ANGLER HARVEST SURVEY SNAFU LAKES 2010

Prepared by:
Aaron Foos, Nathan Millar, and Oliver Barker

Yukon
Environment

December 2013

ANGLER HARVEST SURVEY
SNAFU LAKES 2010

Yukon Department of Environment
Fish and Wildlife Branch
TR-13-20

Acknowledgements

Rory Masters conducted the field work and compiled the report, under contract to Yukon Department of Environment. Jean Carey, and Karen Clyde reviewed the report.

© 2013 Yukon Department of Environment

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
E-mail: environmentyukon@gov.yk.ca

Also available online at www.env.gov.yk.ca
Suggested citation:

FOOS, A., N. MILLAR AND O. BARKER. 2013. Angler Harvest Survey: Snafu Lakes, 2010. Yukon Fish and Wildlife Branch Report TR-13-20. Whitehorse, Yukon, Canada.

Key Findings

- Angling effort has shown a slow decline (20% over 2 surveys since 1999) to our 2010 summer estimate of 3,783 hours expended by 1,173 anglers in 475 parties. This is very high effort for a small lake fishery and equals 5.8 angler hours per hectare, about 12 times higher than the Yukon median.
- Angler success (number of lake trout caught per hour of angling) has remained far below average (0.03) compared to other Yukon fisheries surveyed to date (0.15).
- 103 lake trout were caught, but only 5 were harvested - one of the lowest retention rates for lake trout in the Yukon.
- All evidence points to the lake trout in Snafu Lakes, in particular Lower Snafu, being severely depleted. Data suggest that any harvest is likely unsustainable and will impede recovery.
- 1,851 northern pike were caught and 221 were harvested. This resulted in a moderate harvest of 485 kilograms of northern pike.
- Northern pike harvest is high and may be approaching a level that could impact the quality of the fishery.

Table Contents

List of Figures

List of Tables

Introduction

We conduct angler harvest surveys, also called creel surveys, on a number of Yukon recreational fisheries each year. We use these surveys, together with other fish- and fishery-related assessments, to find out if the harvest of fish from the lake is sustainable. Environment Yukon tries to conduct angler harvest surveys on key fisheries either every 5 years or according to angler patterns and management concerns. The results of the surveys directly contribute to management decisions that make sure fisheries are sustainable over the long term.

Snafu Lakes are located in south central Yukon within the traditional territories of the Carcross/Tagish First Nation and the Taku River Tlingit First Nation. The lakes are 25 km south on the Atlin Road within the proposed Agay Mene Territorial Park. Snafu Lakes are a series of small, shallow, interconnected lakes with complex shorelines. They are all connected by Snafu Creek which drains into the Lubbock River and ultimately into Atlin Lake, a Yukon River headwater lake. Access to the lakes is primarily through a Yukon government campground and boat launch located on the lower lake or “Lower Snafu”. The upper lake or “Upper Snafu” is reached by navigating upstream through narrows and past beaver dams on Snafu Creek. Depending on beaver activity, some years are easier than others to reach Upper Snafu.

The Snafu Lakes area has much to offer recreationally, and is known for being one of the first lakes to thaw in spring; it contains sheltered waters in a beautiful setting. Snafu Lakes attracts many visitors, both day users and campers, and is a particularly popular weekend destination for Whitehorse adventurers. Space at the official campground is limited as there are only 10 sites. However, campers make use of the many well used campsites on Crown land both near the campground and along the lakeshores of both Upper and Lower Snafu.

Snafu Lake has long been identified as a lake of fisheries management interest by Yukon government and both harvest and population studies have been carried out with regular frequency. The recreational angling fishery has been assessed on 3 previous occasions: 1991, 1999, and 2005.

The 2010 survey was done to

- determine how much time anglers spent fishing (effort);
- understand the characteristics of the fishery and patterns of use;
- measure success rate of anglers;
- measure the level of harvest in relation to the productive capacity of the lake;
- record biological information on harvested fish;
- provide anglers with information about regulations; and
- establish a fisheries management presence.

Harvest Regulations

Snafu Lake has been under "Special Management Waters" angling regulations since 2001/2002. These regulations were put in place to reduce harvest pressure on easily accessible small lakes that have smaller populations of lake trout. Barbless hooks are required. The daily catch limit for lake trout is one fish per day and all fish over 65 cm must be released. The possession limit is also one fish per day. The daily catch limit for Arctic grayling is 2 fish per day and all fish over 40 cm must be released. The possession limit is also 2 fish per day. The daily pike catch limit for northern pike is 4 fish per day and all fish over 75 cm must be released. The possession limit is also 4 fish per day. General catch and possession limits apply to all other species.

The regulation history for Snafu Lake is detailed in Appendix 1.

Methods

Survey

In 1990 the Yukon government adopted survey methodology developed by the Ontario Ministry of Natural Resources (Lester and Trippel 1985). A field worker conducts face-to-face interviews with anglers on selected sample days throughout the summer. The worker asks a standard set of questions about the social and biological aspects of the fishery.

Data gathered include:

- How much time did anglers spend fishing?
- What fishing methods did anglers use?
- How did anglers fish (boat, shore, etc…)?
- Were anglers guided?
- Where were anglers from?
- What type of visitor were anglers (day users, campers, etc…)?
- What kinds of fish were anglers trying to catch?
- How many fish did anglers catch?
- How many fish did anglers release?

Any other information offered by anglers about their fishing experience is also recorded.

The field worker also collects biological data on the catch of cooperative anglers. Biological data gathered include: length (mm), mass (g), sex, maturity, scales or an otolith (a small ear bone from the fish's head) for aging, and stomachs for content analysis in the lab. Any other information about general health and condition of the fish is recorded by the field worker (e.g., abnormalities, disease, lesions).

The field worker subjectively assesses the weather's effect on fishing over the entire sample day (no possible adverse effect, possible adverse effect, definite adverse effect).

The timing of the survey depends on management objectives, key species, and the nature of the fishery.

It typically runs from ice out in the spring until either just after Labour Day or the end of September. The goal is to sample at least 20% of the total survey days. The survey is subdivided into several seasonal periods (usually 3 or 4) to better understand changes in angler activity. These periods are further divided into weekends and weekdays. Each period has its sample days, with a higher weighting for those periods with the higher projected angler use and a minimum number of samples for each period.

Sample days are 14 hours long, 8:00AM to 10:00PM. On sample days, the field worker interviews all willing anglers. The field worker also records anglers who are observed but not interviewed.

Analysis

At the completion of the survey, the data are entered into an Access database and analyzed using standard statistical methods. The ages of sampled fish are determined by counting growth rings in an ageing structure; otoliths (a small bone in the fish's head) for lake trout and Arctic grayling, and the cleithrum (a bone on the body where the gill cover closes) in northern pike. Diet is determined by examining the stomach contents.

Lake Productivity and Sustainable Harvest Level

The productivity of a lake determines the amount of fish produced annually and can guide how much harvest can be sustained.

We estimate lake productivity based on average lake depth, the concentration of total dissolved solids, and the average annual air temperature at the lake. This overall estimate of productivity is a lake-wide estimate for all fish in the lake and is expressed as the maximum sustainable yield (MSY). MSY is a theoretical maximum level of harvest that can be maintained indefinitely. MSY has frequently been used as a metric in the management of commercial fisheries where the goal is to maximize harvest; managing to MSY relies on reducing the fish population to a point where population growth is maximized. It does not, however, consider things that are important to management of Yukon freshwater fisheries like fish quality (size of fish) and fishing quality (ability of an angler to catch a fish). A more appropriate management goal in this context is the optimum sustainable yield (OSY) – this is a harvest level below MSY at which fish and fishing quality are also maintained.

Lake trout

The initial MSY values that we calculate are for all fish in the lake; we must then partition this value among species.

Based on average species composition data gathered from netting surveys in lakes across Yukon, lake trout generally comprise about 30% of the fish biomass in lakes (Environment Yukon data).

When we have a survey that provides specific information suggesting a value other than 30%, we use this revised value.

Based on work of O'Connor (1982), we set the target OSY for lake trout at 15% of the lake trout component of MSY, with the goal to maintain high quality fisheries in lightly- to moderately-fished lakes. We have compared current lake trout harvest levels against this benchmark level in Yukon fisheries for the past 25 years, and have increasing confidence that this level maintains quality fisheries. Further information and details of the calculations are provided in Appendix 3.

Northern pike

We have far less data and management history for northern pike populations than we do for lake trout populations in Yukon. Consequently, our understanding of the population dynamics, safe harvest levels, and signs of population trouble are less developed than for lake trout. In addition, the methods, tools, and analyses we use for lake trout populations and harvest do not translate well to northern pike.

As we move forward, building pike fishery data sets and gathering more detailed Yukon pike information, we aim to further develop and refine our understanding of safe harvest thresholds for northern pike by comparing indicators of the quality of the fishery with productivity information.

Given the data limitations and uncertainty, we must use all the sources of information available and employ the precautionary principle to northern pike management so as to minimize the risk of a decline in the population or in angling quality. We use a combination of approaches to estimate sustainable harvest of northern pike.

First, we use available information from surveys that have been conducted to estimate the northern pike proportion of fish biomass in the lake. We can then apply the productivity model to determine a pike-specific MSY. We do not, in the case of pike, have an OSY level against which to compare. Pike have a very different life history strategy than lake trout: they grow faster, die younger, mature earlier, and have more offspring than lake trout.

Whereas for lake trout, we used an OSY level of 15% of MSY, for pike we compare the harvest to MSY, and supplement this with other indicators of fishing quality like angler catch per unit effort (CPUE; number of fish caught per hour of angling), and fish size for an overall assessment of the sustainability of the harvest. Over time we hope to be able to define an appropriate OSY value for pike.

Second, we estimate northern pike productivity using a model developed in Alaska (Simpson 1998). This model estimates a lake's northern pike productivity based on the proportion of the nearshore area, or lake area that is less than 5 m in depth. The estimate provided from this model is carrying capacity (K), the theoretical maximum pike population size.

Assuming logistic population growth, MSY is defined as half of K. Again, we assess what percentage of MSY the current harvest level is, and compare that to other indicators of fishing quality (CPUE, fish size, etc.) to assess if harvest appears sustainable.

Further information and details of these calculations are provided in Appendix 4.

2010 Snafu Lake Survey

The survey began May 23 (ice out) and concluded September 8, 2010.

We used an access survey methodology, meaning the field worker was stationed at the government campground and boat launch (Figure 1) for the entire sample day and interviewed angling parties at the end of their fishing trip. Previous surveys and local knowledge suggest that most anglers access Snafu Lake from this location.

The survey period was partitioned into 6 time periods, weekends and weekdays in late May/June, July and August/early September. Of the 110 day survey period, 20 days were sampled, resulting in a sampling effort of 18%.

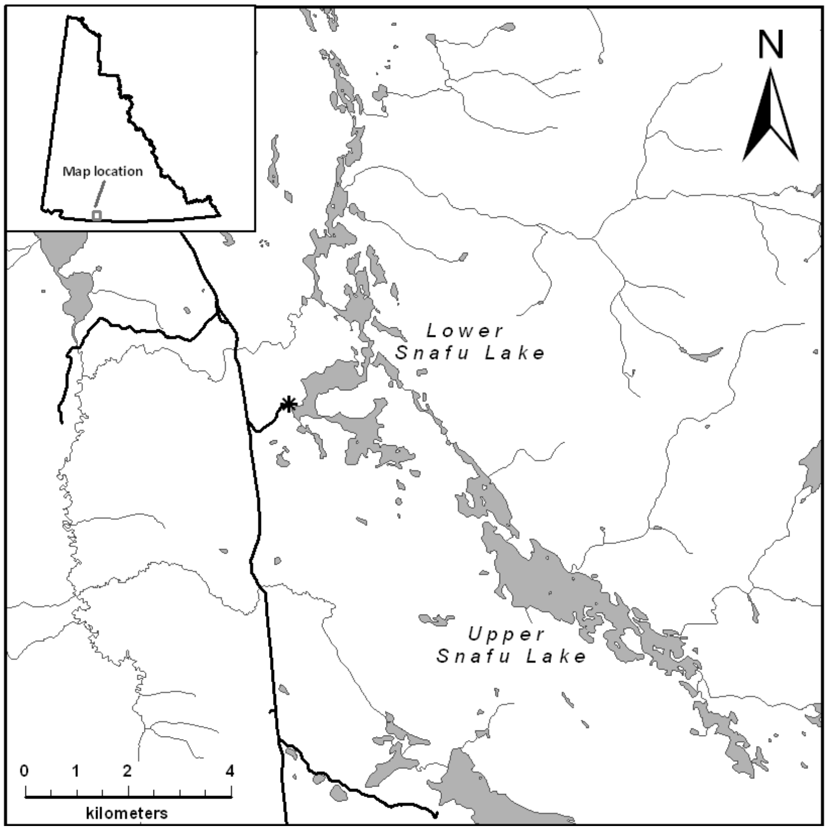

Figure 1. Upper and Lower Snafu Lake, showing location of 2010 Angler Harvest Survey (*).

We analyzed the data in 2 parts. In the first part, we combined data across all 6 time periods, and in the second part we compared results between time periods (Appendix 2). With a few exceptions, we grouped and analyzed data by individual angler.

Results of the 2010 Survey

Effort

We estimate a total of 3,783 hours of angler effort (fishing time) were expended on Snafu Lakes in 2010.

Altogether, 1,173 anglers in 475 parties fished for an average of 3.2 hours per angler. Fishing activity averaged 34.4 hours per day. This equates to a summer effort of 5.8 angler hours per hectare, nearly 12 times the median level of effort on Yukon lakes (see Appendix 4).

The survey was further divided into Upper and Lower Snafu with the Lower Lake being more heavily fished (Table 1).

Table 1. Estimated fishing effort.

	Lower Snafu	Upper Snafu
Hours	2,697	1,086
Anglers	977	196
Parties	399	76

Fishing Methods

Trolling was the most popular method of fishing, followed by spin casting and combinations of methods (Table 2).

Table 2. Fishing methods. (percent of anglers**).**

	Lower Snafu	Upper Snafu
Still		
Jig		
Drift		
Troll	69%	69%
Spin Cast	24%	6%
Fly Cast		
Other or Combination	6%	25%

Methods of Access

The majority of anglers accessed the lake by motorboats (Table 3). Canoes were popular on Lower Snafu and kayaks were popular on Upper Snafu.

Table 3. Methods of access (percent of parties).

	Lower Snafu	Upper Snafu
Canoe	20%	
Rowboat		
Motorboat	74%	86%
Shore	3%	
Other	4%	14%

Guided Anglers

There was only one guided party (Table 4).

Table 4. Guided anglers (percent of anglers).

	Lower Snafu	Upper Snafu
Yes	2%	
No	98%	100%

Angler Origin

Whitehorse anglers were the majority, followed by Canadian anglers (Table 5). Upper Snafu had a much higher percentage of Whitehorse anglers.

Table 5. Angler origin (percent of anglers).

	Lower Snafu	Upper Snafu
Local	1%	
Whitehorse	62%	92%
Yukon	2%	
Canada	23%	
U.S.	5%	
Other	8%	8%

Visitor Type

Anglers staying in the government campground were the most prevalent users, followed closely by day users (Table 6). The proportion of crown land campers was higher on Upper Snafu.

Table 6. Angler visitor type (percent of anglers).

	Lower Snafu	Upper Snafu
Day Users	42%	36%
Camper – Territorial Campground	47%	42%
Camper – Crown Land	11%	22%
Camper – Private Campground		

Weather

Weather on sample days showed an adverse effect on fishing activity, primarily due to windy conditions (Table 7).

Table 7. Sample day weather (percent of days).

	Upper and Lower Snafu
No Possible Adverse Effect	15%
Possible Adverse Effect	75%
Definite Adverse Effect	10%

Catch and Harvest

Northern pike catches were high in both Upper and Lower Snafu. Retention was higher in the lower lake. Lake trout catches were very low, especially in Lower Snafu (Table 8). Retention rates were extremely low for lake trout. Lake whitefish were caught only in Upper Snafu and all fish were retained.

Table 8. Angler catch and harvest.

Lower Snafu	# Caught		# Kept		Retention Rate (Observed)
	Observed	Estimated	Observed	Estimated	
Lake trout	3	12	0	0	0%
Northern pike	220	1101	32	167	15%
Lake whitefish					
Arctic grayling					
Upper Snafu	**# Caught**		**# Kept**		**Retention Rate (Observed)**
	Observed	**Estimated**	**Observed**	**Estimated**	
Lake trout	20	91	2	5	10%
Northern pike	216	751	15	54	7%
Lake whitefish	3	13	3	13	100%
Arctic grayling	1	4	0	0	0%

Estimated angler success rates, calculated over the entire survey as numbers of fish caught per hour of angling effort (CPUE), is presented for all anglers (regardless of target species) in Table 9.

Table 9. Estimated catch per unit of effort (fish/hour).

	Lower Snafu	Upper Snafu
Lake trout	0.004	0.08
Northern pike	0.41	0.69
Lake whitefish		0.01
Arctic grayling		0.004

Biological Data

We conducted detailed biological sampling on 18 northern pike. Mean fork length was 603 mm, and mean weight was 1,620 g. The sex ratio was 5 males per female.

A similar number of northern pike were harvested across a wide range of size classes from 525 to 800 mm (Figure 2), and ages ranged from 3 to 10 years with an average age of 6 years (Figure 3).

Diet analysis was conducted on 18 northern pike stomachs. Of these, 11 were empty or had very small traces of contents and the remaining 7 averaged 37% full. Slimy sculpins were the most common diet item identified (Table 10).

Table 10. Sampled northern pike stomach contents.

	Percent Volume
Slimy Sculpin	36%
Unidentified Fish	36%
Burbot	9%
Least Cisco	9%
Dragonflies, Damselflies	9%
Unidentified Vegetation	Trace

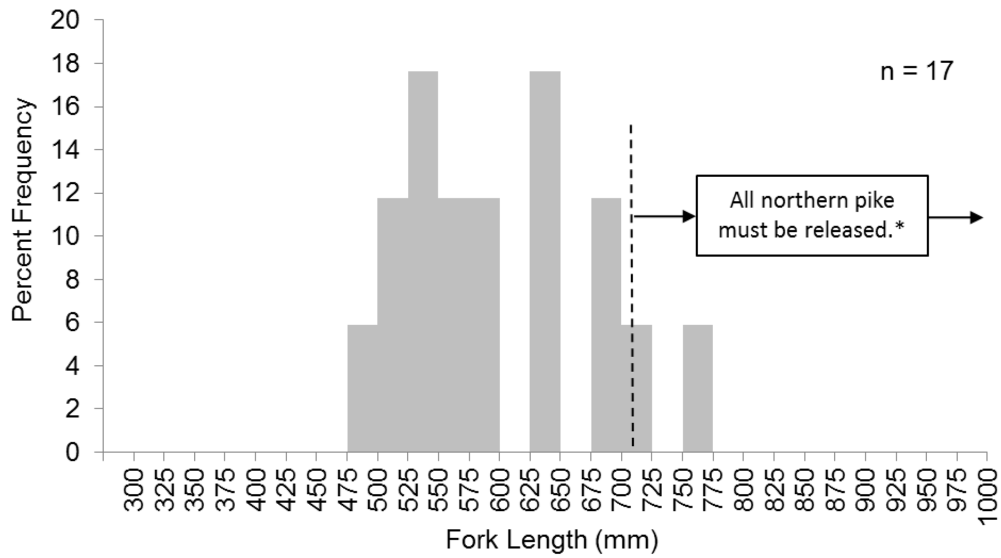

Figure 2. Lengths of sampled northern pike harvested by anglers. *Northern pike greater than 75 cm in total length must be released by licenced anglers, this equates to 71 cm in fork length.

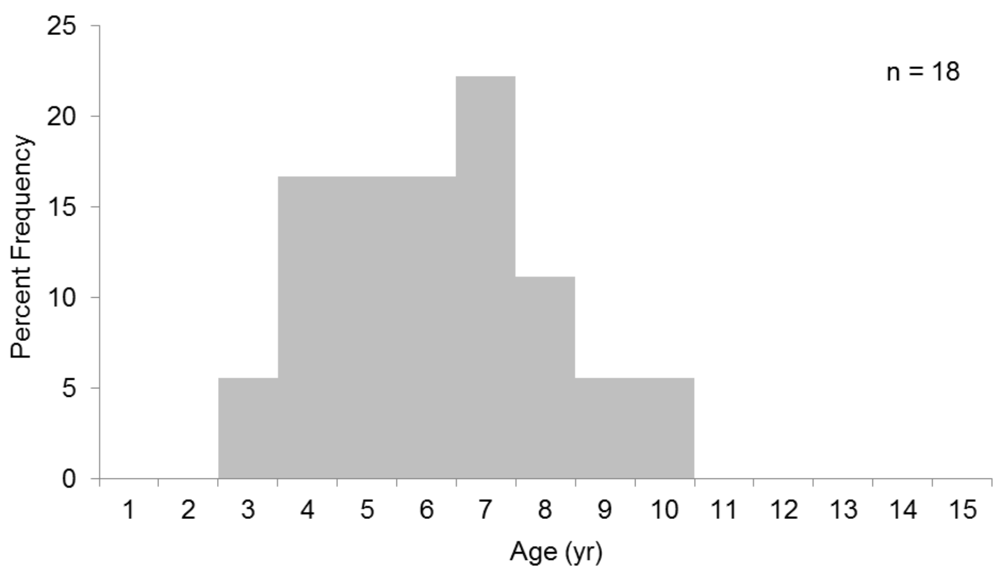

Figure 3. Ages of sampled northern pike harvested by anglers.

Three lake whitefish were sampled for biological data. Mean fork length was 331 mm, and mean weight was 475 g. The sex ratio was 2 males per female, and the average age was 8 years. The stomachs of these fish averaged 72% full.

Water fleas and pond snails were the most common diet items identified (Table 11). One lake trout was sampled for biological data. It was a male with a fork length of 395 mm, a weight of 610 g, and an age of 11 years. Its stomach was 100% full of non-biting midges.

Table 11. Sampled lake whitefish stomach contents**.**

	Percent Volume
Water Fleas	33%
Pond Snails	33%
Non-Biting Midges	32%
Scuds, Sideswimmers	2%
Seed Shrimps	Traces

Comparison with Previous Surveys

Angler harvest surveys were previously completed on Snafu Lakes in 1991, 1999, and 2005.

These surveys were of similar methodology and design and are directly comparable with the 2010 survey. To facilitate comparison amongst surveys, we combine the 2010 results for the Upper and Lower lakes as these data are not easily separable for past years.

Effort

Estimated summer open water angler effort on Snafu Lakes over the past 19 years peaked in 1999, and has declined by about 10 percent each survey since (Table 12). We estimate 3,783 angler hours of effort over the 2010 survey. This estimate remains higher than the 1991 survey.

Table 12. Total estimated angler hours**.**

	2010	2005	1999	1991
Hours	3,783	4,222	4,634	2,827

Fishing Methods

Fishing methods have shifted over the surveys (Table 13). Trolling has increased in popularity (it was a large portion of the combination methods in 2005) while spin casting has declined (also a portion of the combination category in 2005). These data are not available from 1991.

Table 13. Fishing methods (percent of anglers).

	2010	2005	1999	1991
Still				
Jig				
Drift				
Troll	69%	25%	42%	N/A
Spin Cast	21%	13%	45%	
Fly Cast			3%	
Other or Combination	9%	61%	9%	

Methods of Access

Method of access has been dominated by motorboats, with an increasing percentage in 2010 (Table 14).

Canoes and shore fishing have declined in popularity while other methods of access remain sparsely used. These data are not available from 1999 or 1991.

Table 14. Methods of access (percent of parties).

	2010	2005	1999	1991
Canoe	17%	28%		
Rowboat				
Motorboat	76%	63%	N/A	N/A
Shore	2%	6%		
Other	6%	3%		

Guided Anglers

A formally guided party was seen for the first time in 2010 (Table 15). These data are not available from 1991.

Table 15. Guided anglers (percent of anglers).

	2010	2005	1999	1991
Yes	1%			N/A
No	99%	100%	100%	

Angler Origin

Whitehorse origin anglers have been dominant in all surveys, however the proportion of Whitehorse anglers in 2010 was the lowest of all surveys (Table 16). Non-resident Canadian anglers and anglers from other countries (usually Europe) have increased from previous surveys.

Table 16. Origin of anglers (percent of anglers).

	2010	2005	1999	1991
Local	1%			
Whitehorse	67%	83%	72%	82%
Yukon	2%		1%	
Canada	19%	8%	11%	10%
U.S.	4%	3%	12%	6%
Other (Europeans)	8%	5%	4%	1%

Visitor Type

Visitor type has been dominated by government campground users in past years, but in 2010 we saw a decrease and a corresponding increase in day users (Table 17). Crown Land users remain relatively consistent. These data were not collected in 1991.

Table 17. Visitor type (percent of anglers).

	2010	2005	1999	1991
Day Users	41%	22%	18%	
Camper – Territorial Campground	46%	70%	63%	N/A
Camper – Crown Land	13%	8%	17%	
Camper – Private Campground				

Weather

The field worker's subjective assessment of weather effects on angling activity over the sample day indicates that weather was much poorer (mostly wind) in 2010 than in 2005 (Table 18). Weather data were not collected in 1999 or 1991.

Table 18. Weather effects on angling activity (percent of days).

	2010	2005	1999	1991
No possible adverse effect	15%	75%		
Possible adverse effect	75%	25%	N/A	N/A
Definite adverse effect	10%	0%		

Catch and Harvest

The catch of northern pike has increased steadily over the past 20 years (Table 19). The harvest went up significantly in 2005 because of a higher retention rate and then returned to just over 200 fish in 2010.

The catch of lake trout has varied between surveys and no trend is evident (Table 19). However, because of a steadily declining retention rate, the number of lake trout harvested has also declined steadily over the last 20 years.

Arctic grayling catches and harvest have been low in all surveys, with no catch reported in 2005.

Lake whitefish were only reported in the 2010 and 1999 survey. Few were caught in either year, and all were kept in 2010. Estimated CPUE over the entire survey can reflect the changes in the fishery because it incorporates effort and catch.

Dramatic decreases in CPUE for a particular species could indicate problems in terms of the health or status of the fish species in question. However, relying on CPUE of anglers alone is not recommended (see the section entitled "Invisible Collapse" in Status of Yukon Fisheries 2010 [Environment Yukon, 2010]). Anglers are very good at finding fish even when the population is in decline.

Table 19. Estimated number of fish caught, fish kept, and retention rate.

		2010	2005	1999	1991
Lake trout	Caught	103	65	124	59
	Kept	5	8	22	49
	Released	98	57	102	10
	% Kept	5%	12%	18%	83%
Northern pike	Caught	1,852	1,661	1,482	1,046
	Kept	221	375	221	203
	Released	1,631	1,286	1,261	843
	% Kept	12%	23%	15%	19%
Arctic grayling	Caught	4		65	10
	Kept	0		17	10
	Released	4		48	0
	% Kept	0		26%	100%
Lake whitefish	Caught	13		26	
	Kept	13		9	
	Released	0		17	
	% Kept	100%		35%	

Lake trout CPUE remained consistently low over all surveys (Table 20). Results are far below the Yukon average for lakes surveyed to date (0.15).

Northern pike CPUE steadily increased since a slight dip in 1999. The CPUE is very high compared to the average for northern pike fisheries in the Yukon (0.18).

Table 20. Estimated catch per unit of effort (fish/hour).

	2010	2005	1999	1991
Lake trout	0.03	0.02	0.03	0.02
Northern pike	0.49	0.39	0.32	0.37
Arctic grayling	0.001		0.01	0.00
Lake whitefish	0.003		0.01	

The CPUE data for species other than lake trout and northern pike are not robust on account of the small amount of effort targeted towards these species. Lake whitefish, although occasionally targeted specifically, are usually an incidental catch.

Fishery Sustainability

Angling regulations on Snafu Lakes have evolved over time.

In 1993/1994 Snafu Lakes changed from General Regulations Waters to High Quality Waters. Catch limits were reduced and slot limits were introduced to protect the larger reproducing fish, while allowing the retention of one trophy fish in each species. In 2001/2002, Snafu Lakes were reclassified as Special Management Waters; catch limits were further reduced for lake trout and slot limits were replaced with maximum size limits for lake trout, pike, and grayling. The retention of a trophy fish was no longer allowed (Appendix 1). Despite these increasingly conservative regulations over the years, we found concerning trends and indicators for lake trout and northern pike stocks in both Upper and Lower Snafu Lakes.

Lake trout

The 2010 angler harvest data was partitioned between the Upper and Lower Lakes. To facilitate comparison with previous years where this distinction was not always made, we also combined these data (Snafu Lakes combined).

Lower Snafu

We estimate that Lower Snafu Lake could sustain a total annual lake trout harvest of about 46 kg (see Methods – *Lake Productivity and Sustainable Harvest Level* and Appendix 3) and maintain a quality fishery. However, our estimates of productivity assume that the fish population is healthy. If fish populations are depleted (i.e., there is a reduced stock size), then the productivity of the population will be lower until the population has recovered.

All available evidence indicates that the population of lake trout in Lower Snafu Lake is severely depleted. Lake trout monitoring surveys in both 2005 and 2010 failed to capture a single lake trout (Jessup and Millar 2013) and angler CPUE is extremely low (0.004). The sustainable annual harvest level for lake trout on Lower Snafu Lake is therefore far below the calculated 46 kg; in fact these data suggest that even a very small harvest in Lower Snafu is likely unsustainable at current population levels.

The estimated lake trout harvest (harvest estimate x mean weight) from the 2010 summer's angling is 3 kg, this includes 0 kg of harvest and 3 kg of additional mortality from live release (Table 21).The additional harvest component is based on an estimated live release mortality of 15%. We use this value for management purposes based on studies reviewed by the Yukon Fish and Wildlife Management Board (1998).

Table 21. 2010 estimated summer lake trout harvest by lake.

	Lower Snafu	Upper Snafu
Lake trout harvest (kg)	0	9
Mortality of released fish (15%) (kg)	3	25
Total harvest and mortality (kg)	3	34

Upper Snafu

We estimate that Upper Snafu Lake could sustain a total annual lake trout harvest of about 40 kg. However, evidence again indicates a depleted population. Angler CPUE, although much better than Lower Snafu, is still low (0.08) and about half of the Yukon average. These data suggest that any harvest in Upper Snafu is potentially unsustainable at current population levels. Additionally, lake trout monitoring surveys show that lake trout biomass composition has been reduced to about 10% (Environment Yukon files). For our calculation of MSY, we use a 30% value, so our productivity estimate is likely too high.

We estimate 9 kg of harvest and 25 kg of additional mortality, totaling 34 kg, occurred in Upper Snafu Lake in summer 2010 (Table 21). Lake trout harvest on Upper Snafu is probably approaching or exceeding sustainable limits.

Snafu Lakes combined

Several lines of evidence point to the lake trout population in the Snafu lakes being depleted for some time. Angler success is poor in Upper Snafu Lake and extremely low in Lower Snafu Lake and lake trout comprise much less than 30% of the biomass. Lake trout stocks have been seriously depleted by historical overfishing, and monitoring surveys have shown a depleted population through almost 20 years of survey data. None of the population or harvest indicators point to any improvement.

If there was a healthy population of lake trout, the Snafu lakes could theoretically sustain an annual harvest of about 86 kg of lake trout and still maintain a quality fishery. However, given the depleted lake trout population in Snafu lakes, the sustainable harvest level will be much lower than this. We recommend that total harvest is kept well below this level.

The open water mortality of lake trout in the summer of 2010 was 36 kg (Table 22). This is a similar level of harvest to 2005, and about half of the harvest seen in the 1990s. This estimated harvest is a minimum estimate.

A minimal ice fishery occurs on the Snafu lakes, and although it has never been formally monitored, anecdotal information suggests that effort and harvest are low. No data are available for First Nations subsistence harvest in the Snafu lakes at this time.

The lake trout stock has not shown any sign of rebounding despite reduced harvest levels, indicating that even the current light levels of harvest are unsustainable. Further management actions will be required to facilitate a recovery and/or ward off further depletion of lake trout in the Snafu lakes.

Table 22. Estimated summer lake trout harvest by anglers.

	2010	**2005**	**1999**	**1991**
Lake trout harvested	5	8	22	49
Lake trout released	98	57	102	10
Mortality of released fish (15%)	15	9	15	2
Total harvest and mortality	20	17	37	51
Mean Weight (kg)	1.8*	2.0	1.6	1.7
Harvest and mortality (kg)	36	34	59	87

*Estimate based on average weight of 3 previous surveys.

Northern Pike

Angling pressure on the northern pike population in the Snafu lakes is high and increasing. This may be a result of low and declining success in the lake trout fishery causing anglers to switch target species. This is a concerning trend for northern pike management.

Lower Snafu

The estimated northern pike harvest (harvest estimate x mean weight) from the 2010 summer's angling in Lower Snafu Lake is 347 kg. This includes 271 kg of harvest and an additional 76 kg of live release mortality (Table 23).The additional harvest estimate due to live release mortality is a conservative estimate (5%) that we use for management purposes and is based on studies reviewed by the Yukon Fish and Wildlife Management Board (1998).

This 347 kg harvest equates to about 75% of the calculated MSY (460 kg) using the lake productivity method with 45% pike biomass (from recent surveys), and about 20% of the calculated MSY (1,650 kg) using the Alaska model (see discussion in *Methods – Lake Productivity and Sustainable Harvest Level* and Appendix 4).

Angler CPUE for pike in Lower Snafu was 0.41, well above the Yukon average (0.18).

Table 23. Estimated summer 2010 northern pike harvest by lake.

	Lower Snafu	Upper Snafu
Northern pike harvest (kg)	271	87
Mortality of released fish (5%)(kg)	76	57
Total harvest and mortality (kg)	347	144

Upper Snafu

The estimated northern pike harvest (harvest estimate x mean weight) from the 2010 summer's angling in Upper Snafu Lake is 144 kg. This includes 87 kg of harvest and an additional 57 kg of live release mortality (Table 23).

This harvest is about 35% of the calculated MSY (425 kg) using the lake productivity method with 45% pike biomass (from recent surveys), and about 25% of MSY (640 kg) using the Alaska model.

Angler CPUE for pike in Upper Snafu was 0.69, well above the Yukon average (0.18).

Snafu Lakes combined

The 2010 creel data was partitioned between the Upper and Lower lakes. However, to facilitate comparison with previous years where this distinction was not made, we also combined these data.

The estimated northern pike harvest by anglers from the Snafu lakes in the summer of 2010 is 485 kg (Table 23). As with lake trout, this is a minimum estimate as it does not include ice fishing or subsistence harvest. Despite increased catch of pike, current harvest has declined from the most recent survey in 2005 to a level similar to results from the 1990s (Table 24).

From data gathered in lake trout surveys on the Snafu lakes we estimate northern pike comprise about 45% of the total fish biomass.

Using this value in the lake trout productivity model, we calculate MSY for northern pike at 860 kg. Using the Alaska northern pike productivity model, we calculate MSY at 2,300 kg.

Our minimum northern pike harvest estimate for the Snafu lakes in 2010 is 485 kg. This is about 57% of the lake productivity MSY estimate, and is 21% of MSY estimate from the Alaska model.

Table 24. Estimated summer northern pike harvest by anglers.

	2010	2005	1999	1991
Northern pike harvested	221	375	221	203
Northern pike released	1,631	1,286	1,261	843
Mortality of released fish (5%)	82	64	63	42
Total harvest and mortality	303	439	284	245
Mean fork length (mm)	603	586	584	n/a
Mean Weight (kg)	1.6	1.5	1.7	1.7
Harvest and mortality (kg)	485	659	483	417

We are uncertain which of these values is more accurate, and we are also uncertain at what percentage of MSY we begin to see declines in the quality of the fishery, so we must look to other indicators to inform us.

Other lines of evidence indicate that the quality of this fishery is being sustained at the current harvest level.

Angler CPUE for pike has remained above Yukon averages and increased over the surveys to the current lake wide value of 0.49 fish per hour (Table 19), and the size of retained northern pike has remained consistent with a possible slight increase across surveys(Table 24 and Figure 4) although sample sizes are too small for robust conclusions.

Our survey results suggest that the population of northern pike in the Snafu lakes is healthy. It appears that the quality northern pike fishery on the Snafu lakes is being sustained at the current level of harvest, however we are unsure how close to a quality threshold the current harvest level is. A high level of vigilance is recommended for this fishery because:

- Angler effort is very high;
- There are no population assessments of northern pike so only data from the fishery are used to make management decisions;
- Northern pike harvest is somewhere between 20 and 60% of MSY; and
- There are uncertainties about sustainable yield and harvest rate for northern pike populations.

Angler activity and the harvest of northern pike from the Snafu lakes should be closely monitored. Methods to assess the population health and the biology and size structure of northern pike populations in Yukon are needed. This will help accurately assess sustainable yield and harvest rate for pike and document changes in size structure through time.

Given the high level of angler effort that the Snafu lakes receives, and concerns around both depleted lake trout stocks and potential overharvest of northern pike, we recommend this fishery be assessed again within 5 years.

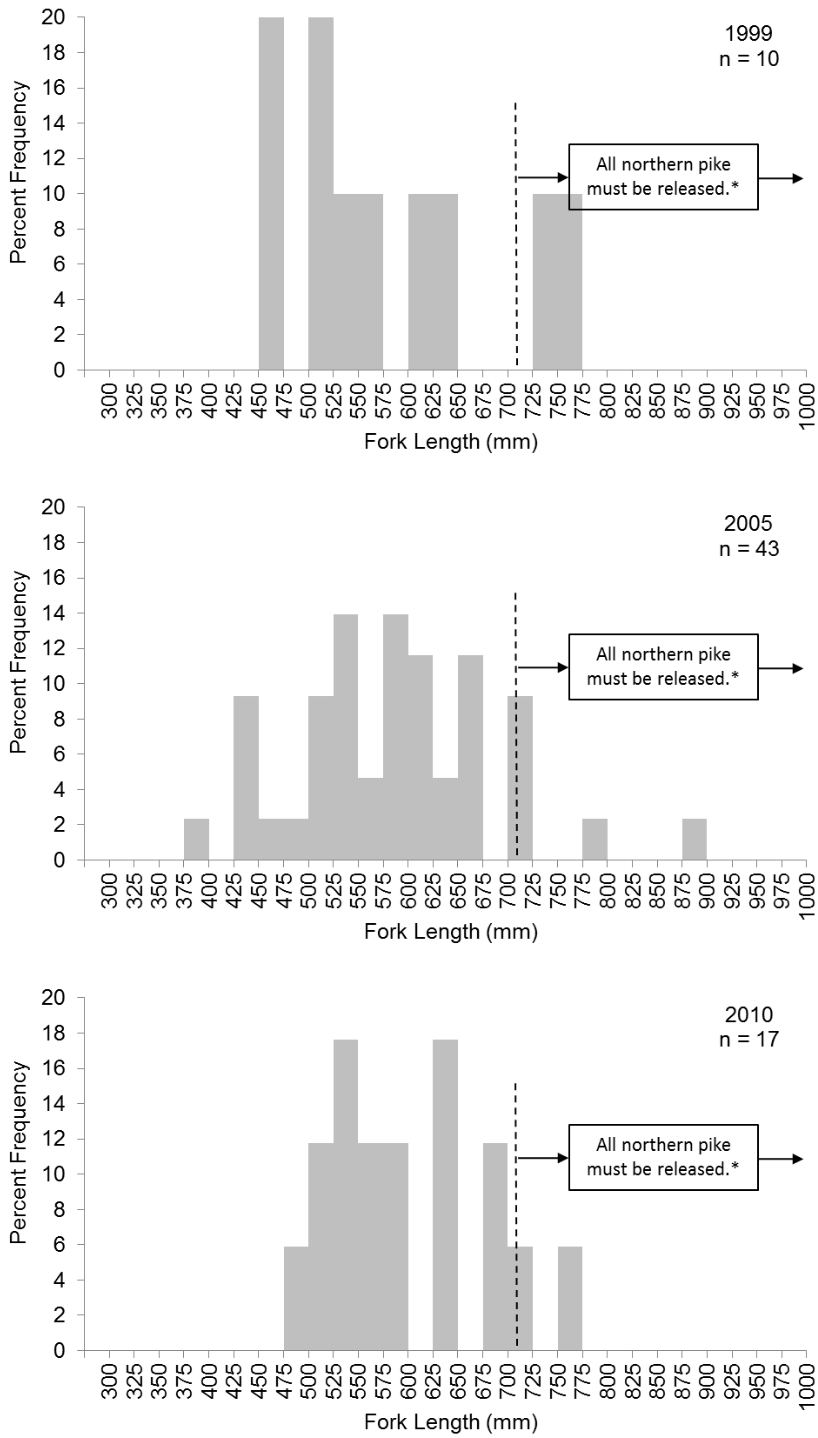

Figure 4. Lengths of northern pike caught by anglers in 1999, 2005, and 2010. 1991 data are not available for comparison. *Northern pike greater than 75 cm in total length must be released by licenced anglers, this equates to 71 cm in fork length.

Literature Cited

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. Fish and Wildlife Branch Report MR-10-01.

JESSUP, L. AND N. MILLAR. 2013. Lake trout population assessment: Lower Snafu Lake 2010. Yukon Fish and Wildlife Branch Report TR-12-13, Whitehorse, Yukon, Canada.

LESTER, N. P. AND E. A. TRIPPEL. 1985. CREESYS Users' Manual. Second Edition. Ontario Ministry of Natural Resources.

O'CONNOR, J. 1982. Unpublished data from Manitoba Government files. Department of Natural Resources, Winnipeg, Manitoba.

RYDER, R. A, S. R. KERR, K. H LOFTUS AND H. A REGIER. 1974. The Morphoedaphic Index. A Fish Yield Estimator – Review and Evaluation. Journal of the Fisheries Research Board of Canada 31(5):663-668.

SCHLESINGER, D. A. AND H. A. REGIER. 1982. Climatic and morphoedaphic indices of fish yields from natural lakes. Transactions of the American Fisheries Society 111:141-150.

SIMPSON, T. D. 1998. Lake productivity indices as estimators of carrying capacity for burbot and northern pike in interior Alaska. M.Sc. Thesis. University of Alaska Fairbanks.

YUKON FISH AND WILDLIFE MANAGEMENT BOARD (YFWMB). 1998. An evaluation of hooking mortality resulting from live-release fishing practices. Whitehorse, Yukon.

Appendix 1. Snafu Lake angling regulation changes 1989 to 2010.

Year	Species	Catch limit	Possession limit	Size restrictions
1989/90*		General Regulations		
	Lake trout	5	10	none
	Arctic grayling	5	10	none
	Northern pike	5	10	none
	Whitefish	5	10	none
1990/91	Lake trout	3	6	Only one fish over 80cm
1993/94		High Quality Water		
	Lake trout	2	2	No fish between 65 and 100cm, only one fish over 100cm
	Arctic grayling	4	4	No fish between 40 and 48cm, only one fish over 48cm
	Northern pike	4	4	No fish between 75 and 105cm, only one fish over 105cm
2001/02		Special Management Water		
	Lake trout	1	1	No fish over 65cm
	Arctic grayling	2	2	No fish over 40cm
	Northern pike	4	4	No fish over 75cm

* Yukon government obtained responsibility for freshwater fisheries management from the Federal Government in 1989.

Appendix 2. 2010 Results: Comparisons between Periods.

Effort

Mean daily angler effort on Lower Snafu was consistently high on weekends in every period (Figure 2.1). Weekday effort was also high throughout the season, peaking in August/September.

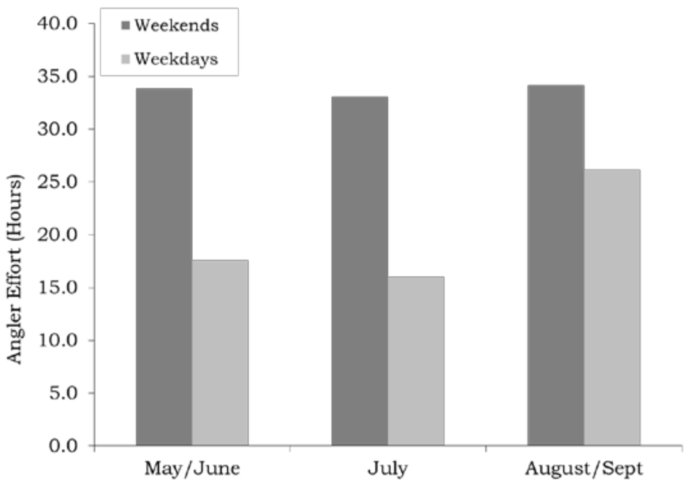

Figure 2.1. Estimated angler effort per day, Lower Snafu Lake.

Mean daily angler effort on Upper Snafu was highest on weekends in August/September (Figure 2.2). Overall, effort was high in May/June then dropped in July before becoming very high in August/September. There was no effort on weekdays in July.

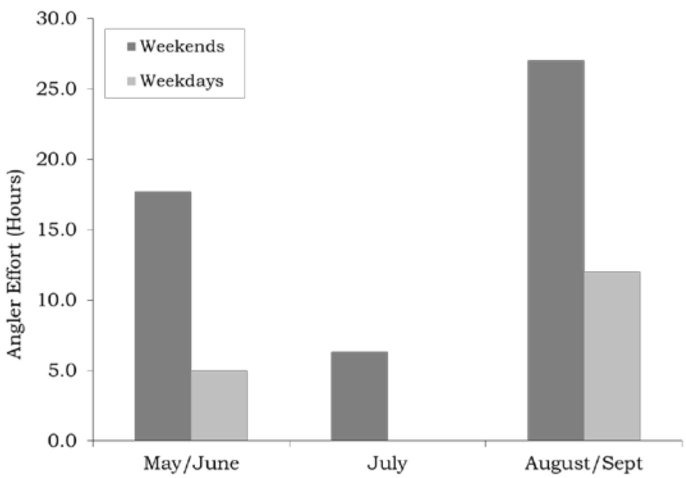

Figure 2.2. Estimated angler effort per day, Upper Snafu Lake.

Catch

Lower Snafu lake trout CPUE was extremely low with only 2 periods recording any catches (Table 2.1). Northern pike CPUE was high throughout much of the season but decreased in August/September. No other species were caught in Lower Snafu Lake.

Upper Snafu lake trout CPUE was low or non existent until August/September when it picked up and reached levels above Yukon averages on the weekdays (Table 2.2).

Northern pike CPUE was extremely high early in the season, especially on weekdays in May/June when CPUE was recorded at over 2 fish per hour. The high CPUE dropped slightly as the season went on and was very low on weekdays in August/September.

Table 2.1. Estimated catch per unit of effort (fish/hour) by period.

Lower Snafu	Lake Trout	Northern Pike	Lake Whitefish
May/June weekends		0.54	
May/June weekdays		0.98	
July weekends	0.02	0.37	
July weekdays		0.5	
August/September weekends	0.01	0.14	
August/September weekdays		0.11	

Table 2.2. Estimated catch per unit of effort (fish/hour) by period.

Upper Snafu	Lake Trout	Northern Pike	Lake Whitefish
May/June weekends	0.08	1.23	
May/June weekdays		2.1	
July weekends	0.05	1.58	
July weekdays			
August/September weekends	0.12	0.85	
August/September weekdays	0.22	0.06	0.05

Appendix 3. Calculating productivity for lake trout.

Estimates of lake productivity are calculated using average lake depth, the concentration of total dissolved solids (TDS), and the average annual air temperature at the lake.

Ryder's morphoedaphic index (MEI) (1974)

MEI = TDS/Average depth (m)

is used and incorporated into Schlesinger and Regier's equation (1982) for calculation of a maximum sustained yield (MSY) for all species.

$\log_{10}MSY = 0.050Temp + 0.280\log_{10}MEI + 0.236$

From here, we calculate an MSY specifically for lake trout. From data gathered in netting surveys of lakes across the Yukon, we find that lake trout generally comprise 30% of the fish biomass in a lake. Where we have data to suggest a different value (e.g., from a recent lake specific survey), then we will use this instead.

Following the work of O'Connor (1982), 15% of MSY provides an "optimum" sustained yield (OSY), with the goal to maintain high quality fisheries on lightly to moderately fished lakes (Table 3.1).

Table 3.1. Data and results for lake trout productive capacity estimation.

Lake	Surface area (ha)	Average depth (m)	Average air temperature (° C)	MEI (kg)	MSY (kg)	Lake trout comp. (%)	LT OSY (kg)
Lower Snafu	284	6.3	-1.5	25.24	1015	30	46
Upper Snafu	343	14.7	-1.5	8.11	892	30	40

Appendix 4.Calculating productivity for northern pike.

We use a productivity model to predict the carrying capacity of northern pike in Snafu Lakes (Table 4.1). The model was developed in Alaska, using lakes in the Fairbanks area (Simpson 1998). The model is based on the percent nearshore area (i.e., the proportion of the lake area that is less than 5 m deep) which is determined from GIS analysis of bathymetric contour lines. Carrying capacity (K) is measured in kilograms per hectare (kg/ha) for fully recruited (≥500 mm fork length) northern pike. Carrying capacity is the theoretical maximum population size that a lake can sustain.

The model

K (kg/ha) = -2.976 + 0.2968 X

Where,

K = carrying capacity, and

X = percent nearshore area (< 5 m depth)

Adding these two estimates provides a total Snafu Lakes carrying capacity of 4,594 kg of northern pike.

Table 4.1. Data and results for northern pike carrying capacity estimation.

Lake	Surface area (ha)	Nearshore area (ha)	Nearshore area (%)	K (kg/ha)	Entire lake K (kg)
Lower Snafu	284	140	49	11.65	3,306
Upper Snafu	343	78	23	3.76	1,288

Caveats

The sample size of lakes used to produce this model was small at only 4 lakes. Though the model explained 87.4% of the variation in carrying capacity among the lakes, it was not statistically significant (P = 0.065) because of the low number of lakes used to build the model.

Appendix 5. Estimated summer angler hours for surveyed Yukon fisheries.

Lake/Fishery	Lake Size (ha)	Year	Estimated Hours	Hours/ha.
Aishihik Lake	14500	2006	2456	0.17
Bennett Lake	9680	2009	1020	0.11
Braeburn Lake	558	2001	299	0.54
Caribou Lake	32	1996	115	3.61
Dezadeash Lake	8250	2006	3037	0.37
Ethel Lake	4610	2012	2271	0.49
Fish Lake	1320	2010	2376	1.80
Fox Lake	1660	2001	3277	1.97
Frances Lake	9941	2009	1592	0.16
Frenchman Lake	1441	2012	4564	3.17
Johnson's Crossing - Spring	n/a	2001	322	n/a
Kathleen Lake	3376	2004	2265	0.67
Kathleen River	n/a	2004	3757	n/a
Kluane Lake	39275	2004	2024	0.05
Kusawa Lake	14200	2006	4325	0.30
Laberge Lake	20100	2007	6706	0.33
Little Atlin Lake	4033	2008	4175	1.04
Louise Lake (Whitehorse)	65	2011	757	11.65
Lubbock River - Spring	n/a	2010	454	n/a
Marsh Lake	9630	2007	3174	0.33
McIntyre Creek	n/a	2004	3190	n/a
Nares River	n/a	2009	2041	n/a
Pine Lake	548	2009	1185	2.16
Quiet Lake	5441	2011	1204	0.22
Simpson Lake	2030	2002	608	0.30
Snafu Lakes (Upper & Lower)	651	2010	3783	5.81
Tagish Bridge	n/a	2007	2420	n/a
Tagish Lake	35460	2003	6888	0.19
Tarfu Lake	419	2005	2446	5.84
Tatchun Lake	654	2005	750	1.15
Teslin Lake	35400	2008	6812	0.19
Watson Lake	1320	2002	2543	1.93
Stocked Lakes				
Cantlie Lake	222	2005	853	3.85
Chadden Lake	60	2005	172	2.87
Hidden Lakes - 1 & 3	39	2005	1534	39.84
Scout Lake	21	2005	2412	115.96