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Restoration of Salmonid Habitat by Control and Removals of Invasive Northern Pike, Kenai Peninsula, 2003

by

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and

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May 2005

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
mideye-to-fork	MEF
mideye-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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ABSTRACT

Northern pike are not native to aquatic habitats of southcentral Alaska south of the Alaska Range. Introduction of northern pike into these freshwater systems may have deleterious effects on native fish, including various species of Pacific salmon. This project was an effort to restore salmonid habitat by removing northern pike known to inhabit freshwater ecosystems on the Kenai Peninsula. In 2003, 1,590 northern pike were captured and removed from three Kenai Peninsula Area lakes. Mean fork length of northern pike was 557 mm (SE = 16 mm) at Stormy Lake, 335 mm (SE = 3 mm) at West Mackey Lake and 352 mm (SE = 4 mm) at East Mackey Lake. Catch per unit effort for hoop nets deployed at Stormy Lake was 0.0021 northern pike per hour, while the catch per unit effort of gill nets used at East and West Mackey lakes was 0.1187 and 0.1434, respectively. Ninety percent of the northern pike sampled for maturity at Stormy Lake were mature. Northern pike ranged in age from 2 to 10 years old with the majority aged 4 to 6 years old. Time volunteered by community residents and schools were an integral component of this habitat restoration program, and improved the stewardship of community members towards freshwater salmonid habitats. We plan to continue netting operations on the Mackey lakes and initiate programs on other area lakes that contain northern pike. These efforts will allow us to evaluate if capture and removal of pike impacts the abundance and/or population structure of the northern pike, if netting is a cost effective tool to restore negatively impacted salmon habitat, and to further community-based stewardship of restoring aquatic habitats.

Key words: Kenai Peninsula, Stormy Lake, East Mackey Lake, West Mackey Lake, habitat restoration, northern pike, invasive species

INTRODUCTION

The Kenai Peninsula is one of the premier sport fishing areas in Alaska (Howe et al. 1995, 1996, 2001 a-d; Jennings et al. 2004, *In prep* a, b; Mills 1979-1980, 1981a-b, 1982-1994; Walker et al. 2000). Most fishing effort on the Peninsula is expended on the Kenai River, renowned world-wide for its large Chinook salmon *Oncorhynchus tshawytscha* and the site of other popular fisheries on coho salmon *O. kisutch,* sockeye salmon *O. nerka*, rainbow trout *O. mykiss*, and Dolly Varden *Salvelinus malma*.

Although much of the Peninsula is within the boundaries of national forests or national wildlife refuges, there is significant urbanization around many of the rivers, particularly the lower Kenai River, in the cities of Kenai and Soldotna. Half of Alaska's population lives in Anchorage, within a two-hour drive of the Kenai River. The local urbanization and accessibility of the area results in significant awareness of the resource base by local sport fishing groups and resource agencies; consequently, there is wide support of habitat protection efforts. One of these protection efforts pertains to the reduction of the northern pike *Esox lucius* population in the area (Figure 1).

One of the targeted sites of the pike control effort will be lakes in the Soldotna Creek drainage lakes, a tributary of the Kenai River. A survey conducted by the Alaska Department of Fish and Game in 2002 through a grant from the Cook Inlet Coastal Program of the US Fish and Wildlife Service found northern pike in seven of the eight major lakes in the Soldotna Creek drainage. The other targeted site is Stormy Lake, a potential access point for northern pike to the Swanson River system, which is about 46 miles in length and drains directly into Cook Inlet, entering salt water about 30 miles north of the mouth of the Kenai River. A survey conducted by the department in 2001 found northern pike in the lake, but pike are currently believed to be absent from the Swanson River itself. The drainage's upper section, however, consists of broad stretches of muskeg bordering a slow flowing main channel and is considered suitable habitat for northern pike. The appropriate habitat and the fact that the river also drains numerous lakes, many of which are interconnected by small streams, makes it especially important that northern pike are restricted from this system.

The goal of this project was to restore and maintain freshwater salmonid habitat on the Kenai Peninsula by reducing northern pike from area lakes, and to restrict their migration within these and to other areas. If successful, this effort will contribute to the long-term integrity of the Kenai Peninsula sport fisheries and the economies of the communities that rely on these resources.

OBJECTIVES

The objectives of this study were to:

1 Capture and remove northern pike from Stormy Lake, part of the Swanson River drainage, and from East and West Mackey lakes, part of the Soldotna Creek drainage.

2 Estimate the mean length of northern pike captured and removed from Stormy Lake and Soldotna Creek drainage lakes.

3 Estimate the catch of northern pike per unit effort by hoop nets in Stormy Lake and gillnets in Soldotna Creek drainage lakes.

4 Design a fish-control structure for the outlet of Stormy Lake that will prevent northern pike from entering the Swanson River system.

METHODS

STUDY DESIGN AND DATA COLLECTION

Stormy Lake

In 2003, hoop nets 5 ft in diameter with two 50 ft leads were set continuously at Stormy Lake from 7 June through 17 July and again from 3 October through 31 October. In addition, a weir with a fyke net was placed at the Stormy Lake outlet to capture and prevent northern pike migration between the lake and the Swanson River. The weir was in place for the entire calendar year of 2003. Finally, the feasibility of developing a fish passage control structure was conducted. The structure would be built at the outlet of Stormy Lake to prevent movement of northern pike from Stormy Lake into the Swanson River drainage. An engineering firm was contracted for this work.

Northern pike captured at Stormy Lake were sampled for sex, maturity, length, and age. Maturity status was determined through internal examination of the body cavity for the presence of ovaries or eggs in female and milt or gonads in male northern pike. Immature fish were identified as those without the above reproductive structures. Length was measured from mid-eye to fork of tail to the nearest millimeter. To determine age, a minimum of three scales were removed from the preferred zone above the pelvic fins adjacent to but not on the lateral line (Williams 1955). Scales were mounted directly onto gummed cards. The cards were used to make scale impressions on 20 mm acetate sheets using a Carver press at 137,895 kPa and heated to 93°C for 45 seconds. The age from scales was determined with a Micron 770 microfiche reader (32X) using established criteria (Cassleman 1967, Williams 1955).

Biological data was recorded by gear, species, and date. Set (start) and pull (stop) time of each net was recorded to the nearest minute. Local community residents and a public high school biology class volunteered time to assist in monitoring and checking the nets, sampling captured northern pike, and recording data.

East and West Mackey Lakes

Sinking gillnets, each 120 ft long by 6 ft deep with six panels of mesh (1 each of 1/2", 5/8", 3/4", 1", 1 1/2", and 2"), were set to capture and remove northern pike from East and West Mackey lakes. Captured northern pike were measured for length from mid-eye to fork of tail to the nearest millimeter. Start and stop time of each net was recorded to the nearest minute. Property owners on these lakes volunteered time to assist in monitoring and checking the nets, sampling captured northern pike, and recording data. Because no public access to the East and West Mackey lakes exists, private landowners granted daily access to these lakes.

Captured northern pike ~420 mm or larger in length were taken to the Kenai Peninsula Food Bank for distribution to local families. Northern pike smaller than ~420 mm were distributed to local public schools for educational uses.

DATA ANALYSIS

Age, Sex and Length Compositions

The proportion of northern pike of age, sex or length class *k*, in the catch from lake *L* was estimated as:

$$\hat{p}_{Lk} = \frac{n_{Lk}}{n_L} \qquad (1)$$

where

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

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

The variance of each proportion was estimated as (Cochran 1977):

$$V\hat{a}r(\hat{p}_{Lk}) = \frac{\hat{p}_{Lk}(1-\hat{p}_{Lk})}{n_L - 1}. \qquad (2)$$

Catch Per Unit Effort

Catch per unit effort was estimated for each lake *L* as:

$$\hat{C}_L = \frac{n_L}{E_L}, \qquad (3)$$

where

n_L = number of northern pike caught in lake *L*, and

E_L = total minutes of operation of nets in lake *L*.

Volunteer Effort

The proportion of daily volunteer effort was estimated by dividing the total number of days worked by volunteers at each site by the total number of days worked at each site. Hourly volunteer effort was estimated similarly; however, hours spent working at each site were used for estimation. Note that these are not estimates of the total number of volunteer hours or days because the amount of time spent sampling was not expanded by the number of volunteers assisting each day.

RESULTS

Stormy Lake

Fifty-five northern pike were captured in nets at Stormy Lake. Mean length of all northern pike captured was 557 mm (SE = 16 mm). Age was estimated for 47 of the northern pike captured (Table 1). Nearly 80% of the northern pike were 4, 5 or 6 years old. Sex and maturity status was determined for 54 fish of which about 74% (n = 40) were female (Table 2). The majority (91%) of northern pike sampled were mature.

Nets operated for 25,614.23 hours in Stormy Lake for a catch per unit effort (CPUE) of 0.0021 northern pike per hour (Table 3). CPUE varied among the seasons and was greatest during the spring and fall. Volunteer work effort accounted for about 53% of the days and 51% of the hours worked netting at Stormy Lake (Table 4).

The weir and fyke net placed at the Stormy Lake outlet to the Swanson River was checked on an opportunistic basis throughout the year for the presence of migrant northern pike. No pike were captured. Species captured included juvenile coho salmon, rainbow trout, long nose suckers, lampreys, Dolly Varden and stickleback.

A report describing the feasibility of building a fish passage control structure to prevent the migration of adult northern pike from Stormy Lake to the Swanson River is presented in Appendix A. This structure would require little maintenance and relatively low capital costs to build. As detailed the structure would provide a substantially more effective barrier to migration than the conventional high maintenance weir and fyke net currently in place at the Stormy Lake outlet.

East and West Mackey Lakes

Netting operations at the Mackey lakes resulted in the harvest of 1,535 northern pike. Mean length was 334 mm (SE = 3 mm) at East Mackey and 352 mm (SE = 4 mm) at West Mackey (Table 5). Netting effort was similar for each lake: 5,973.74 hours and 5,760.85 hours were expended at East and West Mackey, respectively (Table 5). The CPUE at East Mackey was 0.1187 and at West Mackey was 0.1434 northern pike per hour. About 23% of the days and 25% of the hours worked at East Mackey Lake included volunteer work effort, while volunteers worked approximately 16% of the days and 15% of the total hours during netting operations at West Mackey Lake (Table 6).

RECOMMENDATIONS

Department staff expended substantial effort interacting with local residents and at schools. Therefore, this project improved stewardship of local landowners, the sport fishing public, and school children on the Kenai Peninsula regarding the negative impacts and importance of the removal of northern pike from aquatic habitats. Traditional ecological knowledge supplied by area residents of the project lakes, particularly the Mackey lakes, indicated that the historic fish community of these lakes was comprised of rearing anadromous salmonids, rainbow trout, and Dolly Varden. In 2003 we captured only northern pike at Mackey lakes, indicating that invasive northern pike have changed the species assemblage of these lakes. Furthermore, the vast majority of local residents support pike removal and control efforts as well as the restoration of salmonid habitat. The local community-based volunteer efforts and outreach at local schools was a major factor in the success of this project.

During 2004 gill net operations continued at East and West Mackey lakes and were expanded to include two additional lakes within the drainage. Size distribution and CPUE of northern pike declined in both lakes in 2004 relative to 2003. While these results may indicate removal of northern pike improved salmonid habitat, it is not clear if this approach is cost-effective nor the degree of habitat restored. The use of hoop nets at Stormy Lake was discontinued due to the low catch rates. In addition, the weir and fyke net remains in place and is being monitored at the Stormy Lake outlet creek. Comparison of catch rates between years at the different lakes will help guide future northern pike removal and control efforts at Kenai Peninsula area lakes.

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TABLES AND FIGURES

Table 1.–Estimated sex and age composition and mean length-at-age, with associated standard errors (SE), of northern pike captured at Stormy Lake, Alaska, 2003.

	Age								
	2	3	4	5	6	7	8	10	Total
Females									
Number sampled	2	1	8	12	8	3	1	1	36
Estimated Proportion	0.04	0.02	0.17	0.26	0.17	0.06	0.02	0.02	0.77
SE Proportion	0.03	0.02	0.06	0.06	0.06	0.04	0.02	0.02	0.06
Mean Length	548	345	479	566	547	571	602	755	
SE Mean Length	67		42	32	15	7			
Males									
Number sampled		1	4	3	2	1			11
Estimated Proportion		0.02	0.09	0.06	0.04	0.02			0.23
SE Proportion		0.02	0.04	0.04	0.03	0.02			0.06
Mean Length		673	557	476	552	618			
SE Mean Length			47	123	83				
All									
Number sampled	2	2	12	15	10	4	1	1	47
Estimated Proportion	0.04	0.04	0.26	0.32	0.21	0.09	0.02	0.02	
SE Proportion	0.03	0.03	0.06	0.07	0.06	0.04	0.02	0.02	
Mean Length	548	509	505	549	548	583	602	755	
SE Mean Length	67	164	33	34	17	13			

Table 2.–Estimated proportion and mean length, with associated standard errors (SE), relative to maturity status of northern pike captured at Stormy Lake, Alaska, 2003.

	Immature	Mature	Total
Females			
Number sampled	3	37	40
Estimated Proportion	0.06	0.69	0.74
SE Proportion	0.03	0.06	0.06
Mean Length	380	572	
SE Mean Length	38	19	
Males			
Number sampled	2	12	14
Estimated Proportion	0.04	0.22	0.26
SE Proportion	0.03	0.06	0.06
Mean Length	485	569	
SE Mean Length	50	34	
All			
Number sampled	5	49	54
Estimated Proportion	0.09	0.91	
SE Proportion	0.04	0.04	
Mean Length	422	571	
SE Mean Length	37	16	

Table 3.–Number of northern pike captured, number of net-hours of effort, and catch per unit effort (CPUE) at Stormy Lake, Alaska, 2003.

Time Interval	Number Pike	Effort (hours)	CPUE
7 June – 11 June	14	1488.17	0.0094
12 June – 18 June	5	3413.97	0.0015
19 June – 2 July	11	6891.43	0.0016
3 July – 9 July	2	7373.78	0.0003
2 October – 8 October	5	1486.83	0.0034
9 October – 16 October	7	2631.37	0.0027
17 October – 23 October	5	1673.38	0.0030
24 October – 30 October	1	626.92	0.0016
31 October	5	28.38	0.1762
Spring (7 June – 21 June)	27	9251.49	0.0029
Summer (22 June – 9 July)	5	9915.86	0.0005
Fall (2 October – 31 October)	23	6446.88	0.0036
All	55	25,614.23	0.0021

Table 4.–Volunteer work effort to capture northern pike at Stormy Lake, Alaska, 2003.

Date	Hours:minutes	Volunteers Present
7 June	2:55	Y
8 June	5:15	Y
9 June	3:50	Y
10 June	3:00	Y
12 June	4:20	Y
14 June	4:15	Y
16 June	4:15	Y
20 June	4:35	Y
28 June	4:40	Y
3 July	4:55	N
9 July	4:40	Y
17 July	5:05	N
3 October	4:40	N
8 October	4:30	N
10 October	5:05	N
20 October	4:50	N
27 October	3:55	N
29 October	4:25	N
30 October	7:48	N
Total	81 hours 58 minutes	
	42 hours 20 minutes volunteers present	
	51%	Volunteer hours
	53%	Volunteer days

Table 5.–Number of northern pike captured, mean length with associated standard error (SE), number of net-hours of effort, and catch per unit effort (CPUE) at East and West Mackey lakes, Alaska, 2003.

Lake	Season[a]	Number Pike	Mean Length	SE Mean Length	Effort (hours)	CPUE
East Mackey	Spring	138	355	9	572.26	0.2412
	Summer	167	337	7	1030.61	0.1620
	Fall	404	327	4	4370.87	0.0924
	Total	709	334	3	5973.74	0.1187
West Mackey	Spring					
	Summer	276	357	6	1078.91	0.2558
	Fall	550	350	4	4681.94	0.1175
	Total	826	352	4	5760.85	0.1434

[a] Spring is 18 June–20 June, summer is 25 June–4 July, and fall is 23 September–24 October.

Table 6.–Volunteer work effort to capture northern pike at East and West Mackey lakes, Alaska, 2003.

	East Mackey Lake		West Mackey Lake	
Date	Hours:minutes	Volunteers Present	Hours:minutes	Volunteers Present
18 June	3:35	Y		
19 June	4:20	Y		
20 June	3:30	Y		
25 June	3:00	Y	3:25	Y
26 June	3:50	Y	3:20	Y
27 June	3:35	N	3:50	N
2 July	3:05	N	2:50	N
3 July	3:15	Y	3:45	N
4 July	3:25	N	3:20	Y
23 September	2:55	Y	3:40	Y
24 September	3:00	N	3:15	N
25 September	3:00	N	3:30	N
26 September	3:10	N		
29 September	2:55	N	3:10	N
30 September	3:15	N	3:25	N
1 October	3:05	N	3:15	N
2 October	3:00	N	3:15	N
3 October	3:20	N	3:45	N
6 October	2:45	N	3:00	N
7 October	3:45	N	3:00	N
8 October	3:40	N	4:01	N
9 October	3:06	N	2:50	N
10 October			2:59	N
14 October	3:10	N	3:15	N
15 October	3:10	N	3:05	N
16 October	3:21	N	3:31	N
17 October	3:23	N	4:10	N
21 October	2:55	N	3:18	N
22 October	3:01	N	3:18	N
23 October	3:23	N	3:04	N
24 October	3:10	N	3:50	N
Total	98 hours 30 minutes		91 hours 6 minutes	
Volunteers present	24 hours 25 minutes		14 hours 5 minutes	
Volunteer days	23%		16%	
Volunteer hours	25%		15%	

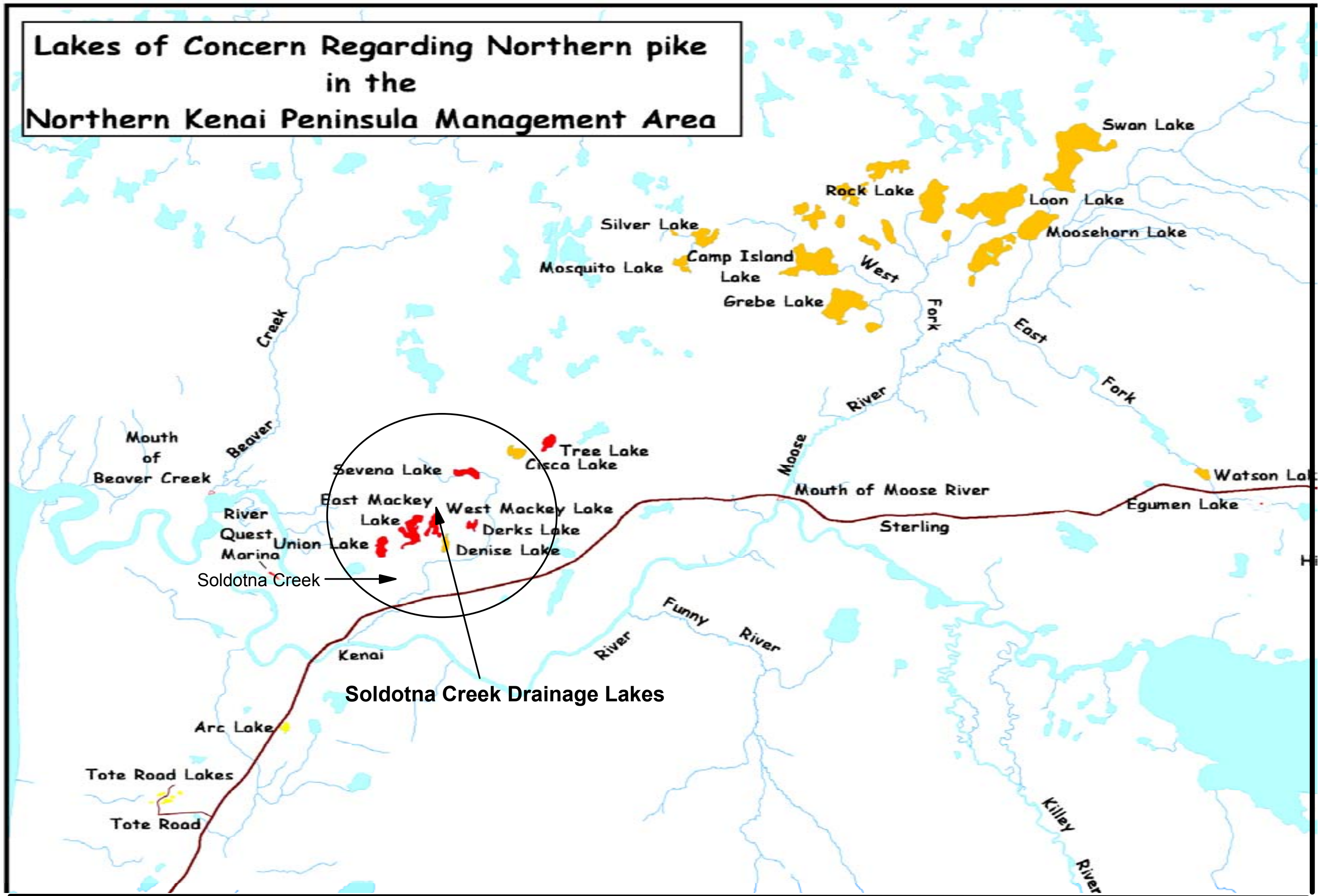

Figure 1.–Kenai Peninsula area lakes of concern regarding northern pike and the Soldotna Creek drainage lakes sampled in 2003 and 2004.

APPENDIX A.
STORMY LAKE FISH TRAP FEASIBILITY STUDY

STORMY LAKE FISH TRAP FEASIBILITY STUDY

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Stormy Lake Fish Trap Feasibility Study

SITE DESCRIPTION

Stormy Lake is a natural, uncontrolled, approximately 600-acre lake with no major surface water inputs, located within Captain Cook State Park near Nikiski, Alaska. The lake is located less than a mile away from Bay Number Three of the Cook Inlet, and is perched at an elevation well above the high tide level. There is one outlet from the lake, an unnamed stream that flows approximately one-quarter mile to the Swanson River, crossing one gravel road through a 48-inch culvert along the way. The outlet is ephemeral; there is apparently no surface flow out of the lake during certain parts of the year. Estimates of the flows in the outlet channel are based on observation only. Normal operating flows range from low flows of 1-4 cubic feet per second (cfs) to high flows of 10-20 cfs in a normal year. Flood events, such as during the heavy storms in October 2002, may hit a peak flow of as much as 40-50 cfs.

The major fish species in Stormy Lake are rainbow trout, Dolly Varden, longnose sucker, three-spine stickleback, and coho salmon juveniles, which hatch downstream of the lake and migrate upstream into the lake. Northern pike have only recently appeared in Stormy Lake, presumably having been introduced to the watershed sometime in the last 10-20 years. Adult northern pike is a notorious predatory fish, known for its voracious appetite for juvenile salmonids. Northern pike is a resident species throughout much of Alaska, but is not a resident species in Stormy Lake. ADF&G staff members are concerned that as northern pike proliferate in Stormy Lake, adults will move into the relatively slow-moving outlet channel and the tidally influenced Swanson River, and feed on the migratory coho salmon fry before they move into the lake. A fish trap at the outlet of Stormy Lake has been proposed to restrict the movement of adult northern pike.

PROBLEM STATEMENT

A fish trap is proposed to prevent passage of northern pike from Stormy Lake into the outlet channel. The trap would allow bi-directional movement of fish of all species up to 1 inch in width, and would be staffed 1-3 days weekly to facilitate sorting of trapped fish. The three critical design criteria for the trap are as follows:

- Blocks movement of adult pike
- Low capital cost
- Low maintenance costs, including labor

PROPOSED DESIGN

Fish Trap Box: The proposed fish trap design is a one-unit, reversible trap with removable picket panels and a downstream check structure for water level control. A conceptual plan drawing is shown in Figure 1. The design trap box is approximately 3 feet in width, 10 feet in length, and 2 feet in height from the floor of the box. The box includes footings for anchoring the trap and for stability. The sides of the box are solid, and the back (downstream) side of the box is a picket gate, removable for cleaning and maintenance. A removable picket panel V-trap extends from the sides of the trap on the upstream face to the apex of the V near the center of the box. At the apex, a frame with three removable pickets allows different size fish to enter the trap by adding or removing the pickets. The arrangement of the removable pickets could be adjusted to allow fish of widths between 3 and 7 inches to enter the trap box.

During fish trap design, the potential for water piping and undermining of the structure should be assessed. The designed trap should not be susceptible to changes in invert elevation due to underflow or ice jacking.

Picket Panels, Guides, and Sills: Guides for the removable picket panel V-trap and the removable picket gate would be included on both the upstream and downstream ends of the box. This design feature makes the fish trap "reversible," allowing the operator to manually set the trap to prevent either upstream or downstream movement of adult northern pike. The picket panels on the upstream face connect to removable picket guidance panels that extend along the banks of the lake on either side of the box. These panels would allow flow to pass during high flow events, but would not allow passage of adult pike. Sills would be constructed on the outlet banks on either side of the downstream face of the box to control flow in the high flow sections.

The removable picket panels in the trap box should be constructed of 1-inch to 1½-inch aluminum bars with 1-inch spacing and an aluminum frame to pass juvenile fish, and should be sized for velocities of 1-2 feet per second to prevent impingement of adult fish. A conceptual detail drawing of the removable picket panels is shown in Figure 2. The trap box, check structure, and footings should also be constructed of aluminum. While this structure could be built using concrete or treated wood, aluminum is the recommended construction material because of its weight, cost, longevity, and ease of field mobility and adjustment.

If it is determined that the fish trap should prevent the movement of fish less than 1-inch in width, the spacing of all pickets should be reduced accordingly prior to fabrication of the trap.

The picket guidance panels and sills on the bank of the lake should be of the same specifications as those for the trap box (see Figures 1 and 2). The panels would be installed at an angle. This alignment would "guide" adult fish along the panels in a downstream direction and into the trap box or discourage them from downstream movement. These panels are not expected to be submerged very often, and therefore could be constructed of aluminum or treated wood. The sills could be constructed of concrete, galvanized steel, treated wood, or logs.

Design Flow: The box is designed to handle flows up to 10 cfs, and the picket guidance panels should be installed so that the most common high flows exit the lake through the high flow sections. These high flows are likely 40 to 50 cfs. The design flows are based on judgment and the lake outlet flow estimates given in the site description.

Maintenance and Staffing: This trap design has a compulsory staffing component. One worker must staff the fish trap no less than three times a week during periods of adult migration from the lake, and no less than once a week during other periods. The responsibilities of the on-site staff would be to sort by hand the trapped adult fish and release the appropriate individuals to the lake or the stream, and to clean the removable picket panels of trash, algae, and other debris that may block flow and increase velocities in or approaching the trap box. Cleaning would be especially important in the fall when floating leaves could clog the pickets. The staff should also remove trash, plant material, or debris blockage from the high flow section, and should inspect the structures and record damage incurred by plant roots, wildlife, or vandalism.

CONSTRUCTION, INSTALLATION, AND COSTS

***Trap Construction*:** One of the critical design criteria for the fish trap is low capital costs. The design calls for aluminum, which is one of the more cost effective fabricated materials when balancing initial capital cost with project life and maintenance. Aluminum is also ideal for underwater use. Several fabricators in the Anchorage area or on the Kenai Peninsula have the capability to construct the trap box and picket panels. The flow control sills could be built in-house by ADF&G. The manufacture of an aluminum trap box and picket panels with treated wood sills would cost on the order of $30,000 for this project component.

***Trap Installation*:** This design is also tailored for low installation costs and would likely require little or no large equipment. A trencher, a small loader and possibly a backhoe might be necessary, but much of the work could likely be done by hand. A construction manager or experienced foreman would be required. The cost of installation is dependent on the number of volunteer workers and amount of donated equipment that ADF&G could secure for this project. If the project were to be performed by a local contractor at Davis-Bacon wages, the labor and equipment costs would be approximately $7,700.

Surveyor Costs: Crucial to the performance of the trap box is the setting of the elevations for the floor of the box and the sill, the length of the picket guidance panel, as well as any excavation that must occur to accommodate the high flow sections. These parameters should be identified with care during the design process, and a professional land surveyor should be utilized both during design and during installation. The cost of survey labor during the project would be about $8,000.

Engineering Costs: Engineering design would be required for the manufacture and installation of the trap. Design would include site plans, bank and vegetation restoration plans, and details of the trap box, removable picket panels, picket guidance panels, and sills. Specifications would also be developed for their manufacture and installation. The cost of design would be on the order of $8,000.

Bank and Vegetation Restoration Costs: Design of the fish trap should include bank and vegetation restoration plans. Installation of the trap, specifically construction of the high flow area, would disturb the lake bank. The construction should allow for vegetative restoration to occur immediately before or during the growing season. If this is not possible, the banks should be stabilized over the winter and restoration should occur soon after break-up. The cost of design and construction of this component of the project would be approximately $9,800.

Estimated Total Cost: The total cost of the project, assuming no volunteer labor or donated materials, is estimated to be $63,500. The preliminary cost estimate detailed in this section is summarized in Table 1. This amount does not include trap maintenance or the construction and maintenance of access to the lake outlet from the nearby parking lot or access road. The estimate also does not include the operational cost of staffing the trap. It should be noted that while the outlet may be ephemeral in the summer, flow is typically constant in the winter and spring months. Operation and maintenance may be problematic in the winter months due to snow and ice.

Permitting Costs: In addition, ADF&G would need to secure permits to construct this project. Permits that may be applicable to this trap include a Fish Habitat Permit, Section 404 Permit, Coastal Zone Consistency Determination, and any permits required by the Kenai Peninsula Borough. The approximate cost of researching, preparing, and applying for these permits (not including Borough permits) is $10,000. This cost is not included in the estimated total cost given above.

Construction Timing: The fish trap may be installed any time of year. Winter work may increase installation costs by 20-40%, as additional equipment might be needed, such as floodlights, heaters, water pumps for an ice road or ice pad, etc. Deep snow or extreme cold may further increase costs. However, the use of ice pads and/or ice roads would protect the outlet creek and adjacent wetlands that would otherwise be impacted during the summer, which would significantly reduce the restoration costs. Consequently, the construction season might be an issue in the permitting process, but it would not affect design, operation, or performance of the fish trap.

SUMMARY

To prevent the movement of adult northern pike from Stormy Lake, a fish trap design that features low maintenance requirements and low capital costs is proposed for the lake outlet. The proposed trap constrains all adults of the larger fish species in the lake, and thus requires a staff member to sort the fish in the trap while the outlet is flowing. The trap would be approximately 3 feet × 10 feet × 2 feet (W × L × H) and would be constructed of aluminum sheets, removable aluminum picket panels, and aluminum footings appropriate to anchor the trap in the outlet channel. The trap would be reversible to limit either upstream or downstream movement of adult fish. A high flow section would be constructed adjacent to the trap; this section would include picket guidance panels that would be constructed of aluminum, and flow control sills that may be constructed of concrete, galvanized steel, treated wood, or logs. A maximum of about 10 cfs would flow through the trap box; flows above 10 cfs would be routed through the high flow section. The picket guidance panels would guide fish either into the trap box or away from the lake outlet, and would not allow adult fish passage through the high flow section.

The trap box and its components could be manufactured by any of several companies in Anchorage or on the Kenai Peninsula. Bank restoration would be necessary after installation is complete. Installation of the trap and construction of the high flow area could likely be done using volunteer labor and donated equipment, though several professional staff should be involved in the project, including a professional engineer for design, a professional land surveyor for correct siting of the trap, and a construction manager or foreman to lead the construction effort. The cost of the design, manufacture, and installation of the trap box, assuming construction labor costs and summer construction, would be on the order of $63,500. This figure does not include operation and maintenance costs, or the costs associated with obtaining the necessary permits.

Possible difficulties and unknowns concerning this design include the uncertainty of the outlet flows. Discharges from the lake have not been measured, and the trap size was designed based on similar projects and engineering judgment. Another consideration is that the ephemeral outlet stream typically flows throughout the winter. The trap should be staffed year-round based on maintenance needs, adult fish migration patterns, and the effects of snow and ice on the trap.

Figure 1. Stormy Lake Fish Trap Site Plan

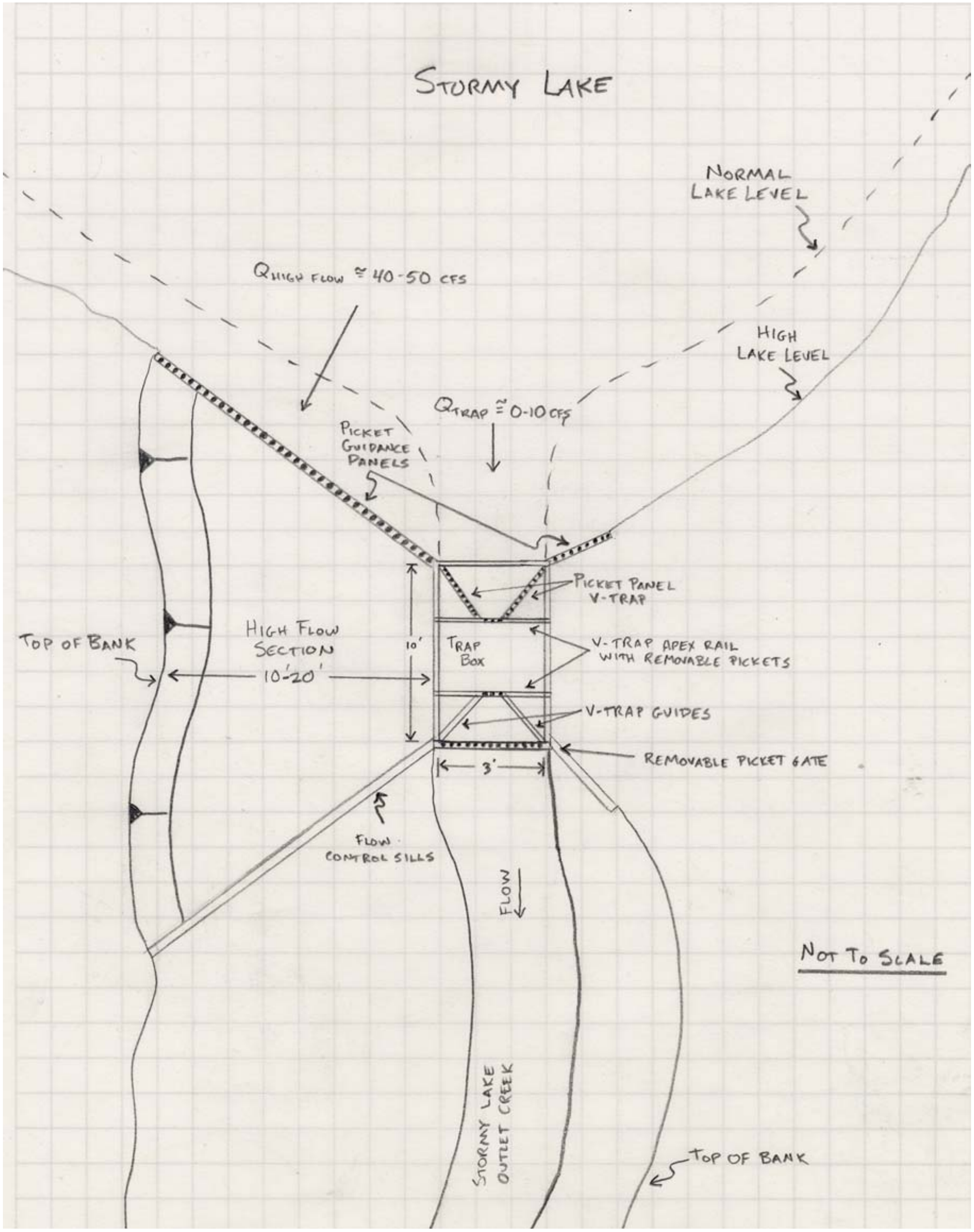

Figure 2. Removable Picket Gate Details

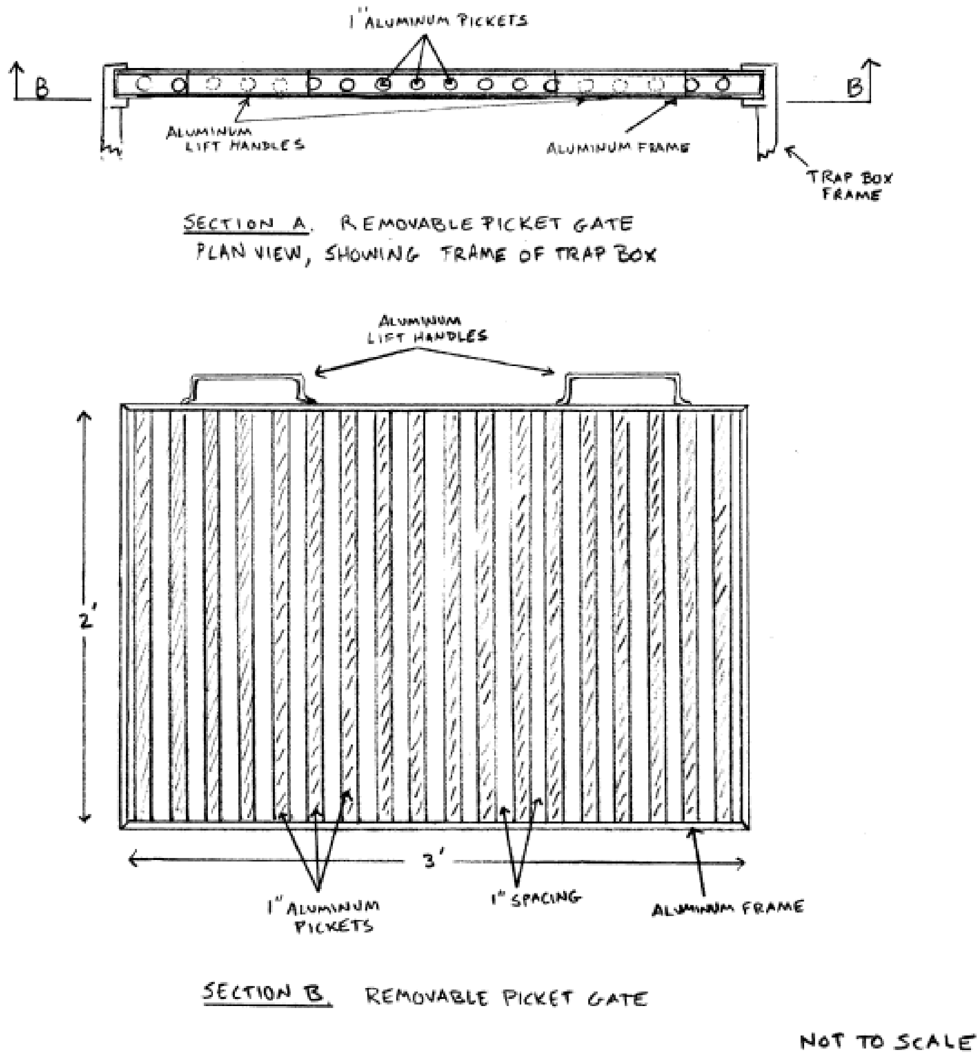

Table 1. Stormy Lake Fish Trap Preliminary Cost Estimate

FABRICATION

Work Description	Quantity	Pay Unit	Unit Price	Total
Fish trap and picket panels	1	L.S.	$ 29,000.00	$ 29,000.00
Treated wood sills	1	L.S.	$ 1,000.00	$ 1,000.00
			Subtotal	$ 30,000.00

SURVEY

Work Description	Quantity	Pay Unit	Unit Price	Total
Survey Crew - field work	48	HR.	$ 135.00	$ 6,480.00
Survey Crew - office work	16	HR.	$ 90.00	$ 1,440.00
			Subtotal	$ 8,000.00

INSTALLATION & CONSTRUCTION

Work Description	Quantity	Pay Unit	Unit Price	Total
Laborer	64	HR.	$ 50.00	$ 3,200.00
Backhoe & operator	16	HR.	$ 150.00	$ 2,400.00
Bobcat & operator	16	HR.	$ 130.00	$ 2,080.00
			Subtotal	$ 7,700.00

RESTORATION

Work Description	Quantity	Pay Unit	Unit Price	Total
Design	1	L.S.	$ 5,000.00	$ 5,000.00
Willow cuttings	100	LF	$ 30.00	$ 3,000.00
Willow transplants	20	EA.	$ 40.00	$ 800.00
Seeding	1.5	MSF	$ 300.00	$ 450.00
Erosion control	1	L.S.	$ 500.00	$ 500.00
			Subtotal	$ 9,800.00

DESIGN

Work Description	Quantity	Pay Unit	Unit Price	Total
Plans & Specifications	1	L.S.	$ 8,000.00	$ 8,000.00
			Subtotal	$ 8,000.00

Total project cost estimate: $ 63,500.00

Note: Cost estimate does not include operation & maintenance or permitting costs.