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Fall Walleye Index Netting on Redgut Bay of Rainy Lake, Ontario 2008

Darryl McLeod and Alyson Bisson

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SUMMARY

Fall Walleye Index Netting (FWIN) was conducted in 2008 on Redgut Bay of Rainy Lake, located directly northeast of Fort Frances, Ontario. The lake is situated on the international border between Ontario and Minnesota; however Redgut Bay lies entirely in Ontario. A diversity of fish species were captured in gill nets, and detailed biological data relating to walleye, northern pike and smallmouth bass were obtained. In general, walleye populations in the Redgut Bay appear to be recovering, with most life history parameters (CUE, age composition, length and age at 50% maturity) showing improvement relative to the 1998 and 2003 FWIN projects and long-term index netting since 1965. A total of 15 age classes (12 with n>1) were captured, with a maximum age of 19 years and a mean age of only 3.30 years. The geometric mean CUE of walleye ≥450 mm in total length was 0.9 walleye/net, and the Shannon Diversity Index for adult females was 0.80. Comparisons of walleye population structure (e.g., number of age classes, maximum age, Shannon Diversity Index) to regional benchmarks indicate a "healthy" fishery, although some parameters (geometric mean CUE ≥450 mm , mean age, Fishing Quality Index) still indicate a "stressed" or recovering fishery. Current management strategies appear to be having the desired affect of improving abundance and structure as reflected by a significant increase in catch per unit effort from 7.5 walleye/net in 1998 to 17.8 walleye/net in 2008 (geometric mean increased from 6.5 to 12.8 walleye/net). Harvest restrictions should remain in place until all population parameters indicate a healthy fishery, and fishing quality objectives are achieved.

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INTRODUCTION

Rainy Lake is situated on the international border between Ontario and Minnesota, and is divided into three geographically distinct basins; Redgut Bay and the North Arm which lie entirely in Ontario, and the South Arm which lies nearly equally in Minnesota and Ontario (Figure 1). Water levels in the lake are regulated by the International Rainy Lake Board of Control (IRLBC) through the International Joint Commission (IJC). The outlet into the Rainy River is controlled by a hydroelectric dam at Fort Frances-International Falls. Inflows are regulated by a hydroelectric dam at Sturgeon Falls (Crilly) on the Seine River system, and by control dams at the outlet of Namakan Lake at Kettle Falls and Squirrel Falls. Three additional water control structures located at Big Canoe, Footprint, and Manitou Rivers, contribute to the regulation of inflows and water levels.

Water levels are regulated based on the **"**rule curve". The first order of regulation for Rainy Lake and the Namakan Reservoir was established in 1949, and supplementary orders were issued in 1957 and 1970. Dissatisfaction with the 1970 order led to changes in the rule curve which were put in place in January 2000 and consolidated in 2001. The new curve consists of virtually identical spring refill patterns, with a period of stable water levels in the summer, and gradual and earlier drawdown in the fall. The new curve was intended to improve fish stocks that spawn in both fall (e.g. lake whitefish, *Coregonus clupeaformis*) and spring (e.g. walleye, S*ander vitreus,* northern pike, *Esox lucius)*. The changes to the rule curve involve a monitoring strategy to evaluate long term impacts, in which Fall Walleye Index Netting (FWIN) was included (IRLBC, 1999; USGS, 2000).

Rainy Lake covers an area of 92,100 ha (212,010 acres), of which 76 %, or 70,150 ha (173,000 acres) is in Ontario. Redgut Bay covers a surface area of 8,300 ha (20,600 acres). The lake is located in the southern range of the boreal forest in North America, and is typical of Canadian Shield lakes with soft water and little submerged aquatic vegetation. Characteristics of the three mesotrophic basins have been summarized in Table 1. A diverse, coolwater fish community is present in the lake, including 55 known species (Appendix 1). Redgut Bay was assessed using FWIN standards in 1998 (M^{c}Leod et al., 2004) and 2003 (McLeod and Taillon, 2004) and will continue to be assessed on a five-year cycle. The North Arm was assessed using FWIN standards in 1998, 2002 and 2007; and the South Arm in 1999, 2004 and 2009. Additional fisheries assessment programs also included annual monitoring of commercial harvests, catch sampling, roving creel surveys (2001/02), aerial effort survey (SOR – 2000/01), and annual smallmouth bass (*Micropterus dolomieu*) sampling through the Fort Frances Canadian Bass Championship. Index netting from 1965 to 1998 was conducted in early September and utilized multifilament gill nets at fixed sites, similar to standards used by the Minnesota Department of Natural Resources (MDNR) (M^{c}Leod at al., 2004).

Approximately 26,600 people, closely divided between Minnesota and Ontario, permanently resided in the area of Rainy Lake and upper Rainy River in 2001. Of the Ontario population, 61% live in the town of Fort Frances (OMNR and MDNR, 2004). In addition, five of the twenty-one Ontario commercial tourist resorts on Rainy Lake are

located in Redgut Bay, with three more located nearby in the Bears Pass area of the South Arm.

Table 1: Physical and chemical characteristics of the Rainy Lake basins (Ontario waters only).

Parameter	Redgut Bay	North Arm	South Arm	Rainy Lake, Ontario
Surface Area - Ontario (ha)	**8,300**	34,570	27,260	70,150
Mean Depth (m)	**6.9**	8.0	11.5	9.3
Maximum Depth (m)	**31.2**	41.0	49.1	49.1
Mean Summer Secchi Depth (m)	**2.1**	3.3	2.7	2.7
Perimeter Shoreline (km)	**276**	583	439	1,298
Island Shoreline (km)	**55**	440	396	891
T.D.S. (mg/L)	**35**	55	43	53
M.E.I.	**5.1**	6.9	3.7	5.7

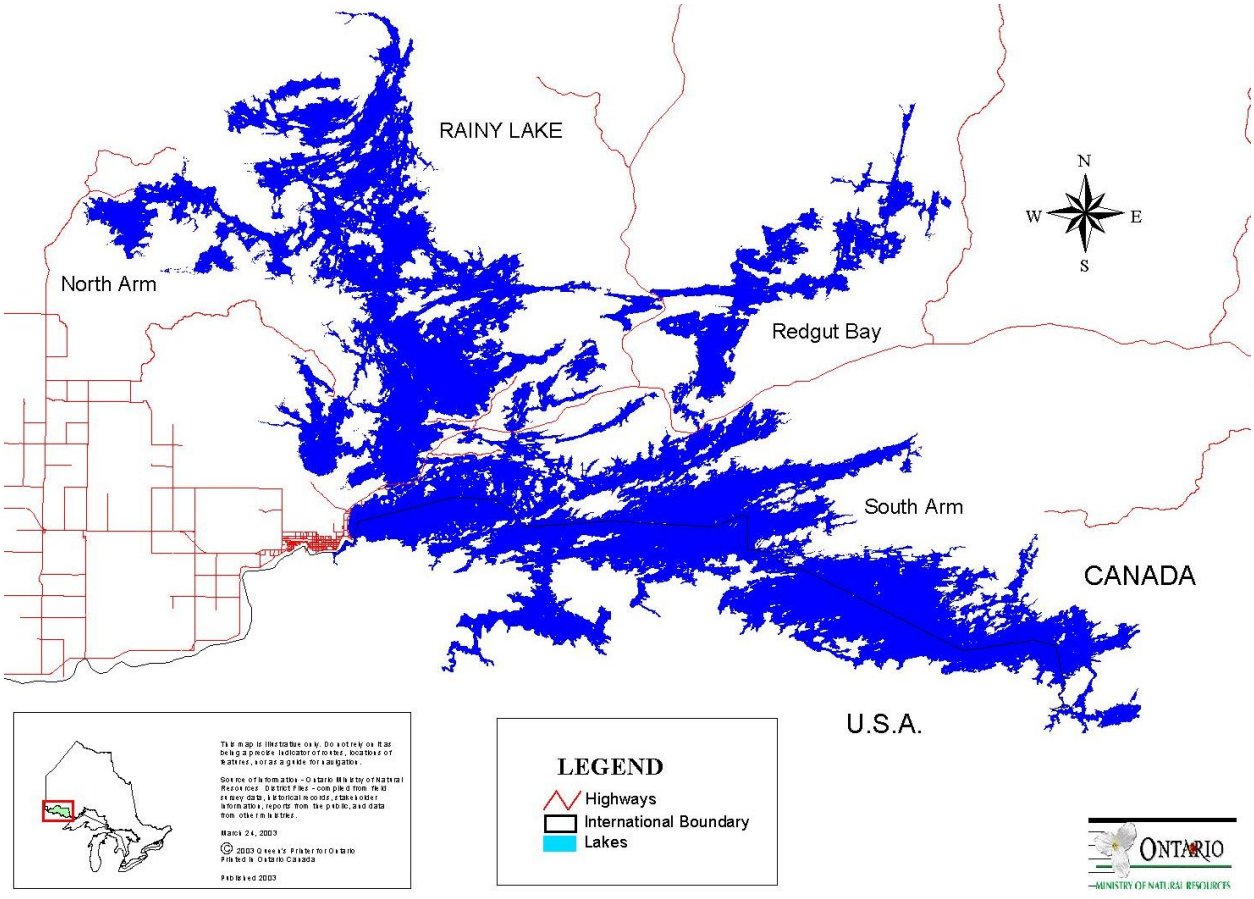

Figure 1: Location of Rainy Lake, Ontario

Commercial fishing on Rainy Lake dates back prior to the 1890s for lake sturgeon (*Acipenser fulvescens)* and lake whitefish. Commercial fishing since the 1920s was primarily for whitefish, northern pike, walleye and more recently black crappie (*Pomoxis nigromaculatus*). The commercial walleye fishery on Redgut Bay was eliminated in 1971 due to mercury contamination, and only small incidental harvests were reported from 1972-1984. No commercial walleye harvest has occurred on this basin since quota management was established for walleye in 1978 and for all other species in 1984. In 2008, there were a total of four commercial fishing operations and six commercial licenses remaining on the Ontario waters of Rainy Lake. Currently, commercial harvest on Redgut Bay is limited to one licence, with species quotas for whitefish, northern pike and black crappie.

A roving creel survey on Redgut Bay in 2001 indicated that the majority (68 %) of fishing pressure is from non-resident (U.S.) anglers, with 62 % based in Ontario and 6 % from Minnesota. Angling effort based on surveys in 2001/02 revealed that overall angling effort was highest on Redgut Bay at 8.9 rod-hrs/ha (73,700 rod-hours) (M^{c}Leod, 2003). Overall angler effort on Rainy Lake was highest for walleye, accounting for 59 % of the total effort. The majority of angler effort on Redgut Bay is directed at walleye (84 %), with lesser effort directed at northern pike (18 %), smallmouth bass (18 %) and black crappie (17 %). Muskellunge (*E. masquinongy*) are also present in Redgut Bay, and offer limited trophy opportunities for anglers. The higher effort directed at walleye may be attributed to the high catch rates (1.37 walleye/rod-hour) relative to the other basins (0.25 walleye/rod hour on the North Arm and 1.00 walleye/rod hour on the South Arm). Angler

creel surveys in 2001/02 indicated that an estimated 87 % of walleye were released in Rainy Lake increasing from 82 % in 1994/95. Release rate of walleye was highest in Redgut Bay (89 %) and lowest in the North Arm (70 %). The majority of the walleye being released is attributed to the restrictive harvest slot and trophy size limits introduced in 1994, and lower daily limits for non-resident anglers introduced in 2000 (M^{c}Leod, 2003).

Exploited walleye populations often exhibit characteristics associated with over-harvest in many fisheries. These include: reductions in numbers, changes in population structure, and physiological (life history) changes (OMNR, 1983). Exploited walleye populations often exhibit inconsistent recruitment and a population structure dominated by younger fish (Morgan et al., 2003). Life history adaptations observed in exploited walleye populations include increased juvenile (pre-maturation) growth rates, earlier age at maturity and high investment in reproduction, which are viewed as compensatory mechanisms (Lester et al., 2000).

Historically, walleye populations on Rainy Lake have fallen below expected and desired levels. The Redgut Bay fishery has been classified as depressed since 1965, and has shown signs of over-exploitation stress (Wepruk et al., 1992). Although population abundance based on index net catches showed a slight increasing trend since 1965, walleye abundance appeared to be declining through the late 1980's while angler exploitation was high. The 1998 FWIN catch of only 7.5 walleye/net suggested that abundance was still low and dominated primarily by small fish (OMNR and MDNR, 2004). Attempts to rehabilitate the Redgut Bay fishery have included angling regulation

changes and sanctuaries adjacent to known spawning sites. In order to allow the walleye population to recover, recommended harvest levels for Redgut Bay were lowered to 2,000 kg/yr in 1992 (MDNR et al., 1992), and revised to 3,800 kg/yr in 2004 (OMNR and MDNR, 2004). The potential yield of walleye is estimated at 7,600 kg/yr, while annual harvests have averaged only 5,400 kg/yr from 1997-2002, compared to previous high levels of 8,760 kg/yr from 1970-84. The highest angler harvest was reported at 10,300 kg in 1992, and exceeded the potential yield by 36 %.

Since 1994, walleye harvest, particularly by non-resident anglers was restricted to those based in Ontario. Pending a NAFTA trade challenge by the U.S., more general regulations were put in place in 2000 to limit harvest by all non-resident anglers. The daily catch limit for non-resident anglers of one walleye or sauger *(S. canadensis)* per day, with a possession limit of four (walleye and sauger in combination) was introduced. Harvest by anglers was previously limited by the 1994 regulation changes to a possession limit of three walleye and sauger in combination. Both resident and non-resident anglers have been regulated by a harvest slot and trophy size limit, whereby only walleye between 35 cm and 45 cm (13.75 to 17.75") with only one walleye greater than 70 cm (27.5") could be legally harvested. Consistent with the entire Northwest Region, the daily catch and possession limit was increased from three to four walleye in 2000. In order to evaluate the effectiveness of these regulation changes, assessment programs including Fall Walleye Index Netting (FWIN) on each basin of the Rainy Lake were initiated (M^{c}Leod, 2002). The FWIN program will also provide baseline data for the evaluation and monitoring of water level changes initiated by the IRLBC (USGS, 2000).

METHODS

Standard FWIN gillnetting was conducted on Redgut Bay between September 8 and September 23, 2008 following the Manual of Instructions: Fall Walleye Index Netting Surveys (Morgan, 2002). Gear consisted of standard OMNR FWIN gillnets constructed of clear monofilament, and made up of eight 7.6m panels with stretched mesh sizes of 25mm, 38mm, 51mm, 64mm, 76mm, 102mm, 127mm, and 152mm (made by *Les Industries Fipec Inc*., Quebec, catalog #FEX-03). Nets were set as close to perpendicular (90^{o}) from shore as each net site would allow.

Ten net sites were selected using the fixed locations from gill net sampling efforts between 1970 and 1998. An additional ten sites were selected in 2003 based on stratified random sampling, within 2 depth strata (shallow = 2-5 m, deep = 5-15m), as outlined in the FWIN manual (Morgan, 2002). Sampling intensity in each strata was determined by the relative amount of shallow versus deep areas of the lake. As a result, 45% (9/20) of nets were in the deep strata, and 55% (11/20) were in the shallow strata. Surface water temperatures were warmer than desired during the sampling, and ranged from 17.0°C to 19.5°C with thermal stratification still present. The timing of the project coincides with index netting efforts on the South Arm by the Minnesota Department of Natural Resources.

All walleye, northern pike, muskellunge and smallmouth bass were sexed and sampled for maturity by comparing gonad development (Duffy et al., 1999), and aging structures were taken (otiliths for walleye, 4^{th} dorsal spine for smallmouth bass; and cleithra for

pike and muskellunge). All aging structures were assessed by the OMNR Northwest Regional Aging Facility in Dryden, Ontario. All other fish species were measured for fork and total length and weighed, but no aging structures were taken. Data were compiled and analyzed using FISHNET2 (Lester and Korver, 1996) as part of the Ontario Fisheries Information System (OFIS). Additional information regarding the overall health of the Redgut Bay fishery was determined based on NW Regional means for life history (Lester et al., 2000) and population structure (Morgan et al., 2003).

RESULTS

A total of 14 species were captured in 20 gill net sets on Redgut Bay. Walleye were the most abundant species, representing 38.9 % of the catch by number with an arithmetic mean of 17.8 fish/net. Yellow perch (*Perca flavescens*) were captured an average of 9.1 fish/net and represented 20.0 % of the total number of fish caught. Sauger and lake herring (*C. artedii*) were the third most abundant species at 4.3 fish/net and 9.3 % of the total catch. The total percid composition (walleye, sauger, yellow perch) was 68.2 % of the catch by number. Meanwhile, rock bass (*Ambloplites rupestris*) comprised 3.4 fish/net and 7.4 % of the catch. No other single fish species comprised greater than 5 % of the total catch, as indicated in a summary of catch data for all species (Table 2). The FWIN efforts on Redgut Bay produced a fish community with a Simpson's Diversity Index value of 4.58.

Table 2: Summary of catch data from Fall Walleye Index Netting (FWIN) in Redgut Bay of Rainy Lake (20 net sets), 2008.

Species	# Nets Captured In	Total # Caught	Mean (#/net)	Standard Error (SE)	% RSE	% of Total Catch
Lake Whitefish	4	7	0.35	0.17	47.6	0.8
Lake Herring	14	85	4.25	1.20	28.1	9.3
Northern Pike	15	30	1.50	0.29	19.0	3.3
Muskellunge	2	2	0.10	0.07	68.8	0.2
Mooneye	7	14	0.70	0.26	37.5	1.5
White Sucker	13	30	1.50	0.37	24.9	3.3
Shorthead Redhorse	2	3	0.15	0.11	72.9	0.3
Spottail Shiner	1	1	0.05	0.05	100.0	0.1
Rock Bass	16	67	3.35	0.87	26.0	7.4
Smallmouth Bass	10	18	0.90	0.27	30.1	2.0
Black Crappie	9	33	1.65	0.63	38.4	3.6
Yellow Perch	19	182	9.10	2.06	22.6	20.0
Sauger	17	85	4.25	1.10	26.0	9.3
Walleye	20	355	17.75	2.98	16.8	38.9
TOTAL	**20**	**891**	**44.55**	**-**	**-**	**100.0**

WALLEYE

The catch of walleye in index netting programs on Redgut Bay for the period of 1965-2008 is illustrated in Figure 2. In 1998, provincial FWIN standards were first used in a detailed comparison with historical index netting techniques. Walleye abundance between 1965 and 1990 remained relatively stable, with high levels of variability within sampling years. The long-term arithmetic mean from 1965 to 1998 index netting was 10.3 ± 1.5 walleye per net. The arithmetic mean catch per unit effort (CUE) of walleye declined slightly in 2008 to 17.8 walleye/net, after a significant increase from 7.5 walleye/net in 1998 to 19.5 walleye/net in 2003. Walleye abundance in 2008 was the second highest observed since 1965. The geometric mean CUE in 2008 was 12.8 walleye/net compared to 13.7 walleye/net in 2003, which was double the 6.5

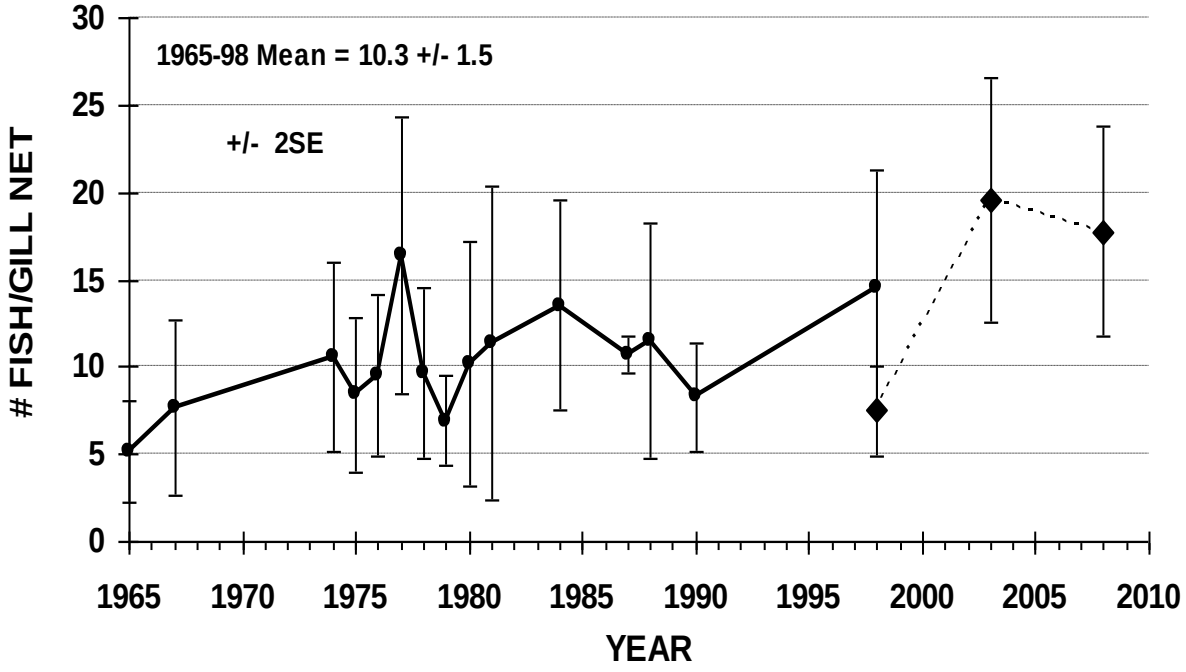

Figure 2: Historical abundance of walleye based on catch-per-unit-effort from index netting (1964-1998) and Fall Walleye Index Netting (1998, 2003, 2008).

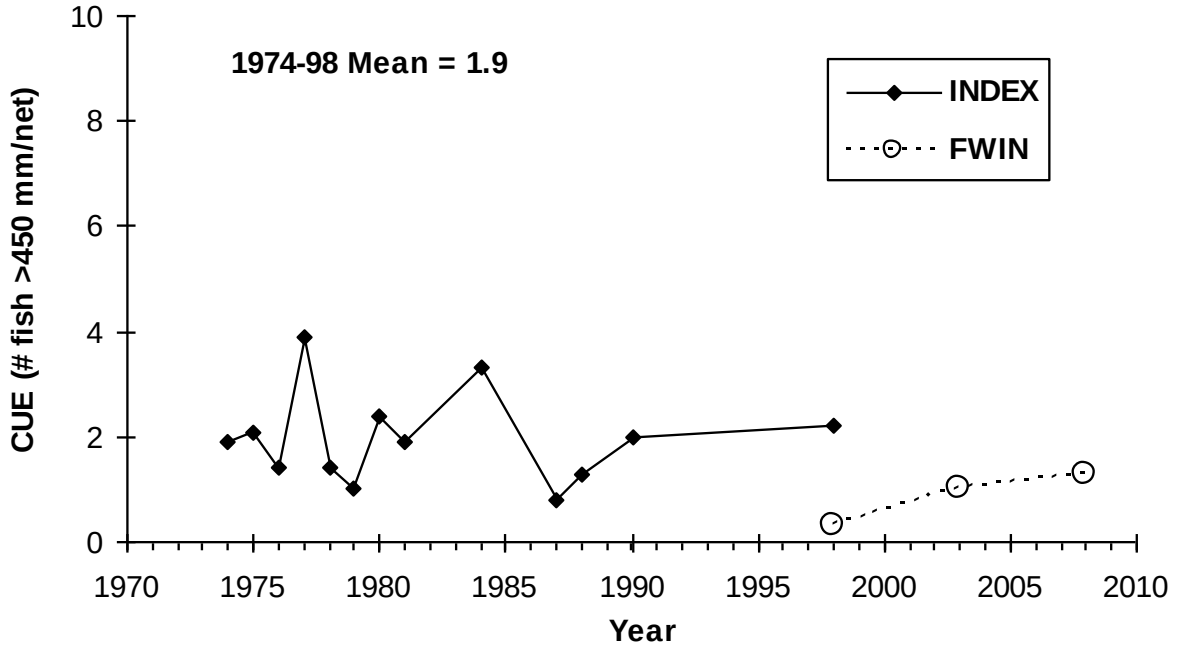

Figure 3: Historical abundance of walleye >450 mm TL based on catch-per-unit-effort from index netting (1974-1998) and Fall Walleye Index Netting (1998, 2003, 2008).

walleye/net observed in 1998. The catch of spawning stock walleye ≥450 mm is represented in Figure 3, and would suggest there has been a recent increase based on FWIN sampling from 1998 to 2008. The CUE (>450 mm) from historical index netting had remained relatively stable, averaging 1.9 walleye ≥450 mm /net from 1974-1998, compared to 1.3 in 2008. The geometric mean CUE for walleye of 12.8 walleye/net is higher than observed in 1998, but similar (not significantly different) from 2003 (Figure 4). The geometric mean CUE (walleye ≥450 mm) was estimated at 0.9 in 2009 and represents a continued increase since 1998 (Figure 5).

The increases in FWIN catch by number coincided with increases in catch by weight, which increased to 5.40 kg/net in 2008 compared to 2.52 kg/net in 1998 and 6.03 kg/net in 2003. The mean weight of walleye sampled in 2008 was 0.30 kg (SE = 0.02 kg) similar to the average weight of 0.29 kg from 1998 FWIN, but lower than the long term (1965-1998) average of 0.56 kg; (SE = 0.04 kg).

Age two (2006 year class) and age 3 (2005 year class) walleye comprised 51.8% of the total catch, representing 37% and 15 % respectively. As a result, the mean age of catch was only 3.30 years, and a total of 15 age classes (12 age classes n>1) were present with a maximum age of 19 years (Figure 6). The very strong 2001 year class (age 7) that existed in previous assessments continues to persist at 5.4% of the total catch in 2008. The 2000 (age 8) year class was especially weak and was not represented in the catch.. Similarly, absence of age 16 and 17 year old walleye also reflects the very poor 1993 and 1992 year classes previously observed across a broad area of the Northwest Region. A

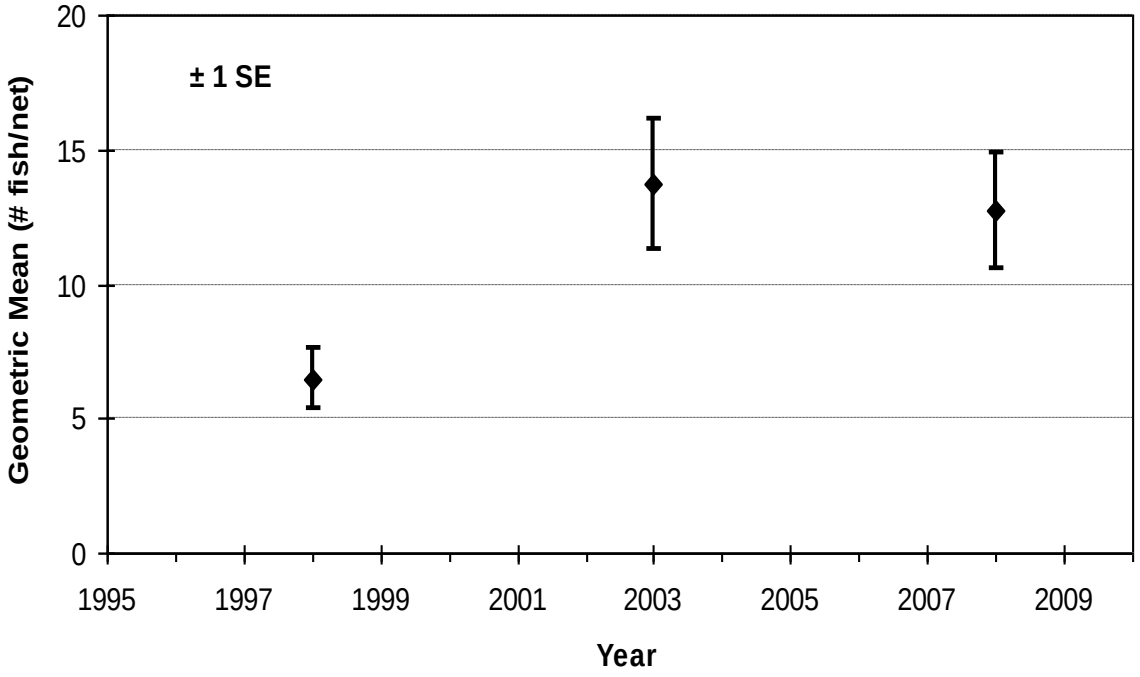

Figure 4: Geometric mean catch of walleye in Redgut Bay of Rainy Lake based on 1998, 2003 and 2008 Fall Walleye Index netting (FWIN).

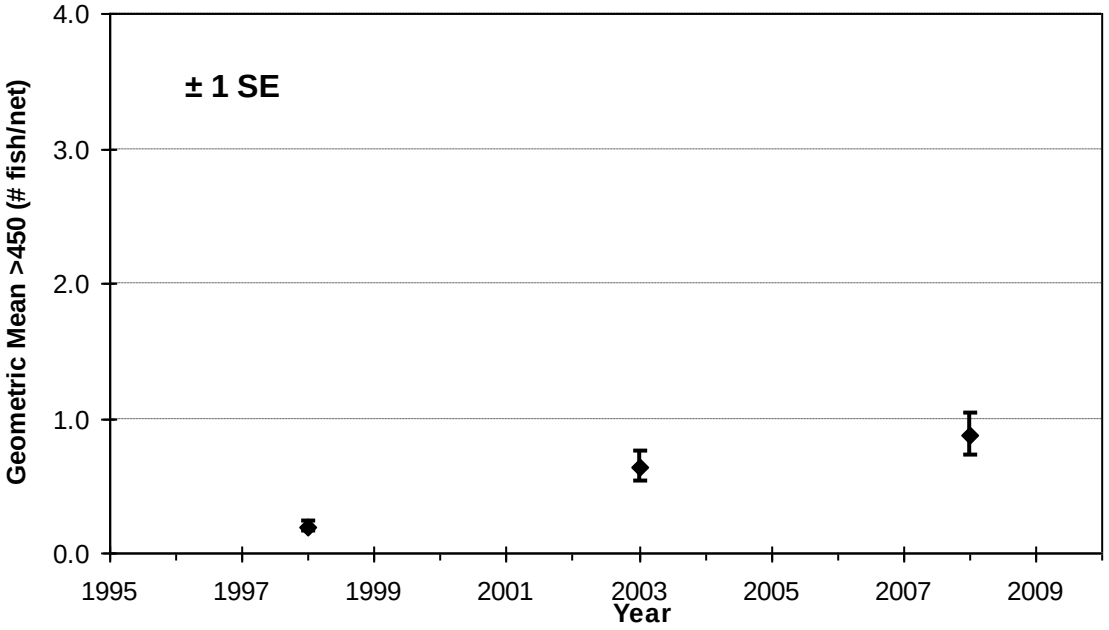

Figure 5: Geometric mean catch of walleye ≥450 mm TL in Redgut Bay of Rainy Lake based on 1998, 2003 and 2008 Fall Walleye Index Netting (FWIN).

successful recruitment of the 2008 year class. Total annual mortality (sexes combined) was estimated at 28%, and compared to 30% for males (5+ years) and 27% for females (5+ years).

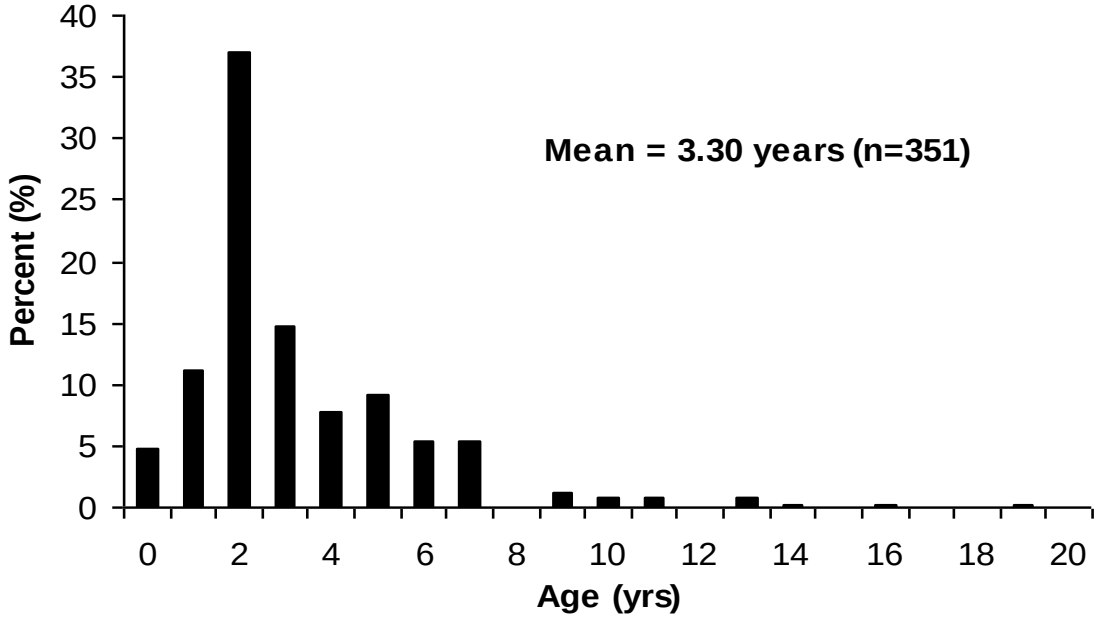

Figure 6: Age composition of walleye in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

The age composition of the catch was also compared to the 2003 FWIN (Figure 7) and to the long-term mean (1974-1998) from previous index netting efforts (Figure 8). The mean age of the 2008 FWIN catch was slightly higher than the 2003 catch, but still lower than the long-term mean of 3.80 years, as was expected due to minor differences in gear type. Although the age compositions were similar, there were obvious differences based on year class strength, higher representation of young fish (0 and 1 years) in the FWIN catch with smaller (25 mm) mesh size, and a relatively few older fish sampled (>12

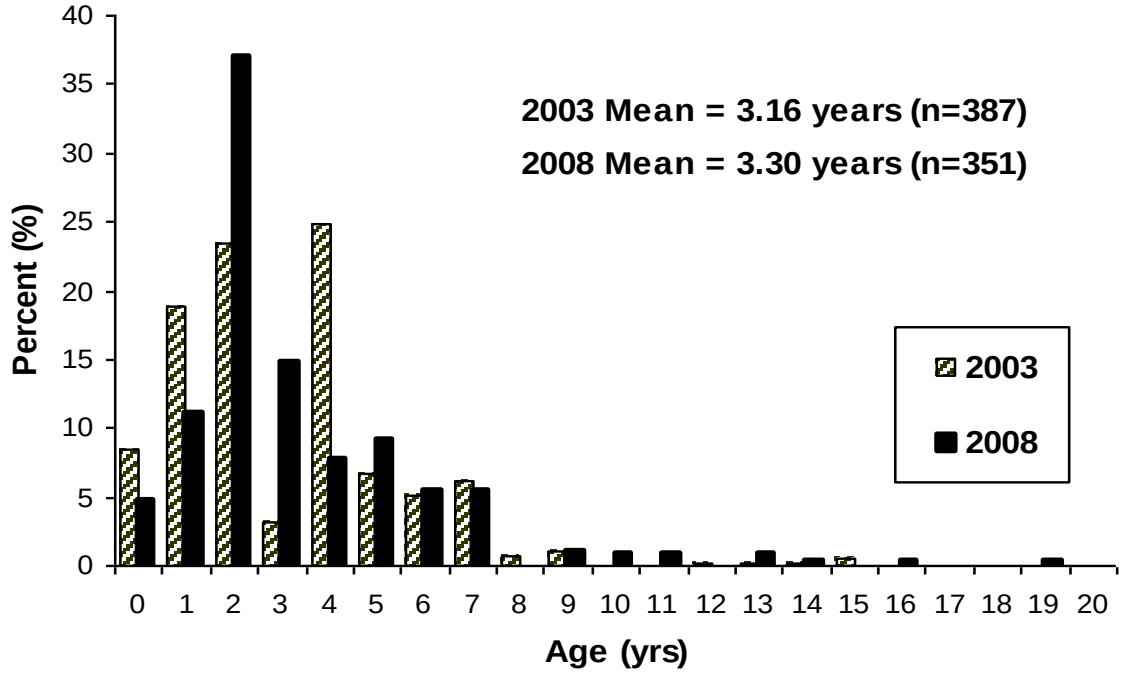

Figure 7: Age composition of walleye in Redgut Bay of Rainy Lake based on the 2003 and 2008 Fall Walleye Index Netting (FWIN).

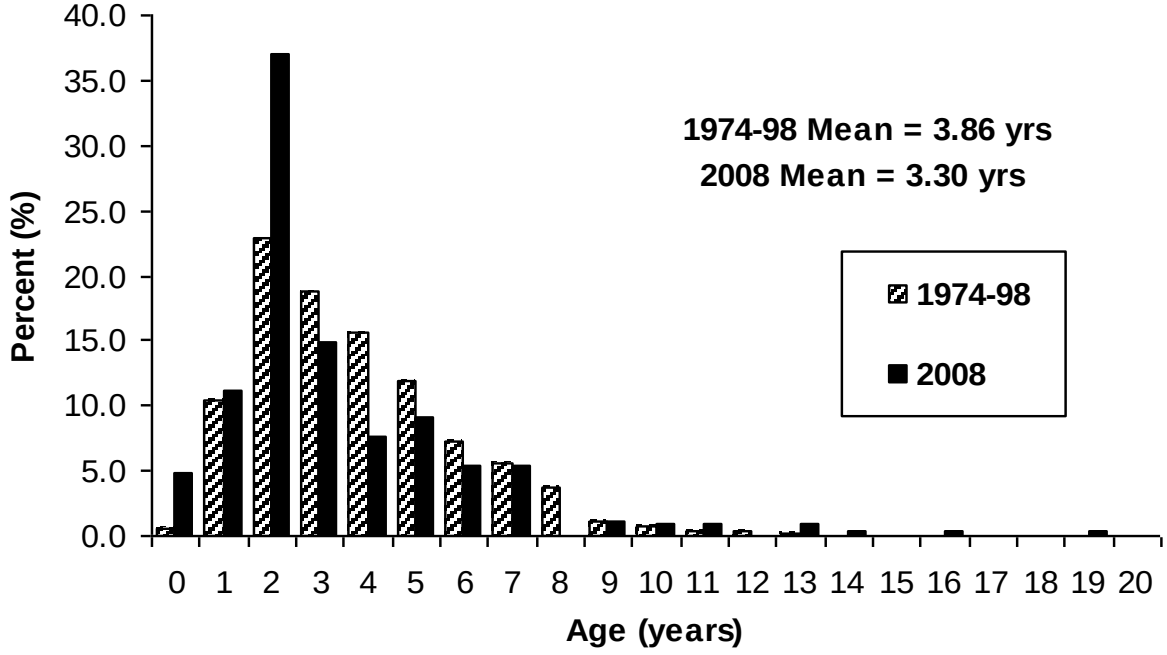

Figure 8: Age composition of walleye in Redgut Bay of Rainy Lake based on 2008 Fall Walleye Index Netting (FWIN) compared to long-term index netting (1974-1998).

years). The 2008 FWIN catch continues to provide slightly better representation of older age classes (>10 years) than previous netting efforts.

Overall mean total length of walleye (sexes combined) was 288 mm, with good representation of fish in the smaller size classes. Only one walleye greater than 700 mm was sampled and there was an obvious reduction in the abundance of fish greater than 400 mm. The majority (86%) of fish captured were in the range of 180-400 mm total length. This was highly influenced by the abundance of age 2 fish in the catch. The length distribution of walleye captured in Redgut Bay is illustrated in Figure 9.

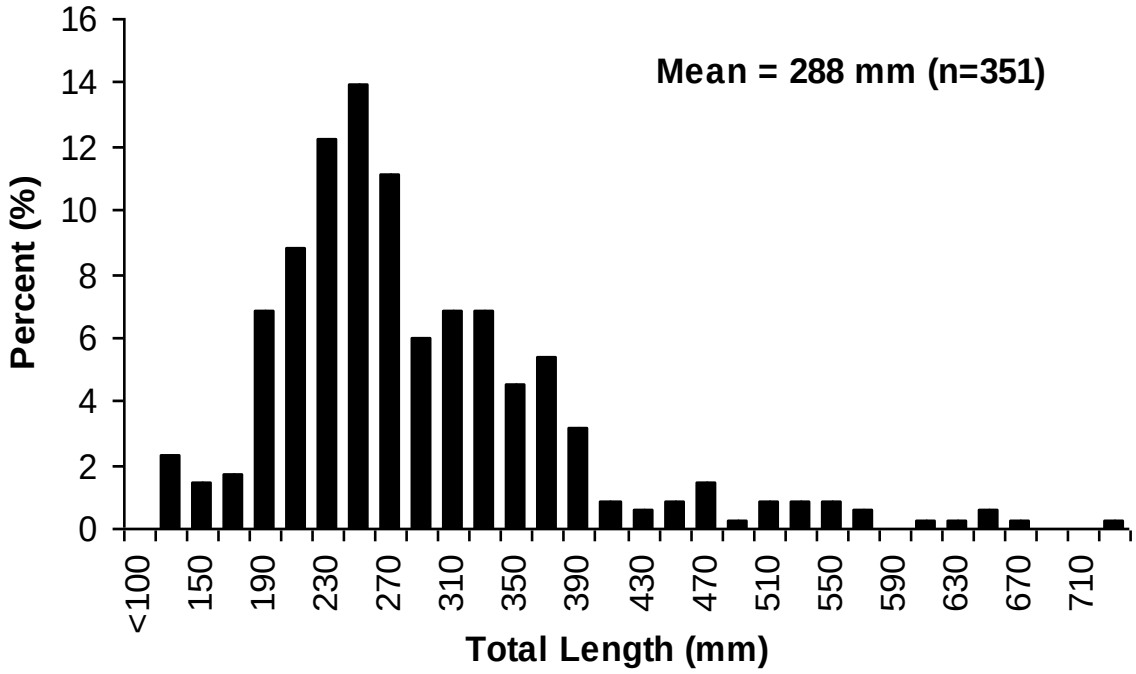

Figure 9: Walleye length composition in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

Redgut Bay walleye exhibited typically sexually dimorphic growth patterns, with males and females growing at a very similar rate during the first 4 years, with male growth levelling off and females continuing to grow larger in terms of both length (Figure 10) and weight (Figure 11). Differences were more obvious when considering body weight, as expected given the differences in gonad weight between the two sexes.

Growth of juvenile (age 1 to 4 years) walleye has remained relatively unchanged over the period from 1965 to 2008 (Figure 12), except for a modest decline in the growth (mean length) of age 3 and 4 walleye over the past 2 decades. Comparison of mean total length at age through time may help evaluate the response of walleye to increased abundance, harvest restrictions or invasions of exotic species (e.g. rainbow smelt *Osmerus mordax* in 1991; spiny water flea *Bythotrephes longimanus* in 2006).

The growth of walleye in Rainy Lake also differs among basins. Mean length at age is consistently higher in the North Arm, than both Redgut Bay and the South Arm (Figure 13). Although age 0 fish are of similar size, Redgut Bay walleye are slower growing than the North Arm especially through age classes 1 to 13 years. Walleye in Redgut Bay also appear to have identical growth to fish sampled from the South Arm in 2009.

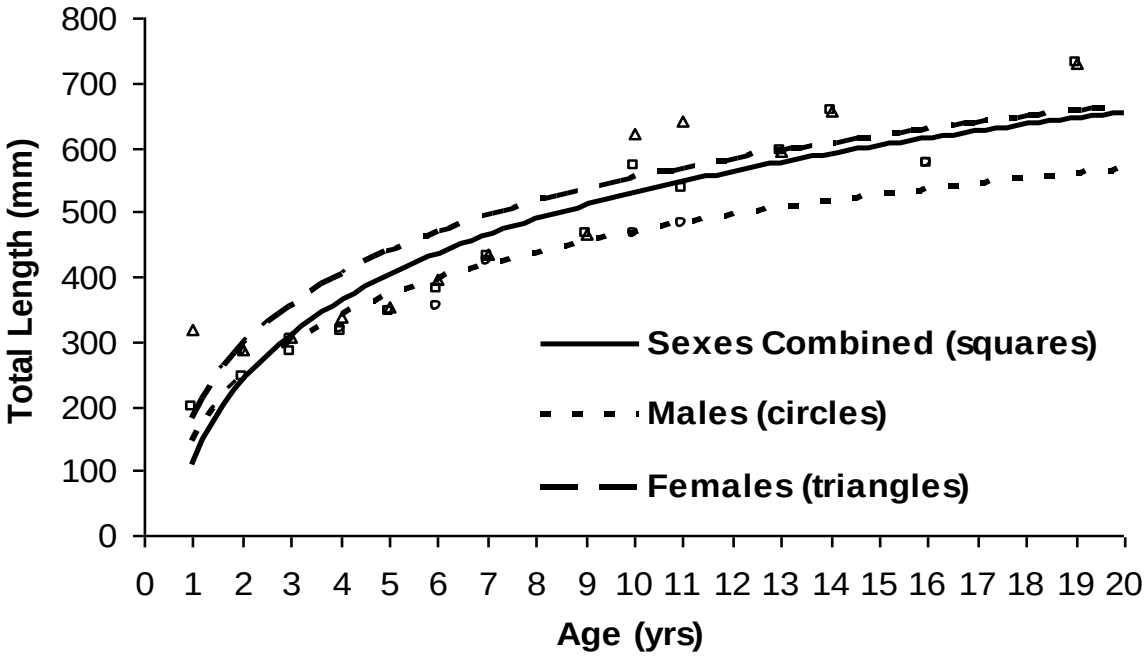

Figure 10: Walleye growth (total length at age) for males, females, and combined sexes in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

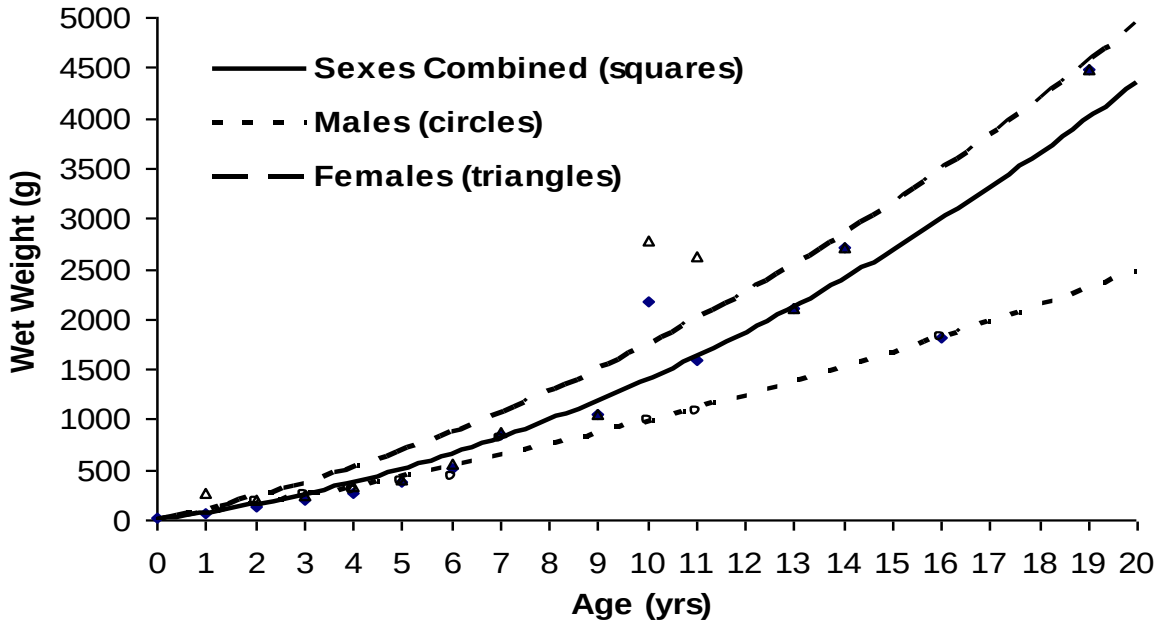

Figure 11: Walleye growth (weight at age) for males, females, and combined sexes in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

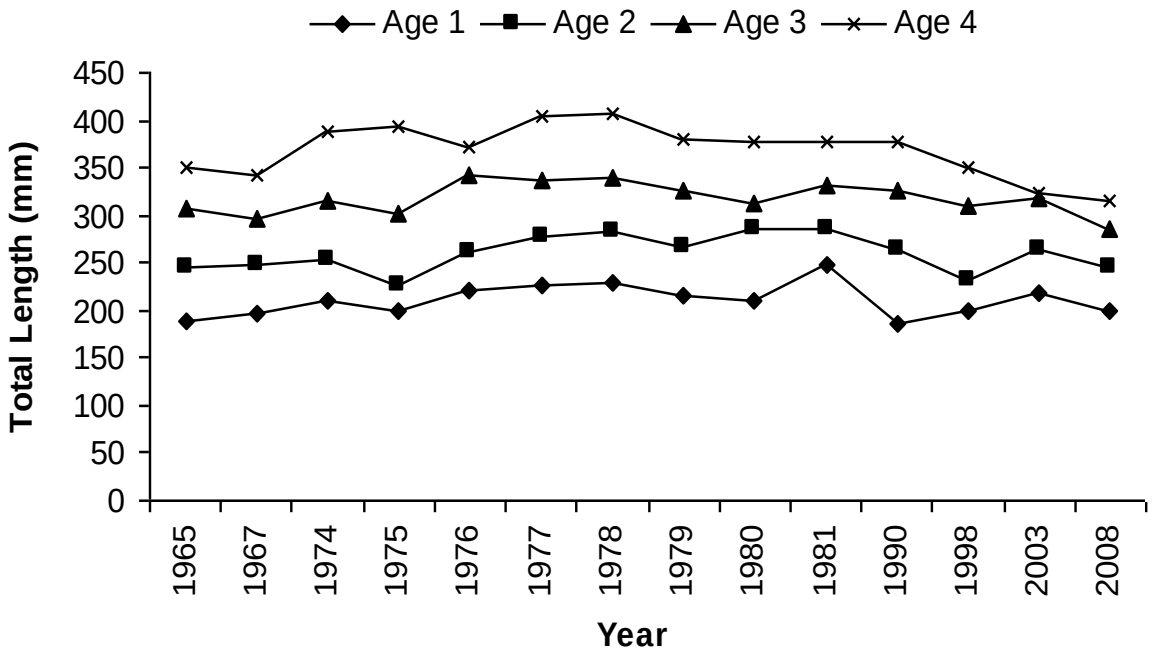

Figure 12: Mean length at age of juvenile (age 1-4) walleye in Redgut Bay of Rainy Lake, 1974-2008.

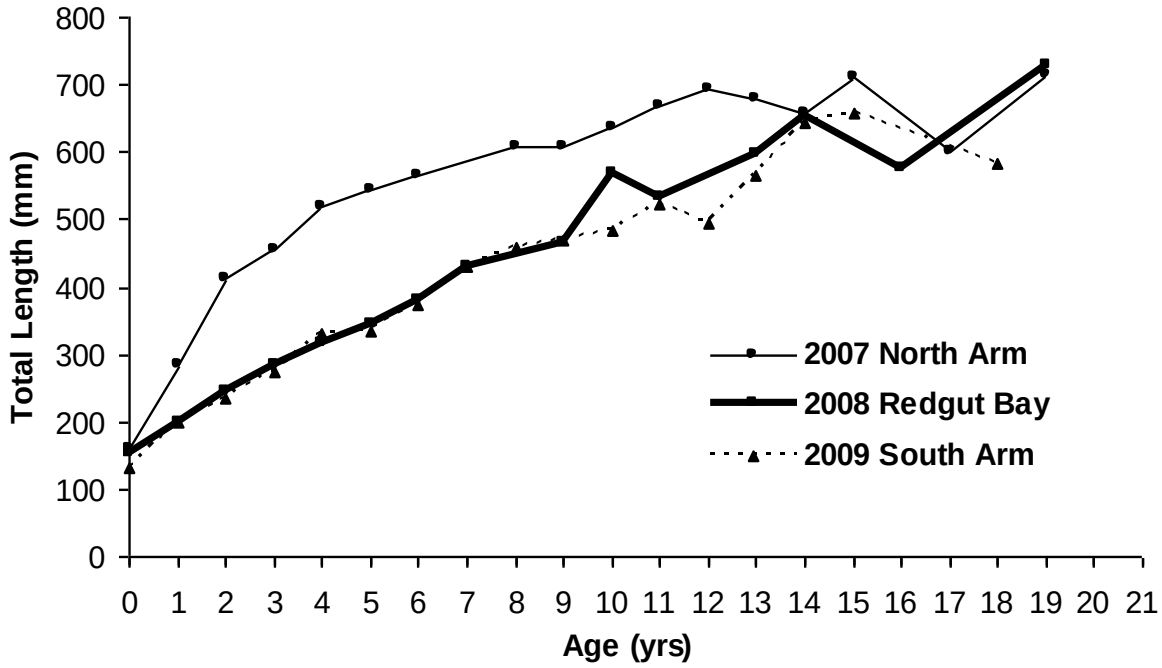

Figure 13: Mean length at age of walleye captured in Fall Walleye Index Netting (FWIN) for each basin of Rainy Lake, 2007-2009.

Shannon Diversity Index for adult females (age ≥5 years) in Redgut Bay was high (0.80) in 2008, and well above the benchmark indicative of healthy walleye populations in Ontario (≥0.66). Maturity schedules for walleye in the Redgut Bay were similar between the sexes, with females maturing at a slightly larger size and age than males. These small differences between the sexes were apparent when comparing total length at maturity (Figure 14) than age at maturity (Figure 15). The mean age at 50 % maturity was 5.24 years for males and 6.68 years for females. The mean total length at 50 % maturity was 355 mm for males and 435 mm for females.

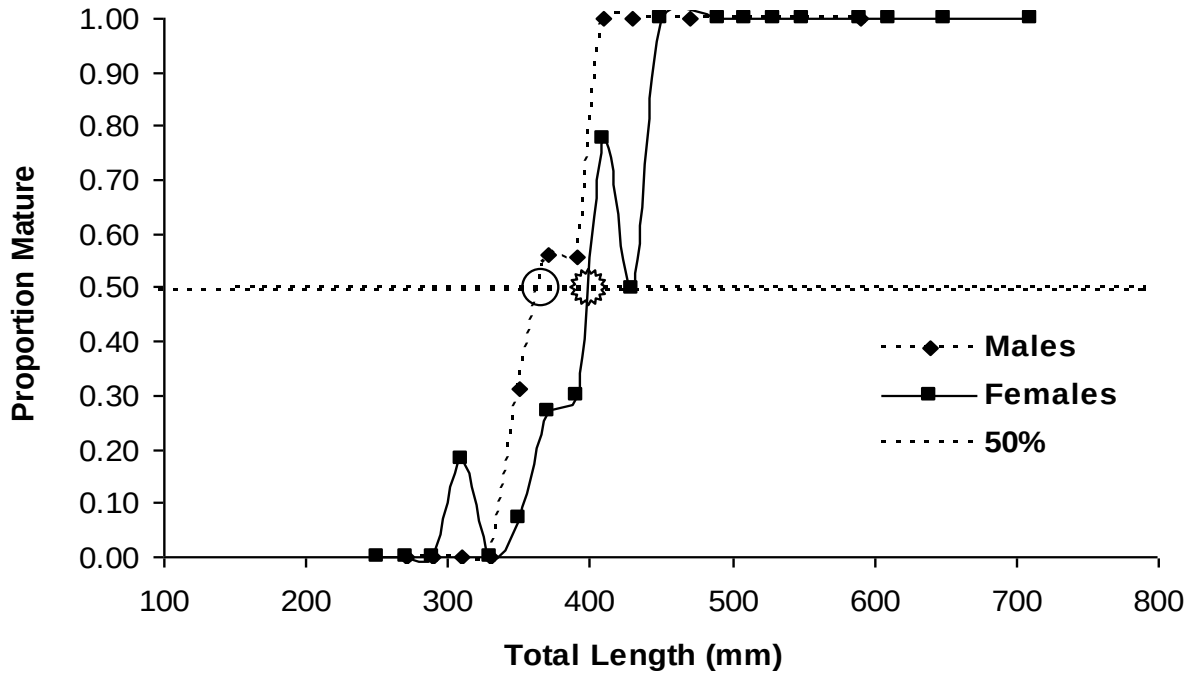

Figure 14: Maturity schedule (total length at maturity) of walleye in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008. Calculated length at 50 % maturity is indicated by (O) for males and (☼) for females.

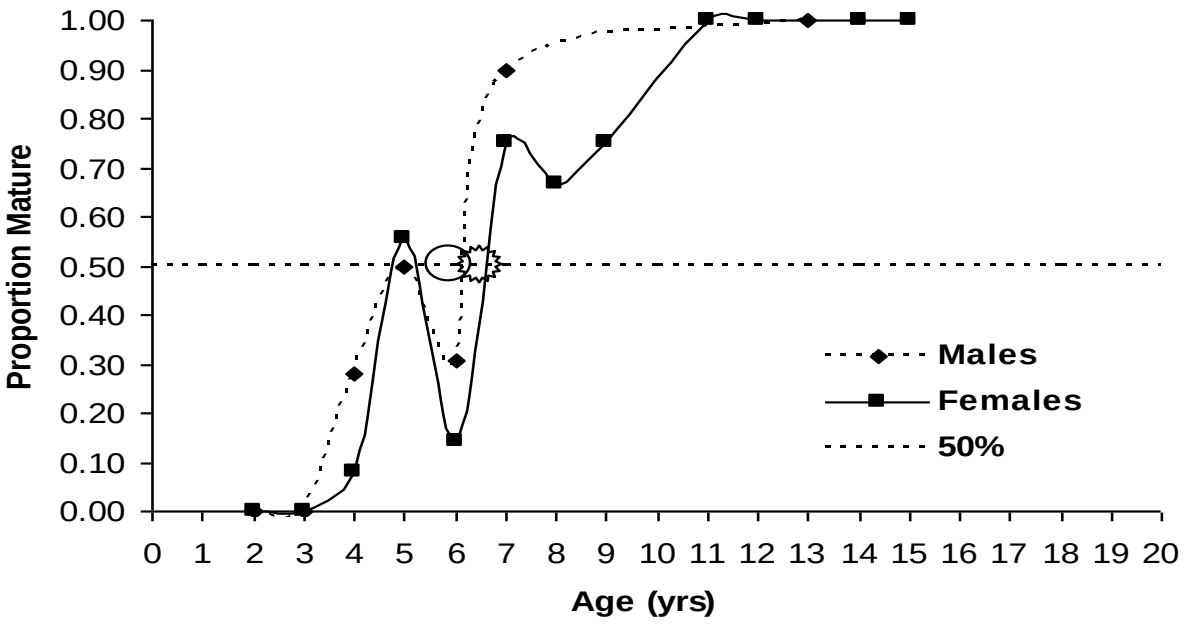

Figure 15: Maturity schedule (age at maturity) for walleye in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008. Calculated age at 50 % maturity is indicated by (O) for males and (☼) for females.

Fishing Quality Index (FQI) values based on Relative Stock Density (RSD) (Gabelhouse, 1984) were very low with a value of 29 for Redgut Bay walleye in 2008, unchanged from a value of 28 in 1998 and 2003. The RSD values for 'quality' walleye (380-510 mm), increased slightly from 1998 to 2003. 'Memorable' walleye (630-760 mm) actually increased in 2008 after a decline in 2003, but still account for only a small portion of the total stock.. No trophy fish (≥760 mm) were captured in any year based on the size parameters described. A summary of the RSD values for walleye populations in 1998, 2003 and 2008 is provided in Table 3.

Table 3: Relative Stock Density (RSD) values for walleye in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (1998 and 2003).

Category (Total Length)	1998	2003	2008
Quality (380-510 mm)	.185	.216	.197
Preferred (510-630 mm)	.074	.059	.070
Memorable (630-760 mm)	.019	.008	.019
Trophy (≥760 mm)	.000	.000	.000
FQI	**28**	**28**	**29**

Comparison to Northwest Ontario Walleye Benchmarks

Walleye catch per unit effort in Redgut Bay of Rainy Lake could be considered in the high average to high abundance category (~18 walleye/net) and was the 11th highest value observed in all other FWIN assessments conducted on Fort Frances District lakes since 1994 (Figure 14). The arithmetic mean walleye catch-per-unit-effort (17.8 fish/net) was above the Fort Frances District average (12.2 walleye/net), the Northwest Region large lake average (17.9 walleye/net), and the Northwest Region average for all lakes (14.1 walleye/net). Furthermore, this represented a 137% increase in the number of fish

relative to the 1998 FWIN. However, a large proportion (37 %) of the 2008 catch was from the 2006 year class (Figure 6).

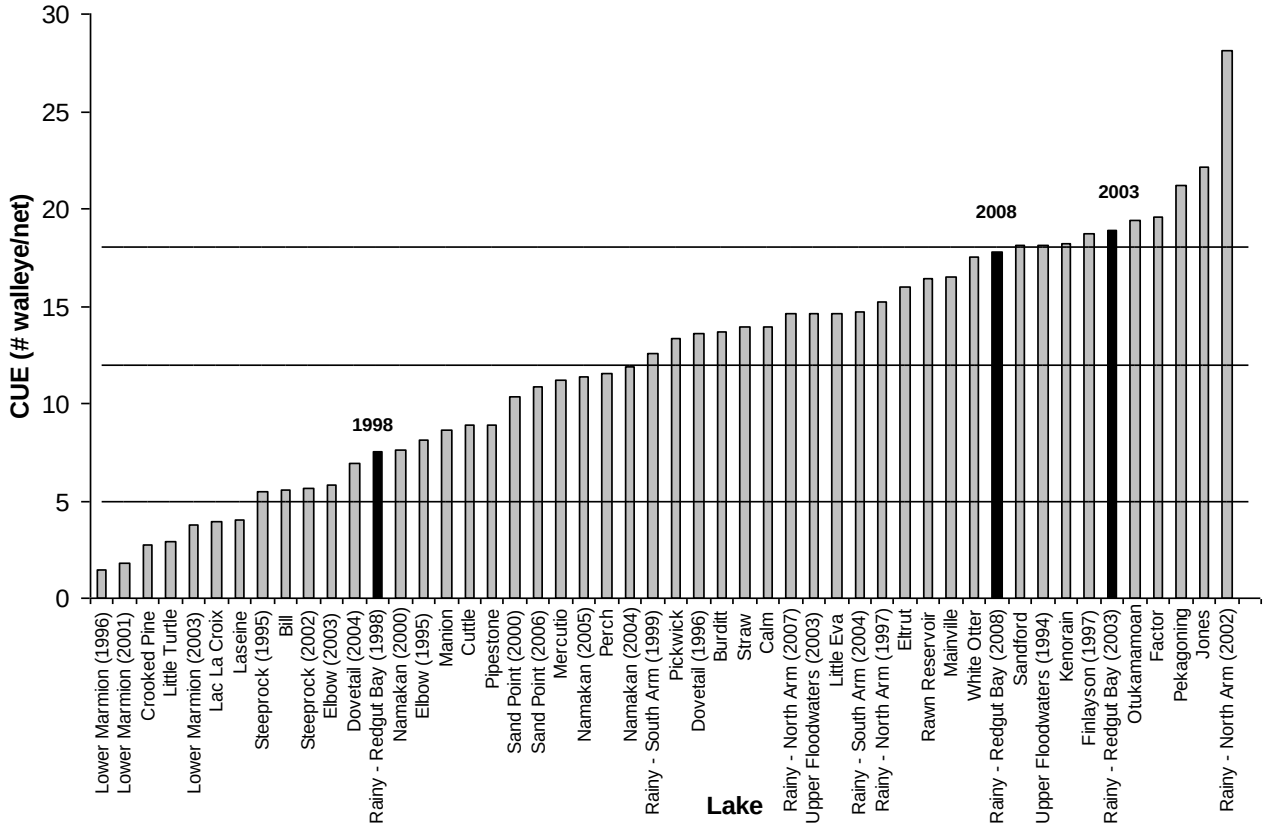

Figure 16: Comparison of walleye abundance in Redgut Bay of Rainy Lake with other Fort Frances District lakes using FWIN standards, 1994-2003. Walleye catch-per-unit-effort (CUE) between 0-5 are low, 5-12 low-average, 12-18 high average, and >18 high walleye abundance.

The geometric mean CUE for Redgut Bay walleye (12.8 fish/net) was very similar to the Northwest Region large lake mean of 13.1 fish/net, but exceeded the mean for all lakes of 10.7 fish/net. Although increasing since 1998, the geometric mean of catch of walleye ≥450 mm TL was still very low in 2008 at 0.9 fish/net, and is well below the large lake average of 2.5 fish/net for the Northwest Region. Relative to other Ontario waterbodies

and a benchmark CUE for walleye >450 mm of 2.0 fish/net (Figure 17), this would characterize the population as unstable or "stressed". The Shannon Diversity Index value of 0.80 indicated sufficient diversity in adult female age classes to be considered a healthy population (>0.66). However, the mean age (3.30 years) still falls well below the average for healthy populations of 4.20 years and greater, and below the NW Regional average. A summary for 1998, 2003 and 2008 FWIN assessments on Redgut Bay is presented in Table 4, with a detailed comparison of walleye population and life history parameters for the Northwest Region.

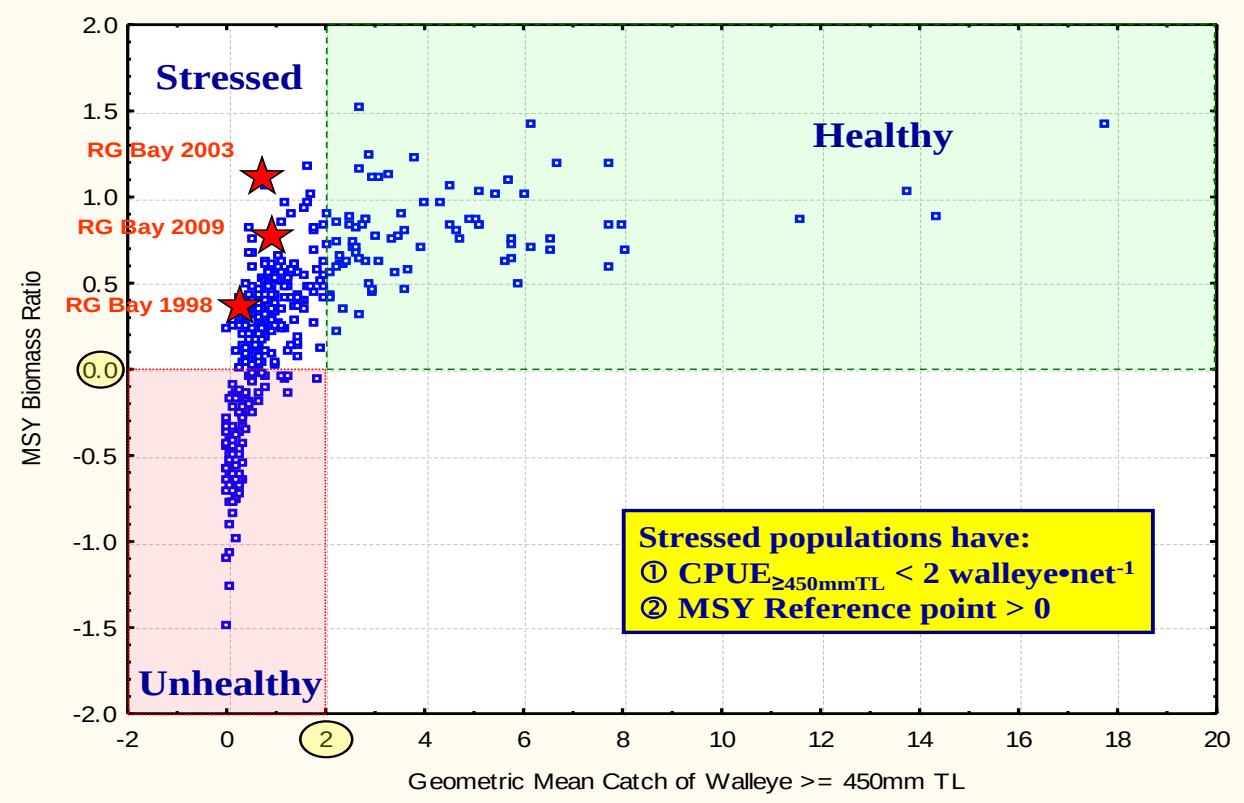

Figure 17: Comparison of walleye abundance (geometric mean catch of walleye >=450mm TL) in Redgut Bay of Rainy Lake to other Ontario lakes using FWIN standards, 1998-2008.

Table 4: Summary of Redgut Bay walleye population parameters based on FWIN standards, relative to NW Regional benchmarks.

VARIABLE	NW MEAN (all lakes)	NW MEAN (large lakes)	REDGUT BAY (2008)	REDGUT BAY (2003)	REDGUT BAY (1998)
SECCHI (m)	3.0	2.7	2.1	2.1	2.1
MEI	8.7	6.4	5.1	5.1	5.1
MSY (kg/ha/yr)	-	-	0.90	0.90	0.90
MSY Ref. (log_{10} FWIN/MSY)	-	-	0.78	1.15	0.39
DEGREE DAYS (GDD> 5C)	1415	1432	1646	1646	1646
MEAN CUE (kg/net)	-	-	5.40	6.04	2.19
MEAN CUE (#/net)	**14.1**	**17.9**	**17.8**	**19.5**	**7.5**
CUE ≤300 mm	4.1	5.9	11.3	10.5	4.4
CUE ≥350 mm	7.5	8.0	3.5	5.2	1.5
CUE ≥450 mm	3.1	3.5	1.3	1.0	0.3
MEAN CUE (walleye & sauger)	-	20.3	22.0	23.5	10.4
MEAN CUE (GEO) (#/net)	**10.7**	**13.1**	**12.8**	**13.7**	**6.5**
CUE ≥450 mm (GEO) (#/net)	**3.2**	**2.5**	**0.9**	**0.6**	**0.2**
TL @ 50% MATURITY ♀ (mm)	441	458	435	398	-
AGE @ 50% MATURITY ♀ (yrs)	4.80	5.24	6.68	6.28	-
TL @ 50% MATURITY ♂ (mm)	**356**	**369**	**355**	**365**	**371**
AGE @ 50% MATURITY ♂ (yrs)	3.49	3.81	5.24	5.76	4.99
MALE MORTALITY (5+ yrs)	0.30	0.29	0.30	-	0.19
FEMALE MORTALITY (5+ yrs)	0.28	0.30	0.27	-	0.11
MORTALITY >300 mm	-	0.34	0.28	0.33	0.44
TOTAL MORTALITY (A)	-	-	0.28	0.30	0.28
NUMBER OF AGE CLASSES (all)	-	14	15	14	12
NUMBER OF AGE CLASSES (n>1)	**10**	**13**	**12**	**11**	**5**
MEAN AGE (yrs)	**4.20**	**3.89**	**3.30**	**3.16**	**3.16**
MAXIMUM AGE (yrs)	**16**	**18**	**19**	**15**	**13**
AGE CLASSES >8	5	8	7	5	4
AGE CLASSES >10	4	6	5	4	2
SHANNON INDEX (mature females)	**0.65**	**0.79**	**0.80**	**0.80**	**0.30**
PRE_MATURATION GROWTH (h)	89	90	57	68	70
FEMALE BRODY COEFFICIENT (K)	**0.155**	**0.158**	**0.132**	**0.128**	**-**
FEMALE TL inf (mm)	**733**	**741**	**785**	**736**	**-**
MALE TL inf (mm)	**613**	**635**	**621**	**553**	**553**
FISHING QUALITY INDEX (FQI)	-	-	29	28	28
MEAN TOTAL LENGTH (mm)	**376**	**351**	**288**	**294**	**289**
MEAN ROUND WEIGHT (grams)	705	-	304	310	287
TL @ AGE 2 (mm)	302	293	245	264	234

HEALTHY

STRESSED

UNHEALTHY

Walleye life history characteristics in Redgut Bay for 2008 were largely consistent with the Regional averages. The population is average to late maturing indicated by the age and length at maturity of both sexes (Table 4). Pre-maturation growth rate (h) was 57 mm/yr and lower than 2003 and 1998 values of 68 and 70 mm/yr, but well below the Regional benchmark value (89-90 mm/yr).

OTHER FISH SPECIES

Northern pike were captured at an average of 1.5 fish/net on Redgut Bay (n = 30), which represents a decrease in CUE from the 2003 FWIN (2.2 pike/net). Although direct comparisons are invalid (McLeod et al., 2004), the average number of pike caught in FWIN nets was lower than previous index netting efforts (Figure 18). The long-term mean of 3.7 pike/net from index netting (1965-98) was considerably higher than FWIN.

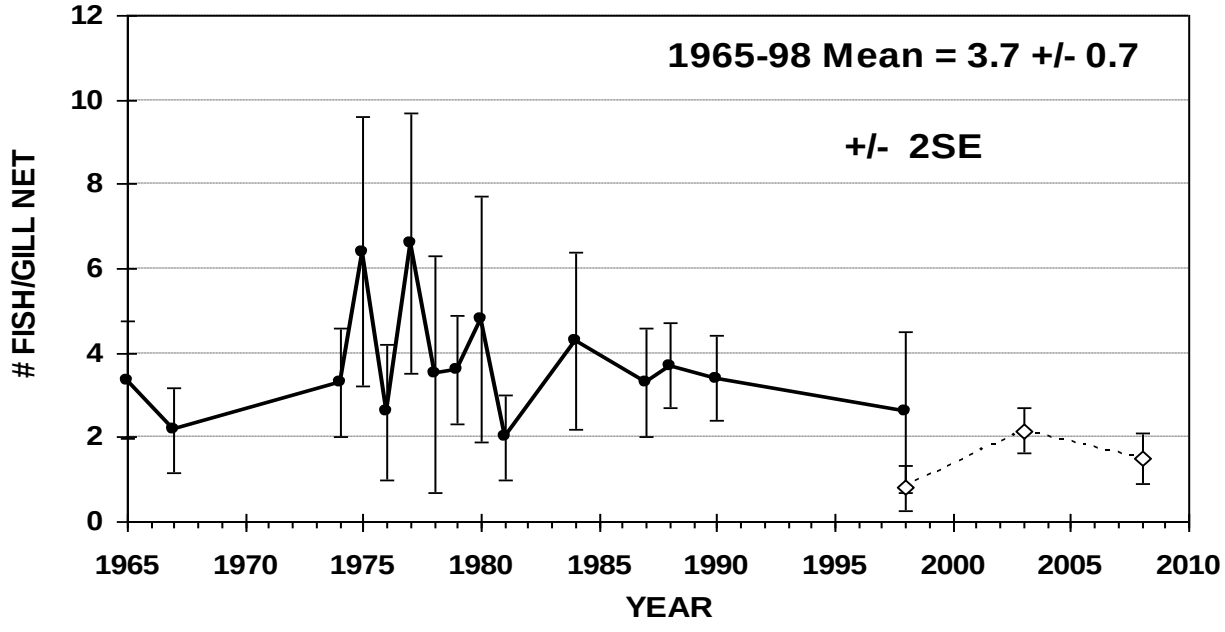

Figure 18: Historical abundance of northern pike based on catch-per-unit-effort from index netting (1965-1998) and Fall Walleye Index Netting (1998, 2003, 2008).

Pike captured in the 2008 FWIN ranged in age from 2-10 years, however a number of older year classes (11-15 years) were absent (Figure 19). The catch was dominated by age 3 fish (2005 year class), which accounted for 20 % of the total catch. The mean age of catch in the 2008 FWIN was 5.20 years (SE=0.41). The poor representation of older year classes is consistent with the length distribution, which was relatively evenly distributed, with no fish greater than 940 mm in total length (Figure 20). Three fish were captured from the 'trophy' class (>900 mm TL), with the largest fish having a total length of 931 mm. The mean total length was 676 mm (SE = 30) based on a sample of only 30 fish. The mean weight of northern pike sampled was relatively high at 2.23 kg (SE = 0.29) compared to only 1.40 kg in 2003. However, the largest fish caught weighed only 5.04 kg (11.1 lbs) compared to 7.59 kg (16.7 lbs) in 2003. The growth rate of northern pike in Redgut Bay was rapid during the first two years; with age 2 fish exceeding 429 mm in total length. Growth increments in subsequent years were relatively consistent, with an overall decrease in growth rate as age increases (Figure 21).

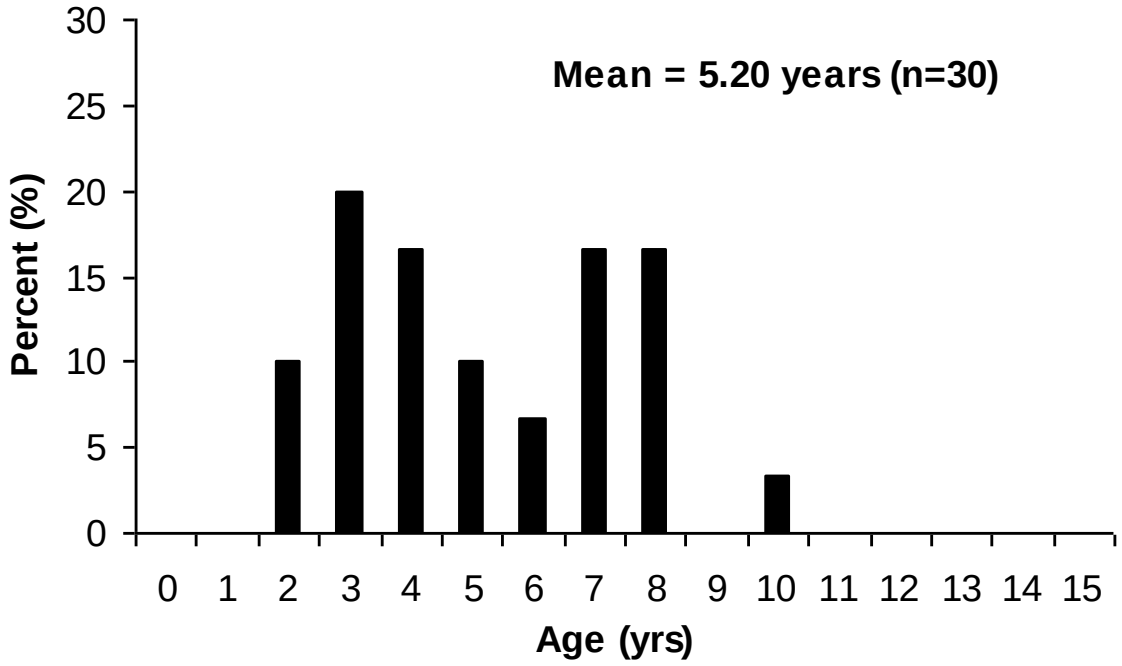

Figure 19: Age composition of northern pike in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

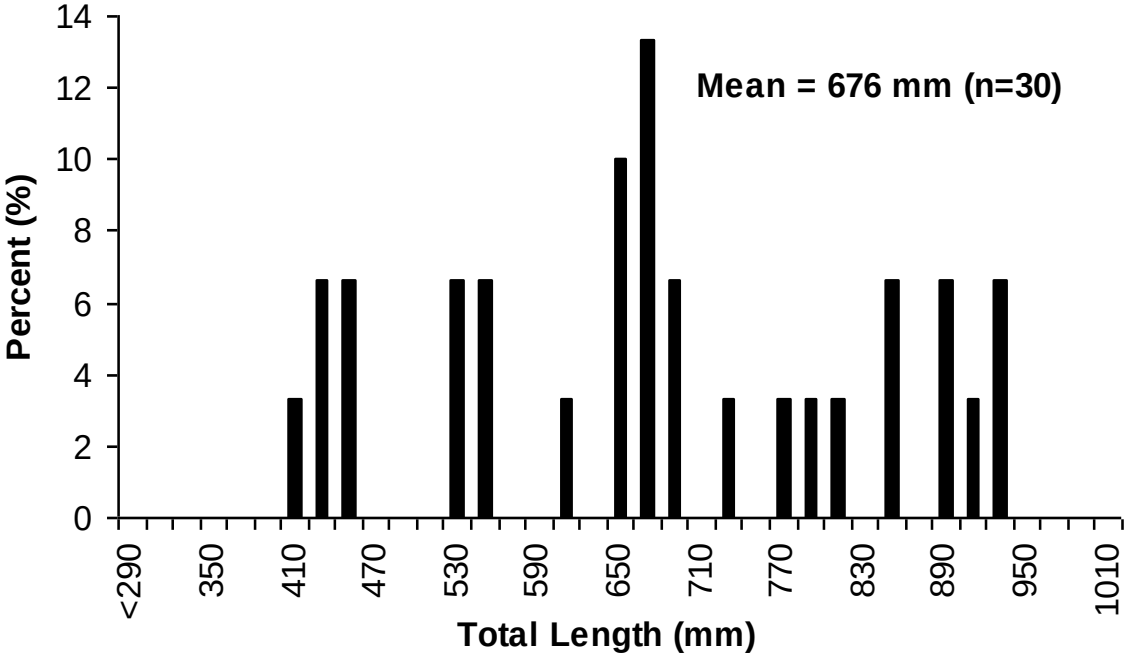

Figure 20: Length composition of northern pike in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

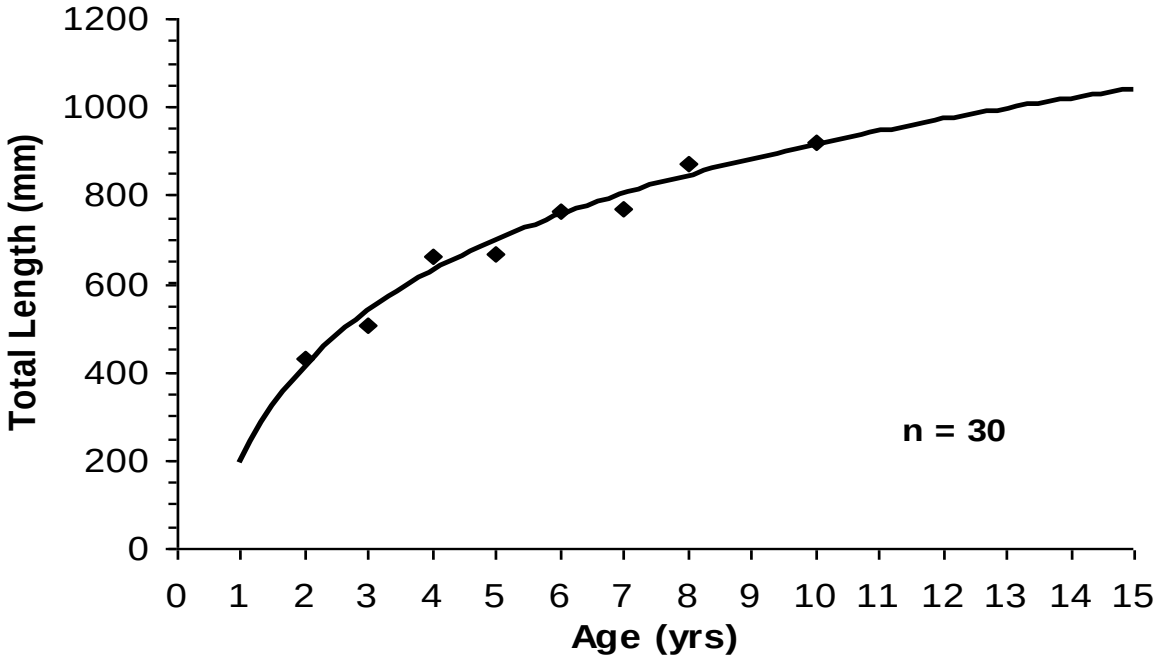

Figure 21: Growth (mean total length at age) of northern pike in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

A smallmouth bass CUE of 0.90 fish/net (SE = 0.27) in the 2008 FWIN represented a steady decline from the 2.92 fish/net observed in the 1998 FWIN. The mean CUE in 2008 was similar to the long-term (1965-1998) from index nets of only 1.0 fish/net. Overall abundance appears to have been increased steadily from 1975 to a peak abundance in 1998.(Figure 22).

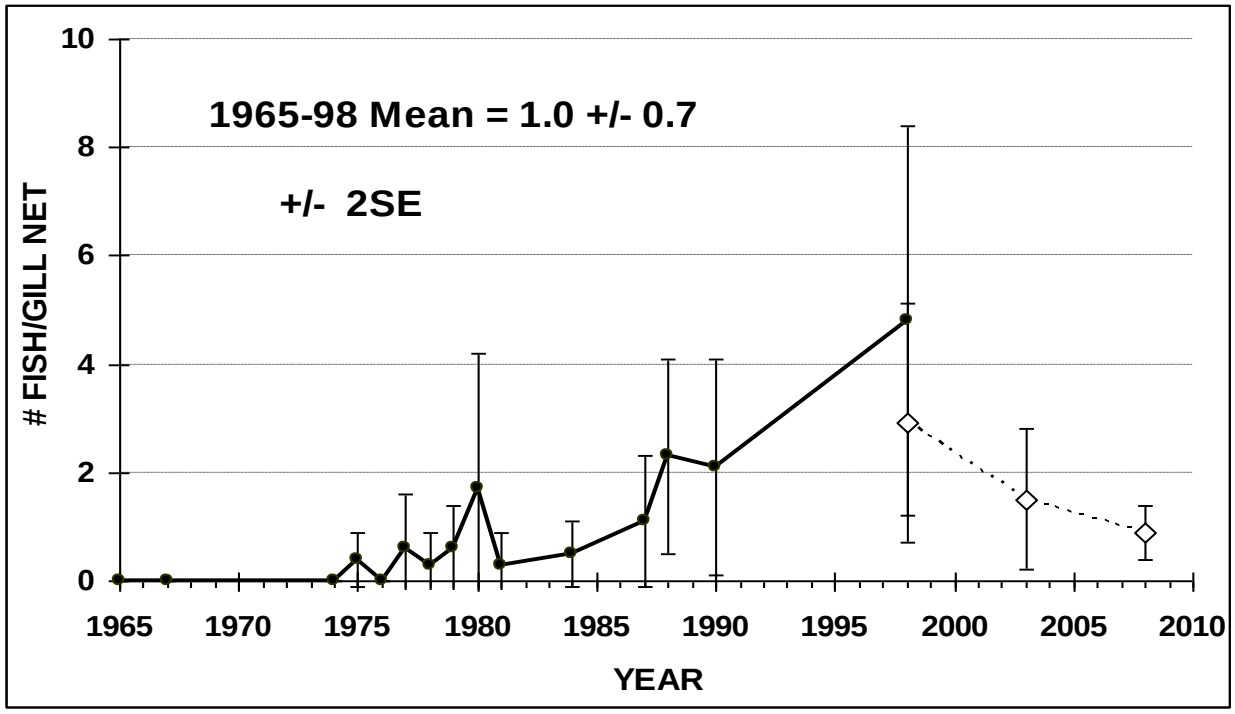

Figure 22: Historical abundance of smallmouth bass based on catch-per-unit-effort from index netting (1965-1998) and Fall Walleye Index Netting (1998, 2003, 2008).

Smallmouth bass ranged in age from 1 to 13 years; although sample size was limited to only 17 fish (Figure 23). Age classes 1-3 were generally well represented, with no fish observed in ages 7 to 9 years (2001-2003 year classes). Smallmouth bass catch was not dominated by any particular age class, and no age 15 fish were sampled from a very weak year class known from 1993. The mean age of smallmouth bass in the sample was high at 5.71 years (SE= 0.90), however sample size was very limited.

The length composition of smallmouth bass is reflective of the age distribution. Size distribution was limited by sample size and ranged from 180-500 mm, with the largest bass having a total length of 495 mm (Figure 24). The largest proportion of fish sampled was in 5 different size classes, with no size class representing more than 12% of the

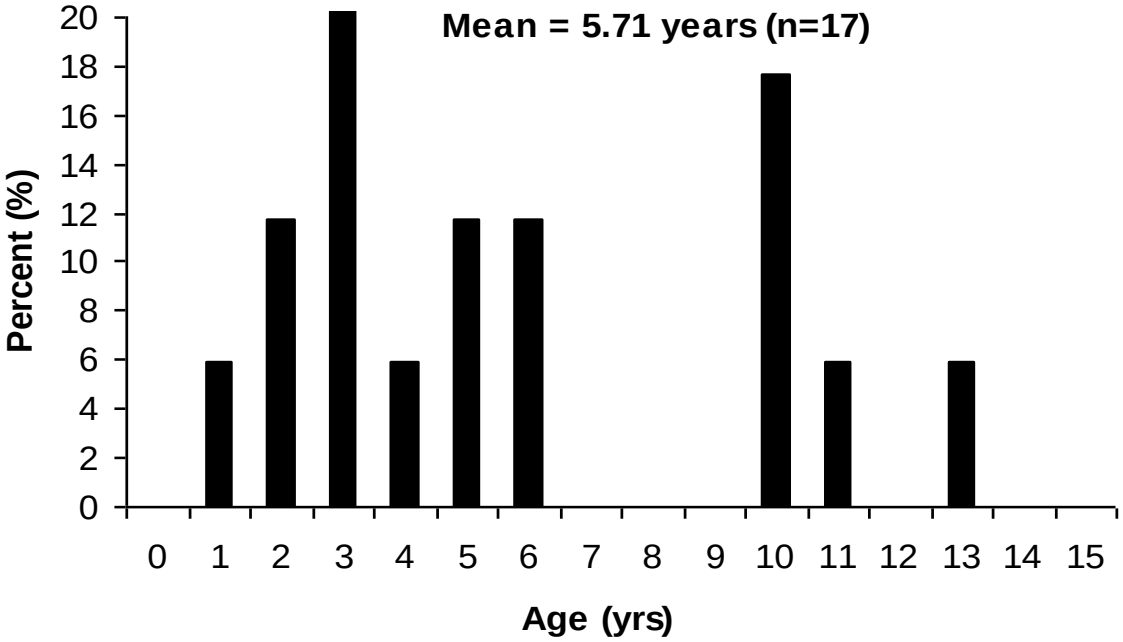

Figure 23: Age composition of smallmouth bass in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

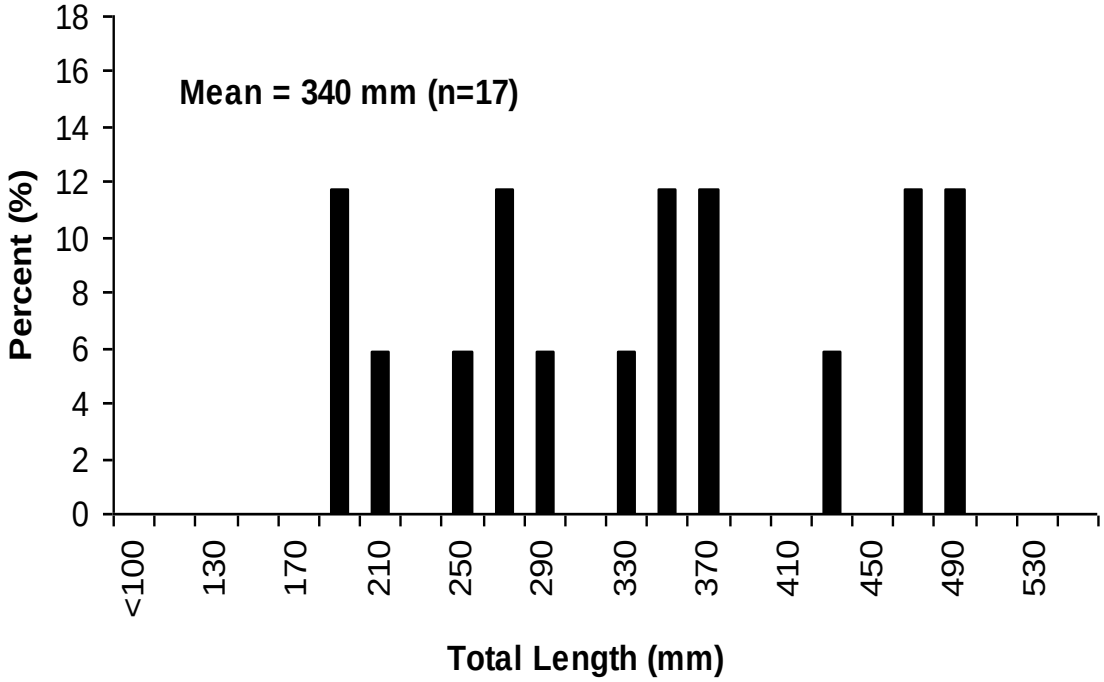

Figure 24: Length composition of smallmouth bass in Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

sample. A length frequency distribution for all fish species sampled has also been provided in Appendix 2.

The growth rate of smallmouth bass in Redgut Bay shows a trend similar to other fish species. Growth is rapid during the first few years, with a gradual levelling off beyond age six (Figure 25), as adult bass presumably begin to invest more heavily in reproduction rather than growth.

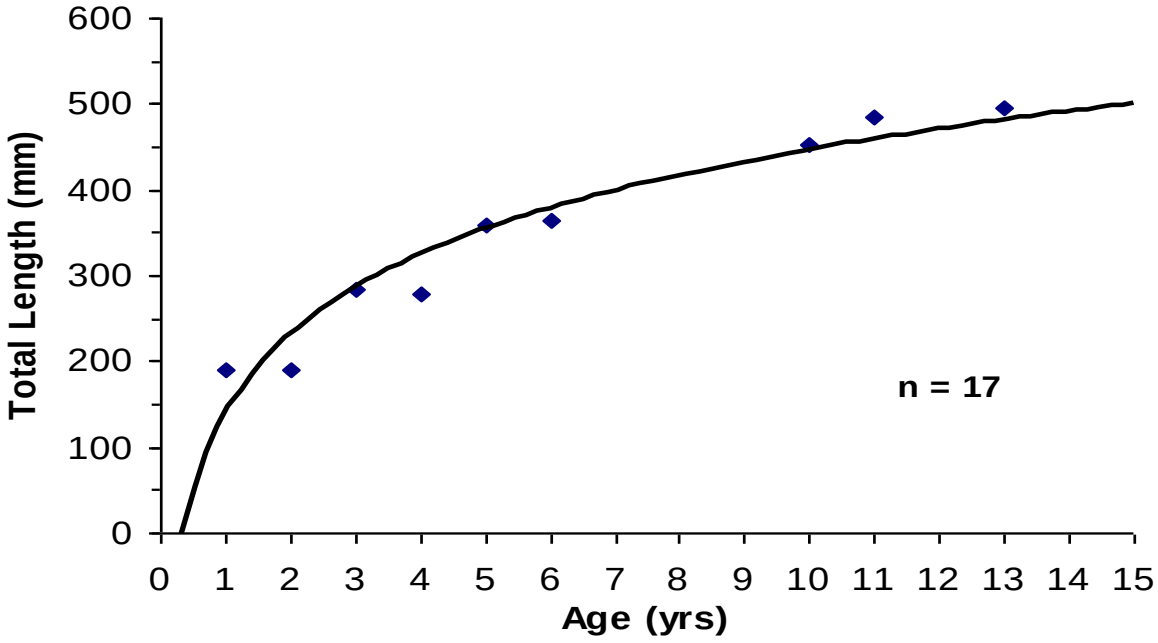

Figure 25: Growth (mean total length at age) of smallmouth bass from the Redgut Bay of Rainy Lake based on Fall Walleye Index Netting (FWIN), 2008.

Redgut Bay also provides a fishery for other fish species including sauger, muskellunge and black crappie. Sauger were well represented in the FWIN with a total of 85 fish with an arithmetic mean CUE of 4.25 fish/net (SE = 1.10). In combination with walleye, this provides a total CUE of 22.0 fish/net, which exceeds the Northwest Region large lake

average of 20.3 walleye & sauger/net. Sauger were rather small in size with a mean total length of 223 mm (140-343 mm) and a mean round weight of only 0.09 kg (range 0.02-0.26 kg).

A total of 2 muskellunge were also captured in the 2008 FWIN nets for only the second time in any index netting efforts since 1965. Three muskellunge were also captured in 2003. The two fish captured in 2008 were 5 and 15 years of age, with total lengths of 835 and 1217 mm and round weights of 3.79 and 15.5 kg (34.1 lbs). Black crappie were captured in gill nets with a mean CUE of 1.7 fish/net. From this sample of 33 fish, mean total length was estimated at 239 mm (74-310 mm) with a mean round weight of 0.25 kg (0.01-0.52 kg). A summary of total length composition for all remaining fish species sampled has been provided in Appendix 2.

DISCUSSION

A diverse fish community was sampled in Redgut Bay of Rainy Lake, with a number of predator and prey species, although catch by number was dominated by the three percid species (walleye, yellow perch, and sauger). Other species known to compete with walleye such as northern pike, muskellunge, smallmouth bass, lake whitefish, and black crappie were also present. The higher abundance of yellow perch (9.1 fish/net) likely provides an important prey resource for adult walleye (Scott and Crossman, 1998). Unlike the other basins of Rainy Lake, neither rainbow smelt nor brown bullhead have ever been captured in index nets from Redgut Bay. However, two muskellunge were captured for only the second time in index netting efforts on Rainy Lake since 1965.

The initiation of the fisheries assessment program on five-year rotation (M^{c}Leod, 2002) provides an excellent opportunity to monitor changes in fish population structure and life history parameters through time. Data from the 2008 FWIN project on Redgut Bay can be compared to data from previous studies using standardized methodology on the other basins, and most importantly to previous index netting efforts on Redgut Bay. However, it is recognized that the lower number of historical sample sites (n=10) have produced wide confidence intervals (Figure 2), and have made interpretation of long-term trends in abundance difficult.

In 2003 and 2008, 20 nets were set in Redgut Bay, an increase from the 12 nets set during the 1998 FWIN. This increased sample size ultimately did not improve the percent relative standard error (%RSE), which was 16.8 % for walleye in 2008 and 17.4% in 1998. However, total mortality and sample size for walleye did increase with the additional nets sites. The 355 walleye captured in 2008 (n=390 in 2003) exceeded the provincial recommendation of 200-250 walleye (Morgan, 2002). Although currently not an issue, the increase in sampling mortality may become more important in future FWIN assessments on Redgut Bay as the abundant, younger age classes continue to mature.

Rapid early growth and early maturity are often characteristic of exploited fish populations (Lester et al., 2000). These life history parameters are known to act as a compensatory mechanism for exploitation allowing populations to mature earlier and invest more heavily in reproduction as populations decline. Generally, the life history characteristics of the walleye population in the Redgut Bay did not deviate from the

Northwest Regional means, and generally show improvements compared to the 1998 and 2003 FWIN studies (Table 4). Walleye in the Redgut Bay show lower size at maturity for females and higher age at maturity for both sexes relative to Northwest Region averages. The number of age classes, maximum age, maximum total length ($L\infty$), and age at maturity for both sexes has all increased relative to the 1998 FWIN. Shannon Diversity Index values have increased considerably as well, indicating greater diversity of adult females and presumably a more stable spawning population. This data suggests that regulation changes made to improve walleye populations, and/or environmental variables are providing Redgut Bay walleye populations with the opportunity to recover. However, the absence of data associated with fecundity and relative condition pose limitations on the ability to draw definitive conclusions regarding reproductive investment of walleye populations from 1998 to 2008.

The most positive signs regarding the status of Redgut Bay walleye population are the much higher catch rates (number of fish per net) relative to 1998, and to other Fort Frances District waterbodies. Compared to 1998, the overall catch by number has increased by 97 %, which appears to be driven by very strong year classes from 2001 and more recently (e.g. 2006). This suggests the recovery of spawning stocks to some degree, and these stronger year classes will continue to provide a foundation for the future walleye production as they reach maturity. Along with the dramatic increase in the numbers of fish, the catch by weight also increased by 146 %.

Poor year classes in 2000, and possibly 2002, are cause for some concern, although both are likely naturally occurring. The 2000 year class appeared to be weak on other District lakes including the North Arm of Rainy Lake (McLeod and Taillon, 2003), Little Turtle Lake (Taillon and Fox, 2003), and Namakan Reservoir (Taillon, 2003), suggesting that large scale environmental factors may be limiting recruitment in some years (e.g. spring warming or water levels). Inconsistent recruitment is characteristic of many walleye populations under various levels of exploitation, and must be considered in the development of future management strategies. Factors known to contribute to low levels of recruitment and/or poor year classes include low abundance of spawning fish (Colby et al., 1979), the absence of suitable spawning habitat (Auer and Auer, 1990), spring warming rate and weather conditions (Busch et al., 1975; Koonce et al., 1977; Madenjian et al., 1996; Hansen et al., 1998), and/or cannibalism by adults (Forney, 1976). A number of fish species known to compete with, or prey upon, larval walleye are present in Rainy Lake, and collectively may limit the reproductive success of individual year classes.

Johnston (1997) also determined that the energetic demands of reproduction are so high that many females are unable to obtain sufficient resources to spawn on consecutive years. The average growth rate of adult walleye in Redgut Bay suggests that food resources are not likely the limiting factor on recruitment. Walleye fecundity and spawning success is positively related to female body size (Johnston, 1997), and the continued low catch of larger (>450 mm) and older fish (particularly females) may be contributing to inconsistent recruitment. The mechanism for poor year classes is likely dependent on the interaction between the physical, environmental and biological

characteristics at a given time. Clearly, the fishery must be managed to improve the abundance of older, larger fish to help contribute to future recruitment.

Further comparisons of walleye population structure of Redgut Bay walleye does raise some concern. Mean age and mean CUE of fish ≥450 mm, are both below mean values for the Northwest Region (Morgan et al., 2003). Overall, a mean age of 3.30 years is also low enough to be of concern and mean CUE ≥450 mm falls below the Regional averages. In addition, pre-maturation growth rates are lower than average, and subsequently age at maturity is higher than average. The Redgut Bay walleye population has shown significant improvement since 1998 and past levels of exploitation, and is currently showing very few signs of stress. A proposed Walleye Benchmark Classification Key would suggest the population is recovering well and approaching a healthy state with an overall score of 2.75 (G. Morgan, pers. comm.).

The catch rate of large fish (≥450 mm) was generally below the Northwest Regional means for walleye populations identified by Morgan et al. (2003), but has been increasing since 1998. A reduction in the number of adult fish reduces the quality of the spawning population and can contribute to recruitment variability. In addition, fishing quality and the economic value of the fishery is greatly reduced by the absence of large, 'memorable' or 'trophy' class fish. The Fishing Quality Index (FQI) value remains low at 29 in 2008, compared to 28 in for both 1998 and 2003.

The apparent recovery of walleye stocks that is occurring in all basins of Rainy Lake is encouraging, especially when considering that similar fisheries in the Northwest Region have been slower to recover. The catch in Shoal Lake (Lake of the Woods) has been dominated by young, fast growing and early maturing fish despite over 20 years of closure to recreational and commercial fishing. Forage for walleye in Shoal Lake was apparently abundant, and the factors inhibiting the recovery were unclear (Seyler, 2001; Gillies, 2002).

Growth curves, particularly those based on weight; do not show definite asymptotic curves typical of many fish populations, including walleye. This may be attributable to the absence of older fish (greater than 19 years old) from the sample. Growth of younger walleye appears to be slowing over time, particularly for age 3 and 4 walleye sampled since 1965.

Sauger continue to show good representation in the fish community of Redgut Bay, with a catch rate of 4.3 fish/net in 2008. With a mean summer secchi transparency of 2.1 m, the basin is probably well suited to sauger production with the species contributing a portion of the estimated annual yield of 7,600 kg/year (0.90 kg/ha/yr) for percids. However, the small average size of sauger (226 mm and 0.07 kg) currently provides limited angler harvest opportunities with only 113 kg harvested in 2002 (McLeod, 2003).

Northern pike and bass populations in Redgut Bay appear to be healthy and sustainable at existing harvest levels. Although catch rates of pike were lower than the long-term index

netting means, there was good representation from a number of size and age classes. Age composition of pike suggests total mortality after age 8 could be high, although gear selectivity has not been fully evaluated. The lower abundance of large pike relative to other lakes in the District (e.g. Little Turtle Lake – Taillon and Fox, 2003) and NW Region suggests that the pike fishery is currently producing as a quantity rather than a quality fishery. However, large trophy fishing opportunities are still available, since the combined angler, commercial and subsistence harvest of 1,500 kg/year (1997-2002) has been declining and remains well below the management objective of 4,000 kg/year (OMNR and MDNR, 2004). Changes to the pike angling regulations in Northwest Ontario in 1999 provide additional protection for large fish (700-900 mm), and evaluation of this protected slot should be incorporated in monitoring programs. The catch of two muskellunge (835-1217 mm total length) was very encouraging, and represents only the second catch of this species in index netting efforts since 1965.

Although smallmouth bass abundance appeared to increasing in Redgut Bay from 1975 to 1998, recent FWIN assessment might suggest that numbers are declining. Based on a very small sample of 17 fish in 2008, there appears to be good representation of age classes, with a mean age of 5.71 years. Angling for smallmouth bass remains an important component of the sport fishery in Redgut Bay, while providing a quality angling experience (OMNR and MDNR, 2004). Harvest of bass averaged only 300 kg from 1997-2002, and is well below the management objective of 500 kg/yr and potential yield of 1,000 kg/yr.

CONCLUSIONS

- Overall abundance of walleye is high with an arithmetic mean CUE of 17.8 fish/net (geometric mean of 12.8 fish/net), and represents a significant increase since 1998. The catch was still largely dominated by small and younger fish, with age two showing good representation from a strong, above average year classes in 2006. There has also been a significant increase in abundance from the long term (1965-98) index netting mean of 10.3 walleye/net.
- Catch rates of large adult fish (≥450 mm TL) increased relative to the 1998 FWIN, but are still below the Northwest Region averages and indicate a 'stressed' or unstable fishery.
- Most life history parameters, including number of age classes (12), maximum age (19), Shannon Diversity Index (0,.80), and age at maturity (5.24 years ♂, 6.68 years ♀) continue to show improvement relative to the 1998 and 2003 FWIN on Redgut Bay. A proposed Walleye Benchmark Classification Key for Ontario suggests the walleye population is improving, and is approaching a 'healthy/stable' state..
- The walleye population in Redgut Bay exhibits relatively low juvenile growth rates, but fish mature at ages that are slightly higher than other populations in Rainy Lake and the Northwest Region.
- Although total mortality rates remain relatively low at 28 %, existing levels of exploitation appear to be impacting the length composition of the population, especially of fish greater than 400 mm in size. Annual mortality is well below the level of 50 % which would entail high risk of instability or collapse (OMNR, 1983).

- The 2000 year class (8 years old) appears to be quite weak, consistent with previous assessments on the North Arm in 2002/2007 and the Namakan Reservoir in 2000. However, the 2006 year class (2 years old) appears strong based on the 2008 catch composition. Recruitment is variable but may be naturally occurring, or due to continued exploitation. Identification of the mechanisms for variation in recruitment should be the focus of future investigations.
- Reduced levels of exploitation and target harvest levels should be continued for all users, at least until harvest and effort is evaluated through creel surveys in 2010/11. A continuation of the restrictive size limits, fish sanctuaries, non-resident angling restrictions, no commercial quotas, as well as the new water level management regime introduced in 2000 (IRLBC, 1999) should all contribute to the continued recovery of walleye in Redgut Bay.
- Northern pike and smallmouth bass populations appear healthy from the limited diagnostics available. Further monitoring and interpretation is recommended, along with more detailed investigation of muskellunge and lake sturgeon populations.

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Appendix I: Fish Species Present in Rainy Lake, Ontario

Common Name	Scientific Name	MNR Species Code
Silver Lamprey	*Ichthyomyzon unicuspis*	013
Lake Sturgeon	*Acipenser fulvescens*	031
Lake Trout	*Salvelinus namaycush*	081
Lake Whitefish	*Coregonus clupeaformis*	091
Cisco (Lake Herring)	*Coregonus artedii*	093
Rainbow Smelt	*Osmerus mordax*	121
Northern pike	*Esox lucius*	131
Muskellunge	*Esox masquinongy*	132
Central Mudminnow	*Umbra limi*	141
Mooneye	*Hiodon tergisus*	152
Longnose Sucker	*Catostomus catostomus*	162
White Sucker	*Catostomus commersoni*	163
Silver Redhorse Sucker	*Moxostoma anisurum*	168
Shorthead Redhorse Sucker	*Moxostoma macrolepidotum*	171
Northern Redbelly Dace	*Phoximus eos*	182
Finescale Dace	*Phoxinus neogaeus*	183
Lake Chub	*Couesisus plumbeus*	185
Brassy Minnow	*Hybognathus hankinsoni*	189
Golden Shiner	*Notemigonus crysoleucas*	194
Emerald Shiner	*Notropis atherinoides*	196
Common Shiner	*Notropis cornutus*	198
Blackchin Shiner	*Notropis heterodon*	199
Blacknose Shiner	*Notropis herolepis*	200
Spottail Shiner	*Notropis hudsonius*	201
Mimic Shiner	*Notropis volucellus*	206
Bluntnose Minnow	*Pimephales notatus*	208
Fathead Minnow	*Pimephales promelas*	209
Blacknose Dace	*Rhinichthys atratulus*	210
Longnose Dace	*Rhinichthys cataractae*	211
Creek Chub	*Semotilus atrmaculatus*	212
Black Bullhead	*Ictalurus melas*	231
Brown Bullhead	*Ictalurus nebulosus*	233
Tadpole Madtom	*Noturus gyrinus*	236
Burbot	*Lota lota*	271
Brook Stickleback	*Culaea inconstans*	281
Ninespine Stickleback	*Pungituus pungitius*	283
Trout-Perch	*Percopsis omiscomaycus*	291
Rock Bass	*Ambloplites rupestris*	311
Green Sunfish	*Lepomis cyanellus*	312
Pumpkinseed	*Lepomis macrochirus*	313
Bluegill	*Lepomis macrochirus*	314

Appendix I: cont'd

Common Name	Scientific Name	MNR Species Code
Longear Sunfish	*Lepomis megalotis*	315
Smallmouth Bass	*Micropterus dolomieu*	316
Largemouth Bass	*Micropterus salmoides*	317
Black Crappie	*Pomoxis nigromaculatus*	319
Yellow Perch	*Perca flavescens*	331
Sauger	*Sander canadensis*	332
Walleye (Yellow Pickerel)	*Sander vitreus*	334
Rainbow Darter	*Etheostoma caeruleum*	337
Iowa Darter	*Etheostoma exile*	338
Johnny Darter	*Etheostoma nirgrum*	341
Logperch	*Percina caprodes*	442
Brook Silverside	*Labidesthes siculus*	361
Mottled Sculpin	*Cottus bairdi*	381
Slimy Sculpin	*Cottus cognatus*	382

Total Species: 55

Appendix II: Total length frequency distribution of fish species captured in 20 FWIN gill net sets on Redgut Bay of Rainy Lake, 2008.

Total Length (mm)	Walleye	N. Pike	SM Bass	Musk-ellunge	Yellow Perch	Lake Herring	Whitefish
0 – 99						1	
100-119					9	6	
120-139	8				2	6	
140-159	5				65	3	
160-179	6				39	17	
180-199	24		2		35	11	
200-219	31		1		11		
220-239	43				8	5	
240-259	49		1		9	3	
260-279	39		2		1	6	
280-299	21		1		2	13	1
300-319	24					6	1
320-339	24		1			1	1
340-359	16		2			3	
360-379	19		2				
380-399	11					1	
400-419	3	1				1	
420-439	2	2	1				
440-459	3	2				1	1
460-479	5		2				
480-499	1		2				1
500-519	3						
520-539	3	2					1
540-559	3	2					
560-579	2						
580-599							
600-619	1	1					1
620-639	1						
640-659	2	3					
660-679	1	4					
680-699		2					
700-719							
720-739	1	1					
740-759							
760-779		1					
780-799		1					
800+		8		2			
Total	**351**	**30**	**17**	**2**	**181**	**85**	**7**
Mean	**288**	**676**	**340**	**1026**	**174**	**225**	**432**
Min	**122**	**412**	**180**	**835**	**101**	**98**	**291**
Max	**729**	**931**	**495**	**1217**	**289**	**448**	**605**

Appendix II: (cont'd)

Total Length (mm)	White Sucker	Red-horse Sucker	Sauger	Rock Bass	Black Crappie	Mooneye	Spottail Shiner
0 – 99					2		
100-119				2	1		1
120-139				5			
140-159			10	4	1		
160-179			9	11			
180-199	2		11	23	1		
200-219	2		9	11			
220-239			9	3	10		
240-259			8		3		
260-279			11	1	7		
280-299	1		6	1	6		
300-319	3		5	1	2		
320-339	2		3			2	
340-359	2		1			1	
360-379	1					6	
380-399						4	
400-419	1						
420-439	8						
440-459	3						
460-479	2						
480-499	1	2					
500-519							
520-539							
540-559							
560-579							
580-599							
600-619							
620-639							
640-659							
660-679							
680-699							
700-719							
720-739							
740-759							
760-779							
780-799							
800+							
Total	**28**	**2**	**82**	**62**	**33**	**13**	**1**
Mean	**370**	**495**	**226**	**185**	**239**	**366**	**100**
Min	**182**	**494**	**140**	**100**	**74**	**325**	**100**
Max	**484**	**495**	**343**	**304**	**310**	**399**	**100**