GREAT LAKES FISHERY COMMISSION

1990 Project Completion Report[1]

Proposal for the Experimental Manipulation of Lake Trout and Sea Lamprey Populations in Stuart Lake, Ontario

by:

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PROPOSAL FOR THE EXPERIMENTAL MANIPULATION OF LAKE TROUT AND SEA LAMPREY POPULATIONS IN STUART LAKE, ONTARIO

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INTRODUCTION

Purpose

This proposal outlines a whole lake manipulation of lake trout (Salvelinus namaycush) and sea lamprey (Petromyzon marinus) populations. Our study is intended to quantify major elements of sea lamprey - lake trout interactions through field studies. Secondarily, we will be able to define aspects of the stock-recruitment relationships for sea lamprey. This document describes our proposed methodologies for testing these relationships through the manipulation of lake trout and lamprey populations in Stuart Lake, Ontario.

Rationale

The mandate of the Great Lakes Fishery Commission (GLFC), in co-operation with U.S. and Canadian fisheries agencies, is to develop and implement integrated management of sea lamprey (IMSL) and fish populations (from Great Lakes Fisheries Convention Act and Strategic Great Lakes Fisheries Management Plan (SGLFMP 1982). Fishery managers need to know the abundance of parasitic sea lamprey and what the expected impact of this species will be on the salmonid fishery so that decisions regarding fishery and sea lamprey management goals can be made. The GLFC has issued its strategy for the integrated management of sea lamprey, IMSL (see Davis and Manion 1982). The IMSL strategy is designed to minimize deleterious effects of lamprey parasitism to facilitate fish stock rehabilitation programs. IMSL consists of a systematic series of approaches which are expected to achieve the broader goals of the GLFC without sacrificing the existing control effort (Davis and Manion 1982). A major impediment to achieving IMSL has been the lack of quantitative data to evaluate the changes in size and impact of sea lamprey populations upon fish stocks from the sea lamprey management program. An accurate, quantitative assessment of salmonid mortality induced by sea lamprey is fundamental to defining the required sea lamprey management objectives and assessing control program success.

The sea lamprey - lake trout interaction in lakes is complex and poorly understood (Beamish and Hanson 1987; Swink and Hanson 1989). Estimating salmonid mortality induced by sea lamprey has been difficult because the variability of natural annual mortality and the accuracy of fishing mortality statistics in large systems (e.g. the Great Lakes) is unknown. Consequently, the range of lake trout mortality rates reported among populations without lamprey overlaps mortality among lake trout populations with lamprey (e.g. Youngs and Oglesby 1972; Youngs 1980). Lake trout survival may be density dependent (Martin and Fry 1973) and the compensatory/depensatory contribution of lamprey to this relationship is not known. Walters et al. (1980) suggest that uncertainties surrounding the lamprey - lake trout interactions leaves open the question of whether lamprey are predators or benign parasites. However, Pycha (1980) used regression analysis to determine that sea lamprey wounding data accounted for over 85% of the variability in annual lake trout natural mortality in Michigan waters of Lake Superior. More recently, Bergstedt and Schneider (1988) concluded that sea lamprey were the primary source of mortality in age 3^+ and older lake trout, other than fishing, in Lake Ontario. Their study indicated that natural mortality from sources other than sea lamprey was negligible. Thus, while it is apparent that sea lamprey are a major factor in lake trout mortality, our current state of knowledge is inadequate to accurately describe sea lamprey - lake trout interactions.

The ability to interpret the effects of sea lamprey control and to establish socio-economically acceptable targets for control is constrained by gaps in our knowledge of sea lamprey population biology. Laboratory studies have provided valuable information concerning the sea lamprey - lake trout interaction to date. However, Walters et al. (1980) recognized that uncertainties concerning the sea lamprey biology will not be fully resolved by more laboratory research because these studies cannot consider the animal's behaviour in an open lake or the interaction with the habitat and other fish species. Walters et al. (1980) also suggested that greater resolution will not likely emerge from longer observation of overall system behaviour since nature will not produce the necessary contrasts in possible causal factors. Therefore, field experiments directed at furthering the understanding of population ecology of sea lamprey appear necessary to an integrated research plan. It is our contention that a whole lake manipulation of lake trout and sea lamprey is suitably scaled to address questions concerning the impact of sea lamprey on the population dynamics of lake trout.

Understanding the magnitude of ecosystem-level responses and the degree to which the ecosystem can recover is essential for effective natural resource management (Schindler 1987). Whole ecosystem experiments are appropriately scaled to many management issues and thus are especially useful in applied ecology (Frost et al. 1988; Kitchell et al. 1988). Attempting to use an entire Great Lake in an experimental approach would result in data with low resolution and precision because of the inherently high sampling variability in systems of this size. Conversely, conditions imposed on small scale laboratory experiments often are not a realistic simulation of those in natural ecosystems (Schindler 1988). At the community level, whole-system manipulations of large mobile predators have revealed responses at much larger spatial scales than in experimental enclosures (Carpenter et al. 1987; Schindler 1987). In aquatic systems, whole-lake manipulations have been successfully applied to the evaluation of anthropogenic stresses including lake acidification (Schindler 1980; Schindler and Turner 1982; Schindler et al. 1985), eutrophication (Schindler et al. 1971; Schindler et al. 1973; Schindler et al. 1978; Mills 1985) and fish stock exploitation (Stenson et al. 1978; Healey 1978). We believe that a whole-lake manipulation with sea lamprey - lake trout will provide similar insights of considerable value to sea lamprey and fishery management efforts.

Hypotheses to be Addressed

In support of activities directed by the Great Lakes Fisheries Convention Act and the GLFC IMSL strategy, we propose to use an experimental approach to address the following questions and hypotheses:

1. What proportion of lake trout mortality is attributable to sea lamprey attacks? What is the relationship between scarring/wounding rates of lake trout and lamprey abundance? We intend stocking an experimental lake with known numbers of lake trout and sea lamprey. The lake trout population dynamics in similar inland lakes without sea lamprey will be contrasted with observations from the experimental lake. We will test the hypothesis that current model projections (Koonce and Locci-Hernandez 1989) describe the observed the levels of mortality and marking observed in the field.

2. What are the changes in the biomass and production within the fish community following introductions of lake trout and sea lamprey? We will estimate production and biomass of the fish community prior to, during, and after our whole lake manipulations. We will test the hypothesis that lamprey are selective for salmonids. If lamprey are not selective for lake trout, non-salmonid species should be attacked based on their proportion of the fish community.

3. What is the growth and survival rates of ammocoetes produced in Stuart L? Our data will be limited because there will be at most two spawning periods before the completion of the study. However, we will examine growth and survival of ammocoetes during these periods and how varying the abundance of stocked transformers affects spawning activity and young-of-the-year produced.

4. How do the findings of the experiments directed at mortality and marking compare with the current understanding of sea lamprey - lake trout interactions? We will examine predictions of the IMSL and other models with observations from our whole lake manipulation.

MATERIALS AND METHODS

I. Feasibility of Stuart Lake

Stuart Lake is located on the Echo River system in the Algoma District of Ontario (Figure 1). It is believed to have had an endemic population of lake trout which was supplemented with stocked lake trout, among other species. Local residents report that while lake trout fishing has declined considerably, lake trout are still present in the lake. Fish in Stuart L. have been wounded by sea lamprey in the past (SLCC and OMNR records) and ammocoetes are still present in the tributaries of Stuart L (SLCC surveys). We are not proposing the introduction of any new species to this lake. We are proposing an augmentation and manipulation of current populations of lake trout and lamprey in Stuart L.

Preliminary sampling of fish, invertebrates and water chemistry from Stuart L. was conducted in October, 1989 (see Table 1) to assess its suitability for lake trout stocking. Although our data are restricted, we confirmed OMNR assessment studies that Stuart L. has the physical/chemical conditions to support a cold water fishery. The landscape surrounding Stuart L. consists of extensive relief resulting in steep contours within the lake. The vegetation surrounding the lake is dominated by a mixed maple-coniferous forest. Maximum depth of Stuart L. is approximately 26 m. Acid neutralizing capacity

(229.5 ueq*L^{-1}) and pH (7.02) is also typical of lake trout lakes in northern Ontario (Martin and Olver 1976). Fish yield based on the MEI (Ryder 1965) suggested that Stuart Lake can support a sustained yield in excess of 2 kg*ha^{-1}.

Gill net captures were dominated by suckers and northern pike. Both species exhibited a wide range in size classes. Invertebrate surveys indicate similar community structure and standing crop to lakes in the Turkey lakes watershed and other Algoma Lakes. These data indicate that lake trout enhancement will be successful in Stuart Lake because the physical/chemical conditions and forage base are adequate to support the proposed population.

In summary, Stuart Lake is a desirable experimental lake for examining lake trout - sea lamprey interactions because, 1) Stuart Lake falls near the modes for chemistry and morphometry of Ontario lake trout lakes (Martin and Olver 1976), 2) lake trout (from 1950's stocking) have been wounded by lamprey and 3) lamprey ammocoetes are still present in Stuart Lake tributaries.

II. Manipulation of the experimental lake

Yearling lake trout will be stocked in the experimental lake at the rate of 0.4 kg*ha^{-1} (OMNR) in June, 1990 (and subsequent years). We will be supplementing the yearling stocking with either two or three year old fish from OMNR hatchery stock (20*ha^{-1}) or by introducing juvenile and/or adult lake trout from Lake Superior. We expect high survival from our introductions of older year classes of fish based on results of previous studies (eg. Gunn et al. 1987; Rawson 1945). Details of this introduction will be dictated by the results of preliminary assessment of the remnant lake trout population of Stuart Lake. Our goal will be to produce a realistic size structure through age 6^+ (Table 2). Introduced stocks will be fin clipped and individually tagged (V.I. Tag and Manufacturing, Inc.) to identify source and year of introduction. Application has been made to OMNR for sanctuary status for Stuart Lake to restrict fishing pressure. We will monitor fishing pressure throughout the experiment until sanctuary status is approved. Historical stocking indicates that this lake trout management approach is realistic for Stuart Lake.

We used growth and mortality estimates from Schneider et al. (1983) to project size, structure, and yield of the lake trout population (Table 2). Our projections indicate that approximately 1000 lake trout averaging 1.5 kg will be present from our stocking of yearling and juvenile fish prior to the introduction of sea lamprey transformers. Sea lamprey transformer introductions (see below for details) will be initiated during the third year of the study.

The OMNR currently operates a lake trout stocking program in the Algoma district. In cooperation with OMNR, we intend to monitor lake trout populations in lakes within the Algoma district with similar stocking protocols and lake morphometry to Stuart Lake. These "reference" lakes will enable estimation of natural variability in lake trout dynamics.

A two-way lamprey trap (to be designed by T. McCauley, SLCC-Sault Ste. Marie) will be constructed in 1991 at the experimental lake outlet to control sea lamprey immigration and emigration. The effectiveness of this trap will depend on its ability to trap animals during high water periods. The outlet of Stuart L has a mean annual discharge of .34 m^3*sec^{-1}. Our initial calculations suggest that flow will vary < 50% of the annual mean (T. McCauley, pers. comm) because, a) the drainage area above the lake is small (< 22 km^2) and, b) the lake will act as a reservoir to moderate the variation in flow. Consequently, we should be able to maintain high sampling efficiency throughout the ice-free season. All tributary streams will be surveyed for ammocoete abundance (1990) and subsequently treated with TFM to prevent unknown sources of sea lamprey from entering the lake. Transforming sea lamprey will be stocked in the spring of 1992 and in following years for the duration of the project. The transformers used in this study will be supplied by SLCC-Sault Ste. Marie (G. Weise). Large ammocoetes will be collected and reared to the transformation stage.

Our objective in the first year of sea lamprey introduction will be to impose a lamprey induced lake trout mortality of 75%. Our projection of lake trout biomass (Table 2) indicates that there will be at least 1200 kg of lake trout vulnerable to sea lamprey predation. The parasitic phase submodel (Spangler and Jacobson 1985; Koonce and Locci-Hernandez 1989) is driven by size and number of prey available to sea lamprey. We used this model (Koonce and Locci-Hernandez 1989) to calculate the number of transformers needed to facilitate a reduction of 75% of the lake trout population. The size and number of lake trout was based on our projected population. We recognize that lamprey will utilize other forage fish in the lake and that the number of transformers added to the system will have to account for this using the multi-species disc equation. The IMSL model predicted that 220 feeding phase animals would be required to meet our mortality objectives. An initial transformer mortality of 50% is anticipated (Koonce and Locci-Hernandez 1989). Therefore, we would require approximately 400 transformers for stocking. Transformers will be dye marked (Hanson 1972) to facilitate mark - recapture studies using the protocol of Robson and Regier (1964). In the two subsequent years we will attempt to induce reductions of 50 and 25%, respectively. The number of transformers added will based on the same protocol.

III. Lamprey - Lake Trout Interactions

1) Mortality and Wounding of Lake Trout

The purpose of this component of the study is to quantify the changes in lake trout mortality and growth induced by sea lamprey parasitism. We will make Petersen and Seber-Jolly (Ricker 1975) estimates of abundance and calculate survival during the spring and fall of each year of the study. Stuart L will be fished with monofilament gill nets consisting of four panels of 2.54, 3.81, 5.08 and 6.35 cm stretched mesh and/or with trap nets (6′ box). Nets will be set to straddle the thermocline depth contour. Gill nets will be lifted regularly (1 - 2 hours) to avoid capture mortality. All fish captured will be sampled for fork length, weight, scale sample, and sex if in spawning condition. As well, fish will be examined for tags and wounds induced by sea lamprey. During each fishing period (ie. spring or fall), we will fish at least until M*C > 3*N (where M = number marked, C = number examined for marks, and N = population abundance) to avoid bias in our population estimates (Robson and Regier 1964). We assume that the coefficient of variation in our mark-recapture study will be approximately 20% based on Youngs and Robson (1975). Thus, our sampling protocol will have a probability in excess of 90% of detecting a change in lake trout survival of 7% (Figure 2, Gerrodette 1987). This is within the range of change in lake trout survival we intend to impose with the introduction of sea lamprey transformers. Survival will also be calculated by catch and effort statistics in years 4 and 5 of the experiment. The result will be an accumulation of a parallel time series of growth and survival estimates of lake trout spanning 5 years from both the experimental and control lakes. The data from Stuart L. will cover the 2 years prior to the lamprey introduction and 3 years post-introduction.

Natural mortality in Stuart L. prior to introduction of transformers will equal total mortality from mark - recapture studies. In the reference lakes (Table 4), natural mortality will be determined by the difference between total mortality and fishing mortality determined from stratified random creel surveys. Following the introduction of lamprey, sea lamprey induced mortality in Stuart L will be calculated from the difference between total mortality in Stuart L and the average of natural mortality prior to lamprey introduction and natural mortality calculated from the reference lakes. Mortality will also be partitioned based on SCUBA and/or modified drag surveys (Bergstedt and Schneider 1988) for dead lake trout. We will use a form of randomized intervention analysis (Stewart-Oaten et al. 1986; Carpenter et al. 1989) to determine if patterns of mortality observed in Stuart L. are significantly different from those in the reference lakes.

A second component of this section will enable us to observe the relationships between lamprey wounding of lake trout in Stuart L. and lake trout mortality. The development of this relationship will be dependent on our estimation of survival of sea lamprey transformers and lake trout in addition to the observed wounding rate in lake trout. We will use only wounds acquired during the year of sampling to determine this rate. The estimation of lake trout survival has been addressed above and wounding rate will be observed during the spring and fall sampling periods.

We intend to stock transformers into Stuart L. each spring (see Manipulation of the Experimental Lake for details). Monitoring the abundance of parasitic phase lamprey will be difficult because no efficient method of collection has been developed to date. However, trawl surveys (R.J. Beamish - pers. comm.) have been used with some success in British Columbia. We will explore the feasibility of developing a modified trawl for use in Stuart L. Collection by indirect sampling of parasitic phase animals has been employed by collecting lamprey attached to hosts (R. MacDonald - pers. comm.) and by introducing artificial hosts for mark - recapture studies.

Our sampling will provide us with estimates of lamprey and lake trout abundance along with wounding rates at three different levels of lake trout mortality. This will enable us to derive a relationship between the number of lamprey and the subsequent wounding rate and the rate of lake trout survival.

2) Production and Biomass of the Fish Community

The purpose of this study is to examine the effects of lake trout and sea lamprey introductions on the biomass, production, and size structure of the resident fish community. The resident fish population will be assessed during the bi-annual netting for lake trout. All fish captured will be sampled for length, weight, scales and examined for lamprey wounds. These fish will be tagged and released for Petersen estimates of abundance. Bioacoustic surveys (Kelso and Minns 1975) will be completed twice each summer to assess abundance and biomass of the teleost populations. This community will be monitored before and after lake trout and lamprey introductions for the duration of the study. This will able us to determine the effect of lamprey on non-lake trout species and whether there is a selectivity for lake trout by sea lamprey.

3) Larval Sea Lamprey

We believe that transformers introduced in the experimental lake will mature to the spawning phase because of a favourable temperature regime in Stuart L. and an abundance of prey fish. Counting weirs will be established in the four tributaries of the experimental lake as the temperature approaches the optimal (>10°C) for lamprey spawning runs and the number of spawning sea lamprey will be assessed. Annual fall surveys will be conducted to establish the distribution and relative abundance of ammocoetes. Ammocoetes will be sampled for length and weight. Animals will be marked to identify year class and returned to the stream. These studies will augment previous studies regarding growth and survival of ammocoetes in streams.

4) Examination of Current Assumptions

We have drawn heavily upon the models of Koonce and Locci-Hernandez (1989) in order to determine the number of transformers required to induce a specific mortality in lake trout and the expected rate of marking from these simulated populations. Our observations will allow us to test the hypothesis regarding survival and marking generated by the GLFC models. We recognize that other models of lake trout - sea lamprey interactions exist and others will be generated during this study. It is our intention to assess all points of view in our analysis of these field experiments.

MILESTONES

1990 Complete assessment of resident fish community in Stuart Lake and initiate creel survey on reference lake.

Complete ammocoete distribution surveys in Stuart Lake tributaries and chemically treat areas with sea lamprey.

Initial assessment of stocking success and first year survival and growth.

Annual report to the GLFC outlining initial abundance estimates of resident teleosts and larval lamprey.

1991 Stock yearling trout, supplemented with older year classes, if needed.

Complete technical report of lake trout mortality (literature review).

Primary publication, "Effect of lake trout stocking on resident teleost community structure, biomass and production".

Annual report to the GLFC for 1991.

1992 Annual stocking of yearling trout, supplemented with older year classes, if needed.

Initial stocking of lamprey transformers.

Continuation of reference lake creel surveys.

Assessment of changes in lake trout and other teleost survival, growth, and marking following introduction of sea lamprey.

Annual report to the GLFC for 1992.

1993 Annual stocking of yearling lake trout, supplemented with older year classes, if needed.

Stocking of sea lamprey transformers.

Assessment of changes in lake trout and other teleost survival, growth, and marking from sea lamprey.

Continuation of reference lake creel surveys.

Assessment of sea lamprey spawning and distribution of ammocoetes.

Primary publication, "Initial assessment of sea lamprey induced mortality and wounding of lake trout in relation to lamprey abundance in Stuart Lake".

Annual report to the GLFC.

1994 Annual stocking of yearling lake trout, supplemented with older year classes, if needed.

Final stocking of sea lamprey transformers.

Assessment of changes in lake trout and other teleost survival, growth, and marking from sea lamprey.

Completion of reference lake creel surveys.

Assessment of sea lamprey spawning and distribution of ammocoetes.

Dam removal and chemical treatment of tributaries of Stuart Lake to eliminate lamprey ammocoetes and restore Stuart Lake to its pre-experimental conditions.

Primary publication, "Sea lamprey induced mortality and wounding of lake trout in relation to lamprey abundance in Stuart Lake".

Primary publication, "Effect of parasitic sea lamprey on the survival and production of non-salmonid teleosts in Stuart Lake".

Technical report, "Growth and survival of sea lamprey ammocoetes in Stuart Lake following the introduction of sea lamprey transformers".

Technical report, "Evaluation of current model predictions of sea lamprey-lake trout interactions in relation to the Stuart Lake field experiments".

Project completion report to the GLFC.

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Table 1: Preliminary data collected from Stuart Lake in the fall (October 25-26) of 1989. (a) Summary of water chemistry results; (b) summary of fish species captured in: i. gill net sets and ii. minnow traps.

(a)

Parameter	Measurement
Secci Disc Reading	5.0 m
pH	7.02
Conductivity	42.0 $uS*cm^{-1}$
Alkalinity	11.5 $mg*L^{-1}$
Total Dissolved Solids	32.0 $mg*L^{-1}$
MEI	3.38
Production	2.0 $kg*ha^{-1}*y^{-1}$

(b)

Species (common name)	N	Length (mm)	Weight (g)	CPUE ($\#*m^{-1}*24h^{-1}$)
i.				
Esox lucius (Pike)	10	381 - 696	400 - ~3000	0.039
Catostomus commersoni (Sucker)	20	260 - 467	240 - 1540	0.080
Amblopites rupestris (Rock Bass)	3	122 - 170	90 - 100	0.012
Notemigonus crysoleucas (Golden Shiner)	3	144 - 149	40 - 50	0.012
ii.				
Amblopites rupestris (Rock Bass)	4			
Micropterus dolomieui (Small Mouth Bass)	1			

Table 2. Estimated equilibrium yield from stocking yearling and juvenile lake trout in Stuart L

Age	Length	Weight	G	M	F	G–M–F	YF	STOCK WEIGHT	YIELD	NUMBER OF FISH
1.500	128.000	0.018						72.000		4000.000
			2.433	0.500	0.000	1.933	6.908		0.000	
2.500	299.000	0.205						497.355		2426.123
			1.606	0.500	0.000	1.106	3.021		0.000	
3.500	489.000	1.021						1502.420		1471.518
			0.360	0.350	0.000	0.010	1.010		0.000	
4.500	546.000	1.463						1517.074		1036.961
			0.291	0.350	0.100	–0.159	0.853		154.916	
5.500	597.000	1.958						1294.621		661.196
			0.242	0.350	0.150	–0.258	0.773		198.395	
6.500	643.000	2.495						1000.583		401.035
			0.206	0.350	0.150	–0.294	0.746		150.570	
7.500	685.000	3.067						746.018		243.240
			0.176	0.350	0.150	–0.324	0.723		110.573	
8.500	723.000	3.657						539.527		147.533
			0.146	0.350	0.150	–0.354	0.702		78.785	
9.500	756.000	4.230						378.513		89.483
			0.131	0.350	0.150	–0.369	0.691		54.884	
10.500	787.000	4.822						261.710		54.274
			0.110	0.350	0.150	–0.390	0.677		37.568	
11.500	814.000	5.383						177.203		32.919
			0.099	0.350	0.150	–0.401	0.669		25.299	
12.500	839.000	5.941								

Table 3. Timetable of activities for proposed manipulation of Stuart L.

	1990				1991				1992				1993				1994			
Activity	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W
Yearling Stocking	x				x				x				x				x			
Immature/Adult Stocking	x		x		*				*				*				*			
Gill/trap netting	x		x		x		x		x		x		x		x		x		x	
Bioacoustic census		x				x				x				x				x		
Carcass surveys											x				x				x	
Creel Surveys (reference lakes)			x	x			x	x			x	x			x	x			x	x
Parasitic assessment		x	x			x	x			x	x			x	x			x	x	
Spawning assessment													x				x			
Ammocoete survey															x				x	
Ammocoete treatment		x																	*	
Weir/trap construction							x			x										

x = activity
* = only if necessary

Figure 1. Stuart Lake and its tributaries.

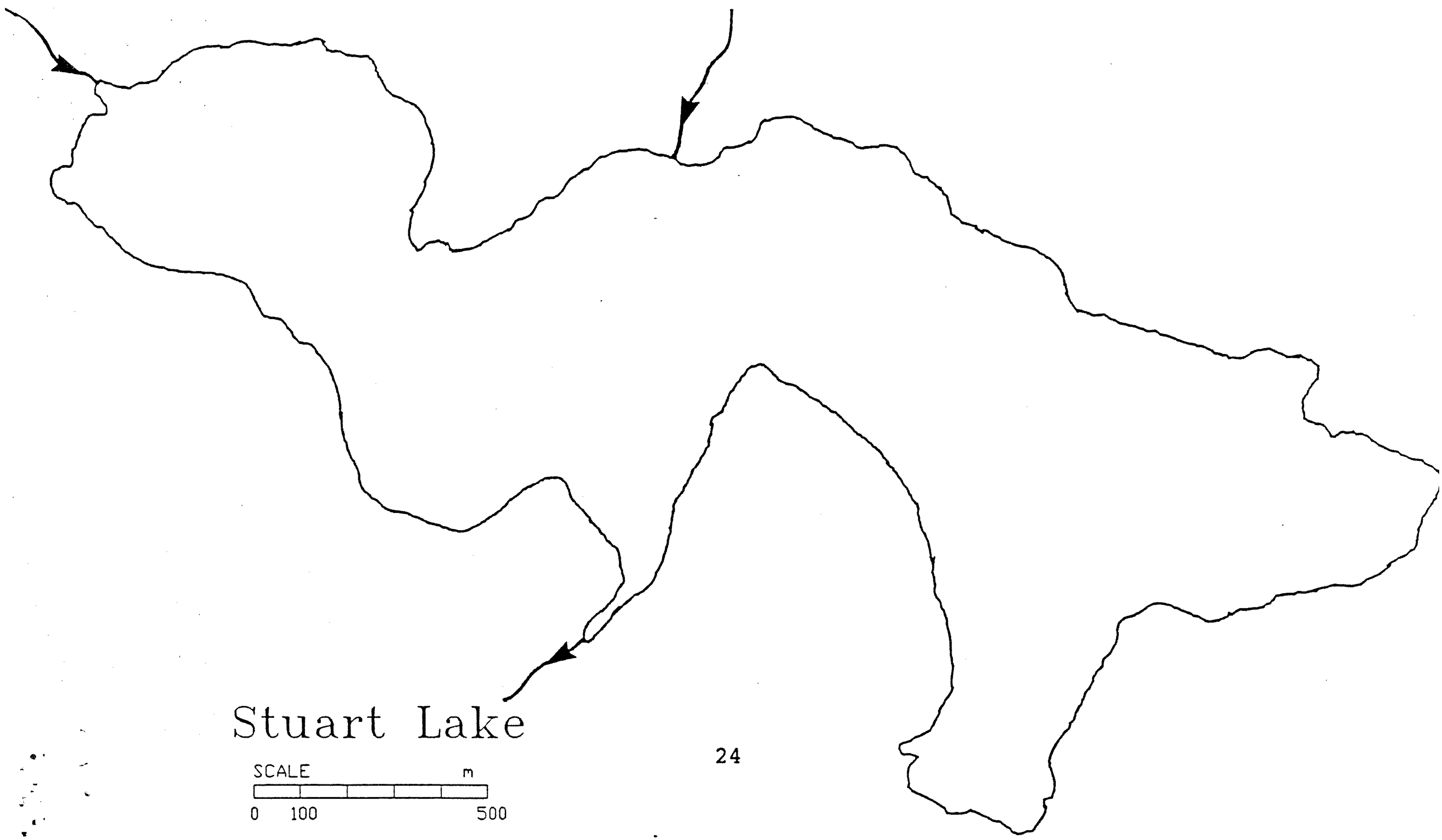
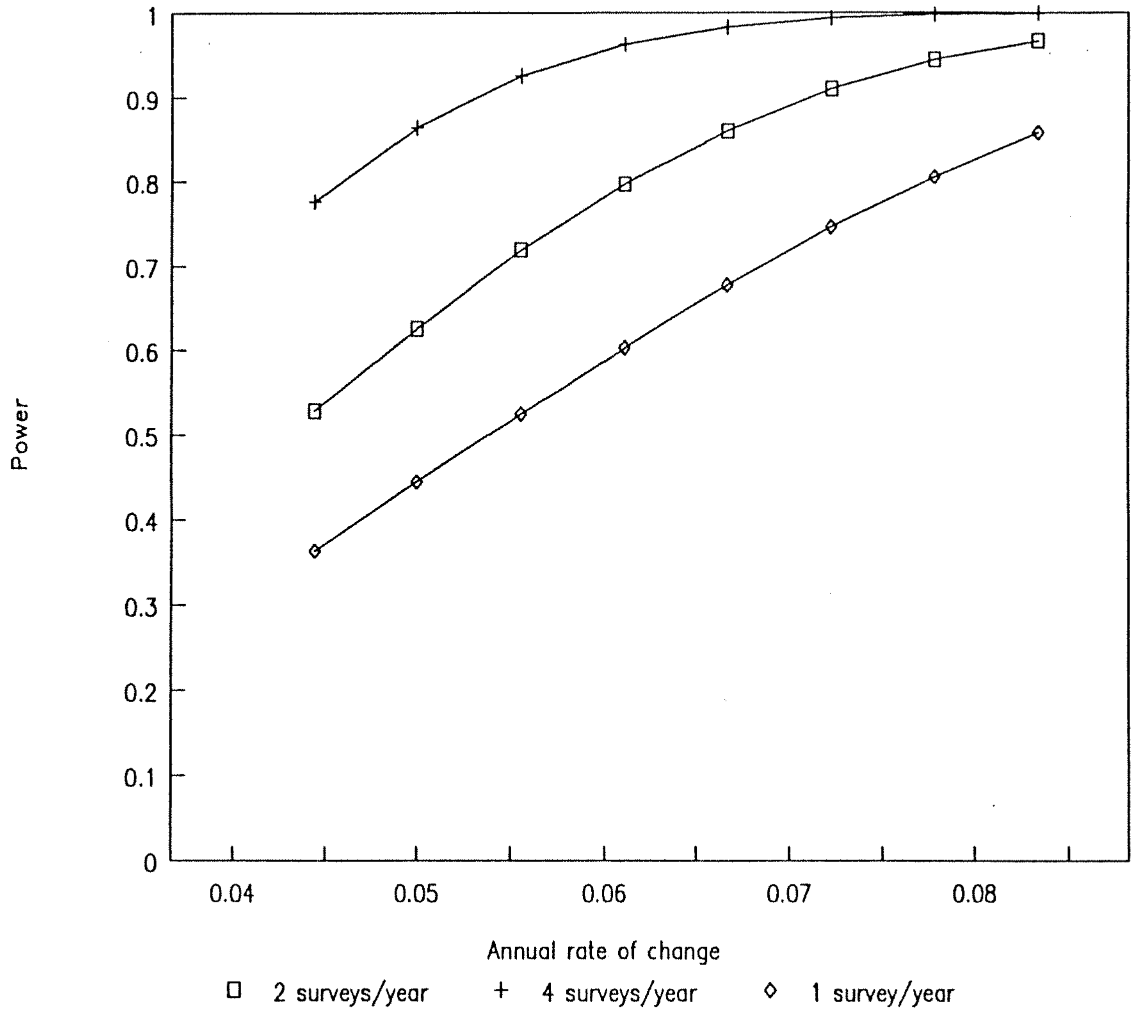


Figure 2. Power analysis as a function of sample size.



Resources requested from GLFC ($000 using 1989 dollars)

	1990	1991	1992	1993	1994
A: PERSONNEL					
Biologists (2)	84.0	84.0	84.0	84.0	84.0
Students (2)	12.0	12.0	12.0	12.0	12.0
Short term field help (creel surveys etc)	6.0	6.0	6.0	4.0	4.0
Total Personnel Costs	102.0	102.0	102.0	100.0	100.0
B: OPERATING COSTS					
Estimated travel expenses (conferences, meetings)	3.5	4.0	4.5	5.0	5.5
Computer expenses:					
data entry	1.0	1.5	2.5	2.5	2.0
other costs	1.5	1.5	1.0	0.5	0.5
Statolith/otolith aging	3.5	0.0	3.5	4.5	5.0
Field Gear	1.5	1.0	1.5	1.5	1.0
Gear/net repair	0.5	1.5	1.0	1.0	0.5
Nets	2.5	0.0	0.0	0.0	0.0
Construction: wiers,traps	0.0	10.0	6.0	0.0	0.0
Vehicle expenses:					
rental/leasing	4.5	4.5	4.0	3.5	3.5
gas,mileage,maintenance	2.5	2.5	1.5	1.5	1.5
snow machine rental	0.0	1.5	1.0	1.0	0.5
Field Expenses:					
water chemistry	2.5	2.0	1.5	1.0	1.0
equipment maintenance	1.0	2.5	2.0	1.5	1.5
lamprey assessment (parasitic & spawning)	3.0	1.5	2.5	2.0	2.0
fisheries assessment	4.5	3.5	2.5	2.0	1.5
carcass survey	0.0	1.0	1.5	1.5	1.5
ammocoete assessment	2.5	2.0	0.0	2.5	2.0
emigration	0.0	1.5	2.0	2.0	1.5
Publication costs	1.0	1.0	1.5	2.0	2.0
Total operating costs	35.5	43.0	40.0	35.5	33.0
Total A	102.0	102.0	102.0	100.0	100.0
Total B	35.5	43.0	40.0	35.5	33.0
Grand total	137.5	145.0	142.0	135.5	133.0

Resource contribution from DFO and OMNR

	1990	1991	1992	1993	1994
A: PERSONNEL (Person Years)					
John Kelso, DFO	0.1	0.1	0.2	0.3	0.3
Ken Minns, DFO	0.0	0.1	0.2	0.2	0.2
Biologist, DFO	0.3	0.2	0.2	0.2	0.2
Technical Support	0.1	0.1	0.1	0.1	0.1
Student Support	0.2	0.2	0.2	0.2	0.2
Scott Jones, OMNR	0.1	0.1	0.1	0.1	0.1
Mike Jones, OMNR	0.0	0.0	0.0	0.1	0.1
Technician, OMNR	0.1	0.1	0.1	0.1	0.1
Total PY's	0.9	0.9	1.1	1.3	1.3
Total Value of PY's ($000)	41.4	41.4	50.6	59.8	59.8
B: OPERATING COSTS					
I. DFO					
Vehicle expences	4.0	4.0	4.0	4.0	4.0
Equipment maintenance	2.5	2.5	2.5	2.5	2.5
Gear/net repair	1.0	1.0	1.0	1.0	1.0
Acoustic maintenance	1.5	1.5	1.5	1.5	1.5
Field disposables	6.0	6.0	6.0	6.0	6.0
Total DFO O&M	15.0	15.0	15.0	15.0	15.0
II. OMNR					
Vehicle expences	3.6	3.6	3.6	3.6	3.6
Snowmachine	1.0	1.0	1.0	1.0	1.0
Field disposables	0.5	0.5	0.5	0.5	0.5
Total OMNR O&M	5.1	5.1	5.1	5.1	5.1
TOTAL OPERATING COSTS	20.1	20.1	20.1	20.1	20.1
Total A	41.4	41.4	50.6	59.8	59.8
Total B	20.1	20.1	20.1	20.1	20.1
Grand Total	61.5	61.5	70.7	79.9	79.9

B: CAPITAL EQUIPMENT	VALUE
I. DFO	
Acoustic Equipment	120.0
Boat, motor, trailer	5.5
Sampling equipment	9.0
Computer facilities	10.0
II. OMNR	
Snow machine	6.0

TOTAL PROJECTED COSTS					
A. Requested from GLFC	137.5	145.0	142.0	135.5	133.0
B. Contributed by DFO and OMNR	61.5	61.5	70.7	79.9	79.9
TOTAL	199.0	206.5	212.7	215.4	212.9