Fishery Data Series No. 98-30

Hatching Success of Lake Trout Eggs In Artificial Incubation Substrates in Harding and Seven Mile Lakes

by
Tim Viavant

November 1998

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

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

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 98-30

HATCHING SUCCESS OF LAKE TROUT EGGS IN ARTIFICIAL INCUBATION SUBSTRATES IN HARDING AND SEVEN MILE LAKES

by

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Lake trout *Salvelinus namaycush* eggs and milt were taken from fish captured in September, 1997, from Seven Mile Lake. After being fertilized, eggs were allowed to water-harden for 1.5 h, and then placed into artificial incubation substrates which were placed at two different water depths in Seven Mile and Harding lakes. A fixed volume of eggs equaling approximately 225 eggs was hand counted into each of two layers of 12 artificial incubation substrates at each lake. Six substrates were placed on known lake trout spawning areas (at Seven Mile Lake) or onto introduced spawning substrates (at Harding Lake) at both 1.5 m and 3.0 m deep (12 total in each lake). Eggs and substrates were blocked by order of handling, one block consisting of one substrate placed at each depth. Twelve substrates in six blocks were placed in Seven Mile Lake immediately after the eggs water-hardened, and the same process was carried out 6 h later after the remaining eggs were transported to Harding Lake. Soon after ice melt in the spring of 1998 (May 21 at Harding Lake, June 20 at Seven Mile Lake), substrates were recovered and the unhatched eggs and dead fish were counted and the number recorded. The average percentage of eggs hatching was 66.2% at Seven Mile Lake and 49.7% at Harding Lake. There were no significant differences in the percentage hatching at either lake due to the depth of the substrates or among blocks.

Key words: lake trout, *Salvelinus namaycush*, artificial incubation substrates, hatching success.

INTRODUCTION

A number of lakes in interior Alaska are stocked annually or semi-annually with lake trout *Salvelinus namaycush* fingerlings or subcatchables in order to provide a diversity of angling opportunity to the public. Many of these lakes do not contain substrates suitable for lake trout spawning, and may be unlikely to develop a resident spawning population. In several interior Alaska lakes inhabited by wild stocks of lake trout, low productivity combined with harvest pressure has resulted in stock declines that have required restrictive regulations to be put into place. Because survival of lake trout eggs from spawning to hatching may be limited due to lack of suitable spawning habitat (Marsden and Krueger 1991) and/or egg predation (Wagener 1992, Martin and Olver 1980). Annual recruitment of lake trout could possibly be increased by increasing the survival of eggs to the fry stage.

Previous research (Swanson 1980, Viavant 1996) has shown that lake trout eggs can be successfully hatched in artificial incubation substrates. This method of providing an annual or semi-annual stocking of lake trout to area lakes has a number of potential advantages over stocking hatchery reared fish. Because hatchery operating costs are high, stocking fertilized eggs in artificial incubation substrates could result in a more cost effective method of providing lake trout for stocking. Even if survival of hatched fry to the fingerling stage is low using artificial incubation substrates in lakes, the costs of incubating fertilized eggs in lakes is much lower per egg than the cost of incubating eggs and rearing fish in a hatchery. The survival of eyed lake trout eggs planted directly onto spawning reefs has been found to be extremely low (1.8% or less) in Lake Michigan (Wagener 1992), however, lake trout have been successfully hatched in artificial substrates in Lake Superior, with hatching success rates of 70 to 90% (Swanson 1980), and in Donnelly Lake, Alaska, with hatching rates around 43% (Viavant 1996).

Another benefit of stocking fertilized eggs instead of hatchery reared fish is the potential for establishing spawning populations, particularly in combination with enhancing spawning habitat. Several studies have found considerable evidence that lake trout return to their natal reef to spawn (Eschmeyer 1955, Martin 1957, Loftus 1958, Rahrer 1968, Swanson 1974), and that lake trout imprint on the reef on which they emerged (Horrall 1981). If the introduction into a lake of artificial spawning habitat is to be used successfully to enhance lake trout populations, it likely that the success of establishing a spawning population imprinted on newly created artificial spawning habitat would depend on having fry emerge directly over such new habitat, so that these fish would be imprinted on the artificial spawning habitat as their natal reef. It is important to know what proportion of fertilized lake trout eggs successfully hatch in a given lake, and the influence of depth on hatching success. This experiment was designed to determine the proportion of fertilized lake trout eggs successfully hatching from artificial incubation substrates at two different depths in Seven Mile and Harding lakes.

Seven Mile Lake

Seven Mile Lake (Figure 1) contains a relatively small population of wild stock lake trout that supports a small sport fishery. A detailed description of Seven Mile Lake and of previous research on the lake trout population can be found in Burr (1994) and Taube (1997). Lake trout eggs used for the production of hatchery fish have been obtained from wild stock fish on a bi-annual basis from Seven Mile Lake for the past eight years. Because some of the annual production of wild stock lake trout is removed from Seven Mile Lake every other year for hatchery production, and because there are known spawning locations at Seven Mile Lake, the lake was chosen as one location to conduct this experiment.

Harding Lake

Harding Lake (Figure 2) contains a small, self-reproducing population of lake trout that originated from stocked lake trout, and supports a small amount of harvest and catch, but contains only a very small amount of suitable spawning habitat (Viavant 1997). A detailed description of Harding Lake can be found in Doxey (1991). Because there is limited lake trout spawning habitat in Harding Lake, and because introduced lake trout are known to have established a spawning population there, Harding Lake was chosen as a location to both introduce new spawning habitat, and to introduce fertilized lake trout eggs in artificial incubation substrates placed on newly introduced spawning habitat.

The objectives and task of this study were to:

1. count the proportion of successfully hatched lake trout eggs placed into artificial incubation substrates in Seven Mile Lake and Harding Lake, and;
2. test the hypothesis (H_o) that the proportion of lake trout eggs that successfully hatch from artificial incubation substrates placed at two different water depths are the same, versus the alternative hypothesis (H_a), that the proportion of lake trout eggs that successfully hatch from artificial incubation substrates placed in water 1.5 m deep and 3.0 m deep are not the same, such that a difference of at least 40% can be detected with the probabilities of Type I and Type II errors being 0.10 and 0.22, respectively.

The project task was to place two small (2 m wide x 6 m long x .33 m deep) artificial spawning reefs into Harding Lake at 1.5 m and 3.0 m deep near (within 50 m) an existing lake trout spawning location and observe both reefs during lake trout spawning to determine if lake trout use these reefs.

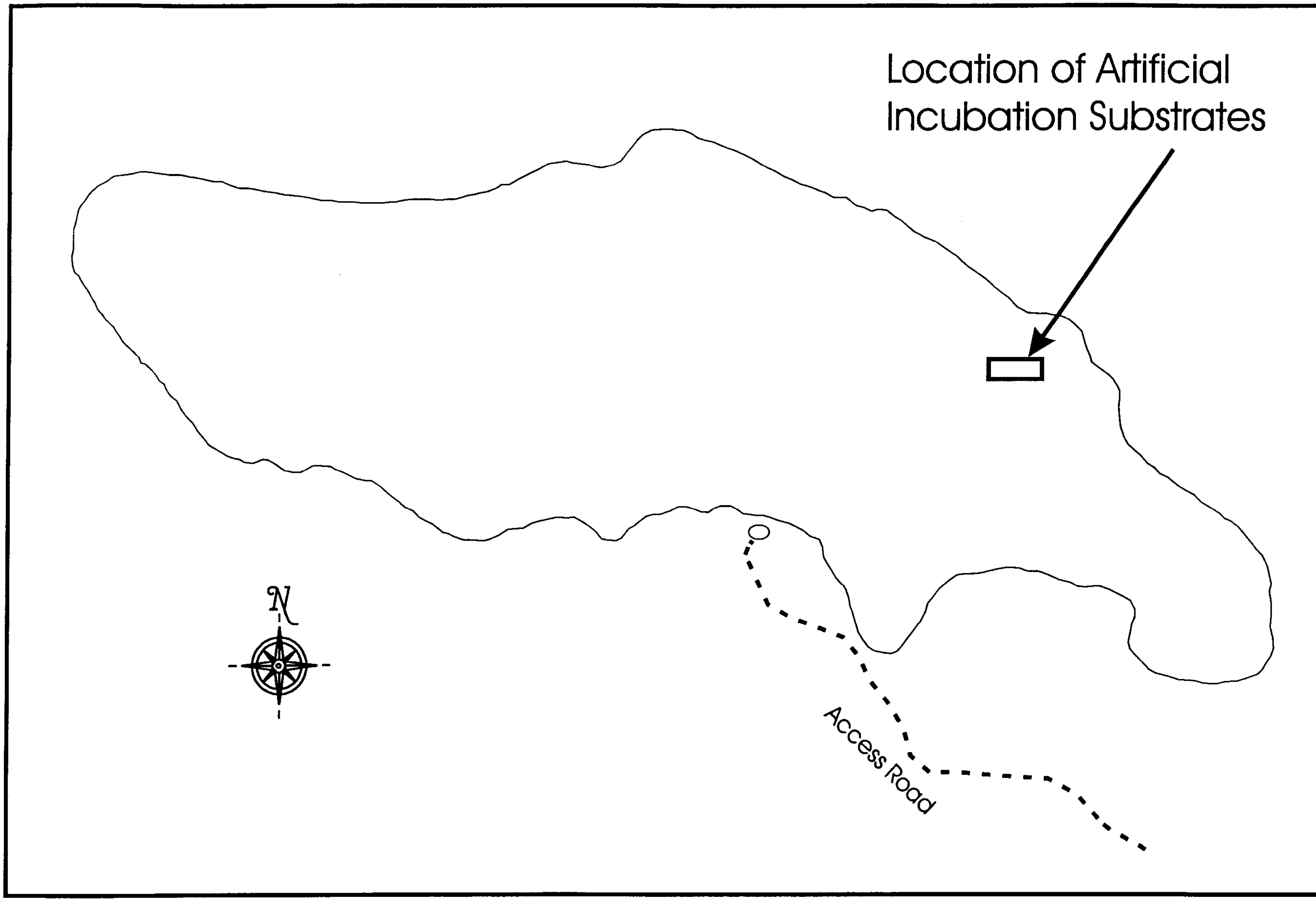

Figure 1.-Map of Seven Mile Lake showing location of artificial incubation substrates.

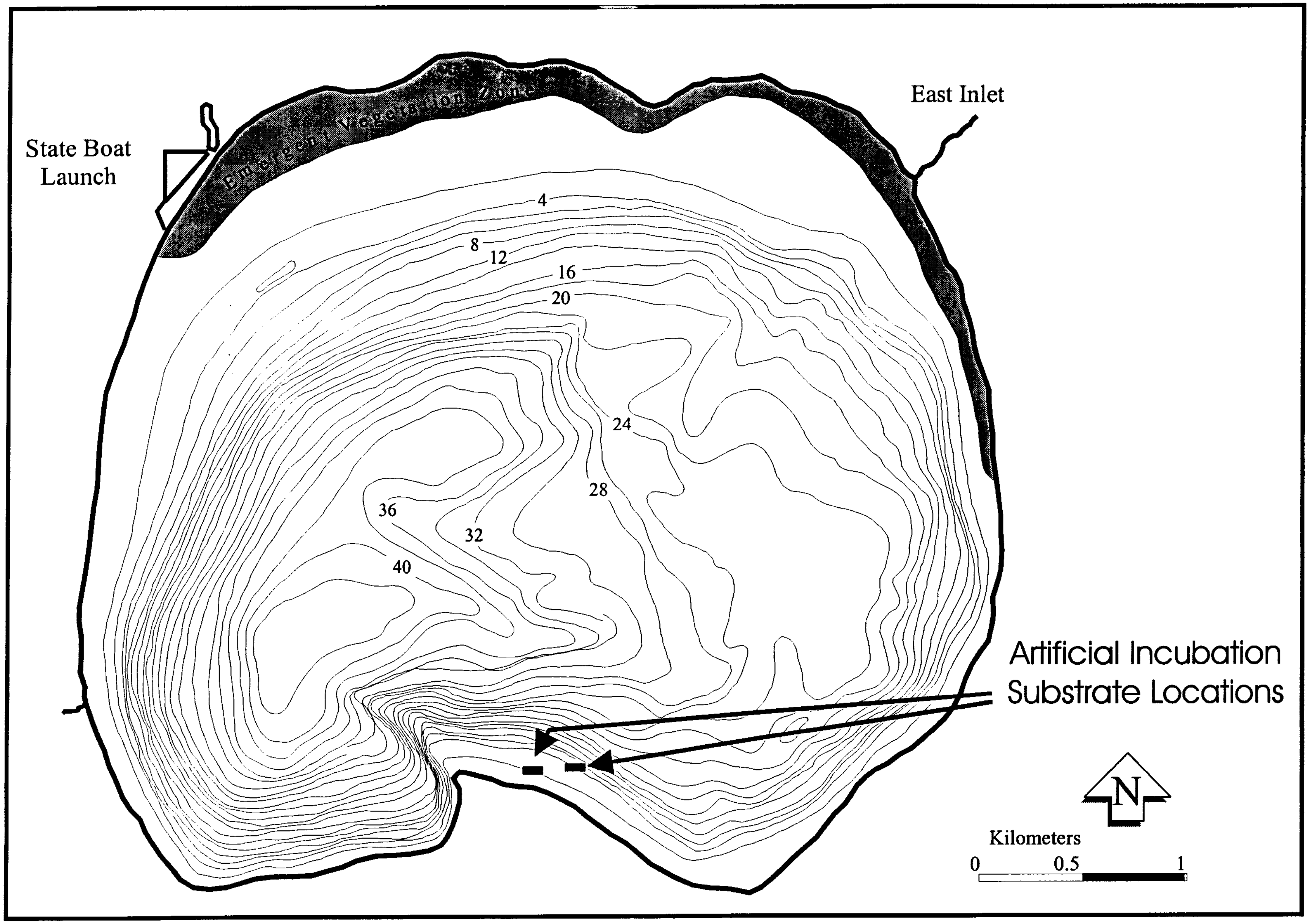

Figure 2.-Map of Harding Lake showing location of artificial incubation substrates.

METHODS

Artificial substrates were constructed of four sheets of AstroTurf™ (two layers of two sheets each) sandwiched together in a welded aluminum frame. Substrates were similar to those used by Swanson (1980), and a schematic representation can be found in Viavant (1996). Sheets of AstroTurf™ were 30.5 cm wide by 91.5 cm long, and were positioned such that each layer consisted of two sheets with the turf sides facing each other. Fertilized eggs were spread by hand on one sheet of AstroTurf™ in each layer, and then covered by the second sheet in each layer. Frames were constructed to hold the layers in place with as little movement as possible of the AstroTurf™ sheets and as much possible water flow through and around the layers.

During early September 1997, lake trout eggs and milt were taken from lake trout captured as part of the hatchery egg-take scheduled for Seven Mile Lake. After fertilization at Seven Mile Lake, the eggs were allowed to water harden for 1.5 h. Substrates were placed into Seven Mile Lake and Harding Lake. At Seven Mile Lake, substrates were loaded with eggs and placed on a known spawning location immediately after water hardening. At Harding Lake, eggs were transported in jars in a cooler of water from Seven Mile Lake (for temperature control) for approximately 4 h, and then substrates were loaded with eggs and placed onto artificially introduced spawning reefs. A fixed volume equaling approximately 225 eggs was hand counted onto each layer in each substrate. Substrates were then placed at 1.5 and 3.0 m depths. Six replicates were placed at each depth in each lake. Within each lake, replicate substrates were blocked by order of handling, with each block consisting of one substrate placed at each depth. A total of 5,417 eggs were placed into Seven Mile Lake and a total of 4,780 eggs were placed into Harding Lake.

Substrates were recovered just after each lake became ice free, and the number of dead eggs in each layer of each substrate was counted. The difference between the number of live eggs counted in each layer of the substrates in the fall and the number of dead eggs counted the following summer was assumed to be the number of eggs successfully hatched from each layer of each substrate.

The proportion of successfully hatched eggs from each substrate was calculated as:

$$P_h = \frac{K - M}{K} \qquad (1)$$

where:

P_h = the proportion of lake trout eggs successfully hatching from a substrate;

K = the number of eggs placed into the artificial substrate; and,

M = the number of unhatched eggs counted after the substrates were recovered.

Analysis of variance was used on the proportions to examine the effects of lake, depth and handling order (blocking) on hatching success. Each substrate was considered an experimental unit. Each block consisted of a pair of substrates within a lake, handled at the same time, one placed at each depth. This experiment was a split-plot design with block effects nested within lake effects, and fixed treatments. The model used followed the ANOVA table below.

Source	Degrees of Freedom
Lake	1
Block (within Lake)	5 + 5
Depth	1
Lake x Depth	1
Error	10

RESULTS AND DISCUSSION

The proportion of successfully hatched eggs averaged 0.497 at Harding Lake (SE = 0.046) and 0.662 at Seven Mile Lake (SE = 0.088). Hatching success was significantly different between lakes ($F = 48.1$, $p \leq 0.01$). Although hatching success was greater at Seven Mile Lake than at Harding Lake, this experiment was not designed to detect differences between lakes, since differing results could be the result of either differing conditions in the lakes or differences in the handling of the eggs placed into each lake. Hatching success did not differ significantly between depths at either lake ($F = 0.0$, $p = 0.98$). The effects of handling order (blocking) were also not significant ($F = 0.95$, $P = 0.354$). The numbers of live eggs initially placed into each incubation substrate and dead eggs counted the following spring appear in Appendix A.

The proportions of eggs successfully hatching from artificial incubation substrates from both Seven Mile and Harding lakes were similar, though higher, to the hatching success observed in Donnelly lake in an earlier study (Viavant 1996) where the proportion successfully hatching eggs averaged 0.434. Lake trout eggs taken as part of the same egg-take from Seven Mile Lake as those used in this study were incubated and hatched at Fort Richardson Hatchery. These eggs had an overall fertilization rate of 0.87, and the proportion successfully hatching (from green eggs to hatch) was 0.27 (G. Wall, Alaska Department of Fish and Game, Anchorage, personal communication).

The results of this experiment indicate that the introduction of fertilized lake trout eggs in artificial incubation substrates may be a cost effective method of enhancing lake trout production. Although this method of enhancement only increased survival from the egg to fry stage, the method probably also results in a higher proportion of egg production resulting in fertilization, since fertilization rates during natural spawning are likely to be lower than in artificial spawning. The method also results in a high rate of survival from fertilization to hatching compared to natural incubation conditions. This is likely since all egg predation is eliminated, and since fertilized eggs are maintained in a stable environment in artificial incubation substrates. The method may also be particularly cost effective when stocking remote lakes only accessible by float plane. This would be true since the cost of transporting fertilized eggs to a remote lake would be much lower than transporting fingerling fish.

Further research is needed to attempt to quantify survival beyond hatching. This research would be problematic, since lake trout stocked as fertilized eggs would not recruit to the type of sampling gear used for population estimation until the fish had reached the age of four or five. Because the proportion of eggs stocked that would be expected to survive to age 5 would be very low, a large number of eggs would have to be stocked initially in order to result in a population large enough to successfully conduct a population estimate. This problem could be overcome by stocking fertilized eggs for several years in a row. Any such research would necessarily have to be conducted in a lake that did not already contain lake trout.

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APPENDIX A

Appendix A.-Page 2 of 2.

Lake	Block	Depth (m)	Layer	Initial Live Eggs	Dead Eggs	Number Hatched	Percent Hatched
Harding	2	1.5	2	217	93	124	0.571
Harding	2	3	1	199	94	105	0.528
Harding	2	3	2	195	103	92	0.472
Harding	3	1.5	1	194	97	97	0.500
Harding	3	1.5	2	201	105	96	0.478
Harding	3	3	1	208	102	106	0.510
Harding	3	3	2	207	117	90	0.435
Harding	4	1.5	1	201	96	105	0.522
Harding	4	1.5	2	204	89	115	0.564
Harding	4	3	1	198	121	77	0.389
Harding	4	3	2	206	101	105	0.510
Harding	5	1.5	1	180	104	76	0.422
Harding	5	1.5	2	178	80	98	0.551
Harding	5	3	1	201	109	92	0.458
Harding	5	3	2	218	115	103	0.472
Harding	6	1.5	1	203	114	89	0.438
Harding	6	1.5	2	196	108	88	0.449
Harding	6	3	1	164	101	63	0.384
Harding	6	3	2	208	104	104	0.500
			Totals	4,780	2,400	2,380	