Special Publication No. 14-11

Control Efforts for Invasive Northern Pike on the Kenai Peninsula, 2009

by

Rob Massengill

May 2014

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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)

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

In 2005, a population of invasive northern pike was discovered in Scout Lake near Sterling, Alaska, causing the Alaska Department of Fish and Game (ADF&G) to stop stocking fish in this lake. ADF&G treated Scout Lake with liquid and powdered rotenone formulations in October 2009 to eradicate the northern pike population. Gillnet sampling in spring 2010 after treatment indicated the northern pike population had been eradicated. Water quality sampling in Scout Lake indicated similar water quality characteristics before and after treatment. Comparisons of zooplankton and macroinvertebrate presence between summer 2009 (before treatment) and 2010 (after treatment) indicated that species diversity remained similar, although some zooplankton species were far less common in posttreatment samples. In August 2010, ADF&G restocked Scout Lake with rainbow trout and Arctic grayling fingerlings.

Key words: Kenai Peninsula, Scout Lake, rotenone, northern pike, chemical treatment, restoration, invasive species, eradication.

INTRODUCTION

Northern pike (*Esox lucius*) are native to Alaska north and west of the Alaska Range and in a disjunct population near Yakutat, southeast of the Chugach and Wrangell ranges. Northern pike do not naturally occur in Southcentral Alaska (Figure 1) and first appeared there from an illegal introduction into Bulchitna Lake in the Yentna River drainage in the 1950s (ADF&G 2007). Northern pike on the Kenai Peninsula are believed to have originated from an illegal introduction to the Soldotna Creek drainage (a Kenai River tributary) during the 1970s and quickly spread by natural dispersion and additional introductions (McKinley 2013; anonymous report[1]).

The Kenai Peninsula is one of the premier sport fishing areas in Alaska, receiving over 502,778 freshwater angler-days in 2009 and representing 39% of the total freshwater sport fishing effort in Alaska (Jennings et al. 2011).

Northern pike are considered an aquatic nuisance species in Southcentral Alaska because they are nonnative to the region and their introduction can cause economic and environmental harm (Fay 2002). Northern pike have been implicated in the decline of localized salmonid abundance in Southcentral Alaska (Rutz 1999; McKinley 2013) and have been shown to prefer soft-finned juvenile salmonids over other available prey species (Rutz 1996, 1999). Consumption of native juvenile salmonids by introduced northern pike has also been observed elsewhere in the northwestern United States (Rich 1992; McMahon and Bennett 1996; Schmetterling 2001; Muhlfeld et al. 2008). In Southcentral Alaska, potential prey species may be particularly vulnerable to northern pike predation because they evolved in the absence of these predators and may lack some predator avoidance adaptations. In contrast, interior Alaska prey species share an evolutionary history with northern pike (Oswood et al. 2000).

In Southcentral Alaska, invasive northern pike typically dominate fish communities within lakes they inhabit and greatly reduce or eliminate the native fish populations, particularly in shallow lakes where prey lack deep water refuges (ADF&G 2007; Massengill 2010-2011; McKinley 2013). Native fish populations have already been severely affected by northern pike predation in the Soldotna Creek Drainage and Stormy Lake. Additional losses are likely if northern pike expand into new salmonid-rearing habitats.

[1] Report titled *Northern Pike (Esox Lucius) in the Soldotna Creek System*, anonymous author, available at the Soldotna ADFG Office.

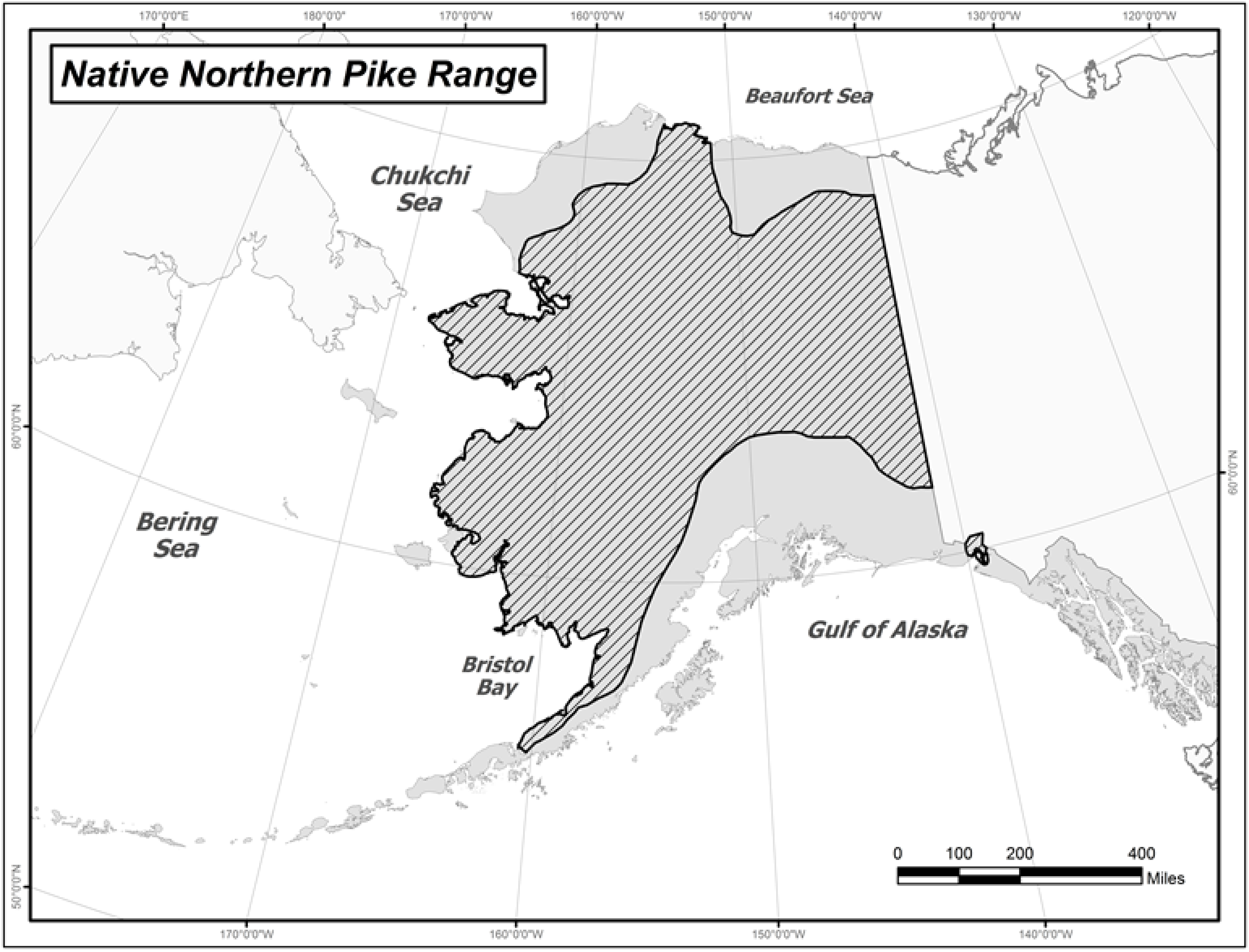

Figure 1.–Native range of northern pike (*Esox lucius*) in Alaska.

The Alaska Department of Fish and Game (ADF&G) has evaluated different strategies for controlling or eradicating invasive northern pike; these strategies are listed in a plan titled the "Management Plan for Invasive Northern Pike in Alaska," available online at http://www.adfg.alaska.gov/static/species/nonnative/invasive/pike/pdfs/invasive_pike_management_plan.pdf. Netting and passage barriers have been used by ADF&G to control northern pike populations in some Kenai Peninsula waters, but these methods rarely eliminate the threat of northern pike to native fisheries (Begich and McKinley 2005; Massengill 2010-2011). ADF&G has concluded that for most cases, the best strategy for eradication of northern pike is to use a piscicide (rotenone).

Rotenone is a naturally occurring plant derivative commonly found in the family Fabaceae (legumes). Rotenone acts by inhibiting oxygen transfer needed for cellular respiration (Ling 2003). It is effective at killing fish in water at low concentrations because it is readily absorbed into the bloodstream through the thin cell layer of the gills. Mammals and other non-gill-breathing animals do not have this rapid absorption route into the bloodstream and can tolerate exposure to higher concentrations than those used to kill fish. Typically, nongilled, nontarget organisms are not negatively affected at concentrations necessary to kill fish (Finlayson et al. 2000; Ling 2003; USEPA 2007[2]).

Since the 1970s, a total of 18 lakes on the Kenai Peninsula and Soldotna Creek have had confirmed northern pike populations (Figure 2). Of these lakes, northern pike were eradicated by ADF&G from Arc Lake and Stormy Lake using rotenone in 2008 and 2012, respectively. Northern pike were also removed from Hall Lake and Tiny Lake in 2011 by intensive gillnetting efforts. Northern pike populations in Tree Lake and Denise Lake have apparently disappeared from natural causes. Low dissolved oxygen concentration during winter is suspected of playing a role in the disappearance of northern pike in Tree Lake. The cause for the apparent disappearance of northern pike from Denise Lake is unknown.

Scout Lake (Figure 3) is located near Sterling, Alaska. It is a closed natural lake, covers 85 surface acres, and is 835 acre-feet in volume; maximum depth is 21 feet and the mean depth is 8.6 feet. Scout Lake is a popular recreational lake that has a long history of being stocked with either salmon or trout or both by ADF&G since at least the 1960s. Between 2003 and 2005, ADF&G stocked Scout Lake with rainbow trout (*Oncorhyncus mykiss*) and coho salmon (*Oncorhyncus kisutch*). Following the discovery of northern pike in Scout Lake during the summer of 2005, all stocking was discontinued because fishery managers were concerned that adding stocked fish to the lake could benefit the northern pike. After stocking was discontinued, fishing success at Scout Lake declined and by 2007, no fish were reported harvested from the lake (Jennings et al. 2010). In 2006, ADF&G surveyed the lake and captured northern pike, including juvenile northern pike as small as 277 mm fork length (FL). Because juvenile northern pike of this length are likely 2 years old (Chihuly 1979), this suggests that northern pike may have been reproducing in the lake for at least 2 years.

[2] USEPA (United States Environmental Protection Agency). 2007. Reregistration eligibility decision for rotenone. Available at www.epa.gov/oppsrrd1/REDs/rotenone_red.pdf

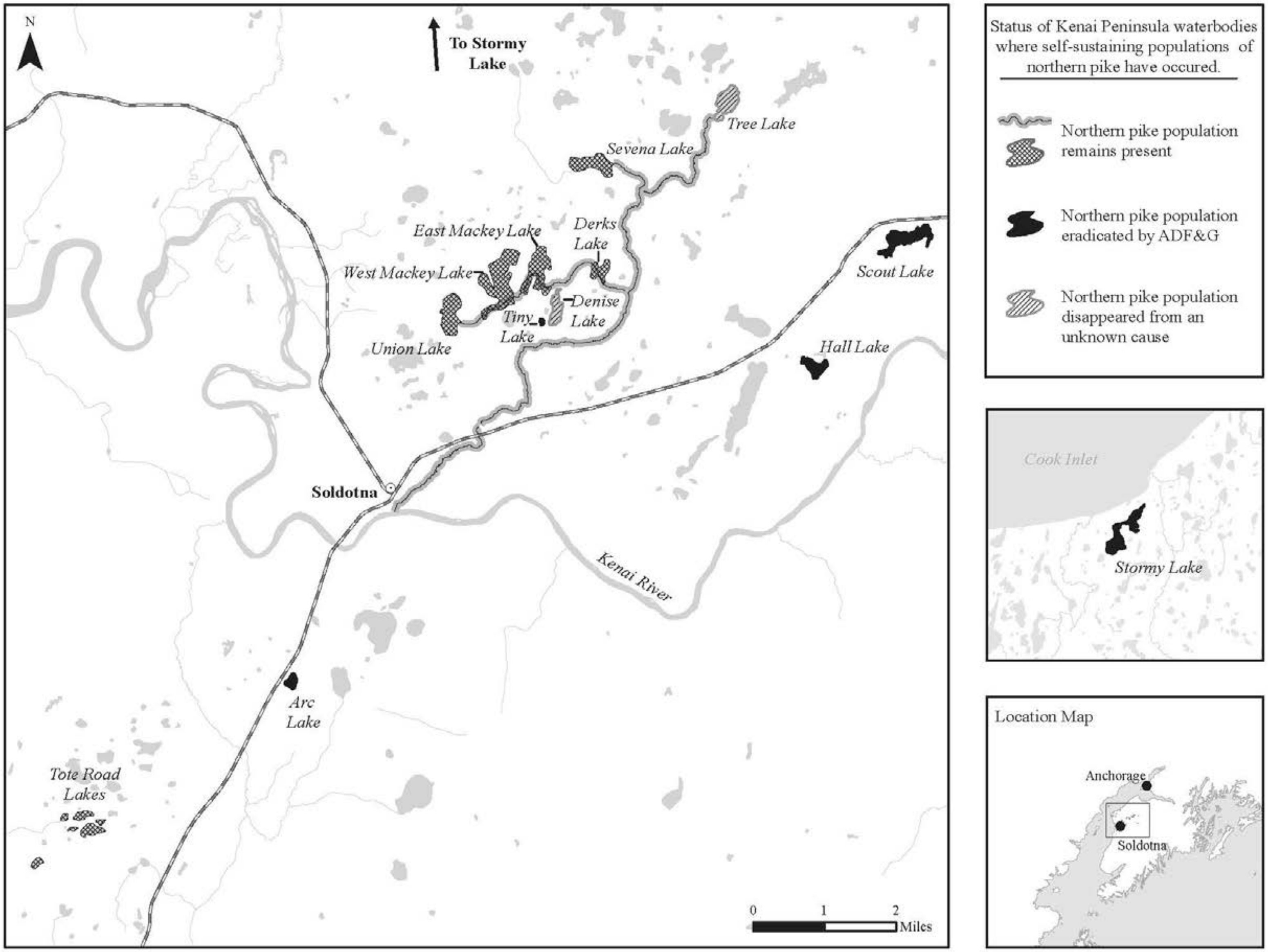

Figure 2.–Status of Kenai Peninsula water bodies that contain or have contained self-sustaining populations of northern pike.

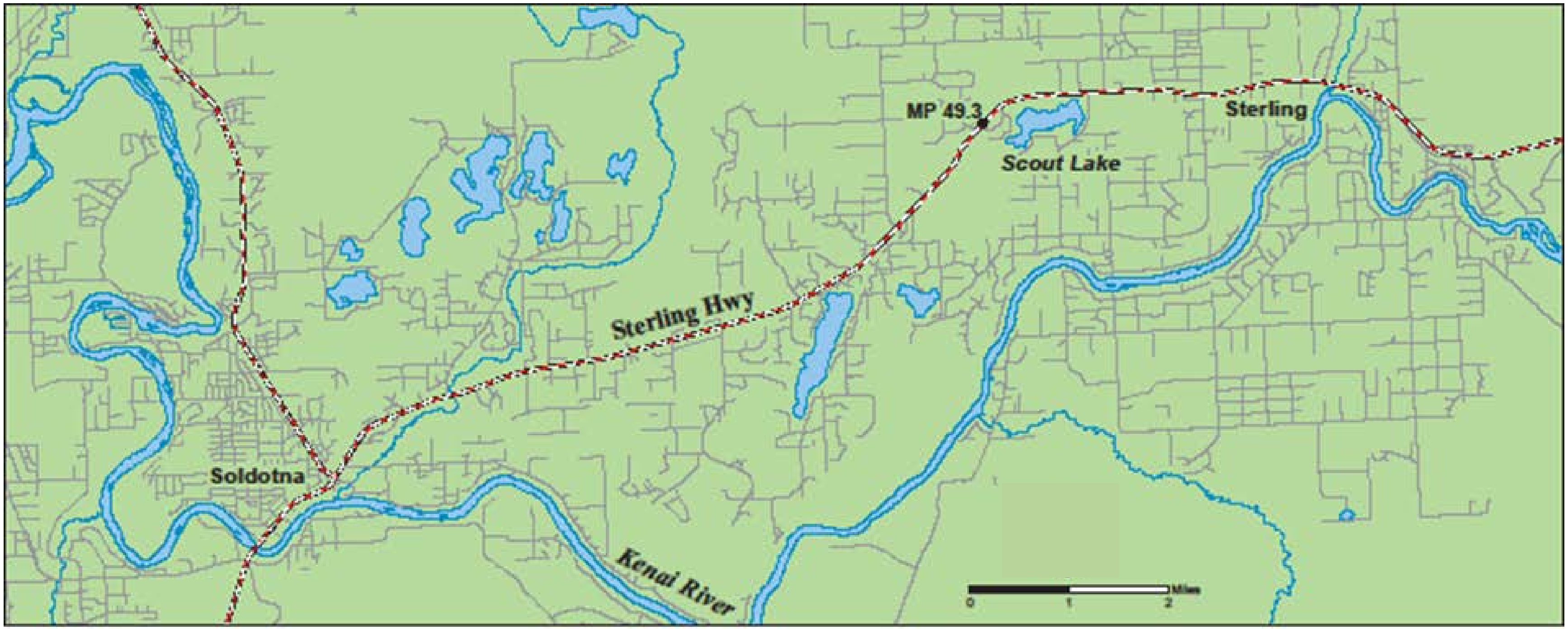

Figure 3.–Map showing the location of Scout Lake near Sterling, Alaska.

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Objectives and Tasks

Objective

- Eradicate the northern pike population from Scout Lake to enable the restoration of its recreational fishery.

Tasks

This project required the successful completion of the following tasks:

1) Initiate scoping and information-sharing for the proposed piscicide treatment with the public, identified stakeholders, and appropriate government agencies.
2) Collect baseline physical, biological, and water-quality data from Scout Lake prior to treatment.
3) Fulfill all permitting and authorization obligations necessary to conduct the piscicide treatment at Scout Lake.
4) Treat Scout Lake with a piscicide (rotenone).
5) Monitor Scout Lake after treatment to determine if the treatment successfully eradicated northern pike, document the natural degradation of rotenone over time, and document when biological and water-quality values are restored sufficiently for restocking.

METHODS

Clearances for Treatment

Many approvals and permits were required for this project. ADF&G also solicited public and stakeholder involvement for this restoration effort. ADF&G obtained all clearances for the Scout Lake restoration project as required and these are summarized below.

National Environmental Policy Act (NEPA) Compliance

The Scout Lake Restoration Project Environmental Assessment was submitted to the United States Fish and Wildlife Service (USFWS) on 23 April 2009 for initial review, and a final version was sent to the USFWS Regional Office on 1 September 2009. A Finding of No Significant Impact (FONSI) was issued on 28 September 2009 (Appendix A1). The environmental assessment can be viewed online at http://www.adfg.alaska.gov/static/species/nonnative/invasive/rotenone/pdfs/scout_lake_ea.pdf.

Notifications

A list of the public scoping actions, notifications, and meetings provided by ADF&G in preparation for the Scout Lake restoration project are provided below:

1) The local ADF&G advisory committees (Kenai–Soldotna, Cooper Landing, and Central Peninsula) and other identified stakeholders were notified of the Scout Lake restoration proposal during winter 2009 by the Soldotna ADF&G Sport Fish Area Management Biologist.
2) A meeting to share the Scout Lake restoration proposal with the public, targeting property owners near Scout Lake, was held on 30 April 2009 in Sterling, Alaska.
3) Public notices for the Scout Lake restoration pesticide use permit application were printed in the Peninsula Clarion on 2 consecutive days (29–30 June 2009) as required by DEC for the pesticide use permitting process (Appendix A2).

4) In an ADF&G news release issued on 30 June 2009, ADF&G announced that the Scout Lake and Sand Lake (Anchorage) public commenting periods were open for the pesticide use applications and environmental assessments (Appendix A3).

State Level Approvals

The required state level authorizations obtained for the Scout Lake restoration project are listed below:

1) An Alaska Department of Environmental Conservation (DEC) Pesticide Use Permit was issued on 23 August 2009 (Appendix A4).
2) An Alaska Coastal Management Program (ACMP) consistency review determination was made by DEC on 2 July 2009 and stated that an ACMP review was not required (Appendix A5).
3) An ADF&G Fish Transport Permit for collecting juvenile coho salmon for bioassay and sentinel fish uses integral to the Scout Lake Restoration Project was issued on 20 July 2009 (Appendix A6).
4) An Alaska Board of Fisheries approval of the Scout Lake restoration project (rotenone treatment) was issued on 11 August 2009 (Appendix A7). Approval by the Division of Sport Fish Director was received via e-mail to the Soldotna ADF&G office on 19 August 2009.

WATER BODY PHYSICAL AND CHEMICAL CHARACTERIZATION

Lake Mapping

A bathymetric survey of Scout Lake was conducted to estimate its volume. A shape file of the lake boundary was created in a geographic information system (GIS) using aerial images and then loaded onto a Trimble GeoTX global positioning system (GPS) unit. Using the Trimble unit to collect GPS coordinates and a Garmin GPSMAP 440s FishFinder[3] mounted on an outboard motorboat to collect water depth data, 180 depth measurements and associated waypoints were collected. The transducer for the FishFinder was secured to an adjustable mount allowing the transducer depth be set at just below the lake surface. The surveyors collected data by first traveling around the entire perimeter of the lake then continuing along a pattern of increasingly smaller concentric loops until the entire lake was covered. An attempt was made to place sample locations relatively equidistant. Sample locations were chosen by visual navigation using the lake image and a cursor indicating the boat's location relative to sample waypoints that were visible on the Trimble screen, thus allowing the surveyors to judge where the next depth measurement and waypoint would be collected. Efforts were made to ensure relatively even spacing between sample locations. At each sample location, the surveyors stopped the boat and allowed the Trimble unit to collect approximately 60 positions (1 position per second for 1 minute). Before moving to the next sample location, the depth measurement was manually entered into the Trimble unit to create a waypoint, which was marked on the shape file and used for navigation.

Throughout the survey, the surveyors manually verified the sonar depth reading using a weighted meter tape. This was done approximately every 20 samples, and this process verified that the FishFinder was accurately measuring depth. After the survey was complete, waypoint and depth

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

data from the Trimble unit were offloaded into PathFinder Office 4.0 and postprocessed using the GPS base station at the Kenai municipal airport. Postprocessing corrects the GPS data so that the final estimate of location (using the multiple positions collected at each one) is at submeter accuracy.

Once postprocessed, the depth, location, and lake outline data were input into ArcGIS, wherein a digital elevation model (DEM) of the lake bottom surface was made. ArcGIS provides a single command to create the DEM from point bathymetry data. The command is called TOPO to Raster and it interpolates a hydrologically correct raster surface from point, line, or polygon data. The lake outline was digitized manually from imagery layers produced by the Kenai Peninsula Borough that were already orthorectified and georeferenced. An ArcGIS tool called "Surface Volume" calculated the projected area, surface area, and volume of a surface relative to a given reference plane. By adjusting the elevation of the reference plane in the Surface Volume tool, estimates for specific depth strata were generated using basic grid algebra techniques and simple subtraction.

Water Quality

Our goal was to collect water quality data once per month for at least one year prior to and following the rotenone treatment. Water temperature, pH, dissolved oxygen, and specific conductivity data were collected from Scout Lake using a Quanta Hydrolab. Water turbidity data were collected and were measured with a Secchi disc. Pretreatment monthly water quality sampling occurred from July 2006 through June 2007. Posttreatment monthly water quality sampling occurred from November 2009 through October 2010. Water quality data were collected from the lake surface to the bottom in 1-meter increments at a single site located near the deepest part of the lake. Turbidity data were measured at the same location where water quality data were collected. The sampling site was marked with a tethered buoy visible during open water and in winter was marked with a flagging stake anchored into the ice.

A single alkalinity sample was collected before treatment to help assess the potential persistence posttreatment of both rotenone and a degradation product (rotenolone). In highly alkaline water (> 170 ppm $CaCO_3$), rotenone deactivation can be delayed (Skorupski 2011), and at very low alkalinity (<15 ppm $CaCO_3$) rotenolone can be a significant degradation byproduct that has about one-tenth the toxicity as rotenone (Ott 2008) but can persist longer (Finlayson et al. 2001). The alkalinity sample was collected at Scout Lake by filling a 500 ml glass jar with water from 60 cm below the lake surface near the lake center. Total alkalinity was analyzed by ADF&G Limnology Lab personnel using the methods described in Koenings et al. (1987).

BIOLOGICAL INVENTORY

Invertebrates

Macroinvertebrate and zooplankton sampling in Scout Lake was conducted during summer both before and after the rotenone treatment to identify taxa present. Sampling was conducted at the same locations both before and after treatment. Locations were recorded with a handheld GPS before treatment so the same locations could be found by GPS and resampled after treatment; these locations are shown in Figure 4. At each sampling site, all collected invertebrates were combined into 1 glass specimen jar filled with 70% ethanol and labeled with the date, site location, and gear type.

Zooplankton collections were made at 2 sites by replicate vertical tows (from the bottom of the lake to the surface) in locations near maximum lake depth using a 0.5-meter diameter Wisconsin net with 153 µm mesh. The Wisconsin net was lowered to near the lake bottom (~5 m) with a hand line and then retrieved at a rate of 1 meter every 2 seconds. As the net was retrieved, captured zooplankton concentrated in the net bottom inside a screened PVC collection bucket. At the surface, the bucket was detached, and captured zooplankton were transferred to a collection jar. Zooplankton samples were generally resolved to the order or family level using illustrations found in Bachmann (1973) and taxonomic keys found in Pennak (1989).

Multiple gear types were used to sample macroinvertebrates. Collected macroinvertebrates were identified to the order, suborder, or family level when feasible, using keys provided by Pennak (1989) and Voshell (2002). To collect benthic macroinvertebrates, a 9-inch Ekman Bottom Grab Sampler was used to collect bottom sediment from 5 offshore sites. The Eckman sampler was deployed from an anchored outboard motorboat at each site in 5 to 10 feet of water. Collected sediment was screened to filter out invertebrates, which were removed from the screen with tweezers. Handheld D-nets were used to sample invertebrates along vegetated nearshore areas (< 0.6 m in depth) in 5 locations. The D-net was swept back and forth through submerged vegetation for 30 seconds. Floating Quatrefoil light traps were also used and tethered to stakes at 2 nearshore locations and fished during at least 1 hour of darkness. The light traps were designed and built by Southern Concepts (Birmingham, Alabama) and featured 6 mm entrance slots and light-emitting diodes (LED lights) powered by dry-cell batteries. Hand picking of visible freshwater mussels and snails was attempted opportunistically in nearshore areas. All invertebrate sampling locations, except handpicking, are shown in Figure 4.

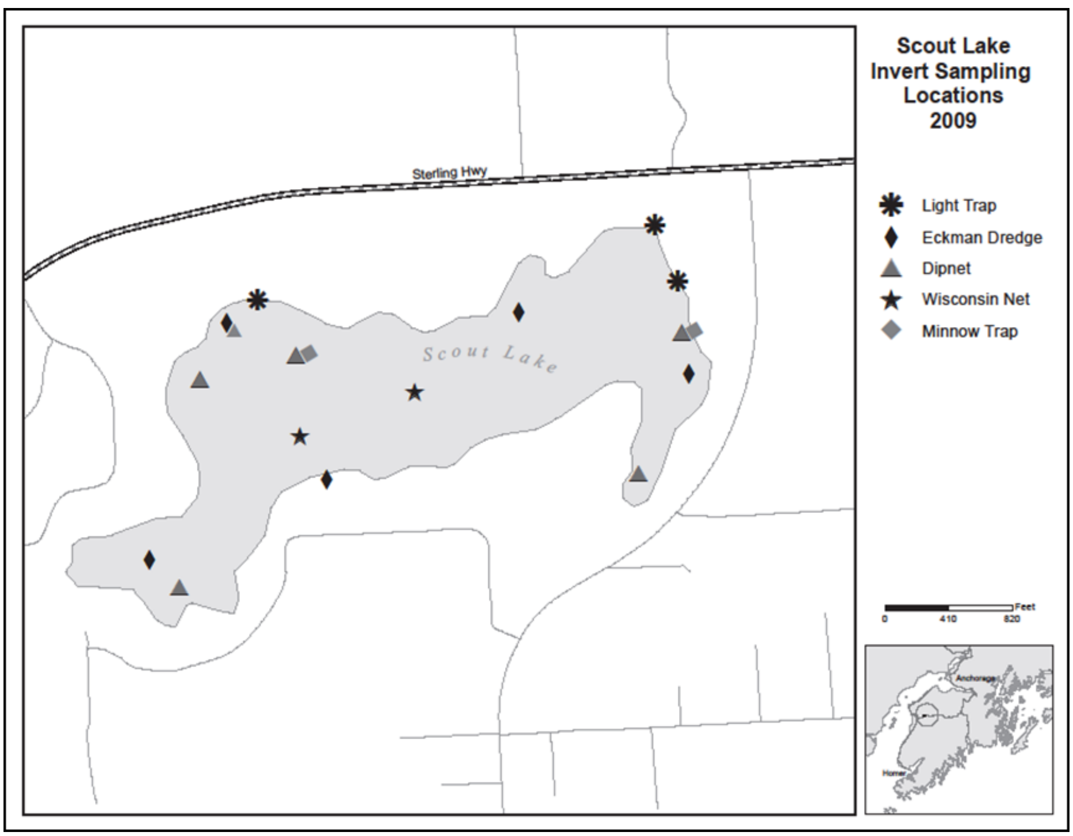

Figure 4.–Scout Lake with symbols identifying invertebrate sampling locations.

Fish

Seventeen unbaited minnow traps were fished in Scout Lake prior to the rotenone treatment in fall 2009 to document the presence of small fish species (e.g., threespine sticklebacks *Gasterosteus aculeatus*). Minnow traps were set near the shoreline in 15 to 60 cm of water for a minimum combined total of 300 hours. Minnow traps were also fished in spring 2010 after treatment to detect survival of any small fish species. At a minimum, at least 300 hours of minnow trapping effort after treatment was desired to match minnow trapping effort conducted before treatment. All minnow traps were fished posttreatment in similar shoreline locations and habitat as the pretreatment minnow trapping.

Gillnets were used to survey the lake for fish both before and after the rotenone treatment. The gillnets were made of single-strand monofilament mesh with floating polypropylene hanging line and half-inch lead line and were manufactured by Christiansen Net Company. Each net was 120 ft long and 6 ft deep, with six 20 ft wide panels of variable mesh net (1 each of sequentially attached half-inch, five-eighths-inch, three-quarter-inch, 1-inch, 1½-inch, and 2-inch stretched mesh).

Before the rotenone treatment in summer 2009, 24 gillnets were set in littoral areas by a 2-person crew operating from an outboard motorboat. The gillnets were fished for 4 continuous days to salvage northern pike for food donation and to detect whether there were fish species present other than northern pike and sticklebacks. Nets were typically tethered near shore to a fencepost with an owl decoy placed on top to discourage bird activity near the net. The small mesh end of the net was tethered nearest the shore. After tethering the net, the net was stretched out from shore by feeding it out from the boat bow by one crew member while the other drove the boat away from shore in reverse. At the end of each net, a 2-pound halibut weight was attached to the lead line (to help anchor the offshore end) and a small buoy or cork was tethered to the end of the hanging line to help the crew relocate the net end later.

Gillnets were also used in spring 2010 to evaluate the treatment's success at removing northern pike from Scout Lake. Calculations of the amount of gillnetting effort needed to detect a small surviving population of northern pike and the corresponding probability of not detecting the population are found in Appendices B1–B3. These calculations are derived from historical netting effort, catch, and abundance estimates for Derks Lake northern pike and account for differences in surface acreage between the lakes. Posttreatment gillnetting was conducted using the same methods used during pretreatment gillnetting.

BIOASSAYS

Bioassays using live fish were conducted in Scout Lake to determine the most appropriate dosages of Prentox Prenfish Rotenone Fish Toxicant Powder and CFT Legumine to use for northern pike eradication. Both products were used in combination to treat Scout Lake at approximately half of the lake volume each. The powdered formulation (Prentox Fish Toxicant Powder) is far less expensive than CFT Legumine and was used to reduce cost. CFT Legumine is much more expensive and has additives that improve its effectiveness by increasing dispersion and emulsification of the rotenone in water.

The goal of the bioassays was to determine an overall minimum effective dose (MED) for the two combined formulations. Because the two formulations were tested individually with bioassay tests, the formulation requiring the highest dosage to achieve an MED was selected for the overall MED. Doing so ensured that Scout Lake would be effectively treated throughout its entirety even if some sections of the lake were exposed only to the least potent formulation as observed from the bioassays.

The criterion for selecting an MED is 5 times the rotenone formulation concentration for which at least half of the bioassay fish are killed after 4 hours of exposure (Brian Finlayson, retired California Department of Fish and Game, personal communication). For example, if the bioassay concentration that kills at least half of the fish after 4 hours of exposure were 0.20 ppm, the MED would be 1.0 ppm (5 × 0.20 ppm = 1.00 ppm). To determine the MED for the powdered rotenone formulation, the following bioassay concentrations were tested using a single bioassay test for each concentration: 0.00 ppm (control), 0.20 ppm, 0.26 ppm, 0.50 ppm, and 1.50 ppm. These concentrations, if expanded to determine their respective MEDs, were mostly within the range allowed by the product label (0.10 ppm to 5.0 ppm; Appendix D1); however, the MED of the highest bioassay concentration (5 × 1.50 ppm = 7.50 ppm) exceeded the allowable concentration by 50%. Although the MED for highest bioassay concentration was above what could be legally applied, conducting a bioassay for 1.50 ppm would provide insight on the toxicity of the product if long-term storage had greatly reduced its effectiveness. The toxicity of the powdered rotenone formulation was in question because the product had been stored since 2000 and might have degraded or otherwise changed. Although the stored powdered rotenone had been assayed by analytic chemistry and shown to be at full rotenone strength, compaction and clumping or other physical changes in the product due to long-term storage could have reduced the product's ability to mix in water and thus reduce its effectiveness.

Reference charts listing the amount of rotenone premixture (liquid or powdered rotenone formulation diluted with water) needed to attain various rotenone concentrations for the bioassays can be found in Appendices C1 and C2.

Juvenile coho salmon (fingerlings) were collected from the Moose River confluence (Kenai River drainage) for the bioassays. Coho salmon were used because it is difficult to catch northern pike of appropriate size for the bioassay tests (larger fish would likely exceed the recommended 1 g fish per liter of water [Finlayson et al. 2010]). Juvenile coho salmon have a higher tolerance to rotenone than northern pike (Marking and Bills 1976); therefore, concentrations fatal to coho salmon should effectively kill northern pike as well.

Each bioassay was a single test to determine the response of fish over time to a specific concentration of a rotenone formulation. There were 5 bioassays for the powdered formulation and 3 bioassays for the liquid formulation (see above). For each bioassay, 4 fish were placed in a 33-gallon (125-liter) gas-permeable "breathable" polyethylene bag. Although all fish were of similar size, we weighed several of the largest fish to make sure that we did not exceed 1 g fish per liter of water, as recommended in Finlayson et al. (2010). The bags were 91 cm by 122 cm low-density polyethylene (LLD) drum liners about 1.0 to 1.5 mm thickness purchased online at http://www.linersandcovers.com/polyethylene-plastic.php. These bags were selected for the bioassays because their polyethylene membranes exhibit permeability to oxygen (http://chemicalland21.com/plasticrawmaterial/pvc/LDPE%20FB3000.htm), allowing some oxygen to pass from surrounding water into the bags and therefore reducing the need for aeration (Horton 1997; Finlayson et al. 2000).

Each bioassay bag was filled with approximately 38 liters (10 gallons) of Scout Lake water treated with a preselected amount of rotenone formulation. Temperature in each bag was maintained close to that found in Scout Lake by keeping the bags suspended in the lake by means of spring clamps attached to an improvised post-and-beam rack set off shore about 4.5 m in about 70 cm of water. Each bag was mostly submerged in the lake with the bag opening about 30 cm above the water line.

A conservative approach was taken to avoid undertreating Scout Lake. Because powdered rotenone is considered less effective at dispersing and emulsifying compared to liquid formulations, we decided that the overall target rotenone formulation concentration for the treatment would be determined by the powdered rotenone bioassay results.

CALCULATING PRODUCT VOLUME

A combination of rotenone formulations (liquid and powdered) was used to treat Scout Lake. The number of gallons of liquid CFT Legumine and the number of pounds of Prentox Prenfish Rotenone Fish Toxicant Powder required to treat Scout Lake was calculated based on bioassay results (see Results section) and the volume of Scout Lake. Examples of the methods used to calculate the amounts of product needed to treat Scout Lake are provided below with an assumed target concentration of 1.4 ppm of product.

Scout Lake is about 835 acre-feet in volume; we assumed that half of the lake volume (approximately 417.5 acre-feet) would be treated with liquid formulation and the other half with powdered formulation. In the examples below, we used this assumption to attain an overall rotenone product target concentration of 1.4 ppm, but the actual target concentration could differ from this example based on a different bioassay result.

CFT Legumine Example

The calculation to determine the number of gallons of liquid CFT Legumine product (G_p) required to treat 417.5 acre-feet of water at a target concentration of 1.4 ppm is deduced from the product label as follows:

$$G_p = 0.\overline{33} \times D_c \times V_e \quad (1)$$

where

$0.\overline{33}$	=	gallons of CFT Legumine product required to treat 1 acre-foot of water at 1.0 ppm (per product label; Appendix D1), and
D_c	=	desired target concentration (1.4 ppm) of CFT Legumine
V_e	=	estimated volume (417.5 acre-feet) for one half of Scout Lake

Therefore it follows that for a desired target concentration of 1.4 ppm for 417.5 acre-feet,

$G_p = 0.\overline{33} \times 1.4 \times 417.5 = 194$ gallons of CFT Legumine.

Prentox Prenfish Rotenone Fish Toxicant Powder Example

The following calculations are an example of the method used to determine the number of pounds of Prentox Prenfish Rotenone Fish Toxicant Powder (P_p) required to treat one half of Scout Lake (417.5 acre-feet) at a target concentration of 1.4 ppm:

$$P_p = 2.7027 \times D_c \times V_e \quad (2)$$

where

2.7027	=	pounds of Prentox Fish Toxicant Powder product required to treat 1 acre-foot of water at 1.0 ppm (per product label; Appendix D2), and
D_c	=	desired target concentration (1.4 ppm) of Prentox Fish Toxicant Powder
V_e	=	estimated volume (417.5 acre-feet) for one half of Scout Lake

Therefore it follows that for a desired target concentration of 1.4 ppm for 417.5 acre-feet,

$P_p = 2.7027 \times 1.4 \times 417.5 = 1{,}579.7$ pounds of Prentox Fish Toxicant Powder.

To compensate for the higher assayed rotenone concentration found printed on the container labels of the Prentox Prenfish Rotenone Fish Toxicant Powder (7.4%) than was printed on the product label directions (5%), an adjustment to the calculation was required. That is, the pounds of Prentox Fish Toxicant Powder required to treat 417.5 acre-feet at 1.4 ppm of product (1,579.7 pounds) was multiplied by a coefficient derived by dividing the actual assayed rotenone concentration on the container label (7.4%) by the rotenone concentration percentage used in product label directions (5%) as follows: 5 ÷ 7.4 = 0.676.

Therefore it follows that for a target concentration of 1.4 ppm,

$P_p = 1{,}579.7 \times 0.676 = 1{,}068$ pounds of Prentox Prenfish Rotenone Fish Toxicant Powder.

TREATMENT APPLICATION

Treatment Timing

The Scout Lake treatment was planned to occur just prior to freeze-up. Near freezing water temperature has been shown to slow the natural degradation of rotenone, sometimes prolonging rotenone persistence for months (Gilderhus et al. 1986; Finlayson et al. 2010). ADF&G treated Arc Lake (Kenai Peninsula) with rotenone just prior to freeze-up in 2008 and the lake remained toxic to fish until ice-out the following year (Massengill *In prep*). The treatment timing (mid-October) selected for Scout Lake ensured northern pike would be exposed to a lethal concentration of rotenone for as long as possible, thus increasing the likelihood of project success.

Treatment Partitioning

Volumes of discrete sections of Scout Lake, including volumes of each 10-foot depth stratum, were estimated for each lake section (Appendix E1) to promote a more even distribution of rotenone during the application. These volume estimates were used to calculate the amount of product (CFT Legumine or Prentox Prenfish Rotenone Fish Toxicant Powder) to apply to each section and depth stratum. Tethered buoys visibly defined each lake section during the treatment and additional buoys (of a different color) delineated the area within each section containing depths greater than 10 feet to assist boat applicators using weighted hoses targeting deeper areas.

Sentinel Fish

Caged juvenile coho salmon were placed in the lake immediately prior to the treatment and served as sentinel fish to monitor the effect of treatment in real time. These fish were suspended at 3 different depths that included the following: 1) near surface (~1 ft; 0.3 m), 2) midwater column (~7.5–10 ft; 2.3–3 m), and 3) near maximum depth (~15–20 feet; 4.5–6 m). Between 3 and 5 fish were placed in each cage. The fish were frequently monitored to determine the time of visible effect and mortality.

Liquid Rotenone Application

Both liquid and powdered rotenone formulations require premixing with water prior to application (Appendices D1 and D2). The liquid formulation was applied via outboard powered boats equipped with gas-powered semi-closed pumping apparatuses and by individuals with backpack sprayers. For boat applications, the liquid rotenone formulation was premixed with lake water within the pumping apparatus. The pumping apparatus consisted of a Honda trash pump with intake and discharge hoses. The intake hose pumped lake water from below the waterline near the boat transom. Mixing of lake water and the liquid rotenone occurred in the pump discharge line that eventually discharged the premixture below the waterline near the boat's bow. Mixing was accomplished by connecting an inline polypropylene venturi mixing siphon (Mazzei 885X injector) to the discharge hose of the pump. The mixing siphon creates a venturi vacuum as pressurized water is forced through the body of the device. A smaller diameter siphon line incorporated into the body of the mixing siphon draws liquid piscicide from a container (drum) and mixes it with lake water in a 1:10 ratio. Selection of the proper size mixing siphon to achieve a 1:10 pesticide to water premixture was critical and was accomplished by providing the specific application pump discharge rate and pressure to the mixing siphon manufacturer, who recommended an appropriate model mixing siphon.

An electronic depth finder (Garmin GPSMAP 440s FishFinder) was used by the boat applicators for applying both liquid and powdered rotenone formulations. Applicators could adjust boat speed and application rate throughout the treatment according to water depth readings. The depth finder display screen provided instant depth, boat speed, and path tracking, allowing the boat operator to detect gaps in rotenone coverage. Printed reference charts (Appendices F1 and F2) helped applicators adjust boat speed in relation to observed water depths to promote even distribution of both liquid and powdered rotenone products.

Backpack applicators spot-treated shallow marshy nearshore areas of the lake that were difficult to access by boat. Backpack applicators premixed rotenone with lake water in a 2:100 volume:volume ratio within the 4-gallon tank of each backpack sprayer.

Powdered Rotenone Application

Powdered rotenone was only applied via outboard-powered boats that were also equipped with gas-powered semi-closed pumping apparatuses similar to the liquid application boats. These pump systems also used Honda trash pumps with intake and discharge hoses. The discharge hose was equipped with an inline cast-iron chemical eductor (1.5-inch inside diameter made by Scot Pump and recommendation by Brad Koenen, fisheries technician with the Minnesota Department of Natural Resources). The eductor uses the venturi effect to siphon powdered or liquid chemicals into the discharge line. The mixing ratio of water and powdered rotenone was controlled by a vent valve in the siphon line, which decreased the vacuum as the valve was opened.

Scout Lake has a maximum depth of about 21 ft (6.4 m), so near-surface application alone was deemed insufficient to evenly distribute rotenone throughout the water column, particularly in areas greater than 10 ft (3 m) in depth (Grant Grisak, Fisheries Biologist, Montana Fish Wildlife and Parks, personal communication). For areas greater than 10 ft (3 m) in depth, both a near-surface boat application and a midwater column boat application (via a weighted discharge hose) were done to more evenly disperse rotenone throughout the water column.

Application and Cleanup Techniques

In each lake section, the lake perimeter was treated first with liquid rotenone formulation using a handheld spray nozzle. The lake perimeter was treated first to discourage fish from seeking refuge in shoreline seepages or vegetated bog edges and to encourage movement into open water. After the perimeter application, the piscicide was applied to the lake from boats by pumping both liquid and powdered rotenone formulations below the water surface and into the boat propeller wash (to aid in mixing) while driving the boat in increasingly smaller concentric circles toward the center of each lake section. Application swath widths did not exceed 30 feet, as suggested by Randall (2006).

After completing the rotenone application, all equipment was triple-rinsed with lake water and dried. All empty rotenone containers were triple-rinsed as they became available and stored at the boat launch. Boats and pumping systems were completely drained into the lake before final clean-up with soap and clean water using a pressure washer offsite.

ROTENONE SAMPLING

Water and sediment samples were collected before and shortly after rotenone treatment to verify rotenone concentration. Both water and sediment samples were collected periodically after the treatment until the rotenone had degraded to a concentration no longer toxic to fish after several days of exposure. The sampling schedule was dependent on the observed rate of rotenone degradation but was anticipated to be months between sampling events after the initial sampling on the treatment day.

Composite water samples were obtained by lowering a weighted, tethered container (1 gallon amber-colored glass jug) to the lake bottom in a deep area of the lake, remotely opening the container (with a pull string attached to a rubber stopper), and then slowly retrieving the container to the lake surface as the jug slowly filled with water and air concurrently bubbled out through the relatively small jug opening. This was repeated again from a second location (~100 meters apart from first sample). Half of each 1-gallon sample was combined to create a single 1-gallon composite sample. Sediment samples (50–70 ml each) were collected from 6 sites and were dug from the lake bottom along the northern shoreline using a hand shovel. Sediment samples were combined into a single composite sample and placed in an amber-colored 500 ml glass jar. Both water and sediment composite samples were labeled with the date and sample location and then placed in cold storage. The samples were shipped as soon as possible, with appropriate chain-of-custody paperwork, to the Washington State Department of Agriculture (WSDA) Chemical and Hop Lab located in Yakima, Washington for analysis.

RESULTS

WATER BODY PHYSICAL AND CHEMICAL CHARACTERIZATION

Mapping

A bathymetric map and volume estimate for Scout Lake was produced in summer 2009. Scout Lake was estimated to cover 85 surface acres and to have a volume of 835 acre-feet, a maximum depth of 21 feet, and a mean depth of 8.6 feet. A map depicting the lake divided into treatment partitions was also developed to assist the applicators during the treatment (Figure 5).

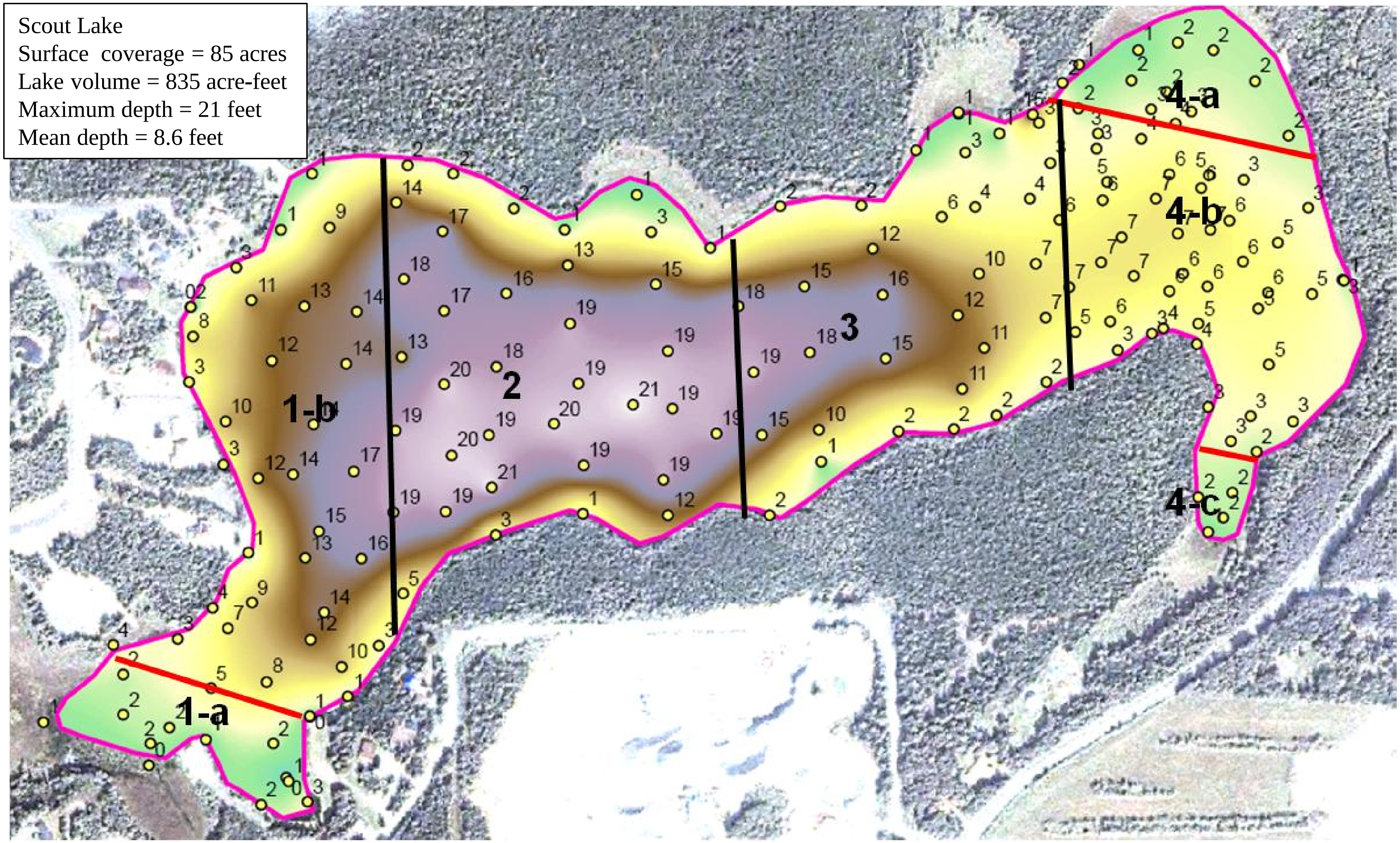

Figure 5.–Bathymetric map of Scout Lake showing partitions that correspond to the rotenone application requirements found in Appendix E1.

Note: yellow dots indicate depth sampling sites used for bathymetry mapping.

Water Quality

Pretreatment water quality sampling occurred monthly during the period of July 2006 through June 2007. Posttreatment water quality sampling occurred monthly during the period of November 2009 through October 2010.

Monthly water temperature, specific conductance, dissolved oxygen, and pH were similar before and after rotenone treatment (Figures 6–9, respectively), but there was a noticeable increase in water clarity during the spring in 2010 following rotenone treatment (Figure 10).

A single alkalinity sample was collected 2 ft (about 0.6 m) below the lake surface on 27 August 2009, and total alkalinity was measured as 12.6 mg/L $CaCo_3$.

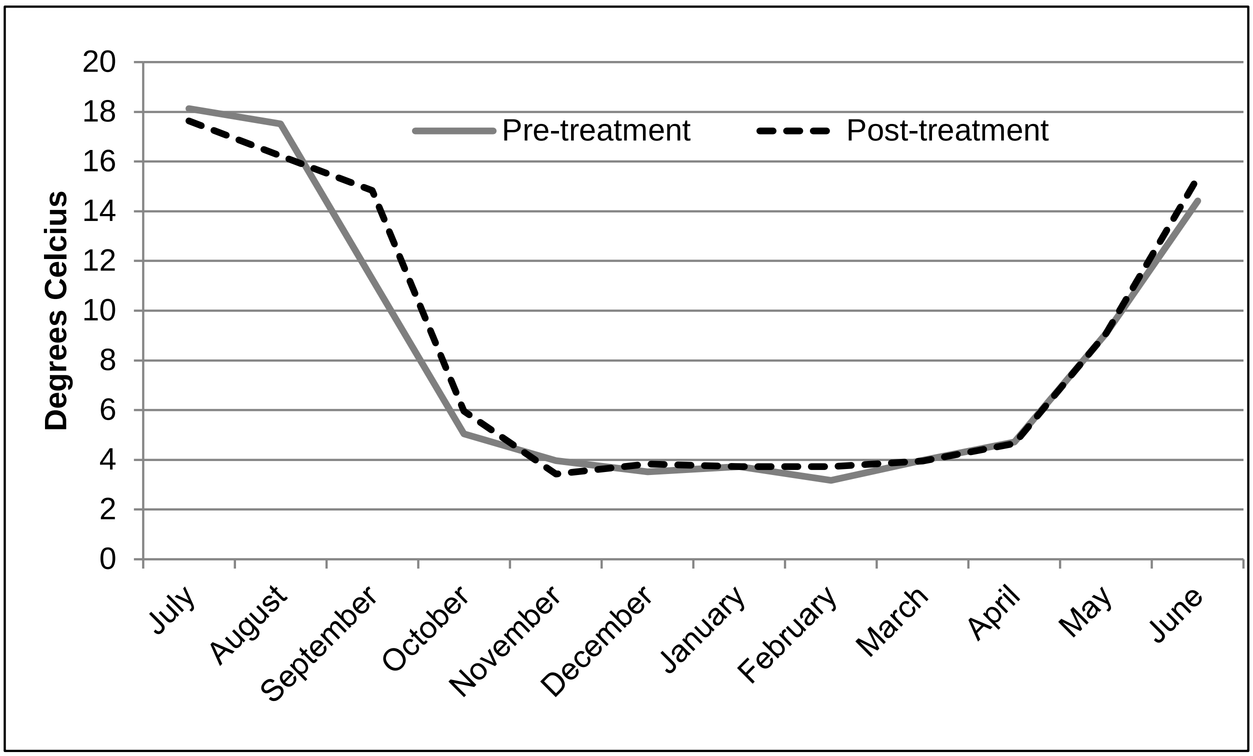

Figure 6.–Scout Lake average midmonth water temperature (Celsius) before rotenone treatment (July 2006–June 2007; solid line) and after (November 2009–October 2010; dotted line).

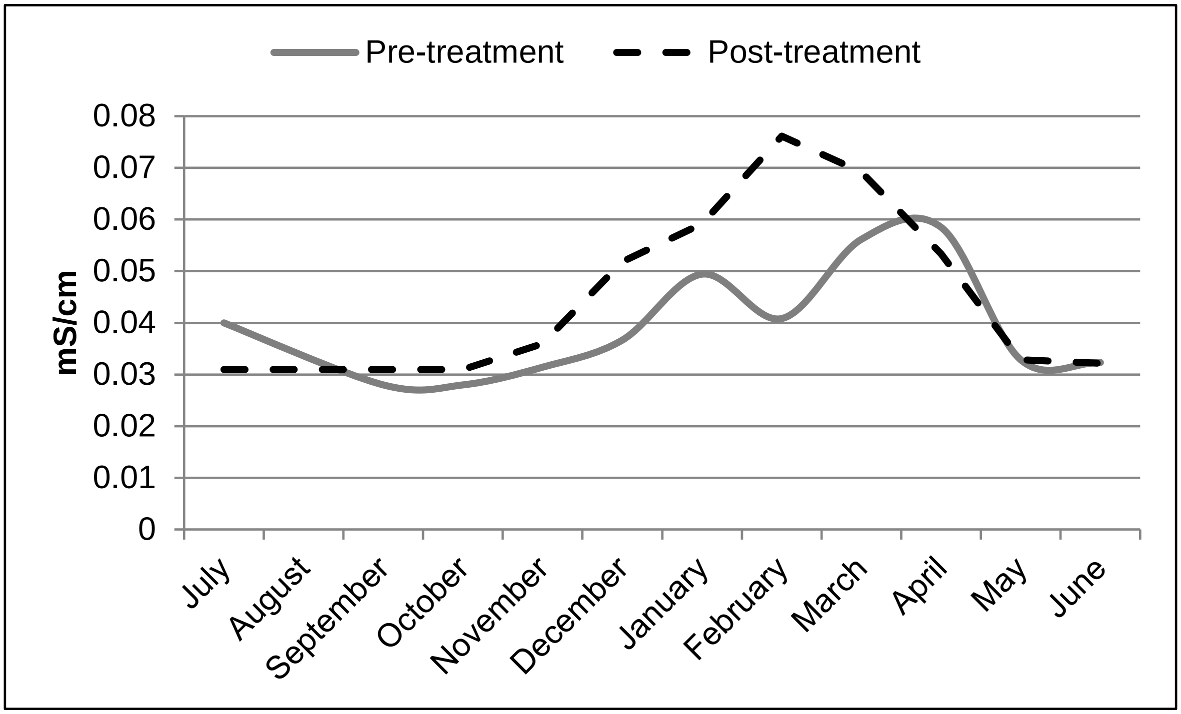

Figure 7.–Scout Lake average midmonth water specific conductance (mS/cm) before rotenone treatment (July 2006–June 2007; solid line) and after (November 2009–October 2010; dotted line).

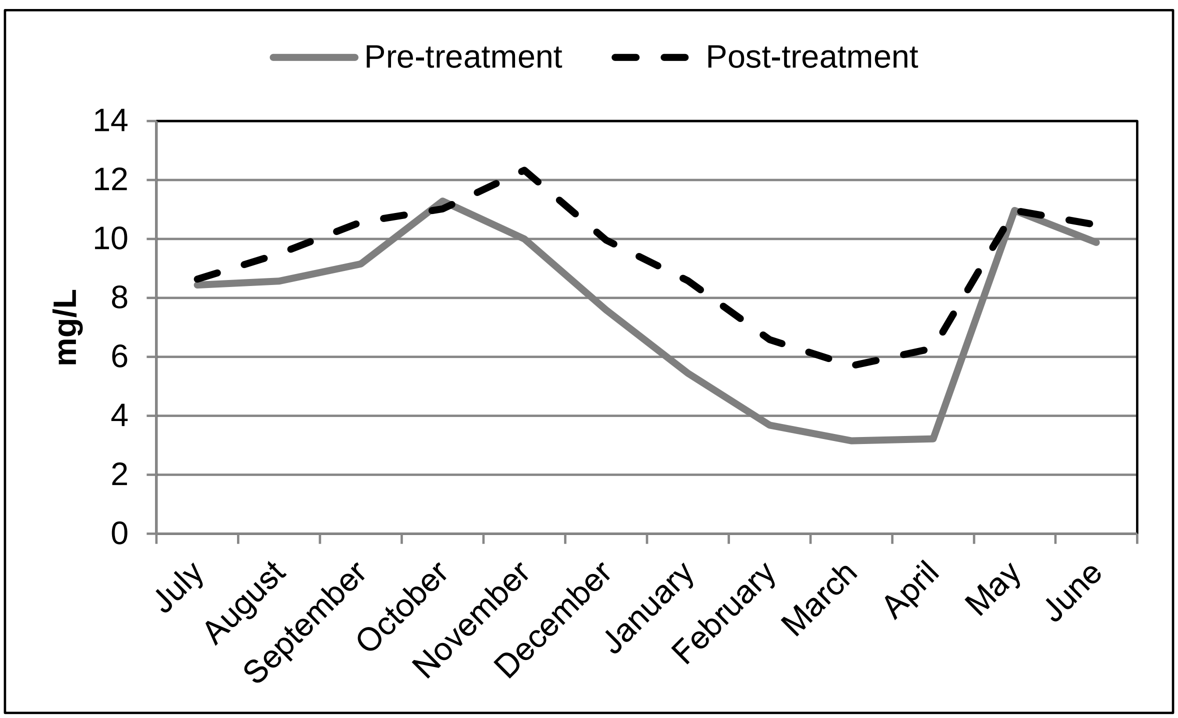

Figure 8.–Scout Lake average midmonth water dissolved oxygen concentration (mg/L) before rotenone treatment (July 2006–June 2007; solid line) and after (November 2009–October 2010; dotted line).

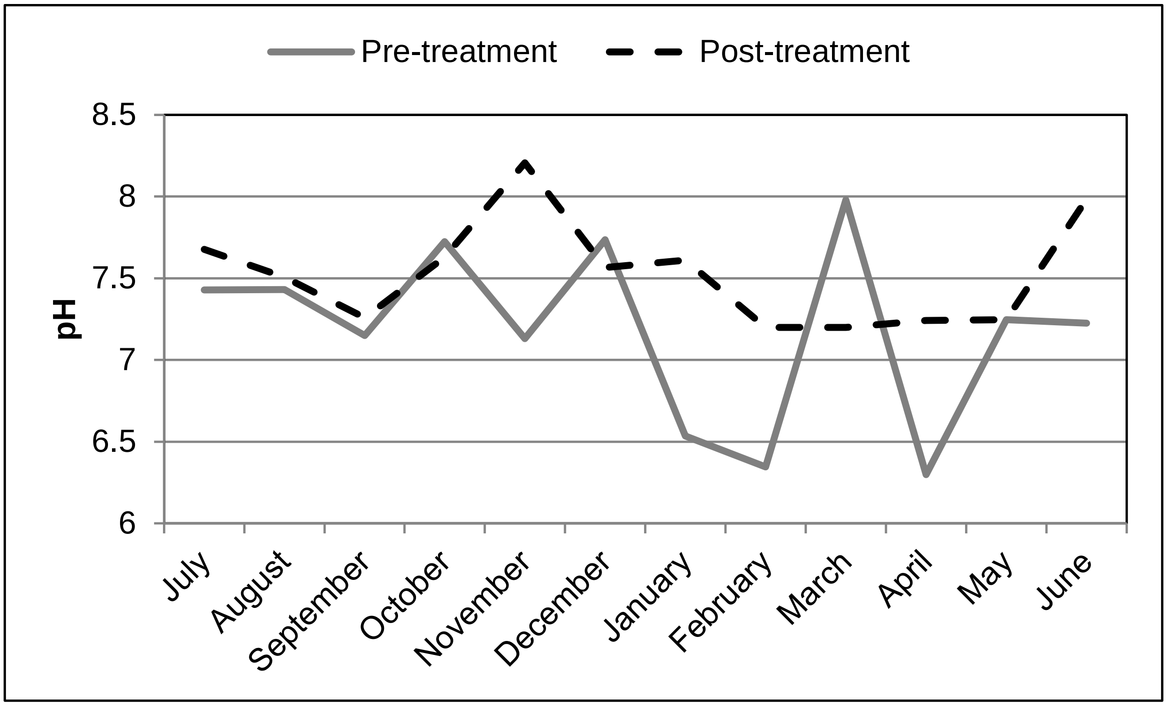

Figure 9.–Scout Lake average midmonth water pH before rotenone treatment (July 2006–June 2007; solid line) and after (November 2009–October 2010; dotted line).

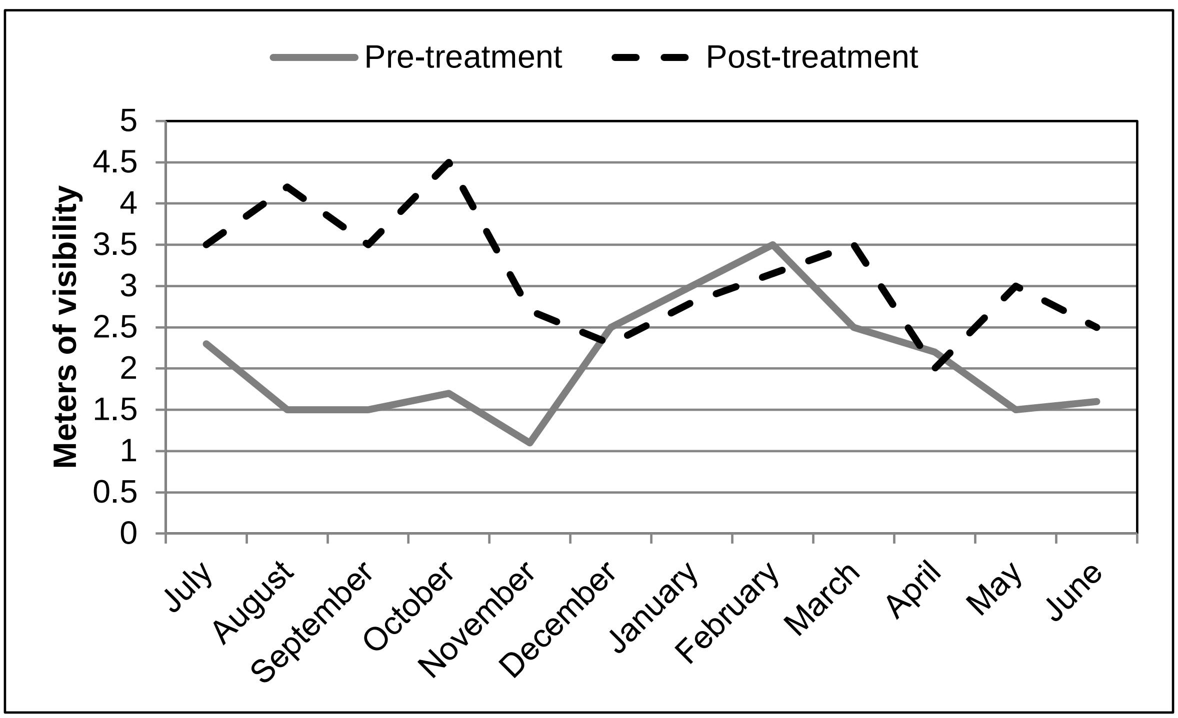

Figure 10.–Scout Lake average midmonth water turbidity before rotenone treatment (July 2006–June 2007; solid line) and after (November 2009–October 2010; dotted line).

BIOASSAYS

Bioassays were conducted in Scout Lake during the afternoon of 12 October 2009 to evaluate an appropriate overall MED for lake treatment. At the time of the bioassays, surface water temperature was 9.8°C, specific conductivity was 0.3 mS/cm, dissolved oxygen was 13.76 mg/l, and pH was 8.09.

For the powdered rotenone formulation bioassays, the minimum concentration that caused at least 50% mortality (2 of 4 fish) within 4 hours of exposure was the 0.20 ppm rotenone formulation concentration; 3 of 4 fish died after 4 hours of exposure. All fish died within 4 hours of exposure in the bioassays with higher rotenone formulation concentrations (i.e., 0.26 ppm, 0.50 ppm and 1.50 ppm). None of 4 fish died in the control bioassay.

We conducted the bioassays for the liquid formulation after the bioassays for the powdered formulation were completed. Liquid rotenone formulations are generally more effective because of additives that aid in dispersal of the rotenone, so based on the bioassay results for the powdered formulation, it was unnecessary to test the two highest concentrations (0.50 ppm and 1.50ppm). The bioassays for the liquid formulation tested the following concentrations: 0.0 ppm, 0.20 ppm and 0.26 ppm. For the liquid rotenone formulation bioassays, the minimum concentration that caused at least 50% mortality within 4 hours of exposure was 0.2 ppm. All 4 fish in each liquid formulation bioassay (0.20 ppm and 0.26 ppm) died within 2 hours; no fish died in the control.

For both rotenone formulations, the MED criterion was met using a bioassay rotenone formulation concentration of 0.20 ppm. The MED criterion is 5 times the concentration that kills at least half the fish after 4 hours of exposure (Brian Finlayson, retired California Department of Fish and Game, personal communication); thus, the overall MED for both formulations was 5 × 0.2 ppm = 1.0 ppm.

We decided to increase the overall target concentration above 1.0 ppm MED as a conservative measure to compensate for any error in underestimating lake volume and to help accommodate any effect the lake's high organic substrate may have in binding rotenone. The target concentration selected was 1.4 ppm (0.07 ppm active ingredient [rotenone]), which represents a 40% (0.4 ppm) increase over the MED and accounts for a difference similar to the 30% rotenone formulation concentration shortfall experienced during the rotenone treatment of Arc Lake in 2008. Arc Lake had a treatment target rotenone formulation concentration of 1.0 ppm, but only 0.70 ppm of rotenone formulation was achieved (Massengill *In prep*).

ROTENONE TREATMENT

Rotenone was applied to Scout Lake beginning 13 October and ending 14 October 2009. Based on the proportion of approximately 50% liquid to 50% powdered formulation and a target concentration of 1.4 ppm (0.07 ppm active ingredient [rotenone]), a total of 185 gallons of liquid rotenone formulation (CFT Legumine) and 1100 pounds of Prentox Prenfish Rotenone Fish Toxicant Powder was applied to the lake. Almost all of the rotenone was applied from outboard boats. A small amount of rotenone (less than 5 gallons) was applied with backpack sprayers targeting the western end of the lake, which contains a boggy shoreline and a small manmade pond linked to the lake by a short canal. The application on 13 October began around 1200 hours, and all 1,100 pounds of powder formulation and 180 of 185 gallons of liquid formulation was applied by 1830 hours. The entire application on 13 October, including equipment set-up and removal, took about 12.5 hours. During the treatment, the air temperature was about 4°C, wind was negligible, and skies were overcast with light ground fog and sprinkling present until early afternoon. The water temperature averaged 8.4ºC.

Just prior to initiating the treatment, caged sentinel fish (about 4 juvenile coho salmon per cage) were placed in predetermined locations in the lake, encompassing varying water depths and distances from the shore, to document the toxicity of the treatment. All sentinel fish died by the completion of the treatment on 13 October 2009 except those in waters greater than 15 feet in depth. All remaining fish died by the following morning, indicating rotenone was distributed throughout different lake depths.

On 14 October 2009, 2 ADF&G staff walked the perimeter of the lake to look for fish either alive or dead. At several nearshore weedy areas on both the western and eastern shores, small groups of sticklebacks (less than 20 per group) were observed alive; some fish were even observed burrowing into the lake substrate in an apparent effort to avoid rotenone. All locations where live sticklebacks were observed were also areas that had dense aquatic vegetation, which may have prevented rotenone mixing.

As a result of this observation and concerns that northern pike may also be surviving in the same vegetated areas, 5 of the 185 gallons of CFT Legumine applied by this project was sprayed along the lake perimeter in weedy and boggy shoreline locations 1 day following the primary treatment. Often, within 10 minutes after spraying, sticklebacks would emerge from the mud showing symptoms of rotenone impairment. After 14 October 2009, no live fish were observed in Scout Lake.

The surface of Scout Lake froze completely by 1 November 2009, 19 days following the completion of the treatment, and the lake remained ice-covered until 4 May 2010.

Fish Cleanup

About 40 dead northern pike were recovered between 13 and 14 October 2009, and an estimated 200 pounds (~90 kg) of dead sticklebacks were removed from the northwestern shoreline of the lake. Additional stickleback carcass removal occurred on 15–16 October 2009. What proved to be an effective method to collect dead sticklebacks was to rake them into piles along the shoreline and then shovel them into garbage bags. Another option was to rake them into the water where most would sink. For about 10 days posttreatment, the odor of decaying fish was present but not overwhelming. The fish odor greatly abated toward the end of October, when freezing temperatures were common. No complaints about odors were received by ADF&G although one lakeside landowner confided to staff, who were collecting dead fish, that the odor of fish was noticeable to their family.

ROTENONE SAMPLING

No rotenone was detected from the Scout Lake water sample collected just prior to the start of the rotenone application on 13 October 2009. The lake sediment sample collected just prior to the rotenone application contained a low concentration of rotenone (0.004 ppm).

Rotenone concentrations in water and sediment samples taken immediately after the treatment on 14 October 2008 were as follows: 0.031 ppm rotenone in water, 0.017 ppm rotenone in sediment. Periodic posttreatment sampling of lake water revealed a decreasing rotenone concentration steadily through winter but posttreatment sampling of lake sediment showed increasing rotenone concentration during this time until April 2010 (Figure 11). A sediment sample collected on 29 March 2010 contained 0.11 ppm rotenone, the highest of any water or sediment sample collected. The target rotenone concentration in lake water (0.07 ppm rotenone) was never realized.

The final water and sediment samples analyzed for Scout Lake were collected on 17 June 2010 and the rotenone concentration was 0.0006 ppm for water and 0.01 ppm for sediment. The final samples indicate that less than 1% of the target concentration of the active ingredient (0.07 ppm rotenone) remained in the water and about 15% of the target concentration remained in the sediment, where it was probably adsorbed by organics in the sediment and unable to affect fish.

In addition to using analytic chemistry methods to assess the degradation of rotenone over time in Scout Lake, caged juvenile coho salmon were regularly placed in Scout Lake at various depths during spring 2010 to help pinpoint when the lake was no longer toxic to fish. These test fish revealed the lake was toxic to juvenile coho salmon for at least a month after ice-out, which occurred sometime after 4 May 2010. It wasn't until 14 June 2010 that juvenile coho salmon began to consistently survive several days of exposure in Scout Lake, indicating detoxification was sufficient for restocking.

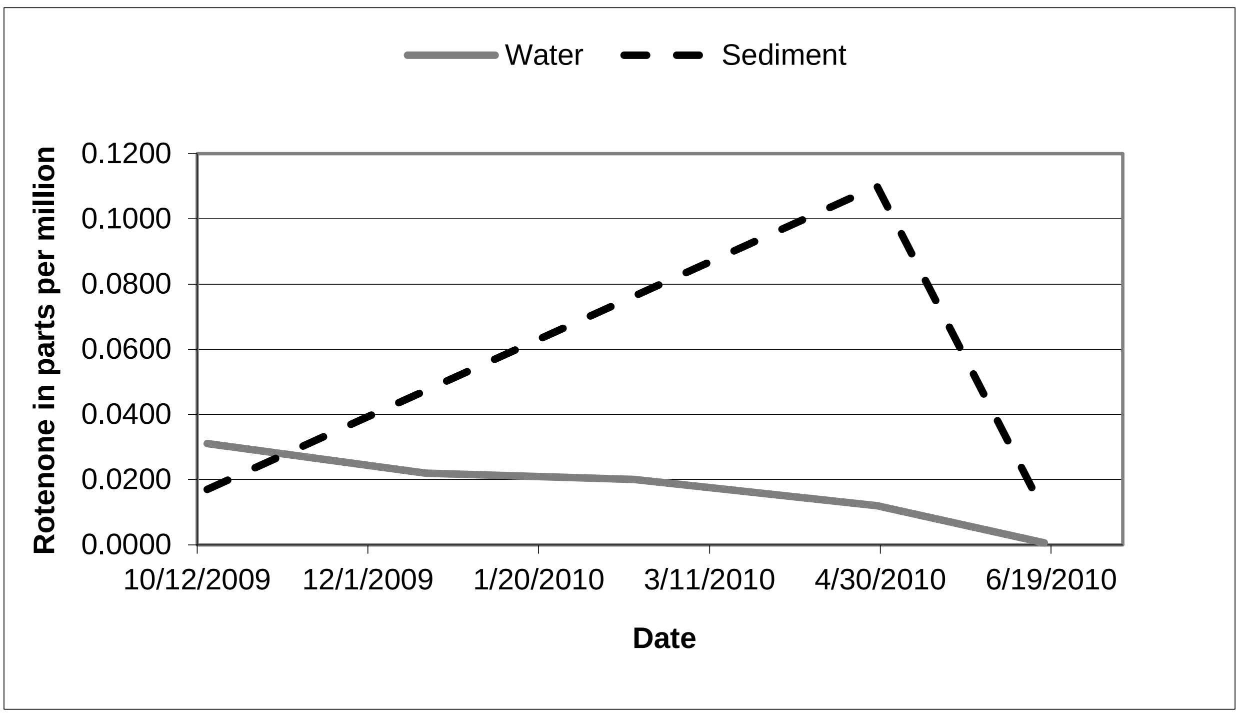

Figure 11.–Rotenone concentration (parts per million) over time in Scout Lake water (solid line) and sediment samples (dashed line).

BIOLOGICAL INVENTORY

Invertebrate Surveys

Macroinvertebrate and zooplankton surveys were conducted to determine whether forage species were present posttreatment for juvenile stocked fish and to assess whether drastic changes in composition in the invertebrate community had occurred in conjunction with the rotenone treatment.

A total of 18 different taxa were identified during the pretreatment sampling in 2009. Twenty different taxa were identified during the posttreatment sampling in 2010 (Table 1, Appendix G1). A total of 23 separate taxa were identified altogether. Three taxa were identified in pretreatment samples that were not found in posttreatment samples, and 5 taxa were identified in posttreatment samples that were not found in pretreatment samples.

Table 1.–Invertebrate taxa detected in Scout Lake before and after rotenone treatment.

Taxon	Detected before treatment	Detected after treatment
Acariformes (mites)	X	X
Amphipoda (scud)	X	X
Anispotera (dragonflies)	X	X
Araneae (spiders)	X	X
Asplanchna (rotifers)	X	X
Ceratopogonidea (no-seeums)		X
Chironomidae (non-biting midges)	X	X
Chrysomelidae (leaf beetles)		X
Cladocera (water fleas/daphnia)	X	X
Coleoptera (beetles)	X	X
Corixidae (water boatmen)		X
Diptera (flies), unknown adult	X	X
Dixidae (dixid midges)		X
Dysticidae (predacous diving beetles or whirligigs)	X	X
Eucopepoda (copepods)	X	X
Gastropoda (snails)	X	X
Hymenoptera (wasp/ant)	X	X
Hirudinea (leeches)[a]	X[b]	
Oligochaeta (earthworms)	X[b]	
Pelecypoda (molluscs)	X	X
Plecoptera (stone flies)		X
Trichoptera (caddis flies)	X[b]	
Zygoptera (damselflies)	X	X
Total taxa detected	18	20

Note: Taxon identification was resolved to at least the order level, often family level, except for the following: Nemotoda (phylum) and Oligochaeta, Hirudinea, Pelecypoda, and Gastropoda (class).

[a] Hirudinea specimens were identified dead immediately following the rotenone treatment, indicating their pretreatment live presence, but no live specimens were detected using sampling gear before or after treatment.

[b] Taxa only detected before the treatment.

Rotifers were common in the July posttreatment Wisconsin net samples but were not detected in July pretreatment collections. It is suspected that pretreatment zooplankton samples may have degraded during storage due to the dilution of the ethanol preservative with lake water resulting in decomposition and rendering samples difficult to identify. Temporary but drastic decreases in zooplankton abundance posttreatment were expected (Chlupach 1977; Finlayson et al. 2000; Ling 2003).

The presence of cladocerans, dipterans, and other terrestrial and aquatic insects in posttreatment samples suggested a wide range of invertebrate species were present by midsummer 2010 that could serve as forage for restocked hatchery-reared fish.

Interestingly, within a few days of rotenone treatment, numerous worms and leeches were found dead, particularly near the boggy shoreline on the east side of Scout Lake.

Fish Surveys

Pretreatment and posttreatment fish inventories were compared to assess the treatment's success at eradicating the northern pike population as well as the treatment's effect on other fish, if present.

The pretreatment fish inventory utilized between 22 and 29 gillnets daily during daylight hours between 5 and 7 August 2009 and resulted in a combined total of 401.4 hours of net soak effort (1 hour effort equals 1 net fished for 1 hour). The total pretreatment gillnet catch was 87 northern pike and no other fish species (Table 2). All northern pike were donated to the local food bank or used for educational purposes.

Table 2.–Scout Lake pretreatment gillnetting effort and catch, 5–7 August 2009.

Set date	Net number	Hours of fishing effort	Number of northern pike caught
5 Aug	1	6.2	3
5 Aug	2	6.3	2
5 Aug	3	6.1	0
5 Aug	4	5.9	1
5 Aug	5	6.0	1
5 Aug	6	6.0	2
5 Aug	7	6.0	3
5 Aug	8	6.0	4
5 Aug	9	6.0	2
5 Aug	10	6.0	1
5 Aug	11	6.0	2
5 Aug	12	6.1	3
5 Aug	13	6.1	1
5 Aug	14	6.1	3
5 Aug	15	6.2	2
5 Aug	16	4.4	2
5 Aug	17	4.5	1
5 Aug	18	6.0	2
5 Aug	19	6.1	0
5 Aug	20	6.1	1
5 Aug	21	6.0	0
5 Aug	22	6.0	5
5 Aug	23	5.8	1
5 Aug	24	5.6	2
5 Aug	25	5.6	3
5 Aug	26	5.5	1
5 Aug	27	5.5	2
5 Aug	28	5.5	1
5 Aug	29	3.6	1

-continued-

Table 2.–Part 2 of 2.

Set date	Net number	Hours of fishing effort	Number of northern pike caught
6 Aug	1	5.3	1
6 Aug	2	5.3	1
6 Aug	3	5.4	2
6 Aug	4	5.4	0
6 Aug	5	5.4	2
6 Aug	6	5.4	0
6 Aug	7	5.4	0
6 Aug	8	5.4	3
6 Aug	9	5.4	1
6 Aug	10	5.3	2
6 Aug	11	5.5	1
6 Aug	12	5.4	1
6 Aug	13	5.3	2
6 Aug	14	5.3	1
6 Aug	15	5.3	0
6 Aug	16	5.3	1
6 Aug	17	5.2	0
6 Aug	18	5.2	0
6 Aug	19	6.8	1
6 Aug	20	6.8	1
6 Aug	21	6.8	0
6 Aug	22	6.8	2
7 Aug	1	4.3	0
7 Aug	2	4.3	0
7 Aug	3	4.3	0
7 Aug	4	4.4	0
7 Aug	5	4.4	2
7 Aug	6	4.4	0
7 Aug	7	4.5	0
7 Aug	8	4.5	1
7 Aug	9	4.5	0
7 Aug	10	4.5	2
7 Aug	11	4.5	0
7 Aug	12	4.6	1
7 Aug	13	4.6	0
7 Aug	14	4.6	0
7 Aug	15	4.7	1
7 Aug	16	4.7	1
7 Aug	17	4.8	1
7 Aug	18	4.9	0
7 Aug	19	4.9	0
7 Aug	20	4.9	1
7 Aug	21	5.0	0
7 Aug	22	5.0	1
7 Aug	23	5.0	2
7 Aug	24	5.0	0
Total		401.4	87

[a] No fish other than northern pike were caught in the gillnetting effort.

The posttreatment evaluation used 20 gillnets that were continuously fished nonstop from the afternoon of 10 May through the afternoon of 14 May 2010. A combined total of 1,919 hours of netting effort was expended and no fish were caught (Table 3).

Table 3.–Scout Lake posttreatment gillnetting effort and catch, 10–14 May 2010.

Net number	Hours of fishing[a]	Number of northern pike[b]
1	98.0	0
2	97.8	0
3	97.6	0
4	97.4	0
5	97.2	0
6	96.9	0
7	96.7	0
8	96.4	0
9	96.2	0
10	96.0	0
11	95.8	0
12	95.6	0
13	95.4	0
14	95.3	0
15	95.1	0
16	94.9	0
17	94.7	0
18	94.5	0
19	93.9	0
20	93.9	0
Total	1,919.3	0.0

[a] Hours of effort reflect the total hours fished from the initial set date (10 May 2010) until the nets were pulled 4 days later.

[b] No fish of any species were caught in the gillnetting effort.

Based on the posttreatment netting results and associated probabilities of not detecting a small surviving population of northern pike (Appendices B1–B3), there is an estimated 27% probability that a surviving population of 4 individuals went undetected in Scout Lake.

Seventeen unbaited minnow traps were fished prior to rotenone treatment between 11 and 12 October 2009. The pretreatment minnow trapping expended 326.5 hours of effort, and 2,114 threespine sticklebacks were collected and no other fish species were caught (Table 4). All sticklebacks captured were euthanized, preserved in ethanol, and provided to researchers from the University of Alaska for use in comparative morphological studies.

Table 4.–Scout Lake pretreatment minnow trapping results, 2009.

Set Date	Set time	Pull date	Pull time	Minnow trap	Fish catch
11 Oct	16:30	12 Oct	9:13	16.7	185
11 Oct	16:30	12 Oct	9:26	16.9	54
11 Oct	16:32	12 Oct	9:32	17.0	81
11 Oct	16:33	12 Oct	9:39	17.1	37
11 Oct	16:33	12 Oct	9:47	17.2	108
11 Oct	16:36	12 Oct	9:56	17.3	167
11 Oct	16:37	12 Oct	10:05	17.5	232
11 Oct	16:42	12 Oct	10:19	17.6	170
11 Oct	16:42	12 Oct	10:29	17.8	177
11 Oct	16:45	12 Oct	10:36	17.9	149
11 Oct	16:50	12 Oct	14:30	21.7	15
11 Oct	16:50	12 Oct	14:32	21.7	188
11 Oct	16:53	12 Oct	14:45	21.9	101
11 Oct	16:53	12 Oct	14:50	21.9	117
11 Oct	16:56	12 Oct	14:56	22.0	109
11 Oct	16:56	12 Oct	15:03	22.1	72
11 Oct	17:00	12 Oct	15:08	22.1	152
			Total	326.5	2,114

Minnow traps baited with salmon eggs were fished posttreatment periodically between 5 May and 17 June 2010. A total of 438.33 hours of minnow trapping effort was expended and no fish were caught (Table 5).

Table 5.–Scout Lake posttreatment minnow trapping results, 2010.

Set date	Set time	Pull date	Pull time	Minnow trap effort	Fish catch
11 May	14:20	12 May	12:05	21.8	0
11 May	14:25	12 May	12:11	21.8	0
11 May	14:35	12 May	12:23	21.8	0
12 May	13:05	13 May	11:09	22.1	0
12 May	13:12	13 May	11:13	22.0	0
12 May	13:36	13 May	11:58	22.4	0
13 May	11:50	14 May	12:29	24.7	0
13 May	12:07	14 May	12:11	24.1	0
13 May	12:09	14 May	12:08	24.0	0
13 May	12:16	14 May	12:08	23.9	0
14 Jun	12:00	17 Jun	10:00	70.0	0
14 Jun	12:00	17 Jun	10:00	70.0	0
14 Jun	12:00	17 Jun	10:00	70.0	0
			Total	438.33	0

RESTOCKING

Area fish managers decided to deviate from the original plan to restock Scout Lake with coho salmon and instead stocked the lake with hatchery-raised rainbow trout (*Onchorhynchus mykiss*) and Arctic grayling (*Thymallus arcticus*).

Scout Lake was restocked on 18 August 2010 with 9,714 Arctic grayling that averaged 5.6 cm (2.2 inches) in length and 9,500 rainbow trout that averaged 4.6 cm (1.8 inches) in length.

DISCUSSION

The Scout Lake restoration effort was the second project designed by ADF&G to eradicate an invasive northern pike population from a Kenai Peninsula lake using rotenone. This project was much larger in scale than the previous rotenone project conducted at Arc Lake in fall 2008 and involved at least 9 staff working as applicators, loaders, safety attendants or public contacts.

ROTENONE CONCENTRATION

This restoration effort tried to attain a target concentration of 0.07 ppm active ingredient (rotenone) by treating Scout Lake with both liquid and powdered rotenone formulations. Subsequent water analysis documented a peak lake water concentration of rotenone at 0.03 ppm (44% of the target concentration).

Possible reasons that the target concentration was not realized may include the following:

1) errors occurred in estimating the amount of product needed or estimating the lake volume
2) product contained less active ingredient (rotenone) than product labeling indicated
3) errors occurred in water sampling or lab analysis
4) rotenone in the water samples degraded during shipping or handling
5) the rotenone mixed poorly in the lake
6) rotenone bound to sediment or organics in the lake

The amount of product needed was calculated from the product label (Appendices D1 and D2), and this calculation is an unlikely source for error. The lake volume was estimated twice using different techniques. The first Scout Lake volume estimate was done by ADF&G in 1965 and the surveyors estimated lake volume at 1,243 acre-feet, surface acreage of 95 acres, and mean depth of 13.1 feet. The 2009 survey estimated lake volume at 835 acre-feet, surface acreage of 85 acres, and mean depth of 8.6 feet. The differences between survey results align with local knowledge that many Kenai Peninsula lakes have receded since the 1960s. The two lake volume estimates are significantly different, but we opted to use the lowest value (835 acre-feet) generated more recently in 2009. The 2009 estimate is believed most accurate because the survey coverage was more thorough than in 1965, when depth measurements were manually collected along north-to-south and east-to-west transects rather than a more complete coverage using GPS, depth finder, and GIS tools. Furthermore, the 2009 methods are the same ones that have been used by ADF&G to estimate volume in other area lakes. In 2013, ADF&G's efforts to create new volume estimates used different equipment and methods available through ciBioBase, a subscription-based lake mapping service provided by Contour Innovations. The 2013 method greatly increased the number of depth records collected compared to 2009 methods, which should increase the accuracy of volume estimates. We compared volume estimates for area lakes where both mapping methods were used, and these showed little difference, suggesting our 2009 method was adequate to estimate volume. We believe any error in the 2009 Scout Lake volume estimate would have contributed insignificantly to the below-target rotenone concentration.

We did not confirm through independent lab analysis that the liquid rotenone product (CFT Legumine) contained at least 5% rotenone as stated on container labeling; however, we did confirm that the powdered product actually surpassed the assayed rotenone value of 7.4% listed on the containers. Laboratory analysis by WSDA in 2009 of the powdered rotenone formulation (Prentox Fish Toxicant Powder) indicated the rotenone concentration was 8.7%, after nearly a decade of storage.

All Scout Lake samples collected for laboratory analysis of rotenone concentration were composite samples that combined subsamples collected throughout the water column at 2 different locations or at 6 different sediment sampling sites. This sampling strategy was expected to provide an average rotenone concentration in the lake waters and sediments and to reduce the likelihood that the sampling was biased. However, it is conceivable that the rotenone in our water samples degraded significantly during shipping to the lab. Rotenone is susceptible to natural detoxification through a variety of mechanisms such as water chemistry, water temperature, organic load, and exposure to oxygen and sunlight (Loeb and Engstrom-Heg 1970; Engstrom-Heg 1972; Ware 2002; ODFW 2008[4]). The degradation rate of rotenone, which influences its effectiveness, is affected primarily by temperature and sunlight (Gilderhus et al. 1986). Care was taken to keep all samples refrigerated after collection and contained in amber-colored glass containers to prevent photolysis. Shipping of the samples typically took 2 days. Significant degradation during shipping appears to be an unlikely explanation for the observed low rotenone concentrations.

The peak rotenone concentration in Scout Lake water was detected immediately after the treatment was completed. A suggestion by Brain Finlayson (retired California Fish and Game, personal communication, 2010) for future rotenone projects is to collect water samples at a 1-meter depth the day following a treatment. It is possible that poor mixing biased the first posttreatment sampling and that allowing another day for rotenone dispersion to occur may help give a more accurate measure of rotenone concentration within the lake.

A low concentration of rotenone was detected in a Scout Lake sediment sample collected before the treatment. Detection of any rotenone in the lake water or sediment prior to treatment was unexpected. This detection probably resulted from contamination from the bioassays performed 1 day before the application at a shoreline location 100 yards from the sediment sampling site. After the bioassays were completed on 12 October 2009, all rotenone-treated water from the bioassay containers was dumped into the lake. Presumably, wave action dispersed some of this rotenone to the sediment sampling site.

The lower-than-expected rotenone concentration achieved in Scout Lake was similar to that experienced during the Arc Lake rotenone treatment in 2008 (Massengill *In prep*) and suggests something in the local lake environments may be responsible for the less-than-anticipated rotenone concentrations. Analyses of sediments following the 2009 treatment at Scout Lake, and also following the 2008 rotenone treatment of Arc Lake, indicate that rotenone concentration in

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[4] ODFW (Oregon Department of Fish and Wildlife). 2008. Rotenone: frequently asked questions. Oregon Department of Fish and Wildlife web page, Diamond Lake Home Page. http://www.dfw.state.or.us/fish/local_fisheries/diamond_lake/FAQs.asp (Accessed May 2014).

sediments in both lakes increased over time and peaked during the winter months. The ability of rotenone to adsorb to organics and retard its effectiveness is well documented in the literature (Dawson et al. 1991; Spitler 1970; Orn 1962 cited in Schnick 1974; Berry and Larkin 1954) and may explain why rotenone concentrations in both lakes were never achieved.

Scout Lake has very low alkalinity(12.6 mg/L $CaCo_3$), which is a variable that can promote the conversion of rotenone to rotenolone, a more durable metabolite of rotenone but only about one-tenth as toxic (Brian Finlayson, retired California Department of Fish and Game, personal communication, 2008). Rotenolone may have been present in Scout Lake in spring 2009 and contributed to the lengthy toxicity of the lake water, although we were unable to locate a laboratory capable of testing for rotenolone to confirm this.

Given these factors and provided the water sampling was accurate, it may be prudent to greatly increase the target rotenone concentration for future rotenone treatments of lakes with highly organic substrates. Although the target rotenone concentration in Scout Lake water (0.07 ppm rotenone) was never realized, evidence that the treatment was successful stems from the results of the caged sentinel fish placed in the lake during the rotenone treatment and again months later after ice-out during May 2010; in all cases, all sentinel fish died regardless of the location or depth at which they were placed. Furthermore, the collective evidence from all posttreatment netting and minnow trapping suggest no fish in Scout Lake survived the rotenone treatment.

INVERTEBRATE SAMPLING

Time constraints prevented a more thorough posttreatment aquatic invertebrate inventory, but posttreatment sampling was enough to determine that a wide range of forage prey species were available for stocked fish.

The pretreatment and posttreatment invertebrate sampling was intended to detect whether drastic reductions of invertebrate diversity occurred after rotenone exposure. It appears some invertebrates in Scout Lake may have suffered severe reductions in abundance from the treatment, particularly zooplankton such a cladocerns and copepods, which were less evident in posttreatment samples. Although some invertebrate species were detected only before treatment, their absence after treatment does not necessarily indicate that they were eradicated; in most cases, invertebrate species do not permanently disappear following a rotenone treatment (Bradbury 1986). We did not attempt to estimate the abundance of invertebrates; however, copepods and cladocerans were less prevalent in our collections than expected both before and after the rotenone treatment, particularly in the pretreatment Wisconsin net sampling, which we expected to be most effective for capturing these organisms.

In Southcentral Alaska, the effect of rotenone to aquatic invertebrate communities is typically temporary in nature and usually requires 1–3 years for posttreatment levels of zooplankton to be restored to pretreatment levels (Chlupach 1977). This is longer than reported in many other areas of North America where invertebrate recovery often takes a year or less (Kiser et al. 1963; Hamilton et al. 2009). Other studies show that zooplankton such as cladocerans and copepods have rotenone resistant eggs capable of reseeding a lake after a rotenone treatment (Bradbury 1986; Melaas et al. 2001). Fall applications may help zooplankton communities recover because many species are in rotenone-resistant life stages and there is time for population recovery before spring (Melaas et al. 2001).

In light of the relatively short-term effect that rotenone typically has on invertebrate populations, it may be reasonable to reduce or eliminate invertebrate sampling for future rotenone-based restoration projects because it can be assumed that invertebrates will recover within several years to reflect pretreatment composition and abundance.

APPLICATION AND SAFETY OBSERVATIONS

More than 6 hours were required to complete the boat application of rotenone at Scout Lake. The time required was limited by the pesticide siphoning rate of our pumping system. Testing of the pumping system beforehand revealed the maximum pumping rate was about 30 gallons of pesticide per hour (when using water as a surrogate for a liquid pesticide). At that rate, the entire application could have been completed in 3 hours, including stops for refueling and opening and rinsing the rotenone containers. However, the application took much longer because the pesticide was more viscous than water and siphoned at a rate slower than expected.

Ad hoc boat speed adjustments (mostly slowing down) were made during pesticide application to better disperse the pesticide, given the pesticide siphoning rate was slower than expected. To decrease the application time in future treatments, a larger pumping system is desired that could siphon liquid pesticide at a rate approaching 100 gallons per hour.

Fogging was a problem with the safety goggles the applicators wore during a previous application in 2008 at Arc Lake (Massengill *In prep*). During the Scout Lake rotenone application, some applicators wore full-face respirators with face shields, which proved to be more comfortable and had fewer fogging problems; these are recommended for future rotenone applications.

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APPENDIX A: DOCUMENTS FOR TREATMENT CLEARANCE

Appendix A1.–Scout Lake restoration project *Finding of No Significant Impact* determination by the United States Fish and Wildlife Service on 29 September 2009.

U.S. Department of the Interior
Fish and Wildlife Service
Region 7, Alaska

FINDING OF NO SIGNIFICANT IMPACT

Proposed Removal of Invasive Northern Pike *Esox lucius* from Scout Lake
Scout Lake, near Soldotna, Alaska

The Alaska Department of Fish and Game (ADF&G), Sport Fish Division, proposes the removal of an illegally introduced northern pike population using the piscicide rotenone in Scout Lake, five and a half miles east of the Soldotna, Alaska city limits. Planned activities include the complete eradication of northern pike from the lake and subsequent restocking with hatchery produced coho salmon and/or rainbow trout. It is anticipated the removal of northern pike from Scout Lake will lessen the risk that the population will expand through illegal introduction into nearby critically important systems like the Kenai River. The proposed actions will also restore a quality angling opportunity for the public in the area. The proposed project will be funded through the U.S. Fish and Wildlife Service under the Aquatic Nuisance Species Program, Wildlife and Sportfish Restoration Program and ADF&G. The Alaska Board of Fisheries supports the use of rotenone to eradicate non-indigenous northern pike in Scout Lake.

Alternatives Considered

Three alternatives were evaluated, including the use of gill nets and/or trap nets to selectively remove northern pike. However, the mechanical removal alternative was dismissed from further consideration as Scout Lake exceeds the surface area criteria necessary for success and due to the potential for exposing bald eagles, migratory birds, and aquatic mammals to the risk of net entanglement in the water. The "no action" alternative was also rejected since there would be continued risk that northern pike could be transported from Scout Lake to nearby wild fisheries.

Public Review

Three local ADF&G advisory committees on the Kenai Peninsula and other known stakeholders were notified in the winter of 2009. A public meeting, targeting property owners near Scout Lake, was held on April 30, 2009 in Sterling, Alaska, to share the Scout Lake restoration proposal. In addition, on June 30, 2009, ADF&G issued a press release announcing 30-day public comment periods for 1) the Environmental Assessment (EA) prepared by ADF&G, and 2) a proposed Alaska Department of Environmental Conservation (ADEC) Pesticide Use Permit for this project.

Public notices for the Scout Lake pesticide use permit application were printed in the Peninsula Clarion newspaper on two consecutive dates in June 2009, as part of the ADEC permitting process. A synopsis of the proposed project was also distributed to all landowners having

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property adjacent to Scout Lake during May, 2009. The EA was posted on the ADF&G internet site and copies were mailed to individuals upon request.

There were no formal comments submitted for the Scout Lake Restoration Project EA during the 30-day public comment period. However, during the public review process, and based on discussions with several university professors who share research and conservation interests in threespine sticklebacks in Southcentral Alaska, a question arose as to the potential effects to the Scout Lake threespine stickleback population from the proposed rotenone treatment.

ADF&G participated in discussions with several university professors who share research and conservation interests in threespine sticklebacks in Southcentral Alaska. As a result of the concerns raised about the potential for the native threespine stickleback population being eradicated along with the northern pike population, it was agreed that introducing anadromous threespine stickleback from Rabbit Creek Slough (Anchorage) would be a feasible restorative action. ADF&G and the researchers concur that there will be value in studying the evolutionary changes of anadromous sticklebacks introduced into another land-locked lake such as Scout Lake.

Conclusions

Study of the ecologic and socio-economic effects of the proposal has shown them not to represent a negative impact on the quality of the human environment. Further, no wetlands or other sensitive habitat will be affected by the work as proposed. Accordingly, I find that all reasonable alternatives were considered in the evaluation of this project. I also find that this project complies with the meaning of Executive Order 11990 and 11988. Therefore, based on a review and evaluation of the enclosed, environmental assessment, I have determined the proposed removal of invasive northern pike as described in the project entitled, "Scout Lake Restoration Project" is not a major federal action which would significantly affect the quality of the human environment within the meaning of Section 102 (2) (c) of the National Environmental Policy Act of 1969.

The Environmental Assessment, prepared by the Alaska Department of Fish and Game has been adopted by the U.S. Fish and Wildlife Service according to rules contained in 40 CFR 1506.3. Accordingly, preparation of an environmental impact statement on the proposed action is not required.

for [signature] 28 Sept 09

Geoffrey L. Haskett
Regional Director

Date

Appendix A2.–ADF&G public notice printed in the *Peninsula Clarion* announcing the public commenting period for the Alaska Department of Environmental Conservation (DEC) *Scout Lake Pesticide Use Application*.

NOTICE OF APPLICATION FOR PERMIT

TO APPLY PESTICIDES

The Alaska Department of Fish and Game (ADFG) has applied to the Alaska Department of Environmental Conservation (ADEC) for a permit to apply pesticide during October of 2009 to the waters of Scout Lake located approximately five and a half miles east of the Soldotna city limits and just south of the Sterling Highway.

The following project is proposed and is being reviewed by the appropriate regulatory agencies. ADEC requests comments from the public regarding the permit application. To be considered, written comments must be submitted to ADEC at the following address:

Kim Jordan, Administrative Assistant ADEC – Pesticide Program

555 Cordova Street

Anchorage, Alaska 99501

Phone: (907) 269-7581

Fax (907) 269-7600

Email: kim.jordan@alaska.gov

Written comments must be received on or before **July 30, 2009 (5:00pm).**

PROJECT NAME: Scout Lake Restoration Project.

PROJECT SUMMARY AND LOCATION: ADF&G proposes to apply a pesticide to the waters of Scout Lake during fall 2009 to eradicate an illegally introduced northern pike (*Esox lucius*) population. Northern pike are an invasive species in southcentral Alaska and the population in Scout Lake eliminated the stocked rainbow trout and coho salmon fisheries there. Scout Lake covers approximately eighty-five surface acres, contains approximately 835 acre-feet of water, and has no surface water inlets or outlets.

The pesticide products selected to treat Scout Lake are called CFT Legumine™ (EPA Registration No. 75338-2) and Prentox® Prenfish™ Fish Toxicant Powder (EPA Registration No. 655-691), both of which contain a naturally occurring plant derivative called rotenone that is toxic to fish. Rotenone has been used extensively across the country for fisheries work and naturally degrades with sunlight and warm temperatures. Pending bioassay results, it is anticipated the treatment concentration in the lake would be 1 to 1.3 parts per million of combined pesticide products. Application of the pesticide during late fall just prior to freeze-up would be expected to prolong the active life of the pesticide and increase the likelihood of

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successfully eradicating northern pike while limiting impacts to many other organisms. There is no known human health risks from waters treated with rotenone at the recommended treatment concentrations. Environmental impacts from this treatment are expected to be minimal.

PROJECT NEED: The presence of invasive northern pike in Scout Lake has eliminated a stocked lake fishing opportunity and provides a source of northern pike for illegal transplants elsewhere. Restoring Scout Lake by eradicating its northern pike population using a pesticide provides an opportunity for ADF&G to develop technical treatment knowledge useful for planning future restoration efforts of larger and more complex waterbodies with similar invasive northern pike populations.

PERMIT APPLICANT: Alaska Department of Fish and Game

APPLICANT ADDRESS: 43961 Kalifornsky Beach Road, Suite B, Soldotna, AK 99669

A copy of the application is available upon request. ADEC will hold a public hearing on the application if 50 or more residents in an affected area, or the governing body of an affected municipality, make a request within 30 days after first publication of this notice (June 29, 2009) to the ADEC office noted below.

Individuals with disabilities who may need auxiliary aids, services, or special modifications to participate in this review may contact the number above.

FOR SPECIFIC INFORMATION REGARDING THE APPLICATION CONTACT:

Department of Environmental Conservation
Pesticide Program,
1700 E. Bogard Rd. Suite 103B
Wasilla, AK 99654

Contact: Karin Hendrickson
Phone: (907) 376-1856
Fax: (907) 376-2383
Email: Karin.Hendrickson@alaska.gov

Appendix A3.–ADF&G news release issued on 30 June 2009 announcing the Scout Lake public commenting periods for the DEC *Pesticide Use Applications and Environmental Assessments*.

Region 2-Southcentral News Release

(Released: **June 30, 2009**)

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Back to Previous Page

NEWS RELEASE

ALASKA DEPARTMENT OF FISH AND GAME
Denby S. Lloyd, Commissioner

DIVISION OF SPORT FISH
Charles O. Swanton, Director

Contact:
Dan Bosch
Area Management Biologist
Phone: (907) 267-2153

June 30, 2009

PUBLIC INPUT SOUGHT FOR PLAN TO USE ROTENONE TO REMOVE INVASIVE NORTHERN PIKE

The Alaska Department of Fish and Game plans to use a naturally occurring pesticide to eradicate northern pike in two Southcentral lakes and is seeking public comment. ADF&G has prepared environmental assessment documents and applied for pesticide application permits for both lakes through the Alaska Department of Environmental Conservation. The public participation processes are now beginning for these projects. The environmental assessments can be viewed online at:

http://www.sf.adfg.state.ak.us/Static/invasive_species/PDFs/SandLakeEA.pdf
http://www.sf.adfg.state.ak.us/Static/invasive_species/PDFs/ScoutLakeEA.pdf

Written public comments on these projects will be accepted through July 30, 2009.

Northern pike are native to most of Alaska, but were illegally introduced to waters in Southcentral, south of the Alaska Range. Where northern pike are native, they are valuable sport and subsistence fish. Outside their native range, northern pike can cause tremendous ecological and economic damage. Pike deplete populations of salmon and trout in shallow, vegetated water bodies, and have severely affected local fisheries.

Sand Lake in Anchorage and Scout Lake near Sterling both contain populations of illegally-introduced northern pike. The pike are damaging fisheries in both lakes and have the potential to spread to other local waters where they could threaten other wild and stocked fisheries. ADF&G is currently proposing to treat Sand and Scout lakes with rotenone to remove pike from those lakes.

In recent years, ADF&G has addressed the pike issue in Southcentral Alaska by liberalizing bag limits and methods for harvesting pike, and in some instances, setting gill nets to reduce pike populations. These efforts will not permanently removed significant numbers of pike. In 2008, rotenone was used to eradicate illegally-introduced populations of invasive northern pike in Cheney Lake in Anchorage and Arc Lake in Soldotna. Both treatments were successful.

Appendix A4.–A copy of the DEC *Pesticide Use Permit for the Scout Lake Restoration Project*.

STATE OF ALASKA

SEAN PARNELL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION
DIVISION OF ENVIRONMENTAL HEALTH
PESTICIDES PROGRAM

555 Cordova Street
Anchorage, Alaska 99501
PHONE: (907) 269-7690
FAX: (907) 269-7600
http://www.dec.state.ak.us/

Certified Mail # 7007 2560 0001 6559 4591
Return Receipt Requested

August 3, 2009

Robert Massengill
Alaska Department of Fish and Game
43961 Kalifornsky Beach Road, Suite B
Soldotna, Alaska 99669

Subject: Permit to Apply Pesticides, # **09-AQU-01**

Dear Mr. Massengill:

The Department of Environmental Conservation (DEC) has completed its evaluation of your request for a permit for the application of the pesticide **CFT Legumine Fish Toxicant**, EPA Registration Number **75338-2** and **Prentox Rotenone Fish Toxicant Powder**, EPA Registration Number **655-691** to waters of the state to eradicate invasive Northern Pike in Scout Lake, 5½ miles east of Soldotna, Alaska. DEC is issuing the enclosed permit in accordance with Alaska Statute 46.03.330 and Title 18, Chapter 90.525 of the Alaska Administrative Code (18 AAC 90.525) for a period not to exceed two years.

Any person who disagrees with this decision may request an adjudicatory hearing in accordance with 18 AAC 15.195 - 18 AAC 15.340, or an informal review by the Division Director in accordance with 18 AAC 15.185. Informal review requests must be delivered to the Division Director, Alaska Department of Environmental Conservation, 555 Cordova Street, Anchorage, AK 99501 within 15 days of the permit decision. Adjudicatory hearing requests must be delivered to the Commissioner of the Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska 99801, within 30 days of the permit decision. In addition, please send a copy of the request to ADEC Pesticide Program, 1700 E. Bogard Road, Building B Suite 103, Wasilla, AK 99654. If a hearing is not requested within 30 days, the right to appeal is waived.

Sincerely,

Robert J. Blankenburg, P.E.
Solid Waste & Pesticides Program Manager

Appendix A5.–A copy of the *Coastal Management Program Consistency Review* determination for the Scout Lake Restoration Project.

STATE OF ALASKA

DEPT. OF ENVIRONMENTAL CONSERVATION
DIVISION OF ENVIRONMENTAL HEALTH
PESTICIDES PROGRAM

SARAH PALIN, GOVERNOR

1700 E. Bogard Rd. Bldg B. Ste 103
Wasilla, Alaska 99654
PHONE: (907) 376-1856
FAX: (907) 376-2382
http://www.dec.state.ak.us/

July 10, 2009

Robert Massengill
Fisheries Biologist
Alaska Department of Fish and Game
43961 Kalifornsky Beach Road, Suite B
Soldotna, Alaska 99669

Subject: Scout Lake Pesticide Permit Application

Dear Mr. Massengill:

The Department of Environmental Conservation (DEC) has determined that an Alaska Coastal Management Program (ACMP) consistency review of your project is not required. This determination is based on the Kenai Peninsula Borough coastal district's response that this project does not include activities that are subject to a district enforceable policy.

DEC will continue processing your application under DEC authorities and procedures. The affected coastal districts will have an opportunity to provide comments as part of the permitting process.

If you have any questions, please contact me at (907) 376-1856 or e-mail Karin.Hendrickson@alaska.gov.

Sincerely,

Karin Hendrickson
Environmental Program Specialist
Pesticides Permitting

cc: Gary Williams, KPB Coastal District Coordinator
Randy Bates, DNR, DCOM
Dan Easton, DEC, Deputy Commissioner

Appendix A6.–Fish transport permit issued by ADF&G on 20 September 2009 for the Scout Lake restoration project.

FISH TRANSPORT PERMIT

Applicant Robert Massengill	**Organization** ADF&G Sport Fish Div. Soldotna Office
Mailing Address 43961 K-Beach Road, Suite B Soldotna, AK 99669	**Phone** 907-262-9368 / **Species** coho salmon
Stock Origin/Original Donor Stock Kenai River	**Proposed Stocking Location** Scout Lake

Project summary- Summary statement of precisely what is being proposed.
This project is an effort to eradicate invasive northern pike from Scout Lake located just south of the Sterling Highway about five and one half miles east of the city limits of Soldotna. Plans are to eradicate the northern pike by treating the lake with a piscicide called rotenone. Before and during the treatment, test fish are needed for bioassays (assessing the appropriate concentration of rotenone to use) and for sentinel fish (to document if the rotenone worked and how long it remains toxic to fish). This project proposes to capture up to 150 coho salmon fingerlings from the Kenai River drainage using minnow traps, transport them to Scout Lake and place them in wire or plastic containers suspended in the lake at various depths. All fish will be destroyed following completion of their use. If the treatment is unsuccessful at eradicating northern pike, a repeat of the treatment, including the capture and use of more test fish (juvenile coho salmon), may be repeated up to two more times during the period of October 2009 and October 2010.

Permit #

For Department Use Only

__ **State Fish Transport Permit**		**FTP Number**	**09A-0070**	
Consistent with facility/project plans	**Yes**		**No**	
__ **Private Nonprofit Hatchery Fish Transport Permit**				
Consistent with PNP permit	**Yes**		**No**	
Requires Permit Alteration prior to review	**Yes**		**No**	
Continuation of project	**Yes**		**No**	
New Project	**Yes**		**No**	
__ **Other -**	**Yes**		**No**	
Status				
Forms Complete	**Yes**	**No**	**Date**	
Disease History Complete	**Yes**	**No**	**Date**	
In review process	**DATE** 6/19/09			
Returned to applicant	**DATE** 7/20/09			

5 AAC 41.005. PERMIT REQUIRED. (a) No person may transport, posses, export from the state, or release into the waters of the state, any live fish unless the person holds a fish transport permit issued by the Commissioner of his authorized designee. The Fish Transport Permit (FTP) is the single document, approved by the Commissioner of Alaska Department of Fish and Game (ADF&G), that allows for movements of fish and eggs on an interstate and intrastate basis.

-continued-

STAFF RECOMMENDATIONS

FTP PERMIT NO. 09A-0070

SIGNATURE PAGE

Comments

		Agree	Disagree	Date	Comments Provided	
					Yes	No
1.	Fish Health Services Pathologist - Division of Commercial Fisheries (CF) Signature Ted Meyers	X		6/19/09	X	
	Incomplete					
2.	Regional Resource Development Biologist - CF Bert Lewis	X		6/30/09	X	
3.	Regional Supervisor - CF Bert Lewis for Jeff Regnart	X		6/19/09		X
4.	Regional Supervisor - Division of Sport Fish Matt Miller for James Hasbrouck	X		6/22/09	X	
5.	Principal Geneticist - CF William Grant	X		7/13/09	X	
6.	Deputy Director - CF Sue Aspelund	X		7/7/09		X

		Approval	Disapproval	Date
7.	Commissioner [illegible]	✓		7/17/09

-

Appendix A7.–A copy of the Alaska Board of Fisheries approval of the Scout Lake restoration project (rotenone treatment) issued on 11 August 2009.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

BOARD OF FISHERIES

SEAN PARNELL, GOVERNOR

ADF&G
P.O . BOX 115526
JUNEAU, AK 998011-5526
PHONE: (907) 465-4110
FAX: (907) 465-6094

Charles O. Swanton
Division Director
ADF&G, Sport Fish
PO Box 115526
Juneau, AK 99811-5526

August 18, 2009

Dear Charles,

The Board of Fisheries received your August 11, 2009 letter asking for consent to use Rotenone to eradicate a non-indigenous Northern Pike population from Sand Lake in Anchorage and Scout Lake near Sterling as per Alaska Statute 16.35.200. The Board of Fisheries supports its use in this project. The board members were polled and there was no opposition.

Please contact Jim Marcotte, the board's Executive Director (465-6095) if you have any questions on this.

Regards,

John E. Jensen

John Jensen
Chairman, Alaska Board of Fisheries

cc: Board of Fisheries members
Kristine Dunker, ADF&G
Rob Massengill, ADF&G
James Hasbrouck, ADF&G
Rob Bentz, ADF&G

APPENDIX B: CALCULATING THE PROBABILITY OF DETECTING NORTHERN PIKE WITH GILLNETTING EFFORTS

Appendix B1.–Calculating the probability of failing to detect northern pike with gillnetting efforts.

Estimating the probability (D_p) of failing to detect a small abundance of northern pike (p) in a target lake of known surface acreage with a selected amount of gillnetting effort (net density and days of fishing) can be achieved as follows:

$$D_p = \hat{P}_f^{\,(T \times R)} \tag{E1}$$

where,

$\hat{P}_f$ = the estimated probability that none of p remaining fish are captured on the final day of netting at the reference lake with gillnet density f nets/surface acre,

T = number of days of gillnetting effort (24-hour day) at the target lake, and

R = relative net density at the target lake.

where,

$$R = \frac{N/A}{f} \tag{E2}$$

and

N = desired number of nets set in the target lake,

A = surface acreage of the target lake,

F = nets/acre used at the reference lake on final day of netting for that lake.

In order to calculate D_p for Scout Lake with p = 4 northern pike, we used an estimated catch rate for the final 24-hour day of a netting period intended to remove northern pike from Derks Lake. Northern pike were intensively removed from Derks and Sevena lakes (Figure 2) using gillnets during 2005–2007 (Appendix B2). Although the catch rate on the last day of netting at Derks Lake during fall 2007 was the lowest estimated, it was not used to estimate D_p because emigration of northern pike during the removal period was suspected. The second-lowest estimated capture rate was for Derks Lake in fall 2005. Emigration was not observed during the removal period, so the capture rate of 0.118 was used in estimating the probability of not detecting northern pike in Scout Lake (Appendices B2 and B3). In addition, this capture rate serves as a conservative surrogate to be used when estimating northern pike detection probabilities in other lakes with small abundances. The surrogate capture rate can be adjusted by the surface acreage of a particular lake and the number of gillnets and days fished when assuming the catchability of northern pike is proportional to the density of nets in the lake as well as the duration the nets are soaked.

The 0.118 capture rate can be viewed as the probability of capture per individual fish in a single 24-hour day of gillnetting effort where gillnet density (f) of the reference lake is equal to 0.364 nets/acre (Appendix B2). Therefore, the probability of an individual fish not being captured in the reference lake under those conditions is equal to 1 − 0.118 = 0.882. The probability of not capturing any of 4 fish remaining in the target lake is $\hat{P}_f = (0.88)^4 = 0.605$. Probabilities of failing to detect northern pike in Scout Lake with 20 gillnets and with a remaining abundance of 4 fish under different levels of netting effort (days) are presented in Appendix B3.

Appendix B2.–Historical net effort and catch-and-removal population estimates for Derks and Sevena lakes during the years 2005–2007.

	2005				2006				2007			
	Sevena Lake		Derks Lake		Sevena Lake		Derks Lake		Sevena Lake		Dirks Lake	
Attributes	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Nets fished per day	12	12	12	12	12	12	12	12	24	n/a	24	24
Net density (nets/surface acres)	0.166	0.166	0.364	0.364	0.166	0.166	0.364	0.364	0.332	n/a	0.729	0.729
Catch on last day	5	27	6	15	7	3	1	12	2	n/a	10	32
Total seasonal catch	643	1403	143	312	344	38	74	276	10	n/a	80	469
Population estimate	653	1425	149	424	352	44	74	352	10	n/a	86	978
Estimated population size at start of last day	15	49	12	127	15	9	1	88	2	n/a	16	541
Capture rate on last day	0.333	0.551	0.500	0.118	0.467	0.333	1.000	0.136	1.000	n/a	0.625	0.059
Percent of available population caught per net on last day	0.028	0.046	0.042	0.010	0.039	0.028	0.083	0.011	0.042	n/a	0.026	0.002

Note: Sevena Lake is 72.23 surface acres; Derks Lake is 32.94 surface acres.

Appendix B3.–Probabilities of not detecting 4 northern pike in Scout Lake using 20 gillnets and a $\hat{P}_f$ value of 0.605 are listed for a given number of days of effort.

	T (days of effort)									
	1	2	3	4	5	6	7	8	9	10
Probability (D_p)	0.7228	0.5224	0.3775	0.2729	0.1972	0.1425	0.1030	0.0745	0.0538	0.0389

Note: Scout Lake is 85 surface acres.

Note: Probability calculated using the following parameters: surface acres = 85, number of nets = 20, nets/acre = 0.2353, R (relative net density) = 0.6459.

APPENDIX C: AMOUNTS OF PRODUCT PREMIXTURE REQUIRED TO ATTAIN DESIRED TARGET ROTENONE PRODUCT CONCENTRATIONS IN VARIOUS BIOASSAY CONTAINER VOLUMES

Appendix C1.–Milliliters of (liquid) CFT Legumine premixture required to attain desired target rotenone product concentrations in various bioassay container volumes.

	Premix (ml) for bioassay container volume [b]			
Target concentration (ppm)[a]	1 liter	10 liter	1 gallon (3.8 l)	10 gallon (37.9 l)
0.05	0.0006	0.006	0.002	0.02
0.10	0.0011	0.011	0.004	0.04
0.20	0.0023	0.023	0.009	0.09
0.50	0.0056	0.056	0.021	0.21
1.00	0.0113	0.113	0.043	0.43
1.50	0.0169	0.169	0.064	0.64
2.00	0.0225	0.225	0.085	0.85
3.00	0.0338	0.338	0.128	1.28
4.00	0.0450	0.450	0.170	1.70

[a] Target concentration refers to the amount of total product (CFT Legumine) and not the active ingredient in parts per million.

[b] Premix solution consists of 10 parts water to 1 part product.

Appendix C2.–Milliliters of Prentox Prenfish Rotenone Fish Toxicant Powder premixture required to attain a desired target rotenone product concentration in various bioassay container volumes.

Target concentration in ppm [a]	Premix (ml) for bioassay container volume [b]			
	1 liter	10 liter	1 gallon (3.8 l)	10 gallon (37.9 l)
0.10	0.067	0.672	0.254	2.542
0.20	0.134	1.343	0.508	5.084
0.50	0.336	3.358	1.271	12.710
1.00	0.672	6.715	2.542	25.420
1.50	1.007	10.073	3.813	38.131
2.00	1.343	13.431	5.084	50.841
3.00	2.015	20.146	7.626	76.261
4.00	2.686	26.861	10.168	101.682

[a] Target concentration refers to the amount of total product (Prentox Prenfish Fish Toxicant Powder) and not the active ingredient in parts per million.

[b] Premix solution consists of 1 gram of powder per 1 liter of water.

APPENDIX D: PRODUCT SPECIMEN LABELS

Appendix D1.–CFT Legumine specimen label.

RESTRICTED USE PESTICIDE
Due to aquatic toxicity
For retail sale to, and use only by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

CFT Legumine™

Fish Toxicant

For Control of Fish in Lakes, Ponds, Reservoirs, and Streams

ACTIVE INGREDIENTS:

Rotenone .... 5.0% w/w
Other Associated Resins 5.0%
OTHER INGREDIENTS[1] 90.0%
Total 100.0%

[1] Contains Petroleum Distillates

CFT Legumine is a trademark of CWE Properties Ltd., LLC

KEEP OUT OF REACH OF CHILDREN
WARNING

FIRST AID	
Have product container or label with you when obtaining treatment advice.	
If swallowed	• Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. • Do not give any liquid to the person. · Do not anything to an unconscious person • Do not induce vomiting unless told to do so by the poison control center or doctor.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If inhaled	• Move person to fresh air. • If person is not breathing, call an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a physician, Poison Control Center, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice.
Note to Physician: Contains Petroleum Distillates. Vomiting may cause aspiration pneumonia. For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.	

EPA Reg. No. 75338-2 EPA Est. No. 655-GA-1
Manufactured for CWE Properties Ltd., LLC, P.O. Box 336277, Greeley CO 80633

-continued-

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
WARNING

May be fatal if inhaled or swallowed. Causes moderate eye irritation. Harmful if absorbed through skin. Do not breathe spray mist. Do not get in eyes, on skin, or on clothing. Wear goggles or safety glasses.

When handling undiluted product, wear either a respirator with an organic-vapor-removing cartridge with a prefilter approved for pesticides (MSHA/NIOSH approval number prefix TC-23C), or a canister approved for pesticides (MSHA/NIOSH approval number prefix 14G), or a NIOSH approved respirator with an organic vapor (OV) cartridge or canister with any R, P, or HE prefilter.

Wash thoroughly with soap and water after handling and before eating, drinking, or using tobacco. Remove contaminated clothing and wash before reuse. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

CHEMICAL AND PHYSICAL HAZARDS

FLAMMABLE: KEEP AWAY FROM HEAT AND OPEN FLAME. FLASH POINT MINIMUM 45°F (7°C).

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store only in original containers, in a dry place inaccessible to children and pets. This product will not solidify nor show any separation at temperatures down to 40°F and is stable for a minimum of one year when stored in sealed drums at 70°F.

PESTICIDE DISPOSAL: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your state pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse or equivalent. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

CFT Legumine is registered for use by or under permit from, and after consultation with State and Federal Fish and Wildlife Agencies.

GENERAL INFORMATION

This product is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, ponds, reservoirs and streams.

-continued-

Since such factors as pH, temperature, depth and turbidity will change effectiveness, use this product only at locations, rates, and times authorized and approved by appropriate State and Federal Fish and Wildlife Agencies. Rates must be within the range specified on the label.

Properly dispose of unused product. Do not use dead fish for food or feed.

Do not use water treated with rotenone to irrigate crops or release within ½ mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir.

Re-entry Statement: Do not allow swimming in rotenone-treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to labeling instructions.

FOR USE IN PONDS, LAKES, AND RESERVOIRS

The actual application rates and concentrations of rotenone needed to control fish will vary widely, depending on the type of use (e.g., selective treatment, normal pond use, etc.) and the factors listed above. The table below is a general guide for the proper rates and concentrations.

This product disperses readily in water both laterally and vertically, and will penetrate below the thermocline in thermally stratified bodies of water.

Computation of Acre-Feet: An acre-foot is a unit of volume of a body of water having the area of one acre and the depth of one foot. To determine acre-feet in a given body of water, make a series of transects across the body of water taking depths with a measured pole or weighted line. Add the soundings and divide by the number made to determine the average depth. Multiply this average depth by the total surface area in order to determine the acre-feet to be treated. If number of surface acres is unknown, contact your local Soil Conservation Service, which can determine this from aerial photographs.

Amount of CFT Legumine Needed for Specific Uses: To determine the approximate number of gallons needed, find your "Type of Use" in the first column of the table below and then divide the corresponding numbers in the fourth column, "Number of Acre-Feet Covered by One Gallon" into the number of acre-feet in your body of water.

Type of Use	Parts per Million		Number of Acre-Feet Covered by One Gallon
	CFT Legumine	Active Rotenone	
Selective Treatment	0.10 to 0.13	0.005 to 0.007	30 to 24
Normal Pond Use	0.5 to 1.0	0.025 to 0.050	6.0 to 3.0
Remove Bullheads or Carp	1.0 to 2.0	0.050 to 0.100	3.0 to 1.5
Remove Bullheads or Carp in Rich Organic Ponds	2.0 to 4.0	0.100	1.5 to 0.75
Preimpoundment Treatment Above Dam	3.0 to 5.0	0.150 to 0.250	1.0 to 0.60

*Adapted from Kinney, Edward. 1965. Rotenone in Fish Pond Management. USDI Washington, DC Leaflet FL-576

Pre-Mixing and Method of Application: Pre-mix with water at a rate of one gallon of CFT Legumine to 10 gallons of water. Uniformly apply over water surface or bubble through underwater lines.

-continued-

Detoxification: Water treated with this product will detoxify under natural conditions within one week to one month depending upon temperatures, alkalinity, etc. Rapid detoxification can be accomplished by adding chlorine or potassium permanganate to the water at the same rate as CFT Legumine in parts per million, plus enough additional to meet the chlorine demand of the untreated water.

Removal of Taste and Odor: Waters treated with this product do not retain a detectable taste or odor for more than a few days to a maximum of one month. Taste and odor can be removed immediately by treatment with activated charcoal at a rate of 30 ppm for each 1 ppm of CFT Legumine remaining. (Note: As this product detoxifies, less charcoal is required.)

Restocking After Treatment: Wait 2 to 4 weeks after treatment. Place a sample of fish to be stocked in wire cages in the coolest part of the treated waters. If the fish are not killed within 24 hours, the water may be restocked.

USE IN STREAMS IMMEDIATELY ABOVE LAKES, PONDS, AND RESERVOIRS

The purpose of treating streams immediately above lakes, ponds and reservoirs is to improve the effectiveness of lake, pond and reservoir treatments by preventing target fish from moving into the stream corridors, and not to control fish in streams per se. The term "immediately" means the first available site above the lake, pond or reservoir where treatment is practical, while still creating a sufficient barrier to prevent migration of target fish into the stream corridor.

In order to completely clear a fresh water aquatic habitat of target fish, the entire system above or between fish barriers must be treated. See the use directions for streams and rivers on this label for proper application instructions.

In order to treat a stream immediately above a lake, pond or reservoir you must: (a) Select the concentration of active rotenone, (b) Compute the flow rate of the stream, (c) Calculate the application rate, (d) Select an exposure time, (e) Estimate the amount of product needed, (f) Follow the method of application.

To prevent movement of fish from the pond, lake, or reservoir, the stream treatment should begin before and continue throughout treatment of the pond, lake or reservoir until mixing has occurred.

1. Concentration of Active Rotenone

Select the concentration of active rotenone based on the type of use from those listed on the table. Example: If you select "normal pond use" you could select a concentration of 0.025 parts per million.

2. Computation of Flow Rate for Stream

Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles. Divide the surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. In slowly moving streams, determine the velocity by dropping a float attached to 5 feet of loose monofilament fishing line. Measure the time required for the float to move 5 feet. For fast-moving streams, use a longer distance. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{Ws \times D \times L \times C}{T}$$

Where F = flow rate (cubic feet/second), Ws = surface width (feet), D = mean depth (feet), L = mean distance traveled by float (feet), C = constant (0.8 for rough bottoms and 0.9 for smooth bottoms), T = mean time for float (sec.).

4

-continued-

3. Calculation of Application Rate
In order to calculate the application rate (expressed as gallons/second), convert the rate in the table (expressed as gallons/acre-feet) to gallons per cubic feet and multiply by the flow rate (expressed as cubic feet/second). Depending on the size of the stream and the type of equipment, the rate could be expressed in other units, such as ounces/hour, or cc/minute.
The application rate for the stream is calculated as follows:

$$R_s = R_p \times C \times F$$

Where R_s = application rate for stream (gallons/second), R_p = application rate for pond (gallons/acre-feet), C = 1 acre-foot/43560 cubic feet and F = flow rate of the stream (cubic feet/second).

4. Exposure Time
The exposure time would be the period of time (expressed in hours or minutes) during which CFT Legumine is applied to the stream in order to prevent target fish from escaping from the pond into the stream corridor.

5. Amount of Product
Calculate the amount of product for a stream by multiplying the application rate for streams by the exposure time.

$$A = R_s \times H$$

Where A = the amount of product for the stream application, R_s = application rate for stream (gallons/second) and H = the exposure time expressed in seconds.

FOR USE IN STREAMS AND RIVERS
Only state or Federal Fish and Wildlife personnel or professional fisheries biologists under the authorization of state or Federal Fish and Wildlife agencies are permitted to make applications of CFT Legumine for control of fish in streams and rivers. Informal consultation with Fish and Wildlife personnel regarding the potential occurrence of endangered species in areas to be treated should take place. Applicators must reference the Stream and River use Monograph before making any application to streams or rivers.

CFT LEGUMINE STREAM AND RIVER USE MONOGRAPH

USE IN STREAMS AND RIVERS
The following use directions are to provide guidance on how to make applications of CFT Legumine to streams and rivers. The unique nature of every application site could require minor adjustments to the method and rate of application. Should these unique conditions require major deviation from the use directions, a Special Local Need 24(c) registration should be obtained from the state.
Before applications of CFT Legumine can be made to streams and rivers, authorization must be obtained from state or federal Fish and Wildlife agencies. Since local environmental conditions will vary, consult with the state Fish and Wildlife agency to ensure the method and rate of application are appropriate for that site.
Contact the local water department to determine if any water intakes are within one mile downstream of the section of stream, river, or canal to be treated. If so, coordinate the application with the water department to make sure the intakes are closed during treatment and detoxification.

Application Rates and Concentration of Rotenone
Slow Moving Rivers: In slow moving rivers and streams with little or no water exchange, use instructions for ponds, lakes and reservoirs.
Flowing Streams and Rivers: Apply rotenone as a drip for 4 to 8 hours to the flowing portion of the stream. Multiple application sites are used along the length of the treated stream, spaced

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approximately ½ to 2 miles apart depending on the water flow travel time between sites. Multiple sites are used because rotenone is diluted and detoxified with distance. Application sites are spaced at no more than 2 hours or at no less than 1-hour travel time intervals. This assures that the treated stream remains lethal to fish for a minimum of 2 hours. A non-toxic dye such as Rhodamine-WTR or fluorescein can be used to determine travel times. Cages containing live fish placed immediately upstream of the downstream application sites can be used as sentinels to assure that lethal conditions exist between sites.

Apply rotenone at each application site at a concentration of 0.25 to 1.0 part per million of CFT Legumine. The amount of CFT Legumine needed at each site is dependent on stream flow (see Computation of Flow Rate for Stream).

Application of Undiluted Material

CFT Legumine can drain directly into the center of the stream at a rate 0.85 to 3.4 cc per minute for each cubic foot per second of stream flow. Flow of undiluted CFT Legumine into the stream should be checked at least hourly. This is equivalent to from 0.5 to 2.0 ppm of this product, or from 0.025 to 0.100 ppm rotenone. Backwater, stagnant, and spring areas of streams should be sprayed by hand with a 10% v/v solution of CFT Legumine in water to assure a complete coverage.

Calculation of Application Rate:

$$X = F\ (1.699\ B)$$

X = cc per minute of CFT Legumine applied to the stream, F = the flow rate (cu.ft/sec.) see Computation of Flow Rate for Stream section of the label, B = parts per million desired concentration of CFT Legumine

Total Amount of Product Needed for Treatment: Streams should be treated for 4 to 8 hours in order to clear the treated section of stream of fish. To determine the total amount of CFT Legumine required, use the following equation:

$$Y = X\ (0.0158\ C)$$

Y = gallons of CFT Legumine required for the stream treatment, X = cc per minute of CFT Legumine applied to the stream, C = time in hours of the stream treatment.

Application of Diluted Material

Alternatively, for stream flows up to 25 cubic feet per second, continuous drip of diluted CFT Legumine at 80 cc per minute can be used. Flow of diluted CFT Legumine into the stream should be checked at least hourly. Use a 5 gallon reservoir over a 4 hour period, a 7.5 gallon reservoir over a 6 hour period, or a 10 gallon reservoir over an 8 hour period. The volume of the reservoir can be determined from the equation:

$$R = H \times 1.25$$

Where R = the volume of the reservoir in gallons, H = the duration of the application in hours.

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The volume of CFT Legumine diluted with water in the reservoir is determined from the equation:

$$X = Y(102\ F)H$$

Where X = the cc of CFT Legumine diluted in the reservoir, Y = parts per million desired concentration of CFT Legumine, F = the flow rate (cubic feet/second), H = the duration of the application (hours).

For flows over 25 cubic feet per second, additional reservoirs can be used concurrently. Back-water, stagnant and spring areas of streams should be sprayed by hand with a 10% v/v solution of CFT Legumine in water to assure a complete coverage.

Detoxification

To limit effects downstream, detoxification with potassium permanganate can be used at the downstream limit of the tre ated area. Within ½ to 2 miles of the furthest downstream CFT Legumine application site, the rotenone can be detoxified with a potassium permanganate solution at a resultant stream concentration of 2 to 4 parts per million, depending on rotenone concentration and permanganate demand of the water. A 2.5% (10 pounds potassium permanganate to 50 gallons of water) permanganate solution is dripped in at a continuous rate using the equation:

$$X = Y(70\ F)$$

Where X = cc of 2.5% permanganate solution per minute, Y = ppm of desired permanganate concentration, F = cubic feet per second of stream flow.

Flow of permanganate should be checked at least hourly. Live fish in cages placed immediately above the permanganate application site will show signs of stress signaling the need for beginning detoxification. Detoxification can be terminated when replenished fish survive and show no signs of stress for at least four hours.

Detoxification of rotenone by permanganate requires between 15 to 30 minutes contact time (travel time). Cages containing live fish can be placed at these downstream intervals to judge the effectiveness of detoxification. At water temperatures less than 50°F detoxification may be retarded, requiring a longer contact time.

WARRANTY STATEMENT

Our recommendations for the use of this product are based upon tests believed to be reliable. The use of this product being beyond the control of the manufacturer, no guarantee, expressed or implied, is made as to the effects of such or the results to be obtained if not used in accordance with directions or established safe practice. To the extent consistent with applicable law, the buyer must assume all responsibility, including injury or damage, resulting from its misuse as such, or in combination with other materials.

Appendix D2.–Prentox Prenfish Fish Toxicant Powder specimen label.

RESTRICTED USE PESTICIDE
DUE TO AQUATIC, ACUTE ORAL AND INHALATION TOXICITY
For retail sale to, and use by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

PRENTOX

ROTENONE FISH TOXICANT POWDER

ACTIVE INGREDIENTS:

Rotenone- Minimum Guaranteed	7.4% w/w
Other Associated Resins	11.1%
OTHER INGREDIENTS:	81.5%
TOTAL:	100.0% w/w

ROTENONE ASSAY ____________________ % ROTENONE

PRENTOX® - Registered Trademark of Prentiss Incorporated

KEEP OUT OF REACH OF CHILDREN

DANGER
POISON

FIRST AID

Have the product container or label with you when calling a poison control center or physician, or going for treatment.

If swallowed	• Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the Poison Control Center or physician. • Do not give anything by mouth to an unconscious or convulsing person.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.
If inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. • Call a Poison Control Center, physician, or the National Pesticide Information Center at 1-800-858-7378 for treatment advice.

For information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378.

SEE INSIDE LEAFLET FOR ADDITIONAL PRECAUTIONARY STATEMENTS AND DIRECTIONS FOR USE

Manufactured by: 5/02 **E.P.A. REG. NO. 655-691**
E.P.A. EST. NO. 655-GA-1

PRENTISS INCORPORATED

Plant: Kaolin Road, Sandersville, GA 31082
Office: C.B. 2000, Floral Park, NY 11002-2000

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
DANGER

Fatal if inhaled or swallowed. Harmful if absorbed through the skin. Causes moderate eye irritation. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Do not breathe dust. Use a dust/mist filtering respirator (MSHA/NIOSH approval number prefix TC-21C), or a NIOSH approved respirator with any N, R, P or HE filter. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco. Remove contaminated clothing and wash clothing before reuse.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate untreated water when disposing of equipment washwaters.

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STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.
STORAGE: Store only in original container, in a dry place inaccessible to children and pets. If spilled, sweep up and dispose of as below.
PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
CONTAINER DISPOSAL: Completely empty bag into application equipment. Then dispose of bag in a sanitary landfill or by incineration, or if allowed by State and local authorities by burning. If burned, stay out of smoke.

DIRECTIONS FOR USE
It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

USE RESTRICTIONS:
Use against fish in lakes, ponds, and streams (immediately above lakes and ponds).

Since such factors as pH, temperature, depth, and turbidity will change effectiveness, use this product only at locations, rates, and times authorized and approved by appropriate state and Federal fish and wildlife agencies. Rates must be within the range specified in the labeling.

Properly dispose of dead fish and unused product. Do not use dead fish as food or feed.

Do not use water treated with rotenone to irrigate crops or release within ½mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir.

Note to User: Adjust pounds of Rotenone according to the actual Rotenone Assay as noted under the Ingredient Statement on this label. For example, if the required amount of 5% rotenone is 21 pounds, and the Rotenone Assay is 7%, use $^5/_7$ of 21 pounds or 15 pounds of this product to yield the proper amount of active rotenone.

APPLICATION DIRECTIONS:

Treatment of Lakes and Ponds

1. **Application Rates and Concentrations of Rotenone**
The actual application rates and concentrations of rotenone needed to control fish will vary widely, depending on the type of use (e.g. selective treatment, normal pond treatment, etc.) and the factors listed above. The table below is a general guide for the proper rates and concentrations.

2. **Total Amount of Product Needed for Treatment**
To determine the total number of pounds needed for treatment, divide the number of acre-feet covered by one pound for a specific type of use (e.g., selective treatment, etc.), as indicated in the table below, into the number of acre-feet in the body of water.

General Guide to the Application Rates and Concentrations of Rotenone Needed to Control Fish in Lakes and Ponds[1]

Type of Use	No. of Acre-Feet Covered by One Pound	Parts Per Million Active Rotenone	Parts Per Million 5% Product
Selective Treatment	3.7 to 2.8	0.005 - 0.007	0.10 - 1.3
Normal Pond Use	0.74 to 0.37	0.025 - 0.050	0.5 - 1.0
Remove Bullheads or Carp	0.37 to 0.185	0.050 - 0.100	1.02 - 2.0
Remove Bullheads or Carp in Rich Organic Ponds	0.185 to 0.093	0.100 - 0.200	2.0 - 4.0
Pre-impoundment Treatment above Dam	0.123 to 0.074	0.150 - 0.250	3.0 - 5.0

5. **Restocking**
Waters treated with this product detoxify within 2 to 4 weeks after treatment, depending on pH, temperature, water hardness, and depth. To determine if detoxification has occurred, place live boxes containing samples of fish to be stocked in treated waters. More rapid detoxification can be accomplished by adding Potassium Permanganate or chlorine at a 1:1 ratio with the concentration of rotenone applied, plus sufficient additional compound to satisfy the chemical oxidation demand caused by organic matter that may be present in the treated water.

Treatment of Streams Immediately Above Lakes and Ponds
The purpose of treating streams immediately above lakes and ponds is to improve the effectiveness of lake and pond treatments and not to control fish in streams per se. The term "immediately" means the first available site above the lake or pond where treatment is practical.

In order to treat a stream immediately above a lake or pond, you must select a concentration of active rotenone, compute the flow rate of a stream, calculate the application rate, select an exposure time, estimate the amount of product needed, and follow the method of application.

1. **Concentration of Active Rotenone**
Select the "Concentration of Active Rotenone" based on the type of use from those on the table. For example, if you select "Normal Pond Use" you could select a concentration of "0.025 Parts per Million".

2. **Computation of Flow Rate for Stream**
Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles. Divide the surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. In slowly moving streams, determine the velocity by dropping a float attached to 5 feet of loose, monofilament fishing line. Measure the time required for the float to move 5 feet. For fast-moving streams, use a longer distance. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{Ws \times D \times L \times C}{T}$$

where F = flow rate (cu. ft./sec.), Ws = surface width (ft.), D = mean depth (ft.), L = mean distance traveled by float (ft.), C = constant (0.8 for rough bottoms and 0.9 for smooth bottoms), and T = mean time for float (sec.).

For example, after using the above formula, you might have computed the stream's flow rate to be "10 cu. ft. per sec."

3. **Calculation of Application Rate**
In order to calculate the application rate (expressed as "pound per sec"), you convert the rate in the table (expressed as "pound per acre-feet"), to "pound per cu. feet" and multiply by the flow rate (expressed as "cu. ft. per sec."). Depending on the size of the stream and the type of equipment, the rate could be expressed in other units, such as "ounces per hr."

The application rate for the stream above is calculated as follows:

$$R_s = R_p \times C \times F$$

where R_s = Application Rate for Stream (lb/sec), R_p = Application Rate for Pond (lb/acre feet), C = 1 acre foot/43560 cu. ft., and F = Flow Rate (cu. ft/sec).

In the example, the Application Rate for Stream would be:
R_s = 1 lb/0.74 acre-foot x 1 acre-foot/43560 cu. ft. x 10 cu. ft./sec.
R_s = .00031 lb/sec or 17.9 oz./hr.

4. **Exposure Time**
The "Exposure Time" would be the period of time (expressed in hours or seconds) during which target fish should **not** enter the lake or pond under treatment. In the example, this period of time could be 4 hours.

5. **Amount of Product**
Calculate the "Amount of Product" for a stream by multiplying the "Application Rate for Stream" by the "Exposure Time". In the example, the "Amount of Product" would be 71.6 oz. (17.9 oz./hr. x 4 hr.) or 4.5 lb.

RE-ENTRY STATEMENT
Do not allow swimming in rotenone-treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to labeling instructions.

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[1]Adapted from Kinney, Edward, 1965 Rotenone in Fish Pond Management. USDI Washington, D.C. Leaflet FL-576.

Computation of acre-feet for lake or pond: An acre-foot is a unit of water volume having a surface area of one acre and a depth of one foot. Make a series of transects across the surface, taking depths with a measured pole or weighted line. Add the measurements and divide by the number made to determine the average depth. To compute **total acre-feet**, multiply this average depth by the number of surface acres, which can be determined from an aerial photograph or plat drawn to scale.

3. **Pre-Mixing Method of Application**

Pre-mix one pound of Rotenone with 3 to 10 gallons of water. Uniformly apply over water surface or bubble through underwater lines.

Alternately place undiluted powder in burlap sack and trail behind boat. When treating deep water (20 to 25 feet) weight bag and tow at desired depth.

4. **Removal of Taste and Odor**

Rotenone treated waters do not retain a detectable taste or odor for more than a few days to a maximum of one month. Taste and odor can be removed immediately by treatment with activated charcoal at a rate of 30 ppm. for each 1 ppm. Rotenone remaining (Note: As Rotenone detoxifies, less charcoal is required).

APPENDIX E: ESTIMATES OF SCOUT LAKE WATER VOLUME AND AMOUNT OF ROTENONE PRODUCT NEEDED BY AREA AND DEPTH STRATA

Appendix E1.–Estimates of Scout Lake water volume (acre-feet) by depth and area strata including calculated rotenone product requirements for each.

	Water volume in acre-feet			Barrels liquid rotenone			Gallons liquid rotenone			Drums powdered rotenone			Pounds powdered rotenone		
Area [a]	0–15 ft	>15 ft	Total	0–15 ft	>15 ft	Total	0–15 ft	>15 ft	Total	0–15 ft	>15 ft	Total	0–15 ft	>15 ft	Total
Area 1-a	7.4	0.0	7.4	0.1	0.0	0.1	4.0	0.0	4.0	0.0	0.0	0	0	0	0
Area 1-b	194.8	14.0	208.8	2.8	0.2	3.0	84.3	6.1	90.4	0.0	0.0	0	0	0	0
Area 2	293.0	59.6	352.6	0.6	0.9	1.5	18.0	25.8	43.8	5.5	0.0	5.5	600	0	600
Area 3	168.9	12.8	181.7	0.0	0.2	0.2	0.0	5.5	5.5	3.6	0.0	3.6	0	0	0
Area 4-a	7.6	0.0	7.6	0.1	0.0	0.1	4.0	0.0	4.0	0.0	0.0	0	0	0	0
Area 4-b	75.5	0.0	75.5	1.1	0.0	1.1	32.7	0.0	32.7	0.0	0.0	0	0	0	0
Area 4-c	1.6	0.0	1.6	0.1	0.0	0.1	2.0	0.0	2.0	0.0	0.0	0	0	0	0
Combined	748.9	86.4	835.3	4.8	1.2	6.1	145.0	37.4	182.4	9.1	0.0	9.1	600	0	600

Note: Because calculations were made for acre-feet per product label instructions, depth strata are given in feet (15 ft = 4.6 m) and area strata are given in acre-feet.

[a] Areas are shown in Figure 5.

APPENDIX F: PARAMETERS NEEDED TO CALCULATE OPTIMAL BOAT SPEEDS FOR TREATMENT APPLICATION

Appendix F1.–Parameters needed to calculate optimal boat speeds for applying Prentox Prenfish Rotenone Fish Toxicant Powder to Scout Lake over varying water depths.

Water depth (ft)	Water volume (ft^3)[a]	Water volume (acre-feet)	Product (lbs)[b]	Boat travel (min)[c]	Boat speed (mph)
1	3,000	0.069	0.266	0.03	42.74
2	6,000	0.138	0.532	0.05	21.37
3	9,000	0.207	0.798	0.08	14.25
4	12,000	0.275	1.064	0.11	10.68
5	15,000	0.344	1.330	0.13	8.55
6	18,000	0.413	1.595	0.16	7.12
7	21,000	0.482	1.861	0.19	6.11
8	24,000	0.551	2.127	0.21	5.34
9	27,000	0.620	2.393	0.24	4.75
10	30,000	0.689	2.659	0.27	4.27
11	33,000	0.758	2.925	0.29	3.89
12	36,000	0.826	3.191	0.32	3.56
13	39,000	0.895	3.457	0.35	3.29
14	42,000	0.964	3.723	0.37	3.05
15	45,000	1.033	3.989	0.40	2.85

Note: Target treatment concentration was 1.4 ppm of rotenone product. It was assumed that the boat can apply 10 pounds of powdered product per minute.

[a] Water volume (ft^3) in every 100 linear-foot stretch of an application swath 30 ft wide.

[b] Pounds of product needed per 100 linear feet of boat travel to apply product at a concentration of 1.4 ppm.

[c] Minutes of travel needed for a boat to cross 100 linear feet to apply product at a concentration of 1.4 ppm.

Appendix F2.–Parameters needed to calculate optimal boat speeds for applying CFT Legumine to Scout Lake over varying water depths.

Water depth (ft)	Water volume (ft^3)[a]	Water volume (acre-feet)	Product (gal)[b]	Boat travel (min)[c]	Boat speed (mph)
1	3,000	0.069	0.023	0.02	49.55
2	6,000	0.138	0.046	0.05	24.77
3	9,000	0.207	0.069	0.07	16.52
4	12,000	0.275	0.092	0.09	12.39
5	15,000	0.344	0.115	0.11	9.91
6	18,000	0.413	0.138	0.14	8.26
7	21,000	0.482	0.161	0.16	7.08
8	24,000	0.551	0.183	0.18	6.19
9	27,000	0.620	0.206	0.21	5.51
10	30,000	0.689	0.229	0.23	4.95
11	33,000	0.758	0.252	0.25	4.50
12	36,000	0.826	0.275	0.28	4.13
13	39,000	0.895	0.298	0.30	3.81
14	42,000	0.964	0.321	0.32	3.54
15	45,000	1.033	0.344	0.34	3.30

Note: Target treatment concentration was 1.4 ppm of rotenone product. It was assumed that the boat can apply 1 gallon of liquid rotenone product per minute.

[a] Water volume (ft^3) in every 100 linear-foot stretch of a 30-ft wide application swath.

[b] Gallons of product needed per 100 linear feet of boat travel to apply product at a concentration of 1.4 ppm.

[c] Minutes of travel needed for a boat to cross 100 linear feet to apply product at a concentration of 1.4 ppm.

APPENDIX G: PRETREATMENT AND POSTTREATMENT SCOUT LAKE INVERTEBRATE SAMPLING RESULTS BY DATE AND GEAR TYPE

Appendix G1.–Pretreatment and posttreatment Scout Lake invertebrate sampling counts by date and gear type.

Sampling period	Date	Taxon	Ekman bottom grab	Kick net	Light trap	Minnow trap	Wisconsin net
Pretreatment							
	26 Jul 2009	Dysticidae (predacous diving beetle or whirligig)		1			
	26 Jul 2009	Chironomidae (non-biting midges)	2				
	26 Jul 2009	Amphipoda (scud)		1			
	26 Jul 2009	Pelecypoda (molluscs)		18			
	26 Jul 2009	Gastropoda (snails)		1			
	26 Jul 2009	Araneae (spiders)		1			
	26 Jul 2009	Asplanchna (rotifers)					1
	26 Jul 2009	Eucopepoda (copepod)					Present
	26 Jul 2009	Cladocera (water fleas/daphnia)					Present
	26 Jul 2009	Hymenoptera (wasp/ant)		2			
	26 Jul 2009	Anispotera (dragonflies)		7			
	26 Jul 2009	Zygoptera (damselflies)		9			
	26 Jul 2009	Diptera - unkown adult	1				
	26 Jul 2009	Oligochaeta (earthworms)		1			
	26 Jul 2009	Trichoptera (caddis flies)		1			
	26 Jul 2009	Coleoptera (beetles)		9			
	12 Aug 2009	Acariformes (mites)			1		
	12 Aug 2009	Asplanchna (rotifers)			Present		
	12 Aug 2009	Cladocera (water fleas/daphnia)			Present		
	12 Aug 2009	Trichoptera (caddis flies)			1		
	11 Oct 2009	Dysticidae (predacous diving beetle or whirligig)				36	
	11 Oct 2009	Amphipoda (scuds)				2	
	11 Oct 2009	Anispotera (dragonflies)				2	

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Sampling period	Date	Taxon	Ekman bottom grab	Kick net	Light trap	Minnow trap	Wisconsin net
Posttreatment							
	17 Jun 2010	Dysticidae (predacous diving beetle or whirligig)		6		6	
	17 Jun 2010	Chironomidae (non-biting midges)	3	4		1	
	17 Jun 2010	Amphipoda (scud)		18			
	17 Jun 2010	Pelecypoda (molluscs)		7			
	17 Jun 2010	Gastropoda (snails)		1			
	17 Jun 2010	Araneae (Spiders)		4			
	17 Jun 2010	Anispotera (dragonflies)		9		6	
	17 Jun 2010	Zygoptera (damselflies)		6			
	17 Jun 2010	Corixidae (water boatmen)		21			
	17 Jun 2010	Ceratopogonidea (no-seeums)		1			
	17 Jun 2010	Diptera - unkown adult		2			
	17 Jun 2010	Chrysomelidae (leaf beetles)		1			
	17 Jun 2010	Coleoptera (beetles)		4			
	24 Jun 2010	Dysticidae (predacous diving beetle or whirligig)			3		
	24 Jun 2010	Chironomidae (non-biting midges)			1		
	24 Jun 2010	Acariformes (mites)			1		
	24 Jun 2010	Eucopepoda (Copepod)			Present		
	24 Jun 2010	Cladocera (water fleas/daphnia)			Present		
	24 Jun 2010	Corixidae (water boatmen)			13		
	24 Jun 2010	Diptera - unkown adult			1		
	24 Jun 2010	Coleoptera (beetles)			1		

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Sampling period	Date	Taxon	Ekman Bottom grab	Kick net	Light trap	Minnow trap	Wisconsin net
Posttreatment							
	22 Jul 2010	Chironomidae (non-biting midges)		4			
	22 Jul 2010	Amphipoda (scud)		7			
	22 Jul 2010	Pelecypoda (molluscs)		4			
	22 Jul 2010	Asplanchna (rotifers)					Present
	22 Jul 2010	Hymenoptera (wasp/ant)		1			
	22 Jul 2010	Plecoptera (stone flies)		7			
	22 Jul 2010	Zygoptera (damselflies)		11			
	22 Jul 2010	Corixidae (water boatmen)		79			
	22 Jul 2010	Ceratopogonidea (no-seeums)		3			
	22 Jul 2010	Dixidae (dixid midge)		1			
	22 Jul 2010	Diptera - unkown adult		8			
	22 Jul 2010	Chrysomelidae (leaf beetles)		3			
	22 Jul 2010	Coleoptera (beetles)		2			

Note: Taxa identification was resolved to at least the Order level, often Family level, except for the following: Oligochaeta, Hirudinea, Pelecypoda, and Gastropoda (Class).

Note: Invertebrate catch data reflects the actual enumeration of each taxon observed by gear and date except for rotifers (Asplanchna), eucopepods (Copepods), and daphnia (Cladocera), which were not enumerated but listed if present.