5 and 4; 6.0 +/- 5.5 fry per m^3 (95% C.I., n = 38), and stations 4 and 1.

The number of walleye fry estimated to have left the Salmon River during the 14 days of fry sampling between 08 May and 03 June 1994 was 54,000,000 (Table 20). An additional 47,000,000 walleye fry are estimated to have left the Salmon River on the 12 days when no sampling was done. The total number of walleye fry drifting down the Salmon River between 8 May and 3 June 1994 was estimated at around 101,000,000.

Based on mean temperature of the Salmon River, there is reason to expect that walleye eggs fertilized and incubated in the Salmon River after 12 April took longer than 18 days to hatch (1 May) and, conservatively, hatching probably initiated after about 22 days (5 May). Assuming fry abundance prior to initiation of sampling was comparable to mean abundance observed during the first three days of sampling (09 - 10 May, 10 - 11 May, and 13 - 14 May), the number of walleye fry estimated to have hatched between 5 May and 8 May was 46,000,000 fry. The total contribution of walleye spawning to the Bay of Quinte was, then, estimated as 147,000,000 fry.

The mean total length of walleye fry identified from collected samples was 7.8 +/- 0.1 mm (95% C.I., range = 6.5 - 10.0 mm, n = 583) (Figure 25, Annex 14). With the exception of two fry measuring 10 mm, all fry were observed to have large yolk sacs and oil globules. These observations indicate that the fry collected between 8 May and 3 June were hatched shortly before collection.

Estimation of Number of Walleye Eggs Spawned

Under normal, natural conditions walleye egg survival to hatch is around 10% (Johnson 1961, Mathias et al. 1992), although it has been estimated to be as high as 30% under optimal conditions (Forney 1975b). If, indeed, 10% of walleye eggs spawned in the Salmon River survived to hatch, it was estimated that 1,470,000,000 eggs must have been spawned.

Estimation of Number of Spawning Female Walleye

Based on size and spawning condition of 2,228 speared females, it was estimated that around 90,000,000 eggs out of the total 1,470,000,000 eggs were spawned prior to spearing (Table 21). According to the estimated fecundity for female walleye spawning in the Salmon River, each female produced an average of about 3,284 +/- 881 eggs per centimeter length. Female walleye of average fork length (57.8 cm) therefore produced between 139,000 and 240,000 eggs. To successfully spawn the remaining 1,380,000,000 eggs, between 5,750 and 10,000 females must have escaped harvest and successfully spawned in the Salmon River. The estimated number of spawning female walleye present during the 1994 spawning run was, therefore, between 8,000 and 12,200.

Estimation of Number of Spawning Male Walleye

The male-female ratio observed from spear fishing results was almost 2 females to 1 male. Therefore, it was estimated that at least 4,000 to 6,100 male walleye were also present at the Salmon River spawning area during the walleye spawning run. A number of authors cited by Colby et al. (1979) observed that the sex ratio among walleyes during spawning runs and on the spawning grounds usually favors males which mature earlier. This would suggest that the number of male walleye present during the Salmon River spawning run was much larger. Conservatively, there were quite probably at least as many males as females, or, around 8,000 to 12,200 males. If the results of the hoop net capture at the Salmon River mouth are considered unbiased, there was an even higher male to female ratio (2.3:1). The male walleye population present during the 1994 spawning run was, then, estimated at between 18,400 to 28,000 males.

Estimation of Spawning Walleye Population Abundance

The overall spawning population estimate for walleye ranged from a low of 12,000 to a maximum of about 40,000. This population represented around 1% to 3% of all walleye 2 years or older estimated for the Bay of Quinte and Eastern Lake Ontario (1,418,301 walleye) in 1994 (OMNR, personal communication 1997).

Potential for Walleye Population Enhancement

The maximum number of walleye eggs that were lost due to spearing was estimated at around 440,000,000 (Table 21). Correcting for spawning condition of speared females at time of removal, the number of eggs actually lost was estimated to be closer to 350,000,000. Using the assumption that there was a 10% survival of eggs to hatch, approximately 35,000,000 walleye fry were lost due to spearing or 19% of the Salmon River's potential contribution of walleye fry to the Bay of Quinte fishery.

Approximately 1,000,000 eggs were stripped from female walleye captured from the Napanee and Salmon Rivers on 18, 19 and 20 April 1994 (Table 22). Around 42% (414,000 eggs) of the eggs were successfully fertilized and 59% of these (245,000 eggs) eyed-up. Hatch occurred on 5 May, after 16 - 18 days (173 T.U. - 185 T.U.). Although fry were not enumerated, unrecorded visual observations suggested that well over 50% (120,000 fry), perhaps as high as 90% (220,000 fry), of eyed eggs hatched. About 85,000 sac fry, 21% of fertilized eggs, were collected and released back into the Salmon River or into aquaculture ponds.

An additional 140,000 eggs were incubated in experimental hatching jars for comparative (quality control) purposes (Table 23). Napanee River and Salmon River eggs had around a 40% fertilization rate (57,000 fertile eggs) and about 50% of fertile eggs eyed (29,000 eggs). Eggs hatched on 25 April and 26 April (138 T.U., 144 T.U.), respectively. Although not enumerated, unrecorded visual observations suggested that more than 50% (> 15,000 fry) of eyed eggs hatched.

On 23 April, approximately 54,000 eggs spawned from speared Salmon River walleye and 81,000 eggs spawned from walleye gill netted from the Bay of Quinte were stocked in experimental jars (Table 23). Around 22% of eggs from speared or gill netted walleye were successfully fertilized (11,000 eggs and 19,000 eggs, respectively). Approximately 74% of fertile eggs from speared walleye and 40% of fertile eggs from gill netted walleye eyed-up (8,000 eggs and 7,000 eggs, respectively). Eggs hatched on 30 April (134 T.U), but were not enumerated. Unrecorded visual observations suggested that 50% (> 4,000 and 3,500 fry, respectively) or more of eyed eggs hatched.

Water temperature at inflow for the 5 L Bell hatching jars averaged 11.0 +/- 0.5°C (95% C.I., range = 10.0°C - 12.5°C, n = 18 days) and was significantly different (Student's t-test, $p < 0.01$) from the mean temperature for water circulated through 1 L experimental hatching jars which averaged 16.7 +/- 1.8°C (95% C.I., range = 10°C - 21°C, n = 18 days) (Table 24, Annex 15).

Dissolved oxygen level of water at inflow for all Bell hatching jars averaged 6.3 +/- 0.3 mg/L O_2 (95% C.I., range = 6.0 mg/L O_2 - 7.8 mg/L O_2, n = 18 days) and was significantly different (Student's t-test, $p < 0.01$) from the dissolved oxygen level for water circulated through experimental hatching jars (7.9 +/- 0.5 mg/L O_2 95% C.I., range = 6.2 mg/L O_2 - 9.2 mg/L O_2, n = 18 days) (Table 25, Annex 15). Both DO levels were well above the lowest advisable level (i.e., 5.0 mg/L O_2).

DISCUSSION

Habitat Suitability

Temperature of the Salmon River during weeks 2 and 3 was optimal for spawning; mean weekly water temperatures were greater than 6°C but less than 9°C. Becker (1983) noted that "walleye spawning commences at 3.3°C to 6.7°C with peak activity at 5.6°C to 10°C." A "peak" in spawning activity for Salmon River fish was evident as 86% of walleye harvested were taken during the first two weeks of the spearing season (14 - 28 April) (Table 11). Mean daily water temperatures for the first 2 weeks of spawning were between 6.4°C and 11.0°C and optimum, according to Koenst and Smith (1976), for walleye egg fertilization. Mean weekly water temperatures for weeks 4, 5, 6, and 7 ranged from 10.1°C to 19.5°C and were optimum for walleye egg incubation (Koenst and Smith 1976). Based on a mean and range of temperatures (9.4 +/- 0.8°C 95% C.I., range = 6.7°C - 13.2°C, n = 22 days) and cumulative temperature units (215 T.U.), walleye egg hatch probably began during week 4, 18 to 22 days after initiation of spawning (Johnson 1961, Allbaugh and Manz 1964, Hurley 1972, McElman and Balon 1985). Egg hatch, confirmed by fry sampling during week 5, decreased significantly by the end of week 7. Mean water temperature of the Salmon River for week 8 was around 15.9 +/- 2.0°C (95% C.I., n = 12) and between the beginning of week 8 and 1 June ranged from 12. 9°C to 19.8°C. No walleye fry were collected in samples after 1 June and a decision was made to discontinue temperature monitoring.

Busch et. al. (1975) observed that "steady spring warming rates of greater than 0.28°C per day have been positively correlated with (walleye) embryo and fry production (under natural conditions) and that poor survival of (walleye) embryos is associated with cold water temperatures due to slow spring warming rates of less than 0.18°C per day." The warming rate observed in the Salmon River spawning area between 12 April and 3 June, around 0.22°C per day, while not considered by Busch et. al. to be optimal, appeared from fry sampling results to have been sufficient for good production of fry.

Eschmeyer (1950) and Priegel (1970) observed that walleye preferred to spawn in shallow riffle and littoral areas. Johnson (1961) observed that walleye prefer to spawn in depths less than 0.3 m. Both Johnson and Priegel agreed that most walleye spawning normally takes place in water less than 1.5 m. Changes in river level can, therefore, impact availability of areas suitable for walleye spawning and be a factor in fry hatching success.

Between 14 April and 10 May, a decline in river level of more than 0.3 m in the 90 m section below the dam increased the area with depth less than 0.3 m by approximately 275%, from around 432 m^2 to 1630 m^2. This, in turn, decreased the spawning area of suitable depth (> 0.3 m and < 1.5 m) in this section by around 44%, from around 2700 m^2 to around 1500 m^2. Between initiation of spawning and 21 April, lower levels in mid river areas previously greater than 1.5 m deep actually resulted in a 12% increase in available spawning area. The decline in river level after 21 April further reduced available spawning area, but with little impact on spawning. Observations suggested that by 21 April spawning was nearing completion; nearly 75% of the speared walleye had been reported and there was an increase in numbers of speared spent females and a decrease in numbers of speared males.

In the 90 m section below the dam, a lower river level could have impacted walleye egg incubation by exposing some eggs to desiccation. With available data, it was not possible to quantify the impact of decreasing river level on incubating walleye eggs. Down river of the 90 m reference point, river level decreased less than 0.3 m and there was a negligible loss of suitable habitat for spawning or egg incubation.

Busch et al. (1975) observed that in western Lake Erie availability of spawning habitat was an important factor in spawning success. Based on Busch's observations, McMahon et al. (1984) determined that at least 20% of a water body had to have suitable spawning habit (i.e., depth and substrate) for walleye to spawn successfully. Overall, the area of the Salmon River impacted by unsuitable depth (< 0.30 m) was only about 20% of the total usable spawning area. Walleye spawning was observed to be successful and substantial numbers of post-hatch fry were positively identified drifting to the mouth of the Salmon River between 6 May and 1 June. It was suggested, therefore, that the loss of suitable habit due to a lower river level probably had little impact on spawning or egg incubation.

Habitat variables related to water quality and water quantity are not constant from year-to-year, while habitat variables such as spawning substrate quality, under normal conditions, remain relatively constant. The HSI for walleye spawning in the Salmon River, therefore, should vary from year-to-year due to dynamic weather conditions that impact water quality and quantity. The determinant HSI habitat variable for walleye spawning in spring of 1994 was water level which, according to McMahon et. al. (1984), might indicate that the contribution of walleye fry from the Salmon River to the Bay of Quinte fishery was not at a "peak" level. This conclusion, however, was not possible to substantiate because: (1) it was not part of this study to verify the appropriateness of assumptions used by McMahon et. al. to determine SI values, (2) no historical data pertaining to spawning in the Salmon River were available, (3) no comparable data pertaining to spawning in other Bay of Quinte tributaries were obtained during spring of 1994, and (4) sampling results indicated fry abundance was substantial.

Based on habit suitability criteria, the Salmon River below the boat launch area was not considered optimal for walleye spawning (Johnson 1961, Priegel 1970).

The increase in width, depth and, perhaps, the influence of the Bay slow the river's current considerably and result in heavy deposition (e.g., small organic debris, silt and muck). The substrate types observed in this area (particle diameter < 0.2 cm) were not optimal for walleye egg incubation and hatching (Johnson 1961) (Table 8). Continuous deposition of organic debris over any walleye eggs spawned in areas below the boat launch would have impacted successful hatching by smothering the eggs as well as providing conditions that encourage low oxygen levels (Colby and Smith 1967). Although hard substrate was located in an isolated area of the lower river, depth (> 1.5 m) made that area less than optimal for spawning.

Description of the Spawning Walleye Population

In estimating abundance with a mark-recapture study it was assumed that the same population was being sampled at the mouth of the Salmon River and at the spawning area up river. Indications that the same population was sampled were: (1) no significant differences in fork length between walleye, male or female, sampled at either site and (2) combined fork length frequencies of walleye sampled at the two sites had a normal distribution (Figure 18).

According to Robson and Regier (1964), with over 3,400 speared walleye examined for tags or marks, a minimum capture and tagging of 150 individuals was necessary to make a reasonable estimate ($p = 0.25$) for a population of at least

12,000 walleye. An adequate number of walleye were not marked, largely, for two reasons. First, initiation of hoop net capture (18 April) did not coincide with initiation of the spawning run (12 April) due to hazardous conditions on the Bay of Quinte and availability of hoop nets. Additionally, hoop nets employed to capture migrating walleye were quite likely less effective than standard "spring" trap nets recommended by the OMNR. Hoop nets captured an average of 3.6 +/- 1.0 walleye per day (95% C.I., range = 0 - 7 walleye, n = 20 days). Most effective were hoop nets 3 and 4 capturing 24 walleye at around 1.9 +/- 1.3 walleye per day (95% C.I., range = 0 - 5, n = 13 days) and 24 walleye at around 1.8 +/- 1.3 walleye per day (95% C.I., range = 0 - 5, n = 12 days), respectively. Hoop net 1 caught the most walleye, 25, but averaged around 1.3 +/- 1.0 walleye per day (95% C.I., range = 0 - 6, n = 20 days). Hoop net 2 caught no walleye (n = 11 days). Differences in catch per unit effort were probably due to placement, date of deployment and the fact that nets were not identical. Hoop net "catch" included at least 15 other fish species and was dominated by white perch (*Morone americanus*), brown bullhead (*Ameiurus nebulosus*) and suckers (Catostomidae) (Annex 16).

Using back calculations based on fry abundance, the overall spawning population of walleye in the Salmon River was estimated at between 12,000 and 40,000 individuals. It was estimated that 10% to 30% of the spawning walleye population was removed by spear fishing. If spear fishing had a substantial impact on walleye abundance during the spawning run, then a lower spawning population estimate (i.e., 12,000 individuals) would be appropriate. Impact of spear fishing, however, on the spawning population was questionable considering river condition (i.e., flow). According to Hynes (1970), river velocity can influence temporal and spatial distribution of fish. Under high flow conditions, the optimal holding location for walleye, particularly as energy was being expended for the spawning act, would have been in areas with low velocity (< 1.0 m/s) such as shoreline, close to bottom, and in and around structure. Flow conditions during the Salmon River spawning run (> 1/0 m/s) limited spear fishers to shallow shoreline areas (< 0.60 cm). Walleye located in shoreline areas were most vulnerable to spear fishing. However, since a majority of the spawning area was inaccessible to spear fishers and walleye were not limited to shallow shoreline areas, it was not likely that spear fishing had a significant impact on the walleye population or spawning success. This argues for a higher walleye spawning population estimate (i.e., > 12,000 individuals).

Harvest, based on catch per day, in the spawning area was closely correlated with discharge, both decreased rapidly after the first week of spawning and continued to decrease over time ($r^2 = 0.83$). The dramatic change in catch rate between the first week and the ensuing weeks could have indicated that: (1) the number of walleye present at the spawning area declined rapidly after the first week, (2) walleye became less susceptible to spearing after the first week as flow decreased, or (3) both a decrease in abundance and susceptibility influenced spearing success.

Harvest could have also been influenced by reduced spearing effort as community members satisfied their needs. This was not likely, however, as spear fishing effort was: (1) restricted by river flow, (2) limited by time (i.e., 1600 hrs to 0000 hrs nightly), (3) regulated by use of permits (i.e., 3 walleye limit per permit per night), and (4) partitioned equitably according to tradition (1-2 spear fishers per shoreline per 100 m). Although no census of spear fishers was done, spear fishing effort did not appear to diminish after the second week of the spawning run.

According to Rawson (1956), male walleye are the first to migrate to a spawning area and signal initiation of the spawning run. The predominance of male walleye observed at the mouth of the river supports Rawson's observations. The observed sex ratio at the mouth of the river also supports observations by both Eschmeyer (1950) and Priegel (1970) who noted that walleye spawning runs tended to be dominated by males since males typically mature at a younger age than females.

The sex composition of walleye speared at the spawning area was obviously different from that of walleye captured in hoop nets and differed from the observations of Eschmeyer (1950) and Priegel (1970). Eschmeyer (1950) noted that females made up greater than 50% of the walleye captured from a Muskegon River (Michigan) spawning area in Spring of 1947 and 1948. He suggested that the higher female to male ratios compared with other sex ratio observations at spawning might be explained by the use of dip nets to collect fish. Dip netters may have been selective for females that were both larger and, being burdened with eggs, slower. Crowe (1955) observed almost 50% female walleye in samples he collected with dip nets from the same river in 1953 and concurred with Eschmeyer that, possibly, use of dip nets could explain the higher than typical occurrence of females. It would appear likely, therefore, that the sex ratio observed at the Salmon River spawning area reflects selectivity by spear fishers for larger, slower, and shallower females. Selectivity for females (sampling bias), again, argues favorably for a larger walleye population estimate (i.e., > 12,000 individuals).

Ellis and Giles (1965) observed that male walleye have the potential for spawning over extended periods of time. The highest percentages of ripe males (81%, n = 64) were observed during the first two weeks of the spawning run after which time speared males tended to be green or spent. The highest percentages of ripe females (85%, n = 99) were, also, observed during the first two weeks of the spawning run. Ellis and Giles (1965) observed that female walleye often "spawn out" in one evening. A relatively high percentage of spent females speared between 21 and 23 April most likely indicated the initial wave of spawning was concluding. This, again, reinforced the idea that a substantial decrease in walleye abundance after the first week of spawning was, most likely, not attributable to spear fishing.

The walleye population spawning in the Salmon River, based on length and weight, appeared to be in good condition ($K_r > 1.0$). No significant differences were observed in mean weight between Salmon River male walleye and Payne's Bay of Quinte male walleye (Student's t-test, $p = 0.09$) or between Salmon River female walleye and Payne's Bay of Quinte female walleye (Student's t-test, $p = 0.9$). Payne (1963) found mean weight of male walleye sampled from the Bay of Quinte each spring between 1959 and 1962 was 1.6 +/- 0.13 kg (95% C.I., range = 0.5 - 3.4 kg, n = 118) and mean weight of females was 2.4 +/- 0.15 kg (95% C.I., range = 0.8 - 4.4 kg, n = 101) (Annex 17). No significant differences were found in mean weights of Payne's Bay of Quinte walleye (sexes combined) and weights of walleye with same lengths from the 1994 Salmon River population (Student's t-test, $p = 0.40$). The regression equation developed by Payne (1963) for male and female walleye captured from the Bay of Quinte, published in it's logarithmic form, was;

$$\log \text{weight (lbs)} = -3.690 + 3.271 \log \text{length (in)}.$$

The log transformed regression equation generated (using the same units of measure) for male and female (combined) walleye sampled from the Salmon River between 14 April and 13 May 1994, was;

$$\log \text{weight (lbs)} = -3.6643 + 3.2381 \log \text{length (in)}.$$

No significant difference was noted between the slopes of the 1994 Salmon River walleye length-weight regression equation and the 1959 to 1962 Bay of Quinte walleye equation (Student's t-test, $p > 0.20$). This was relevant, as it suggested that the condition factor of spawning walleye in the Bay of Quinte remained constant for over 30 years.

Other than the most obvious peaks in length frequency at around 46.5 cm for male and 58.5 cm for female walleye, distinct peaks in length frequency were not apparent for the combined hoop net and spearing capture data ($n = 880$) (Figure 18). This is most likely due to a small sample size. All male walleye measured from the Salmon River had a fork length greater than 29.5 cm and all female walleye measured had a fork length greater than 35.5 cm. According to Scott and Crossman (1973), male walleye mature at 2 to 4 years of age (FL > 27.9 cm) and female walleye mature at around 3 to 6 years of age (FL > 35.6 cm - 43.2 cm). Payne (1963) observed that virtually all male walleye sampled from the Bay of Quinte were mature by age 3 (38.0 cm) and nearly all females were mature by age 4 (46.0 cm). Ninety-seven percent of male walleye measured from the Salmon River had a fork length greater than 38.0 cm and 98% of females had a fork length greater than 46.0 cm.

Mean fecundity estimated for female walleye speared from the Salmon River in spring 1994 did not differ from fecundity estimated by Payne (1963) (Student's t-test, $p = 0.20$). Mean fork length of Payne's females was 60.6 +/- 58 cm (95% C.I., range = 47.5 - 71.9 cm, n = 11). No significant difference was observed in mean fork length of Payne's Bay of Quinte females and the Salmon River females (Student's t-test, $p = 0.35$). For Payne's walleye, the overall mean number of eggs per female was about 262,476 +/- 97,347 eggs (95% C.I., range = 75,366 - 466,594, n = 11). The overall mean number of eggs per centimeter of female walleye observed by Payne was around 4,110 +/- 827 eggs (95% C.I., range = 1,587 - 7,004, n = 11) and was not significantly different from the Salmon River sample (Student's t-test, $p = 0.25$). Payne's data also showed a positive correlation between length of female walleye from the Bay of Quinte and egg production ($r^2 = 0.84$). Payne's linear regression equation was:

$$\text{egg production} = -675196.708 + 15477.794 \times \text{length (cm)}.$$

When the regression equation for the Salmon River data was compared with the regression equation for the Bay of Quinte data, no significant difference was observed (Student's t-test, $p > 0.20$). This implies that fecundity of walleye in the Bay of Quinte has not changed in the past 35 years.

Walleye Spawning Success

Walleye fry were noted in the first samples collected on 6 May. Observations made by Johnson (1961), Allbaugh and Manz (1964), Hurley (1972), McElman and Balon (1985) and several other researchers suggested that fry hatch could have occurred after 1 May. Compared with hatchery water temperatures observed by Allbaugh and Manz (1964) during walleye egg incubation to hatch, water temperature conditions during spawning and egg incubation in the Salmon River showed no significant differences (Student's t-test, $p = 0.97$). Mean water temperature observed in the hatchery was 9.4 +/- 0.8°C (95% C.I., range = 6.7°C - 12.2°C) and hatch occurred after 22 days and 216 T.U. Mean water temperature observed at the Salmon River spawning area after initiation of the walleye spawning run (12 April) was 9.4 +/- 0.8°C (95% C.I., range = 6.7°C - 13.2°C) for the first 22 days (215 T.U.) All other conditions were, also, similar (i.e., dissolved oxygen at or near saturation and neutral pH). This implied that walleye eggs incubating in the Salmon River began hatching around 5 May.

In a practical comparison, water used to incubate walleye eggs in the ARC hatchery had a mean temperature of 11 +/- 0.4°C 95% C.I. and the eggs hatched after 18 days (198 T.U.). The mean water temperature of the Salmon River for the first 18 days after initiation of the spawning run (after 12 April) was 9.0 +/- 0.8°C 95% C.I. and significantly lower than the hatchery water (Student's t-test, $p < 0.01$). This suggested that eggs incubating in the Salmon River would not have hatched in less than 18 days or before 1 May.

To estimate the number of walleye fry that were produced over the entire spawning run in the Salmon River, the following assumptions were made: (1) intensive spawning began after 12 April, when small numbers of adult male walleye were first observed at the base of the dam on the Salmon River, (2) based on a mean water temperature in the Salmon River of 9.4 +/- 0.8°C 95% C.I., walleye egg hatch began 18 to 22 days after initiation of spawning (Johnson 1961, Allbaugh and Manz 1964, Hurley 1972, McElman and Balon 1985, personal observations 1994) or between 1 and 5 May 1994, and (3) based on the numbers of walleye speared each day for the duration of the spawning run, the greatest numbers of eggs were spawned during the first 7 days of spawning or between 14 April and 21 April. Based on the preceding assumptions, it was likely that the greatest numbers of fry drifted down the Salmon River between 1 and 12 May. This seemed reasonable based on the numbers and densities of walleye fry observed at initiation of fry sampling and the decline in walleye fry numbers and densities after 12 May.

Walleye fry hatch at between 6.0 mm and 8.6 mm total length (Scott and Crossman 1973). Newly hatched "prolarval" walleye fry average between 7.0 mm and 7.6 mm (Priegel 1970, McElman and Balon 1985, and Auer and Auer 1987) and possess both a yolk sac and large oil globule (Nelson 1968, Houde 1969, Hardy 1978, Colby et. al. 1979, McElman and Balon 1985, Corbett and Powles 1986). Barrows et. al. (1988) observed that newly hatched fry grow at about 0.2 mm to 0.6 mm per day. Rate of absorption of the yolk sac is temperature related and is usually complete in 3 to 5 days or when the fry reaches 10 mm to 11 mm total length (Colby et. al. 1979).

Houde (1969) observed that newly hatched walleye fry used visual and tactile cues to orient and maintain their positions in currents of 0.05 m/s, but when exposed to velocities of 0.07 m/s and greater they lost orientation and drifted randomly. Corbett and Powles (1986) observed that walleye fry were displaced downstream during periods of decreasing light as their ability to orient visually diminished. The mean rate of flow observed at the surface of the Salmon River during fry sampling was 0.10 m/s or greater. It was approximately 1.8 km from the boat launch area to the fry sampling site just above the mouth of the Salmon River. A walleye fry hatched at the spawning area and entering into the swiftest current of the river at dusk (@1900 hours) could have, conceivably, passed by the fry sampling site after approximately 5 hours, or just after 0000 hours. This agrees with the results of the fry sampling in terms of time of night when the greatest numbers and densities of fry were collected.

A mean size of 7.8 mm and the presence of a yolk sac and large oil globule on walleye fry collected in drift samples between 8 May and 3 June were significant for two reasons: (1) size and stage of development of fry collected from the Salmon River was consistent with a short time period between hatch and drift and (2) fry of this size tend to drift randomly in currents of at least 0.07 m/s (Houde 1969).

Differences in fry density were observed between sampling stations. This was to be expected as current is not uniform across a river channel or from surface to bottom (Elliot 1970, Hynes 1970). Obstructions and an uneven bottom also impact current. Drifting fry tend to be less randomly dispersed in slower currents (< 0.05 m/s) and more randomly dispersed in faster currents (> 0.07 m/s) (Corbett and Powles 1986). Also, larval fry as small as 7.0 mm are able to avoid nets in slow current (Forney 1975a, Franzin and Harbicht 1992).

The "prolarval" stage is considered to be complete once the oil globule is absorbed, usually at a total length of around 10 mm (Nelson 1968). The two 10 mm "post larval" fry identified in the drift samples on 26 and 27 May, may have originated from the Bay of Quinte. As witnessed by Forney (1976) in Oneida Lake, walleye fry at this size should be present along shallow shorelines of the Bay of Quinte, including shoreline areas bordering the mouth of the Salmon River. Walleye fry of around 10 mm TL can swim and possibly swam up the river to the area of fry sampling. The fry were probably aided by a reversal of river surface water flow due to the strong south winds that preceded a rain storm across the Bay of Quinte on that particular night.

Potential for Walleye Population Enhancement

No significant differences were observed in fertilization success of walleye eggs taken from 2 different sources on 3 different days (Table 22) and stocked into Bell hatching jars (ANOVA, p = 0.24). Walleye eggs spawned on 18 April and 20 April had a significantly greater rate of eye-up than eggs spawned on 19 April, however (Student's t-tests with $p < 0.01$ and $p = 0.02$, respectively). Rates of egg eye-up were not significantly different for eggs spawned 18 April and 20 April (Student's t-test, $p = 0.29$). A lower eye-up rate for 19 April walleye eggs is attributed to an exaggerated loss of viable eggs (i.e., bias) due to poor handling technique and not the hatchability of the eggs. It is likely that had equal quantities of eggs remained in each of the hatching jars, no significant differences in eyeing rates would have been noted.

No significant difference (Student's t-test, $p = 0.28$) was noted in fertilization success or in eye-up rate (Student's t-test, $p = 0.87$) between eggs stocked on 18 and 20 April and incubated in experimental jars (Table 23). No significant differences (Student's t-test, $p = 0.13$) were observed when fertilization success of eggs incubated in Bell jars was compared with fertilization success of eggs incubated in experimental jars or when eye-up rates were compared (Student's t-test, $p = 0.17$). However, when eye-up rate of walleye eggs stocked in Bell and experimental jars on 18 April and 20 April only were compared, the rates were significantly different (Student's t-test, $p < 0.01$). Eye-up rate of eggs incubated in Bell jars was higher than the eye-up rate of eggs incubated in the experimental jars.

The differences in eye-up rates between eggs incubated in the two types of spawning jars can be explained by the prevalence of fungus in the experimental hatching unit. One of the goals of the aquaculture program at Tyendinaga is to provide the Tyendinaga community with "contaminant-free" food fish and, therefore, no prophylactic treatment with formalin was administered to eggs spawned on 18 and 20 April and incubated in the experimental hatching system. Unfortunately, fungal infection rate was exacerbated in the experimental hatching unit due to higher water temperature and the constant recirculation of infected water through all the individual hatching jars.

No significant difference (Student's t-test, $p = 0.39$) was noted in fertilization success between eggs spawned from speared walleye and eggs spawned from gill netted walleye. Fertilization success of eggs spawned from live dip netted walleye was significantly greater (Student's t-test, $p < 0.01$) than fertilization success of eggs spawned from speared or gill netted walleye. Egg eye-up rates were significantly greater (one tailed Student's t-test, $p < 0.01$) for eggs spawned from speared walleye than eggs spawned from gill netted walleye and eggs spawned from dip netted walleye and incubated in experimental hatching jars. In terms of production of eyed eggs per unit of eggs spawned, however, 20% of eggs spawned from dip netted walleye produced eyed eggs, as opposed to 15% of eggs spawned from speared walleye and less than 10% of eggs spawned from gill netted walleye.

Eggs stripped from dip netted (i.e., uninjured) walleye had a significantly higher rate of fertilization, almost double that of walleye eggs stripped from speared or gill netted (i.e., injured and dying) walleye. It would appear that, while eye-up rates varied, overall, the number of fry produced from live spawned walleye will probably be greater than fry produced from injured and dying walleye. Although the number of samples used in this investigation was small, it is likely that further testing would show comparable results. Eggs and milt extruded manually from both injured female and male walleye were consistently observed to be tainted with blood clots and blood though no injury was observed near the abdominal area. This phenomenon may be related to the shock and stress of receiving an injury or being entangled in netting for several hours. Whatever the cause, there appears to be an impact on the physiology of the fish that reduces the potential for egg fertilization.

Time between walleye egg fertilization and hatch is related to incubation temperature (Johnson 1961, Allbaugh and Manz 1964, Hurley 1972, Koenst and Smith 1976, McElman and Balon 1985). Walleye egg hatch occurred in experimental hatching jars in fewer days than egg hatch in the large Bell jars due to the higher mean temperatures of the water continuously recirculated through the experimental hatching system. Length of time to hatch for eggs incubated at specific water temperatures in the ARC hatchery were consistent with results obtained by Johnson (1961) and Koenst and Smith (1976) (Table 24).

One objective of establishing a hatchery near the Salmon River spawning area was to make it possible for the Mohawks of the Bay of Quinte to incubate and hatch walleye eggs to mitigate any potential impact of spear fishing on fry recruitment to the bay's fishery. In it's first season of operation, the ARC had a maximum maintainable water flow during egg incubation of approximately 10 L per minute. The available water delivery system, duration of incubation, and availability of walleye in ripe spawning condition limited the number of walleye eggs incubated to around 1,200,000 or less than 1% of the 350,000,000 eggs lost due to spearing.

Of the total number of fry hatched at the ARC, only around 55,000 were actually collected by hatchery staff and released into the river. Minimally, hatch rate at the ARC, based on unrecorded visual observations at fry hatch, was greater than 10% (100,000) for eggs incubated in Bell jars. Fry production results obtained by experienced researchers have varied widely with hatching rates ranging between 50% and 90% common (Eschmeyer 1950, Johnson 1961, Hurley 1972, Auer and Auer 1987). In the future, as staff gain experience, hatching results could be expected to improve and, under the same conditions, a production of 500,000 - 900,000 fry could be targeted.

Under natural conditions, influenced by environmental variables, hatching success of walleye eggs has been known to vary greatly from year-to-year, ranging from 10% to around 30% under optimal conditions (Johnson 1961, Mathias et al. 1992, Forney 1975b, Busch et al. 1975). Additionally, Forney (1975b), Fielder (1992), and Williams and Larscheid (1992) observed that, in nature, walleye fry have a 1% to 10% survival rate to fingerling size. The removal of over 2,000 productive female walleye from the spawning population during the 1994 spawning run potentially translated to a loss in recruitment of 30,000,000 walleye fry or 300,000 to 3,000,000 fingerlings to the Bay of Quinte fishery.

At similar levels of spearfishing and with an improved hatchery hatch rate of 50% or better, the ARC staff would need to capture and strip at least 375 ripe females and produce at least 37,500,000 fry from 75,000,000 eggs. At least 30,000,000 fry would be needed to replace fry loss as a result of spearing. At least 7,500,000 additional fry, assuming a natural hatch rate of around 10%, would have to be produced to replace natural fry production lost due to capturing and stripping 375 live female walleye from the river. A minimum water flow of around 675 L per minute would need to be maintained in order to stock and incubate the optimum number of eggs in the ARC hatchery. An effort of this magnitude would also require additional space, equipment, supplies, labor, management, and supervision at the ARC. Increasing fry production capacity at the ARC, however, would not guaranty a corresponding increase in fingerling recruitment in the Bay of Quinte. As observed by Forney (1975b) and others, stocking larval walleye for stock enhancement purposes where significant populations already exist is not often successful.

The main objective of the ARC hatchery, in it's first year of fry production, was to produce at least 30,000 walleye fry for pond aquaculture production. This was done successfully. As a result of the first year's efforts, the technology and infrastructure exists at Tyendinaga to produce more walleye each year with aquaculture than the number of walleye reported speared during the 1994 walleye spearing season. With nearly 2 hectares of ponds, 5,000, 0.5 kg adult walleye could be harvested every year. Pond culture of walleye (or other species) could reduce the need to harvest large numbers of adult walleye for food during the spawning season. With an additional source of walleye, spearers, who retain a traditional right to fish, could concentrate on harvesting smaller, male walleye. This would benefit the community as a whole by decreasing the capture and consumption of large walleye (> 55 cm) from the Bay of Quinte, which are known to have potentially unacceptable levels of contamination (Ontario Ministry of Natural Resources 1993, Vaillancourt 1994). Harvest of mostly male walleye would also reduce any possibility, real or perceived, of impacting walleye fry recruitment from the Salmon River to the Bay of Quinte.

EXECUTIVE SUMMARY

On 12 April 1994, the first adult walleye were observed migrating up the Salmon River from the Bay of Quinte to spawn below the Shannonville dam. Between 14 April and 10 May, approximately 12,000 to 40,000 walleye spawned in the approximately 9,000 m^2 spawning area. Most of the spawning appeared to have been accomplished within the first week, 14 - 21 April, while conditions were optimal. Spawning concluded by 10 May.

Mean fork length and weight of walleye spawning in the Salmon River was around 48.0 cm and 1.4 kg and 57.0 cm and 2.4 kg for males and females, respectively. Both male and female walleye appeared to be in good health, with relative condition factors of just over 1.0. Condition of the Salmon River walleye population in terms of average weight and weight-length relation when compared with walleye sampled from the Bay of Quinte 30 years ago appeared to be unchanged. The observed male-female ratio of walleye sampled at the mouth of the Salmon River was, as expected, 2 males to one female. The observed male-female ratio of walleye sampled at the spawning area, however, was around one male to two females and was likely due to differential selectivity by spearfishers.

Approximately 97% of male and 98% of female walleye were estimated to have been mature, with ages estimated between 3.5 years and 6.5 years for males and

5.0 years and 9.0 years for females. Over 60% of males and females were in a ripe spawning condition when sampled, with the highest daily percentages of ripe males and females observed during the first week. Female walleye had an average fecundity of between 135,000 and 250,000 eggs per fish or a little over 3,000 eggs per centimeter fork length. Fecundity of Salmon River spawning walleye did not differ from fecundity of Bay of Quinte walleye observed 30 years earlier. Conservatively, over 1,470,000,000 eggs were spawned, producing around 147,000,000 fry. It was expected that 1% to 10%, or 1,470,000 to 14,700,000 fry recruited from the Salmon River, would survive their first year in the Bay of Quinte.

During the 1994 spawning run, chemical (i.e., water temperature, dissolved oxygen and pH) and physical (i.e., water level, spawning substrate) conditions determined by McMahon et. al. (1984) to be critical to walleye spawning and embryo development were monitored in the Salmon River. The resulting Habitat Suitability Index for walleye spawning and embryo development (0.8) was slightly less than optimal (1.0) due to a decline in water level between 14 April and 10 May.

Water quality parameters that could effect spawning and hatching success were optimal for fertilization, incubation and hatching of walleye eggs. The rate of warming of the Salmon River (0.22°C/day) was slightly lower than what has been observed for optimal recruitment (0.28°C/day). There was no way, however, to determine if the observed warming rate did, in fact, have any impact on hatching success. Mean temperature and warming rate did provide insight into the approximate date of fry hatch in the river, 18 to 21 days after spawning initiated or between 1 and 5 May.

Bottom substrate in the Salmon River spawning area was ideal for walleye spawning, composed principally of limestone bedrock, boulder, cobble-rubble and large gravel. After initiation of spawning, however, the volume and level of the Salmon River dropped continuously through 10 May decreasing the area of spawning substrate with suitable depth for spawning and embryo development by around 20%. While most spawning took place before the river reached critical (i.e., low) levels, fertile eggs incubating in shallow shoreline areas, particularly in the upper third of the spawning area, may have been exposed to desiccation. Although it was not possible to observe eggs amongst the substrate and, therefore, assess the impact of the lower river level on the eggs directly, it was assumed that less than 20% of the incubating eggs may have been at risk of not hatching.

Around 3,400 walleye, approximately 1,200 male and 2,200 female, were speared from the Salmon River by Tyendinaga community members between 14 April and 11 May, 1994. Along with a loss of 10% to 30% of the productive, mature, mostly female fish, the impact of spearing on walleye recruitment was estimated to have been a loss of up to 350,000,000 eggs or, potentially, 35,000,000 fry. As a potential means of mitigating the impact of spearing on the Salmon River spawning population, walleye eggs were successfully stripped, stocked, incubated and hatched at the Tyendinaga Aquaculture Research Center (ARC) hatchery. Over 1,000,000 fertile walleye eggs were stocked and incubated under optimal conditions (i.e., water temperature, DO, and pH) with 40% to over 70% of fertile eggs surviving to "eye-up." Fry hatch occurred on 5 May, after 16 to 18 days, and about 85,000 post hatch fry were released in the Salmon River or into aquaculture ponds.

While walleye eggs were successfully hatched in a controlled environment, the overall hatching success was probably not much better than eggs spawned and incubated naturally in the Salmon River. Inexperience of hatchery personnel was a key factor in the hatchery results. With more opportunities, hatching success will likely improve. It is problematic whether stocking fry from the hatchery into the Salmon River will, however, have an impact on walleye recruitment to the Bay of Quinte. Incubating fertile eggs from speared walleye, while significantly less successful than incubating eggs from dip netted walleye, possibly would be a means of recuperating a small percentage of the eggs lost each spearing season.

Spawning and incubation of eggs and stocking fry into aquaculture ponds does hold promise. While harvesting walleye each spring will remain an important tradition, walleye grown in aquaculture ponds could provide a constant supply of walleye to the Tyendinaga community. Lower consumer demand at spawning would take some of the pressure off the large, mainly female walleye that make up a majority of the spearing harvest. Additionally, consumers could be sure that they are not exposing themselves to unhealthy levels of contaminants (e.g., mercury) that are known to accumulate at significant levels in large, adult Bay of Quinte walleye.

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Table 1. Methods used to measure water temperature, dissolved oxygen, and pH of the Salmon River during 9 weeks, from 8 April to 3 June, 1994. All parameters measured at a site located above the Shannonville dam.

parameter		frequency	method
temperature (C)		2 times/day	standard thermometer
		A.M. @ 0800 - 0900	
		P.M. @ 1600 - 1800	
dissolved oxygen		2 times/day	potentiometrically w/Model 16046(Hach) meter w/Clark-type membrane covered polarographic probe
		A.M. @ 0800 - 0900	
		P.M. @ 1600 - 1800	
pH		3 times/wk	Hach I Laboratory pH meter w/Model 44200 Combination pH electrode and temperature sensor
	week 1	04/09, 04/10, 04/11	
	week 2	04/13, 04/15, 04,17	
	week 3	04/19, 04/21, 04/23	
	week 4	04/26, 04/28, 04/30	
		1 time/wk	Hach I Laboratory pH meter w/Model 44200 Combination pH electrode and temperature sensor
	week 5	05/04	
	week 6	05/12	
	week 7	05/22	
	week 8	05/24	
	week 9	06/01	

Table 2. Hoop net deployment for mark-recapture study of walleye in the Salmon River between 18 April and 8 May 1994. All sets were at depths of 1.5 to 2 m and, except one 6 hr trial on 25 April, along the east shoreline.

hoop net #	diameter (m)	date of deployment	location	date of removal
1	1.2	18-Apr	400 m upriver	08-May
2	1	21-Apr	500 m upriver	04-May
3	1	25-Apr	50 m downriver of boat launch (mid river)	25-Apr
3	1	26-Apr	100 m upriver	08-May
4	1.2	26-Apr	450 m upriver	08-May

Table 3. Results of walleye stripping to obtain eggs for fry production at the Tyendinaga Aquaculture Resource Center (ARC) during spring 1994.

broodstock source	date stripped	method of capture	males (number)	females (number)	"water hardened" eggs stocked at ARC (volume)	hatching jar stocked
Napanee River	18-Apr	dip net/hand	8	6	3.00 L	ARC: 1, 2
" "	" "	" "	" "	" "	0.45 L	EXP: 1, 2, 3
Salmon River	19-Apr	dip net	8	4	2.00 L	ARC: 3, 4
Salmon River	20-Apr	dip net	6	6	2.33 L	ARC: 5, 6
" "	" "	" "	" "	" "	0.60 L	EXP: 4, 5, 6
Bay of Quinte	23-Apr	gill net	5	4	0.60 L	EXP: 7, 8, 9
Salmon River	23-Apr	spear	3	4	0.40 L	EXP: 10, 11

Table 4. Mean, standard deviation, and range of water quality parameters monitored daily in the Salmon River between 5 April and 3 June, 1994 at the Shannonville dam.

week		water temperature (C)	dissolved oxygen (mg/L)	pH
week 1				
(4/05 - 4/11)	n	7	7	3
	mean	4.0	12.1	7.82
	st. dv.	2.1	2.2	0.28
	range	1.2 - 7.5	7 - 14.2	7.50 - 8.02
week 2				
(4/12 - 4/18)	n	7	7	3
	mean	7.4	12.1	8.0
	st. dv.	1.2	0.6	0.04
	range	5.9 - 10.0	10.8 - 12.9	7.96 - 8.04
week 3				
(4/19 - 4/25)	n	7	7	3
	mean	8.7	11.8	8.09
	st. dv.	1.7	0.6	0.10
	range	6.1 - 12.0	10.8 - 12.5	8.02 - 8.20
week 4				
(4/26 - 5/02)	n	7	7	3
	mean	10.8	10.5	8.01
	st. dv.	0.9	0.6	0.02
	range	9.5 - 13.0	9.0 - 11.7	8.00 - 8.03
week 5				
(5/03 - 5/09)	n	5	5	1
	mean	12.9	10.1	8.05
	st. dv.	1.6	0.8	0.00
	range	9.5 - 14.5	8.9 - 11.0	-
week 6				
(5/010 - 5/16)	n	6	6	1
	mean	12.6	9.8	8.1
	st. dv.	1.1	0.4	0.00
	range	10.9 - 14.2	9.3 - 10.4	-
week 7				
(5/17 - 5/23)	n	7	7	1
	mean	15.2	9.3	8.13
	st. dv.	2.5	0.6	0.00
	range	12.6 - 19.5	8.0 - 9.9	-
week 8				
(5/24 - 5/30)	n	7	7	1
	mean	15.9	8.8	8.14
	st. dv.	3.0	1.0	0.00
	range	12.6 - 19.5	7.6 - 10.1	-
week 9				
(5/31 - 6/03)	n	1	1	1
	mean	18.1	8.5	8.04
	st. dv.	0.1	0.5	0.00
	range	-	-	-

Table 5. Water quantity (flow, depth, and level) as observed at the reference point below the Shannonville bridge from 5 April to 1 June 1994.

date	total discharge (m3/sec)	depth (cm)	level change (cm)
05-Apr	37.1	-	ice cover
06-Apr	37.7	-	"
07-Apr	36.2	-	"
08-Apr	36.4	-	"
09-Apr	36.1	110.6	0
10-Apr	36.4	111.2	1
11-Apr	36.0	110.5	0
12-Apr	34.8	108.2	-2
13-Apr	37.8	113.7	3
14-Apr	42.4	121.8	11
15-Apr	40.8	119.0	8
16-Apr	41.5	120.2	10
17-Apr	41.7	120.6	10
18-Apr	40.2	117.9	7
19-Apr	38.4	114.7	4
20-Apr	36.9	112.1	2
21-Apr	35.7	109.8	-1
22-Apr	34.6	108.0	-3
23-Apr	33.1	105.2	-5
24-Apr	31.6	102.5	-8
25-Apr	30.2	100.0	-11
26-Apr	30.4	100.4	-10
27-Apr	29.2	98.3	-12
28-Apr	27.8	95.6	-15
29-Apr	26.0	92.4	-18
30-Apr	24.5	89.8	-21
01-May	23.8	88.3	-22
02-May	22.7	85.9	-25
03-May	21.3	83.1	-28
04-May	19.9	80.3	-30
05-May	18.8	78.5	-32
06-May	18.2	77.4	-33
07-May	17.8	76.9	-34
08-May	17.6	76.5	-34
09-May	16.8	75.2	-35
10-May	16.2	74.2	-36
11-May	15.3	72.8	-38
12-May	15.6	73.3	-37
13-May	15.2	72.4	-38
14-May	14.1	70.6	-40
15-May	13.5	69.7	-41
16-May	14.2	70.9	-40
17-May	15.0	72.2	-38
18-May	15.0	72.2	-38
19-May	14.6	71.4	-39
20-May	13.8	70.2	-40
21-May	13.2	69.1	-42
22-May	12.7	68.1	-43
23-May	12.0	66.8	-44
24-May	11.2	65.2	-45
25-May	10.8	64.2	-46
26-May	12.3	67.1	-44
27-May	16.2	74.2	-36
28-May	17.7	76.6	-34
29-May	17.7	76.7	-34
30-May	17.1	75.7	-35
31-May	16.3	74.3	-36
01-Jun	16.1	74.0	-37

Table 6. Estimated mean depths of the Salmon River at various distances below the Shannonville dam on 14 April, 10 May and 1 June 1994.

An asterix (*) represents reference points where water level was actually noted.

	distance below dam (m)	14 April estimated mean depth (cm)	10 May and 1 June estimated mean depth (cm)	change in depth (cm)
	2*	125	73	52
	10	137	82	55
	15	111	51	60
	20	140	65	75
	30	103	52	51
	35*	126	68	58
	40	123	66	57
	50	74	44	30
	60	79	38	41
	70	43	19	24
	80	53	22	31
	90*	55	27	28
	100	66	38	28
	110	74	47	27
	120	88	66	22
	130	86	67	19
	140*	96	78	18
	150	97	79	18
	160	110	91	19
	170	107	89	18
	180	116	98	18
	190*	112	94	18
	200	122	103	19
	210	117	99	18
	220	123	105	18
	230	131	113	18
	240*	128	109	19
	250	135	117	18
	260	136	118	18
mean		103.9	73.0	30.9
st. dev.		27.6	29.3	17.0
95% C.I.		10.4	11.0	6.5

Table 7. Estimated area of Salmon River substrate between the Shannonville Dam and the boat launch area 260 meters downriver having depth suitable for spawning and egg incubation (> 30 cm and < 150 cm, Johnson 1961) on 14 April and 10 May 1994.

distance below dam (m)	total width of Salmon River on 4/14/94 (m)	of width, length w/unsuitable depth < 30cm (m)	of width, length w/unsuitable depth > 150cm (m)	"useable" width of Salmon River on 04/14/94 (m)	total width of Salmon River on 5/10/94 (m)	of width, length w/unsuitable depth < 30cm (m)	of width, length w/unsuitable depth > 150cm (m)	"useable" width of Salmon River on 5/10/94 (m)
2	47.0	5.8	2.0	39.2	37.3	10.7	0.0	26.6
10	41.5	5.0	7.0	29.5	32.3	9.5	0.0	22.8
15	40.6	4.5	0.0	36.1	34.2	6.0	0.0	28.2
20	39.3	2.5	8.0	28.8	35.0	4.5	0.0	30.5
30	22.0	0.0	0.0	22.0	22.0	0.0	0.0	22.0
35	21.6	0.0	1.0	20.6	21.6	0.0	0.0	21.6
40	21.7	0.0	0.0	21.7	20.7	0.0	0.0	20.7
50	33.0	7.0	0.0	26.0	26.0	18.0	0.0	8.0
60	34.7	2.4	0.0	32.3	30.1	16.5	0.0	13.6
70	40.5	13.5	0.0	27.0	35.6	32.5	0.0	3.1
80	38.5	1.9	0.0	36.6	36.5	31.5	0.0	5.0
90	41.0	0.5	0.0	40.5	40.7	33.8	0.0	6.9
100	36.2	2.1	0.0	34.1	34.3	6.0	0.0	28.3
110	30.0	0.0	0.0	30.0	30.0	5.0	0.0	25.0
120	27.5	0.0	0.0	27.5	27.5	2.0	0.0	25.5
130	27.0	0.0	0.0	27.0	27.5	3.0	0.0	24.5
140	26.0	0.0	0.0	26.0	26.0	4.0	0.0	22.0
150	28.0	2.0	0.0	26.0	28.0	6.0	0.0	22.0
160	27.0	0.0	5.0	22.0	27.0	3.0	1.0	23.0
170	32.0	2.0	9.0	21.0	32.0	5.0	2.0	25.0
180	33.0	1.0	12.0	20.0	33.0	4.0	7.0	22.0
190	33.0	3.0	10.0	20.0	33.0	7.0	8.0	18.0
200	31.0	1.0	12.0	18.0	31.0	5.0	10.0	16.0
210	34.0	1.0	11.0	22.0	34.0	3.0	8.0	23.0
220	38.0	2.0	19.0	17.0	38.0	4.0	5.0	29.0
230	42.0	2.0	20.0	20.0	42.0	3.0	15.0	24.0
240	48.5	1.5	25.0	22.0	48.5	4.5	16.0	28.0
250	49.5	0.5	23.0	26.0	49.5	2.5	20.0	27.0
260	53.0	1.0	26.0	26.0	53.0	3.0	25.0	25.0
Totals								
1.) mean width =	35.1	2.1	6.6	26.4	33.3	8.0	4.0	21.3
2.) st. dev. =	8.4	2.9	8.6	6.4	7.9	9.4	6.9	7.3
3.) total area* =	8960.3	536.0	1708.5		8587.9	2176.3	1045.0	
4.) area available for spawning (m2) =				6715.8				5366.6
5.) % of river bottom available for spawn =				75%				62%
6.) % of river bottom not available for spawn =		6%	19%			25%	12%	
7.) % decrease in useable bottom area between 04/14 and 05/10 =								20%

* Total area on 14 April and 10 May was estimated by calculating individual areas between successive transect points below the dam (multiplying distance between two successive points by the estimated widths of transects across the river that connect equidistant points) and then adding all of the areas together.

Table 8. Substrate characteristics at selected distances below the Salmon River boat launch area.

distance downriver from boat launch (m)		northwest shore sampling result	midriver sampling result	southeast shoreline sampling result
0	depth (cm)	150	175	150
	bottom	hard	hard	hard
	substrate type	rock, filamentous algae	rock, a little sand, shell fragments	rock, w/little organic deposition
40	depth (cm)	200	200	200
	bottom	hard	hard	hard
	substrate type	gravel, sand, small am't organic dep.	rock, filamentous algae	rock, filamentous algae
80	depth (cm)	200	200	200
	bottom	hard	hard	hard
	substrate type	gravel, sand, small am't organic dep.	gravel, sand, small am't organic dep.	rock, w/little organic deposition
120	depth (cm)	200	250	200
	bottom	moderately hard	hard	hard
	substrate type	sand, large am't organic deposition	sand, shell fragments, twigs, leaves	sand, shell fragments, leaves, twigs
160	depth (cm)	275	200	100
	bottom	moderately hard	moderately hard	moderately hard
	substrate type	sand, large am't organic deposition	sand, shell fragments, organic debris	sand, small organic debris, silt
200	depth (cm)	180	275	200
	bottom	soft	soft	very soft
	substrate type	silt, mud, organic debris, vegetation	sand, shell fragments, organic debris	silt, small organic debris, some sand
240	depth (cm)	250	200	150
	bottom	moderately hard	very soft	very soft
	substrate type	sand, shell fragments, organic debris	sand, silt, organic debris	silt, mud, organic debris, vegetation
280	depth (cm)	120	250	120
	bottom	very soft	very soft	very soft
	substrate type	silt, mud, organic debris, vegetation	sand, shell fragments, organic debris	silt, mud, vegetation
320	depth (cm)	200	250	250
	bottom	soft	moderately hard	moderately hard
	substrate type	silt, mud, vegetation	sand, woody debris, shell fragments	sand, silt, organic debris
360	depth (cm)	150	250	200
	bottom	soft	moderately hard	soft
	substrate type	silt, mud, vegetation	sand, silt, organic debris	silt, mud, organic debris, vegetation

Table 9. Physical characteristics of substrate observed at the Salmon River walleye spawning area from the Shannonville dam to the boat launching area 260 meters downstream.

	distance below dam (m)	width of river (max.) (m)	area of sample (m^2)	substrate type (m^2) bedrock	boulder	rubble	gravel	silt	detritus
	2	47	14.1	12.6	0.0	1.5	0.0	0.0	0.0
	10	42	12.5	5.8	4.1	2.6	0.0	0.0	0.0
	15	41	12.2	1.0	4.5	6.6	0.0	0.0	0.0
	20	39	11.8	1.0	3.1	7.6	0.1	0.0	0.0
	30	22	6.6	0.1	2.5	3.9	0.0	0.0	0.0
	35	22	6.5	2.4	0.9	3.1	0.1	0.0	0.0
	40	22	6.5	0.0	0.9	5.2	0.4	0.0	0.0
	50	33	10.0	4.1	2.4	2.0	1.5	0.0	0.0
	60	35	10.4	2.6	2.8	3.7	1.3	0.0	0.0
	70	41	12.2	0.0	4.0	6.6	1.5	0.0	0.0
	80	39	11.6	0.6	5.1	5.4	0.4	0.1	0.0
	90	41	12.3	0.7	3.7	6.8	0.2	0.0	1.0
	100	36	10.9	0.9	4.6	5.2	0.2	0.0	0.0
	110	30	9.0	1.3	4.6	2.8	0.3	0.0	0.0
	120	28	8.3	1.4	4.1	2.7	0.1	0.0	0.0
	130	27	8.1	0.7	4.8	2.2	0.5	0.0	0.0
	140	26	7.8	0.9	4.3	2.4	0.3	0.0	0.0
	150	28	8.4	1.5	4.6	2.1	0.2	0.0	0.0
	160	27	8.1	2.7	3.7	1.6	0.2	0.0	0.0
	170	32	9.6	3.7	3.6	2.0	0.3	0.0	0.0
	180	33	9.9	2.0	4.3	3.4	0.3	0.0	0.0
	190	33	9.9	4.0	4.1	1.6	0.4	0.0	0.0
	200	31	9.3	5.3	1.4	2.2	0.5	0.0	0.0
	210	34	10.2	4.1	1.9	4.1	0.1	0.0	0.0
	220	38	11.4	1.2	3.2	5.0	1.7	0.0	0.3
	230	42	12.6	2.0	2.8	6.2	1.7	0.0	0.0
	240	49	14.6	6.8	2.7	4.7	0.6	0.0	0.0
	250	50	14.9	5.7	2.5	6.4	0.2	0.0	0.0
	260	53	15.9	4.6	4.8	6.3	0.3	0.0	0.0
Totals	260m		305.6	79.7	96.0	115.9	13.4	0.1	1.3
percent				26%	31%	38%	4%	0%	0%
mean		35.2							
st. dev.		8.5							

Table 10. Sex composition of walleye caught with hoop nets at the Salmon River mouth between 14 April and 11 May 1994. Initial net deployment noted with *. No observations were recorded on days noted with **.

Date	Daily totals of all walleye caught at the river mouth in hoop nets and tagged	Daily totals of male walleye caught in hoop nets					Percentage of male walleye in daily catch	Daily totals of female walleye caught in hoop nets					Percentage of female walleye in daily catch
		net 1	net 2	net 3	net 4	sub-total		net 1	net 2	net 3	net 4	sub-total	
14-Apr	**					-	-					-	-
15-Apr	**					-	-					-	-
16-Apr	**					-	-					-	-
17-Apr	**					-	-					-	-
18-Apr	**	*				-	-	*				-	-
19-Apr	6	1				1	16.7%	5				5	83.3%
20-Apr	3	2				2	66.7%	1				1	33.3%
21-Apr	7	6				6	85.7%	1				1	14.3%
22-Apr	**	-				-	-	-				-	-
23-Apr	3	2	*			2	66.7%	1	*			1	33.3%
24-Apr	**	-	-			-	-	-	-			-	-
25-Apr	1	0	0	*		0	0.0%	1	0	*		1	100.0%
26-Apr	0	0	0	0	*	0	-	0	0	0	*	0	-
27-Apr	6	1	0	1	3	5	83.3%	0	0	1	0	1	16.7%
28-Apr	**	-	-	-	-	-	-	-	-	-	-	-	-
29-Apr	**	-	-	-	-	-	-	-	-	-	-	-	-
30-Apr	11	1	0	4	5	10	90.9%	1	0	0	0	1	9.1%
01-May	**	-	-	-	-	-	-	-	-	-	-	-	-
02-May	7	1	0	2	2	5	71.4%	0	0	1	1	2	28.6%
03-May	7	1	0	5	1	7	100.0%	0	0	0	0	0	0.0%
04-May	7	0	-	4	1	5	71.4%	0	-	2	0	2	28.6%
05-May	7	0	-	1	2	3	42.9%	0	-	0	4	4	57.1%
06-May	2	0	-	0	1	1	50.0%	0	-	1	0	1	50.0%
07-May	**	-	-	-	-	-	-	-	-	-	-	-	-
08-May	4	0	-	1	1	2	50.0%	0	-	1	1	2	50.0%
09-May	**					-	-					-	-
10-May	**					-	-					-	-
11-May	**					-	-					-	-
Totals	71	15	0	18	16	49	69.0%	10	0	6	6	22	31.0%

Table 11. Harvest of walleye by spear fishing in waters monitored by Tyendinaga fish wardens between 13 April and 11 May 1994. The official spearing season on the Salmon River opened 14 April and closed 11 May 1994. Monitored waters include areas outside the Tyendinaga reserve.

* Only speared fish recorded under the names of fish wardens J. Maracle and S. Brant, whose name appeared twice in the 1994 Tyendinaga Pickerel (walleye) Season Report (Maracle 1994) were considered caught from the Salmon River. No observations were recorded on days noted with **.

Date	Estimated # of spearers (min.)	Estimated # of spearers (max.)	Total # of walleye reported harvested	Reported # of walleye speared at spawning ground*	# of speared walleye observed at spawning ground
13-Apr	6	12	36	-	-
14-Apr	28	47	278	257	143
15-Apr	69	124	505	300	48
16-Apr	70	125	676	517	12
17-Apr	71	130	510	403	73
18-Apr	60	113	431	297	74
19-Apr	35	61	277	259	79
20-Apr	58	100	479	379	49
21-Apr	25	40	218	115	16
22-Apr	28	57	171	84	21
23-Apr	30	61	185	45	22
24-Apr	46	92	276	116	31
25-Apr	40	80	242	92	49
26-Apr	15	31	93	93	42
27-Apr	12	25	77	77	3
28-Apr	12	24	73	33	15
29-Apr	22	42	150	**	**
30-Apr	9	19	61	**	**
01-May	21	42	126	110	31
02-May	26	51	167	47	41
03-May	7	13	45	45	30
04-May	6	13	40	40	22
05-May	8	16	48	48	8
06-May	3	7	21	21	**
07-May	2	5	15	15	**
08-May	2	4	12	12	**
09-May	1	2	6	6	**
10-May	2	5	16	16	**
11-May	0	0	0	0 season closed	**
Totals	714	1341	5234	3427	809 (24% of total)

Table 12. Daily mean fork lengths of walleye caught at the Salmon River mouth with hoop nets between 14 April and 13 May 1994. Days where no observations were made represented by " * ".

Date	Male n	Male mean (cm)	Male st. dev.	Male 95% C.I.	Male range (min)	Male range (max)	Female n	Female mean	Female st. dev.	Female 95% C.I.	Female range (min)	Female range (max)
14-Apr	*	-	-	-	-	-	*	-	-	-	-	-
15-Apr	*	-	-	-	-	-	*	-	-	-	-	-
16-Apr	*	-	-	-	-	-	*	-	-	-	-	-
17-Apr	*	-	-	-	-	-	*	-	-	-	-	-
18-Apr	*	-	-	-	-	-	*	-	-	-	-	-
19-Apr	1	62.0	0.0	0.0	-	-	5	57.0	7.9	9.0	46.0	68.0
20-Apr	2	49.5	6.4	20.0	45.0	54.0	1	61.0	0.0	-	-	-
21-Apr	6	45.3	7.3	7.3	36.5	50.0	1	56.0	0.0	-	-	-
22-Apr	*	-	-	-	-	-	*	-	-	-	-	-
23-Apr	2	52.0	8.5	26.3	46.0	58.0	1	58.5	0.0	-	-	-
24-Apr	*	-	-	-	-	-	*	-	-	-	-	-
25-Apr	0	-	-	-	-	-	1	53.5	0.0	-	-	-
26-Apr	*	-	-	-	-	-	*	-	-	-	-	-
27-Apr	5	44.7	6.9	8.0	39.0	56.0	1	55.0	0.0	-	-	-
28-Apr	*	-	-	-	-	-	*	-	-	-	-	-
29-Apr	*	-	-	-	-	-	*	-	-	-	-	-
30-Apr	10	47.0	6.3	4.5	34.0	56.0	1	53.0	0.0	-	-	-
01-May	*	-	-	-	-	-	*	-	-	-	-	-
02-May	5	52.4	4.2	4.9	47.5	58.5	2	54.3	8.1	24.5	48.5	60.0
03-May	7	47.7	4.8	4.3	40.0	56.0	0	-	-	-	-	-
04-May	5	45.0	3.6	4.1	41.0	50.0	2	49.5	2.1	6.5	48.0	51.0
05-May	3	55.0	7.0	13.0	47.0	60.0	4	52.0	6.4	8.9	46.0	58.0
06-May	1	34.5	0.0	0.0	-	-	1	57.0	0.0	-	-	-
07-May	*	-	-	-	-	-	*	-	-	-	-	-
08-May	2	47.0	1.4	4.3	46.0	48.0	2	58.3	10.3	31.4	51.0	65.5
09-May	*	-	-	-	-	-	*	-	-	-	-	-
10-May	*	-	-	-	-	-	*	-	-	-	-	-
11-May	*	-	-	-	-	-	*	-	-	-	-	-
12-May	*	-	-	-	-	-	*	-	-	-	-	-
13-May	5	48.2	9.5	10.8	34.0	60.0	1	62.0	0.0	-	-	-
Totals	54	48.0	6.8	1.8	34.0	60.0	23	55.4	6.0	2.7	46.0	68.0

Table 13. Daily mean fork lengths of walleye speared at the Salmon River spawning area between 14 April and 11 May 1994. Days where no observations were made represented by " * ".

	Male						Female					
date	n	mean (cm)	st. dev.	95% C.I.	range (min.)	range (max.)	n	mean (cm)	st. dev.	95% C.I.	range (min.)	range (max.)
14-Apr	80	48.0	5.8	1.4	35.0	67.0	63	59.0	8.1	2.0	47.0	78.0
15-Apr	22	46.7	7.1	3.1	37.0	63.0	26	58.5	10.1	4.1	43.0	75.0
16-Apr	2	52.0	2.8	8.6	50.0	54.0	10	60.7	6.1	4.2	52.0	72.0
17-Apr	31	51.0	7.8	2.9	34.0	62.0	42	59.9	7.3	2.2	46.0	78.0
18-Apr	35	48.0	7.7	2.6	37.0	71.0	39	57.4	6.5	2.2	48.0	73.0
19-Apr	39	45.4	5.8	1.8	30.0	63.0	39	54.6	6.5	2.2	36.0	66.0
20-Apr	23	47.6	5.5	2.3	36.0	60.0	25	60.2	10.1	4.1	39.0	77.0
21-Apr	4	48.8	6.9	9.7	40.0	56.0	12	57.5	5.8	3.7	49.0	65.0
22-Apr	5	45.0	8.5	9.8	37.0	56.0	16	59.4	4.9	2.5	50.0	68.0
23-Apr	2	45.0	1.4	4.3	44.0	46.0	20	59.3	7.3	3.3	47.0	72.0
24-Apr	4	43.3	3.4	4.7	40.0	48.0	27	58.6	5.9	2.3	49.0	72.0
25-Apr	2	51.5	5.0	15.0	48.0	55.0	47	56.2	5.6	1.6	48.0	76.0
26-Apr	10	55.7	5.9	4.2	47.0	64.0	32	58.1	6.0	2.2	47.0	72.0
27-Apr	1	54.0	0.0	-	54.0	54.0	2	51.0	4.2	13.0	48.0	54.0
28-Apr	1	53.0	0.0	-	54.0	54.0	14	57.1	5.9	3.4	47.0	67.0
29-Apr	*	-	-	-	-	-	*	-	-	-	-	-
30-Apr	*	-	-	-	-	-	*	-	-	-	-	-
01-May	4	45.8	2.1	2.8	44.0	48.0	26	58.2	5.2	2.1	48.0	67.0
02-May	14	48.4	8.0	4.7	37.0	63.0	27	56.2	4.9	2.1	44.0	67.0
03-May	1	43.0	0.0	-	43.0	43.0	26	56.4	4.4	1.9	47.0	64.0
04-May	0	-	-	-	-	-	22	55.0	4.8	2.1	46.0	65.0
05-May	3	46.0	3.6	6.7	42.0	49.0	5	55.8	5.4	6.2	48.0	63.0
06-May	*	-	-	-	-	-	*	-	-	-	-	-
07-May	*	-	-	-	-	-	*	-	-	-	-	-
08-May	*	-	-	-	-	-	*	-	-	-	-	-
09-May	*	-	-	-	-	-	*	-	-	-	-	-
10-May	*	-	-	-	-	-	*	-	-	-	-	-
11-May	*	-	-	-	-	-	*	-	-	-	-	-
Totals	283	48.0	6.7	0.8	30.0	71.0	520	57.8	6.9	0.6	36.0	78.0

Table 14. Spawning condition of adult walleye (n = 77) caught in hoop nets set at the Salmon River mouth between 14 April and 13 May 1994. Days where no observations were made are noted with " * ".

sex	male					female				
condition	ripe	green	spent	unkn.	total	ripe	green	spent	unkn.	total
Date										
14-Apr	*	*	*	*	*	*	*	*	*	*
15-Apr	*	*	*	*	*	*	*	*	*	*
16-Apr	*	*	*	*	*	*	*	*	*	*
17-Apr	*	*	*	*	*	*	*	*	*	*
18-Apr	*	*	*	*	*	*	*	*	*	*
19-Apr	1	0	0	0	1	4	1	0	0	5
20-Apr	2	0	0	0	2	1	0	0	0	1
21-Apr	6	0	0	0	6	1	0	0	0	1
22-Apr	*	*	*	*	*	*	*	*	*	*
23-Apr	2	0	0	0	2	1	0	0	0	1
24-Apr	*	*	*	*	*	*	*	*	*	*
25-Apr	0	0	0	0	0	1	0	0	0	1
26-Apr	*	*	*	*	*	*	*	*	*	*
27-Apr	3	2	0	0	5	1	0	0	0	1
28-Apr	*	*	*	*	*	*	*	*	*	*
29-Apr	*	*	*	*	*	*	*	*	*	*
30-Apr	7	3	0	0	10	1	0	0	0	1
01-May	*	*	*	*	*	*	*	*	*	*
02-May	3	2	0	0	5	1	1	0	0	2
03-May	6	1	0	0	7	0	0	0	0	0
04-May	2	3	0	0	5	0	2	0	0	2
05-May	1	0	2	0	3	3	1	0	0	4
06-May	0	0	0	1	1	0	0	0	1	1
07-May	*	*	*	*	*	*	*	*	*	*
08-May	2	0	0	0	2	2	0	0	0	2
09-May	*	*	*	*	*	*	*	*	*	*
10-May	*	*	*	*	*	*	*	*	*	*
11-May	*	*	*	*	*	*	*	*	*	*
12-May	*	*	*	*	*	*	*	*	*	*
13-May	0	0	5	0	5	0	1	0	0	1
Totals	35	11	7	1	54	16	6	0	1	23
percent of total	64.8	20.4	13.0	1.8	100.0	69.6	26.1	0.0	4.3	100.0

Table 15. Spawning condition of adult walleye (n = 216) speared from the Salmon River between 14 April and 13 May 1994. Days where no observations were made are noted with " * ".

sex	male					female				
condition	ripe	green	spent	unkn.	total	ripe	green	spent	unkn.	total
date										
14-Apr	0	0	0	7	7	5	0	1	0	6
15-Apr	*	*	*	*	*	*	*	*	*	*
16-Apr	*	*	*	*	*	*	*	*	*	*
17-Apr	*	*	*	*	*	*	*	*	*	*
18-Apr	*	*	*	*	*	*	*	*	*	*
19-Apr	17	0	0	0	17	26	0	0	0	26
20-Apr	12	0	0	0	12	7	0	0	0	7
21-Apr	4	0	0	0	4	8	0	4	0	12
22-Apr	5	0	0	0	5	10	0	6	0	16
23-Apr	0	0	0	2	2	17	0	3	0	20
24-Apr	*	*	*	*	*	*	*	*	*	*
25-Apr	*	*	*	*	*	*	*	*	*	*
26-Apr	*	*	*	*	*	*	*	*	*	*
27-Apr	0	0	1	0	1	2	0	0	0	2
28-Apr	*	*	*	*	*	*	*	*	*	*
29-Apr	*	*	*	*	*	*	*	*	*	*
30-Apr	0	0	0	0	0	0	0	0	0	0
01-May	1	0	0	0	1	11	1	0	0	12
02-May	0	0	0	14	14	5	9	8	5	27
03-May	1	0	0	0	1	7	9	0	0	16
04-May	*	*	*	*	*	*	*	*	*	*
05-May	2	0	1	0	3	3	2	0	0	5
06-May	*	*	*	*	*	*	*	*	*	*
07-May	*	*	*	*	*	*	*	*	*	*
08-May	*	*	*	*	*	*	*	*	*	*
09-May	*	*	*	*	*	*	*	*	*	*
10-May	*	*	*	*	*	*	*	*	*	*
11-May	*	*	*	*	*	*	*	*	*	*
12-May	*	*	*	*	*	*	*	*	*	*
13-May	*	*	*	*	*	*	*	*	*	*
totals	42	0	2	23	67	101	21	22	5	149
percent of total	62.7	0.0	3.0	34.3	100.0	67.8	14.1	14.8	3.3	100.0

Table 16. Fecundity - length relationship observed for 10 female walleye speared at Salmon River spawning area between 14 April and 13 May 1994.

date caught	length (cm)	weight (kg)	volume of ovaries (mL)	volume of eggs counted (mL)	mean # eggs per mL ovary (+/- 95% C.I.)	estimated total # eggs (+/- 95% C.I.)	estimated # eggs per cm (+/- 95% C.I.)
03-May	46.0	1.25	195	10.9	552 +/- 41	107601 +/- 8022	2339 +/- 174
03-May	51.0	1.36	305	18.7	322 +/- 13	98241 +/- 3843	1926 +/- 75
03-May	53.0	1.93	280	19.7	309 +/- 37	86408 +/- 10438	1630 +/- 197
05-May	57.0	2.61	595	17.1	354 +/- 23	210392 +/- 21414	3691 +/- 376
03-May	57.5	2.38	510	19.2	312 +/- 36	159273 +/- 11592	2770 +/- 202
03-May	58.0	2.72	542	16.2	371 +/- 18	201082 +/- 9637	3467 +/- 166
02-May	62.0	3.52	515	18.7	324 +/- 40	166963 +/- 20806	2693 +/- 336
03-May	62.0	3.63	745	16.7	363 +/- 16	270137 +/- 23624	4357 +/- 381
20-Apr	63.5	3.63	945	19.9	303 +/- 21	286713 +/- 19996	4515 +/- 315
05-May	65.0	3.63	935	15.9	379 +/- 12	354459 +/- 14577	5453 +/- 224

Table 17. Number of walleye fry caught at five sampling stations located along a transect across the Salmon River between 8 May and 3 June 1994. Samples were collected along the transect three times nightly (transect #1) at @2000 - 0000 hours, (transect #2) at @0000 - 0400 hours, and (transect #3) at @0400 - 0800 hours. A dash (-) denotes no samples taken.

Date	transect	Station 1 total fry caught	Station 2 total fry caught	Station 3 total fry caught	Station 4 total fry caught	Station 5 total fry caught	total # samples (n)	total # fry caught	mean # fry per sample	st. dev.
5/08-09										
	1	-	-	-	-	-	0			
	2	3	31	50	41	64	8	189	23.6	17.8
	3	-	-	-	-	-	0			
5/09-10										
	1	0	0	0	1	7	8	8	1.0	2.4
	2	3	5	20	26	2	8	56	7.0	4.9
	3	4	7	13	1	1	8	26	3.3	2.4
5/10-11										
	1	0	3	2	6	0	8	11	1.4	1.2
	2	2	1	8	8	14	8	33	4.1	4.3
	3	1	1	2	39	19	8	62	7.8	9.6
5/13-14										
	1	0	0	2	3	0	8	5	0.6	0.7
	2	1	2	3	12	5	8	23	2.9	2.3
	3	10	4	2	2	1	8	19	2.4	3.1
5/14-15										
	1	0	0	1	1	0	8	2	0.3	0.3
	2	0	1	1	6	14	6	22	2.8	4.7
	3	2	0	3	0	0	8	5	0.6	0.9
5/16-17										
	1	0	0	0	4	0	8	4	0.5	0.9
	2	1	12	15	3	0	8	31	3.9	3.2
	3	4	5	0	0	0	8	9	1.1	1.6
5/18-19										
	1	0	0	1	0	0	8	1	0.1	0.2
	2	0	3	6	7	2	8	18	2.3	1.2
	3	0	0	0	0	0	8	0	0.0	0.0
5/20-21										
	1	0	0	0	1	0	8	1	0.1	0.2
	2	0	0	9	2	1	8	12	1.5	1.9
	3	0	0	0	0	1	8	1	0.1	0.4
5/22-23										
	1	0	0	0	0	0	8	0	0.0	0.0
	2	0	0	5	12	0	8	17	2.1	2.6
	3	0	0	0	0	0	8	0	0.0	0.0
5/24-25										
	1	0	0	1	0	0	8	1	0.1	0.2
	2	0	0	4	14	1	8	19	2.4	3.0
	3	0	0	0	0	0	8	0	0.0	0.0
5/26-27										
	1	-	0	0	0	0	7	0	0.0	0.0
	2	2	1	1	0	0	8	4	0.5	0.7
	3	0	0	0	0	0	8	0	0.0	0.0
5/28-29										
	1	-	0	0	1	0	7	1	0.1	0.2
	2	0	0	0	0	0	8	0	0.0	0.0
	3	0	0	0	0	0	8	0	0.0	0.0
5/30-31										
	1	0	0	0	0	0	8	0	0.0	0.0
	2	0	1	0	1	1	8	3	0.4	0.4
	3	-	-	-	-	-	0			
6/02-03										
	1	0	0	0	0	0	8	0	0.0	0.0
	2	0	0	0	0	0	8	0	0.0	0.0
	3	-	-	-	-	-	0			
Totals							300	583	3.1	8.2
transect 1										
	# samples						102			
	total fry	0.0	3.0	7.0	16.0	7.0		33		
	mean/sample	0.0	0.2	0.5	1.3	0.5			0.5	
	st. dev.	0.0	0.8	0.8	1.9	1.9				0.5
transect 2										
	# samples						110			
	total fry	12.0	57.0	122.0	132.0	104.0		427		
	mean/sample	0.9	4.1	8.7	9.4	7.4			6.1	
	st. dev.	1.2	8.4	13.3	11.6	17.0				3.6
transect 3										
	# samples						88			
	total fry	21.0	17.0	20.0	42.0	22.0		122		
	mean/sample	1.9	1.5	1.8	3.8	2.0			2.2	
	st. dev.	3.1	2.5	3.9	11.7	5.7				0.9

Table 18. Volume of water sampled at five sampling stations located along a transect across the Salmon River between 8 April and 3 June 1994. Samples were collected along the transect three times nightly (transect #1) at @2000 - 0000 hours, (transect #2) at @0000 - 0400 hours, and (transect #3) at @0400 - 0800 hours. A dash (-) denotes no samples taken.

		Volume (m^3)					
Date	transect	station 1	station 2	station 3	station 4	station 5	Totals
5/08-09							
	1	-	-	-	-	-	
	2	3.6	36.6	3.7	49.0	0.2	93.1
	3	-	-	-	-	-	
5/09-10							
	1	3.8	27.1	2.0	2.2	0.7	35.8
	2	0.3	6.2	1.2	13.5	0.1	21.3
	3	1.2	1.7	4.9	1.0	0.7	9.5
5/10-11							
	1	0.6	4.2	1.0	0.8	0.3	6.8
	2	0.3	0.2	0.7	0.4	0.1	1.7
	3	0.1	0.4	4.2	0.4	0.2	5.3
5/13-14							
	1	0.2	3.0	6.1	0.4	0.2	9.9
	2	0.4	0.5	0.7	0.5	0.5	2.6
	3	0.2	0.9	1.1	1.0	0.6	3.8
5/14-15							
	1	0.3	0.6	0.3	0.5	0.2	1.9
	2	3.1	0.2	0.2	0.2	0.2	3.9
	3	0.2	0.4	0.4	0.5	0.1	1.6
5/16-17							
	1	0.6	1.0	1.6	1.3	0.3	4.8
	2	0.2	5.9	4.8	3.7	0.3	14.9
	3	0.8	4.9	3.4	1.7	1.2	12.0
5/18-19							
	1	0.3	0.5	1.9	1.6	0.3	4.6
	2	0.0	1.9	1.4	1.3	0.2	4.8
	3	0.6	2.2	1.3	1.6	0.5	6.2
5/20-21							
	1	0.3	0.9	1.3	0.4	0.4	3.3
	2	0.0	0.6	0.9	0.8	0.3	2.6
	3	0.4	1.3	1.3	0.7	0.2	3.9
5/22-23							
	1	1.5	1.2	1.4	1.3	0.1	5.5
	2	0.2	0.6	0.9	1.3	0.2	3.2
	3	0.1	1.0	0.6	1.0	0.3	3.0
5/24-25							
	1	0.5	1.0	1.5	1.0	0.4	4.4
	2	0.9	1.0	1.0	1.3	0.3	4.5
	3	0.4	1.0	1.0	1.2	0.6	4.2
5/26-27							
	1	-	0.8	1.2	2.6	0.3	4.9
	2	0.3	0.8	0.8	1.0	0.5	3.4
	3	0.4	0.9	72.4	1.6	0.8	76.1
5/28-29							
	1	-	1.6	8.8	2.5	0.2	13.1
	2	0.4	1.1	1.4	3.1	0.3	6.3
	3	0.4	2.8	6.0	1.8	0.5	11.5
5/30-31							
	1	1.4	2.8	3.6	2.6	0.4	10.8
	2	1.2	3.2	2.0	4.0	2.5	12.9
	3	-	-	-	-	-	
6/02-03							
	1	1.6	1.7	2.2	1.0	0.2	6.7
	2	0.2	2.5	0.8	1.7	0.1	5.3
	3	-	-	-	-	-	
Totals							430
transect 1							
	volume (m^3)	11.1	46.4	32.9	18.2	4.0	112.5 (26.1%)
transect 2							
	volume (m^3)	11.2	61.3	20.5	81.8	5.8	180.6 (42.0%)
transect 3							
	volume (m^3)	4.8	17.5	96.6	12.5	5.7	137.1 (31.9%)
Grand Total (m^3)		27.1 (6.3%)	125.2 (29.1%)	150.0 (34.9%)	112.5 26.2%)	15.5 (3.6%)	

Table 19. Density of walleye fry collected at five sampling stations located along a transect across the Salmon River between 8 May and 3 June 1994. Samples were collected along the transect three times nightly (transect #1) at @2000 - 0000 hours, (transect #2) at @0000 - 0400 hours, and (transect #3) at @0400 - 0800 hours. A dash (-) denotes no samples taken.

Salmon River		Observed density (# fry/m3)						
		station 1	station 2	station 3	station 4	station 5	(weighted) mean density (fry/m3)	st. dev.
(weighting factor)		(0.15)	(0.24)	(0.25)	(0.23)	(0.13)		
date	transect							
5/08-09								
	1	-	-	-	-	-	-	-
	2	0.8	0.8	13.5	0.8	320.0	45.5	106.6
	3	-	-	-	-	-	-	-
5/09-10								
	1	0.0	0.0	0.0	0.5	10.0	1.4	3.4
	2	10.0	0.8	16.7	1.9	20.0	8.9	7.7
	3	3.3	4.1	2.7	1.0	1.4	2.6	1.2
5/10-11								
	1	0.0	0.5	2.2	7.5	0.0	2.4	2.9
	2	6.7	5.0	11.4	20.0	140.0	27.9	43.9
	3	10.0	2.5	0.5	97.5	95.0	37.0	45.0
5/13-14								
	1	0.0	0.0	0.3	7.5	0.0	1.8	3.1
	2	2.5	4.0	4.3	24.0	10.0	9.2	8.4
	3	50.0	4.4	2.5	2.0	1.7	9.9	16.7
5/14-15								
	1	0.0	0.0	3.3	2.0	0.0	1.3	1.4
	2	0.0	5.0	5.0	30.0	70.0	18.5	22.8
	3	10.0	0.0	7.5	0.0	0.0	3.4	4.2
5/16-17								
	1	0.0	0.0	0.0	3.1	0.0	0.7	1.3
	2	5.0	2.0	3.1	0.8	0.0	2.2	1.6
	3	5.0	1.0	0.0	0.0	0.0	1.0	1.7
5/18-19								
	1	0.0	0.0	0.5	0.0	0.0	0.1	0.2
	2	0.0	1.6	4.3	5.4	10.0	4.0	3.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5/20-21								
	1	0.0	0.0	0.0	2.5	0.0	0.6	1.1
	2	0.0	0.0	10.0	2.5	3.3	3.5	4.0
	3	0.0	0.0	0.0	0.0	5.0	0.7	1.7
5/22-23								
	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	5.6	9.2	0.0	3.5	3.9
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5/24-25								
	1	0.0	0.0	0.7	0.0	0.0	0.2	0.3
	2	0.0	0.0	4.0	10.8	3.3	3.9	4.1
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5/26-27								
	1	-	0.0	0.0	0.0	0.0	0.0	0.0
	2	6.7	1.3	1.3	0.0	0.0	1.6	2.2
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5/28-29								
	1	-	0.0	0.0	0.4	0.0	0.1	0.2
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5/30-31								
	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.3	0.0	0.3	0.4	0.2	0.2
	3	-	-	-	-	-		
6/02-03								
	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	-	-	-	-	-		
totals								
transect	1							
	# samples	11	26	26	26	13		
	mean	0.0	0.0	0.5	1.8	0.8	0.7	
	st. dev.	0.0	0.1	1.0	2.7	2.8		0.7
transect	2							
	# samples	14	28	27	27	14		
	mean	2.3	1.5	5.7	7.6	41.2	9.2	
	st. dev.	3.4	1.9	5.3	10.1	89.3		12.6
transect	3							
	# samples	11	22	22	22	11		
	mean	7.1	1.1	1.2	9.1	9.4	4.9	
	st. dev.	14.8	1.8	2.3	29.3	28.4		3.8
all transects								
	# samples	36	76	75	75	38		
	mean	3.1	0.9	2.6	6.0	18.2	5.1	
	st. dev.	8.6	1.6	4.2	16.7	57.9		5.4

Table 20. Total number of walleye fry estimated in drift to the mouth of the Salmon River between 8 May and 3 June 1994. Samples were collected approximately 1 kilometer above the Salmon River mouth at 5 sampling stations along a transect. Samples were collected three times nightly (transect #1) at @2000 - 0000 hours, (transect #2) at @0000 - 0400 hours, and (transect #3) at @0400 - 0800 hours. A dash (-) denotes no samples taken.

		Estimated # fry passing in 4 hours					estimated	estimated
date	transect	station 1	station 2	station 3	station 4	station 5	total fry passing all stations during 4 hours	total fry day + night (1:3.8)
5/08-09								
	1	-	-	-	-	-	*	*
	2	30960	50348	836757	47666	10303488	11269219	14234802
	3	-	-	-	-	-	*	*
5/09-10								
	1	0	0	0	25292	314496	339788	429205
	2	356400	45987	990000	105248	617760	2115395	2672078
	3	116640	230536	154727	53654	43323	598880	756480
5/10-11								
	1	0	27994	128304	402408	0	558706	705733
	2	226080	271296	645943	1039968	4114656	6297943	7955296
	3	328320	131328	26057	4908384	2703168	8097257	10228114
5/13-14								
	1	0	0	17941	377568	0	395509	499590
	2	79380	203213	226800	1168474	275184	1953050	2467011
	3	1522800	216576	126900	93398	43992	2003666	2530947
5/14-15								
	1	0	0	169200	93398	0	262598	331703
	2	0	238464	248400	1371168	1808352	3666384	4631222
	3	291600	0	364500	0	0	656100	828758
5/16-17								
	1	0	0	0	144709	0	144709	182790
	2	157680	102626	164250	39207	0	463763	585805
	3	162000	52898	0	0	0	214898	271450
5/18-19								
	1	0	0	28421	0	0	28421	35900
	2	0	80761	228343	263941	277056	850101	1073812
	3	0	0	0	0	0	0	0
5/20-21								
	1	0	0	0	114264	0	114264	144333
	2	0	0	486000	111780	84240	682020	861499
	3	0	0	0	0	123552	123552	156066
5/22-23								
	1	0	0	0	0	0	0	0
	2	0	0	248000	379097	0	627097	792122
	3	0	0	0	0	0	0	0
5/24-25								
	1	0	0	26880	0	0	26880	33954
	2	0	0	158400	392345	68640	619385	782381
	3	0	0	0	0	0	0	0
5/26-27								
	1	-	0	0	0	0	0	0
	2	205920	61776	64350	0	0	332046	419427
	3	0	0	0	0	0	0	0
5/28-29								
	1	-	0	0	23449	0	23449	29620
	2	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0
5/30-31								
	1	0	0	0	0	0	0	0
	2	0	18036	0	13828	12505	44369	56044
	3	-	-	-	-	-	-	-
6/02-03								
	1	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	3	-	-	-	-	-	-	-
totals							42509447	53696144
transect	1 subtotal	0	27994	370746	1181088	314496	1894324	2392830
transect	2 subtotal	1056420	1072507	4297242	4932720	17561881	28920770	36531499
transect	3 subtotal	2421360	631337	672184	5055437	2914035	11694353	14771815
(daylight hours)	subtotal	(915205)	(455747)	(1405308)	(2939275)	(5471161)	(11186697)	

estimated total # fry drifting past sampling site between 05/05 and 05/08 (including unsampled periods denoted by * on 05/08-09) 46122806

estimated total # fry drifting past sampling site on all unsampled days between 05/08 and 06/03 47447712

Grand Total 147266662

Table 21. Potential egg production potential of female walleye based on a fecundity - length relationship established from 10 female walleye speared at the Salmon River spawning ground between 14 April and 13 May 1994. Regression equation for fecundity versus length is: egg production = -520451.12 + 12427.44 X length (r2 = 0.72).

fork length (cm)	29.5-30.4	30.5-31.4	31.5-32.4	32.5-33.4	33.5-34.4	34.5-35.4	35.5-36.4	36.5-37.4	37.5-38.4	38.5-39.4	totals
# females observed	-	-	-	-	-	-	1	0	0	1	2
% of total # fem. observed	-	-	-	-	-	-	0.19%	0.00%	0.00%	0.19%	
est. # females speared	-	-	-	-	-	-	4	0	0	4	8
potential # eggs/female	-	-	-	-	-	-	-73063	-60636	-48208	-35781	
* estimated # eggs lost	-	-	-	-	-	-	-313048	0	0	-150142	-463190

fork length (cm)	39.5-40.4	40.5-41.4	41.5-42.4	42.5-43.4	43.5-44.4	44.5-45.4	45.5-46.4	46.5-47.4	47.5-48.4	48.5-49.4	
# females observed	0	0	1	1	3	2	6	6	13	18	50
% of total # fem. observed	0.00%	0.00%	0.19%	0.19%	0.58%	0.38%	1.15%	1.15%	2.50%	3.46%	
est. # females speared .	0	0	4	4	13	9	26	26	56	77	214
potential # eggs/female	-23354	-10926	1501	13929	26356	38784	51211	63639	76066	88493	
* estimated # eggs lost	0	0	6433	59680	338779	332346	1316520	1636001	4236876	6824886	14751520

fork length (cm)	49.5-50.4	50.5-51.4	51.5-52.4	52.5-53.4	53.5-54.4	54.5-55.4	55.5-56.4	56.5-57.4	57.5-58.4	58.5-59.4	
# females observed	24	21	28	21	29	28	28	33	24	37	273
% of total # fem. observed	4.62%	4.04%	5.38%	4.04%	5.58%	5.38%	5.38%	6.35%	4.62%	7.12%	
est. # females speared	103	90	120	90	124	120	120	141	103	159	1170
potential # eggs/female	100921	113348	125776	138203	150631	163058	175486	187913	200340	212768	
* estimated # eggs lost	10377772	10198733	15089221	12435099	18716436	19561952	21052863	26569447	20601157	33730249	188332930

fork length (cm)	59.5-60.4	60.5-61.4	61.5-62.4	62.5-63.4	63.5-64.4	64.5-65.4	65.5-66.4	66.5-67.4	67.5-68.4	68.5-69.4	
# females observed	36	28	24	18	8	11	13	14	4	4	160
% of total # fem. observed	6.92%	5.38%	4.62%	3.46%	1.54%	2.12%	2.50%	2.69%	0.77%	0.77%	
est. # females speared	154	120	103	77	34	47	56	60	17	17	686
potential # eggs/female	225195	237623	250050	262478	274905	287332	299760	312187	324615	337042	
* estimated # eggs lost	34735506	28507415	25712850	20243080	9422899	13542201	16696628	18726439	5563398	5776385	178926801

fork length (cm)	69.5-70.4	70.5-71.4	71.5-72.4	72.5-73.4	73.5-74.4	74.5-75.4	75.5-76.4	76.5-77.4	77.5-78.4	78.5-79.4	
# females observed	3	6	11	2	6	2	1	2	2	0	35
% of total # fem. observed	0.58%	1.15%	2.12%	0.38%	1.15%	0.38%	0.19%	0.38%	0.38%	0.00%	
est. # females speared	13	26	47	9	26	9	4	9	9	0	150
potential # eggs/female	349470	361897	374325	386752	399179	411607	424034	436462	448889	461317	
* estimated # eggs lost	4492030	9303540	17642204	3314167	10261982	3527154	1816824	3740142	3846635	0	57944678

total # female walleye observed =	520
estimated # female walleye speared =	2228
estimated # eggs not spawned * =	439492739
estimated # eggs not spawned from 80% females ripe or green =	351594191
estimated # eggs spawned prior to removal of females by spearing =	87898548

* Egg loss estimates are based on the removal of every female prior to initiating egg release (100% gravid). In reality, only around 80% of the captured females appeared to be in spawning condition, with 68% of the females ripe and already releasing eggs and 14% of the females green. A more realistic estimate of number of eggs not spawned from captured females, therefore, should be a maximum of 80% of the projected potential egg production and, perhaps, not less than 50%.

Table 22. Hatch of walleye eggs incubated in jars at the Aquaculture Resource Center (ARC) located on the Salmon River.

hatch jar #	walleye egg source	start date	# eggs stocked	# eggs fertilized	95% C.I.	% eggs fertilized	# eyed eggs eggs	95% C.I.	% fertile eggs eyed	date hatched	# eggs hatched (fry released)*	% fertile eggs hatched
ARC 1/2	Napanee River	18 April	405,900	164,390	11,690	41	119,930	27,970	73	05 May	40,500	25
ARC 3/4	Salmon River	19 April	270,600	110,950	13,150	41	38,260	4,770	39	05 May	22,250	20
ARC 5/6	Salmon River	20 April	317,950	138,840	3,372	44	86,680	27,330	62	05 May	22,250	16
totals			994,450	414,180		42	244,870		59		85,000	21

* Fry were either returned to the Salmon River or stocked into aquaculture ponds.

Table 23. Hatch of walleye eggs incubated in experimental jars at the Aquaculture Resource Center (ARC) located on the Salmon River.

hatch jar #	walleye egg source	start date	# eggs stocked	# eggs fertilized	95% C.I.	% eggs fertilized	# eyed eggs	95% C.I.	% fertile eggs eyed	date hatched
EXP 1/2/3	Napanee River (live fish)	18 April	60,890	23,750	830	39	11,540	1,600	49	25 April
EXP 4/5/6	Salmon River (live fish)	20 April	81,180	33,370	1,160	41	17,070	1,080	51	26 April
subtotals			142,070	57,120		40	28,610		50	
EXP 7/8/9	Bay of Quinte (gill-netted)	23 April	81,180	18,940	4,110	23	7,480	1,600	40	30 April
EXP 10/11	Salmon River (speared)	23 April	54,120	10,730	4,570	20	7,900	2,710	74	30 April
subtotals			135,300	29,670		22	15,380		52	

Table 24. Temperature data collected during walleye egg incubation at the Tyendinaga Aquaculture Resource Center (ARC) between 18 April and 5 May 1994.

hatching jar	source of broodstock	stocking date	initial temp. (C)	final temp. (C)	mean temp. (C)	95% C.I. (C)	temp. range (C)	hatching date	temp. units (T.U.)	researchers observing similar results
ARC 1, 2	Napanee River	18-Apr	10	12.5	11	0.5	10.0 - 12.8	05-May	185	Johnson (1961)
ARC 3, 4	Salmon River	19-Apr	10	12.5	11.1	0.5	10.0 - 12.8	05-May	175	Johnson (1961)
ARC 5, 6	Salmon River	20-Apr	10	12.5	11.1	0.5	10.0 - 12.8	05-May	165	Johnson (1961)
EXP 1, 2, 3,	Napanee River	18-Apr	10	20	18	3.2	10.0 - 21.0	25-Apr	124	Koenst and Smith (1976)
EXP 4, 5, 6	Salmon River	20-Apr	18.7	18.5	19.7	0.8	18.7 - 21.0	26-Apr	120	Koenst and Smith (1976)
EXP 7, 8, 9	Bay of Quinte (gill netted)	23-Apr	20	16.7	16.7	3	10.5 - 20.0	30-Apr	123	Koenst and Smith (1976)
EXP 9, 10	Salmon River (speared)	23-Apr	20	16.7	16.7	3	10.5 - 20.0	30-Apr	123	Koenst and Smith (1976)

Table 25. Dissolved oxygen data collected during walleye egg incubation at the Tyendinaga Aquaculture Resource Center (ARC) between 18 April and 5 May 1994.

hatching jar	source of broodstock	stocking date	initial DO (mg/L O_2)	final DO (mg/L O_2)	mean DO (mg/L O_2)	95% C.I. (C)	DO range (C)	hatching date	# days with suboptimal DO (< 5.0 mg/L O_2)
ARC 1, 2	Napanee River	18-Apr	6.4	5.2	6.3	3	6.0 - 7.8	05-May	0
ARC 3, 4	Salmon River	19-Apr	6.4	5.2	6.3	3.2	6.0 - 7.8	05-May	0
ARC 5, 6	Salmon River	20-Apr	6.3	5.2	6.3	3.3	6.0 - 7.8	05-May	0
EXP 1, 2, 3,	Napanee River	18-Apr	6.2	8.2	7.8	0.5	6.2 - 8.2	25-Apr	0
EXP 4, 5, 6	Salmon River	20-Apr	8.1	8.2	7.8	0.6	6.2 - 8.2	26-Apr	0
EXP 7, 8, 9	Bay of Quinte (gill netted)	23-Apr	8.0	6.2	8	1	6.2 - 8.2	30-Apr	0
EXP 9, 10	Salmon River (speared)	23-Apr	8.0	6.2	8	1	6.2 - 8.2	30-Apr	0

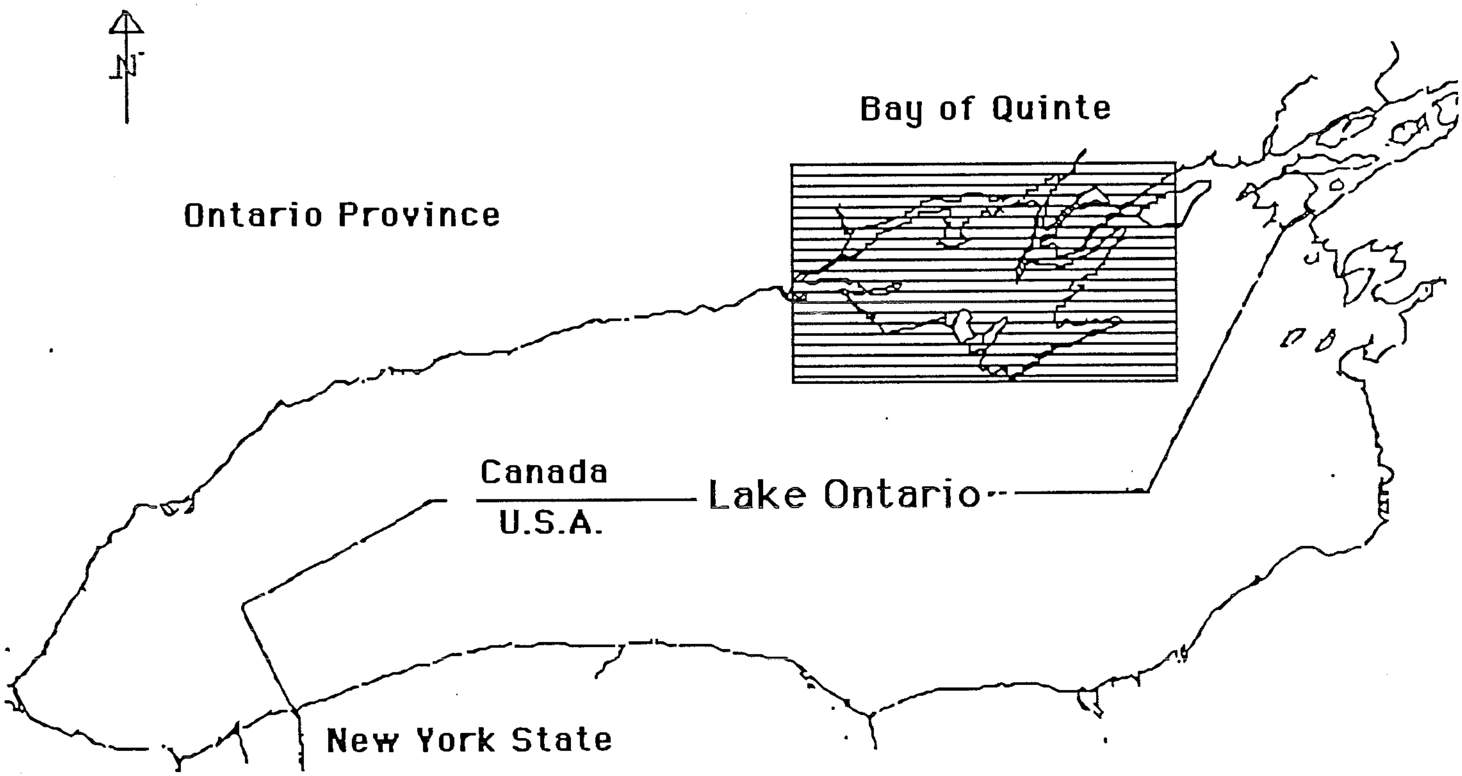


Figure 1. The Bay of Quinte is located in northeastern Lake Ontario.

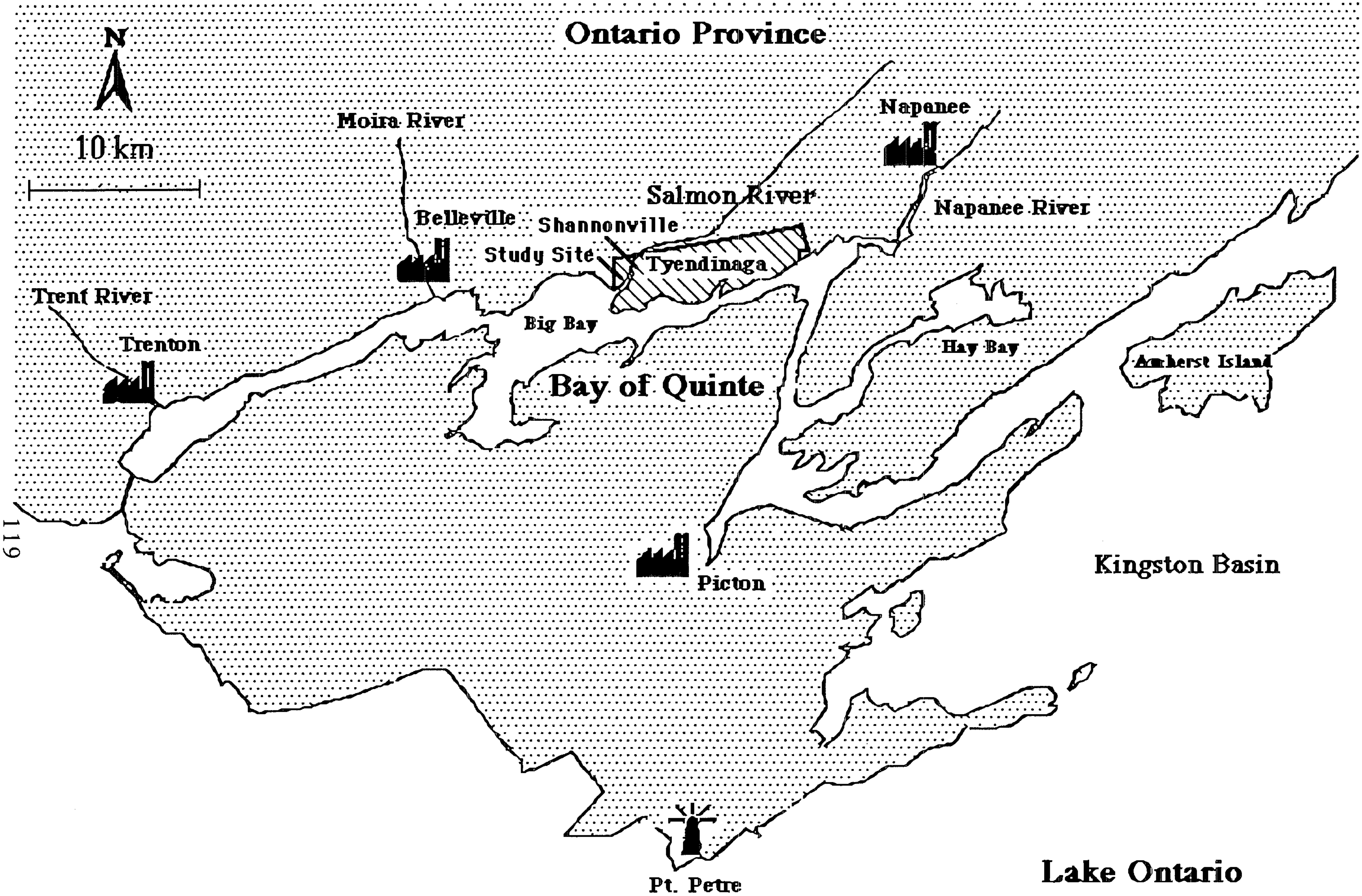


Figure 2. The Salmon River is a tributary of the Bay of Quinte.

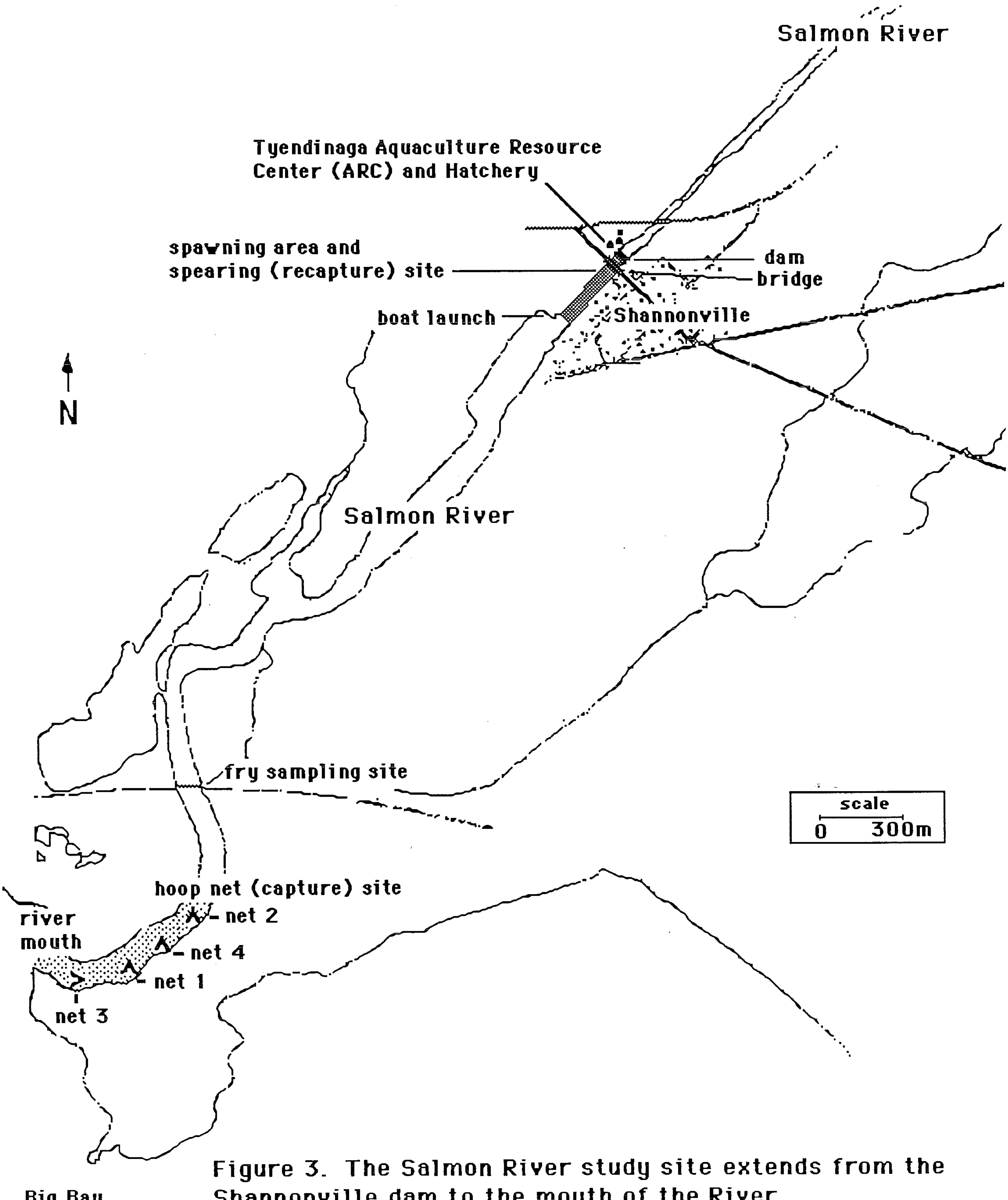


Figure 3. The Salmon River study site extends from the Shannonville dam to the mouth of the River.

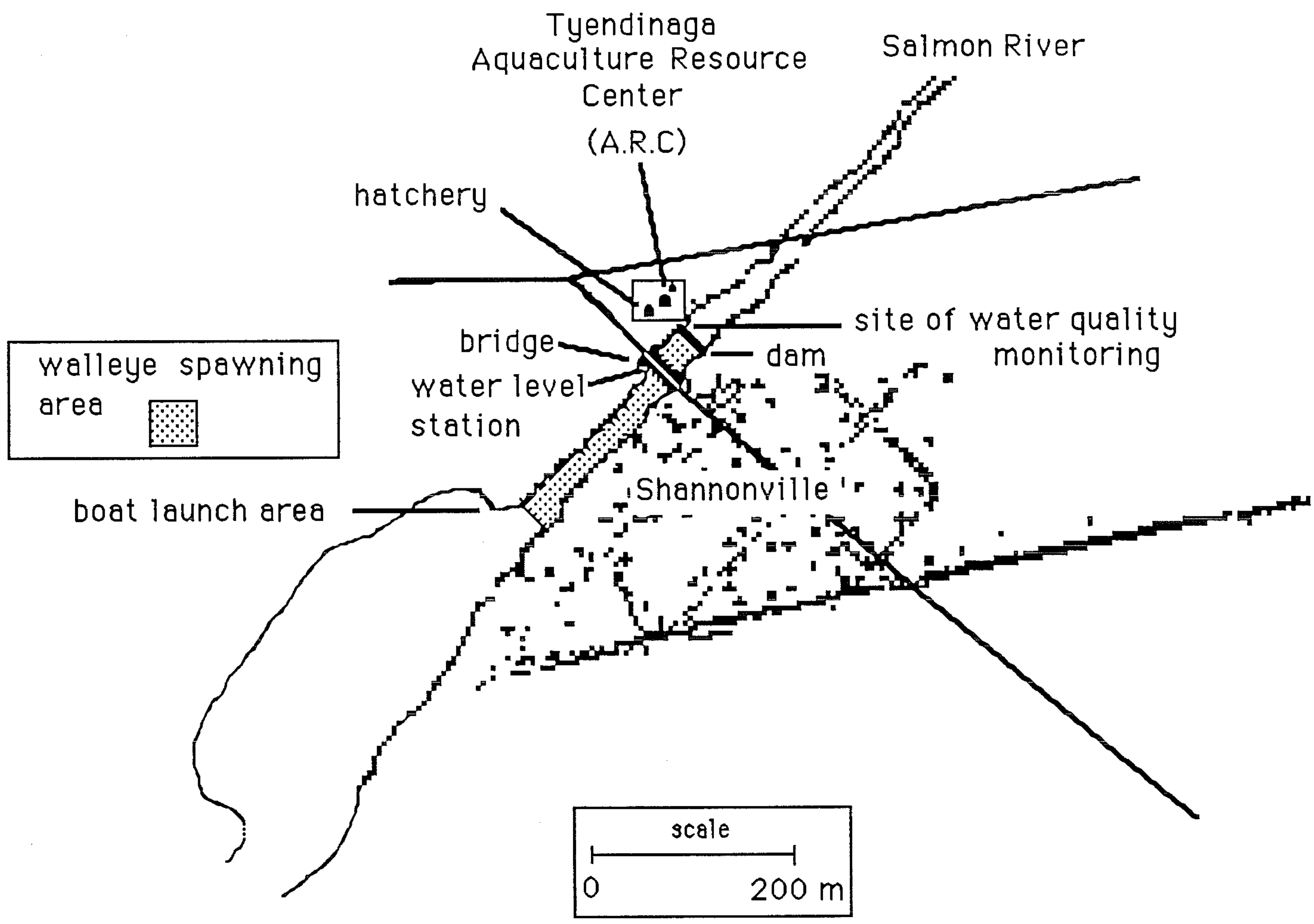


Figure 4. The Salmon River walleye spawning area is located between the Shannonville dam and the boat launch area, 260 meters down river.

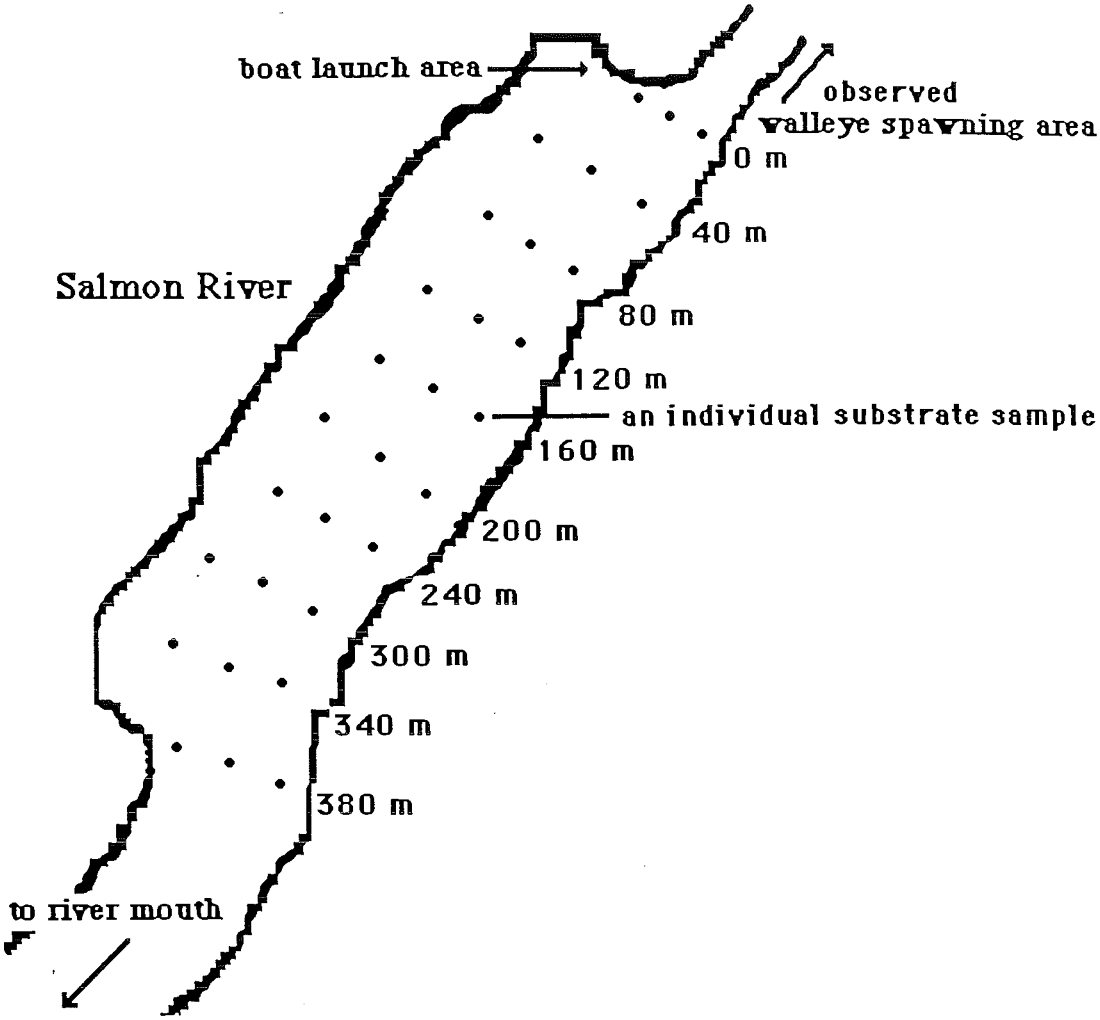


Figure 5. Location of 30 sample sites down river of the boat launch area where depth and substrate quality were assessed to confirm the lower extent of the walleye spawning area in the Salmon River.

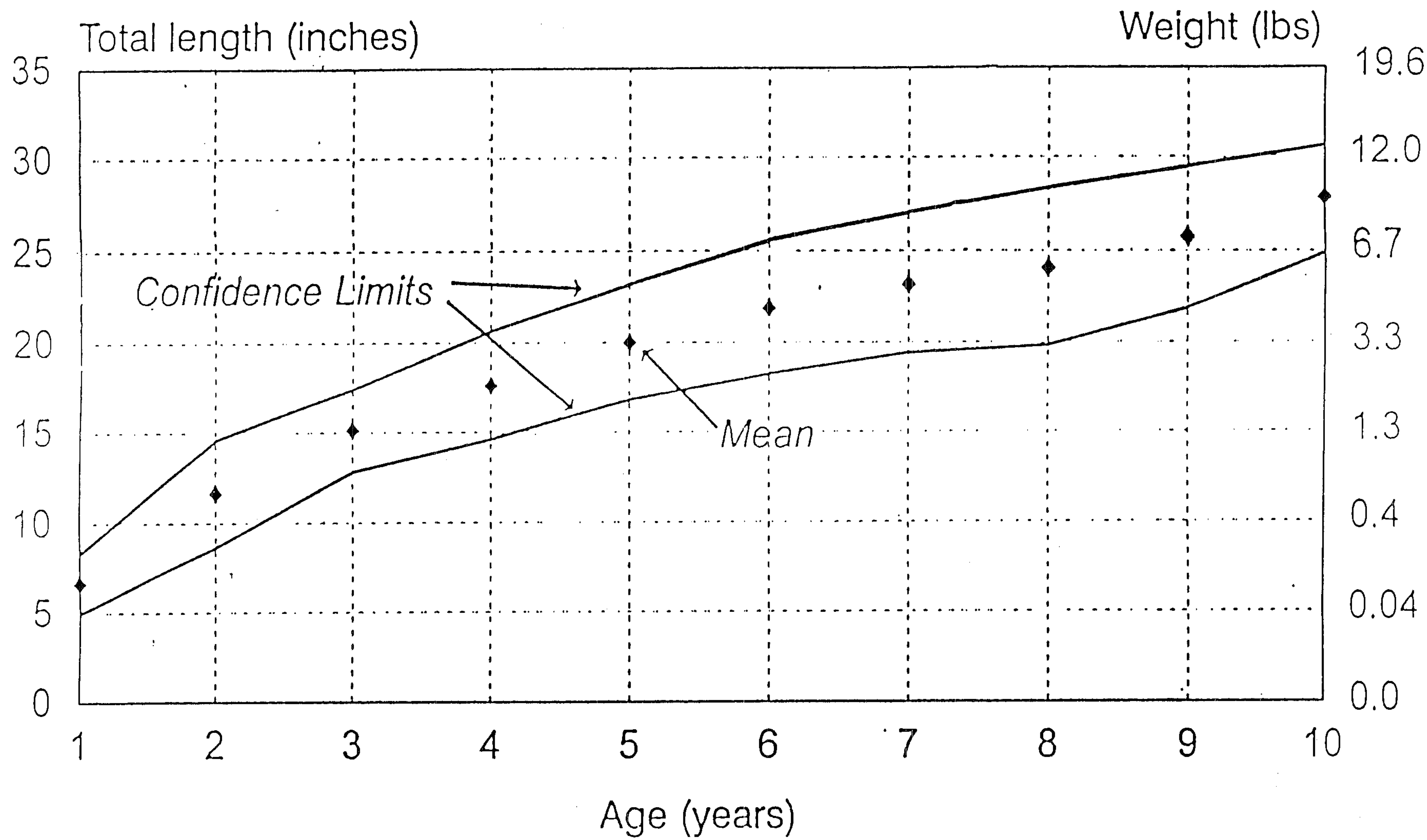


Figure 6. Length - age relationship for walleye in the Bay of Quinte showing mean and upper and lower (95%) confidence limits (OMNR 1993).

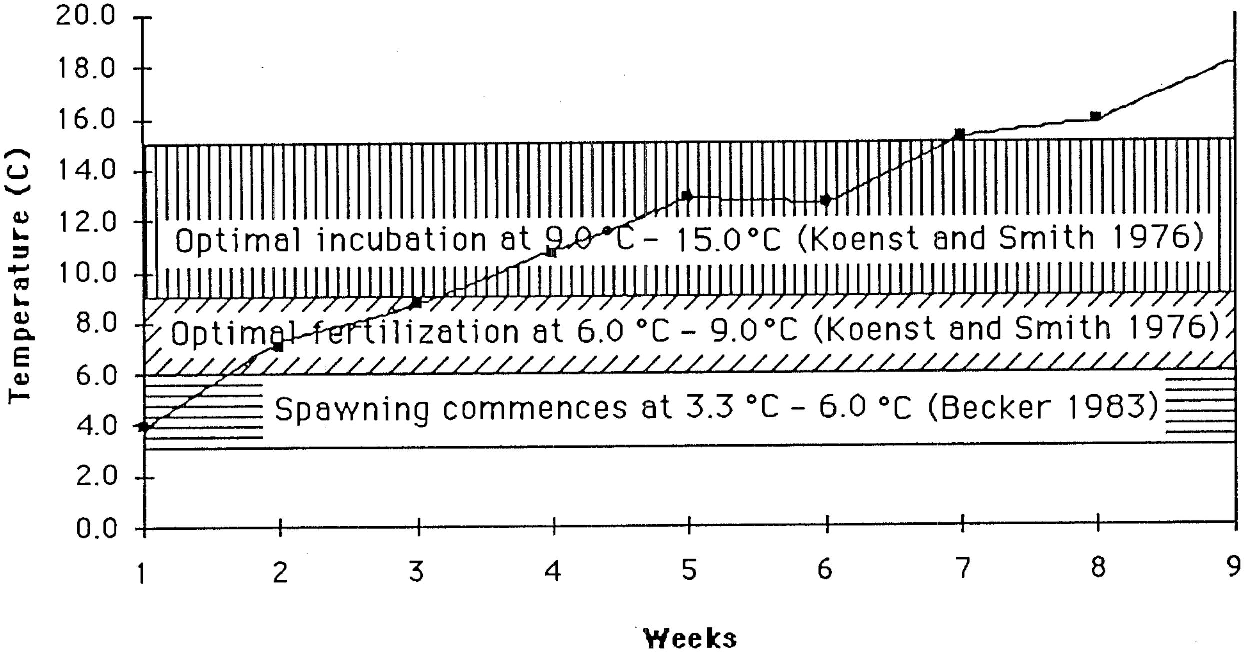


Figure 7. Mean weekly water temperature for the Salmon River between 5 April and 1 June 1994.

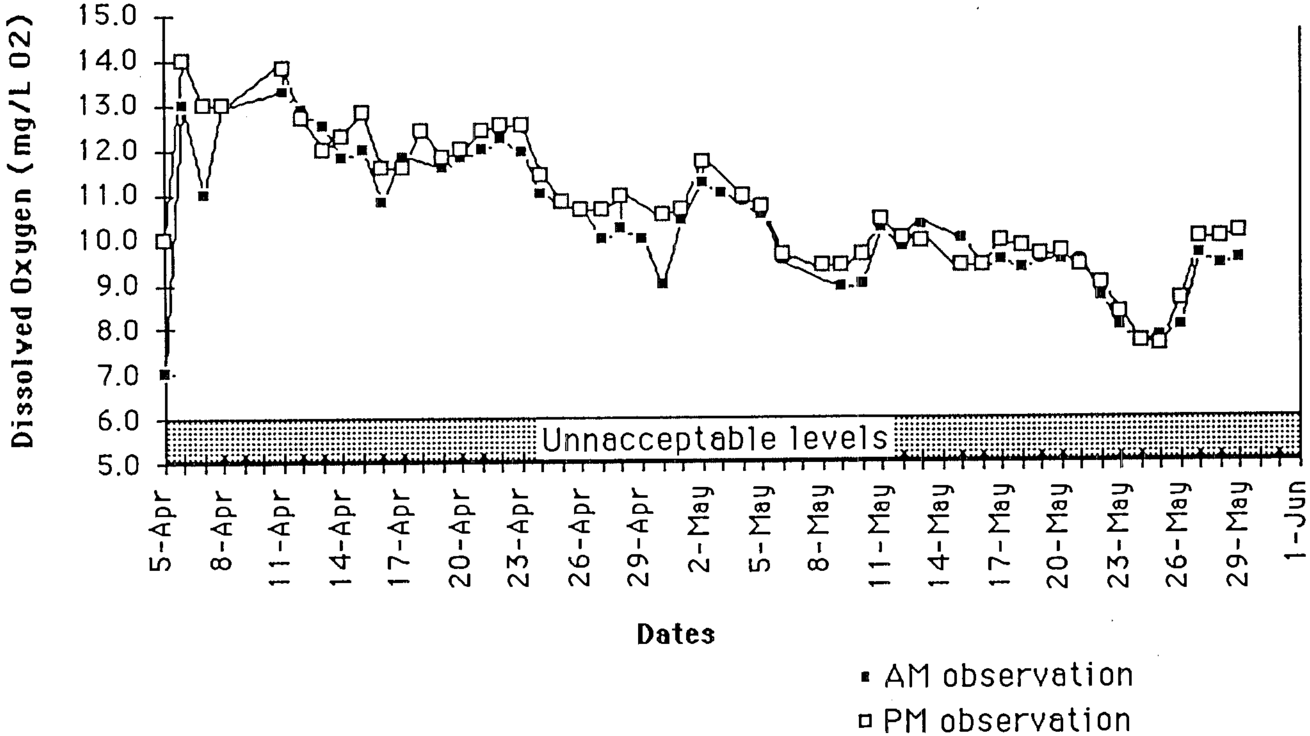


Figure 8. Daily dissolved oxygen levels for the Salmon River between 5 April and 1 June 1994 (n = 52).

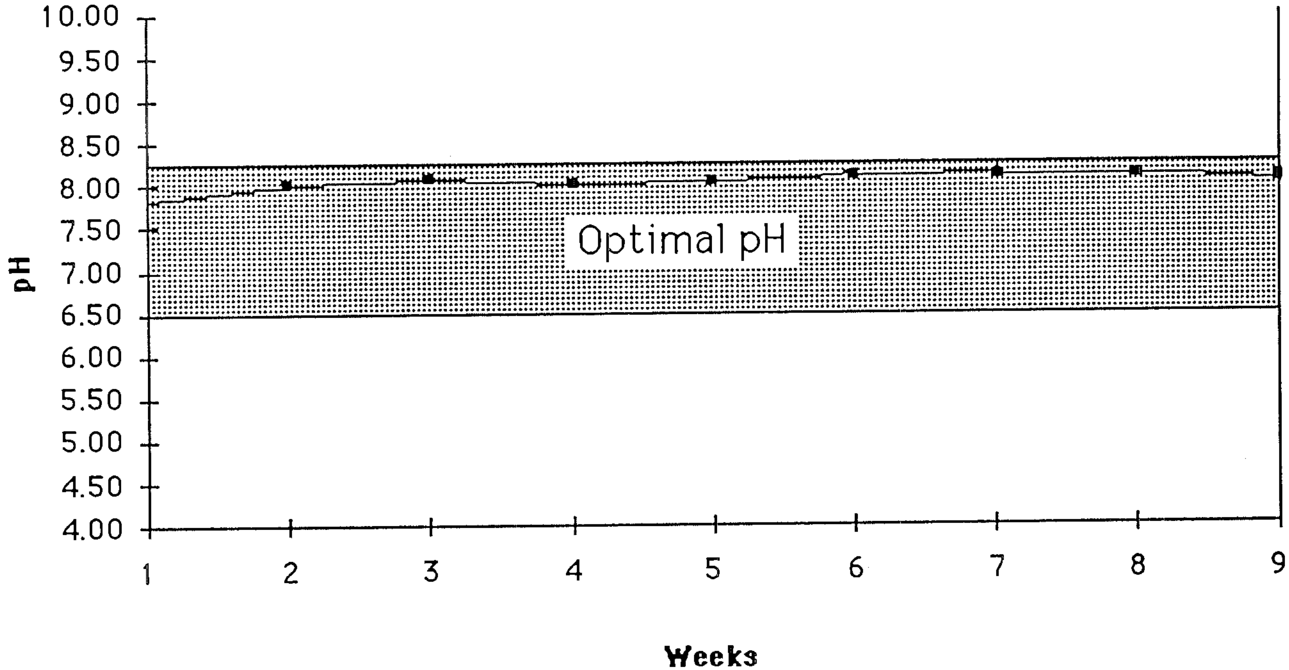


Figure 9. Mean weekly pH for the Salmon River between 5 April and 1 June 1994 (n = 17).

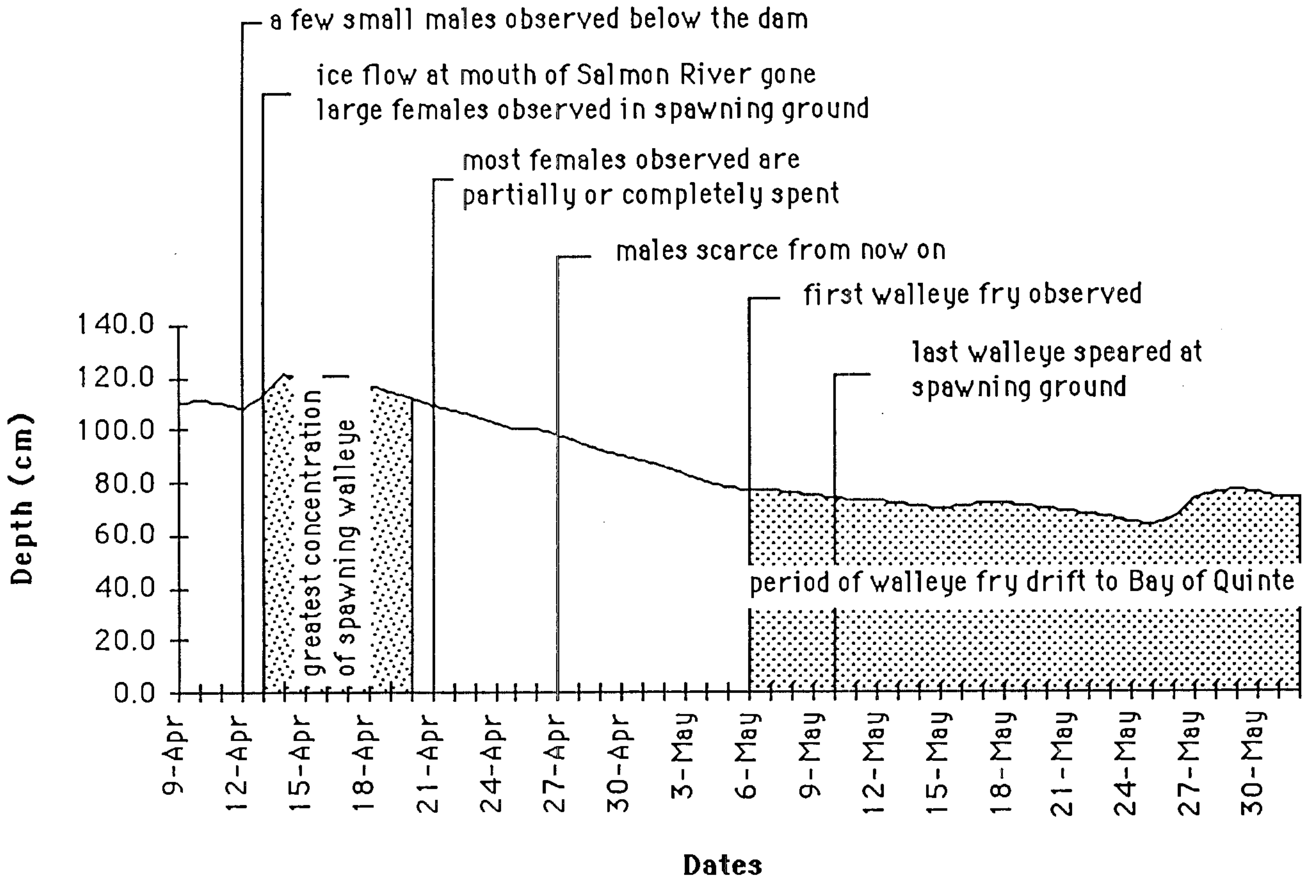


Figure 10. Change in depth of the Salmon River observed at reference point under the Shannonville bridge between 9 April and 1 June 1994 (n = 54).

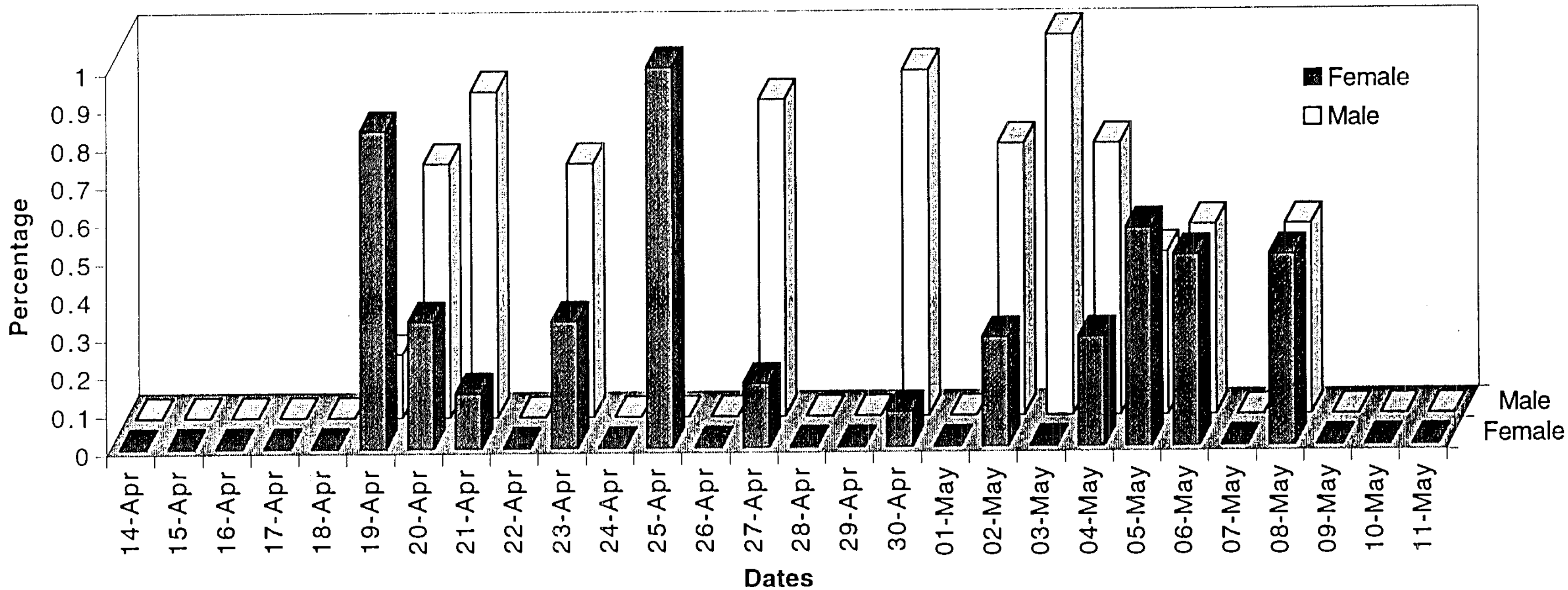


Figure 11. Sex composition by day of walleye caught in hoop nets at the Salmon River mouth between 14 April and 11 May 1994 (n = 71).

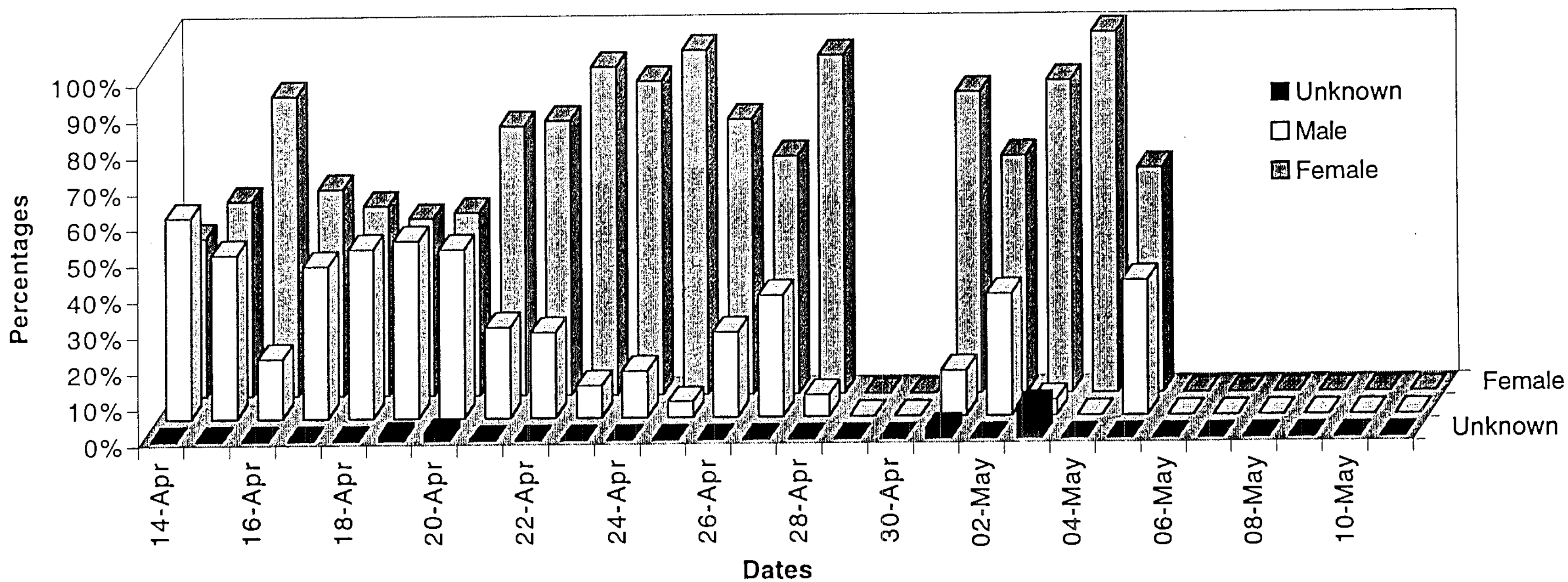


Figure 12. Sex composition by day of walleye speared at the Salmon River spawning area between 14 April and 11 May 1994 (n = 809, no observations made after 5 May.)

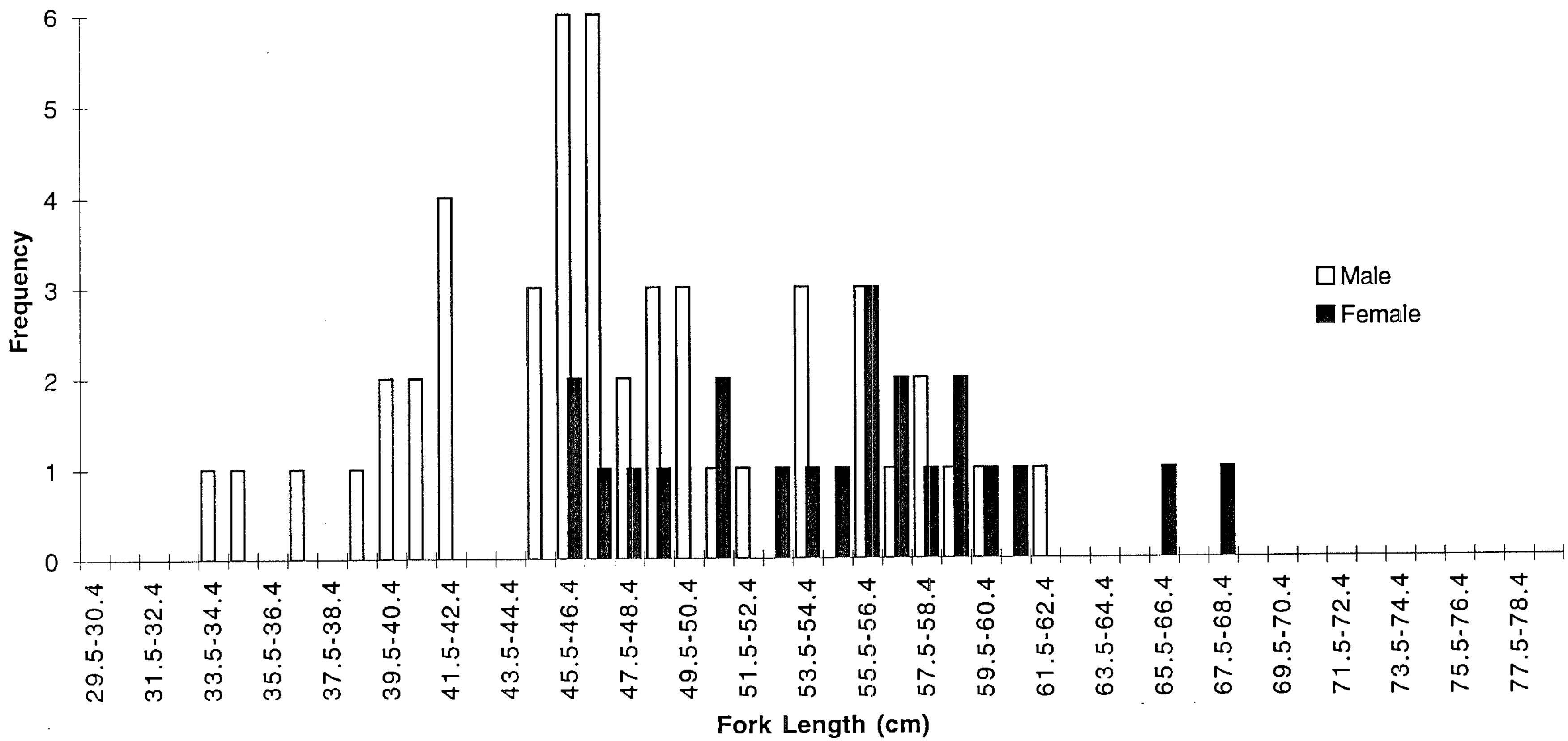


Figure 13. Fork length frequencies of walleye caught by hoop nets set at the Salmon River mouth between 18 April and 13 May 1994 (n = 71).

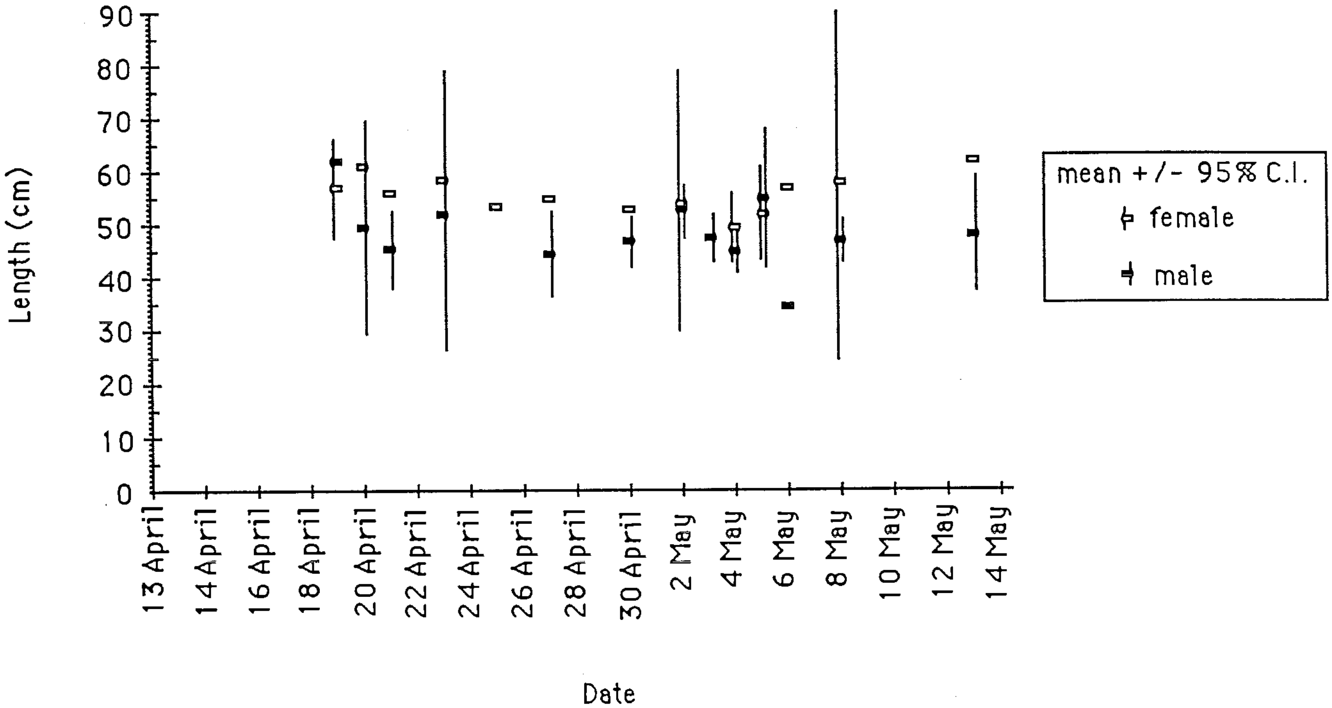


Figure 14. Mean daily fork length of male and female walleye captured at the Salmon River mouth between 14 April and 13 May 1994 (n = 71).

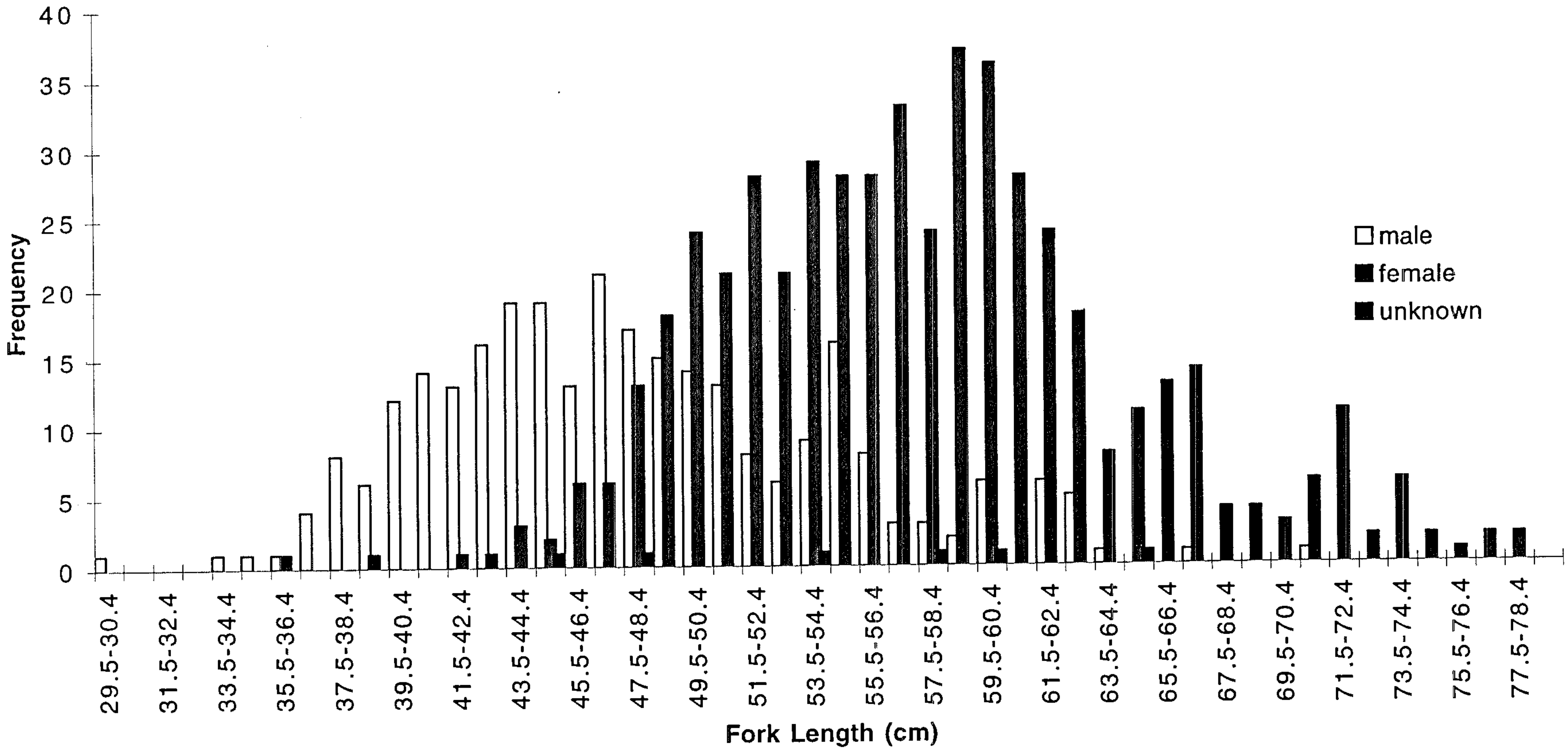


Figure 15. Fork length frequencies of walleye speared at the Salmon River spawning area between 14 April and 11 May 1994 (n = 809).

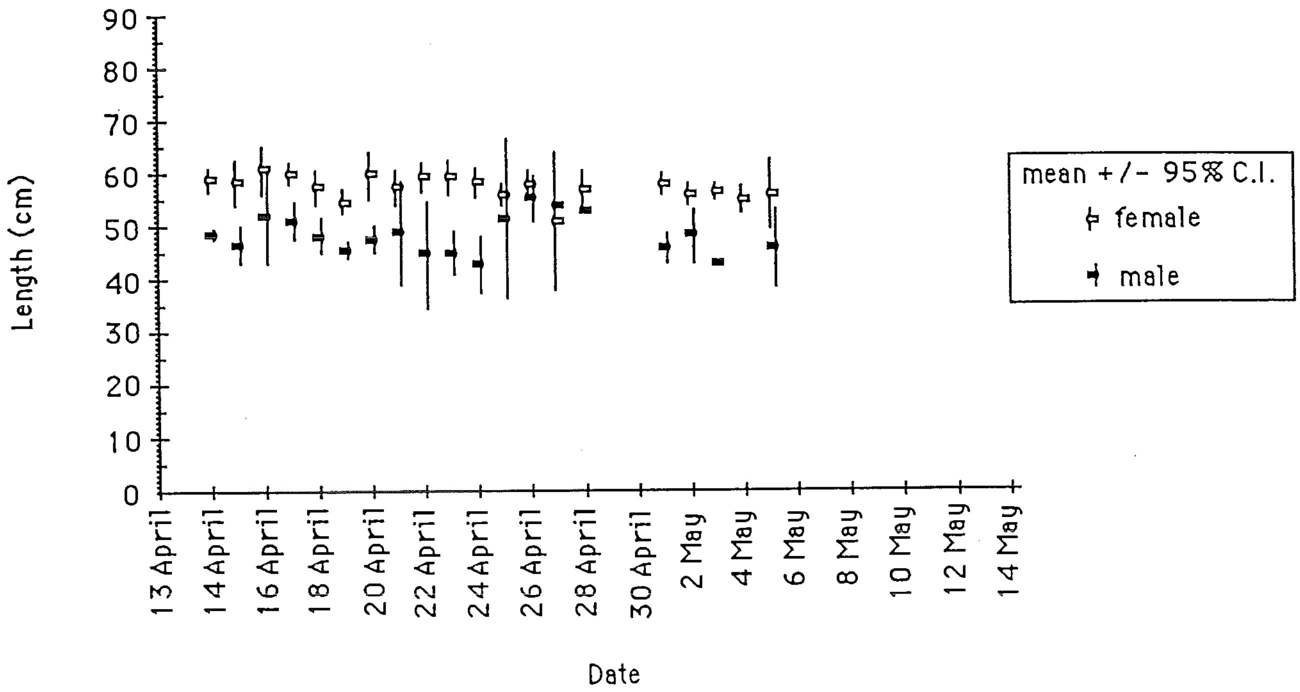
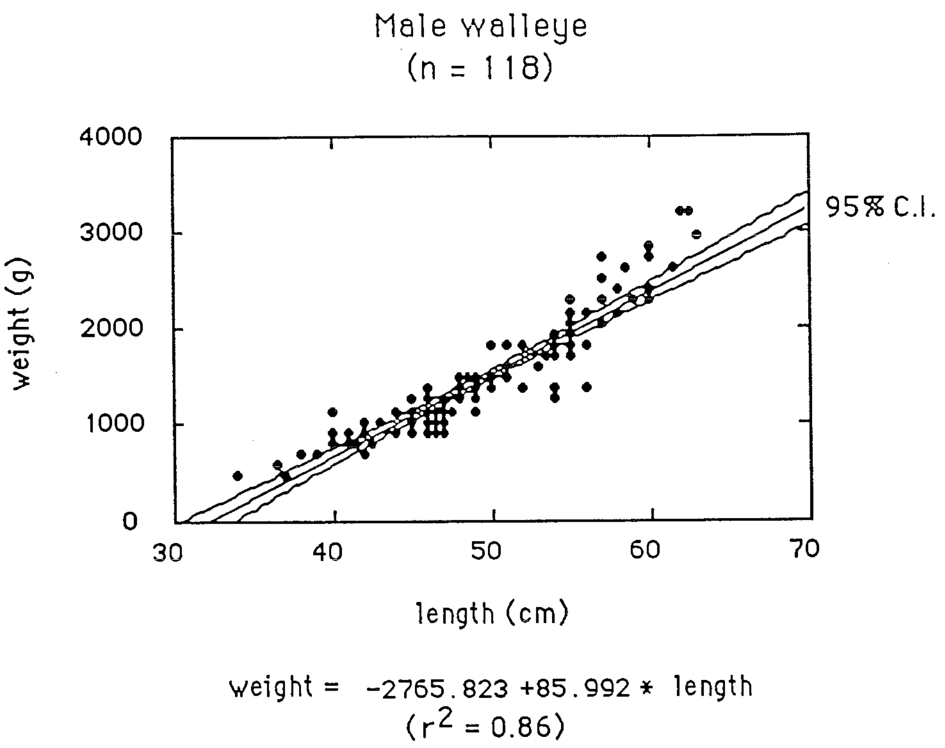


Figure 16. Mean daily fork length of male and female walleye speared at the Salmon River spawning area between 14 April and 13 May 1994 (n = 803).



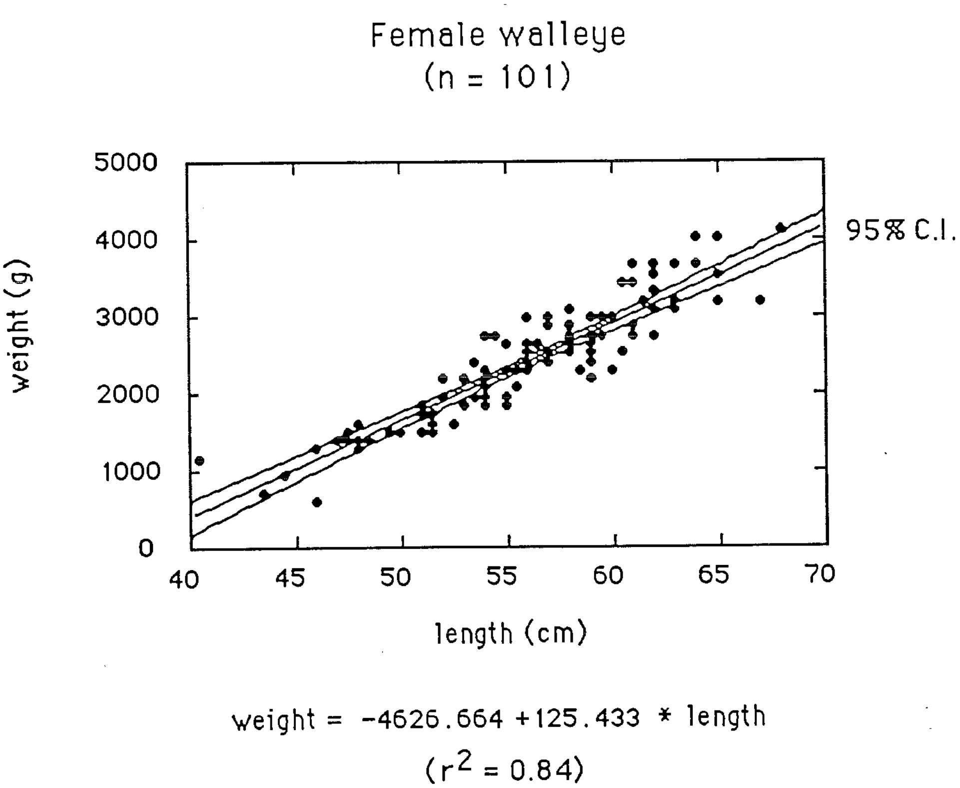


Figure 17. Length - weight relationship of male and female walleye observed from the Salmon River between 14 April and 13 May 1994.

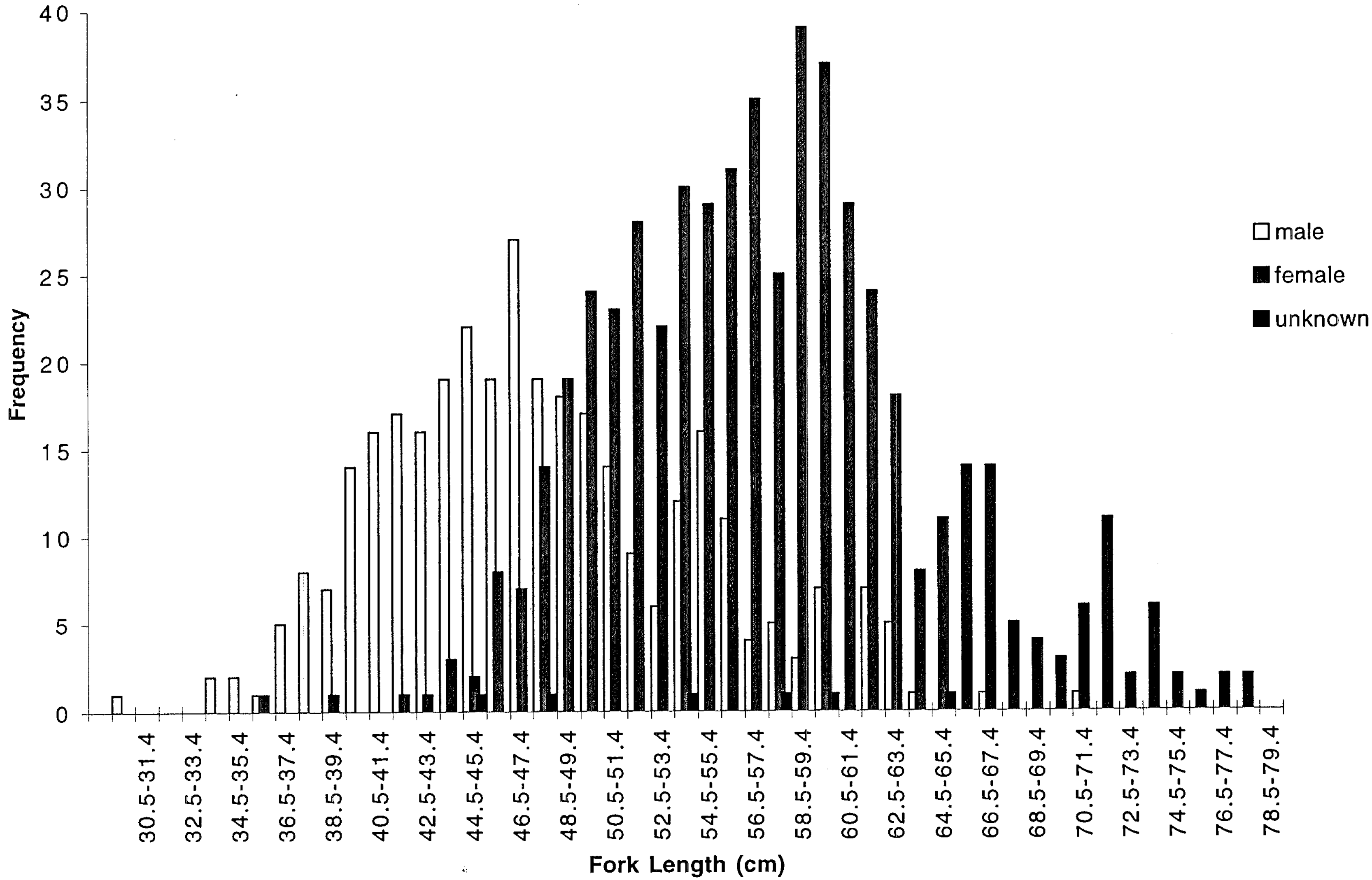


Figure 18. Fork length frequencies of all walleye caught and observed from the Salmon River between 14 April and 13 May 1994 (n = 880).

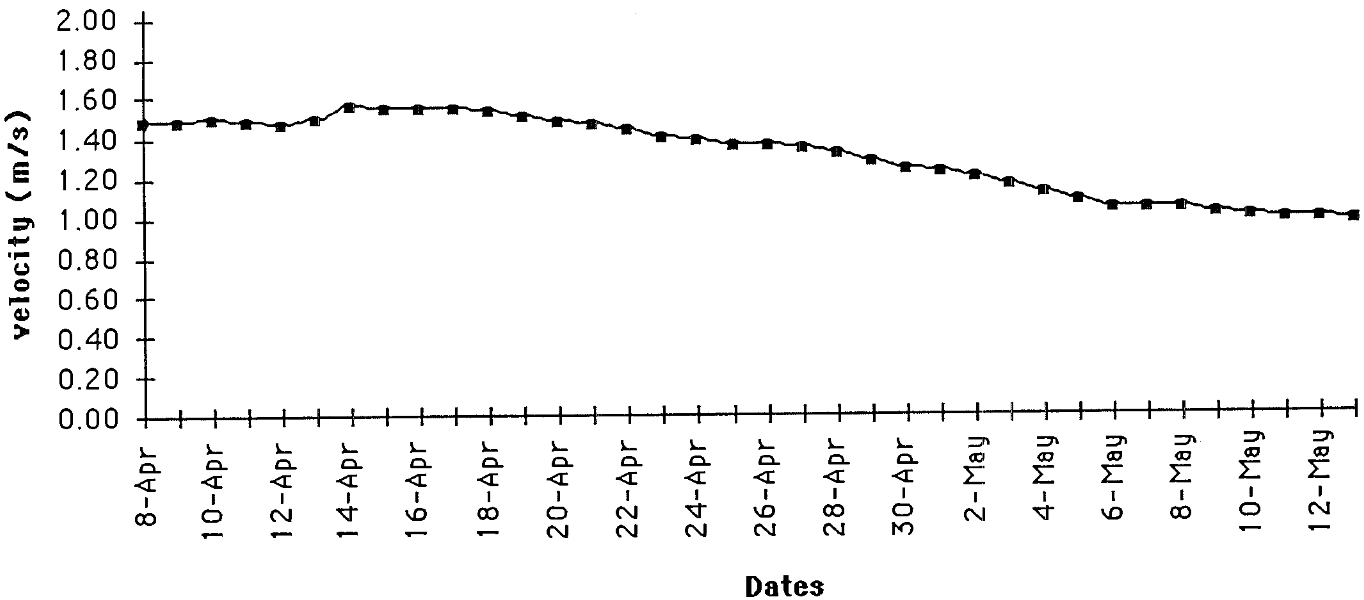
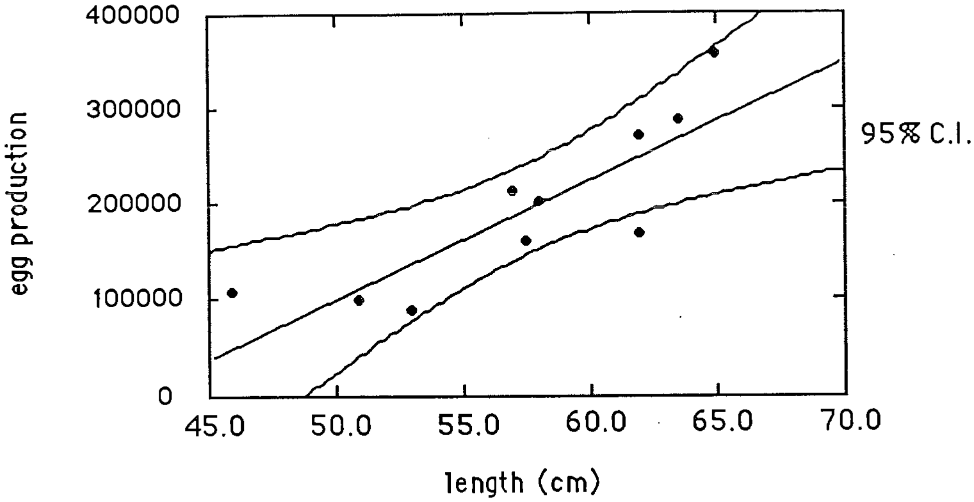
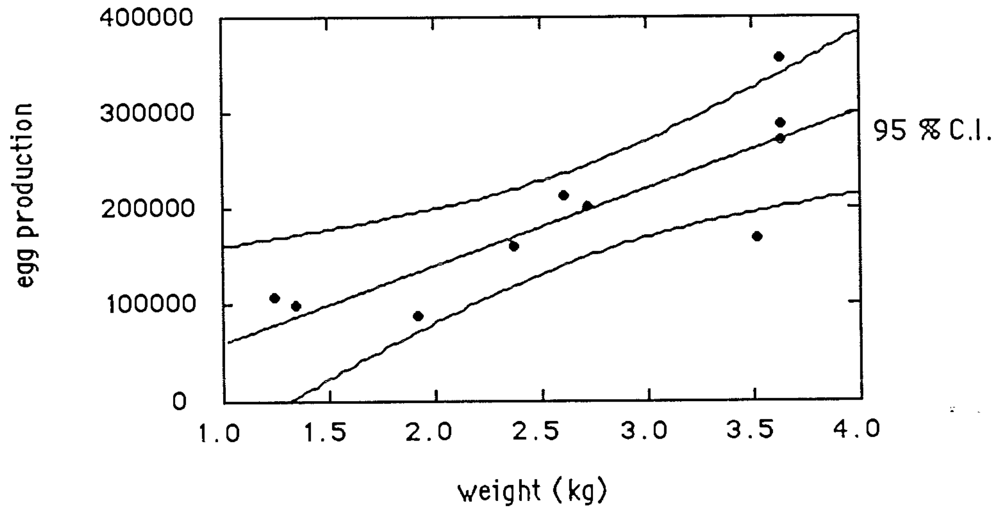


Figure 19. Estimated velocity of the Salmon River under Shannonville bridge between 8 April and 13 May 1994.



egg production = −520451.107+12427.444 * length

($r^2 = 0.72$)



egg production = −19748.709+80223.409 * weight

($r^2 = 0.68$)

Figure 20. Relationships of both length and weight of 10 female walleye to the numbers of eggs produced.

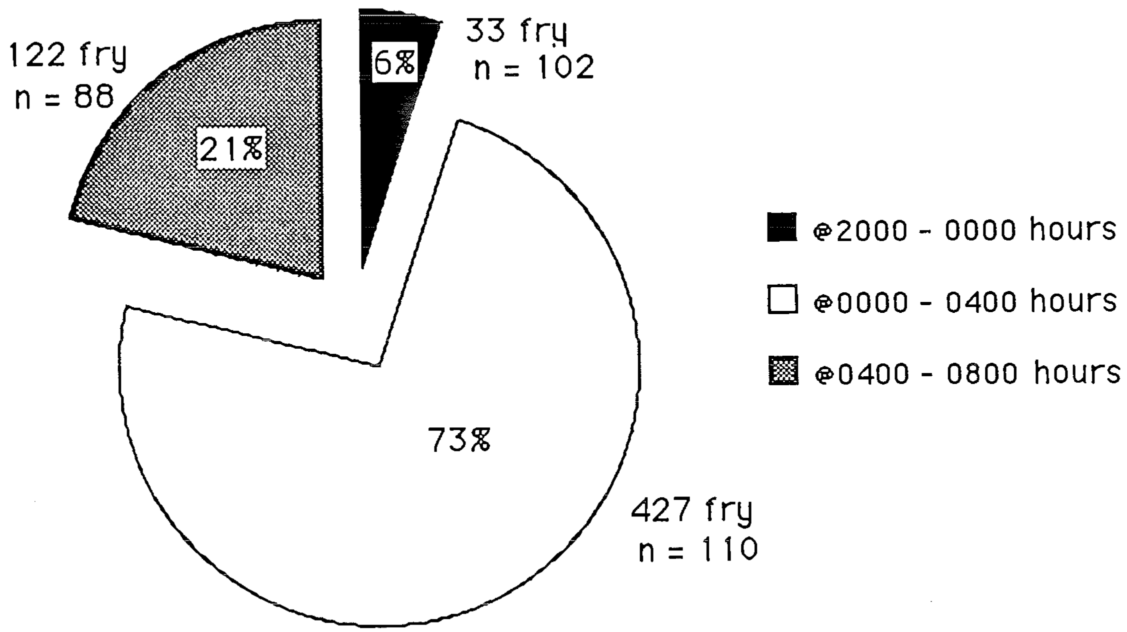


Figure 21. Percentage distribution of walleye fry caught during three, 4 hour periods from dusk (@2000 hours) to dawn (@0800 hours) between 8 May and 3 June 1994.

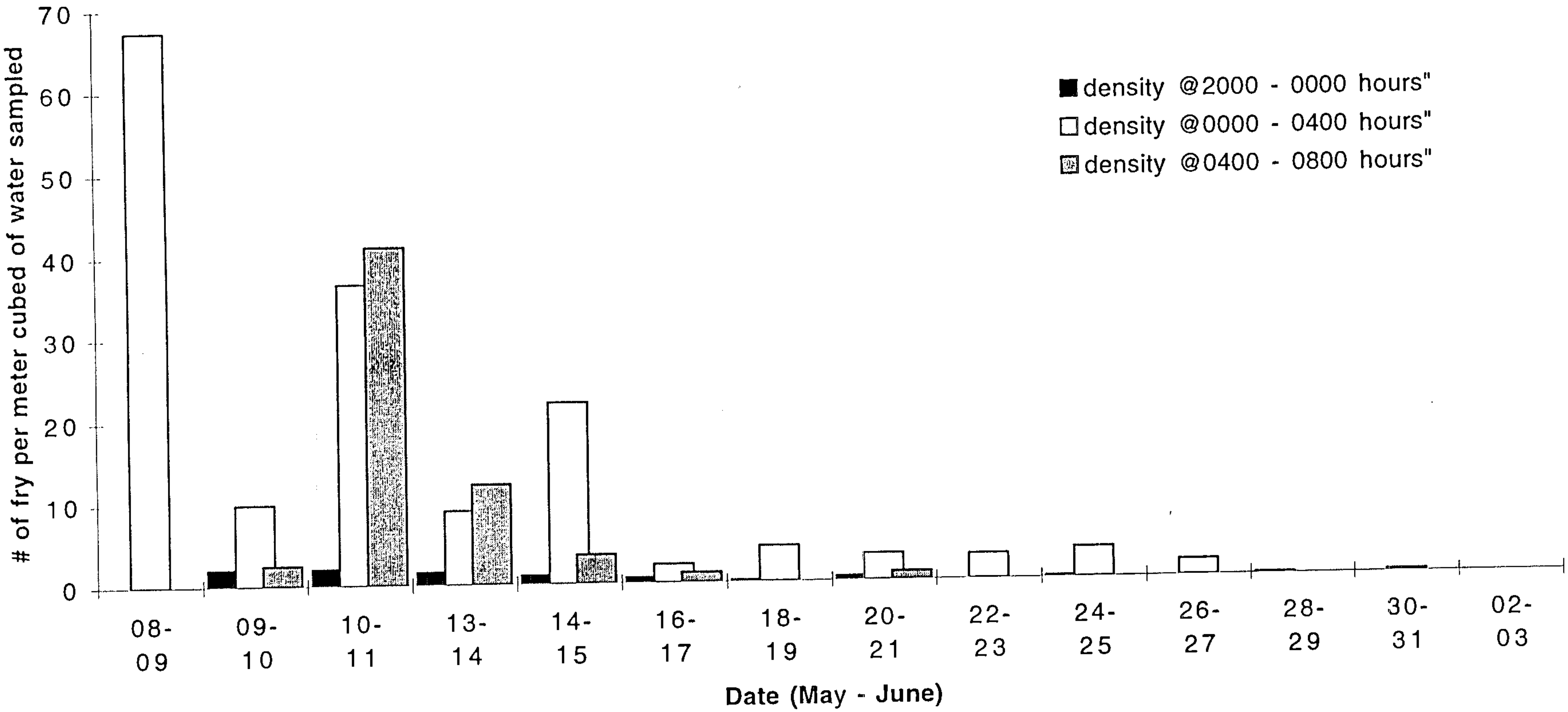


Figure 22. Walleye fry density computed from samples collected in drift near the mouth of the Salmon River between 8 May and 3 June 1994.

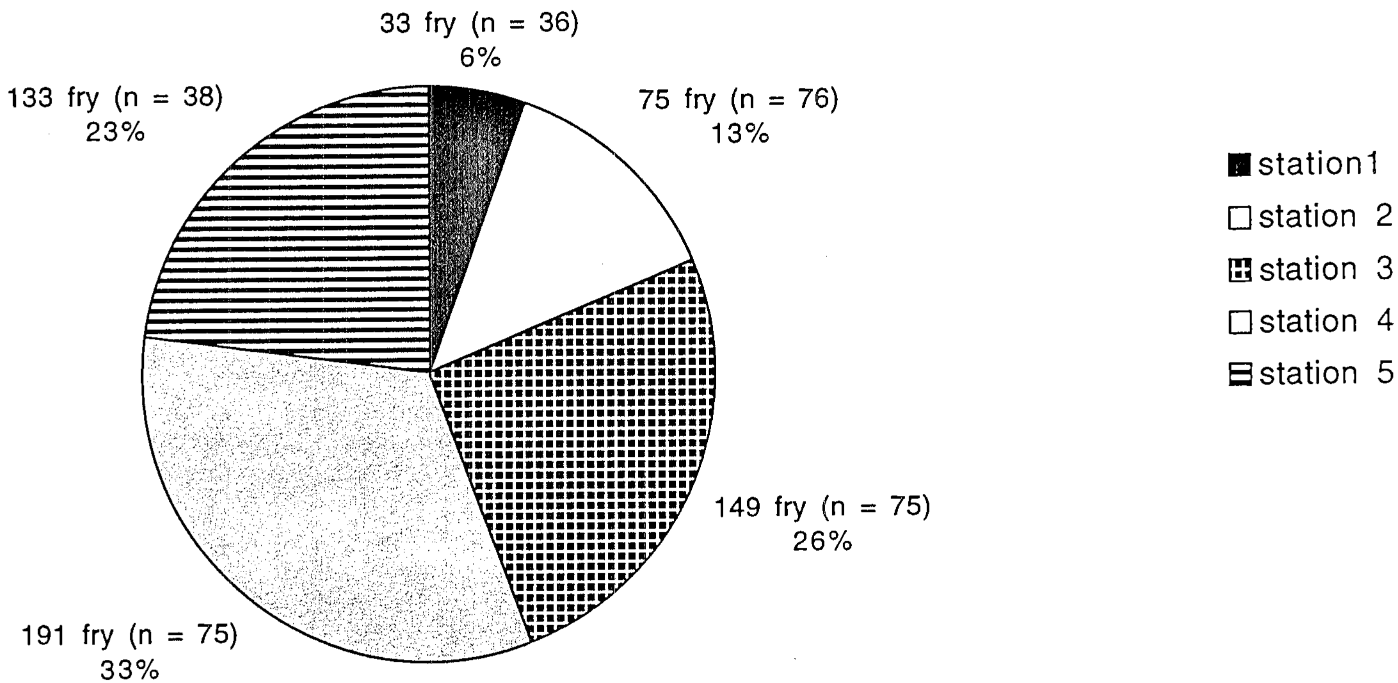


Figure 23. Distribution of walleye fry caught at five sampling stations located 10 m apart along a 60 m transect, samples collected nightly from dusk (@2000 hours) to dawn (@0800 hours) between 8 May and 3 June 1994.

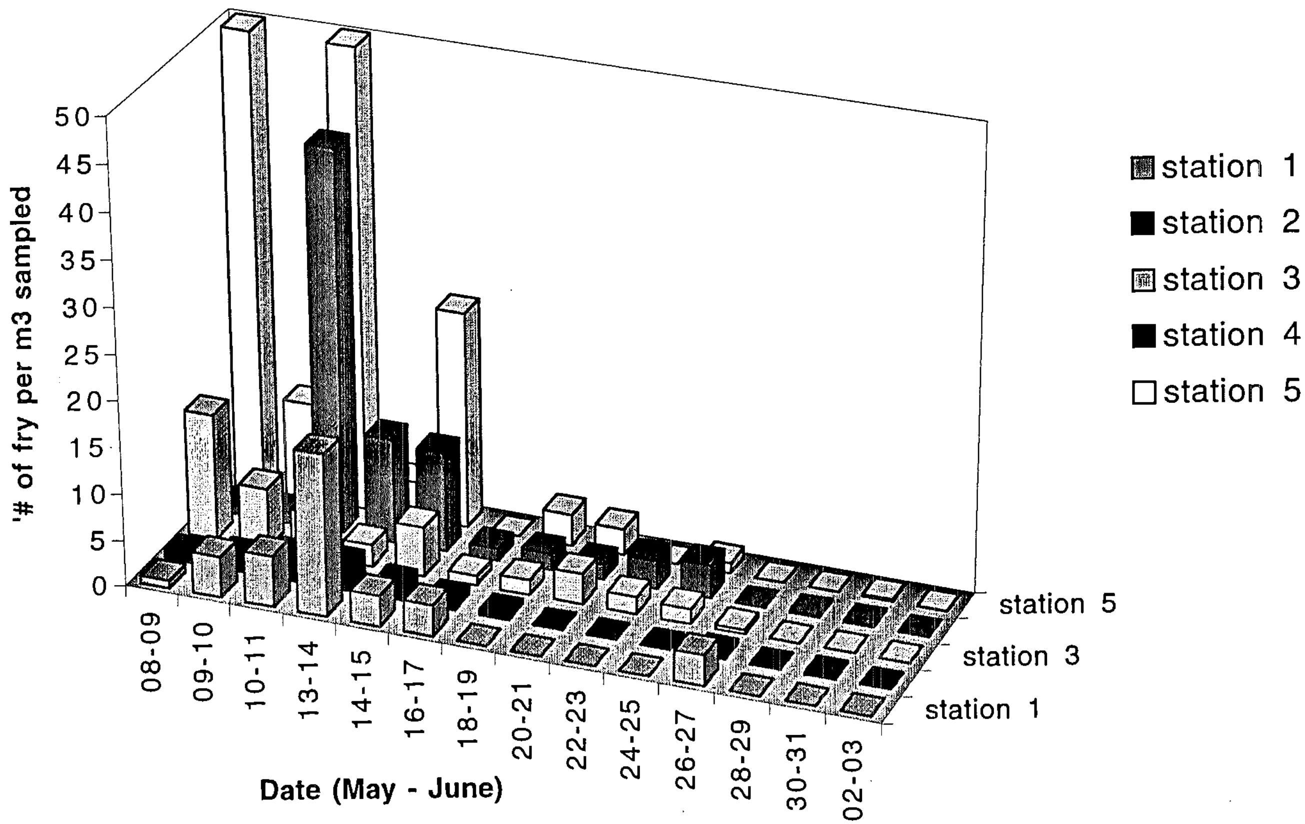


Figure 24. Walleye fry density by day at five sampling stations near the mouth of the Salmon River between 8 May and 3 June 1994.

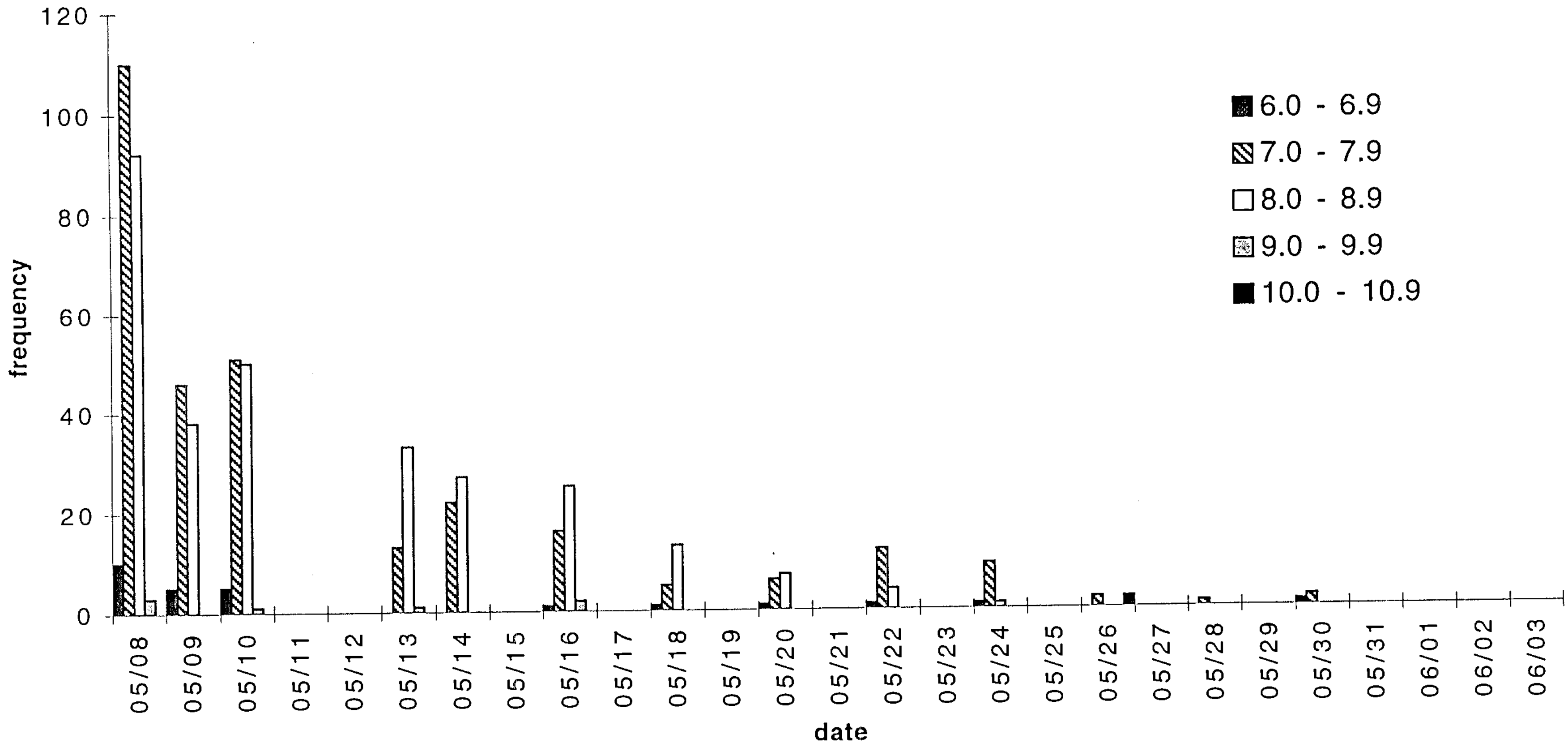


Figure 25. Length frequency of walleye fry by date collected from the Salmon River between 8 May and 3 June 1994.

Annex 1. Tyendinaga Band Counselors present during a presentation of walleye spawning study proposal by Mr. Gordon J. Mengel to R. Donald Maracle, Chief of the Mohawk's of the Bay of Quinte, in February, 1994.

Counselors

Douglas Maracle

Donald Smart

Willard Hill

Willard Brant

Tyendinaga community members that provided direct assistance in field activities.

Aquaculture Team Members

Jonathan Cummings

Donald Green

Sam Brant

Victor Brant

Scott Maracle

Ron Hill

Fish Wardens

Scott Brant

Greg General

James Maracle

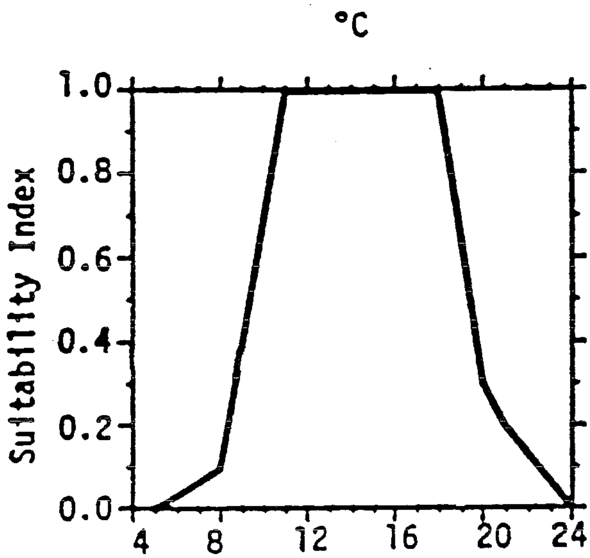
Francis Maracle

Chris Maracle

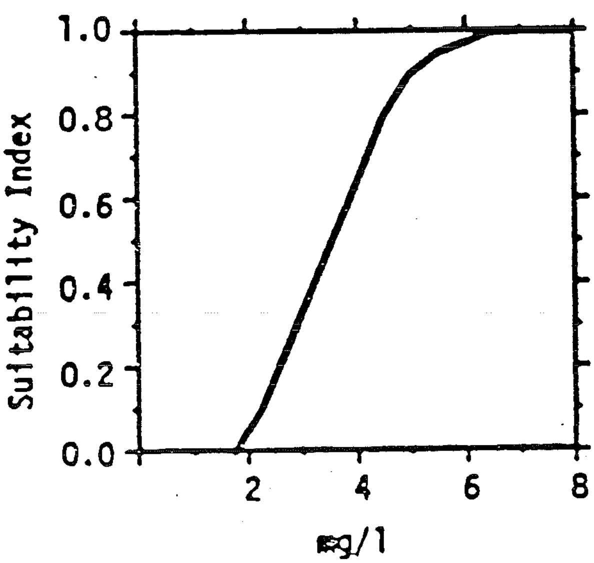
Manson Maracle

Annex 2. Suitability Indices used to assess walleye spawning habitat in the Salmon River during Spring, 1994. (McMahon et al. 1984)

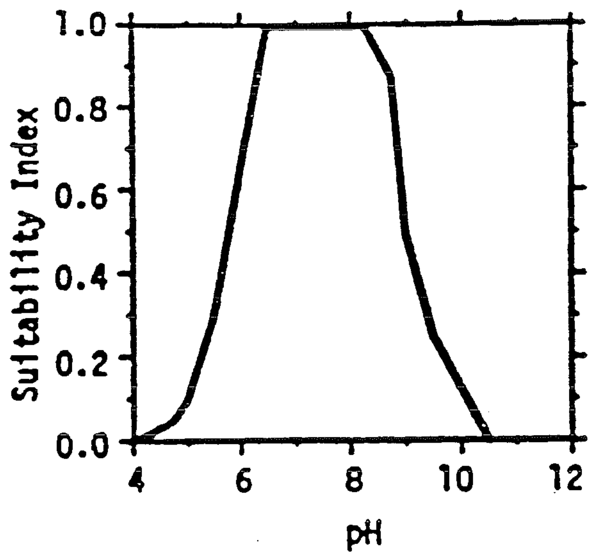
Suitability Index for mean weekly water temperature during spawning and egg development to fry.



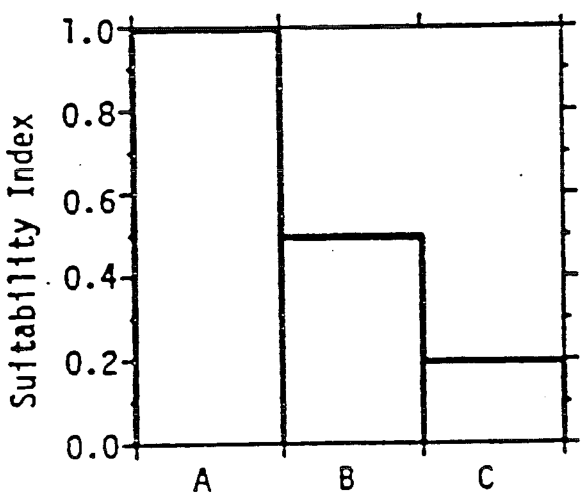
Suitability Index for minimum dissolved oxygen level during egg development to fry.



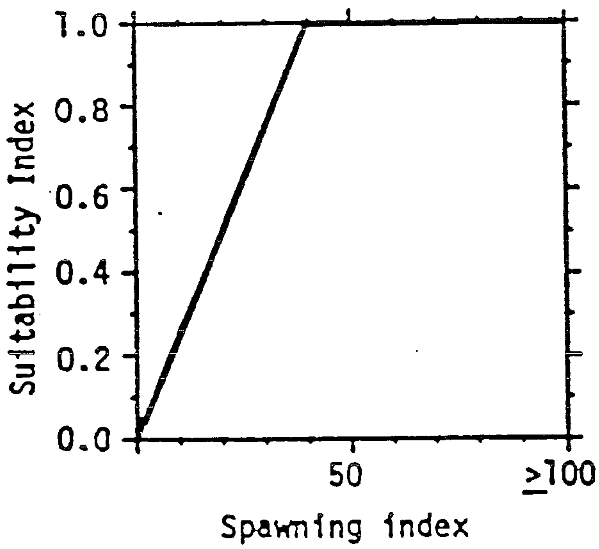
Suitability Index for least suitable pH during spawning and egg development to fry.



Suitability Index for water level during spawning and egg development to fry.



Suitability Index for habitat (habitat index) during spawning and egg development to fry.



Annex 3. Water temperature (°C) of the Salmon River at the spawning area from 5 April to 3 June 1994. Water temperature monitored each morning between 0700 and 0900 hours and each evening between 1600 and 1800 hours.

date	temperature AM	temperature PM	daily mean temperature	daily temperature units (T.U.)
05-Apr	2.1	2.9	2.5	2.5
06-Apr	2.6	2.4	2.5	2.5
07-Apr	1.2	2.6	1.9	1.9
08-Apr	2.6	2.6	2.6	2.6
09-Apr	5.0	7.0	6.0	6.0
10-Apr	5.0	7.0	6.0	6.0
11-Apr	6.0	7.5	6.8	6.8
12-Apr	6.0	6.8	6.4	6.4
13-Apr	6.5	6.8	6.7	6.7
14-Apr	6.0	7.2	6.6	6.6
15-Apr	5.9	8.0	7.0	7.0
16-Apr	9.0	10.0	9.5	9.5
17-Apr	8.0	8.0	8.0	8.0
18-Apr	-	7.8	7.8	7.8
19-Apr	8.5	10.0	9.3	9.3
20-Apr	7.6	8.5	8.1	8.1
21-Apr	7.0	8.0	7.5	7.5
22-Apr	6.1	7.5	6.8	6.8
23-Apr	7.0	8.0	7.5	7.5
24-Apr	9.1	12.0	10.6	10.6
25-Apr	11.0	11.0	11.0	11.0
26-Apr	10.2	10.5	10.4	10.4
27-Apr	11.0	13.0	12.0	12.0
28-Apr	10.5	11.9	11.2	11.2
29-Apr	10.9	-	10.9	10.9
30-Apr	11.0	11.0	11.0	11.0
01-May	10.1	10.1	10.1	10.1
02-May	9.5	10.1	9.8	9.8
03-May	9.5	-	9.5	9.5
04-May	10.5	12.5	11.5	11.5
05-May	12.9	13.5	13.2	13.2
06-May	13.5	13.9	13.7	13.7
07-May	-	-	-	-
08-May	-	13.9	13.9	13.9
09-May	14.5	14.0	14.3	14.3
10-May	13.8	13.5	13.7	13.7
11-May	12.8	13.0	12.9	12.9
12-May	11.9	12.3	12.1	12.1
13-May	10.9	13.1	12.0	12.0
14-May	-	-	-	-
15-May	11.2	14.2	12.7	12.7
16-May	11.4	13.2	12.3	12.3
17-May	12.6	13.5	13.1	13.1
18-May	13.6	13.0	13.3	13.3
19-May	13.7	14.3	14.0	14.0
20-May	13.5	14.5	14.0	14.0
21-May	13.0	16.8	14.9	14.9
22-May	17.0	18.0	17.5	17.5
23-May	19.5	19.5	19.5	19.5
24-May	19.5	20.0	19.8	19.8
25-May	19.5	19.0	19.3	19.3
26-May	17.5	15.0	16.3	16.3
27-May	12.5	14.5	13.5	13.5
28-May	13.2	12.5	12.9	12.9
29-May	13.0	14.5	13.8	13.8
30-May	-	-	-	-
31-May	-	-	-	-
01-Jun	18.0	18.2	18.1	18.1
02-Jun	-	-	-	-
03-Jun	-	-	-	-

Annex 4. Dissolved oxygen levels (mg/L O2) at the Salmon River spawning site from 5 April to 3 June 1994. Dissolved oxygen monitored each morning between 0700 and 0900 hours and each evening between 1600 and 1800 hours.

	dissolved oxygen (mg/L O2)	
date	AM	PM
05-Apr	7.0	10.0
06-Apr	13.0	14.0
07-Apr	11.0	13.0
08-Apr	13.0	13.0
09-Apr	14.2	14.0
10-Apr	12.2	12.5
11-Apr	13.3	13.8
12-Apr	12.9	12.7
13-Apr	12.5	12.0
14-Apr	11.8	12.3
15-Apr	12.0	12.8
16-Apr	10.8	11.6
17-Apr	11.8	11.6
18-Apr	-	12.4
19-Apr	11.6	11.8
20-Apr	11.8	12.0
21-Apr	12.0	12.4
22-Apr	12.2	12.5
23-Apr	11.9	12.5
24-Apr	11.0	11.4
25-Apr	10.8	10.8
26-Apr	10.6	10.6
27-Apr	10.0	10.6
28-Apr	10.2	10.9
29-Apr	10.0	-
30-Apr	9.0	10.5
01-May	10.4	10.6
02-May	11.2	11.7
03-May	11.0	-
04-May	10.8	10.9
05-May	10.5	10.7
06-May	9.5	9.6
07-May	-	-
08-May	-	9.4
09-May	8.9	9.4
10-May	9.0	9.6
11-May	10.2	10.4
12-May	9.8	10.0
13-May	10.3	9.9
14-May	-	-
15-May	10.0	9.4
16-May	9.3	9.4
17-May	9.5	9.9
18-May	9.3	9.8
19-May	9.5	9.6
20-May	9.5	9.7
21-May	9.5	9.4
22-May	8.7	9.0
23-May	8.0	8.3
24-May	7.7	7.7
25-May	7.8	7.6
26-May	8.0	8.6
27-May	9.6	10.0
28-May	9.4	10.0
29-May	9.5	10.1
30-May	-	-
31-May	-	-
01-Jun	8.1	8.8
02-Jun	-	-
03-Jun	-	-

Annex 5. Water pH at the Salmon River spawning site from 5 April to 1 June 1994. The pH was monitored twice weekly during the first four weeks and once weekly during the last five weeks (n = 17 observations).

date	pH
05-Apr	-
06-Apr	-
07-Apr	-
08-Apr	-
09-Apr	7.50
10-Apr	7.95
11-Apr	8.02
12-Apr	-
13-Apr	8.04
14-Apr	-
15-Apr	7.96
16-Apr	-
17-Apr	8.01
18-Apr	-
19-Apr	8.20
20-Apr	-
21-Apr	8.05
22-Apr	-
23-Apr	8.02
24-Apr	-
25-Apr	-
26-Apr	8.00
27-Apr	-
28-Apr	8.01
29-Apr	-
30-Apr	8.03
01-May	-
02-May	-
03-May	-
04-May	8.05
05-May	-
06-May	-
07-May	-
08-May	-
09-May	-
10-May	-
11-May	-
12-May	8.10
13-May	-
14-May	-
15-May	-
16-May	-
17-May	-
18-May	-
19-May	-
20-May	-
21-May	-
22-May	8.13
23-May	-
24-May	8.14
25-May	-
26-May	-
27-May	-
28-May	-
29-May	-
30-May	-
31-May	-
01-Jun	8.04
02-Jun	-
03-Jun	-

Annex 6. Tag numbers given individual walleye captured with hoop nets at the Salmon River mouth between 18 April and 8 May 1994. Days when nets were not checked represented by " - ".

date	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr	01-May	02-May	03-May	04-May	05-May	06-May	07-May	08-May	Totals
male	298	293	290	-	283	-			280	-	-	274	-	263	256	249	239	235	-	232	49
		292	289		282				279			273		262	255	248	237			230	
			288						278			272		261	254	247	236				
			287						276			270		259	253	246					
			286						275			269		257	252	244					
			285									268			251						
												267			250						
												266									
												265									
												264									
female	300	294	291	-	284	-	281		277	-	-	271	-	260		245	242	234	-	233	22
	299													259		243	241			231	
	297																240				
	296																238				
	295																				
Totals	6	3	7	-	3	-	1	0	6	-	-	11	-	7	7	7	7	2	-	4	71

Annex 7. Sex composition of walleye speared at the Salmon River spawning area between 14 April and 11 May 1994 based on information presented in the 1994 Tyendinaga Pickerel Season report* (Maracle 1994) and observations of sex composition of speared fish at the Salmon River spawning ground (n = 809 or 24% of total catch, no observations were made after 05 May).

No observations were recorded on days noted with **.
(Percentages and numbers of male, female, and unknown sex walleye estimated based on overall percentages and numbers.)

Date	Walleye observed (n)	Observed sex ratio (male : female)	Daily number of walleye caught with spears at the spawning ground *	Percentage males in daily catch	Daily catch of male walleye at the spawning ground	Percentage females in daily catch	Daily catch of female walleye at the spawning ground	Percentage unknown sex in daily catch	Daily catch of walleye of undetermined sex
14-Apr	143	1:0.8	257	56%	144	44%	113	0%	0
15-Apr	48	1:1.2	300	46%	137	54%	163	0%	0
16-Apr	12	1:5.0	517	17%	86	83%	431	0%	0
17-Apr	73	1:1.4	403	42%	171	58%	232	0%	0
18-Apr	74	1:1.1	297	47%	140	53%	157	0%	0
19-Apr	79	1:1.0	259	49%	128	49%	128	1%	3
20-Apr	49	1:1.1	379	47%	178	51%	193	2%	8
21-Apr	16	1:3.0	115	25%	29	75%	86	0%	0
22-Apr	21	1:3.2	84	24%	20	76%	64	0%	0
23-Apr	22	1:10.0	45	9%	4	91%	41	0%	0
24-Apr	31	1:6.8	116	13%	15	87%	101	0%	0
25-Apr	49	1:23.5	92	4%	4	96%	88	0%	0
26-Apr	42	1:3.2	93	24%	22	76%	71	0%	0
27-Apr	3	1:2.0	77	34%	26	66%	51	0%	0
28-Apr	15	1:14.0	33	6%	2	94%	31	0%	0
29-Apr	**	-	**	-	-	-	-	-	-
30-Apr	**	-	**	-	-	-	-	-	-
01-May	31	1:6.5	110	13%	14	84%	92	3%	3
02-May	41	1:1.9	47	34%	16	66%	31	0%	0
03-May	30	1:26.0	45	4%	2	87%	39	9%	4
04-May	22	0:22	40	0%	0	100%	40	0%	0
05-May	8	1:1.7	48	38%	18	63%	30	0%	0
06-May	**	(1:1.9)	21	(34%)	7	(65%)	14	(1%)	0
07-May	**	(1:1.9)	15	(34%)	5	(65%)	10	(1%)	0
08-May	**	(1:1.9)	12	(34%)	4	(65%)	8	(1%)	0
09-May	**	(1:1.9)	6	(34%)	2	(65%)	4	(1%)	0
10-May	**	(1:1.9)	16	(34%)	5	(65%)	10	(1%)	0
11-May	**	(1:1.9)	0	(34%)	0	(65%)	0	(1%)	0
Totals	809	1:1.9	3427	34.4%	1180	65.0%	2228	0.5%	19

Annex 8. Fork length frequencies of walleye captured with hoop nets at the mouth of the Salmon River between 14 April and 13 May 1994.

Fork length (FL) (cm)	Male	Female	Sum
29.5-30.4	0	0	0
30.5-31.4	0	0	0
31.5-32.4	0	0	0
32.5-33.4	0	0	0
33.5-34.4	1	0	1
34.5-35.4	1	0	1
35.5-36.4	0	0	0
36.5-37.4	1	0	1
37.5-38.4	0	0	0
38.5-39.4	1	0	1
39.5-40.4	2	0	2
40.5-41.4	2	0	2
41.5-42.4	4	0	4
42.5-43.4	0	0	0
43.5-44.4	0	0	0
44.5-45.4	3	0	3
45.5-46.4	6	2	8
46.5-47.4	6	1	7
47.5-48.4	2	1	3
48.5-49.4	3	1	4
49.5-50.4	3	0	3
50.5-51.4	1	2	3
51.5-52.4	1	0	1
52.5-53.4	0	1	1
53.5-54.4	3	1	4
54.5-55.4	0	1	1
55.5-56.4	3	3	6
56.5-57.4	1	2	3
57.5-58.4	2	1	3
58.5-59.4	1	2	3
59.5-60.4	1	1	2
60.5-61.4	0	1	1
61.5-62.4	1	0	1
62.5-63.4	0	0	0
63.5-64.4	0	0	0
64.5-65.4	0	0	0
65.5-66.4	0	1	1
66.5-67.4	0	0	0
67.5-68.4	0	1	1
68.5-69.4	0	0	0
69.5-70.4	0	0	0
70.5-71.4	0	0	0
71.5-72.4	0	0	0
72.5-73.4	0	0	0
73.5-74.4	0	0	0
74.5-75.4	0	0	0
75.5-76.4	0	0	0
76.5-77.4	0	0	0
77.5-78.4	0	0	0
78.5-79.4	0	0	0
Total	49	22	71
Percent of total	69.0%	31.0%	100.00%
Mean FL (mm)	47.9	55.1	50.1
stand. dev.	6.6	6.0	7.2
stand. err.	0.9	1.3	0.8
95% Conf. Int.	+/- 1.9	+/- 2.7	+/- 1.6
range	34.0 - 62.0	46.0 - 68.0	34.0 - 68.0

Annex 9. Fork length frequencies of speared walleye observed at the Salmon River spawning area between 14 April and 11 May 1994.

Fork length (FL) (cm)	Male	Female	Unknown	Sums
29.5-30.4	1	0	0	1
30.5-31.4	0	0	0	0
31.5-32.4	0	0	0	0
32.5-33.4	0	0	0	0
33.5-34.4	1	0	0	1
34.5-35.4	1	0	0	1
35.5-36.4	1	1	0	2
36.5-37.4	4	0	0	4
37.5-38.4	8	0	0	8
38.5-39.4	6	1	0	7
39.5-40.4	12	0	0	12
40.5-41.4	14	0	0	14
41.5-42.4	13	1	0	14
42.5-43.4	16	1	0	17
43.5-44.4	19	3	0	22
44.5-45.4	19	2	1	22
45.5-46.4	13	6	0	19
46.5-47.4	21	6	0	27
47.5-48.4	17	13	1	31
48.5-49.4	15	18	0	33
49.5-50.4	14	24	0	38
50.5-51.4	13	21	0	34
51.5-52.4	8	28	0	36
52.5-53.4	6	21	0	27
53.5-54.4	9	29	1	39
54.5-55.4	16	28	0	44
55.5-56.4	8	28	0	36
56.5-57.4	3	33	0	36
57.5-58.4	3	24	1	28
58.5-59.4	2	37	0	39
59.5-60.4	6	36	1	43
60.5-61.4	0	28	0	28
61.5-62.4	6	24	0	30
62.5-63.4	5	18	0	23
63.5-64.4	1	8	0	9
64.5-65.4	0	11	1	12
65.5-66.4	0	13	0	13
66.5-67.4	1	14	0	15
67.5-68.4	0	4	0	4
68.5-69.4	0	4	0	4
69.5-70.4	0	3	0	3
70.5-71.4	1	6	0	7
71.5-72.4	0	11	0	11
72.5-73.4	0	2	0	2
73.5-74.4	0	6	0	6
74.5-75.4	0	2	0	2
75.5-76.4	0	1	0	1
76.5-77.4	0	2	0	2
77.5-78.4	0	2	0	2
78.5-79.4	0	0	0	0
Total	283	520	6	809
Percent of total	35.0%	64.3%	0.7%	100.0%
Mean FL (cm)	47.9	57.8	55.0	54.3.
stand. dev.	6.8	6.9	7.5	8.3
stand. err.	0.4	0.3	3	0.3
95% Conf. Int.	+/- 0.8	+/- 0.6	+/- 8.0	+/- 0.6
range	30.0 - 71.0	36.0 - 78.0	45.0 - 65.0	30.0 - 78.0

Annex 10. Fork length and weight of male walleye (n = 118) speared or caught in hoop nets from the Salmon River between 14 April and 13 May 1994.

30 - 39 (cm)		40 - 49 (cm)		50 - 59 (cm)		60 - 69 (cm)	
length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)
34.0	454	40.0	795	50.0	1362	60.0	2270
36.5	568	40.0	795	50.0	1476	60.0	2384
37.0	454	40.0	908	50.0	1816	60.0	2724
38.0	681	40.0	1135	51.0	1476	60.0	2838
38.0	681	41.0	795	51.0	1589	61.5	2611
38.0	681	41.0	908	51.0	1589	62.0	3178
39.0	681	41.0	908	51.0	1589	62.5	3178
		41.0	908	51.0	1816	63.0	2951
		41.5	795	52.0	1362		
		42.0	681	52.0	1816		
		42.0	908	53.0	1589		
		42.0	908	53.5	1703		
		42.0	908	54.0	1249		
		42.0	1022	54.0	1362		
		42.5	795	54.0	1703		
		43.0	1022	54.0	1816		
		43.0	1022	54.0	1930		
		44.0	908	54.0	1930		
		44.0	1135	55.0	1703		
		45.0	908	55.0	1816		
		45.0	908	55.0	1816		
		45.0	1022	55.0	1930		
		45.0	1135	55.0	2043		
		45.0	1249	55.0	2157		
		45.0	1249	55.0	2270		
		45.0	1249	56.0	1362		
		46.0	908	56.0	1816		
		46.0	908	56.0	1816		
		46.0	1022	56.0	1816		
		46.0	1135	56.0	2157		
		46.0	1135	57.0	2043		
		46.0	1135	57.0	2270		
		46.0	1249	57.0	2497		
		46.0	1249	57.0	2724		
		46.0	1362	58.0	2157		
		46.5	908	58.0	2384		
		46.5	1022	58.5	2611		
		46.5	1135	59.0	2270		
		47.0	908				
		47.0	1022				
		47.0	1135				
		47.0	1135				
		47.0	1135				
		47.0	1249				
		47.0	1249				
		47.0	1249				
		47.0	1249				
		47.5	1135				
		47.5	1135				
		48.0	1249				
		48.0	1249				
		48.0	1362				
		48.0	1476				
		48.0	1476				
		48.0	1476				
		48.5	1476				
		49.0	1135				
		49.0	1249				
		49.0	1362				
		49.0	1362				
		49.0	1362				
		49.0	1362				
		49.0	1476				
		49.0	1476				
		49.0	1476				

Mean FL (cm)	48.9
stand. dev.	6.4
stand. err.	0.6
95% C.I.	1.2
range	34.0 - 63.0

Mean W (g)	1437.7
stand. dev.	487.2
stand. err.	44.9
95% C.I.	88.8
range	454 - 3178

Annex 11. Fork length and weight of female walleye (n = 101) speared or caught in hoop nets from the Salmon River between 14 April and 13 May 1994.

30 - 39 (cm)		40 - 49 (cm)		50 - 59 (cm)		60 - 69 (cm)	
length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)
(none)		40.5	1135	50.0	1476	60.0	2270
		43.5	681	51.0	1476	60.0	2270
		44.5	908	51.0	1703	60.0	2951
		46.0	568	51.0	1816	60.0	2951
		46.0	1249	51.5	1476	60.5	2497
		47.0	1362	51.5	1589	60.5	3405
		47.0	1362	51.5	1703	61.0	2724
		47.5	1362	52.0	1930	61.0	2838
		47.5	1476	52.0	2157	61.0	3405
		48.0	1249	52.5	1589	61.0	3632
		48.0	1362	53.0	1816	61.5	3178
		48.0	1589	53.0	2157	62.0	2724
		48.0	1589	53.5	1930	62.0	3065
		48.5	1362	53.5	2384	62.0	3292
		49.5	1476	54.0	1816	62.0	3519
				54.0	1930	62.0	3632
				54.0	2043	63.0	3065
				54.0	2157	63.0	3178
				54.0	2270	63.0	3632
				54.0	2270	64.0	3632
				54.0	2724	64.0	3973
				54.5	2724	65.0	3178
				55.0	1816	65.0	3519
				55.0	1930	65.0	3973
				55.0	2270	67.0	3178
				55.0	2270	68.0	4086
				55.0	2611		
				55.5	2043		
				55.5	2270		
				56.0	2270		
				56.0	2270		
				56.0	2384		
				56.0	2497		
				56.0	2611		
				56.0	2611		
				56.0	2951		
				56.5	2611		
				57.0	2384		
				57.0	2497		
				57.0	2497		
				57.0	2838		
				57.0	2951		
				58.0	2497		
				58.0	2611		
				58.0	2611		
				58.0	2724		
				58.0	2838		
				58.0	2838		
				58.0	3065		
				58.5	2270		
				59.0	2157		
				59.0	2384		
				59.0	2497		
				59.0	2611		
				59.0	2724		
				59.0	2724		
				59.0	2951		
				59.0	2951		
				59.5	2724		
				59.5	2951		

Mean FL (cm)	56.0
stand. dev.	5.5
stand. err.	0.5
95% C.I.	1.1
range	40.5 - 68.0

Mean W (g)	2399.2
stand. dev.	748.2
stand. err.	74.4
95% C.I.	147.7
range	568 - 4086

Annex 12. Relative condition factor (Kr) of male and female walleye using the length (cm) - weight (g) relationship determined from walleye sampled from the Salmon River between 14 April and 13 May 1994 (n = 219).

Log transformed length - weight relationship for Salmon River spawning walleye is: log weight = -2.340 + 3.250 * log length

male				female			
observed fork length (FL) (cm)	actual weight (W) (g)	predicted weight (g)	Kr - relative condition factor	observed fork length (FL) (cm)	actual weight (W) (g)	predicted weight (g)	Kr - relative condition factor
34.0	454	479	0.95	40.5	1135	832	1.36
36.5	568	603	0.94	43.5	681	1047	0.65
37.0	454	603	0.75	44.5	908	1122	0.81
38.0	681	661	1.03	46.0	568	1202	0.47
38.0	681	661	1.03	46.0	1249	1202	1.04
38.0	681	661	1.03	47.0	1362	1288	1.06
39.0	681	708	0.96	47.0	1362	1288	1.06
40.0	795	759	1.05	47.5	1362	1380	0.99
40.0	795	759	1.05	47.5	1476	1380	1.07
40.0	908	759	1.20	48.0	1249	1380	0.90
40.0	1135	759	1.50	48.0	1362	1380	0.99
41.0	795	813	0.98	48.0	1589	1380	1.15
41.0	908	813	1.12	48.0	1589	1380	1.15
41.0	908	813	1.12	48.5	1362	1479	0.92
41.0	908	813	1.12	49.5	1476	1585	0.93
41.5	795	813	0.98	50.0	1476	1585	0.93
42.0	681	871	0.78	51.0	1476	1698	0.87
42.0	908	871	1.04	51.0	1703	1698	1.00
42.0	908	871	1.04	51.0	1816	1698	1.07
42.0	908	871	1.04	51.5	1476	1820	0.81
42.0	1022	871	1.17	51.5	1589	1820	0.87
42.5	795	933	0.85	51.5	1703	1820	0.94
43.0	1022	933	1.09	52.0	1930	1820	1.06
43.0	1022	933	1.09	52.0	2157	1820	1.18
44.0	908	1000	0.91	52.5	1589	1905	0.83
44.0	1135	1000	1.14	53.0	1816	1905	0.95
45.0	908	1072	0.85	53.0	2157	1905	1.13
45.0	908	1072	0.85	53.5	1930	2042	0.94
45.0	1022	1072	0.95	53.5	2384	2042	1.17
45.0	1135	1072	1.06	54.0	1816	2042	0.89
45.0	1249	1072	1.16	54.0	1930	2042	0.94
45.0	1249	1072	1.16	54.0	2043	2042	1.00
45.0	1249	1072	1.16	54.0	2157	2042	1.06
46.0	908	1148	0.79	54.0	2270	2042	1.11
46.0	908	1148	0.79	54.0	2270	2042	1.11
46.0	1022	1148	0.89	54.0	2724	2042	1.33
46.0	1135	1148	0.99	54.5	2724	2188	1.24
46.0	1135	1148	0.99	55.0	1816	2188	0.83
46.0	1135	1148	0.99	55.0	1930	2188	0.88
46.0	1249	1148	1.09	55.0	2270	2188	1.04
46.0	1249	1148	1.09	55.0	2270	2188	1.04
46.0	1362	1148	1.19	55.0	2611	2188	1.19
46.5	908	1202	0.76	55.5	2043	2291	0.89
46.5	1022	1202	0.85	55.5	2270	2291	0.99
46.5	1135	1202	0.94	56.0	2270	2291	0.99
47.0	908	1202	0.76	56.0	2270	2291	0.99
47.0	1022	1202	0.85	56.0	2384	2291	1.04
47.0	1135	1202	0.94	56.0	2497	2291	1.09
47.0	1135	1202	0.94	56.0	2611	2291	1.14
47.0	1135	1202	0.94	56.0	2611	2291	1.14
47.0	1249	1202	1.04	56.0	2951	2291	1.29
47.0	1249	1202	1.04	56.5	2611	2455	1.06
47.0	1249	1202	1.04	57.0	2384	2455	0.97
47.0	1249	1202	1.04	57.0	2497	2455	1.02
47.5	1135	1288	0.88	57.0	2497	2455	1.02
47.5	1135	1288	0.88	57.0	2838	2455	1.16
48.0	1249	1288	0.97	57.0	2951	2455	1.20
48.0	1249	1288	0.97	58.0	2497	2570	0.97
48.0	1362	1288	1.06	58.0	2611	2570	1.02
48.0	1476	1288	1.15	58.0	2611	2570	1.02
48.0	1476	1288	1.15	58.0	2724	2570	1.06
48.0	1476	1288	1.15	58.0	2838	2570	1.10
48.5	1476	1380	1.07	58.0	2838	2570	1.10
49.0	1135	1380	0.82	58.0	3065	2570	1.19
49.0	1249	1380	0.90	58.5	2270	2754	0.82

	49.0	1362	1380	0.99
	49.0	1362	1380	0.99
	49.0	1362	1380	0.99
	49.0	1362	1380	0.99
	49.0	1476	1380	1.07
	49.0	1476	1380	1.07
	49.0	1476	1380	1.07
	50.0	1362	1445	0.94
	50.0	1476	1445	1.02
	50.0	1816	1445	1.26
	51.0	1476	1549	0.95
	51.0	1589	1549	1.03
	51.0	1589	1549	1.03
	51.0	1589	1549	1.03
	51.0	1816	1549	1.17
	52.0	1362	1622	0.84
	52.0	1816	1622	1.12
	53.0	1589	1738	0.91
	53.5	1703	1820	0.94
	54.0	1249	1820	0.69
	54.0	1362	1820	0.75
	54.0	1703	1820	0.94
	54.0	1816	1820	1.00
	54.0	1930	1820	1.06
	54.0	1930	1820	1.06
	55.0	1703	1905	0.89
	55.0	1816	1905	0.95
	55.0	1816	1905	0.95
	55.0	1930	1905	1.01
	55.0	2043	1905	1.07
	55.0	2157	1905	1.13
	55.0	2270	1905	1.19
	56.0	1362	1995	0.68
	56.0	1816	1995	0.91
	56.0	1816	1995	0.91
	56.0	1816	1995	0.91
	56.0	2157	1995	1.08
	57.0	2043	1202	1.70
	57.0	2270	1202	1.89
	57.0	2497	1202	2.08
	57.0	2724	1202	2.27
	58.0	2157	2239	0.96
	58.0	2384	2239	1.06
	58.5	2611	2334	1.12
	59.0	2270	2334	0.97
	60.0	2270	2455	0.92
	60.0	2384	2455	0.97
	60.0	2724	2455	1.11
	60.0	2838	2455	1.16
	61.5	2611	2692	0.97
	62.0	3178	2692	1.18
	62.5	3178	2818	1.13
	63.0	2951	2818	1.05
Totals				
n = 118				
means	48.9	1440	1397	1.04
st. dev.	6.4	593.0	523.9	0.2
st. err.	0.6	54.6	48.2	0.0
95% C.I.	1.2	108.1	95.5	0.0

	59.0	2157	2754	0.78
	59.0	2384	2754	0.87
	59.0	2497	2754	0.91
	59.0	2611	2754	0.95
	59.0	2724	2754	0.99
	59.0	2724	2754	0.99
	59.0	2951	2754	1.07
	59.0	2951	2754	1.07
	59.5	2724	2884	0.94
	59.5	2951	2884	1.02
	60.0	2270	2884	0.79
	60.0	2270	2884	0.79
	60.0	2951	2884	1.02
	60.0	2951	2884	1.02
	60.5	2497	3020	0.83
	60.5	3405	3020	1.13
	61.0	2724	3020	0.90
	61.0	2838	3020	0.94
	61.0	3405	3020	1.13
	61.0	3632	3020	1.20
	61.5	3178	3236	0.98
	62.0	2724	3236	0.84
	62.0	3065	3236	0.95
	62.0	3292	3236	1.02
	62.0	3519	3236	1.09
	62.0	3632	3236	1.12
	63.0	3065	3388	0.90
	63.0	3178	3388	0.94
	63.0	3632	3388	1.07
	64.0	3632	3548	1.02
	64.0	3973	3548	1.12
	65.0	3178	3802	0.84
	65.0	3519	3802	0.93
	65.0	3973	3802	1.04
	67.0	3178	4169	0.76
	68.0	4086	4365	0.94
Totals				
n = 101				
means	56.0	2399	2401	1.00
st. dev.	5.5	748.2	726.7	0.1
st. err.	0.5	74.5	72.3	0.0
95% C.I.	1.1	147.7	143.5	0.0
Combined Sex Total				
n = 219				
means	52.2	1882	1860	1.02
st. dev.	7.0	821.7	800.6	0.2
st. err.	0.5	55.5	54.1	0.0
95% C.I.	0.9	109.5	106.7	0.0

Annex 13. Estimated average velocity of the Salmon River between 14 April and 5 May 1994 using two formulas for velocity; Wetzel and Likens (1991) and Robins and Crawford (1954).

velocity equation #1 (Wetzel and Likens 1991) V = Q/A
velocity equation #2 (Robins and Crawford 1954) V = Q/WDC
(Q = 0.8)

date	total discharge (m3/sec)	estimate #1 velocity (m/s)	estimate #2 velocity (m/s)
14-Apr	42.4	1.56	1.95
15-Apr	40.8	1.54	1.91
16-Apr	41.5	1.55	1.93
17-Apr	41.7	1.55	1.94
18-Apr	40.2	1.53	1.91
19-Apr	38.4	1.50	1.88
20-Apr	36.9	1.48	1.85
21-Apr	35.7	1.46	1.82
22-Apr	34.6	1.44	1.80
23-Apr	33.1	1.40	1.77
24-Apr	31.6	1.39	1.73
25-Apr	30.2	1.36	1.70
26-Apr	30.4	1.36	1.70
27-Apr	29.2	1.34	1.67
28-Apr	27.8	1.31	1.64
29-Apr	26.0	1.27	1.59
30-Apr	24.5	1.23	1.54
01-May	23.8	1.22	1.52
02-May	22.7	1.19	1.49
03-May	21.3	1.16	1.45
04-May	19.9	1.12	1.40
05-May	18.8	1.09	1.36
totals			
mean	31.4	1.37	1.71
st. dev.	7.7	0.2	0.2
st. err.	1.6	0.0	0.0
95% C.I.	3.4	0.1	0.1

Annex 14. Length frequency of walleye fry by day collected from the Salmon River between 8 May and 3 June 1994.

date	05/08-09	05/09-10	05/10-11	05/13-14	05/14-15
lengths (mm)	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10
n (subtotal fry)	10 110 92 3 0	5 46 38 0 0	5 51 50 1 0	0 13 33 1 0	0 22 27 0 0
n (total fry)	215	89	107	47	49
mean length	7.7	7.7	7.7	8	7.8
st. dev.	0.5	0.5	0.5	0.4	0.4
range	6.2 - 9.0	6.0 - 8.7	6.0 - 9.0	7.0 - 8.7	7.0 - 9.0

date	05/16-17	05/18-19	05/20-21	05/22-23	05/24-25
lengths (mm)	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10
n (subtotal fry)	1 16 25 2 0	1 5 13 0 0	1 6 7 0 0	1 12 4 0 0	1 9 1 0 0
n (total fry)	44	19	14	17	11
mean length	7.9	7.9	7.8	7.6	7.3
st. dev.	0.5	0.5	0.5	0.6	0.4
range	6.5 - 9.1	6.8 - 8.6	6.5 - 8.5	6.0 - 8.4	6.5 - 8.0

date	05/26-27	05/28-29	05/30-31	06/02-03
lengths (mm)	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10	6 7 8 9 10
n (subtotal fry)	0 2 0 0 2	0 1 0 0 0	1 2 0 0 0	0 0 0 0 0
n (total fry)	4	1	3	0
mean length	9	7.1	7.3	0
st. dev.	1.7	0	0.5	
range	7.5 - 10.5	7.1	6.8 - 7.8	

Annex 15. Dissolved oxygen, water temperature, and observations made for walleye eggs in 2 types of incubation units used at the ARC hatchery between 18 April and 5 May 1994.

date	hatch unit	water temperature (C)	dissolved oxygen (mg/L)	observations
18-Apr	ARC	10	6.4	ARC 1 + 2 stocked with eggs from Napanee River walleye
	EXP	10	6.2	EXP 1,2,3 stocked with eggs from Napanee River walleye
19-Apr	ARC	10	6.4	ARC 3 + 4 stocked with eggs from Salmon River walleye
	EXP	14.5	8	- air heaters cause 10 degree increase in water temperature in 24 hours in EXP hatch unit
20-Apr	ARC	10	6.3	ARC 5 + 6 stocked with eggs from Salmon River walleye
	EXP	18.7	8.1	EXP 4,5,6 stocked with eggs from Salmon River walleye
21-Apr	ARC	10	6.4	
	EXP	20	8	- Serious fungal growth noted in all EXP hatching jars (treatment with formalin not yet authorized.)
22-Apr	ARC	11	6.1	- Eggs combined in ARC 3 + 4 and ARC 5 + 6 due to inadequate water flow
	EXP	21	7.7	
23-Apr	ARC	12	6	- Eggs in ARC 1/2, 3/4, 5/6 treated with 50 mL formalin per jar for 15 min.
	EXP	20	8	EXP 7,8,9 stocked with eggs from gill netted Bay of Quinte walleye EXP 10,11 stocked with eggs from speared Salmon River walleye
24-Apr	ARC	12.8	6	
	EXP	20	8.1	- Eggs in EXP 1,2,3 "eye up"after 6 days (124 T.U.)
25-Apr	ARC	10.5	6	
	EXP	20	8.2	- Eggs in EXP 1,2,3 hatch after 7 days (144 T.U.), eggs in EXP 4,5,6 "eye up" after 5 days (120 T.U.)
26-Apr	ARC	11	6.2	
	EXP	18.5	6.2	- Eggs in EXP 4,5,6 hatch after 6 days (138 T.U.) - Eggs in EXP 7,8,9,10,11 treated with 85 mL formalin for all jars and for 15 min.
27-Apr	ARC	10.5	6.2	
	EXP	14	9.2	- fresh water added to EXP recirculation system causing temperature drop
28-Apr	ARC	10	6	
	EXP	14	9.2	
29-Apr	ARC	10.1	6.1	- Eggs in ARC 1/2, 3/4, 5/6 treated with 50, 46, 60 mL formalin per jar for 15 min.
	EXP	16.7	8.8	- Eggs in EXP 7,8,9,10,11 "eye up" after 6 days (123 T.U.)
30-Apr	ARC	10.5	6.2	
	EXP	10.5	6.2	- Eggs in EXP 7,8,9,10,11 hatch after 7 days (134 T.U.)
01-May	ARC	10.5	7	
	EXP	11	6.6	
02-May	ARC	12	6	- Eggs in ARC 1/2, 3/4, 5/6 treated with 60, 20, 18.5 mL formalin per jar for 15 min.
	EXP	17	8.9	
03-May	ARC	12	7.8	
	EXP	17.5	8.4	
04-May	ARC	12.5	7.5	- Eggs in ARC jars 1 + 2 combined
	EXP	18	8.3	- Eggs "eye-up" in ARC jars 1/2 (16 days, 173 T.U.), 3/4 (15 days, 163 T.U.), and 5/6 (14 days, 153 T.U.).
05-May	ARC	12.5	5.2	- Eggs hatch in ARC jars 1/2 (17 days, 185 T.U.), 3/4 (16 days, 175 T.U.), and 5/6 (15 days, 165 T.U.).
	EXP	20	8.2	

Annex 16. "By-catch" captured with hoop nets at the Salmon River mouth between 18 April and 8 May 1994. Days when nets were not checked represented by " - ". Days when numbers were not recorded represented by " * ".

Date	April												May								Totals
	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	
Species																					
Ameiurus nebulosus		2	12	-	*	-	19	*	400+	-	-	400+	-	*	*	57	28	28	-	111	1057+
Morone americanus				-	*	-	6	*	20	-	-	42	-	*	*	46	95	49	-	100+	358+
Catostomidae (Moxostoma spp., Catostomus commersoni)				-	*	-	2	*		-	-	12	-	*	*	30	28	12	-	9	93
Perca flavescens		1		-	*	-		*	2	-	-	2	-	*	*	2	2	1	-		10
Lepomis macrochirus			1	-	*	-	2	*		-	-		-	*	*	1	3		-	3	10
Ambloplites rupestris				-	*	-		*		-	-	2	-	*	*		2	3	-	3	10
Ictalurus punctatus				-	*	-		*	3	-	-	1	-	*	*	3	1	1	-		9
Micropterus dolomieu			1	-	*	-	1	*		-	-	1	-	*	*		1	1	-	3	8
Esox lucius	3		2	-	*	-		*		-	-	1	-	*	*		1	1	-		8
Lepomis gibbosus	1			-	*	-		*	1	-	-	1	-	*	*		1	3	-		7
Pomoxis nigromaculatus	1		1	-	*	-		*	2	-	-		-	*	*			1	-		5
Micropterus salmoides			1	-	*	-		*	2	-	-		-	*	*			1	-		4
Amia calva		1		-	*	-		*		-	-	1	-	*	*			1	-		3
Anguilla rostrata				-	*	-		*		-	-	1	-	*	*		1		-		2
Aplodinotus grunniens				-	*	-		*		-	-		-	*	*			1	-		1
Totals	5	4	18	-	*	-	30	*	430+	-	-	464+	-	*	*	139	163	103	-	229+	1585+

Annex 17. Fork length and weight of walleye sampled from the Salmon River between 14 April - 13 May 1994 and estimated lengths and weights of walleye sampled by Payne (1963) in the Bay of Quinte between 1959 and 1962.*

* Weights of Bay of Quinte walleye sampled by Payne in 1959 - 1962 were estimated by substituting lengths of walleye sampled by Mengel (1994) into the length - weight regression equation established by Payne (1963). English units of measure were used since these were the units used by Payne to formulate his regression equation.

Payne's L - W regression (sexes combined) is: $\log W = -3.6894 + 3.2709 \log L$ (n = 1429)
Mengel's 1994 L - W regression equation is: $\log W = -3.6643 + 3.2381 \log L$ (n = 219)

walleye sampled by Payne (1963)*				walleye sampled by Mengel*			
male		female		male		female	
fork length (in)	weight (lbs)	fork length (in)	weight (lbs)	length (in)	weight (lbs)	length (in)	weight (lbs)
13.4	1.0	15.9	1.8	13.4	1.00	15.9	2.50
14.4	1.2	17.1	2.2	14.4	1.25	17.1	1.50
14.6	1.3	17.5	2.4	14.6	1.00	17.5	2.00
15.0	1.4	18.1	2.7	15.0	1.50	18.1	1.25
15.0	1.4	18.1	2.7	15.0	1.50	18.1	2.75
15.0	1.4	18.5	2.9	15.0	1.50	18.5	3.00
15.4	1.6	18.5	2.9	15.4	1.50	18.5	3.00
15.7	1.7	18.7	3.0	15.7	1.75	18.7	3.00
15.7	1.7	18.7	3.0	15.7	1.75	18.7	3.25
15.7	1.7	18.9	3.1	15.7	2.00	18.9	2.75
15.7	1.7	18.9	3.1	15.7	2.50	18.9	3.00
16.1	1.8	18.9	3.1	16.1	1.75	18.9	3.50
16.1	1.8	18.9	3.1	16.1	2.00	18.9	3.50
16.1	1.8	19.1	3.2	16.1	2.00	19.1	3.00
16.1	1.8	19.5	3.4	16.1	2.00	19.5	3.25
16.3	1.9	19.7	3.5	16.3	1.75	19.7	3.25
16.5	2.0	20.1	3.7	16.5	1.50	20.1	3.25
16.5	2.0	20.1	3.7	16.5	2.00	20.1	3.75
16.5	2.0	20.1	3.7	16.5	2.00	20.1	4.00
16.5	2.0	20.3	3.9	16.5	2.00	20.3	3.25
16.5	2.0	20.3	3.9	16.5	2.25	20.3	3.50
16.7	2.1	20.3	3.9	16.7	1.75	20.3	3.75
16.9	2.1	20.5	4.0	16.9	2.25	20.5	4.25
16.9	2.1	20.5	4.0	16.9	2.25	20.5	4.75
17.3	2.3	20.7	4.1	17.3	2.00	20.7	3.50
17.3	2.3	20.9	4.2	17.3	2.50	20.9	4.00
17.7	2.5	20.9	4.2	17.7	2.00	20.9	4.75
17.7	2.5	21.1	4.4	17.7	2.00	21.1	4.25
17.7	2.5	21.1	4.4	17.7	2.25	21.1	5.25
17.7	2.5	21.3	4.5	17.7	2.50	21.3	4.00
17.7	2.5	21.3	4.5	17.7	2.75	21.3	4.25
17.7	2.5	21.3	4.5	17.7	2.75	21.3	4.50
17.7	2.5	21.3	4.5	17.7	2.75	21.3	4.75
18.1	2.7	21.3	4.5	18.1	2.00	21.3	5.00
18.1	2.7	21.3	4.5	18.1	2.00	21.3	5.00
18.1	2.7	21.3	4.5	18.1	2.25	21.3	6.00
18.1	2.7	21.5	4.6	18.1	2.50	21.5	6.00
18.1	2.7	21.7	4.8	18.1	2.50	21.7	4.00
18.1	2.7	21.7	4.8	18.1	2.50	21.7	4.25
18.1	2.7	21.7	4.8	18.1	2.75	21.7	5.00
18.1	2.7	21.7	4.8	18.1	2.75	21.7	5.00
18.1	2.7	21.7	4.8	18.1	3.00	21.7	5.75
18.3	2.8	21.9	4.9	18.3	2.00	21.9	4.50
18.3	2.8	21.9	4.9	18.3	2.25	21.9	5.00
18.3	2.8	22.0	5.1	18.3	2.50	22.0	5.00
18.5	2.9	22.0	5.1	18.5	2.00	22.0	5.00
18.5	2.9	22.0	5.1	18.5	2.25	22.0	5.25
18.5	2.9	22.0	5.1	18.5	2.50	22.0	5.50
18.5	2.9	22.0	5.1	18.5	2.50	22.0	5.75
18.5	2.9	22.0	5.1	18.5	2.50	22.0	5.75
18.5	2.9	22.0	5.1	18.5	2.75	22.0	6.50
18.5	2.9	22.2	5.2	18.5	2.75	22.2	5.75
18.5	2.9	22.4	5.4	18.5	2.75	22.4	5.25
18.5	2.9	22.4	5.4	18.5	2.75	22.4	5.50
18.7	3.0	22.4	5.4	18.7	2.50	22.4	5.50
18.7	3.0	22.4	5.4	18.7	2.50	22.4	6.25
18.9	3.1	22.4	5.4	18.9	2.75	22.4	6.50
18.9	3.1	22.8	5.7	18.9	2.75	22.8	5.50
18.9	3.1	22.8	5.7	18.9	3.00	22.8	5.75
18.9	3.1	22.8	5.7	18.9	3.25	22.8	5.75
18.9	3.1	22.8	5.7	18.9	3.25	22.8	6.00
18.9	3.1	22.8	5.7	18.9	3.25	22.8	6.25
19.1	3.2	22.8	5.7	19.1	3.25	22.8	6.25
19.3	3.3	22.8	5.7	19.3	2.50	22.8	6.75

	19.3	3.3		23.0	5.8		19.3	2.75		23.0	5.00
	19.3	3.3		23.2	6.0		19.3	3.00		23.2	4.75
	19.3	3.3		23.2	6.0		19.3	3.00		23.2	5.25
	19.3	3.3		23.2	6.0		19.3	3.00		23.2	5.50
	19.3	3.3		23.2	6.0		19.3	3.00		23.2	5.75
	19.3	3.3		23.2	6.0		19.3	3.25		23.2	6.00
	19.3	3.3		23.2	6.0		19.3	3.25		23.2	6.00
	19.3	3.3		23.2	6.0		19.3	3.25		23.2	6.50
	19.7	3.5		23.2	6.0		19.7	3.00		23.2	6.50
	19.7	3.5		23.4	6.2		19.7	3.25		23.4	6.00
	19.7	4.0		23.4	6.2		19.7	4.00		23.4	6.50
	20.1	3.7		23.6	6.3		20.1	3.25		23.6	5.00
	20.1	3.7		23.6	6.3		20.1	3.50		23.6	5.00
	20.1	3.7		23.6	6.3		20.1	3.50		23.6	6.50
	20.1	3.7		23.6	6.3		20.1	3.50		23.6	6.50
	20.1	3.7		23.8	6.5		20.1	4.00		23.8	5.50
	20.5	4.0		23.8	6.5		20.5	3.00		23.8	7.50
	20.5	4.0		24.0	6.7		20.5	4.00		24.0	6.00
	20.9	4.2		24.0	6.7		20.9	3.50		24.0	6.25
	21.1	4.4		24.0	6.7		21.1	3.75		24.0	7.50
	21.3	4.5		24.0	6.7		21.3	2.75		24.0	8.00
	21.3	4.5		24.2	6.9		21.3	3.00		24.2	7.00
	21.3	4.5		24.4	7.1		21.3	3.75		24.4	6.00
	21.3	4.5		24.4	7.1		21.3	4.00		24.4	6.75
	21.3	4.5		24.4	7.1		21.3	4.25		24.4	7.25
	21.3	4.5		24.4	7.1		21.3	4.25		24.4	7.75
	21.7	4.8		24.4	7.1		21.7	3.75		24.4	8.00
	21.7	4.8		24.8	7.4		21.7	4.00		24.8	6.75
	21.7	4.8		24.8	7.4		21.7	4.00		24.8	7.00
	21.7	4.8		24.8	7.4		21.7	4.25		24.8	8.00
	21.7	4.8		25.2	7.8		21.7	4.50		25.2	8.00
	21.7	4.8		25.2	7.8		21.7	4.75		25.2	8.75
	21.7	4.8		25.6	8.2		21.7	5.00		25.6	7.00
	22.0	5.1		25.6	8.2		22.0	3.00		25.6	7.75
	22.0	5.1		25.6	8.2		22.0	4.00		25.6	8.75
	22.0	5.1		26.4	9.1		22.0	4.00		26.4	7.00
	22.0	5.1		26.8	9.6		22.0	4.00		26.8	9.00
	22.0	5.1					22.0	4.75			
	22.4	5.4					22.4	4.50			
	22.4	5.4					22.4	5.00			
	22.4	5.4					22.4	5.50			
	22.4	5.4					22.4	6.00			
	22.8	5.7					22.8	4.75			
	22.8	5.7					22.8	5.25			
	23.0	5.8					23.0	5.75			
	23.2	6.0					23.2	5.00			
	23.6	6.3					23.6	5.00			
	23.6	6.3					23.6	5.25			
	23.6	6.3					23.6	6.00			
	23.6	6.3					23.6	6.25			
	24.2	6.9					24.2	5.75			
	24.4	7.1					24.4	7.00			
	24.6	7.3					24.6	7.00			
	24.8	7.4					24.8	6.50			
mean	19.3	3.5	mean	22.1	5.3	mean	19.3	3.2	mean	22.1	5.3
st.dev.	2.5	1.5	st.dev.	2.2	1.6	st.dev.	2.5	1.3	st.dev.	2.2	1.6
st. err.	0.2	0.1	st. err.	0.2	0.2	st. err.	0.2	0.1	st. err.	0.2	0.2
95% C.I.	0.5	0.3	95% C.I.	0.4	0.3	95% C.I.	0.5	0.2	95% C.I.	0.4	0.3

combined totals - Payne (1963)

	length	weight
mean	20.5	4.3
st.dev.	2.7	1.8
st. err.	0.2	0.1
95% C.I.	0.4	0.2

combined totals - Mengel

	length	weight
mean	20.5	4.1
st.dev.	2.7	1.8
st. err.	0.2	0.1
95% C.I.	0.4	0.2