Fishery Data Series No. 11-10

Control Efforts for Invasive Northern Pike *Esox lucius* on the Kenai Peninsula, 2007

by

Robert L. Massengill

May 2011

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mid eye to fork	MEF
mid eye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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CONTROL EFFORTS FOR INVASIVE NORTHERN PIKE *ESOX LUCIUS* ON THE KENAI PENINSULA, 2007

by
Robert L. Massengill
Alaska Department of Fish and Game, Division of Sport Fish, Soldotna

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Robert L. Massengill
Alaska Department of Fish and Game, Division of Sport Fish,
43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669-8367, USA

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ABSTRACT

In 2007, 549 northern pike (*Esox lucius*) were removed from Derks Lake and 10 northern pike were removed from Sevena Lake using gillnets. Northern pike gillnet catch per unit effort (CPUE) did not decrease in Derks Lake between 2006 (0.051) and 2007 (0.052). Large numbers of bycatch of native fish species in Sevena Lake in both 2006 and 2007 halted gillnetting efforts earlier than planned and prevented a CPUE comparison. Spring and fall abundance estimates of northern pike using removal methodology were calculated from gillnet harvest data for 2005 through 2007 for Derks and Sevena lakes. The most recent estimate for Derks Lake (fall 2007) was 978 northern pike (SE = 466) and the most recent estimate for Sevena Lake (spring 2007) was 10 northern pike (SE = 1). Fourteen lakes believed highly vulnerable to invasion by northern pike were inventoried with gillnets in 2007 but no northern pike were caught. Light traps were assessed for their efficacy of capturing larval and juvenile northern pike but capture success was poor as only four larval pike were captured after hundreds of hours of combined trapping effort at various lakes. Water quality was sampled monthly from seven area lakes with northern pike populations and stream discharge measurements were also recorded monthly from six locations within the Soldotna Creek drainage in order to provide data that would help assess pike control options.

Key words: Kenai Peninsula, Derks Lake, Sevena Lake, northern pike, *Esox lucius*, CPUE, invasive species, abundance estimate, removal method.

INTRODUCTION

The Kenai Peninsula is one of the premier sport fishing areas in Alaska, receiving over 443,000 freshwater angler-days in 2006 (33% of the total freshwater sport fishing effort in Alaska; Jennings et al. 2009b). Most angling effort on the peninsula is expended on the Kenai River which is renowned world-wide for its large Chinook salmon *Oncorhynchus tshawytscha* and is the site of other popular fisheries for coho salmon *O. kisutch*, sockeye salmon *O. nerka*, rainbow trout *O. mykiss*, and Dolly Varden *Salvelinus malma*.

A growing threat to sport fisheries on the Kenai Peninsula is the (illegal) introduction and spread of northern pike *Esox lucius* into the lakes and streams of the area. These fish are indigenous north and west of the Alaska Range, but not on the Kenai Peninsula. This species was illegally introduced sometime during the 1970s into the Soldotna Creek system (Figure 1) and the introduction was confirmed by the Alaska Department of Fish and Game (ADF&G) in 1976 (ADF&G *Unpublished*[1]). Soldotna Creek is an open tributary of the Kenai River drainage. Northern pike spread from the initial introduction point to most of the lakes in the Soldotna Creek drainage.

Northern pike are also found in other systems on the Kenai Peninsula including Stormy Lake, a tributary to the Swanson River (Begich and McKinley 2005; McKinley *In prep*). A group of six lakes approximately 5 miles south of the city of Soldotna, accessed via Tote Road and Stubblefield Road, also contain northern pike (Athons *Unpublished*[2]). The most recent discoveries of northern pike include Arc Lake (confirmed in 2000) and Scout Lake (confirmed in 2005) (Massengill *In prep* a-b) and Tiny and Hall lakes in 2010 (Massengill *Unpublished*[3]). Prior to these discoveries, Arc and Scout lakes were regularly stocked with salmon by ADF&G but stocking was discontinued upon the discovery of northern pike. At both lakes, northern pike were successfully removed via rotenone treatments in 2008 and 2009, respectively. Lakes within the Moose River drainage are indirectly linked to the Soldotna Creek drainage and are believed

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[1] Report titled "Northern Pike (*Esox lucius* L.) in the Soldotna Creek System, author unknown. Archived in Soldotna ADF&G office.

[2] Athons, D. E. *Unpublished*. October 19, 1983 memo to Soldotna office sport fish management biologist. On file at the ADF&G area office at 43961 Kalifornsky Beach Road, Suite B in Soldotna, Alaska in the Sport Fish management biologist's *Totes Road Lakes* file.

[3] Massengill, R., ADF&G Fisheries Biologist, Soldotna, Alaska. Author's observations during netting surveys conducted in 2010.

highly vulnerable to northern pike invasion. ADF&G has received two reports of northern pike in the Moose River drainage. In 1986, at least one northern pike was observed in Moose River at a fish weir operated by U.S Fish and Wildlife Service (USFWS) (Booth and Otis 1996). A decade later at least one northern pike was caught from Egumen Lake by a sport angler (L. Marsh, personal communication[4]).

Northern pike prefer slow or calm waters with abundant aquatic vegetation (Inskip 1982), are rarely found far from littoral zones, and share similar habitat preference to that of some resident fish species and rearing salmonids. Prior to the introduction of northern pike, the lakes of Soldotna Creek drainage supported rainbow trout, Dolly Varden, and rearing salmon (primarily coho salmon); species that help sustain the area's large sport fisheries. The introduction of northern pike into local lakes caused the decimation of these species in most of those lakes (McKinley *In prep*).

A survey conducted by ADF&G and funded by a grant from the USFWS Cook Inlet Coastal Program found northern pike in seven of eight major lakes in the Soldotna Creek drainage (East Mackey, West Mackey, Denise, Union, Sevena, Derks and Tree lakes) (McKinley *Unpublished*[5]). A northern pike control program conducted by ADF&G and funded by a grant from the FishAmerica Foundation in 2003, removed 1,535 northern pike from East and West Mackey lakes via gillnetting (Begich and McKinley 2005). In 2004, gillnet operations were continued at East and West Mackey lakes and expanded to include Derks and Sevena lakes (Begich 2010). Since 2005, only Derks Lake and Sevena Lake have been targeted for control efforts as those lakes provide the primary pathway for northern pike to enter Soldotna Creek (Massengill 2010).

The primary goals of this project were to

1. Reduce the number of northern pike in select lakes of the Soldotna Creek drainage,
2. Document northern pike distribution,
3. Test new methods/gear to capture and assess northern pike,
4. Collect stream flow and water quality data, and
5. Assess the impact of ongoing northern pike control efforts on native fish species.

2007 OBJECTIVES AND TASKS

Objectives:

1. Estimate the abundance of northern pike large enough to be captured by gillnets in Derks and Sevena lakes using a removal estimator.
2. Estimate the 2007 catch per unit of effort (CPUE) of northern pike at Derks Lake and Sevena Lake during spring and fall for comparison to previous years' CPUE estimates.
3. Compare the length structures of the 2007 Derks Lake and Sevena Lake northern pike populations to previous years.

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[4] Marsh, L., ADF&G Fishery Biologist, Soldotna, Alaska. Personal communication with an unknown angler who produced a photograph of the northern pike caught at Egumen Lake in 1994.

[5] McKinley, T. R. *Unpublished*. An investigation into the control and removal of northern pike in lakes of the Soldotna Creek drainage, 2002. On file at the ADF&G area office at 43961 Kalifornsky Beach Road, Suite B in Soldotna, Alaska in the Sport Fish research biologist's *Soldotna Creek drainage* file.

4. Detect whether northern pike are present in the Swanson River drainage, unnamed lakes/ponds within a 1.5 mile radius of East Mackey Lake, and unnamed lakes/ponds within a 1.5 mile radius of the cluster of known northern pike lakes near Stubblefield and Tote roads.
5. Collect water quality samples from Stormy Lake and stream discharge measurements from its outflow creek at least once each month.

Tasks:

1. Collect fork length (FL) data (length from tip of nose to fork of tail) from all northern pike catches.
2. Assess the efficacy of light traps at catching larval and juvenile northern pike.

METHODS

STUDY DESIGN AND DATA COLLECTION

Capture and Removal

Sinking gillnets, each 120 ft long, 6 ft deep, with 6 panels of mesh (1 each of ½ in, ⅝ in, ¾ in, 1 in, 1 ½ in, and 2 in) were set to capture and remove northern pike from Derks Lake (33 surface acres) and Sevena Lake (73 surface acres). For each lake, 24 gillnets were used every day until catch rates became negligible during both spring and fall capture/removal periods. Generally, personnel set the nets on a Monday, checked them daily, and then pulled them on a Friday.

Spring capture and removal was planned to begin immediately following ice-out in both Derks and Sevena lakes. Fall capture and removal was planned to commence during the last week of September. Deployment of gillnets was standardized by time of year so that similar life history phases (e.g., post-spawning etc.) could be compared between years.

Captured northern pike were harvested and measured for fork length (FL). Time of each net set and check was recorded to the nearest minute as was the number of northern pike harvested from each net. All other species captured were recorded, and when possible, released alive. Harvested fish were taken to the Kenai Peninsula Food Bank in Soldotna for distribution to local families, or retained and used for educational purposes.

The same methods used for the capture and removal effort were used to provide data for generating abundance estimates of catchable northern pike in Derks Lake and Sevena Lake for both spring and fall sampling periods. Abundance estimates were calculated using removal estimate methodology (described in the data analysis section below) on current (2007) and historic (2005–2006) gillnet capture and removal data. The capture and removal effort, described above, provided data for the removal estimates for all years.

Water Quality/Stream Discharge

From spring 2006 to spring 2007, both lake water quality and stream discharge data were collected monthly from the Soldotna Creek drainage (Sevena Lake, Derks Lake, East and West Mackey lakes, and Union Lake) and from two landlocked lakes near Soldotna (Arc Lake and Scout Lake). Water quality data, including water temperature (to the nearest 0.01^{o}C), dissolved oxygen (DO, to the nearest 0.01 mg/L), pH (to the nearest 0.01 units), and specific conductivity

(SpC, to the nearest 0.01 mS/cm[6]), were collected throughout the water column near the deepest part of each lake using a Quanta Hydrolab.[7] Data were recorded from the lake surface to the lake bottom in 1 meter increments. Water visibility was recorded using the Hydrolab (marked with white tape) as a surrogate for a Secchi disk. Stream discharge measurements were collected from all outlet streams originating from the northern pike lakes within the drainage, including lower Soldotna Creek. Equipment used to collect stream discharge measurements included a Price Pygmy[7] current meter (magnetic head) attached to a Scientific Instruments[7] wading rod and read with an electronic AquaCount[7] display screen. Stream discharge was collected in accordance with principals provided by the Alaska Department of Fish and Game (ADF&G) Statewide Aquatic Resources Coordination Unit training course titled "How to Measure Stream Discharge."

Northern Pike Inventory

Multiple lakes believed to be vulnerable to northern pike invasion or introduction were inventoried for the presence of northern pike in 2006 and 2007 utilizing the same gillnet design used in the capture and removal efforts for Derks and Sevena lakes. Lakes planned for inventory included Spirit Lake (Elephant Lake) located approximately 6 miles north of downtown Soldotna, several unnamed lakes/ponds within 1.5 miles of East and West Mackey lakes, several unnamed lakes/ponds within 1.5 miles of the lakes near Tote Road known to have northern pike, and any lakes with a recent report of northern pike where northern pike had not been confirmed before.

The amount of gillnet effort applied to each lake varied due to logistical and staffing constraints. Generally, two to four gillnets were fished for 1 to 2 days in each lake near locations that appeared to provide optimal habitat (e.g., littoral weeds, etc.). All northern pike captured were measured for FL. Time of each net set and check was recorded to the nearest minute and the number of all fish harvested from each net was recorded. Harvested fish were taken to the Kenai Peninsula Food Bank for distribution to local families or used for educational purposes.

Light Trap Assessment

The quatrefoil light trap design (Floyd et al. 1984) has been shown to be effective at catching juvenile and larval northern pike at night in middle North America at latitudes such as the Midwest of the United States (Pierce et al. 2006; Zigler and Dewey 1995). This device was used in 2007 to assess its efficacy as an inventory tool for detecting the presence of larval or juvenile northern pike.

Quatrefoil light traps with 6 mm entrance openings (manufactured by Southern Concepts) were used as well as several homemade light traps fashioned from 5-gallon buckets with funnel entrances made from clear plastic bottle tops and with Glo-Toobs electronic lightsticks suspended inside the trap. Traps were scheduled to be deployed in Derks and Sevena lakes concurrently with the fall and spring control gillnetting periods with the goal of assessing whether light traps can catch juvenile northern pike in Alaska. In addition, descriptive measurements of select environmental variables (distance from shore, water depth, vegetation present, moon phase, weather conditions, ambient light, water temperature, and air temperature) were collected at each trap.

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[6] mS/cm = miliSiemens per centimeter.

[7] Product names used in this publication are included for completeness but do not constitute a product endorsement.

DATA ANALYSIS

Length Compositions

An array of statistical tests was used to detect changes in the size structure of the northern pike populations subjected to control efforts.

Mean FL was estimated as the arithmetic mean of all fish lengths. Variance was calculated with the squared deviation from the mean (standard variance formula). Standard error of the mean (SE) was calculated as the square root of the variance divided by the square root of the sample size.

Mann-Whitney-Wilcoxon tests were used to evaluate differences in mean FL between years at Derks and Sevena lakes. Kolmogorov-Smirnov tests were also used to examine whether cumulative length distributions changed between years within lakes. All tests were conducted at the 0.05 level of significance.

Fork length distribution data were evaluated by two methods. The first incorporated relative stock density (RSD) described by Gabelhouse (1984). RSD length categories were defined as follows: "juvenile," < 300 mm; "stock," 300 to 524 mm; "quality," 525 to 654 mm; "preferred," 655 to 859 mm; and "memorable," 860 to 1,079 mm. Secondly, length distribution data were partitioned into sixteen 50-mm length classes beginning at 50 mm and ending at 899 mm. The proportion of northern pike of each length class *k*, in the catch from lake *L* was calculated as:

$$p_{Lk} = \frac{n_{Lk}}{n_L} \tag{1}$$

where:

n_{Lk} = the total number of northern pike of length class *k* from lake *L*, and

n_L = the number of northern pike caught in lake *L*.

The variance of the proportion was estimated as:

$$\hat{Var}(\hat{p}_{Lk}) = \frac{\hat{p}_{Lk}(1-\hat{p}_{Lk})}{n_L - 1}. \tag{2}$$

Catch Per Unit Effort

Catch per unit effort (CPUE) of northern pike was calculated for each lake (Derks Lake or Sevena Lake) as:

$$CPUE = \frac{c}{e} \tag{3}$$

where:

c = the total number of northern pike caught in a lake after gillnet fishing, and

e = the total number of hours each gillnet fished summed over all gillnets in a lake.

The mean CPUE for each lake over the sampling period was estimated as a ratio (Thompson 2002):

$$\overline{CPUE} = \sum_{i=1}^{n} c_i \Big/ \sum_{i=1}^{n} e_i \tag{4}$$

where:

c_i = the total number of northern pike captured during week *i*, and

e_i = the total number of hours each gillnet fished during week *i* summed over all gillnets in a lake.

with variance:

$$\hat{V}(\overline{CPUE}) = \frac{\sum_{i=1}^{n} \left(c_i - \overline{CPUE} \times e_i\right)^2}{\bar{e}^2 n(n-1)} \tag{5}$$

where:

$$\bar{e} = \sum_{i=1}^{n} \frac{e_i}{n}$$

and

n = the number of weeks nets soaked during the sampling period.

Two-sample one-tailed *t*-tests were used to evaluate if the estimated mean weekly catch per unit effort ($\overline{CPUE}$) of gillnets set in 2006 and 2007 had decreased since that of 2005. All tests were performed at a 0.05 level of significance.

Abundance Estimate

A removal estimator was used to calculate the abundance of northern pike at Derks and Sevena lakes. The assumptions associated with this estimator are as follows:

1. The population is closed.
2. At least two capture events will occur.
3. The probability of capture for a fish remains constant from event to event.

The removal estimates of northern pike abundance in Derks and Sevena lakes were calculated using the program CAPTURE provided online by the U.S. Geological Survey (USGS) at: http://www.mbr-pwrc.usgs.gov/software/capture.html (accessed December 16, 2010). A goodness of fit test provided by CAPTURE tested if the gillnet catch data corroborated constant probability of capture between events. A standard removal estimate (Zippin 1958) was used if catch data failed to reject the null hypothesis of this test.

CAPTURE also provided a generalized removal estimate of abundance if gillnet catch data failed to corroborate the constant capture probability assumption. This estimate is more flexible because it accounts for heterogeneity in capture probability among events, a condition anticipated for both lakes because a decrease in capture probability was likely after the initial

capture event. However, note that the generalized removal estimate still assumes that capture probability of each individual northern pike remains constant over time. The generalized removal estimator is described in White et al. (1982) and Seber (1982). Precision estimates, based on the proportion of a population captured in 100 or fewer trappings, are given in Appendix A1.

Stream Discharge

Total stream discharge (Q) was calculated as:

$$Q = \sum_{i=1}^{w} A_i V_i \tag{6}$$

where:

A_i = the area of the cross-section of the ith stream partition (maximum depth of partition i multiplied by width of partition i),

V_i = the velocity measured in the center of the ith stream partition, and

W = the total number of stream partitions along a transect crossing the stream perpendicularly.

RESULTS

In spring 2007, netting for capture and removal commenced shortly after ice-out on May 7 at Sevena Lake and was halted on May 9 due to few northern pike catches and many catches of native fish species. Netting for capture and removal was conducted at Derks Lake from May 14 through May 18. During fall, Derks Lake was netted from September 26 through October 20. Sevena Lake was not netted in the fall due to concerns about bycatch of native fish.

Capture and removal netting harvested 559 northern pike from Sevena and Derks lakes. Another 44 northern pike were harvested with a gillnet that barricaded an inlet creek to Derks Lake. The barricade gillnet was an attempt to keep the lake a closed system with regard to northern pike movement. The 44 northern pike caught in the barricade net were not considered part of the population for the Derks Lake removal estimate.

LENGTH COMPOSITION

Of the 603 total fish harvested from the two lakes and inlet creek, 565 were measured for FL. Measurements ranged from 133 mm to 522 mm (Table 1). Some fish could not be measured because they were scavenged while in the nets. Of fish sampled for FL, 555 were removed from Derks Lake and its inlet creek (spring mean length 279 mm, SE = 7.83 mm; fall mean length 307 mm, SE = 3.35 mm), while 10 were removed from Sevena Lake (spring mean length 379 mm, SE = 22.94).

None of the northern pike sampled in either lake were as large or larger than “quality” size based on relative stock density (RSD) described by Gabelhouse (1984) (Table 2).

Mann-Whitney-Wilcoxon tests were conducted to detect if the estimated mean FL of northern pike in 2007 decreased in each lake from the estimated mean FL in 2005 and 2006. Results for Derks Lake indicated mean FL did not decrease from 2006 to 2007 (Mann-Whitney-Wilcoxon

test statistic = 84,674, $P = 0.099$) nor was a decrease detected between 2005 and 2007 (Mann-Whitney-Wilcoxon test statistic = 102,194.5, $P > 0.99$). Results for Sevena Lake were not obtainable due to the small 2007 sample size. Mean FLs for northern pike caught in Sevena and Derks lakes during the years 2004 through 2007 are depicted in Figures 2 and 3, respectively.

The northern pike FL sample distributions for Derks Lake look more similar between 2006 and 2007 than 2005 and 2007; however, both distribution comparisons were significantly different based on Kolmogorov-Smirnov tests (Figures 4 and 5). The upper tail end of these distributions has remained similar from 2005 through 2007 (Figures 4 and 5) with a noticeable small percentage of fish reaching 400 mm in all years. Derks Lake northern pike FL range distributions for the years 2005 through 2007 are found in Figure 6 and demonstrate that very few fish exceeded 400 mm in length during those years.

The high proportions of small northern pike captured from 2005 through 2007 are consistent with results observed from 2003 through 2004 in both lakes (Begich 2010; Massengill 2010).

CATCH PER UNIT EFFORT (CPUE)

The greatest weekly CPUE of northern pike observed in Derks Lake each year from 2005 through 2007 was 0.0844, 0.137, and 0.070, respectively; the estimated mean weekly CPUE for those years was 0.0688 (SE = 0.00305), 0.0507 (SE = 0.00753), and 0.0522 (SE = 0.00355), respectively (Table 3). The greatest weekly CPUE of northern pike observed for Sevena Lake in 2005 and 2006 was 0.543 and 0.173, respectively; weekly CPUE for Sevena Lake in 2007 is not available because the netting program was halted after 2 days. The estimated mean weekly CPUE for Sevena Lake in 2005 and 2006 was 0.241 (SE = 0.0235) and 0.0842 (SE = 0.0191), respectively (Table 4).

For Derks Lake, the mean annual CPUE of northern pike did not significantly decrease between 2005 and 2007 ($t = -1.53$, df = 11, $P > 0.05$) nor was there a significant decrease between 2006 and 2007 ($t = 0.07$, df = 8, $P > 0.05$). Sevena Lake *t*-tests were not calculated due to the small sample size in 2007.

Bycatch

Sevena Lake gillnet bycatch of native fish species was significant and consisted of rainbow trout, Dolly Varden, and juvenile coho salmon (Table 5). The bycatch was so high in spring of 2007 that capture and removal efforts in that lake were aborted and not resumed in the fall. The gillnet bycatch in Derks Lake in 2007 consisted of one juvenile coho salmon.

ABUNDANCE ESTIMATE

Northern pike population estimates were produced for Sevena and Derks lakes for both spring and fall periods for the years 2005 through 2007 (Table 6). Although estimating the northern pike population in these lakes did not become an objective until 2007, estimates were generated for the years 2005 and 2006 using historical catch data. The most recent northern pike population estimate for Derks Lake (fall 2007) was 978 fish (SE = 466). The most recent population estimate for Sevena Lake (spring 2007) was 10 fish (SE = 0.83). The number of individual removal events performed among all estimates varied from 16 to 2 (Appendix A2). The number of fish removed during individual daily removal events ranged from 179 to 2 fish for Sevena Lake, and from 64 to 1 fish for Derks Lake. These estimates are germane to fish of

catchable size (greater than 150 mm FL). Between 2005 and 2007, the numbers of northern pike in Sevena Lake appear to have decreased but not for Derks Lake.

NORTHERN PIKE INVENTORY

In spring 2007, a total of 14 lakes was inventoried with variable mesh gillnet gear to detect if northern pike were present. Most of these lakes are without official names (Figure 1). Two lakes were sampled in the Tote Road area 5 miles south of Soldotna; most others were sampled in the Mackey Lake area just northeast of Soldotna. In fall 2007, the two southern-most lakes in the Crane Lake system (within the lower Swanson River drainage) were surveyed for northern pike with gillnets. No new discoveries of northern pike were found in any lake in 2007. A list of lakes inventoried since 2006, including location coordinates, can be found in Appendix A3.

WATER QUALITY/STREAM DISCHARGE

Stream discharge measurements and lake water quality data were collected monthly from select locations for a full calendar year. Sampling began in spring 2006 and continued through spring 2007. Monthly stream discharge measurements were collected from outlet streams of lakes within the Soldotna Creek drainage, lakes containing northern pike, as well as Soldotna Creek itself. Stream discharge results, including maximum, minimum, and mean discharges, are found in Appendix B1. Some gaps exist in the data due to seasonal ice conditions and/or negligible flow that prevented measurement.

Lake water quality data were recorded for 7 area lakes containing northern pike; 5 are within the Soldotna Creek drainage and 2 are located along the Sterling Highway near Soldotna, both of which were previously stocked with coho salmon by Alaska Department of Fish and Game (ADF&G) personnel until northern pike were discovered. Mean monthly values for all collected water quality parameters are found in Appendix B2. Mean monthly water quality profiles for dissolved oxygen and temperature, pH, and specific conductivity are found in Figures 7 and 8, respectively.

LIGHT TRAP ASSESSMENT

Underwater light traps were used during 2007 to assess their efficacy at catching larval northern pike. Light traps were used in six lakes and two small creeks within the Soldotna Creek drainage and also in Arc Lake, south of Soldotna. Trapping occurred opportunistically at night between May 5 and September 9. A total of 101 individual light trap sets were made resulting in a total of 424 hours of trap soak time (Appendix A4). Only four larval northern pike were captured and all were caught at Union Lake on June 7. Large and species-diverse catches of aquatic invertebrates were normal. Six threespine sticklebacks (*Gasterosteus aculeatus*) were caught in bucket light traps set in Sevena Lake.

DISCUSSION

Prior to 2007, catch per unit effort (CPUE) comparisons among years were used to judge the effectiveness of northern pike capture and removal in Sevena and Derks lakes. Surveys to assess northern pike populations are often conducted with gillnets (Diana 1983; Neumann and Willis 1995; Pierce et al. 1994; Rutz 1996). In general, findings from gillnet surveys of northern pike point out that CPUE or mean CPUE is positively correlated with abundance (Neumann and Willis 1995; Pierce and Tomcko 2003; Paukert and Willis 2003).

Beginning in 2007, direct estimation of abundance, in addition to comparing inter-year CPUE, was done to assess how effective control netting was at reducing the northern pike populations in Sevena and Derks lakes. Removal methodology was used to generate abundance estimates for 2007. Abundance was also estimated for these lakes using historical data from 2005 and 2006 to decipher whether abundance has changed over time. Although gillnets were used in both lakes in 2004, simple removal estimates of abundance were not calculated because the number of nets used (effort) varied among events thus changing the probability of capture of individuals.

It is clear that the Sevena Lake northern pike population has been radically reduced since 2005; however, the northern pike population in Derks Lake appears stable or growing despite intensive control efforts (Figures 9 and 10). In 2007, net barriers were placed in potential travel routes (inlets and outlets) in both lakes to prevent movement during the capture and removal netting. Although no northern pike were caught in a barrier net at Sevena Lake in 2007, 31 were caught in a barrier net while attempting to enter Derks Lake.

It is likely that northern pike immigrated into Derks Lake after the capture and removal netting ended in fall 2006. A source for these immigrants is East Mackey Lake, which lies about 0.5 miles west of Derks Lake and is connected via a small intermittent flowage. It is also possible the barrier net used in 2007 at the Derks Lake inlet creek mouth inadequately excluded fish. The inlet creek meanders through floating bog which is difficult, if not impossible, to completely seal with a net barrier.

What is evident is that native fish populations can quickly rebound in a barrier-free open lake system, like Sevena Lake, where invasive northern pike abundance has been greatly reduced. The capture of any fish species other than northern pike in Sevena Lake was a relatively rare event during the 2004 and 2005 control netting, but by 2006, northern pike were the least dominant species caught. By 2007, the estimated Sevena Lake population of northern pike (greater than 150 mm) was negligible (10 fish). The estimated sport harvest of northern pike on the Kenai Peninsula in 2006 was the lowest since 1997 (Table 7). This decrease in harvest, in part, is likely attributed to the lack of catchable northern pike in Sevena Lake, a lake that until recently was among the most popular local northern pike fisheries (based on anecdotal evidence).

Attempts at light trapping larval and juvenile northern pike in 2007 were not very successful. Only four larval northern pike were caught during hundreds of hours of trap soak time. Light traps were set in five different lakes and a few streams. It is unknown why the light traps performed poorly compared to other light trapping studies from Midwestern states (Pierce et al. 2006; Zigler and Dewey 1995). One possible explanation is that high amounts of ambient light are present during Alaskan summer evenings. Some studies suggest an inverse correlation between fish catch rates and ambient light at night (Secor et al. 1992; Zigler and Dewey 1995). At latitudes like those of the Kenai Peninsula, complete darkness at night does not occur during spring and early summer when larval northern pike are available for capture. By fall, when nighttime ambient light is very low, northern pike juveniles may be either too large to enter the light traps or have lost their phototactic response.

The light traps deployed in 2007 proved to be very efficient at trapping a wide range of aquatic macro invertebrates in various life stages; in fact, every light trap set caught dozens to thousands of macroinvertebrates.

It is encouraging that the 2007 gillnetting surveys of water bodies believed vulnerable to northern pike infestation yielded no new discoveries of northern pike. In fact, sampling results

from Tree Lake (a previously confirmed northern pike lake) indicated a winterkill because no northern pike or any adult fish were caught; only juvenile coho salmon were detected.

The Crane Lake system, which contains high quality northern pike habitat, is within the Swanson River drainage and is geographically close and indirectly water-linked to Stormy Lake. There are confirmed reports of northern pike in Stormy Lake, making the Crane lake system vulnerable to northern pike invasion. The lower Crane Lake system was intensively sampled during fall 2007 and large numbers of native fish species were captured but no northern pike were detected. This provides a measure of optimism that the Swanson River drainage (outside of Stormy Lake) does not yet harbor a reproducing northern pike population.

RECOMMENDATIONS

Sevena Lake was once a premiere lake for northern pike sport fishing and probably northern pike dispersed from this lake into Soldotna Creek and other parts of the Kenai River drainage. Currently, only a remnant northern pike population exists in Sevena Lake and native fish are recolonizing the lake, making control netting unappealing due to high bycatch concerns. We suggest brief gillnet sampling be conducted annually in Sevena Lake to detect if and when northern pike become the dominant species. If this occurs, we suggest that intensive control netting resume with use of larger mesh sizes (greater than 0.75 in) to reduce bycatch of desirable species of rearing fish while still catching most non-juvenile northern pike.

Recent efforts to collect water quality and stream flow data are a positive step towards assessing other control options (e.g., Rotenone, control structures, etc.). Ultimately, the intent is to implement permanent control measures to contain or eradicate invasive northern pike on the Kenai Peninsula. It is crucial to determine if we are already too late to stop the spread of northern pike into the Moose River and Swanson River drainages.

Efforts to verify the presence of northern pike in the Moose River (a highly vulnerable tributary of the Kenai River) were unsuccessful in the past (Palmer and Tobin 1996; T. McKinley, Alaska Department of Fish and Game (ADF&G), Sport Fish biologist, Soldotna, personal communication). Northern pike were not detected in sampling efforts within the Swanson River drainage in 2007, despite recent rumors (received from anglers in the field) of one or two northern pike caught there by anglers. ADF&G plans to take advantage of the enormous sampling potential of sport anglers utilizing the Swanson River and Moose River drainages by asking them to help detect the presence of northern pike. New signage, posted by ADF&G at key access points within each drainage will inform anglers that all northern pike caught should be retained and reported. If northern pike remain undetected in drainages vulnerable to invasion, the use of permanent control/eradication options may be warranted to prevent future invasion.

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TABLES

Table 1.–Mean fork length of northern pike sampled from Derks and Sevena Lakes, 2007.

Lake	Season	n	Mean length	SE	Minimum length	Median length	Maximum length
Derks [a]	Spring	81	279	7.8	155	298	432
Derks [b]	Fall	474	307	3.3	133	310	522
Sevena	Spring	10	380	22.9	192	409	437

Note: Fork length (FL) was measured in millimeters from tip of nose to fork of tail in millimeters.

[a] Derks Lake spring FL sample includes one pike caught in a lake entrance barrier net which was not included in Table 5.

[b] Derks Lake fall FL sample includes five pike caught in a lake entrance barrier net which are not included in Table 5.

Table 2.–Relative stock density estimates (RSD) and standard errors for northern pike sampled from Derks and Sevena Lakes, 2007.

RSD	Gabelhouse Minimum	Derks Lake			Sevena Lake		
Category	Length	RSD	SE	Number [a]	RSD	SE	Number
2007							
Juvenile	< 350 mm	0.782	0.018	434	0.200	0.133	2
Stock	350 mm	0.218	0.018	121	0.800	0.133	8
Quality	530 mm						
Preferred	710 mm						
Memorable	860 mm						
Total				555			10

Note: RSD categories are labeled according to Gabelhouse (1984).

[a] Includes some fish caught in the inlet creek to Derks Lake.

Table 3.–Summary of northern pike catch per unit of effort from Derks Lake, 2005–2007.

Year	Week	Season	Number of Sets [a]	Effort hours fished	Number of northern pike	CPUE [b]
2005						
	05/08–05/14	spring	24	242.0	unknown [c]	
	05/15–05/21	spring	36	562.8	43	0.0764
	05/22–05/28	spring	48	1,185.0	100	0.0844
	05/29–06/04	spring	48	1,030.8	37	0.0359
	09/25–10/01	fall	48	1,172.0	93	0.0794
	10/02–10/08	fall	48	1,176.0	85	0.0723
	10/09–10/15	fall	48	1,163.2	97	0.0834
	10/16–10/21	fall	36	856.6	37	0.0432
Totals			312 [c]	7,146.3 [c]	492	
Mean						0.0688
SE [d]						0.00305
2006						
	05/07–05/13	spring	12	280.4	13	0.0464
	05/14–05/20	spring	48	1,144.1	23	0.0201
	05/21–05/27	spring	48	1,165.4	24	0.0206
	05/28–06/03	spring	36	850.7	14	0.0165
	09/24–09/30	fall	48	1,188.8	163	0.1371
	10/01–10 /07	fall	48	1,141.9	56	0.0490
	10/08–10/14	fall	48	1,128.4	57	0.0505
Totals			288	6,899.6	350	
Mean						0.0507
SE						0.00753
2007 [e]						
	05/13 - 05/19	spring	96	2,291.9	80	0.035
	09/23-09/29	fall	96	2,221.3	156	0.070
	09/30-10/06	fall	48	1,044.2	63	0.060
	10/07-10/13	fall	96	2,153.4	143	0.066
	10/14-10/20	fall	96	2,207.1	75	0.034
	10/21-10/27	fall	24	599.8	32	0.053
Totals			456	10,517.6	549	
Mean						0.0522
SE						0.00355

[a] One set equals one gillnet fished for approximately a 24-hour period.

[b] CPUE = northern pike catch per hour of netting effort.

[c] For 2005, the total number of sets and the total effort does not include the sets fished the first week because catch data are missing for that period.

[d] SE = standard error of the mean.

[e] A barrier net was fished at the Derks Lake inlet during all netting periods to prevent immigration. The barrier net captured 31 northern pike traveling downstream and 13 northern pike traveling upstream. Fish caught in the barrier net are not included in this table because the barrier net differed from the capture and removal nets and was located outside the main lake body.

Table 4.–Summary of northern pike catch per unit of effort from Sevena Lake, 2005–2007.

Year	Week	Season	Number of Sets[a]	Effort hours fished	Number of northern pike	CPUE[b]
2005						
	05/01–05/07	spring	24	589.3	320	0.5431
	05/08–05/14	spring	36	869.3	242	0.2784
	05/15–05/21	spring	48	1,126.3	54	0.0479
	05/22–05/28	spring	48	1,138.0	16	0.0141
	05/29–06/04	spring	36	865.3	11	0.0127
	09/25–10/01	fall	36	810.2	379	0.4678
	10/02–10/08	fall	48	1,112.8	446	0.4008
	10/09–10/15	fall	48	1,143.8	445	0.3891
	10/16–10/21	fall	36	849.2	133	0.1566
Totals			360	8,504.0	2,046	
Mean						0.2406
SE[c]						0.0235
2006						
	05/07–05/13	spring	48	1,158.9	201	0.1734
	05/14–05/20	spring	48	1,123.8	102	0.0908
	05/21–05/27	spring	48	1,150.6	41	0.0356
	09/24–09/30	fall	48	1,105.2	38	0.0344
Totals			192	4,538.5	382	
Mean						0.0842
SE						0.0191
2007[d]						
	05/06-05/12	spring	48	1,180.9	10	0.0085

[a] One set equals one gillnet fished for approximately a 24 hour period.

[b] CPUE = northern pike catch per hour of netting effort.

[c] SE = standard error of the mean.

[d] A barrier net was fished at the Sevena Lake outlet during all netting periods to prevent immigration. No northern pike were captured in this net and netting was discontinued after 2 days due to excessive bycatch of native fish species.

Table 5.–Total gillnet catches of non-target fish species from Derks and Sevena Lakes, 2006–2007.

Lake/Year	Species			
	Rainbow trout	Dolly Varden	Coho Salmon (Juvenile)	Sculpin
Derks Lake				
2006	1	0	3	0
2007	0	0	1	0
Percent change	Undefined		-67%	
Sevena Lake				
2006 [a]	33	902	2,331	4
2007 [b]	71	721	1,011	0
Percent Change	115%	-20%	-57%	Undefined

[a] 12 gillnets were fished for 4 days.

[b] 24 gillnets were fished for 2 days.

Table 6.–Seasonal abundance estimates of northern pike using the general removal or Zippin method for Derks and Sevena Lakes, 2005–2007.

Location	Year	Season	Removal events [a]	Number harvested	Estimated population size [b]	SE [c]	Removal estimator [d]
Derks	2005	spring	10	143	149	3.93	general removal
		fall	15	312	424	50.37	general removal
	2006	spring	12	74	74	0.63	general removal
		fall	11	276	352	41.61	general removal
	2007	spring	4	80	86	4.24	general removal
		fall	15	469	978	466.46	general removal
							general removal
Sevena	2005	spring	16	643	653	7.42	general removal
		fall	14	1,403	1,425	10.46	general removal
	2006	spring	12	344	352	7.35	general removal
		fall	4	38	44	5.21	general removal
	2007	spring	2	10	10	0.83	Zippin

[a] Prior to 2007, a removal event was defined as twelve 120 ft gillnets nets fished for approximately 24 hours. In 2007, a removal event was defined as 24 gillnets fished for approximately 24 hours.

[b] Estimates are germane to catchable-sized fish. Generally, northern pike are considered catchable at approximately 300 mm or greater, although smaller fish (down to 155 mm) were captured as well.

[c] SE = standard error of estimate.

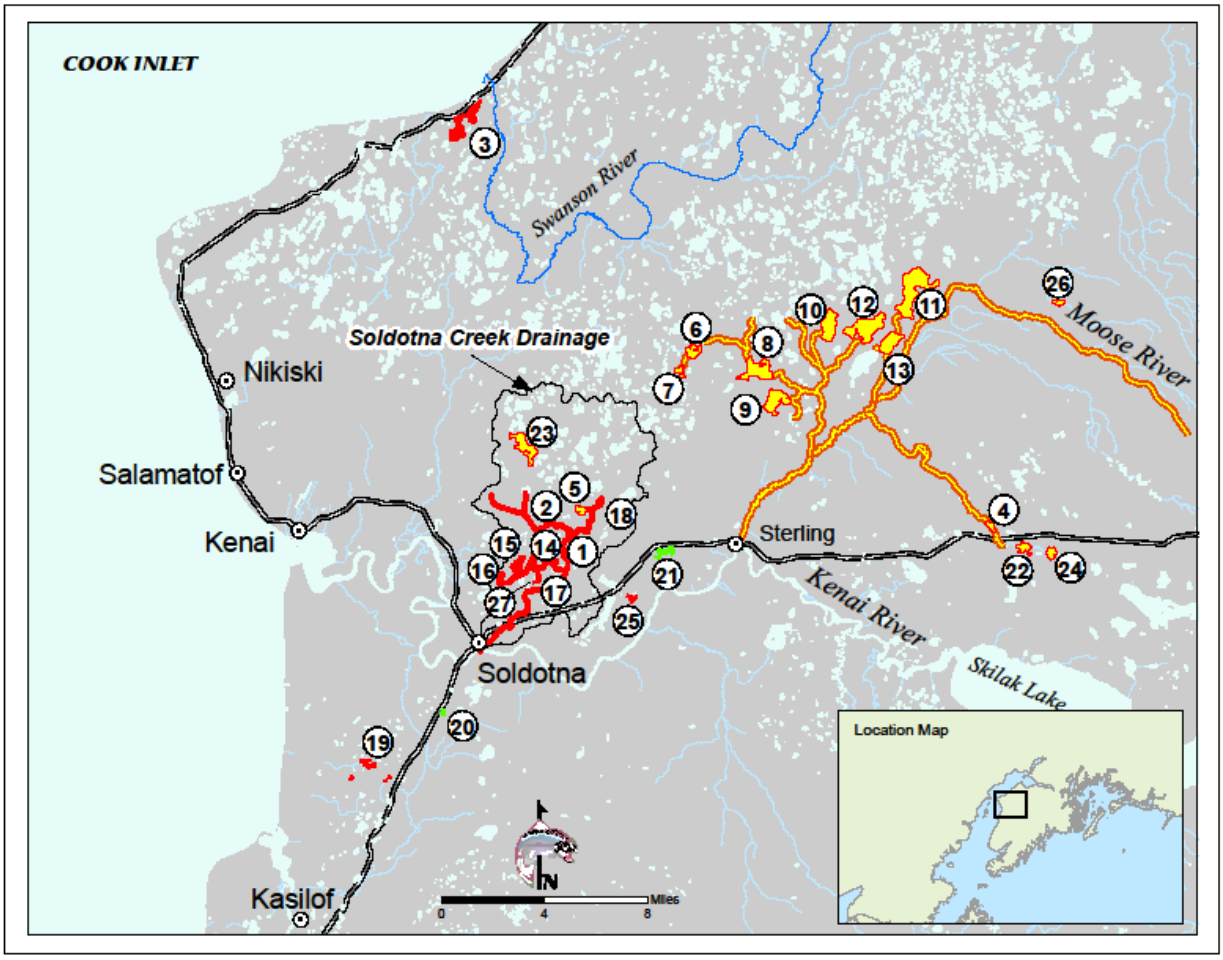
[d] Estimators were used from the USGS program CAPTURE (http://www.mbr-pwrc.usgs.gov/software/capture.html [accessed December 16, 2010]); the Zippen method (which assumes constant probability of capture between events) was used when only two removal events were available, otherwise, the general removal estimator (which makes no assumptions about capture probability between events) was used.

Table 7.–Kenai Peninsula northern pike sport harvest, 1981–2006.

Year	Lakes	Kenai River	Total
1981	32		32
1982	105		105
1983	294		294
1984	187		187
1985	52	69	121
1986	0	0	0
1987	0	12	12
1988	36	0	36
1989	49	18	67
1990	30	10	40
1991	86	0	86
1992	239	0	239
1993	216	26	242
1994	36	0	36
1995	219	29	248
1996	32	92	124
1997	21	7	28
1998	114	0	114
1999	329	0	329
2000	153	6	159
2001	1288	0	1288
2002	368	12	380
2003	641	58	699
2004	2353	58	2411
2005	212	12	224
2006	55	0	55
1981–2006			
Mean	275	19	291
2000–2006			
Mean	724	21	745

Source: Howe et al. 1995, 1996, 2001a-d; Jennings et al. 2004, 2006a-b, 2007, 2009a-b; Mills 1982-1994; Walker et al. 2003.

FIGURES



Note: Location codes are (1) Derks Lake, (2) Sevena Lake, (3) Stormy Lake, (4) Watson Lake , (5) Cisca Lake, (6) Silver Lake, (7) Mosquito Lake, (8) Camp Island Lake, (9) Grebe Lake, (10) Rock Lake, (11) Swan Lake, (12) Loon Lake, (13) Moosehorn Lake, (14) East Mackey Lake, (15) West Mackey Lake, (16) Union Lake, (17) Denise Lake, (18) Tree Lake, (19) Tote Road Area lakes [6], (20) Arc Lake, (21) Scout Lake, (22) Egumen Lake, (23) Spirit Lake , (24) Petersen Lake, (25) Hall Lake, (26) Bear Lake and (27) Tiny Lake.

Figure 1.–Kenai Peninsula waters with confirmed existing northern pike populations (red) and waters having unconfirmed reports of northern pike or believed highly vulnerable to infestation (yellow) and lakes where northern pike have been eradicated (green).

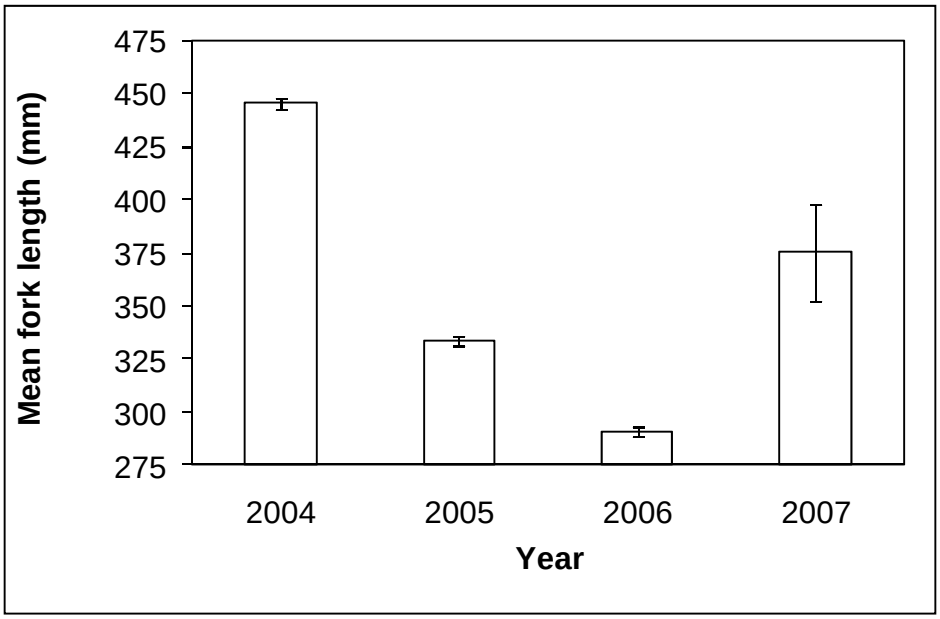


Figure 2.–Mean fork lengths and standard error bars for northern pike captured at Sevena Lake, 2004–2007.

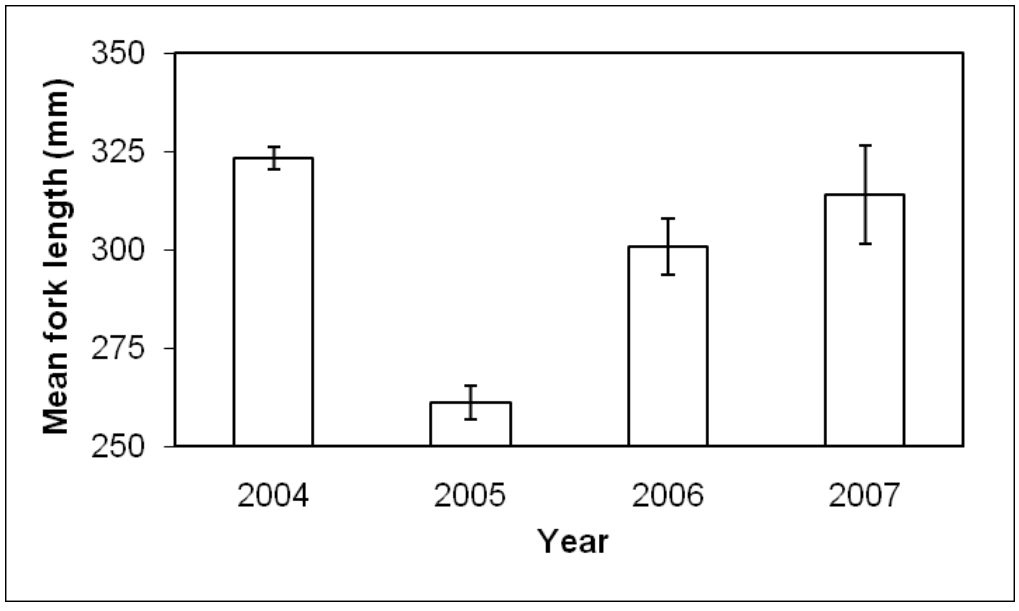


Figure 3.–Mean fork lengths and standard error bars for northern pike captured at Derks Lake, 2004–2007.

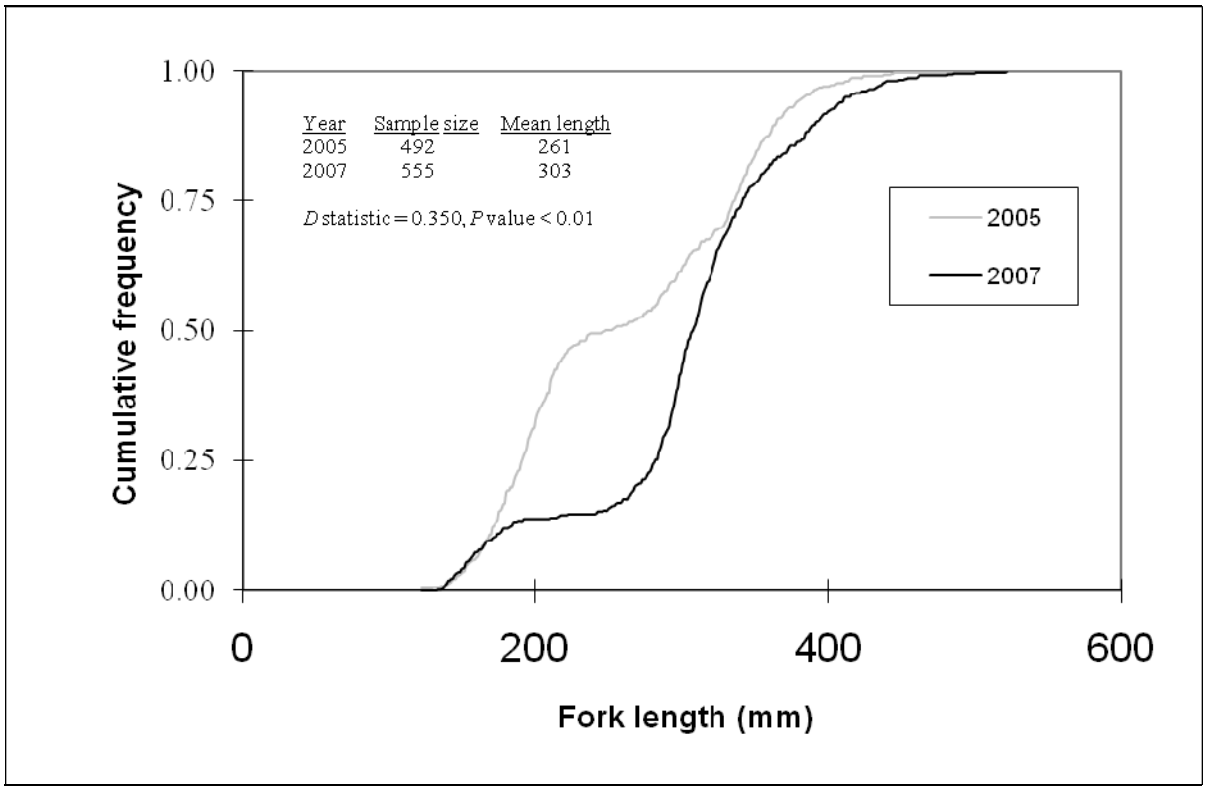


Figure 4.–Kolmogorov-Smirnov test comparing northern pike fork length sample distributions for 2005 and 2007 from Derks Lake.

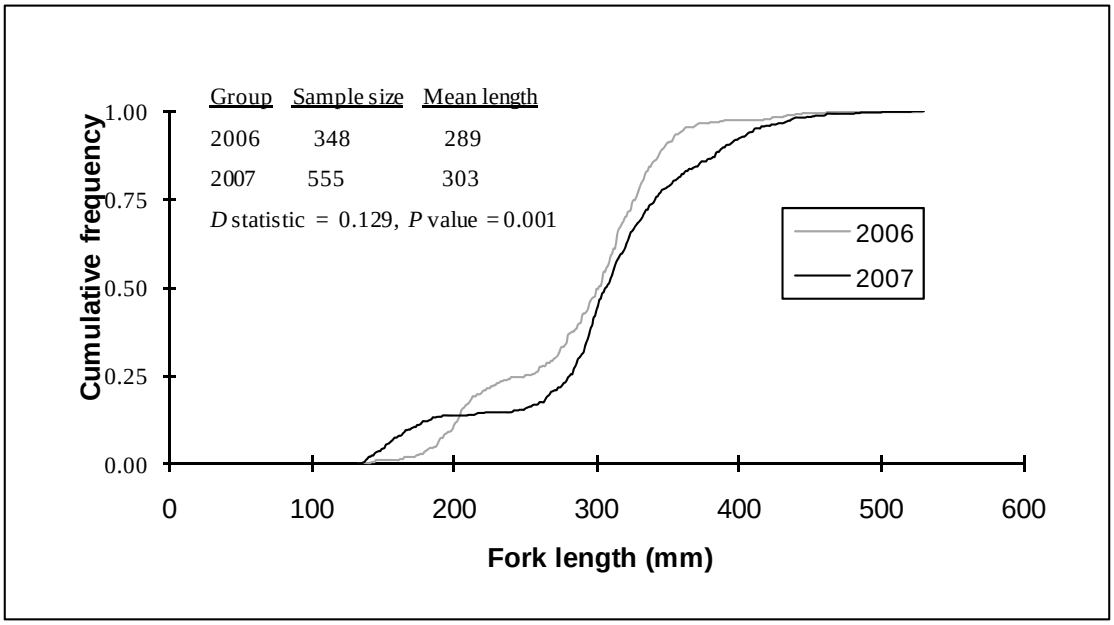


Figure 5.–Kolmogorov-Smirnov test comparing northern pike fork length sample distributions for 2006 and 2007 from Derks Lake.

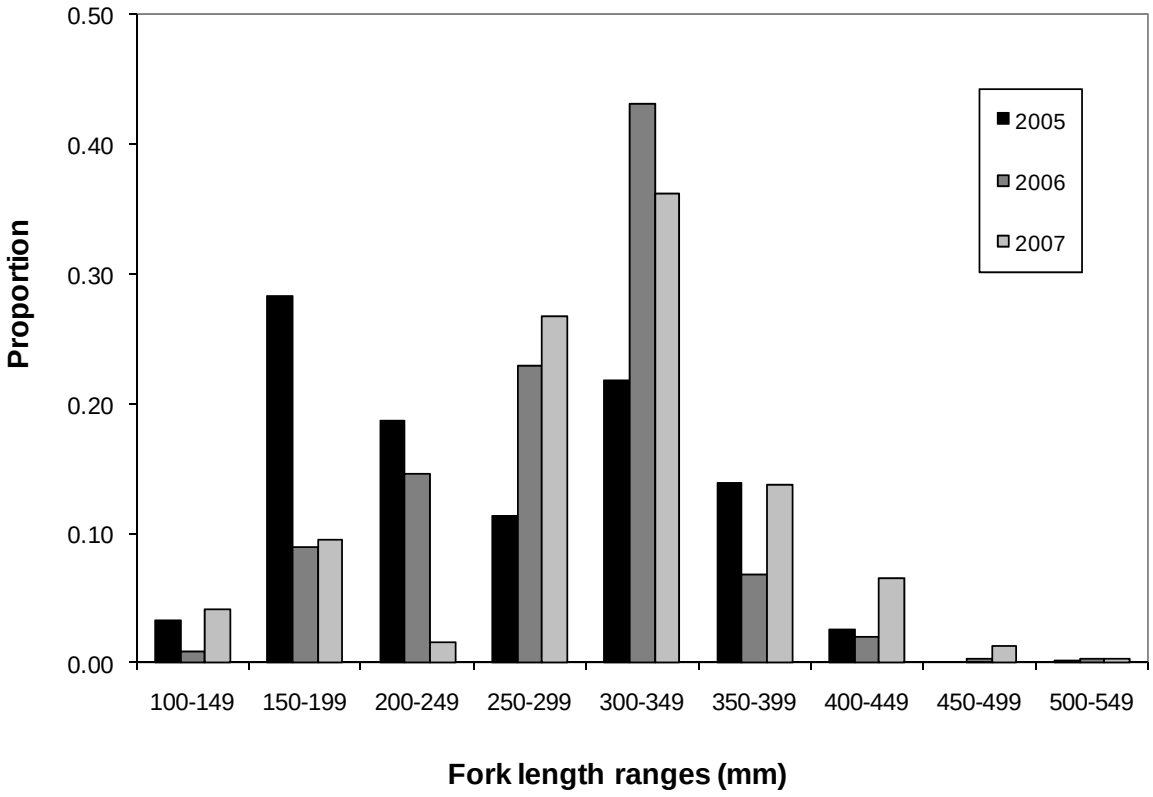


Figure 6.–Fork length range distributions for northern pike caught in Derks Lake, 2005–2007.

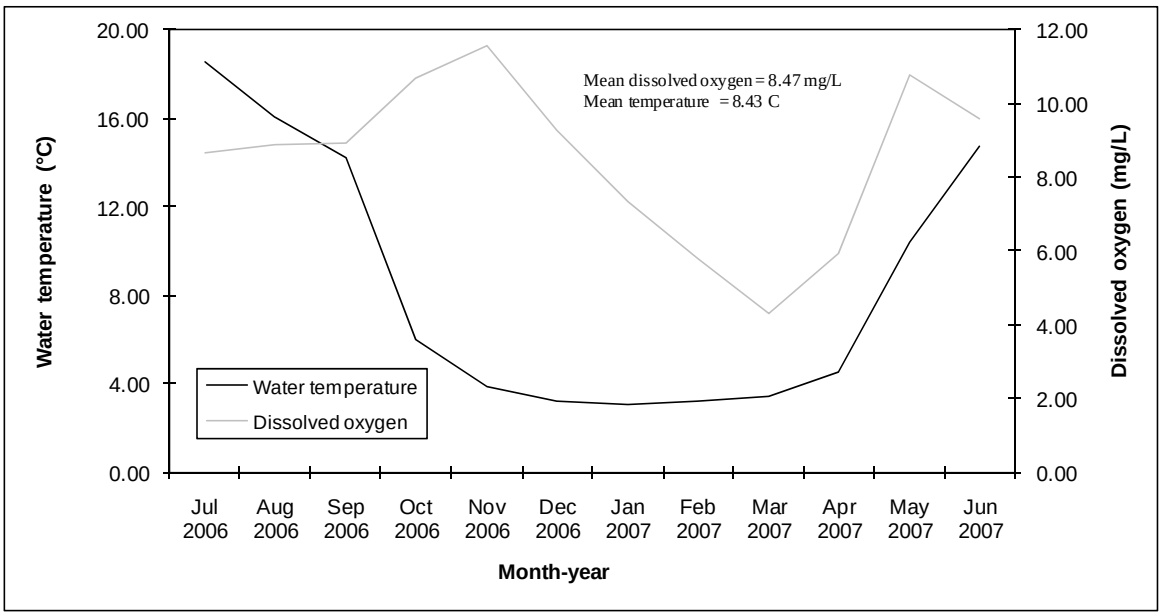


Figure 7.–Mean monthly water temperature and dissolved oxygen measurements from Arc Lake, July 2006 to June 2007.

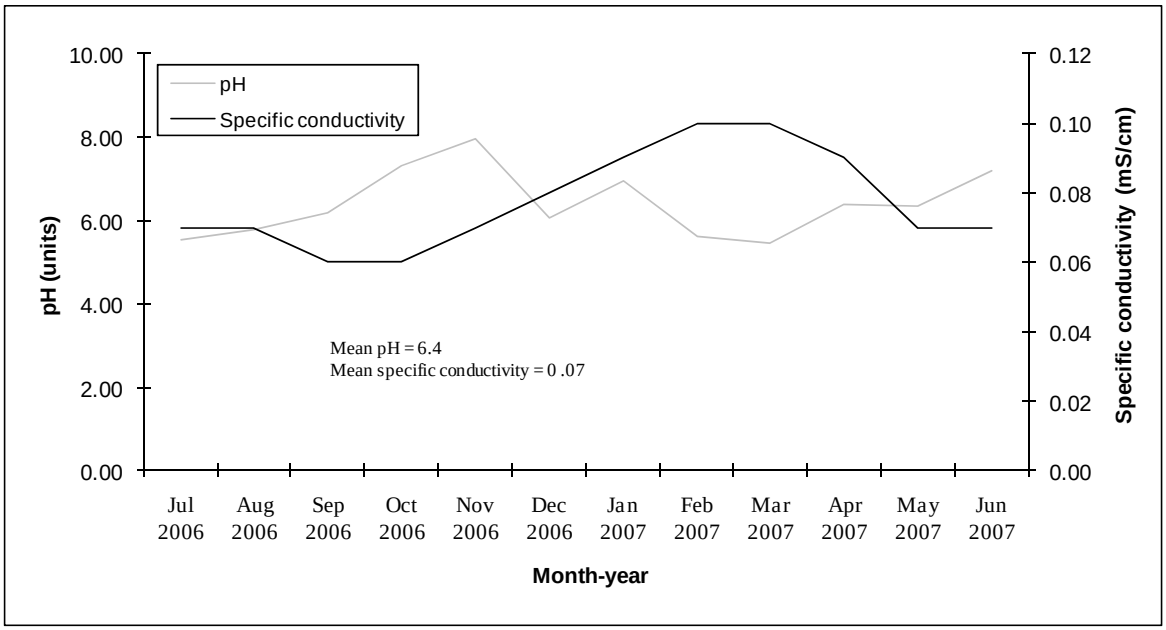


Figure 8.–Mean monthly pH and specific conductivity measurements for water in Arc Lake, July 2006 to June 2007.

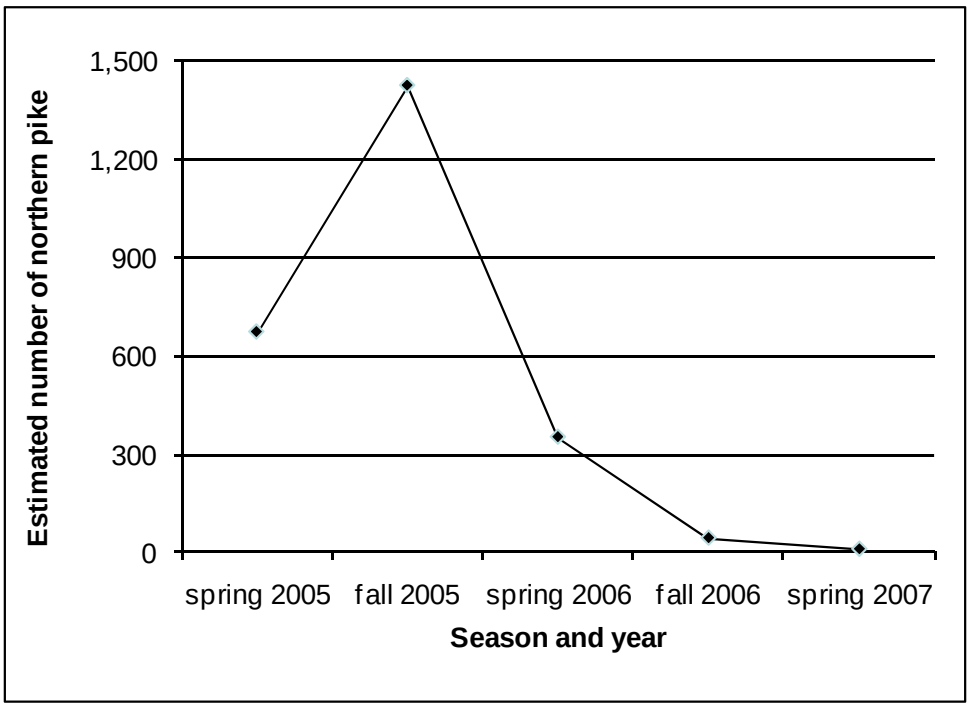


Figure 9.–Spring and fall population estimates for northern pike in Sevena Lake, 2005–2006 and Spring 2007.

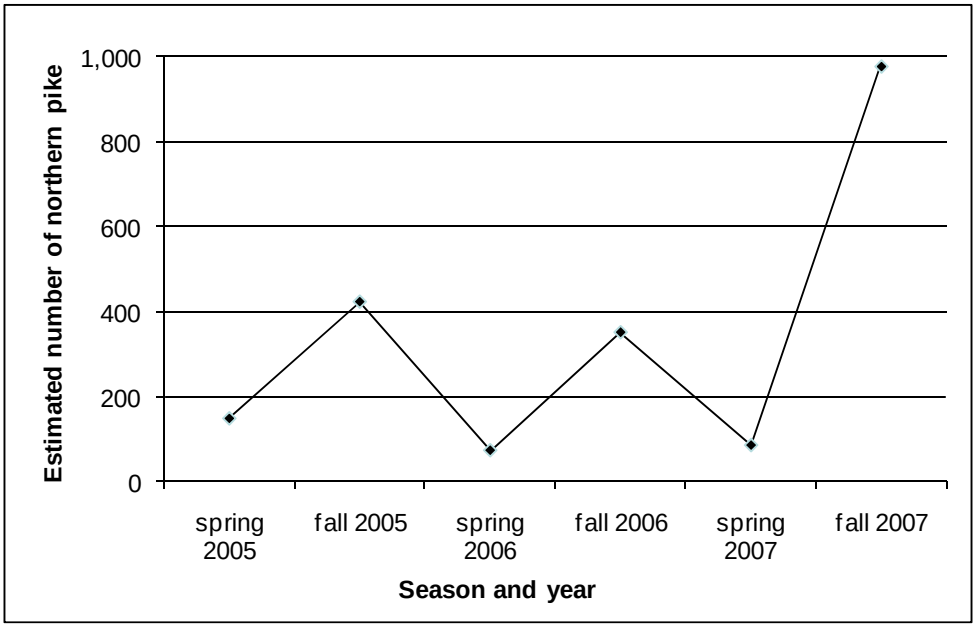


Figure 10.–Spring and fall population estimates of northern pike in Derks Lake, 2005–2007.

APPENDIX A

Appendix A1.–Proportion of population required to be captured for a specified coefficient of variation.

	Coefficent of Variation			
Population Size	30%	20%	10%	5%
200	0.55	0.60	0.75	0.90
300	0.50	0.60	0.75	0.85
500	0.45	0.55	0.70	0.80
1,000	0.40	0.45	0.60	0.75
10,000	0.20	0.25	0.35	0.50
100,000	0.10	0.15	0.20	0.30

Source: Zippin (1958), Table 1.

Note: This table shows proportions (to nearest 0.05) that must be captured in 100 or fewer trappings from select population sizes to meet precision estimates for each coefficient of variation.

Appendix A2.–Summary of daily gillnet harvest data used for estimating northern pike populations in Sevena and Derks lakes using the removal methods, 2005–2007.

Sampling event[a]	Number of northern pike removed										
	Sevena Lake					Derks Lake					
	2005		2006		2007	2005		2006		2007	
	spring 5/05–6/03	fall 9/28–10/20	spring 5/08–5/26	fall 9/25–9/29	spring 5/07–5/09	spring 5/18–6/02	fall 9/27–10/20	spring 5/11–6/02	fall 9/25–10/13	spring 5/14–5/18	fall 9/24–10/23
1	179	100	74	15	8	34	36	13	64	48	49
2	141	166	35	12	2	6	25	12	46	10	41
3	122	113	50	8		3	14	7	26	12	38
4	84	140	42	3		35	18	3	27	10	28
5	36	74	30			22	28	1	24		37
6	24	96	23			14	10	1	12		26
7	12	136	41			17	22	6	8		56
8	13	157	8			5	25	8	16		31
9	5	96	17			1	32	9	14		26
10	5	100	12			6	27	10	15		30
11	4	92	5				19	3	12		17
12	5	79	7				19	1			21
13	2	27					12				22
14	3	27					10				15
15	3						15				32
16	5										
Total	643	1,403	344	38	10	143	312	74	264	80	469

[a] Individual sampling events in 2005 and 2006 typically involved fishing twelve 120 ft variable mesh gillnets for approximately 24 hours. In 2007, the number of variable mesh gillnets was increased to 24 per sampling event.

Appendix A3.–Gillnet sampling results from Kenai Peninsula lakes with known or suspected populations of northern pike, 2006–2007.

Area [a]	Lake name [b]	lat/long coordinates [c]	Northern pike previously confirmed	Northern pike currently confirmed	Sampling date(s)	Netting effort [d]	Species catch [e]				
							NP	C	RB	DV	LNS
Tote Road	BB	60°25′10.81″N, 151°11′47.04″W	N	N	6/8/2006	22.5	0	0	0	0	0
Tote Road	Lake 31	60°25′58.60″N, 151°11′29.88″W	N	N	6/8/2006	53.6	0	0	0	0	0
Tote Road	Big Dog	60°25′27.71″N, 151°11′26.54″W	Y	Y	6/9/2006	48.8	20	0	0	0	0
Tote Road	CC	60°25′18.48″N, 151°11′40.52″W	N	Y	6/9/2006	22.8	3	0	0	0	0
Tote Road	Hope	60°25′16.94″N, 151°11′16.27″W	N	Y	6/9/2006	22.5	42	0	0	0	0
Tote Road	Ranchero	60°25′22.40″N, 151°10′58.98″W	Y	Y	6/9/2006	22.6	31	0	0	0	0
Tote Road	Freds	60°25′27.03″N, 151°11′52.32″W	N	Y	6/15/2006	24.6	5	0	0	0	0
Tote Road	Galloway	60°25′38.16″N, 151°11′46.96″W	N	N	6/15/2006	24.0	0	0	0	0	0
Tote Road	Leisure	60°24′53.51″N, 151°12′35.19″W	N	Y	6/15/2006	25.1	1	0	0	0	0
Tote Road	Lost	60°25′27.29″N, 151°10′40.98″W	N	N	6/15/2006	21.9	0	0	0	0	0
Tote Road	Gaswell pond #1	60°25′35.51″N, 151°12′20.27″W	N	N	6/15/2006	20.0	0	0	0	0	0
Tote Road	Echo Lake	60°26′13.80″N, 151°09′45.02″W	N	N	6/16/2006	18.5	0	0	0	0	0
Tote Road	Levy	60°25′38.58″N, 151°10′25.08″W	N	N	6/16/2006	18.9	0	0	0	0	0
Tote Road	Hollow	60°25′46.55″N, 151°09′11.53″W	N	N	6/20/2006	23.9	0	0	0	0	0
Tote Road	Cabin	60°25′46.68″N, 151°10′38.66″W	N	N	6/20/2006	40.7	0	0	0	0	0
Tote Road	Dragon	60°26′00.34″N, 151°09′48.37″W	N	N	6/20/2006	24.2	0	3	0	1	0
Tote Road	Paddle boat	60°25′46.45″N, 151°11′06.51″W	N	N	6/20/2006	20.7	0	13	1	0	0
Tote Road	Gaswell pond #2	60°25′58.37″N, 151°11′54.49″W	N	N	6/15/2007	48.0	0	0	0	0	0
Mackey	Union	60°31′16.85″N, 150°01′51.95″W	Y	Y	5/23/2007	110.0	40	0	0	0	0
Mackey	West Mackey	60°31′42.11″N, 151°00′36.52″W	Y	Y	5/23/2007	93.5	38	0	0	0	0
Mackey	No Banjo	60°32′43.18″N, 150°57′44.36″W	N	N	5/29-6/1/2007	280.6	0	0	0	0	0
Mackey	Little Bear	60°32′17.02″N, 150°59′36.78″W	N	N	5/30-6/1/2007	267.4	0	7	0	0	0
Mackey	Half Horn	60°32′22.27″N, 150°59′05.99″W	N	N	5/31-6/4/2007	284.0	0	0	0	0	0
Mackey	Redneck Lake	60°32′41.06″N, 150°59′27.95″W	N	N	6/4-6/8/2007	282.5	0	0	2	0	0
Mackey	Stuckfield	60°32′49.83″N, 150°59′58.56″W	N	N	6/4-6/8/2007	277.0	0	0	0	0	0
Mackey	Tangle Twine	60°32′37.05″N, 150°58′43.63″W	N	N	6/4-6/8/2007	191.5	0	0	0	0	0
Mackey	Ben-Thar	60°32′47.79″N, 151°00′14.35″W	N	N	6/5 - 6/8/2007	281.7	0	0	3	0	0
Mackey	Fetch	60°32′34.75″N, 150°59′59.30″W	N	N	6/5 - 6/8/2007	141.9	0	0	1	0	0
Mackey	Scowl	60°32′28.34″N, 150°00′04.49″W	N	N	6/5-6/7/2007	268.8	0	0	0	0	0
Mackey	Lost Lilly	60°32′28.24″N, 150°59′32.65″W	N	N	6/5-6/8/2007	70.4	0	0	0	0	0
Mackey	Tree [f]	60°33′44.53″N, 150°54′47.72″W	Y	N	8/9 & 8/23/2007	215.1	0	116	0	0	0
Swanson	Salmo	60°48′13.74″N, 150°59′20.50″W	N	N	6/6/2006	20.2	0	0	2	0	0
Swanson [g]	Busy Beaver 1	60°48′10.89″N, 150°59′21.86″W	N	N	10/12/2007	116.3	0	0	2	0	0
Swanson [g]	Busy Beaver 2	60°48′10.89″N, 150°59′21.87″W	N	N	10/12-10/15/2007	278.8	0	90	297	7	4

-continued-

Note: Lakes listed are those that are geographically close to Kenai Peninsula waters with known populations of northern pike.

[a] Three distinct areas: Tote Road Lakes located 5 miles south of Soldotna, AK, the Mackey Lakes area 3 miles northeast of Soldotna that had not been previously sampled with exception of Union, Tree and West Mackey Lake, and the Swanson River Drainage located 12 miles northeast of Nikiski, AK.

[b] All lake names except Union, Tree and West Mackey are not official lake names, rather, these names represent names ADF&G created in the absence of official or known lake names.

[c] Global Positioning System (GPS) coordinates are recorded using datum WGS84.

[d] Netting effort is defined as the total number of net soak hours of one or more variable mesh gillnets of 120 feet in length.

[e] Species catch definitions as follows: NP = northern pike, C = coho salmon, RB = rainbow trout, DV = Dolly Varden, and LNS = longnose sucker.

[f] Tree Lake was previously confirmed as a northern pike lake but apparently the lake experienced a complete winterkill of fish, no northern pike were detected in 2007.

[g] Busy Beaver lakes 1 and 2 are names given to the two southernmost lakes in the Crane Lake system.

Appendix A4.–Light trap catch data collected in 2007 for select Kenai Peninsula northern pike water bodies.

Waterbody	Set date	Trap type[a]	Number of trap sets	Effort hours	Larval northern pike	Other
West Mackey Lake	5/7/2007	Bucket	1	23.93	0	Misc. invertebrates
East Mackey Lake	5/7/2007	Bucket	1	23.98	0	Misc. invertebrates
Sevena	5/7/2007	Bucket	1	24.02	0	Misc. invertebrates
						6 stickleback [b]
West Mackey Lake	5/8/2007	Bucket	1	23.82	0	Misc. invertebrates
East Mackey Lake	5/8/2007	Bucket	1	23.80	0	Misc. invertebrates
West Mackey Lake	5/9/2007	Bucket	1	13.75	0	Misc. invertebrates
East Mackey Lake	5/9/2007	Bucket	1	13.58	0	Misc. invertebrates
Arc Lake	5/22/2007	Bucket	1	19.83	0	Misc. invertebrates
West Mackey Lake	5/22/2007	Bucket	1	18.78	0	Misc. invertebrates
Union Lake	5/22/2007	Bucket	2	44.28	0	Misc. invertebrates
Union Lake	5/31/2007	Quatrefoil	6	7.23	0	Misc. invertebrates
Arc Lake	5/31/2007	Quatrefoil	2	30.65	0	Misc. invertebrates
East Mackey Lake Outlet Creek	5/31/2007	Quatrefoil	1	13.87	0	Misc. invertebrates
East Mackey Lake	6/1/2007	Quatrefoil	1	1.97	0	Misc. invertebrates
East Mackey Lake Outlet Creek	6/1/2007	Quatrefoil	1	2.17	0	Misc. invertebrates
West Mackey Lake Outlet Creek	6/1/2007	Quatrefoil	1	2.20	0	Misc. invertebrates
Derks Lake-dam	6/1/2007	Quatrefoil	2	2.10	0	Misc. invertebrates
Union Lake	6/7/2007	Quatrefoil	8	10.47	4	Misc. invertebrates
Arc Lake	6/8/2007	Quatrefoil	2	6.18	0	Misc. invertebrates
East Mackey Lake	6/8/2007	Quatrefoil	1	1.17	0	Misc. invertebrates
East Mackey Lake Outlet Creek	6/8/2007	Quatrefoil	1	1.27	0	Misc. invertebrates
West Mackey Lake	6/8/2007	Quatrefoil	1	1.42	0	Misc. invertebrates
East Mackey Lake Outlet Creek	6/8/2007	Quatrefoil	1	1.20	0	Misc. invertebrates
Derks Lake	6/8/2007	Quatrefoil	1	1.08	0	Misc. invertebrates
Derks Lake-dam	6/8/2007	Quatrefoil	1	1.07	0	Misc. invertebrates
Union Lake	6/14/2007	Quatrefoil	11	14.82	0	Misc. invertebrates
Union Lake	7/6/2007	Quatrefoil	12	22.92	0	Misc. invertebrates
Union Lake	7/6/2007	Bucket	2	3.33	0	Misc. invertebrates
West Mackey Lake	7/13/2007	Bucket	2	3.20	0	Misc. invertebrates
West Mackey Lake	7/13/2007	Quatrefoil	7	12.30	0	Misc. invertebrates
East Mackey Lake	9/1/2007	Bucket	1	3.57	0	Misc. invertebrates
East Mackey Lake	9/1/2007	Quatrefoil	2	7.13	0	Misc. invertebrates

-continued-

Appendix A4.-Page 2 of 2.

Waterbody	Set date	Trap type[a]	Number of trap sets	Effort hours	Larval northern pike	Other
West Mackey Lake	9/1/2007	Bucket	1	3.02	0	Misc. invertebrates
West Mackey Lake	9/1/2007	Quatrefoil	2	6.05	0	Misc. invertebrates
Derks Lake	9/1/2007	Bucket	3	9.30	0	Misc. invertebrates
Derks Lake	9/1/2007	Quatrefoil	1	3.10	0	Misc. invertebrates
Arc Lake	9/1/2007	Quatrefoil	3	9.17	0	Misc. invertebrates
West Mackey Lake	9/9/2007	Quatrefoil	8	7.43	0	Misc. invertebrates
West Mackey Lake	9/9/2007	Bucket	5	4.67	0	Misc. invertebrates
Totals:			101	423.83	4	

[a] Trap types include purchased quatrefoil light traps and hand-made 5-gallon bucket light traps with an electronic lightstick as the attractant.

[b] *Gasterosteus aculeatus*.

APPENDIX B

Appendix B1.–Monthly stream discharge measurements collected within Soldotna Creek drainage, April 2006–April 2007.

Outlet creek location	Sample site coordinates [a]	2006									2007				summary		
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Max.	Min.	Avg.
Derks	60°31′33.9″N, 150°57′45.8″W	2.7	–	–	0.1	0.1	–	–	1.9	0.9	0.4	–	–	0.6	2.7	0.1	1.0
East Mackey	60°31′39.7″N, 150°59′04.3″W	1.4	–	1.1	0.4	0.3	2.4	4.0	2.1	0.8	–	–	–	0.9	4.0	0.3	1.5
Sevena	60°33′00.0″N, 150°55′22.1″W	–	6.8	–	2.2	5.3	4.5	6.8	1.2	–	1.3	1.4	–	13.5	13.5	1.2	4.8
Soldotna [b]	60°29′05.5″N, 150°03′08.1″W	34.3	11.3	–	8.9	25.5	16.9	44.1	6.9	7.4	8.3	–	5.9	37.5	44.1	5.9	18.8
Tree	60°33′20.5″N, 150°55′21.4″W	–	2.0	1.1	0.5	1.3	1.5	1.0	0.6	1.0	1.7	1.5	0.3	2.4	2.4	0.3	1.2
Union	60°31′14.4″N, 150°010′33.6″W	0.1	–	0.0	0.0	0.0	0.4	0.6	0.1	–	–	–	–	0.4	0.6	0.0	0.2
West Mackey	60°31′31.0″N, 150°00′08.4″W	1.1	–	0.5	0.2	0.7	1.5	2.0	0.8	0.5	0.2	0.1	–	0.1	2.0	0.1	0.7

Note: Missing data (–) primarily resulted from negligible and immeasurable stream flow or heavy surface ice preventing measurement.

[a] Global Positioning System (GPS) coordinates are recorded using Datum WGS84

[b] Discharge measurements for Soldotna Creek for the months of December, January and March were supplied courtesy of the Kenai Watershed Forum and collected at a location approximately 0.25 miles upstream of the site used by ADF&G to measure discharge.

Appendix B2.–Mean monthly water quality measurements from select northern pike lakes near Soldotna, Alaska, 2006–2007.

Lake	Location: lat/long coordinates [a]	Measured parameters	Formerly stocked (Y or N)	2006 Jul	2006 Aug	2006 Sep	2006 Oct	2006 Nov	2006 Dec	2007 Jan	2007 Feb	2007 Mar	2007 Apr	2007 May	2007 Jun
Arc	60°26′54.6″N 151°06′10.8″W		Y												
		Temperature (°Celsius)		18.52	16.04	14.20	6.03	3.84	3.22	3.06	3.20	3.44	4.53	10.37	14.71
		Specific Conductivity (S/cm)		0.07	0.07	0.06	0.06	0.07	0.08	0.09	0.10	0.10	0.09	0.07	0.07
		Dissolved Oxygen (mg/L)		8.66	8.89	8.92	10.67	11.55	9.28	7.32	5.78	4.32	5.95	10.77	9.59
		pH		5.56	5.80	6.20	7.30	7.96	6.06	6.95	5.62	5.48	6.37	6.35	7.18
		Visibility (m)		4.4	4.3	4	3.2	1.5	2	2.6	4	4	4	3.1	3.5
		Ice thickness (cm)						20.3	50.8	60.96	69	81	81		
Derks	60°31′45.6″N 151°01′47.6″W		N												
		Temperature (°Celsius)		12.95	12.33	10.93	6.25	3.85	3.27	3.30	3.20	3.61	4.23	7.50	11.20
		Specific Conductivity (S/cm)		0.75	0.07	0.06	0.04	0.05	0.06	0.06	0.07	0.07	0.27	0.05	0.06
		Dissolved Oxygen (mg/L)		3.32	5.07	4.86	8.60	7.45	5.20	3.77	3.38	2.70	3.16	7.00	5.28
		pH		6.81	6.75	6.44	6.77	6.79	7.96	6.25	6.23	6.72	6.67	7.09	7.02
		Visibility (m)		2.4	2.3	1.5	1.2	1	n/a	1.5	1.6	1.2	1.9	0.9	1.3
		Ice thickness (cm)						26.7	50.8	60.96	74	79	81		
East Mackey	60°31′84.9″N 151°59′41.4″W		N												
		Temperature (°Celsius)		17.93	14.86	11.87	5.46	3.96	3.57	3.43	3.33	3.60	4.78	8.43	12.36
		Specific Conductivity (S/cm)		0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.07	0.06	0.05	0.05
		Dissolved Oxygen (mg/L)		8.13	8.69	8.30	10.66	11.72	10.95	9.19	6.80	6.31	4.97	10.49	7.09
		pH		7.29	6.97	6.88	6.96	7.06	7.34	6.33	5.98	6.74	6.31	6.48	6.99
		Visibility (m)		4	3.3	2.2	2.4	1.5	2.6	2.5	3	3	2.8	1.5	3
		Ice thickness (cm)						21.6	50.8	63.5	74	81	76		
Scout	60°32′01.8″N 150°50′45.4″W		Y												
		Temperature (°Celsius)		18.13	17.52	11.27	5.05	3.97	3.51	3.73	3.17	3.98	4.72	9.06	14.41
		Specific Conductivity (S/cm)		0.04	0.00	0.03	0.03	0.03	0.04	0.05	0.04	0.06	0.06	0.03	0.03
		Dissolved Oxygen (mg/L)		8.44	8.57	9.15	11.28	10.00	7.58	5.44	3.69	3.15	3.22	10.97	9.89
		pH		7.43	7.43	7.15	7.72	7.13	7.73	6.53	6.34	7.98	6.29	7.25	7.22
		Visibility (m)		2.3	1.5	1.5	1.7	1.1	2.6	ND	3.5	2.5	2.2	1.5	1.6
		Ice thickness (cm)						24.1	50.8	60.96	69	79	81		

-continued-

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Lake	Location: lat/long coordinates [a]	Measured parameters	Formerly stocked (Y or N)	2006 Jul	Aug	Sep	Oct	Nov	Dec	2007 Jan	Feb	Mar	Apr	May	Jun
Sevena	60°33′6.9″N 150°57′55.4″W														
		Temperature (°Celsius)		15.97	15.34	10.09	5.11	3.30	2.32	2.51	2.90	3.30	3.67	6.30	14.17
		Specific Conductivity (S/cm)		0.11	0.03	0.08	0.07	0.09	0.10	0.11	0.15	0.18	0.13	0.12	0.11
		Dissolved Oxygen (mg/L)		6.15	7.29	8.39	9.52	9.27	8.56	3.28	2.20	1.55	3.33	8.12	10.60
		pH		7.60	7.79	7.47	7.53	7.67	7.48	7.99	7.50	8.87	7.71	7.23	8.23
		Visibility (m)		1.3	1.35	1.3	1.2	1	1.8	2	2	1.5	1.9	0.9	0.8
		Ice thickness (cm)						30.5	50.8	58.42	66	81	81		
Union	60°31′25.1″N 151°58′04.1″W		Y												
		Temperature (°Celsius)		16.86	12.70	10.44	5.05	4.03	3.22	3.18	3.58	3.44	4.58	7.73	11.64
		Specific Conductivity (S/cm)		0.03	0.00	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.08	0.04	0.04
		Dissolved Oxygen (mg/L)		8.14	7.20	7.30	10.80	11.92	11.64	10.52	8.78	7.81	3.87	7.64	6.81
		pH		6.91	7.82	6.60	6.77	7.17	7.23	6.68	6.18	6.49	6.26	6.63	7.26
		Visibility (m)		3.3	3.2	2	2.3	2	1.75	2.4	2.3	2	2.4	1.5	n/a
		Ice thickness (cm)						29.2	50.8	60.96	71	84	66		
West Mackey	60°31′89.1″N 151°00′52.6″W		N												
		Temperature (°Celsius)		18.92	14.53	11.52	5.01	3.90	3.18	3.36	3.15	3.50	4.72	9.00	14.45
		Specific Conductivity (S/cm)		0.09	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.64	0.06	0.03	0.03
		Dissolved Oxygen (mg/L)		8.46	9.63	8.78	10.60	11.68	10.83	9.13	7.67	5.33	4.49	10.03	9.41
		pH		7.24	6.89	7.24	6.76	7.22	6.85	7.11	6.58	7.29	5.92	6.60	7.26
		Visibility (m)		2.8	2.4	2.5	2.4	1.5	ND	2.6	2.5	2.3	2.5	1.6	2.6
		Ice thickness (cm)							50.8	60.96	69	76	81		

Note: Mean values are obtained from the average of the readings taken at 1 meter intervals throughout the water column.

[a] GPS coordinates are recorded using Datum WGS84.