BURBOT POPULATION ASSESSMENT

PINE LAKE

2012

Prepared by:
Oliver Barker

Yukon
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Copies available from:

Yukon Department of Environment
Fish and Wildlife Branch, V-5A
Box 2703, Whitehorse, Yukon Y1A 2C6
Phone (867) 667-5721, Fax (867) 393-6263
Email: environmentyukon@gov.yk.ca

Also available online at www.env.gov.yk.ca

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Summary

Environment Yukon has developed methods for estimating burbot population abundance in lakes. Along with harvest data collected from set-line harvest reports and angler harvest surveys, these population estimates can be used to assess the sustainability of Yukon's burbot fisheries.

We surveyed Pine Lake using mark-recapture methodology, with an initial marking session in May and June 2012, and a recapture session in October 2012.

We captured and marked 205 burbot that were 350 mm total length or longer during the spring capture session. Of the 427 burbot 350 mm total length or longer captured in the autumn recapture session, 70 were burbot that had been marked in spring. The abundance estimate for burbot 350 mm total length or longer was 1,236 (95% CI 1,005 – 1,531), or 2.05 burbot / hectare (ha).

Key Findings

- Pine Lake is a small, productive lake, with a lower-than-expected abundance of burbot, suggesting that the population is depleted.
- Burbot in Pine Lake are relatively small, with a mean total length of 514 mm and weight of 1,017 g, and feed mainly on invertebrates.
- The average age of sampled burbot from Pine Lake was 14, and ranged from 11 to 19.
- Pine Lake burbot did not gain length over the summer, and their condition declined significantly over that time.

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Introduction

Burbot are a commonly-harvested Yukon fish, with most of the recreational harvest occurring in winter. Burbot are also the specific target of a set-line fishery. Reports of declines in burbot size and abundance in some popular fishing areas, combined with measured declines in burbot abundance in other jurisdictions, has prompted concern over the state of Yukon burbot populations. In response, Environment Yukon has begun to assess burbot abundance using mark-recapture methodology.

The mark-recapture methodology has 3 phases:

- an initial capture and marking session;
- a sufficient period of time for marked and unmarked fish to thoroughly mix; and
- at least one subsequent recapture session, when the catch is examined for burbot marked in the previous capture session or sessions.

Burbot mark-recapture surveys provide us information on:

- estimated current burbot density and abundance in a lake;
- changes in burbot density and abundance from previous surveys;
- length and weight of individual burbot;
- growth rates of recaptured burbot; and sex, age and diet of any burbot killed in late May and early June 2012

We used modified black-cod traps to capture burbot in Pine Lake. Each burbot was uniquely marked and released. Marked fish were then allowed to mix with unmarked fish over the summer and in mid-October 2012 we used the same traps to search for marked burbot.

Study Area

Pine Lake is near the community of Haines Junction along the Alaska Highway (Figure 1). It is in the traditional territory of the Champagne and Aishihik First Nations. The lake is approximately 5.5 km long and covers an area of approximately 603 ha. It has a mean depth of 14.7 m and a maximum depth of 28 m. The drainage basin upstream of Pine Lake is very small and the lake is fed chiefly by Marl Creek and a few other small, unnamed creeks. The lake drains via Pine Creek into the Dezadeash River, part of the Alsek River watershed. Pine Lake has a number of permanent residences along the north shore. It also has a government campground with boat launch and a popular day use area on the southwest side. In addition to burbot, fish species present in the lake include lake trout, northern pike, Arctic grayling, and lake whitefish.

A daily catch limit of 10 and a possession limit of 20 were applied to burbot in Yukon in 2003. Before 2003, burbot were not considered a game fish, and there were no daily catch or possession limits.

Environment Yukon began managing Pine Lake under Special Managements Waters regulations in 2004, which introduced mandatory use of barbless hooks. Burbot daily catch and possession limits (10 and 20) remained the same as under General Regulations.

Methods

Estimating Abundance

Burbot abundance can be estimated using mark-recapture methodology. This involves marking burbot, releasing them, waiting a sufficient amount of time for marked individuals to mix with the unmarked population, and capturing a sample of marked and unmarked burbot. In instances where 2 capture sessions are used (an initial marking session and a subsequent recapture session) and the recapture is performed with replacement, the Bailey modification of the Petersen abundance estimate is appropriate (Seber 1982, Krebs 1999). The Bailey method calculates an abundance estimate, N_{est}, such that:

$$N_{est} = \frac{n_2 (n_1 + 1)}{(m_2 + 1)}$$

where n_1 = the number of burbot marked during the initial capture event;

n_2 = the number of burbot captured during the second capture event; and

m_2 = the number of marked burbot captured in the second capture event.

Appropriate methods for estimation of confidence intervals for Bailey mark-recapture abundance estimates vary depending on sample size and ratio of recaptured marks in the second capture session, and follow methods outlined by Seber (1982). In cases where $m_2 / n_2 \leq 0.10$, confidence intervals should be determined using Poisson distribution where $m_2 < 50$, and using the normal distribution where $m_2 > 50$. In cases where $m_2 / n_2 > 0.10$, the binomial distribution should be used. The Bailey method of mark-recapture abundance estimation requires that several criteria be met (see Appendix 1).

Burbot Capture and Handling

We used modified black-cod traps to capture burbot (Redden Custom Nets Ltd., Port Coquitlam, BC). Cod traps were 0.64 m tall, with a bottom diameter of 1 m and a top diameter of 0.69 m. Trap netting was knotless 1.3 cm bar mesh. Cod traps had a throat with a 25 cm wide opening extending from one side to the middle centre of the trap. A bait bag of plastic mesh was suspended from the centre top of the trap, and extended to the floor of the trap. Trap frames were constructed of 1.3 cm diameter metal bar. A bridle was attached to the top hoop of the cod trap. A buoy line without a weight was tied to the bridle. Cod traps used in this study were of the same design used in burbot stock assessments in British Columbia, Idaho and Montana (Giroux 2005, Prince 2007, Hardy et al. 2008, Horton and Strainer 2008).

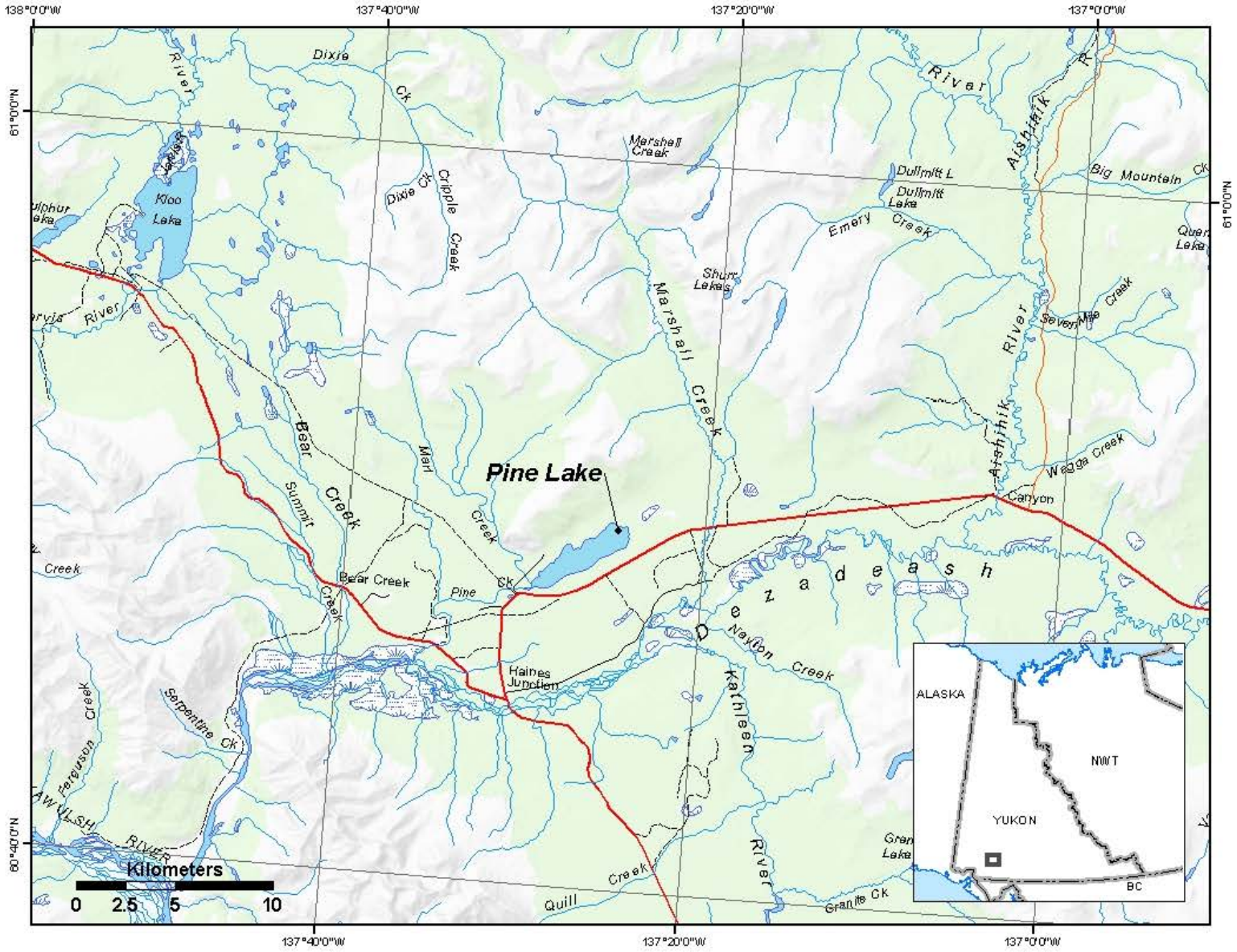

Figure 1. Location of Pine Lake Yukon

We baited each cod trap with about 500 g of frozen smelt and set them overnight. The first traps set in the morning were the first hauled the next morning, giving each trap an approximate 24 h soak time. Burbot are most active at night, so differences in soak time during days when traps are retrieved can be considered inconsequential, as long as all traps have been deployed for a full night (Bernard et al. 1993).

Traps were set throughout the lake at depths from 1 to 15 m; a maximum set depth of 15 m was used to prevent barotrauma (physical injury caused by pressure change in fish retrieved from depth) in captured burbot. To limit competition among adjacent traps, we set traps at least 125 m apart (Bernard et al. 1993, Schwanke 2009).

Burbot catch rates are highest in spring and autumn, just after and just before ice cover, and lowest in summer (Bernard et al. 1993). An initial capture event should be scheduled for just after ice-out or just before freeze-up. The subsequent capture period would typically happen at the next ice-out or freeze-up, but can follow in as little as 3 weeks if initial capture occurs after ice-out (Bernard et al. 1991, 1993). Our initial capture session in Pine Lake was 29 May – 1 June 2012, and our second capture session was 9 – 12 October 2012.

Burbot are sensitive to rapid changes in water temperature and pressure. To ensure high post-release survival, we immediately placed captured burbot in tubs of water. During the first 2 days of sampling, captured burbot held in tubs showed indications of temperature stress. To alleviate this, on all subsequent days we used high-flow pumps to continuously flush tubs with cold water drawn from lake depths of 5 – 8 m. Following handling, any burbot showing difficulty in returning to their original depth because of gas bladder expansion were released at depth using a mechanical deepwater fish release tool (West Marine, Watsonville, CA).

We recorded weight and total length for all burbot. The relationship between a fish's weight and length can be described by its condition factor (K) and is calculated as: $K = (\text{Weight (g)}/\text{Length (cm)}^3) \bullet 100$ (Ricker 1975). The heavier a fish is at a given length, the better its condition. At the individual level, K can be an indication of fish health. We averaged K over the entire catch and used it as an indication of overall condition of burbot within the population. We used a t-test to compare the length, weight, and condition factor of burbot between the first and second capture sessions. Any fish that died was sampled for age (using otoliths or ear "bones") and diet (stomach contents).

In the first capture session, we marked burbot 350 mm or longer total length with an individually-numbered spaghetti tag, inserted just behind the leading edge of the first dorsal fin. A redundant second mark, a clip removing the first 3 rays of the right pelvic fin, was used to establish tag loss rates. Fin clip

material was retained as archival genetic samples. We considered burbot less than 350 mm total length too small to tag.

Water temperature and dissolved oxygen can influence burbot distribution within a lake. We took temperature and dissolved oxygen profiles in the same location during both the first and second capture sessions, using a multi-parameter probe (YSI 600QS; YSI Inc., Yellow Springs, OH).

Results and Discussion

Temperature and Dissolved Oxygen

The temperature profile for early June showed that the lake was already strongly stratified, with the thermocline (zone of steep temperature gradient) between 9 and 10 m (Figure 2). Dissolved oxygen levels were high (> 10 mg/l) until a depth of 22 m, below which they declined sharply (Figure 3). Specific conductivity (a measure of dissolved nutrients in a lake), averaged among depths was 302 microSiemens per cm (µS/cm). The temperature profile for mid-October did not show a thermocline, with the lake nearly isothermal at 6 – 8°C (Figure 3). Dissolved oxygen levels were high (>12 mg/l) from the surface down to 15 m, below which they declined steadily (Figure 4). Average specific conductivity among depths was 263 µS/cm.

Capture Details – Spring Capture Session

Between 29 May and 1 June 2012, we captured 231 burbot in 87 trap-nights of capture effort (see Appendix 2 for set and capture locations, and Appendix 7 for capture details). Discounting the 8 trap-nights using traps set without fresh bait, and the 5 burbot caught in these traps, we calculated a mean CPUE (catch per unit effort) of 2.86 burbot/trap-night (SE = 0.55).

Of the 231 total burbot captures, 14 were instances of within-session recaptures of marked burbot, giving a total of 217 individual burbot caught. Total mortality was 11 burbot, and 1 burbot was considered too small to tag. In total, we marked and released 205 burbot in the spring capture session.

All burbot mortalities were within the first 2 days of sampling, before we implemented the cold-water circulation system. No further mortalities were experienced after we controlled water temperature in the holding tubs by flushing with cold water pumped from lake depths of 5 – 8 m. Almost no burbot were caught in the spring capture session in traps set shallower than 9 m (Figure 4). Catches of up to 20 burbot per trap-night were achieved in deeper sets. The shift in catch rate at depth corresponds with the steep drop in water temperature between 9 and 10 m (Figure 3); burbot may have preferentially inhabited cold water below the thermocline.

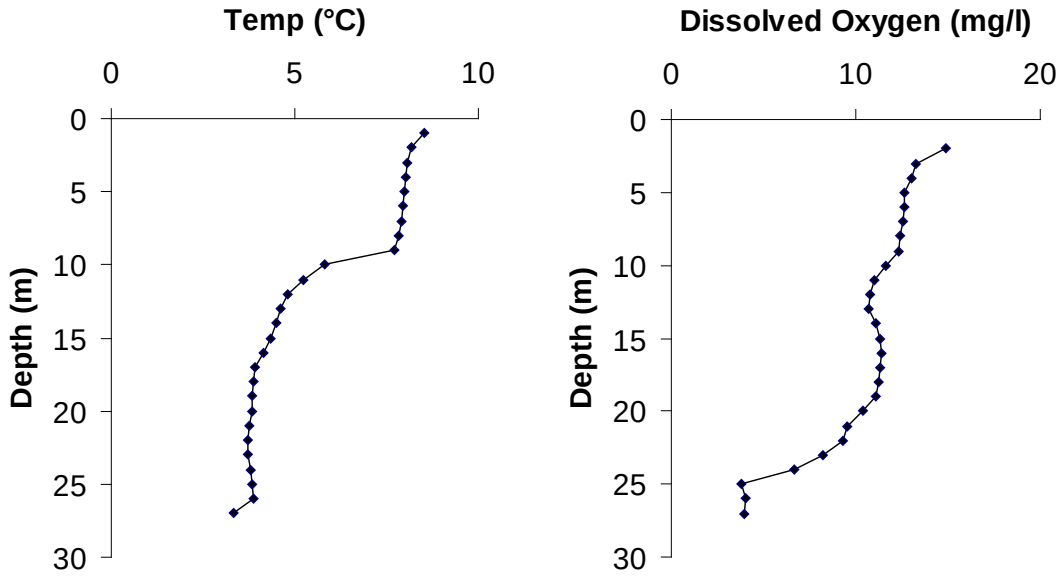

Figure 2. Temperature and dissolved oxygen profile of Pine Lake, taken 1 June 2012.

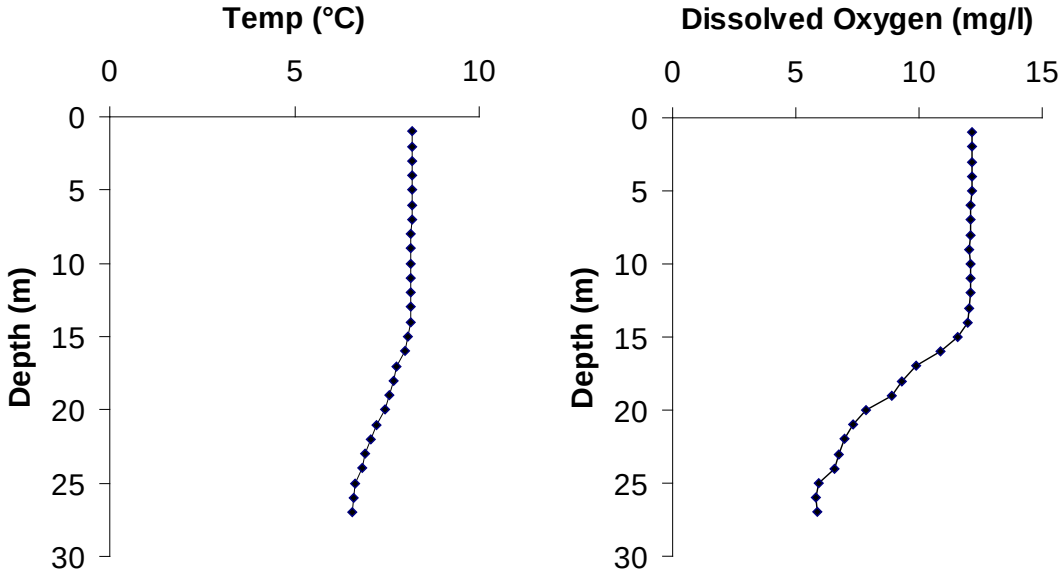

Figure 3. Temperature and dissolved oxygen profile of Pine Lake, taken 9 October 2012.

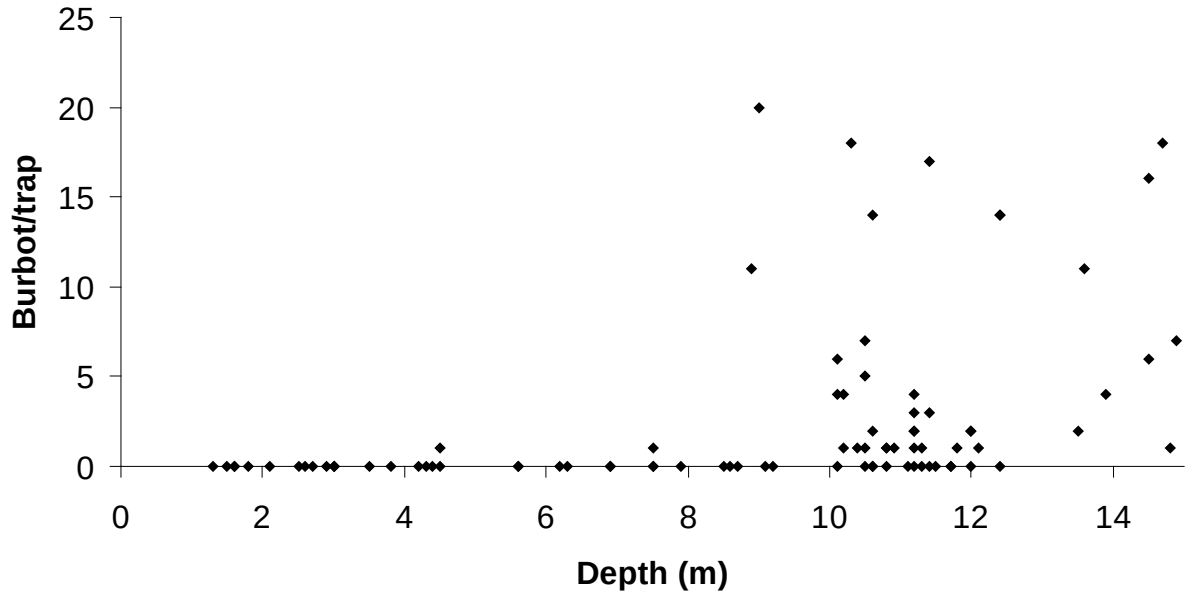

Figure 4. Burbot catch by depth for cod traps set 29 May – 1 June, 2012 in Pine Lake.

Capture Details – Autumn Recapture Session

Between 9 and 11 October 2012, we captured 441 burbot in 71 trap-nights (see Appendix 3 for set and capture locations, and Appendix 7 for capture details). Discounting 1 trap that opened on retrieval and contained no burbot, and 1 trap that was set for 2 nights and contained 27 burbot, we achieved a mean CPUE of 5.71 burbot/trap-night (SE = 0.68).

Two burbot were sacrificed for disease and parasite screening. As in the spring capture session, we controlled the water temperature in holding tubs with pumps circulating water from 5 – 8 m below the surface. There were no additional burbot mortalities during the autumn capture session.

Of the 441 total burbot captures, 14 were burbot considered too small to tag (less than 350 mm total length). Of the remaining 427 burbot, 70 were burbot that we had marked in the first capture session. Four of these recaptured burbot had lost their spaghetti tag but were identified as previously-marked by their right pelvic fin clip; these burbot could be distinguished as unique individuals by length. Of the 66 captures of burbot with individually-numbered spaghetti tags, 13 were within-session recaptures (i.e. burbot marked in spring that were caught multiple times in the autumn capture session).

The number of individual tagged burbot recaptured, compared to the number of burbot recaptured that had lost their spaghetti tags, can

also provide an estimate of the overall tag loss rate. Assuming all burbot caught without tags, but with fin clips, were unique individuals, we estimate the tag loss rate at 5.7% (SE = 2.8%).

Burbot catch rates increased with depth in the autumn recapture session, though burbot were caught in all depths sampled (Figure 5). Waters were isothermal between surface and 15 m during the autumn recapture session (Figure 3); temperature was not a likely factor for higher catch rates in deeper water. Catches of up to 30 burbot per trap-night were achieved in the autumn session.

Biological Characteristics

Burbot caught in spring were significantly longer ($t_{df=630}$ = -4.56, P <0.001), heavier ($t_{df=630}$ = -6.02, P <0.001) and in better condition ($t_{df=630}$ = -3.77, P = 0.002) than those caught in the autumn recapture session (Table 1, Figures 7 and 8). More small burbot were caught in autumn than in spring (Figures 6 and 7). The differences in total length ($t_{df=258}$ = 0.383, P = 0.703), and weight ($t_{df=258}$ = -1.676, P = 0.095) between burbot caught in spring and those marked burbot recaptured in the autumn were not significant. Condition, however, was significantly lower among marked burbot recaptured in autumn ($t_{df=258}$ = -4.633, P <0.001).

Comparison of change in length and weight of individual burbot, tracked from initial spring capture to autumn recapture, showed significant decrease in total length ($t_{df=42}$ = 3.188, P = 0.003), and a significant loss of weight ($t_{df = 42}$ = 6.199, P <0.001; Figure 8). While statistically significant, the mean decrease in length in individual burbot between spring and autumn was 4.6 mm, or 0.8% of spring total length, a biologically insignificant amount. Growth recruitment into or out of the proportion of the population 350 mm total length or longer over the summer was negligible.

Weight loss by individual burbot over summer, combined with poorer overall condition of burbot caught in autumn compared to those caught in spring, suggests poor summer foraging conditions. High water temperatures and low concentrations of dissolved oxygen may limit burbot distribution within the water column during summer. Similar temperature- and oxygen-driven limitations in summer have been observed for lake trout in other Yukon lakes (Jessup and Millar 2012).

While weight loss in individual fish is commonly observed, decreases in length of individual fish is rare (though not unprecedented; Huusko et al. 2011). Differences in burbot measuring techniques among technicians may have also accounted for the observed change in length. Examination of summer growth patterns of individual burbot from future surveys may help clarify the cause of observed decrease in fish length.

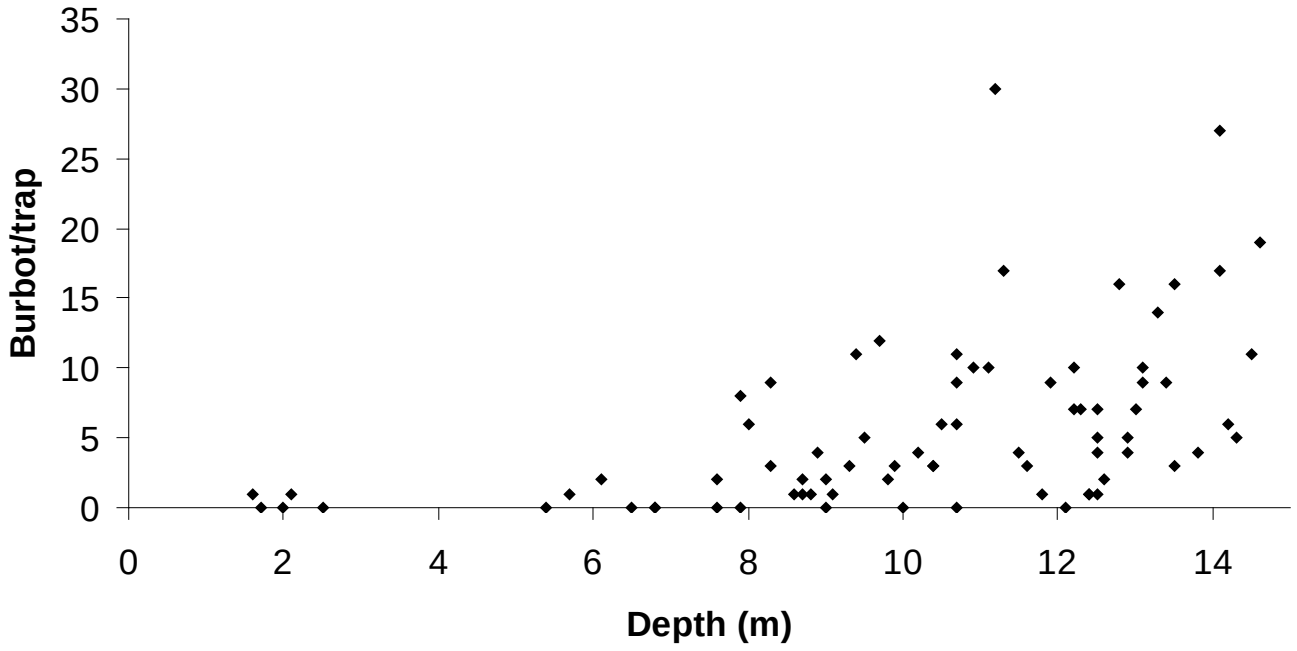

Figure 5. Burbot catch by depth for cod traps set 9 – 11 October 2012 in Pine Lake.

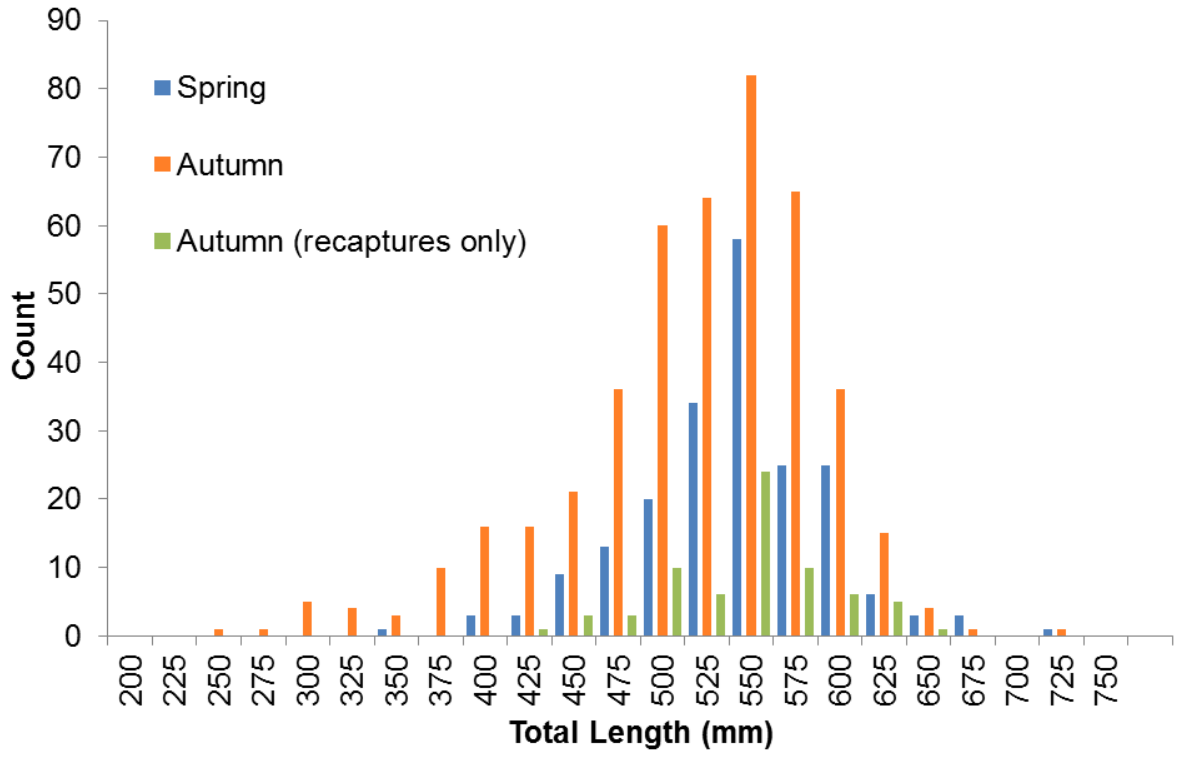

Figure 6. Distribution of burbot total length from the spring capture session (blue), the autumn recapture session (orange), and of marked burbot recaptured in the autumn recapture session (green).

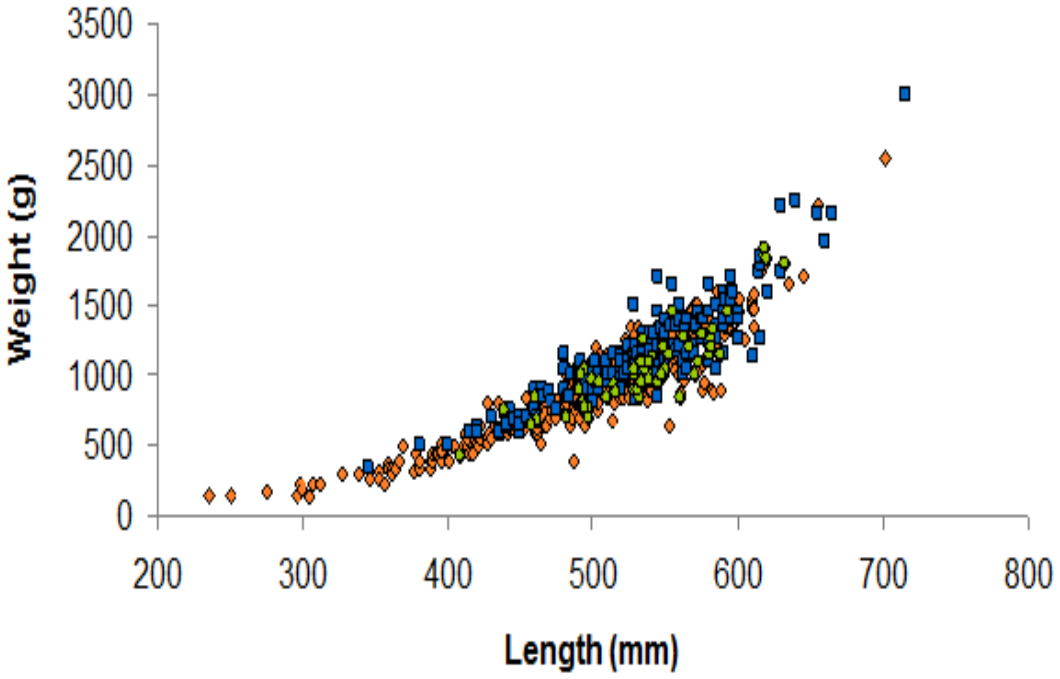

Figure 7. Weight by length of burbot caught in spring (blue squares), autumn (orange diamonds), and autumn recaptures (green circles) from Pine Lake**.**

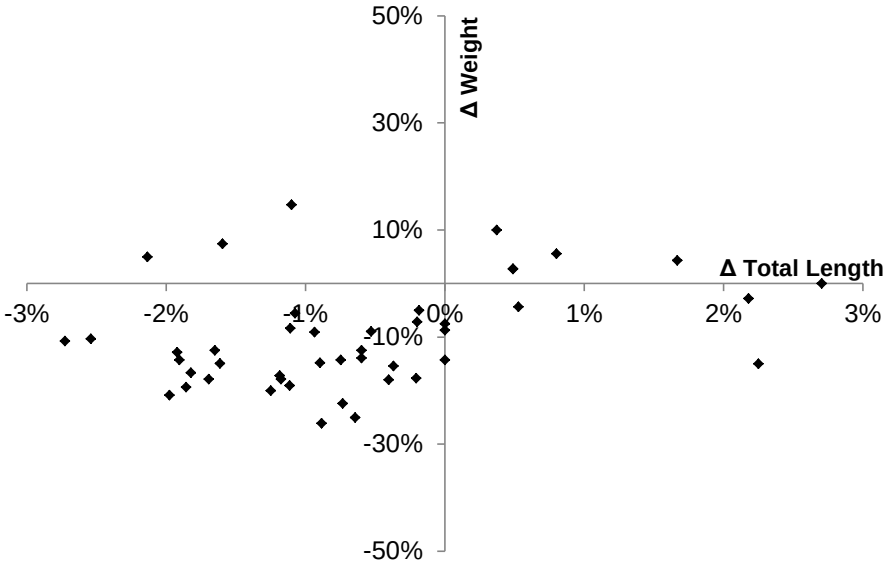

Figure 8. Percent change in total length and weight of individual burbot between spring and autumn in Pine Lake**.**

Table 1. Average length, weight, and condition factor of burbot.

	Sample size	Total Length (mm)	Weight (g)	Condition Factor
Spring	204	532	1137	0.74
Autumn	428	505	960	0.71
Autumn (recaptures only)	57	534	1049	0.68
Average (spring and autumn)	632	514	1017	0.72

The mean age of burbot aged from Pine Lake was 14, and ranged from 11 to 19. The aged sample was composed of 4 males and 7 females, all of which were sexually mature. The sample contained too few young burbot to describe growth patterns of early life stages; the length-age curve for Pine Lake burbot suggests that burbot growth slows at or before 11 years (Figure 9). Stomach contents of sampled burbot, all of which were from the spring capture, showed that their diet was 53% amphipods (freshwater shrimp), 22% unidentified invertebrates, 16% caddisfly larvae, 4% unidentified fish, 2% pond snails, and trace amounts of ram's horn snails and unknown items. Stomachs averaged 28% full. Age, growth, and diet data of Pine Lake burbot are based on otoliths and stomach contents from only 11 sampled fish, and should be used with caution.

Tests for Size Selectivity

The length distributions of burbot caught in spring and in autumn differ significantly ($D_{df = 203,441}$ = 0.182, P = 0.001), indicating size selectivity in the first capture session (i.e. burbot size affected their likelihood of capture; see Appendix 5 for methodological considerations under different size selectivity scenarios). The length distributions of burbot caught in spring and marked burbot captured in autumn, however, were not significantly different ($D_{df = 203,69}$ = 0.074, P = 0.946), demonstrating no significant size selection in the second capture session. Under these conditions (evidence for size selectivity in the first capture session, but not in the second), Bernard and Hansen (1992) suggest an unstratified mark-recapture population estimate is appropriate, though lengths from the second capture event only should be used for estimates of proportion in composition.

Inter-capture Movement and Mixing

The small size of Pine Lake, combined with the long (4.5 months) interval between spring and autumn capture events, allowed for thorough mixing of burbot throughout the lake (Appendix 4). In many cases, individual burbot caught in one end of the lake in spring were recaptured in autumn at the other end, having moved more than 5 km since spring capture.

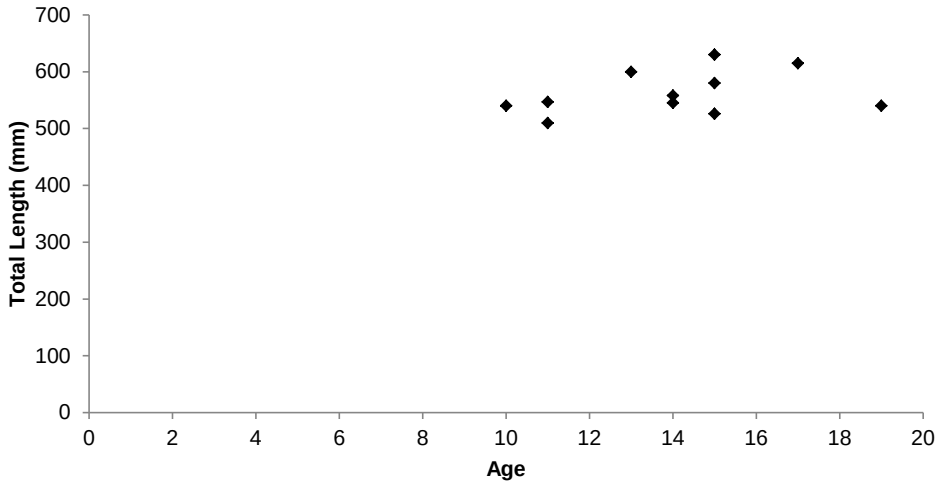

Figure 9. Length at age of burbot captured in Pine Lake.

Abundance Estimate

The Bailey abundance estimate for burbot 350 mm total length or longer in Pine Lake was 1,236 (95% CI 1,005 – 1,531). Confidence intervals were calculated using the binomial distribution. This provides a burbot density estimate of 2.05 burbot/ha (95% CI 1.67 – 2.54 burbot/ha). Using the mean weight of all burbot at least 350 mm total length, (1,017 g), the estimated total mass of the Pine Lake burbot population at least 350 mm total length was 1,257 kg.

Population Status and Conclusions

This was the first burbot population abundance estimate developed for Yukon, so comparisons with other lakes are not possible. Pine Lake contains northern pike and lake trout, both potential competitors with burbot for food resources (although lake trout abundance is low; Jessup and Millar 2011).

Lakes with competitor species are likely to support lower densities of burbot than those without. In relative terms, Pine Lake would be expected to have lower burbot densities than a similar lake without northern pike and lake trout. Based on a model developed in Alaska, Pine Lake has a carrying capacity of 8,566 kg of burbot at least 450 mm total length (see Appendix 6 for methods, data and caveats; Simpson 1998). Lakes used to develop this model ranged from those without competitor species to those containing northern pike, lake trout, and/or rainbow trout. The mark-recapture estimate developed

for Pine Lake burbot incorporates a larger proportion of the population (all burbot at least 350 mm total length) than the carrying capacity model (all burbot at least 450 mm total length), and should therefore be more than 8,566 kg if the population is at carrying capacity. At 1,257 kg, however, the estimated mass of the Pine Lake burbot population is much lower than the predicted carrying capacity. Even considering possible reductions in burbot density through the presence of competitor species, this low estimate compared to modelled carrying capacity suggests a depleted population. Currently, General Regulations on Pine Lake allow each licensed angler to harvest 10 burbot per day, with 20 burbot in possession. Full daily catch and possession limits comprise 0.8% and 1.6%, respectively, of the total estimated population of burbot 350 mm or longer. Under General Regulations, successful fishing sessions by even a relatively small number of individual anglers would continue to reduce burbot population size to low levels.

Future Surveys

Depending on the time interval between the 2012 survey and subsequent mark-recapture surveys, marks applied during the 2012 spring capture session may be used to gain information on growth, survival and changes in abundance between this and future surveys, using multiple-capture methodologies for open populations (e.g. Jolly-Seber method; Seber 1983). Usability of current marks in future surveys, and appropriate methods with which to evaluate them, depends on rates of loss of tagged fish from the population through emigration, mortality, or tag loss. Future surveys should also consider individually marking burbot in all capture sessions, including the final capture session, allowing for improved abundance estimates through the use of robust design mark-recapture analysis (Pollock 1982).

Distribution of burbot catch rates by depth experienced at Pine Lake can guide trap effort in future surveys. Catch rates in traps set deeper than 8 m were considerably higher than those set in shallower water; reallocating effort to depths 8 – 15 m may result in greater trapping efficiency.

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Appendix 1 – Bailey mark-recapture Assumptions.

The Bailey method of mark-recapture abundance estimation requires that several criteria be met (Seber 1982, Krebs 1999):

1. Immigration and/or recruitment to gear are negligible, or if immigration and/or recruitment are present, the population estimate applies to the time of the second capture session only.
2. Emigration and/or mortality are negligible, or if emigration and/or mortality occur, it is at equal rates for marked and unmarked burbot.
3. All burbot have equal catchability in either the first or second capture session, or marked burbot mix completely with unmarked burbot between the first and second session.
4. Tag loss is negligible, and all marked burbot are identified as such in the second capture session.

Adherence to Assumptions

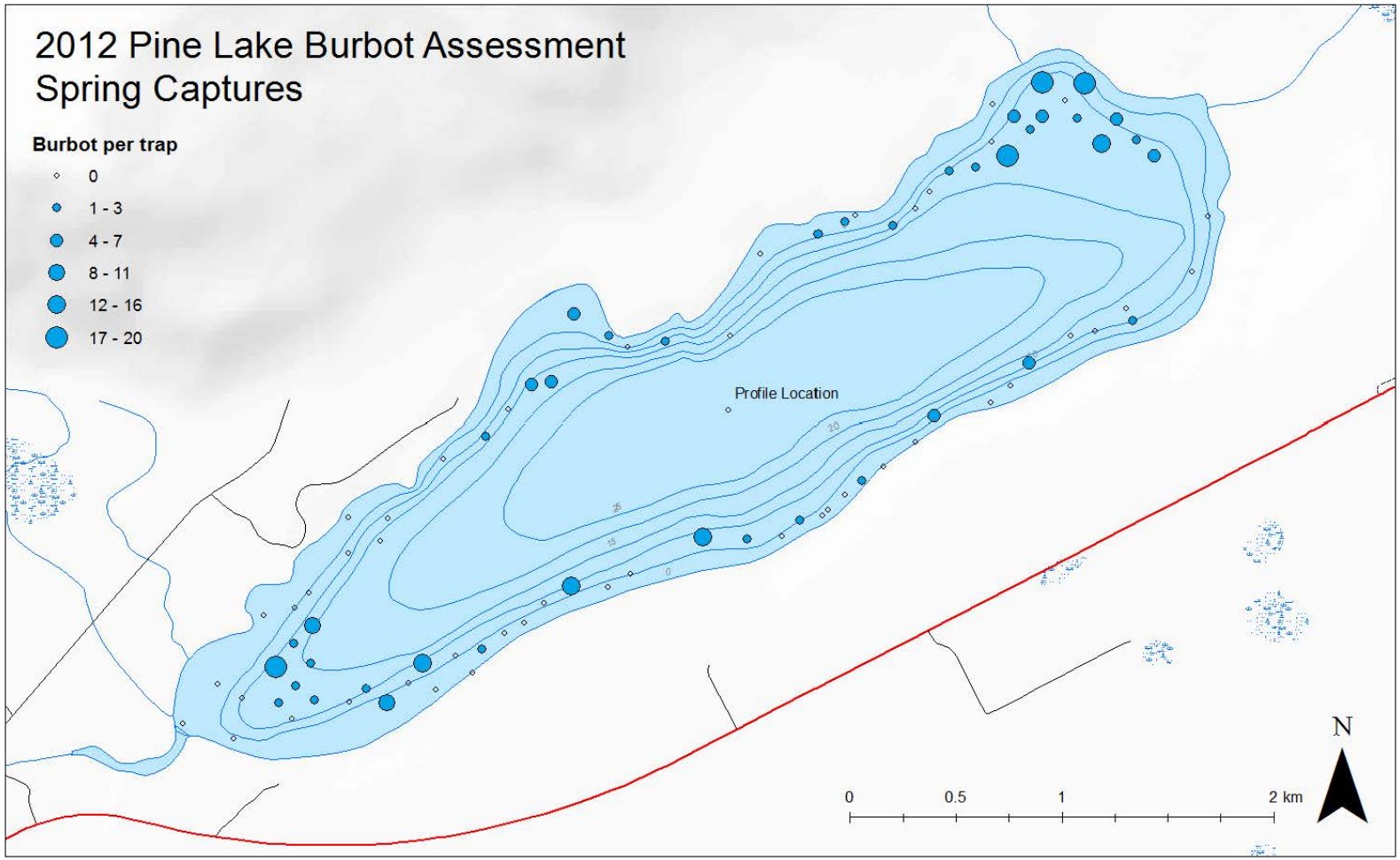
1. In regard to immigration, the Pine Lake burbot population can be considered reasonably isolated, as it is distant from the nearest connected lake (Rainbow Lake – 44 km). A small number of burbot may immigrate to Pine Lake from the Dezadeash River via Pine Creek (9.5 km); we assume immigration to be minimal. For the purposes of mark-recapture population estimation, recruitment refers to growth of burbot between capture sessions such that burbot too small to be vulnerable to capture in the first session become vulnerable to capture by the second session. Burbot growth rates between capture sessions can be observed by examining differences in length in individually-marked burbot captured in both sessions. Where inter-session growth is non-negligible, the population estimate will be considered to apply only to the population at the time of the second capture session.
2. In conjunction with immigration, emigration of burbot from Pine Lake is presumed to be minimal, as Pine Lake is relatively distant from other waterbodies. By limiting the inter-session interval to one open-water season (4.5 months), we anticipated minimal angler harvest and natural mortality of burbot, and assumed any such was equally distributed among marked and unmarked burbot.
3. Equal catchability or complete mixing of marked and unmarked burbot:
    a. The presence of size selectivity in catches can be examined using Kolmogorov-Smirnov comparisons of burbot size distributions (Seber 1982, Schwanke 2009). Evidence of size-selectivity in the first capture session is provided by a significant difference between burbot size distribution in the first and

second capture sessions. Evidence of size-selectivity in the second capture session is provided by a significant difference between burbot size distributions from the first capture event and marked burbot recaptured in the second sampling event. Appendix 5 provides methodologies for abundance estimation under the 4 resulting possible scenarios.

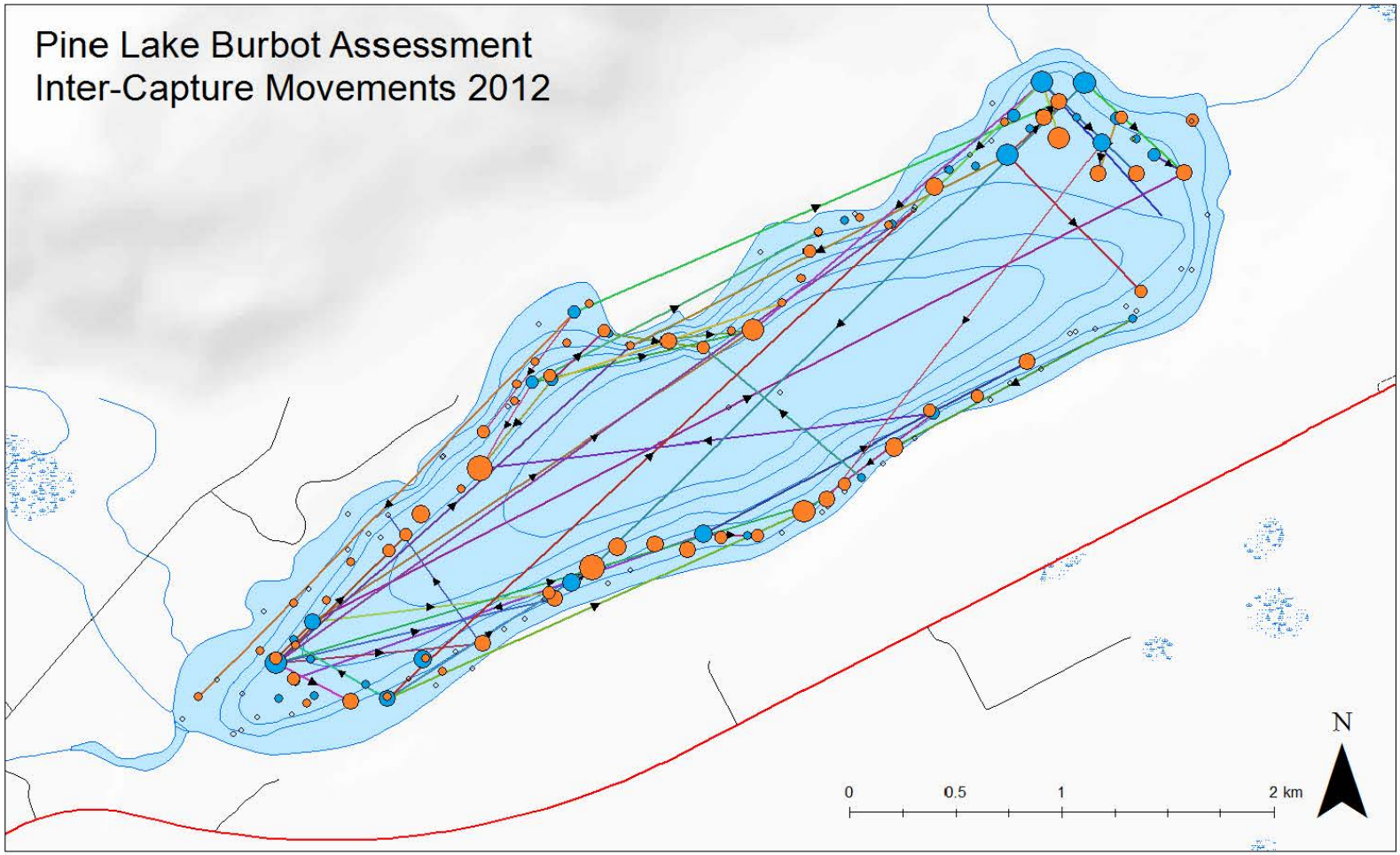
b. In Alaskan studies, marked and unmarked burbot have been found to mix thoroughly within 2 – 3 weeks (Bernard et al. 1993). The relatively small size of Pine Lake, coupled with the 4 ½ month sampling interval, should provide for complete mixing of marked and unmarked burbot. Examination of individual burbot movements between first and subsequent captures can be examined to assess potential for complete mixing.

4. Tag loss can be assessed by double-marking burbot. We marked burbot with an individually-numbered spaghetti tag, and with a redundant pelvic fin clip. By assessing captured burbot for both spaghetti tags and pelvic fin clips, we were able to estimate tag loss rate, which we incorporated into our mark-recapture abundance estimations.

Appendix 2 – Pine Lake set locations, captures, and profile location, May/June 2012.

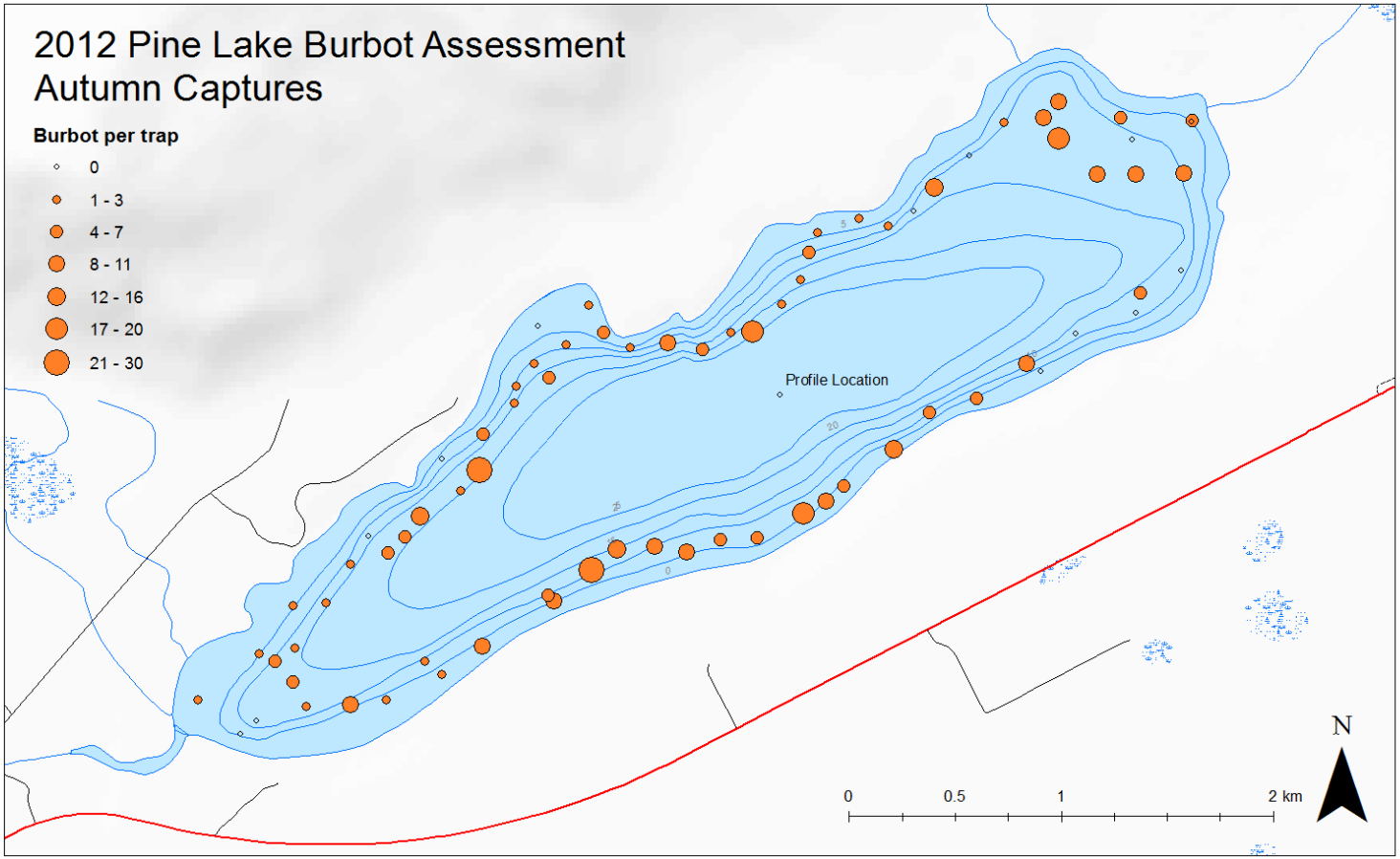


Appendix 3- Pine Lake set locations, captures, and profile location, October 2012.



Appendix 4- Pine Lake intersession movements by individual burbot, between May/June 2012.

Initial capture location (blue circles) and October 2012 recapture locations (orange circles). Individual burbot are denoted by differently-coloured lines, with arrows denoting travel direction.



Appendix 5 – Burbot population abundance estimation methodologies under differing scenarios of size selectivity bias.

	Significant difference between burbot size distribution in first session and recaptures in second session	Significant difference between burbot size distributions in first and second sessions
Case I	No	No
Case II	No	Yes
Case III	Yes	No
Case IV	Yes	Yes

Case I: No evidence for size selectivity in either capture session. Use unstratified abundance estimate. Pool burbot lengths from first and second capture sessions for population composition estimates.

Case II: Evidence for size selectivity in the first capture session, but not the second. Use unstratified abundance estimate, applicable to population estimate at time of second capture session only. Consider only lengths from the second capture session for population composition estimates.

Case III: Evidence for size selectivity in both first and second capture sessions. Stratify abundance estimates within length strata, and sum estimates for total population estimate. Use length distributions from both first and second capture sessions, weighted by stratum capture probabilities, for population composition estimates.

Case IV: Evidence for size selectivity in the second capture session, and unknown status of size selectivity in the first capture session. Stratify abundance estimates within length strata, and sum estimates for total population estimate. Use length distributions from second capture session only, weighted by stratum capture probabilities, for population composition estimates.(after Schwanke 2009)

Appendix 6 – Burbot productivity model.

We used a productivity model to predict the carrying capacity of burbot 450 mm total length or longer in Pine Lake. The model was developed in Alaska, using lakes in the Upper Copper/Upper Susitna Management Area (Simpson 1998). The model is based on the lake conductivity and lake area.

The model

Carrying capacity of burbot (kg/ha) = $10^{-0.266 + 0.00503\ X}$

Where X = lake conductivity in µS/cm

Applying the model to Pine Lake

The model for burbot carrying capacity for Pine Lake is based on the mean of specific conductivity measurements collected at 1-meter intervals through the entire water column in the deepest part of the lake, in June and October 2012:

Mean conductivity of Pine Lake (X) = 282 µS/cm

Burbot carrying capacity (kg/ha) = $10^{-0.266 + 0.00503\ (282)}$

= 14.21

Lake area (ha) = 603

Lake-wide burbot carrying capacity (kg) = 8,566

Based on this model, with a conductivity of 282 µS/cm and an area of 603 ha, Pine Lake is estimated to have a carrying capacity of 8,566 kg of burbot 450 mm total length or longer.

Caveats

The sample size of lakes used to produce the model was small at only 11 lakes. Model fit, however, was good; the model explained 93.6% of the variation in carrying capacity among the lakes, and was statistically significant ($P < 0.001$). Burbot carrying capacity in interior Alaska lakes may differ from those in Yukon.

Burbot carrying capacity may also be influenced by the presence of other competing fish-eating fish, such as northern pike or lake trout, with lakes containing competing fish species likely to have lower burbot carrying capacities. Lakes used to build this model ranged from those having no competitors, to those with northern pike, lake trout and/or rainbow trout.

Appendix 7 – Burbot capture details, Pine Lake 2012.

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
29 May	12	481	1050	Green	1	RP
29 May	12	615	1800	Green	2	RG
29 May	12	472	800	Green	3	RG
29 May	12	497	900	Green	4	RG
29 May	12	461	700	Green	5	RG
29 May	12	585	1500	Green	6	RG
29 May	12	557	1350	Green	7	RG
29 May	12	524	1050	Green	8	RG
29 May	12	525	1200	Green	9	RG
29 May	12	502	1100	Green	10	RG
29 May	12	492	1000	Green	11	RG
29 May	12	548	1150	Green	12	RG
29 May	12	535	1050	Green	13	RG
29 May	12	534	1100	Green	14	RG
29 May	12	538	1050	Green	15	RG
29 May	12	600	1400	Green	16	RG
29 May	12	500	1050	Green	17	RG
29 May	12	545	1200	Green	18	RG
29 May	16	548	1200	Green	19	RG
29 May	16	515	1000	Green	20	RG
29 May	16	462	700	Green	21	RG
29 May	16	597	1600	Green	22	RG
29 May	16	545	1450	Green	23	RP
29 May	16	531	1150	Green	24	RG
29 May	16	522	1000	Green	25	RG
29 May	17	442	750	Green	26	RG
29 May	22	558	1175	Green	27	KD
29 May	22	580	1450	Green	28	KD
29 May	22	542	1300	Green	29	RG
29 May	22	547	1325			KD
29 May	22	554	1350	Green	30	RG
29 May	22	510	1000			KD
29 May	22	475	750	Green	32	RG
29 May	22	505	1000	Green	33	RG
29 May	22	565	1150	Green	34	RG
29 May	22	415	600	Green	35	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
29 May	22	545	1200	Green	36	RG
29 May	22	556	1200	Green	37	RG
29 May	22	571	1350	Green	38	RG
29 May	22	492	1100	Green	39	RG
29 May	22	480	1150	Green	40	RG
29 May	22	592	1550	Green	41	RG
29 May	22	528	1500	Green	42	RG
29 May	22	511	1000	Green		KD
29 May	23	538	1000	Green	43	RG
29 May	23	540	1050	Green	44	RG
29 May	23	564	1350	Green	45	RG
29 May	23	503	950	Green	46	RG
29 May	23	520	1100	Green	47	RG
29 May	23	483	850	Green	48	RG
29 May	23	553	1150	Green	49	RG
29 May	23	557	1175	Green	50	KD
29 May	23	616	1250	Green	77	RG
29 May	23	511	1000	Green	78	RG
29 May	23	484	850	Green	79	RG
29 May	23	563	1100	Green	80	RP
29 May	23	572	1450	Green	81	RG
29 May	23	550	1100	Green	82	RG
29 May	23	595	1550	Green	84	RG
29 May	23	528	1100	Green	85	RG
29 May	23	540	950	Green	86	KD
29 May	23	546	1100	Green	87	RG
29 May	23	600	1450	Green	88	KD
29 May	23	540	1300	Green	89	RG
29 May	24			Green	90	RG
29 May	24			Green	91	RG
29 May	24			Green	92	RG
29 May	24			Green	93	RG
29 May	24			Green	94	RG
29 May	24			Green	95	RG
29 May	24			Green	96	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
29 May	24			Green	97	RG
29 May	24			Green	98	RG
29 May	24	630	1750	Green	99	KD
29 May	24			Green	100	RG
29 May	24			White	51	RG
29 May	24			White	52	RG
29 May	24			White	53	RG
29 May	26	545	1200	White	54	RG
29 May	27	614	1750	White	55	RG
29 May	27	620	1600	White	56	RG
29 May	27	510	950	White	57	RG
29 May	27	455	700	White	58	RG
30 May	36			Green	4	RG
30 May	36			Green	1	RG
30 May	36	545	950	White	59	RG
30 May	36	562	1000	White	60	RG
30 May	36	510	1025	White	61	RG
30 May	36	530	1000	White	62	RG
30 May	36	615	1850	White	63	RG
30 May	36	545	1000	White	64	RG
30 May	36	577	1400	White	65	RG
30 May	36	537	1000	White	66	RG
30 May	36	540	1150	White	67	RP
30 May	35	575	1400	White	68	RG
30 May	35	540	1200	White	69	RG
30 May	35	500	1000	White	71	RG
30 May	35	420	600	White	72	RG
30 May	35	665	2150	White	73	RP
30 May	35	580	1650	White	74	RG
30 May	35	510	1100	White	75	RG
30 May	35	510	1000	White	1	RG
30 May	35	530	1200	White	2	RG
30 May	35	590	1150	White	3	RP
30 May	35	450	650	White	4	RG
30 May	35	485	1000	White	5	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
30 May	35	520	900	White	6	RG
30 May	35	435	600	White	7	RG
30 May	32	655	2150	White	8	RG
30 May	32	510	1100	White	9	RG
30 May	32	585	1050	White	10	RG
30 May	32	465	900	White	11	RP
30 May	32	465	850	White	12	RG
30 May	32	528	1150	White	13	RG
30 May	32	540	1175	White	89	RG
30 May	32	380	500	White	90	RG
30 May	32	450	600	White	91	RP
30 May	32	525	1050	White	92	RG
30 May	32	455	700	White	93	RG
30 May	32	450	700	White	94	RG
30 May	32	445	675	White	95	RG
30 May	32	460	750	White	96	RG
30 May	30	595	1600	White	98	RP
30 May	30	545	1700	White	99	KD
30 May	30	640	2250	White	100	RP
30 May	30	505	900	Blue	1526	RP
30 May	30	430	700	Blue	1527	RP
30 May	30	520	1100	Blue	1528	RP
30 May	30	535	1100	Blue	1529	RP
30 May	30	555	1200	Blue	1530	RP
30 May	30	540	1200	Blue	1531	RP
30 May	30	500	900	Blue	1532	RP
30 May	30	540	950	Blue	1533	RP
30 May	30	550	1100	Blue	1534	RP
30 May	30	550	1050	Blue	1535	RP
30 May	30	560	1500	Blue	1536	RG
30 May	30	345	350	Blue	not tagged	RG
30 May	30	440	625	Blue	1537	RP
30 May	39	420	625	Blue	1538	RG
30 May	40			Green	10	RG
30 May	41	515	1000	Blue	1540	RP

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
30 May	41	480	900	Blue	1541	RP
30 May	41	510	950	Blue	1543	RP
30 May	41	570	1150	Blue	1544	RP
30 May	41	400	500	Blue	1545	RP
30 May	41	590	1600	Blue	1546	RP
30 May	41	555	1650	Blue	1547	RP
30 May	41	440	650	Blue	1548	RP
30 May	41	535	1050	Blue	1539	RP
30 May	41	525	1100	Blue	1542	RP
30 May	41	380	500	White	14	RP
30 May	44	490	900	White	70	RG
30 May	45	495	1050	White	88	RP
30 May	45	590	1400	Blue	1382	RP
30 May	45	555	1200	Blue	1383	RP
30 May	45	580	1450	Blue	1384	RP
30 May	45	520	1125	Blue	1385	RP
30 May	45	595	1400	Blue	1386	RP
30 May	48	510	1000	Blue	1387	RG
30 May	48	570	1200	Blue	1388	RG
30 May	48	585	1350	Blue	1389	RG
30 May	49	535	1250	Blue	1390	RP
30 May	49	540	1150	Blue	1391	RG
30 May	50	530	1000	Blue	1392	RG
30 May	50	550	1100	Blue	1393	RG
30 May	50	460	900	Blue	1394	RG
30 May	50	515	1150	Blue	1395	RG
30 May	51	580	1100	Blue	1396	RG
30 May	51	535	1150	Blue	1397	RP
30 May	51	590	1375	Blue	1398	RG
30 May	51	550	1125	Blue	1399	RG
30 May	52			Green	89	RG
30 May	52			Green	49	RG
30 May	52			Green	95	RG
30 May	52	565	1400	Blue	1400	RP
30 May	52	715	3000	Blue	1676	RP
30 May	52	540	1200	Blue	1678	KD

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
30 May	52	630	2200	Blue	1679	RP
30 May	52	590	1350	Blue	1680	RP
30 May	52	535	1300	Blue	1681	RP
30 May	52	545	1100	Blue	1682	RP
30 May	52	595	1700	Blue	1683	RP
30 May	52	500	1000	Blue	1684	RP
30 May	52	540	1100	Blue	1685	RP
30 May	52	520	975	Blue	1686	RP
30 May	52	530	1000	Blue	1687	RP
30 May	52	520	900	Blue	1688	RP
30 May	52	530	1100	Blue	1689	RP
30 May	57	535	1000	Blue	1691	RG
30 May	71			Green	87	RG
30 May	71	520	1050	Blue	1692	RG
30 May	69	515	1000	Blue	1693	RG
30 May	69	570	1200	Blue	1694	RG
30 May	64	560	1375	Blue	1695	RG
31 May	77	530	1050	Blue	1696	RG
31 May	77	470	875	Blue	1697	RG
31 May	77	600	1250	Blue	1698	RG
1 June	86	465	900	Blue	1699	RG
1 June	86	500	900	Blue	1700	RG
1 June	86	590	1450	Blue	1677	RG
1 June	86	465	900	Blue	1656	RG
1 June	86	495	975	Blue	1657	RG
1 June	86	565	1050	Blue	1658	RP
1 June	85	550	1400	Blue	1659	RP
1 June	84	540	1100	Blue	1660	RG
1 June	83			Blue	1396	RG
1 June	81	548	1150	Blue	1661	RG
1 June	82			Green	50	RG
1 June	82			Green	87	RG
1 June	82	575	1250	Blue	1662	RG
1 June	82	560	1200	Blue	1663	RG
1 June	82	530	825	Blue	1664	RG
1 June	82	545	850	Blue	1665	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
1 June	82	535	1150	Blue	1666	RG
1 June	80			White	54	RG
1 June	80			Green	91	RG
1 June	80	550	1300	Blue	1667	RG
1 June	80	520	1150	Blue	1668	RG
1 June	91			Green	44	RG
1 June	91	535	1000	Blue	1669	RG
1 June	91	585	1250	Blue	1670	RG
1 June	91	505	900	Blue	1671	RG
1 June	91	490	1050	Blue	1672	RG
1 June	93	610	1125	Blue	1673	RG
1 June	94	580	1250	Blue	1674	RG
1 June	94	490	950	Blue	1675	RG
1 June	90	500	800	Blue	1501	RG
1 June	90	510	1100	Blue	1502	RG
1 June	88			White	65	RG
1 June	97	660	1950	Blue	1503	RG
1 June	97	515	1000	Blue	1504	RG
10 Oct	2	618	1900	white	63	RG
10 Oct	2	525	1050			RG
10 Oct	2	548	1200			RG
10 Oct	4	447	700			RG
10 Oct	5	581	1250	green	41	RG
10 Oct	5	552	1150	green	7	RG
10 Oct	23	573	1100	blue	1544	RG
10 Oct	23	554	1300			RG
10 Oct	23	540	1100	green	43	RG
10 Oct	23	437	650			RG
10 Oct	23	609	1550			RG
10 Oct	23	584	1500			RG
10 Oct	23	439	1750	green	26	RG
10 Oct	23	572	1400			RG
10 Oct	23	644	1700			RG
10 Oct	23	569	1300			RG
10 Oct	23	702	2550			RG
10 Oct	23	532	1000			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
10 Oct	23	564	1200			RG
10 Oct	23	577	1400			RG
10 Oct	23	504	950	blue	1700	RG
10 Oct	6	575	1300	blue	1677	RG
10 Oct	24	557	1350			RG
10 Oct	24	501	975			RG
10 Oct	24	566	1200	white	65	RG
10 Oct	24	563	1250			RG
10 Oct	24	618	1850	green	2	RG
10 Oct	24	514	1150			RG
10 Oct	24	548	1050			RG
10 Oct	24	548	1000	green	50	RG
10 Oct	24	560	1300			RG
10 Oct	8	485	750			RG
10 Oct	8	514	900			RG
10 Oct	8	525	850			RG
10 Oct	8	544	1350			RG
10 Oct	8	554	1100			RG
10 Oct	8	510	900			RG
10 Oct	8	507	950			RG
10 Oct	8	486	700			RG
10 Oct	8	545	950	green	37	RG
10 Oct	8	580	1150	blue	1382	RG
10 Oct	10	553	1200			RG
10 Oct	10	555	1450	green	45	RG
10 Oct	10	480	850			RG
10 Oct	10	610	1475			RG
10 Oct	12	535	900			RG
10 Oct	12	367	400			RG
10 Oct	12	560	850	green	34	RG
10 Oct	12	550	1150			RG
10 Oct	12	574	1300			DR
10 Oct	12	578	1450			RG
10 Oct	12	565	1300			KS
10 Oct	14	490	700			RG
10 Oct	14	510	1050			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
10 Oct	14	461	675			RG
10 Oct	14	484	850			RG
10 Oct	14	572	1400			RG
10 Oct	14	390	400			RG
10 Oct	14	514	800			RG
10 Oct	14	415	450			RG
10 Oct	14	570	1400			RG
10 Oct	14	536	1050	white	54	RG
10 Oct	14	565	1275			RG
10 Oct	14	235	150			partly eaten by large burbot
10 Oct	14	609	1500			RG
10 Oct	14	433	650			RG
10 Oct	15	560	1450			RG
10 Oct	15	540	1050			RG
10 Oct	15	496	900			DR
10 Oct	15	549	1200	white	67	RG
10 Oct	15	518	900			RG
10 Oct	15	569	1250			RG
10 Oct	15	512	1100			RG
10 Oct	15	560	1400			RG
10 Oct	15	554	1400			RG
10 Oct	15	460	700			RG
10 Oct	15	441	650			RG
10 Oct	15	531	1350			KS
10 Oct	15	490	900	blue	1672	RG
10 Oct	15	494	850			RG
10 Oct	15	550	1200			RG
10 Oct	15	495	1000			RG
10 Oct	15	369	500			RG
10 Oct	16	593	1450			RG
10 Oct	16	510	1100			RG
10 Oct	16	412	600			RG
10 Oct	16	522	1100			RG
10 Oct	16	451	650			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
10 Oct	16	490	950			RG
10 Oct	16	388	400			RG
10 Oct	16	550	1100			RG
10 Oct	16	441	600			RG
10 Oct	16	590	1300			RG
10 Oct	16	590	1500			RG
10 Oct	17	601	1550			RG
10 Oct	17	535	1150			RG
10 Oct	17	595	1500			RG
10 Oct	17	470	800			RG
10 Oct	17	524	900			RG
10 Oct	17	430	550			RG
10 Oct	17	581	1250			RG
10 Oct	17	611	1350			RG
10 Oct	17	580	1400			RG
10 Oct	17	515	1050			RG
10 Oct	17	574	1100			RG
10 Oct	17	505	1000			RG
10 Oct	17	525	1050			RG
10 Oct	17	556	1050			RG
10 Oct	17	540	1250			RG
10 Oct	17	479	800			RG
10 Oct	17	529	950			RG
10 Oct	17	585	1600			RG
10 Oct	17	540	1300			RG
10 Oct	17	528	1300			RG
10 Oct	17	510	1000			RG
10 Oct	17	598	1300			RG
10 Oct	17	482	1000			RG
10 Oct	17	460	850	white	11	RG
10 Oct	17	550	1050	white	60	RG
10 Oct	17	655	2200			RG
10 Oct	17	488	850			RG
10 Oct	17	588	1400			RG
10 Oct	17	558	1150			RG
10 Oct	17	510	850	blue	1686	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
10 Oct	18	501	850			RG
10 Oct	18	527	950			RG
10 Oct	18	529	1000	green	14	RG
10 Oct	18	488	800			RG
10 Oct	18	461	775			RG
10 Oct	18	515	950			RG
10 Oct	18	559	1000			RG
10 Oct	18	527	1100			RG
10 Oct	18	505	1000			RG
10 Oct	18	390	450			RG
10 Oct	19	296	150			RG
11 Oct	20	588	1150	blue	1386	RG
11 Oct	25	497	775	blue	1532	RG
11 Oct	25	530	1000			RG
11 Oct	25	401	400			RG
11 Oct	25	437	600			RG
11 Oct	25	485	875			RG
11 Oct	25	444	625			RG
11 Oct	26	421	500			RG
11 Oct	48	300	200			RG
11 Oct	27	491	800			RG
11 Oct	27	528	1050		lost tag	RG
11 Oct	27	614	1750			DR
11 Oct	27	458	650		lost tag	RP
11 Oct	27	411	500			RP
11 Oct	27	553	650			RG
11 Oct	27	414	550			RG
11 Oct	27	435	800			RG
11 Oct	27	313	225			RP
11 Oct	27	393	450			RG
11 Oct	27	511	875			RG
11 Oct	27	459	725			RG
11 Oct	27	381	400			RG
11 Oct	27	523	1050			RG
11 Oct	27	487	825			RG
11 Oct	27	457	725			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
11 Oct	28	529	900	blue	1384	RG
11 Oct	28	575	900			RG
11 Oct	28	579	1150			RG
11 Oct	28	400	500			RG
11 Oct	28	460	600			RG
11 Oct	29	590	1350			RG
11 Oct	29	482	880			RG
11 Oct	29	580	1300			RG
11 Oct	29	405	500			RG
11 Oct	29	567	1275			RG
11 Oct	29	523	1200			RG
11 Oct	29	552	1200			RP
11 Oct	30	488	750			RG
11 Oct	31	534	950	blue	1691	RG
11 Oct	31	498	925			RG
11 Oct	31	535	1250	blue	1659	RG
11 Oct	31	442	780	green	26	RG
11 Oct	32	576	1250			RG
11 Oct	32	462	700			RG
11 Oct	32	538	1000	green	19	RG
12 Oct	51	503	800	blue	1700	RG
12 Oct	51	522	1250			RG
12 Oct	51	553	1325			RG
11 Oct	33	616	1750			RG
11 Oct	33	570	1500			RG
11 Oct	33	618	1800	green	2	RG
11 Oct	34	553	1150			RG
11 Oct	34	482	700	green	48	RG
11 Oct	34	494	800			RG
11 Oct	34	454	850			RG
11 Oct	34	532	1200			RG
11 Oct	34	364	350			RG
11 Oct	34	512	1050			RG
11 Oct	34	328	300			RG
11 Oct	34	467	900			RG
11 Oct	34	542	1050			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
11 Oct	34	538	900			RG
11 Oct	34	532	1000			RG
11 Oct	34	554	1150			RG
11 Oct	34	549	1000	green	37	RG
11 Oct	34	497	956			RG
11 Oct	34	553	1150			RG
11 Oct	34	482	875			RG
11 Oct	34	581	1200	blue	1382	RG
11 Oct	34	539	1050			RG
11 Oct	35	509	950			RG
11 Oct	35	554	1150			RG
11 Oct	35	537	825			RG
11 Oct	37	562	1275	blue	1400	RG
11 Oct	37	531	900	blue	1539	RG
11 Oct	37	547	1000	blue	1667	RG
11 Oct	37	571	1450			RG
11 Oct	37	518	1050			RG
11 Oct	37	594	1400			RG
11 Oct	37	609	1475			RG
11 Oct	37	568	1175	green	45	RG
11 Oct	40	503	1050			RG
11 Oct	40	572	1100			RG
11 Oct	40	522	1100			RG
11 Oct	40	568	1450			RG
11 Oct	41	504	1150			RG
11 Oct	41	565	1150			RG
11 Oct	41	497	1075			RG
11 Oct	41	487	775			RG
11 Oct	41	557	1200			RG
11 Oct	41	493	850			RG
11 Oct	41	502	1200			RG
11 Oct	42	593	1350			RG
11 Oct	42	547	1000			RG
11 Oct	42	442	625			RG
11 Oct	42	632	1800	white	100	RG
11 Oct	43	577	1300			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
11 Oct	43	526	1000			RG
11 Oct	43	546	1150			RG
11 Oct	43	528	975			RG
11 Oct	43	497	700	blue	1501	RG
11 Oct	43	512	1100			RG
11 Oct	43	307	225			RG
11 Oct	43	533	1000			RG
11 Oct	43	545	1000			RG
11 Oct	43	578	1350			RP
11 Oct	43	493	900			RG
11 Oct	44	567	1250			RG
11 Oct	44	536	1150			RG
11 Oct	44	492	1050			RG
11 Oct	44	566	1450			RG
11 Oct	44	467	825			RG
11 Oct	44	528	1050	green	14	RG
11 Oct	44	495	1000			RG
11 Oct	44	499	975	green	17	RG
11 Oct	44	526	1350			RG
11 Oct	45	276	175			RG
11 Oct	45	593	1450		lost tag	RG
11 Oct	46	359	375			RG
11 Oct	46	339	300			RG
11 Oct	46	313	225			RG
11 Oct	46	599	1400			RG
11 Oct	46	577	950			RG
11 Oct	46	251	150			RG
11 Oct	46	427	550			RG
11 Oct	46	359	350			RG
11 Oct	46	532	850	green	15	RG
12 Oct	47	488	800			RG
12 Oct	47	299	225			RG
12 Oct	50	495	950			RG
12 Oct	77	567	1325			RG
12 Oct	77	377	325			RG
12 Oct	77	413	500			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
12 Oct	77	409	425	blue	1545	RG
12 Oct	77	448	625			RG
12 Oct	77	503	750	blue	1532	RG
12 Oct	53	509	1150			RG
12 Oct	53	619	1825	white	63	RG
12 Oct	53	353	325			RG
12 Oct	54	488	825			RG
12 Oct	54	527	1150			RG
12 Oct	54	562	1400			RG
12 Oct	54	528	925			RG
12 Oct	54	456	675			RG
12 Oct	55	396	450			RG
12 Oct	55	538	1200			RG
12 Oct	55	494	1050	green	1	RG
12 Oct	55	392	450			RG
12 Oct	55	396	525			RG
12 Oct	55	493	800			RG
12 Oct	56	463	900			RG
12 Oct	57	512	1075			RG
12 Oct	57	422	650			RG
12 Oct	57	515	900			RG
12 Oct	58	484	650			RG
12 Oct	58	523	900			RG
12 Oct	59	353	275			RG
12 Oct	59	468	650			RG
12 Oct	59	455	675			RG
12 Oct	59	540	900	blue	1691	RG
12 Oct	59	515	925	green	20	RG
12 Oct	78	356	225			RG
12 Oct	78	346	275			RG
12 Oct	78	396	400			RG
12 Oct	78	417	450			RG
12 Oct	78	470	700			RG
12 Oct	78	520	975			RG
12 Oct	78	420	575			RG
12 Oct	78	447	650			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
12 Oct	78	439	725	green	26	RG
12 Oct	60	525	1225			RG
12 Oct	60	570	1050	blue	1544	RG
12 Oct	61	380	350			RG
12 Oct	61	499	850	blue	1700	RG
12 Oct	61	465	700			RG
12 Oct	61	474	700			RG
12 Oct	62	502	850			RG
12 Oct	63	505	1075			RG
12 Oct	63	519	1025			RG
12 Oct	63	565	1325			RG
12 Oct	63	494	750			RG
12 Oct	63	514	1100			RG
12 Oct	63	525	1125			RG
12 Oct	63	529	875			RG
12 Oct	63	545	1250			RG
12 Oct	63	560	1375			RG
12 Oct	63	560	875			RG
12 Oct	63	542	1325			RG
12 Oct	63	567	1150			RG
12 Oct	65	586	1200			RG
12 Oct	65	493	750			RG
12 Oct	65	586	1300			RG
12 Oct	65	427	525			RG
12 Oct	65	496	900			RG
12 Oct	65	452	650			RG
12 Oct	65	507	975			RG
12 Oct	65	571	1500			RG
12 Oct	65	518	850			RG
12 Oct	65	497	800			RG
12 Oct	66	588	900			RG
12 Oct	66	562	975			RG
12 Oct	66	604	1250			RG
12 Oct	66	581	900			RG
12 Oct	66	427	800			RG
12 Oct	66	429	1200			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
12 Oct	67	573	1050			RG
12 Oct	67	513	675			RG
12 Oct	67	546	1100			RG
12 Oct	67	521	850			RG
12 Oct	67	536	875			RG
12 Oct	67	538	1100	green	89	RG
12 Oct	67	540	1050			RG
12 Oct	67	537	1025			RG
12 Oct	67	548	1175			RG
12 Oct	64	526	950			RG
12 Oct	64	517	900			RG
12 Oct	64	539	975	blue	1665	RG
12 Oct	64	593	1450			RG
12 Oct	64	552	1350			RG
12 Oct	64	547	1000			RG
12 Oct	64	492	1000	green	97	RP
12 Oct	64	538	1025			RG
12 Oct	64	435	600			RG
12 Oct	49	521	950			RG
12 Oct	49	462	675	blue	1699	RP
12 Oct	49	578	1300			RP
12 Oct	49	516	875	blue	1671	RG
12 Oct	49	482	800			RG
12 Oct	49	528	1050			RG
12 Oct	49	496	900			RG
12 Oct	49	537	1050			RG
12 Oct	49	405	500			RG
12 Oct	49	536	1100			RG
12 Oct	49	455	700			RG
12 Oct	49	403	500			RG
12 Oct	49	493	800	blue	1657	RG
12 Oct	49	476	850			RG
12 Oct	49	491	800			RG
12 Oct	49	566	1150			RG
12 Oct	49	564	1100			RG
12 Oct	49	533	1000			RP

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
12 Oct	49	541	1125	green	23	RG
12 Oct	49	396	475			RG
12 Oct	49	461	600			RG
12 Oct	49	452	700			RG
12 Oct	49	428	600			RG
12 Oct	49	635	1650			RP
12 Oct	49	494	650			RG
12 Oct	49	378	450			RG
12 Oct	69	516	1100			RG
12 Oct	69	467	800			RG
12 Oct	69	488	850			RG
12 Oct	69	529	1050			RG
12 Oct	69	534	1100	blue	1531	RG
12 Oct	69	422	550			RG
12 Oct	69	487	400			RG
12 Oct	69	483	900			RG
12 Oct	69	362	350			RG
12 Oct	69	392	450			RG
12 Oct	69	549	1100			RP
12 Oct	70	549	1300			RG
12 Oct	70	483	1050			RG
12 Oct	70	504	950			RG
12 Oct	70	516	1100			RG
12 Oct	70	517	950			RG
12 Oct	70	535	1100	white	54	RG
12 Oct	70	456	750			RG
12 Oct	71	575	1075			RG
12 Oct	71	522	1025			RG
12 Oct	71	525	1050			RG
12 Oct	71	492	800			RG
12 Oct	71	563	1175			RG
12 Oct	71	476	850			RG
12 Oct	71	467	775			RG
12 Oct	71	499	1050			RG
12 Oct	71	570	1000	green	90	RG
12 Oct	71	548	1050	green	12	RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed

Appendix 7 – Continued

Date	Set #	Total Length (mm)	Weight (g)	Tag colour	Tag #	Fate*
12 Oct	72	461	625			RG
12 Oct	72	494	775		lost tag	RG
12 Oct	72	569	1200			RG
12 Oct	72	538	1000			RG
12 Oct	73	362	300			RG
12 Oct	73	452	625			RG
12 Oct	73	452	675			RG
12 Oct	73	464	525			RG
12 Oct	73	555	1125			RG
12 Oct	73	300	200			RG
12 Oct	73	466	650			RG
12 Oct	73	542	1050			RG
12 Oct	73	531	950			RG
12 Oct	73	388	350			RG
12 Oct	73	632	1800			RG
12 Oct	73	507	1000			RG
12 Oct	73	539	1200			RG
12 Oct	73	599	1275			RP
12 Oct	73	468	750			RG
12 Oct	73	519	925			RG
12 Oct	74	527	975			RG
12 Oct	74	610	1575	green	14	RG
12 Oct	74	471	750			RG
12 Oct	74	487	950			RG
12 Oct	74	583	1325	blue	1546	RG
12 Oct	75	305	150			RG
12 Oct	76	583	875			RG
12 Oct	76	601	1450			RG

* RG=released, good condition; RP=released, poor condition; KD=dead; KS=sacrificed