Method Development:

Burbot Population Assessment Using Longlines, Hoop Traps and Cod Traps Little Fox Lake 2011

Prepared by:
Oliver Barker, Aaron Foos and Nathan Millar

Yukon
Environment
Environnement

February 2014

Method Development: Assessment of Burbot Populations Using Longlines, Hoop Traps and Cod Traps Little Fox Lake 2011

Yukon Department of Environment Fish and Wildlife Branch TR-14-01

Acknowledgements

Coralee Johns assisted with the Little Fox Lake burbot survey methods assessment.

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

Suggested citation:

BARKER, O. E., A. FOOS AND N. P. MILLAR. 2014. Method development: Burbot population assessment using longlines, hoop traps, and cod traps - Little Fox Lake 2011. Yukon Fish and Wildlife Branch Report TR-14-01, Whitehorse, Yukon, Canada.

Summary

Burbot are a commonly-harvested Yukon fish, with most of the recreational harvest 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 develop burbot stock assessment method for Yukon lakes, using mark-recapture methodology for abundance estimation, and catch per unit effort (CPUE) as an index of abundance.

We evaluated 3 methods of burbot capture on the south basin of Little Fox Lake: cod traps, hoop traps, and longlines (all as overnight sets). Two bait types, salted smelt and hotdogs, were also evaluated.

Key Findings

- Burbot were caught at depths of 1 to 15 m during the late fall sampling period in the south basin of Little Fox Lake.
- Burbot were caught in sufficient numbers to make mark-recapture and CPUE index studies feasible.
- CPUE was varied between gear types. Longlines using 5/0 and 2/0 circle hooks had the highest CPUE, followed by cod traps, hoop traps, and longlines with other hook configurations.
- Despite their lower CPUE, cod traps were the most efficient gear for capturing burbot. They could be set and retrieved quickly, did not injure burbot, and had no incidental catch of other species.

Table of Contents

List of Figures

List of Tables

Introduction

Burbot (*Lota lota*) are found in lakes and rivers Yukon-wide. They are the sole freshwater member of the order Gadiformes, which includes major food fishes such as cod and haddock. , Renowned for their white, flaky meat, burbot are a popular target species among ice anglers. Fishers with a special Sport Fishing Licence may also use set-lines on designated lakes in winter to catch burbot. Burbot spawn under the ice in late winter, forming large aggregations on shoals and in shallow bays. Heavily concentrated in dependable locations, spawning burbot are particularly vulnerable to excessive harvest by angling and set-lines.

Both anecdotal and harvest-based evidence suggest that burbot populations in Yukon may be subject to impacts from fishing. According to angler reports, catches of burbot declined significantly in some areas during the 1990s and 2000s (Environment Yukon 2010). Concerns over the sustainability of the catch and waste of fish resulted in a regulation change in 2004 when daily catch and possession limits were introduced. Although effort, catch, and harvest data are incomplete (though improving), records show an increase in harvest since 1996 (Fig. 1). This pattern may show a true increase in set-line harvest, or may simply reflect an increase in compliance with the reporting requirements of set-line licences.

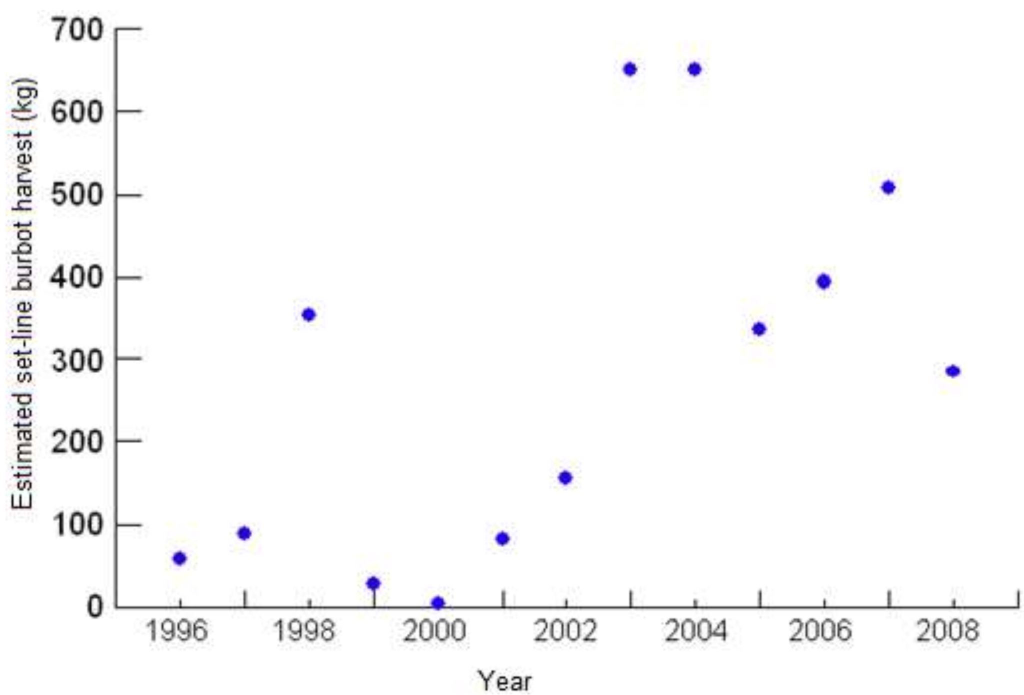

Figure 1. Estimated burbot set-line harvest in Yukon, 1996-2008.

In other jurisdictions, burbot populations have experienced moderate to drastic declines, caused by angler harvest and habitat alteration. In Alaska, burbot stocks in several lakes were found to be in serious decline and the fisheries were subsequently managed with reduced daily bag limits, gear restrictions, and in some cases, complete closure of the fishery (Schwanke 2009, Stapanian et al. 2010). Set-lines, which had previously been a legal fishing method for burbot, were prohibited in certain areas in 1991. In British Columbia, the Kootenay Lake burbot population experienced a collapse in the 1970s; burbot appear to be nearly absent from the lake today (Stapanian et al. 2010). One of the causes for this collapse appears to be fishing pressure (Stapanian et al. 2010).

There is a real potential for recreational and set-line fisheries to impact this species in Yukon; limits are liberal (daily catch limit of 10, possession limit of 20), harvest pressure can be very large (e.g., reports of hundreds of pounds being taken from a single lake over a weekend), and fishing effort is not likely to abate in the near future.

There is no history of burbot stock assessment in Yukon, and little is known about Yukon burbot populations. To determine the status of burbot populations, and to estimate the impact of recreational and set-line harvest and other pressures, a population monitoring program is needed. Recent changes to set-line licence reporting requirements will help track set-line effort and harvest across the territory. Self-reported effort and harvest information, however, is not sufficient for effective burbot management. We require robust burbot stock assessment methods to make informed management decisions about Yukon burbot.

The goals of this research program are to:

- Examine the feasibility of different capture and monitoring techniques for understanding burbot abundance in Yukon lakes;
- Understand the distribution of burbot in a Yukon lake;
- Collect information that will be used to refine estimates of effort needed to conduct burbot monitoring; and
- Provide the first set of Yukon data on which future burbot management decisions can be based.

This information will be used to:

- Discover and manage the impact of the recreational and set-line burbot fisheries;
- Determine where burbot harvest is sustainable, and where more conservative harvest levels are required; and
- Understand variation in burbot abundance among lakes and the factors that influence this variation.

Study area

Little Fox Lake is a small (222 ha), easily-accessible lake, lying next to the Klondike Highway 85km north of Whitehorse (Fig. 2). Little Fox Lake receives angling pressure by recreational anglers seeking lake trout, Arctic grayling, and burbot. Little Fox Lake is also a popular lake for set-line burbot harvest. For the purposes of this field trial, we limited our efforts to the south basin of Little Fox Lake (137 ha). This basin is joined to the north basin (85 ha) by a narrow, shallow channel, which may allow burbot passage through the winter. Subsequent monitoring effort in the north basin will allow us to determine if burbot move between basins over winter.

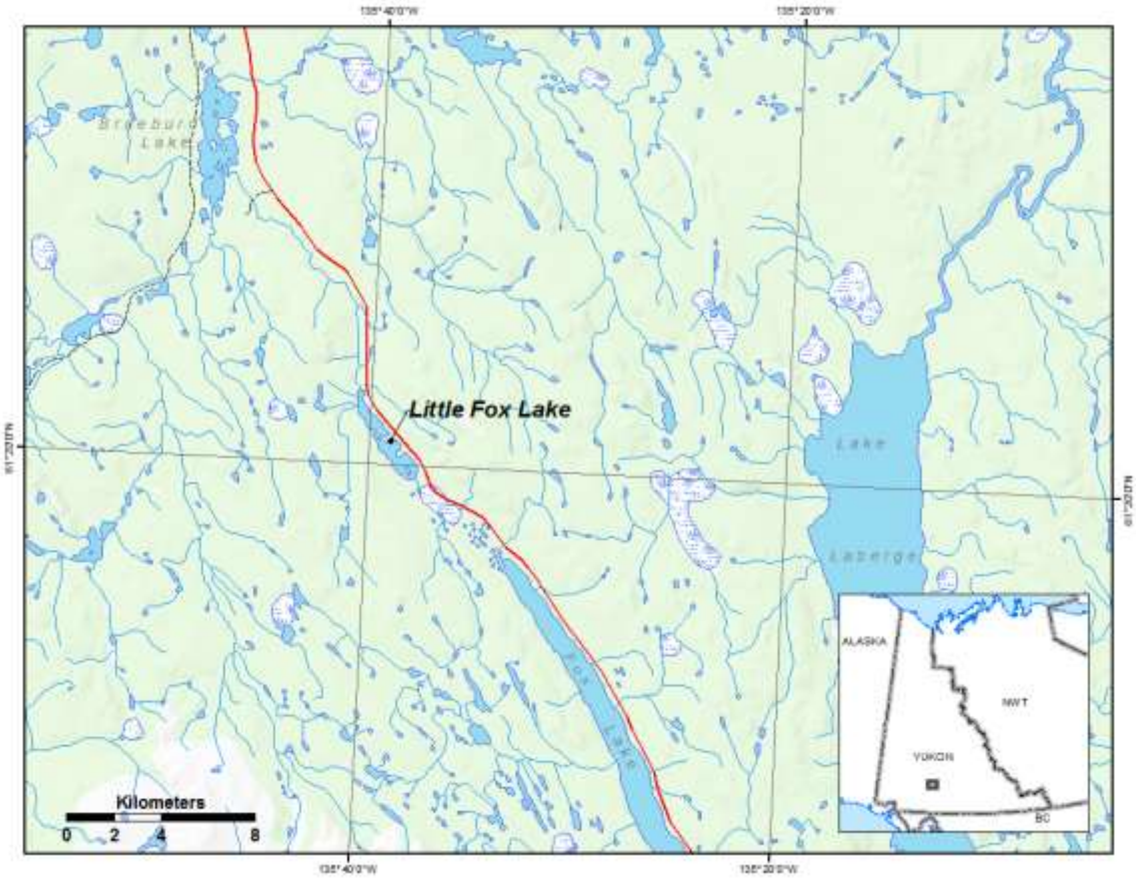

Figure 2. Location of Little Fox Lake, Yukon.

Methods

Monitoring alternatives

The 2 main options available for monitoring burbot populations differ in the amount of time they require and in the type of information that they provide. An index of abundance can be derived directly from catch data, whereas an estimate of the population (numerical abundance) requires a mark-recapture study.

An Index of Abundance

An index is a value that might indicate, relative to other indices, whether there are many or few burbot in the lake. It is relatively easy to obtain, can be tracked through time to understand increases and decreases in the population, and can potentially be used to compare the relative sizes of burbot populations between lakes.

An index, however, does not provide an estimate of the number of burbot in a lake. An index of abundance can be determined using the mean value of a standardized catch.

This value is normally expressed as catch per unit effort (CPUE).

An Estimate of Abundance

The number of burbot in a lake (burbot abundance) can be estimated using mark-recapture methodology. This involves marking fish, releasing them, waiting a sufficient amount of time for marked individuals to mix with the unmarked population, and then performing a subsequent capture session, in which both marked and unmarked burbot are caught. Mark-recapture studies require that several criteria be met:

- Marked fish have the same catchability as unmarked fish;
- Fish do not lose marks between sampling events;
- There is negligible death of fish (marked or unmarked) between sampling events; and
- There is negligible growth of fish (marked or unmarked) between sampling events (i.e., no recruitment to gear).

In Alaska, burbot assessments have met the criteria: burbot movement allowed for effective mixing of marked fish with the unmarked population in as little as 3 weeks in small lakes, death and length recruitment to capture gear (i.e. growth of fish such that they enter the population of interest) over the course of a summer was negligible, and there was minimal tag loss (Schwanke 2009).

For the purposes of abundance estimation using the modified Petersen method (Seber 1982), an initial capture event should be scheduled for just after ice-out or just before freeze-up, when burbot are active and catch rates are high (Bernard et al. 1993). The subsequent capture period should typically be during the next ice-out or freeze-up, but can follow in as little as 3 weeks if the initial capture was after ice-out (Bernard et al. 1991, Bernard et al.1993).

An abundance estimate, N_{est} can then be calculated, such that:

$$N_{est} = \frac{C_t\,(U_{t-1} + 1)}{(R_t + 1)}$$

where:

C_t = the total number of burbot caught in capture event t,

R_t = the number of burbot with previously-existing marks caught in capture event t,

U_{t-1} = the number of burbot marked and released in capture event previous to capture event *t*

Abundance can also be estimated based on a single capture event. This method works by converting catch data into an abundance estimate using a conversion factor (Schwanke 2009). Conversions are only possible once a series of population estimates have been done for several different lakes and a predictive relationship between density and catch is established.

Capture Methods

Obtaining abundance indices or estimates requires catching burbot. We assessed 3 capture methods: longlines, hoop traps, and cod traps.

Longlines

Longlines for this study had a 100 m mainline of 5.6 mm sinking creel line, with hook assemblies placed every 5 m along the mainline. The mainline was marked at 5 m intervals to indicate where hook assemblies should be placed. The mainline was deployed with a small weight, sinking buoy line, and buoy at either end.

We assessed several different hook assemblies on longlines (Fig. 3). The first assembly consisted of a detachable longline snap with a swivel (#448 snap or mini-snap), a 1 m length of #550 nylon gangion (spur line used for connecting hooks to the main longline), and a 5/0 non-offset barbed circle hook (Fig. 3). The second assembly was similar, except the nylon gangion was replaced with 40 lb. monofilament, attached to the hook eye with a 1 cm diameter Perfection Loop knot. The third assembly was similar again, except with a 40 lb. monofilament gangion, 1 cm diameter Perfection Loop knot, and a 14/0 barbed circle hook. The final assembly tested had a 40 lb. monofilament gangion, 1 cm diameter Perfection Loop knot, and a 2/0 barbless circle hook.

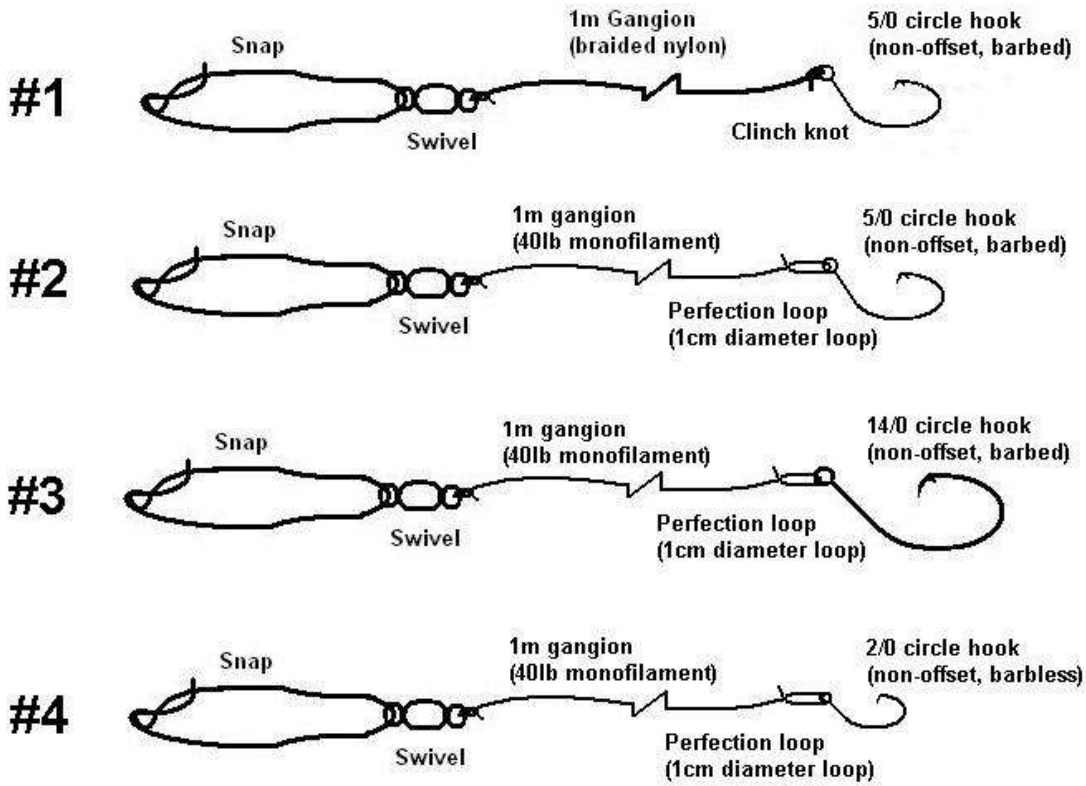

Figure 3. Detail of burbot longline hook assemblies**.**

Longline components (buoy, buoy line, anchors, mainline, and hook assemblies) could be rapidly assembled and disassembled as required. Mainlines were stored coiled in plastic totes, and weights, baited hook assemblies, buoy lines, and buoys (all stored in separate containers) were attached as the line was deployed.

Hooks on longlines were baited with a whole, salted smelt or a hotdog quarter.

Hoop traps

Our hoop traps were of the same construction used in burbot studies in Alaska (Bernard et al. 1991, Bernard et al.1993, Schwanke 2009). Traps were 3.05 m long, and had seven 6.35 mm steel hoops. The traps were tapered from a 0.61 m diameter hoop at the trap mouth to a 0.46 m diameter hoop at the closed end. Traps had a throat at the first and third loops, with 10 cm diameter openings.

Trap netting was 25 mm bar mesh of knotted nylon, treated with asphaltic compound. Traps were manufactured by H. Christensen Net Co. (Duluth, MN).

Traps were stretched open with two 12 mm galvanized steel pipes 3.05 m long, snapped to the first and last hoops. We baited hoop traps with ~250 g of whole, salted smelt inside a perforated 750 ml yogurt container. Hoop traps were equipped with a bridle, and tied to a length of sinking buoy line and a buoy. A small weight was attached to the buoy line 1 m from the bridle, to prevent wave action on the buoy from moving the trap.

Cod traps

Cod traps in this study were of the same design used in burbot stock assessments in British Columbia, Idaho, and Montana (Prince 2007, Hardy et al. 2008, Horton and Strainer 2008). 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. Traps were manufactured by Redden Custom Nets Ltd. (Port Coquitlam, BC).

A bridle was attached to the top hoop of the cod trap. A buoy line without a weight was tied to the bridle. Traps were baited with ~250 g of whole, salted smelt.

Other capture considerations

Longlines and traps were set overnight and retrieved in the same order as set, giving a ~24 hour soak time. Burbot are most active at night, therefore differences in soak time during days when gear is retrieved can be considered inconsequential, as long as all gear has been deployed for a full night (Bernard et al. 1993).

To limit competition between adjacent longlines and/or traps, longlines and traps were set a minimum of 125 m apart (Bernard et al. 1993, Schwanke 2009).

Burbot are most active, and catch rates are highest, just after ice-out and just before freeze-up (Bernard et al. 1993). Sampling during these periods is recommended to maximize sample size for effort expended.

Results and Discussion

Field trials and burbot marking

Burbot capture rates using longlines, hoop traps and cod traps

Between 11 and 16 October 2011, we set and retrieved longlines, hoop traps, and cod traps in the south basin of Little Fox Lake. We tested 4 different longline configurations over the course of the field trial, attempting to find a configuration with high catch rates, low bycatch, and low incidence of deep-hooked burbot (Tables 1, 2). We also re-deployed a number of hoop traps and cod traps for a second night in the same location, without changing the bait, to assess the possibility of increased catch rates with 48-hour sets.

Catch rates (in terms of burbot captured per overnight set) were highest for Longline B (Table 1) at a mean of 7.0 burbot/set (SD=3.1). This was followed by cod traps with fresh bait in new locations, with a mean of 4.3 burbot/set (SD= 3.2). Hoop traps with fresh bait in new locations, and the remaining longline configurations, had catch rates of between 2.6 and 2.0 burbot/set. Catch rates for hoop traps with old bait reset in their original location and cod traps with old bait set in their original location were 0.6 and 0.3 burbot/set, respectively.

Table 1. Effort and catch of burbot and lake trout using longlines, hoop traps and cod traps in the south basin of Little Fox Lake.

Gear type	Gear sub-type (hook assembly, bait or set details)	# overnight sets	Burbot caught	Lake trout caught
Longline A	20 x 5/0 barbed circle hook, nylon gangion (Assembly #1)	10	24	4
	10 with smelt, 10 with hotdog		(19 on smelt, 5 on hotdog)	(2 on smelt, 2 on hotdog)
Longline B	10 x 5/0 barbed circle hook, monofilament gangion (Assembly #2), 10 x 2/0 barbless circle hook, monofilament gangion (Assembly #4)	5	35	1
	smelt		(22 on 5/0 hooks, 14 on 2/0 hooks)	(1 on 5/0 hooks, 0 on 2/0 hooks)
Longline C	8 x 14/0 barbed circle hook, monofilament gangion (Assembly #3)	1	2	0
	smelt			
Longline D	20 x 2/0 barbless circle hook, monofilament gangion (Assembly #4)	5	13	4
	smelt			
Hoop traps	fresh smelt, new location	20	41	0
	day-old smelt, reset in original location	5	3	0
Cod traps	smelt bait, new location	12	51	0
	day-old smelt, reset in original location	3	1	0

CPUE data were non-normal for cod traps (Kolmogorov-Smirnov goodness-of-fit, $D_{12} = 0.758$, $p < 0.001$; Fig. 4) and hoop traps ($D_{20} = 0.641$, $p < 0.001$; Fig. 5). Catches from traps set in their original locations without changing bait were omitted from these calculations.

CPUE data for longline A were also non-normally distributed (D_{10} = 0.877, $p < 0.001$; Fig. 6). Normality was not assessed for CPUE data from other longline types, as the samples sizes were too small ($n \leq 5$).

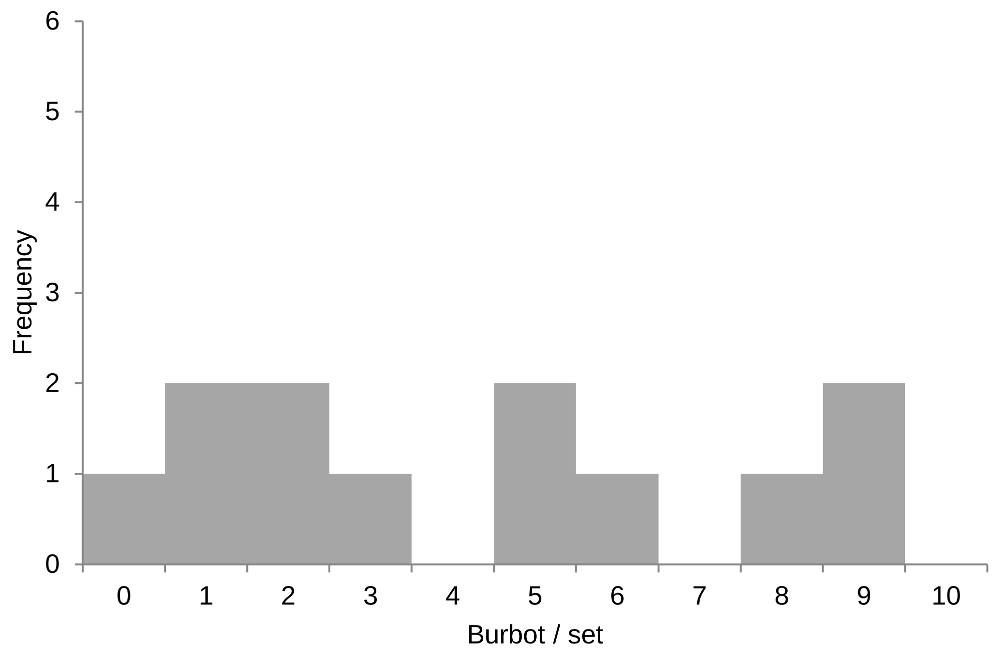

Figure 4. Distribution of burbot catches for cod trap sets.

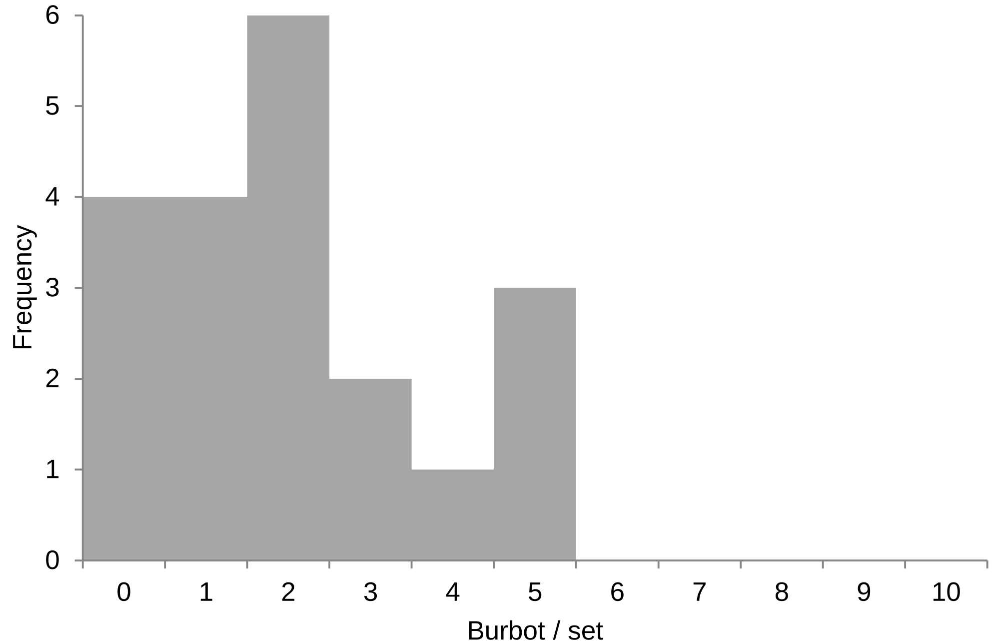

Figure 5. Distribution of burbot catches for hoop trap sets.

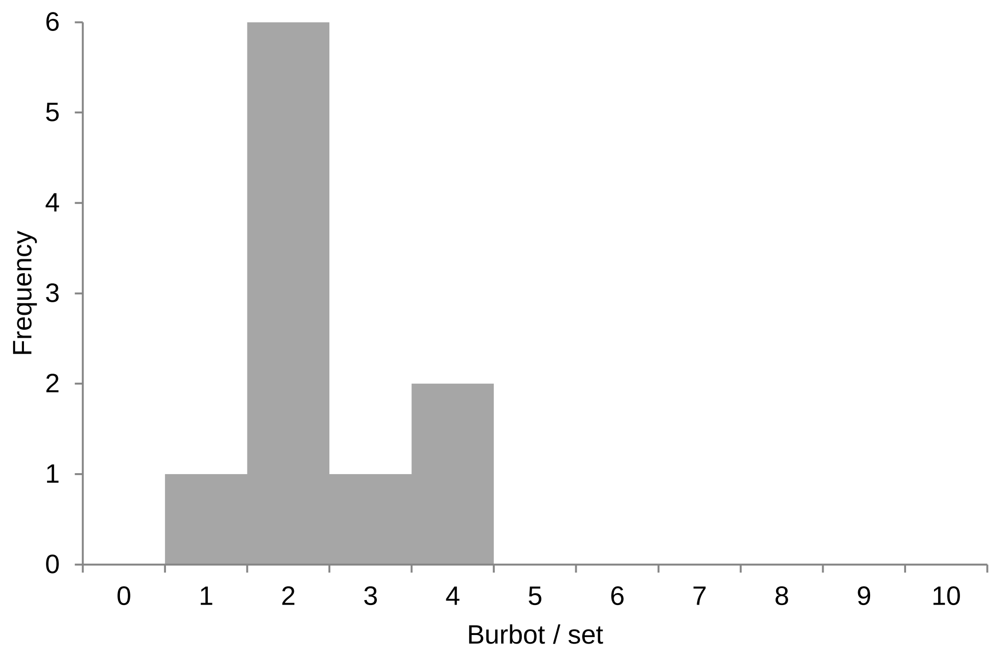

Figure 6. Distribution of burbot catches for longline A sets.

While they had highest catch rates of all the hook assemblies tested, 5/0 barbed circle hooks also had high incidences of deep-hooked burbot (burbot hooked in the back of the mouth or esophagus; Table 2).

At 22%, the incidence of deep-hooked burbot was lowest using 2/0 barbless circle hooks on monofilament gangions. The 2/0 barbless circle hooks could also be removed faster and more easily than the 5/0 and 14/0 barbed circle hooks, particularly in deep-hooked fish.

There were 7 instances of burbot retrieved dead; all were deep-hooked on 5/0 barbed circle hooks.

Table 2. Effort, catch and incidence of deep-hooking of burbot and lake trout on various longline hook assemblies and bait types. (Hook assembly types correspond to Fig. 3).

Hook assembly type	Bait	# hook nights	Burbot caught	Burbot/ hook night	Burbot deep hooked		Lake trout caught	Lake trout deep hooked	
					#	%		#	%
5/0 barbed circle hook, nylon gangion (Assembly # 1)	smelt	100	19	0.19	16	84%	2	0	0%
	hotdog	100	5	0.05	3	60%	2	1	50%
5/0 barbed circle hook, monofilament gangion (Assembly #2)	smelt	50	22	0.44	17	77%	1	0	0%
14/0 barbed circle hook, monofilament gangion (Assembly #3)	smelt	8	2	0.25	2	100%	0	0	0%
2/0 barbless circle hook, monofilament gangion (Assembly #4)	smelt	170	27	0.16	6	22%	4	0	0%

Burbot handling

We recorded weight and total length (TL) for all burbot caught. Live burbot >350 mm total length were marked with a pelvic fin clip, and in most cases a uniquely-numbered T-bar anchor tag, inserted just behind the leading edge of the first dorsal fin. We considered burbot <300 mm TL too small to mark. We marked a total of 153 burbot. Details of mark-recapture population estimation for burbot in Little Fox Lake are provided in a separate report (Barker et al. 2014).

All live burbot were released. The 7 burbot that were retrieved dead were retained for aging and stomach analysis. We retained a section of the clipped fin as a genetic sample from the first 55 burbot sampled.

For lake trout, we recorded a weight and fork length (FL), and released them without marks or tags.

Burbot length, weight and distribution

Mean burbot total length and weight were 467 mm (SD = 57.6 mm) and 729 g (SD = 250 g), respectively, ranging from a minimum of 265 mm and 100 g to a maximum of 665 mm and 1,800 g (Figs. 7,8).

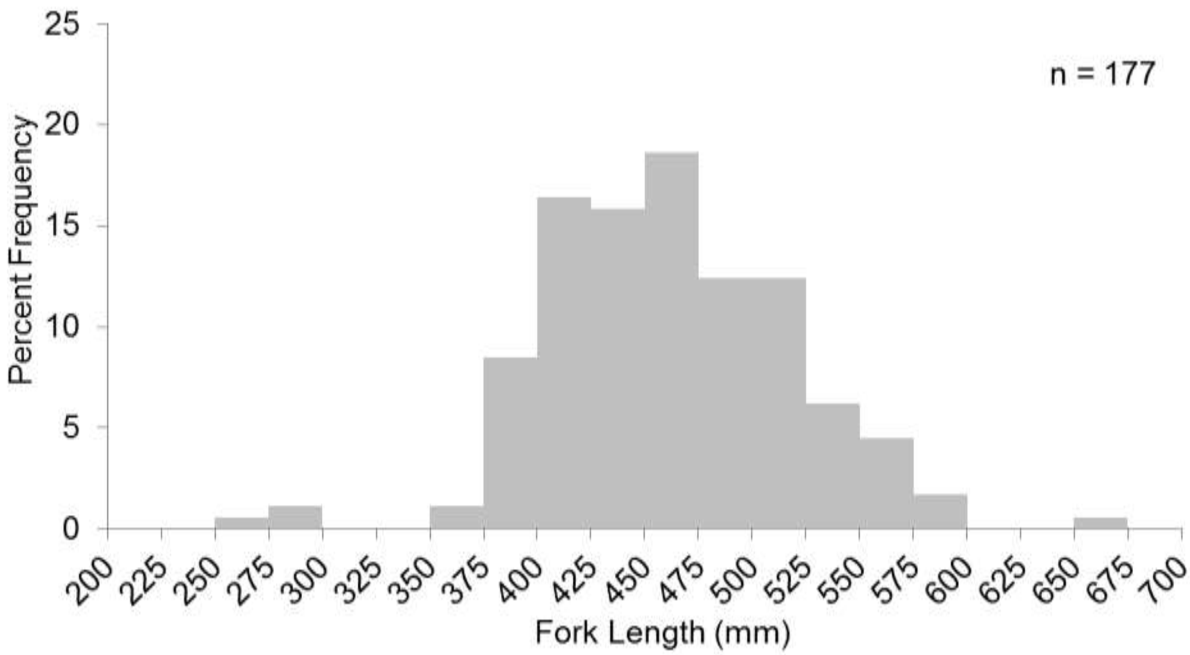

Figure 7. Total length of burbot caught in the south basin of Little Fox Lake, 11 – 16 October 2011.

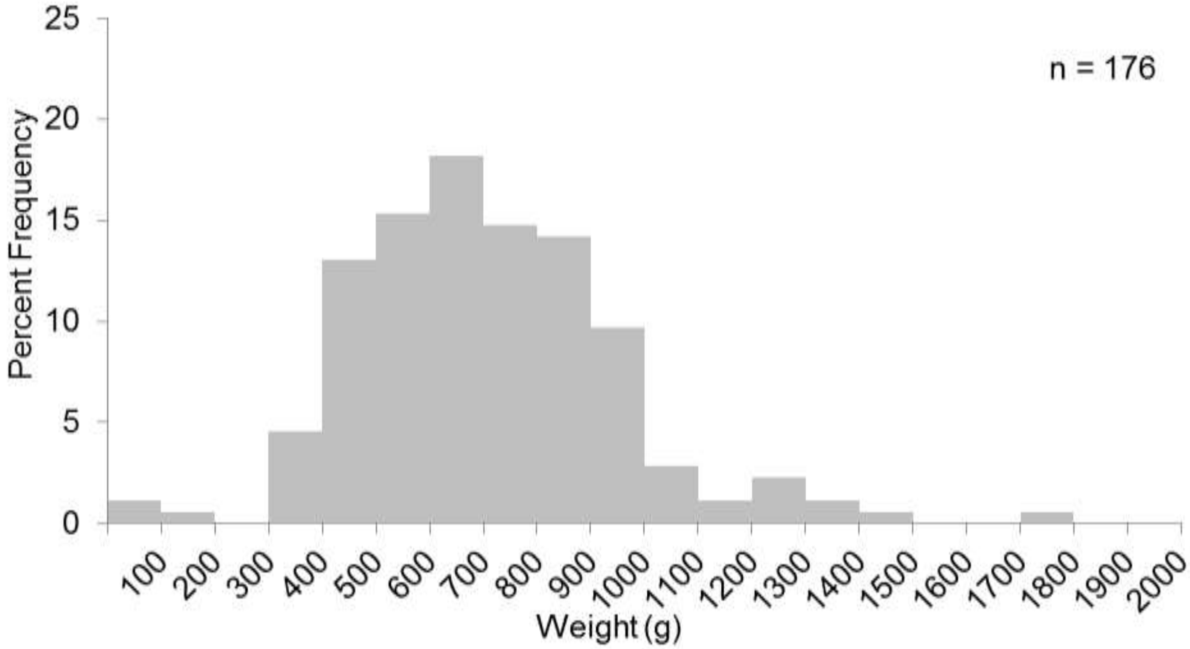

Figure 8. Weight of burbot caught in the south basin of Little Fox Lake, 11 – 16 October 2011.

There was no significant difference in total length ($F_2 = 0.005$, $p = 0.995$) or weight ($F_2 = 0.119$, $p = 0.888$) among burbot caught in hoop traps, cod traps, or on longlines.

For burbot caught in cod traps and hoop traps combined, there was no significant correlation between set depth and total length ($r_{95} = -0.029$, $p = 0.116$; Fig. 9). Depth at which individual burbot were caught was not recorded for burbot caught on setlines.

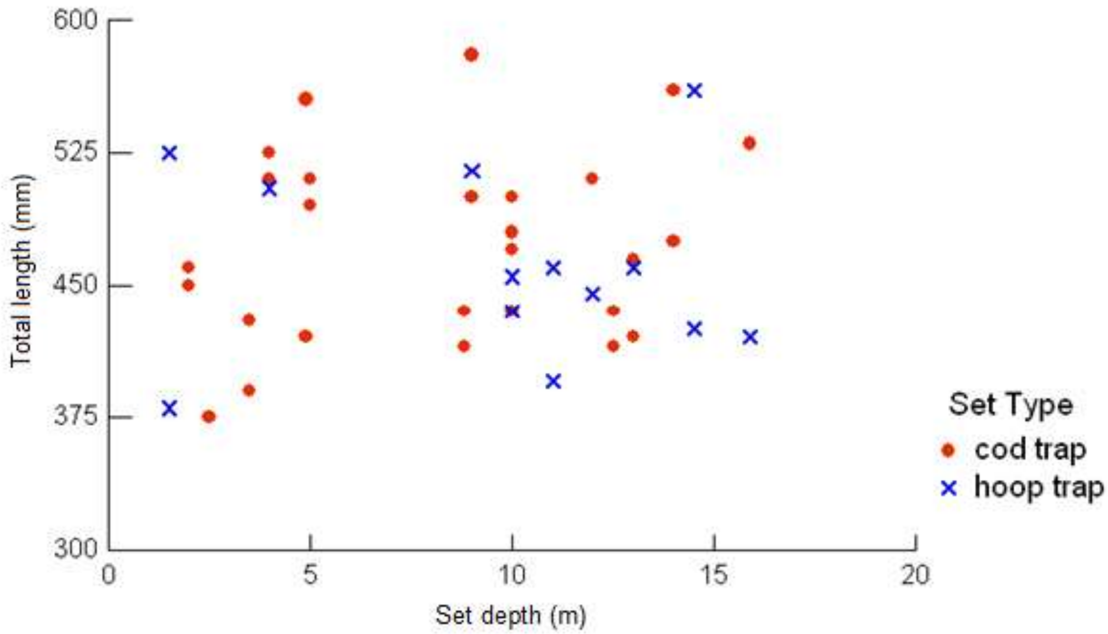

Figure 9. Total length of burbot caught in cod traps and hoop traps compared to depth of set.

For burbot caught in hoop traps and cod traps combined, there was no significant correlation between set depth and weight ($r_{95} = -0.046$, $p = 0.656$; Fig. 10).

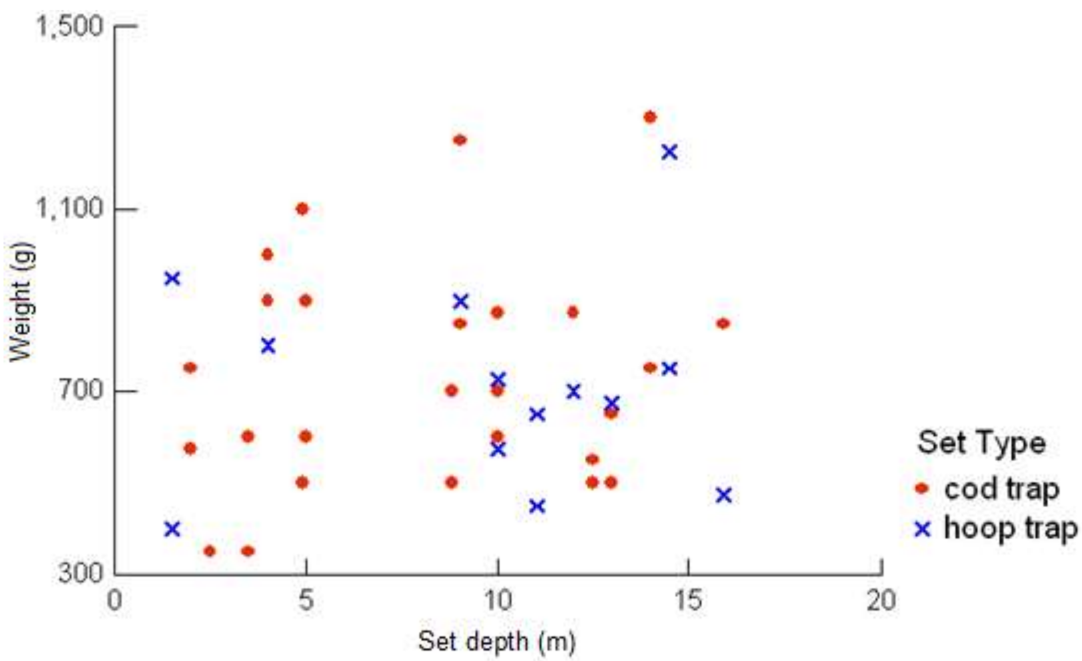

Figure 10. Weight of burbot caught in cod traps and hoop traps compared to depth of set.

There was no significant correlation between set depth and catch rate for cod traps and hoop traps combined (r_{38} = 0.255, p = 0.113; Fig. 11). When separated by trap type, however, there was a significant, positive correlation between set depth and catch rate for cod traps (r_{13} = 0.551, p = 0.033) and a positive but non-significant correlation between set depth and catch rate for hoop traps (r_{23} = 0.170, p = 0.416).

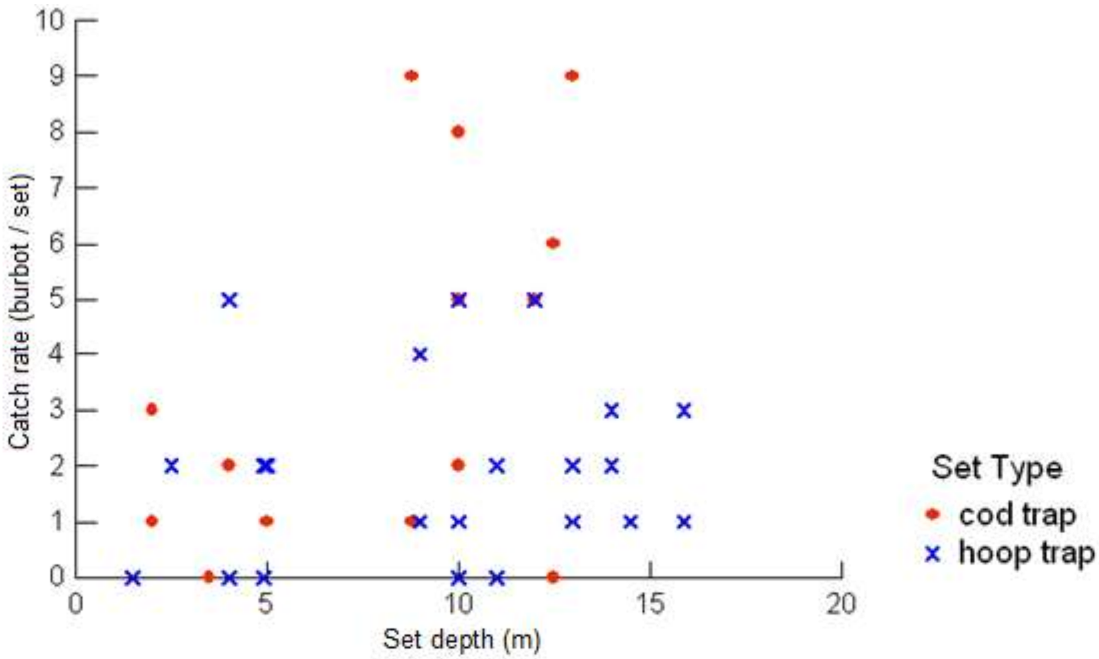

Figure 11. Burbot catch rates for hoop traps and cod traps compared to depth of set.

The catch of burbot was distributed across the south basin of Little Fox Lake. Sets with high catch rates were concentrated on a shoal near the western side of the mid-basin narrows, and catch rates were generally high in the northern portion of the basin. Catch rates were generally lower in the southern portion of the basin, particularly in the north-east corner of the southern portion.

Future directions

Cod traps appear the best gear option for continued burbot studies. Cod traps had a high catch rate and had no incidence of bycatch. Burbot captured in cod traps also appeared vigorous and healthy. Catch rates by cod traps were lower than those for longline B (Table 1), but the high incidence of deep-hooked burbot on longline B made this gear unacceptable for continued use (Table 2). In addition, longlines took approximately twice as long to set and retrieve as cod traps (data not shown), and had minor, but present, bycatch of lake trout (Table 1).

In trials against hotdogs, smelt were the best choice for burbot bait. Catch rates using smelt on longlines were much higher than those on hotdogs (Table 2). While hotdogs were not used as bait in any hoop traps or burbot traps, we assume that their performance would be equally poor. Smelt, stored frozen then thawed in brine overnight before use, should be used as bait in future burbot stock assessments.

By the end of the sampling period, a 2-person crew was able to retrieve a cod trap, remove and process the contained burbot, and re-bait and reset the trap within 15 minutes. Depending on proximity of subsequent set locations, a crew of 2 could retrieve and deploy between 25 and 30 cod traps in 8 hours on the water. If catch rates on other waterbodies are similar to those seen on Little Fox Lake, a crew deploying 25 to 30 cod traps could expect to capture, mark, and release more than 100 burbot per day.

Cod traps were the bulkiest of the capture gears assessed during these trials. A crew would have to deploy cod traps in batches of 10 to 15, which is likely the maximum number of traps that could be transported in Fisheries Section's 19' Lifetimer while still allowing safe operation. For transport to and from the lake, larger stacks of traps could be transported within the trailered 19' Lifetimer if securely tied down, such that 25 to 30 traps could be transported at once. If a smaller boat were used, transport of traps to and from the lake, and deployment of traps within the lake, would necessarily occur in smaller batches.

Cod traps were easy to set and retrieve. After a short training period, cod traps could be used by non-Fisheries staff familiar with boat operation to conduct burbot stock assessments. The ease with which staff could be trained to use cod traps would provide staffing flexibility in pursuing burbot stock assessments across Yukon.

The use of cod traps as capture gear for burbot stock assessment in Yukon would allow for comparison with previous and ongoing burbot research programs using the same trap model in British Columbia, Idaho, and Montana. Future burbot assessment in Yukon will benefit from reference to the body of knowledge and experience accumulated in these jurisdictions.

References

BARKER, O., A. FOOS, AND N. MILLAR. 2014. Burbot population assessment: Little Fox Lake 2012. Yukon Fish and Wildlife Branch Report TR-14-02. Whitehorse, Yukon, Canada.

BERNARD, D. R., AND P. A. HANSEN. 1992. Mark-recapture experiments to estimate the abundance of fish. Alaska Department of Fish and Game - Division of Sport Fish: Anchorage, AK.

BERNARD, D. R., J. F. PARKER AND R. LAFFERTY. 1993. Stock assessment of burbot populations in small and moderate-sized lakes. North American Journal of Fisheries Management 13:657-675.

BERNARD, D. R., G .A. PEARSE, AND R. H. CONRAD. 1991. Hoop traps as a means to capture burbot. North American Journal of Fisheries Management 11:91-104.

ENVIRONMENT YUKON. 2010. Status of Yukon Fisheries 2010: An overview of the state of Yukon fisheries and the health of fish stocks, with special reference to fisheries management programs. Yukon Fish and Wildlife Branch Report MR-10-01.

HARDY, R., V. L. PARAGAMIAN, AND M. D. NEUFELD. 2008. Zooplankton communities and burbot relative abundance in some oligotrophic lakes of Idaho, USA and British Columbia, Canada. In: Burbot: ecology, management, and culture. V. L. Paragamian and D. Bennett (Eds) American Fisheries Society Symposium 59: 79–89.

HORTON, T. B., AND A. C. STRAINER. 2008. Distribution and population characteristics of burbot in the Missouri River, Montana: based on hoop net, cod trap and slat trap captures. In: Burbot: ecology, management, and culture. V. L. Paragamian and D. Bennett (Eds) American Fisheries Society Symposium 59: 201-211.

PRINCE, A. 2007. East Kootenay Burbot Population Assessment. Report prepared for Ministry of Environment, Nelson, B.C.

SCHWANKE, C. J. 2009. Stock assessment and biological characteristics of burbot in Crosswind and Tolsona lakes, 2006 and 2007. Fishery Data Report No. 09-64l. Alaska Department of Fish and Game - Division of Sport Fish: Anchorage, AK.

SEBER, G .A. F. 1982. On the estimation of animal abundance and related parameters, 2nd ed. Griffin and Company, Ltd.: London, UK.

STAPANIAN, M. A., V. L. PARAGAMIAN, C. P. MADENJIAN, J. R. JACKSON, J. LAPPALAINEN, M. J. EVENSON AND M. D. NEUFELD. 2010. Worldwide status of burbot and conservation measures. Fish and Fisheries 11:34-56.

SUKHATME, P. B., B. V. SUKHATME, S. SUKHATME AND C. ASOK. 1984. Sampling theory of survey applications. Iowa State University Press: Ames, Iowa.

ROBSON, D. S., AND H. A. REGIER. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.