DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
REGION 5

FY09 ENVIRONMENTAL CONTAMINANTS PROGRAM
OFF-REFUGE INVESTIGATIONS SUB-ACTIVITY

NH – Investigation of the Population Decline of Common Loons on Squam Lake, NH

Project ID: New
(filename: New-Squam09.doc)

by

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Environmental Contaminants Specialist

for

Michael J. Bartlett, Field Office Supervisor
New England Field Office
Concord, NH
May 1, 2008

Congressional District #NH-1

II. INTRODUCTION

II.A. Background and Justification

Squam Lake, at 6,800 acres, is the second largest lake located entirely within the boundaries of the state of New Hampshire. By some measures, Squam has the most intensively studied and managed breeding population of common loons (*Gavia immer*) in North America. Concerns of Squam Lake residents about the lake's loon population resulted in volunteer-led efforts to monitor loons in the early 1970s. These surveys led directly to the formation of a statewide loon monitoring and advocacy non-profit organization called the Loon Preservation Committee (LPC). Since 1975, LPC biologists, with assistance from lake residents, have been documenting loon nesting success every year on Squam and over 200 additional lakes and ponds in New Hampshire where loons have been observed. As a result of proactive management tools such as nesting platforms and protective signs and floatlines, Squam Lake had held one of the highest densities of loon territorial pairs found on any lake in New Hampshire over the last decade until the summer of 2005 (H. Vogel, Executive Director, Loon Preservation Committee, pers. comm.).

Change in Squam Lake loon territorial pairs between subsequent years for the period 1975-2005 averaged approximately 10% per year. The three largest deceases documented over that period included 1984-1985 (-16%), 1992-1993 (-14%) and 2001-2002 (-21%). **In 2005, LPC recorded a single-year decline of loon territorial pairs of -44% on Squam Lake. From 16 pairs in 2004, biologists documented only nine territorial pairs in 2005 (Taylor et al 2007). A single-year decline of this magnitude has never been recorded on Squam, or any other large multi-territory New Hampshire lake, in the 32 year history of state-wide monitoring of loons by LPC.** This decline cannot be explained as a dispersal of adult loons from Squam Lake. Evers (2004) noted that "*loons have a poor ability to recolonize new areas. Breeding adults generally do not have intra-season movements > 4 km from their previous-year's breeding territory and have not been recorded dispersing greater than 20 km*.". None of the surrounding lakes having suitable breeding habitat within the documented adult loon dispersal distance from Squam Lake exhibited an increase in numbers of adult loons during the 2005 breeding season. The 2006 LPC breeding survey documented that Squam Lake's loon population (nine territorial pairs) had not recovered from the 2005 decline (Taylor *et al.* 2007). The number of territorial pairs on Squam Lake increased in 2007 (12 territorial pairs, +33%), but reproductive success (0.08 chicks surviving/territorial pair) was the lowest ever recorded for Squam Lake (1975-2005 average of 0.45 chicks surviving/territorial pair) and brought Squam's loon population to its lowest level since LPC began to survey Squam Lake in 1975 (H. Vogel, Executive Director, Loon Preservation Committee, pers. comm.).

Increased human use of Squam Lake, and the establishment of eagles on the lake, might contribute to lowered breeding success of Squam's loons. However, there is no reasonable mechanism to link either of these factors with the unprecedented die-off of adult loons between breeding seasons. This decline has been localized to Squam Lake, making it unlikely that the cause is a contaminant or pathogen acquired on the wintering grounds. Previous telemetry studies on Northeastern common loon populations have documented that New England sub-

populations migrate directly to the New England Coast, ruling out effects from the botulism type E outbreak in Lake Erie and Ontario. **Since loons are recognized as indicators of the health of aquatic ecosystems, the decline of Squam's loons could mark a serious environmental problem on the lake. Squam Lake residents and visitors use the lake as a source of drinking water, for recreation, and for fishing; so the die-off may indicate a potential human health concern.**

New Hampshire fisheries biologists have noted a change in fish community structure in Squam Lake over the last decade with a decline in relative abundance of yellow perch (*Perca flavescens*) and an increase in relative abundance of smallmouth bass (*Micropterus dolomieui*) (NH Fish and Game Department, unpublished data). Levels of contaminants in bass are consistently higher than those in perch from the same watebody (Hellyer 2006) due to the fact that they feed higher in the food chain. Because loons are opportunistic feeders, a diet consisting of a greater proportion of bass could significantly alter the biomagnification of contaminants in Squam. The pattern of adult loon mortality between breeding seasons on Squam Lake suggests two possible causes of this decline: (1) point and non-point sources releasing contaminants that are stored in loon fat or muscle tissue. These contaminants could be mobilized when tissues are metabolized during stress events like the fall feather molt and migration, and therefore result in winter mortality; or (2) lake-specific pathogens (e.g. parasites, fungi, bacteria or viruses) that become acute during autumn stress events such as feather molt and migration, and result in winter mortality.

Beginning in the summer of 2007, the Loon Preservation Committee (LPC), Biodiversity Research Institute (BRI), Tufts University School of Veterinary Medicine (Tufts), the University of New Hampshire (UNH), and the New England Field Office initiated a study to examine possible causes of the loon decline on Squam Lake. Broad objectives of this study include a heavy metal and organochlorine scan of archived and newly-collected inviable eggs, carcasses, and blood samples and sampling blood and carcasses for parasites, viruses, bacteria, fungi and other pathogens. Samples of loon blood, eggs, and carcasses from nearby lakes are being analyzed to provide a comparison for samples from Squam Lake (Appendix 1). We request that FWS Environmental Contaminant Off-Refuge funds be used to examine contaminant levels in fish species used as prey by loons to determine if the levels may be contributing to the decline of the loon population on Squam Lake.

II.B. Scientific Objective(s)

1) Determine the levels of metals and OCs in yellow perch and smallmouth bass from two loon breeding lakes in central New Hampshire (Squam Lake and White Oak Pond). By comparing levels between these two lakes (one that has experienced a loon population decline and one that has not), we will be able to either confirm or refute that prey contaminant levels are contributing to the decline of loon numbers on Squam Lake.

II.C. Management Action(s)

Direct Action:

1) If levels of contaminants found in fish from Squam Lake are significantly higher than those in White Oak Pond, we will seek additional partners (NH DES, NH Fish and Game Department, USEPA Region 1) to expand the scope of the study to look for potential sources of these contaminants in the watershed. Once these sources are identified, we will use existing state and federal water quality regulations to eliminate these point sources.

III. METHODS

III.A. Data Collection and Analysis

A total of 45 individual fish from each species (yellow perch and smallmouth bass) will be collected from each lake (90 fish total) using gill nets and/or electrofishing.[1] The target length for each species will be 10-20 cm, the preferred loon prey size (Barr 1996). Fish will be collected from areas within known loon territories on both lakes. Standard measurements (weight, length, scales) will be collected for each individual fish. Individual fish will be combined into 15 three-fish composites in order to assure adequate sample volume for both metal and organochlorine analysis. All samples will be analyzed using ACF approved methodologies and laboratories.

III.B. Proposed Schedule of Milestones

Summer, 2007: Initial sampling of archived samples and collection of eggs and blood (Appendix 1)

Summer, 2008: Band territorial loons on Squam Lake and White Oak Pond, continue monitoring loon nest success, collection of additional blood, egg, and carcass samples

March, 2009: Meeting with all cooperators to draft work plans and QA/QC SOPs

May, 2009: Work plans and QA/QC SOPs complete

July, 2009: Collection of fish samples and submission to ACF contract labs. Continued sampling of eggs, blood, and carcasses by cooperators

January, 2010: Results arrive back from ACF labs. Begin data analysis and report writing

May 2010: Submission of final report

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[1] Sample size was calculated using Power Analysis on an existing NH DES fish mercury dataset (alpha = 0.05).

IV. REFERENCES

Barr, J.F. 1996. Aspects of common loon feeding biology on its breeding ground. Hydrobiologia, 321: 119-144.

Evers, D. C. 2004. Status assessment and conservation plan for the Common Loon (*Gavia immer*) in North America. U.S. Fish and Wildlife Service, Hadley, MA.

Hellyer, G. 2006. Connecticut River Fish Tissue Contaminant Study - Ecological and Human Health Risk Screening, Ecosystem Assessment Unit, USEPA - New England Regional Laboratory, North Chelmsford, MA., May 31, 2006. 411 pp.

Taylor, K., J.Cooley and H. Vogel. 2007. Summary of Loon Preservation Committee Research and Management Activities for the 2006 Field Season. Unpublished Report to NH Fish & Game Department. Moultonboro, NH.

V. ROLES, RESPONSIBILITIES, AND PARTNERSHIPS

V.A. Roles and Responsibilities

Collection of loon blood, egg, and carcass samples will be the responsibility of LPC and BRI. Pathology analysis of loon carcasses will be the responsibility of Tufts. All fish collection and analysis will be the responsibility of the USFWS with assistance from New Hampshire Fish and Game Department.

V.B. Partnerships

To date, LPC has collected a total of $94,910.00 through various grants. As of April 30, 2008, $31,700 has been expended for metal, OC, PBDE, and PFO analysis on egg and blood samples. BRI and Tufts have committed $5,000.00 for in-kind services (sample collection, pathology). Region 5, FWS committed $4,000.00 (emergency analytical) towards analysis of OC and PBDE analysis on addled loon eggs (Appendix 1). The total amount to date is $108,910.00.

VI. BUDGET

VI. BUDGET					
	Year 1	Year 2	Year 3	Year 4	
EXPENDITURES	FY 2009	FY 2010	FY 2011	FY 2012	All Years
Personnel - Field (Bioday = $700)	$5,600.00	$0.00			$5,600.00
Personnel - Data Analysis	$0.00	$2,800.00			$2,800.00
Personnel - Report Writing	$0.00	$2,800.00			$2,800.00
Travel/Per Diem	$400.00	$0.00			$400.00
Supplies	$150.00	$0.00			$150.00
Equipment	$0.00	$0.00			$0.00
Non-ACF Analytical (see below)	$0.00	$0.00			$0.00
Regional Overhead	$0.00	$0.00			$0.00
					$0.00
Operational Subtotal	$6,150.00	$5,600.00	$0.00	$0.00	$11,750.00
					$0.00
ACF Analytical[a]	$37,200.00	$0.00	$0.00	$0.00	$37,200.00
					$0.00
Total Funding	$43,350.00	$5,600.00	$0.00	$0.00	$48,950.00

[a]60 OC Scans ($400) and 60 metal scans ($220)

VII. FY 2009 REVIEW AND APPROVAL

Proposal Title: **– Investigation of the Population Decline of Common Loons on Squam Lake, NH**

Project ID#: _New_

Submitted by: _____ Date: _____
Contaminant Specialist, Field Office

Reviewed by: _____ Date: _____
FO Supervisor

Reviewed by: _____ Date: _____
Regional Environmental Contaminants Coordinator

Approved by: _____ Date: _____
Assistant Regional Director

NOTE: All On-Refuge proposals must be signed by the Refuge Manager. In addition to the required signatures, proposal authors are free to add to this signature page to include other Project Leaders and Offices (especially when other Service programs are involved) and/or to accommodate the required surname process of their respective Regional and Field Offices.

FY 2009 National Criteria Score Sheet

TITLE: **Investigation of the Population Decline of Common Loons on Squam Lake, NH**

PROJECT I.D.: _New_ REGION: ___ RO RANK: _____ TARGET STATES: _NH___

Pass/Fail Criteria

The investigation proposal ***DOES*** __ ***DOES NOT*** __ pass the minimum required standards of the Environmental Contaminants Program. Note: authors should answer the questions below by keeping either "Yes" or "No" (in accordance with what the response would be) and deleting the remaining part of the "Yes/No" phrase.

Yes/No Proposal clearly identifies (1) an environmental problem related to anthropogenic contaminants and (2) site-specific management actions designed to resolve that problem. If not, explain:

Yes/No The proposal clearly identifies a level of biological impacts that must be investigated. Abiotic only sampling is clearly linked to an established threshold level of concern. If not, explain:

Yes/No At least one substantive peer review has been conducted and is attached. The proposal has been revised as appropriate. The study design is sufficient to meet the objectives of the proposal. If not, explain:

Yes/No The required surnames have been obtained. If not, explain:

Ranking Criteria

For the above referenced proposal, determine a score for each of the following criteria in accordance with the criteria definitions described in Chapter 6 of the investigations manual. Identify the location of the text that supports the score. If you disagree with a score previously provided, explain why.

A. Threats to resources are ***DOCUMENTED (20 pts) or SUSPECTED (15 pts)****.*

Field Office Supporting Text (**in bold**): Section _IIA__, ¶ _2___ Score: _20

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

*B. Management actions are **DIRECT (15 pts)** or **INDIRECT (10 pts)**.*

Field Office Supporting Text (**in bold**): Section _IIC__, ¶ _____ Score: 15
Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

*C.1. The study question(s) or hypotheses being addressed by the investigation **ARE (4 pts) or ARE NOT (0 pts)** clearly stated.*

Field Office Supporting Text (**in bold**): Section _IIB__, ¶ _____ Score: __4

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

*C.2. The study design as described in the proposal **WILL (4) or WILL NOT (0 PTS) answer the study question(s)/hypotheses.***

Field Office Supporting Text (**in bold**): Section _IIIA__, ¶ _____ Score: ____4

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

*C.3. The scope or complexity of impacts being addressed by the investigation **IS (4 pts)** or **IS NOT (0 pts)** appropriate.*

Field Office Supporting Text (**in bold**): Section _Appendix 1____, ¶ _____ Score: __4

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

C4. The most severe type of biological impact addressed by the investigation is an ***INDICATOR OF ADVERSE EFFECTS (4 pts) or ACTUAL ADVERSE EFFECTS (7 pts)****.*

Field Office Supporting Text (**in bold**): Section IIA, ¶ 3 Score: 7
Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

C.5. Source of the contaminant ***IS (3 pts) or IS NOT (0 pts)*** *sufficiently addressed.*

Field Office Supporting Text (**in bold**): Section IIA, ¶ 4 Score: 3

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

C.6. Pathway of the contaminant ***IS (3 pts) or IS NOT (0 pts)*** *sufficiently addressed.*

Field Office Supporting Text (**in bold**): Section IIA, ¶ 4 Score: 3

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

D. Final regional rank order is ___ of ___ proposals submitted. Score:

E1. Regional Performance Score Score:

E2. Total Partnership Effort
Field Office Supporting Text: Section VB, ¶ _____ Score: 5

Regional Office Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

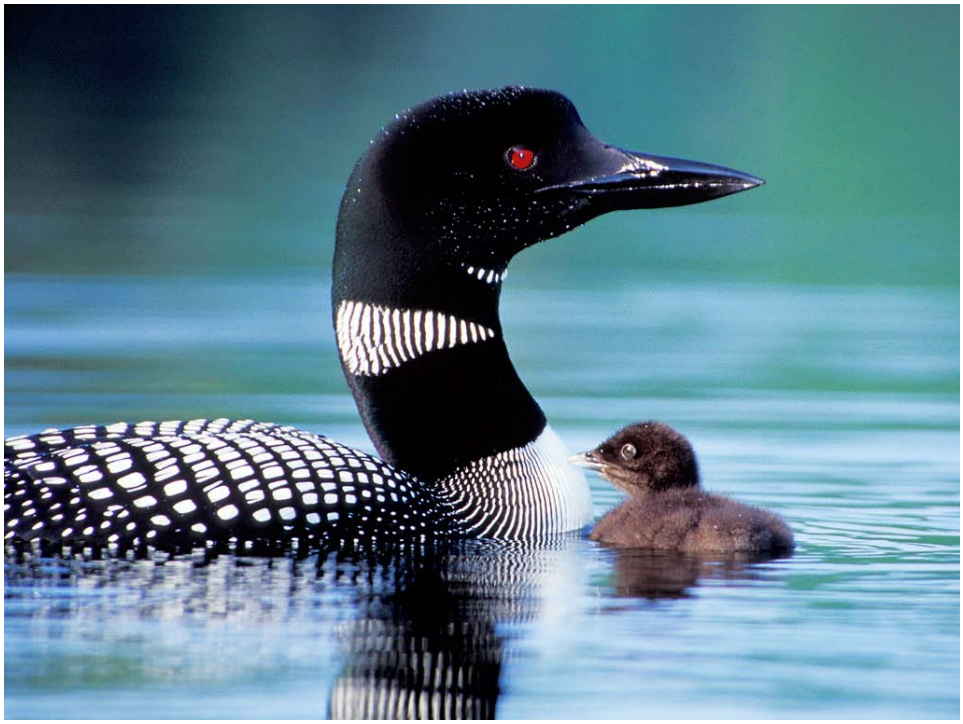
Reviewer Supporting Text: Section _____, ¶ _____ Score:
Explanation (if scores differ):

General Reviewer Comments or Major Concerns:

Appendix 1: The Research Proposal Submitted to The Natural Areas and Wildlife Fund by LPC

An Investigation of the Decline of Squam Lake Loons

A Research Proposal Submitted to
The Natural Areas and Wildlife Fund



Submitted by:

Harry Vogel, Loon Preservation Committee
David Evers, Biodiversity Research Institute
Mark Pokras, Tufts University School of Veterinary Medicine

May 2, 2007

An Investigation of the Decline of Squam Lake Loons

Introduction

Squam Lake holds, by some measures, the most intensively studied and managed population of loons anywhere in the world. Concerns of Squam Lake residents about the lake's loon population resulted in volunteer-led efforts to monitor loons in the early 1970s. These surveys led directly to the formation of the Loon Preservation Committee (LPC) in 1975, and Squam residents continue to actively participate in monitoring the lake's loons. LPC manages Squam's loon population to mitigate the effects of human activities, with the result that Squam has held one of the highest densities of loon pairs found on any lake in New Hampshire.

In 2005, LPC recorded a dramatic single-year decline of seven pairs of loons on Squam Lake (from 16 pairs in 2004 to nine pairs in 2005). A single-year decline of this magnitude (44%) is unprecedented on Squam, or any other large lake, in LPC's 31 years of state-wide monitoring. LPC's surveys in 2006 revealed that Squam's loon population is not recovering from this decline.

Increased human use of Squam Lake, and the establishment of eagles on the lake, might contribute to lowered breeding success of Squam's loons. However, there is no reasonable mechanism to link either of these factors with the large scale die-off of adult loons between breeding seasons. This decline has been localized to Squam Lake, making it unlikely that the cause is an ocean contaminant or pathogen.

Since loons are recognized as indicators of the health of aquatic ecosystems, the decline of Squam's loons could mark a serious environmental problem on the lake. Squam residents and visitors use the lake as a source of household water, for recreation, and for fishing; therefore, the die-off indicates a potential human health concern on Squam as well. Residents have reported changes in fish populations on Squam, including a decline in yellow perch and an increase in smallmouth bass. Food web changes such as these can significantly alter the biomagnification of contaminants in aquatic food webs, and introduce new pathogens into lake ecosystems.

The pattern of adult loon mortality between breeding seasons on Squam suggests two possible causes of this decline: (1) a water-based point source releasing contaminants (e.g., heavy metals or organochlorines) that are stored in fat or muscle tissue. These contaminants could be mobilized when tissues are metabolized during stress events like the fall feather molt and migration, and therefore result in winter mortality; or (2) lake-specific pathogens (e.g. parasites, fungi, bacteria or viruses) that become acute during autumn stress events such as feather molt and migration, and result in winter mortality.

Proposed Study and Investigations

It is imperative that research to assess the presence and impacts of contaminants and pathogens be done as thoroughly as possible, with adequate controls, and as close as possible in time to a mortality event, to determine the cause(s) of a decline. The proposed study includes a thorough investigation, using well-established protocols developed by the Biodiversity Research Institute (BRI), Tufts University School of Veterinary Medicine (Tufts), and the US Fish and Wildlife Service, of contaminants and pathogens that might explain winter mortality of Squam loons. LPC, BRI and Tufts have archived samples of loon eggs, tissues and blood dating back more than 20 years. Broad objectives of this study include a full heavy metal and organic pesticide scan of archived and newly-collected inviable eggs, carcasses, and blood samples of Squam loons; and sampling blood and carcasses for parasites, viruses, bacteria, fungi and other pathogens. A number of blood samples and carcasses will also be tested for PBDEs (flame retardants), which are an emerging concern among wildlife toxicologists. Samples of loon blood, eggs, and carcasses from nearby lakes will be analyzed to provide a comparison for samples from Squam.

Specifically, samples will be tested for 16 heavy metals, including mercury, lead, arsenic, aluminum, selenium, magnesium, and manganese; organochlorines including PCBs (polychlorinated biphenyls), DDT and its derivatives such as DDE, dieldrin, heptachloradane (insecticides); other organic pollutants such as polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), organophosphorus insecticides (OPs), polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs, or flame retardants), and other insecticides and herbicides; viruses such as those causing West Nile Virus, avian influenza, and paramyxovirus; bacteria such as those causing botulism and salmonella, as well as cyanobacteria (blue-green algae) toxins; fungi causing aspergillosis, a disease of the respiratory tract of loons and other birds; and parasites such as leaches, trematodes, cestodes and nematodes. We will determine the presence and concentrations of these contaminants and pathogens in samples collected before and after the decline of loons on Squam, and from nearby lakes that have not experienced a die-off, to determine factors that might account for the decline.

The proposed project also includes an extended field season for an LPC field biologist to conduct early season surveys on loons to determine survival of previously banded and sampled loons, and to relate survival to contaminants and pathogens identified in samples; to identify abnormal behaviors and assess breeding success, and relate them to contaminants and pathogens; and to assess summer and fall mortality and locate loon carcasses through contact with residents, regular observations, and shoreline searches. A Tufts University intern will perform necropsies to identify and quantify parasites and other pathogens, and sample tissues for contaminant analyses. A team of biologists from Biodiversity Research Institute, LPC and Tufts University will band loons in the summer of 2007 and take blood samples to test for contaminants and pathogens.

We anticipate that the proposed investigations will help avoid future declines of loons on Squam Lake or on other lakes; bring to light what could be a much larger, more systemic problem on Squam indicated by the decline of loons; and educate ourselves and the public about loons and the factors affecting loons on Squam Lake and state-wide. Comprehensive analyses of blood, tissues and eggs have not been undertaken in loons, or on Squam Lake. The results of this study will provide basic knowledge of contaminants and pathogens in loons that is lacking at present, and baseline data which will be invaluable to assess changes in the presence and concentrations of these contaminants and pathogens in the future.

The Loon Preservation Committee's mission is to restore and maintain a healthy population of loons throughout New Hampshire; to monitor the health and productivity of loon populations as sentinels of environmental quality; and to promote a greater understanding of loons and the natural world. The unprecedented decline of adult loons on Squam demonstrates that LPC's work, and the investigations promised in this proposal, have never been more relevant and critical to loon preservation. The studies we are recommending in this proposal will provide insight into loons, into the effects of individual and combined stressors on Squam's loon population, and into possible ecosystem-wide consequences of contaminants and pathogens on Squam.

Budget

The appended budget includes $20,000 of income pledged by an LPC member; $2,000 of income from pledges collected in support of an LPC member's swim across Squam Lake; $4,000 committed by the US Fish and Wildlife Service for analyses of organochlorines and PBDEs (flame retardants); $4,000 from the Squam Environmental Preservation Fund; $3,000 from the Loon Preservation Committee, to be supplied from operating funds supplemented by other grant funds as available; $5,000 from Biodiversity Research Institute; and $5,000 from Tufts University. In addition to these committed funds, LPC members and staff will be approaching individual Squam residents to contribute toward the research outlined in this proposal.

If awarded, funding in the amount of $5,000 from the Natural Areas and Wildlife Fund will help ensure that this critical research to address the decline of loons on Squam will go forward, and will help to leverage other funding from Squam residents and from foundations. Thank you for your consideration of this proposal.