

**Pacific Salmon Foundation  
Strategic Salmon Recovery Plan  
2006 FINAL REPORT - UBC study**

**Submitted to:**

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**Proponent and Project Background**

**Squamish Watershed Salmon Recovery Plan (SSRP)**

**Project Title:** Survival assessment of coho salmon smolts from the Squamish River watershed during the downstream and early ocean migration

**Project Activity Type:** Stock Assessment; Research project

**Target Species:** Coho salmon

**Project Review and Application Authorization:**

Has this project been reviewed by relevant government agencies and authorities to ensure compliance with current and emerging policy, to reduce redundancy and duplication of similar works and to create opportunities for leveraging and synergistic cost sharing or scientific data sharing  YES  NO

**Applicant Information**

**Applicant's Legal Name:** Michael C. Melnychuk

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**List Subcontractors and contact information:** N/A

**Project Information**

**Amount Requested from the PSF:** \$10,000

**Total Project Value:** \$111,895

**Is this project a result of a previous PSF Project?**

**YES (partly)**

**Project Start Date:** May 15, 2006

**Project End Date:** Dec. 31, 2006

## Project Relevance and Significance

### Brief overview of the project:

Many salmonid populations in British Columbia have declined over the last couple of decades, largely as a result of decreased marine survival rates that do not include fishing. Data are scarce for most salmonid populations in B.C. including those of the Squamish River watershed, but the few populations that have been monitored showed such declines in marine survival rates during the 1990s. Causes for the declines in marine survival rates are not well understood. Before these causes can be properly addressed, we need to better understand the patterns of mortality—where and when mortality predominantly occurs during the first few months of ocean life. These patterns have traditionally been difficult to study in the ocean, especially in juveniles, but recent advances in acoustic telemetry technology have made it possible to gain detailed information on fish migrations. By deploying a series of acoustic hydrophone receivers in strategic listening lines on the seabed in coastal areas where salmon migrate, it is possible to track the movements of individual salmon implanted with acoustic tags and estimate survival rates of populations. These patterns will better allow us to understand the causes of mortality, which in turn will be necessary for recommending appropriate management and policy options in order to conserve and/or rebuild Squamish River watershed salmonid populations.

We conducted a study in 2006 combining radio-tagging and acoustic-tagging to monitor the migrations of juvenile coho salmon and estimate specific times and locations of mortality in-river and in Howe Sound. This work follows up on similar studies in 2004 and 2005 as we try to build a time-series and address inter-annual variation in survival. We used the POST project's stationary array of hydrophone receivers in Howe Sound and simultaneously conducted a mobile sampling program for acoustic tags to look at more detailed movement and mortality patterns. Also in 2006 we began a radio-tracking project to monitor the downstream migration of radio-tagged fish in order to calibrate measures of survival from acoustic-tagging methods, study in-river predation in more detail, and assess tag-related effects on swimming speeds and survival since the radio tags were considerably smaller. Through a combination of support from the POST project and another small grant, we had sufficient funding to cover the acoustic tracking portion of our study in 2006. We used the PSF funding specifically to fund the radio-tracking portion of our study described in our proposal.

In-river detection rates of radio-tagged fish on radio receivers were lower than those of acoustic-tagged fish on acoustic receivers. This is most likely due to the small-sized radio tags necessarily having low power output (they're called Nanotags for a reason!). The small-sized radio tags would have been ideal for being able to assess tag-related effects of the larger acoustic tags, but the low detection rates will make this difficult to assess. We are currently analyzing both radio and acoustic in-river detection data from the Cheakamus and Squamish Rivers, and are waiting for stationary receiver data from ocean lines before we can properly estimate mortality rates. However, we do have preliminary results from the mobile tracking portion of our study in Howe Sound. We ran transects in Howe Sound in May as the coho smolts migrated through the sound, and then repeated a full sampling effort later in August to verify tag locations previously detected in May, as well as some new locations, reasonably representing approximate locations of mortality. These inferred locations of mortality are shown in Figure 2 along with ones from 2004 and 2005.

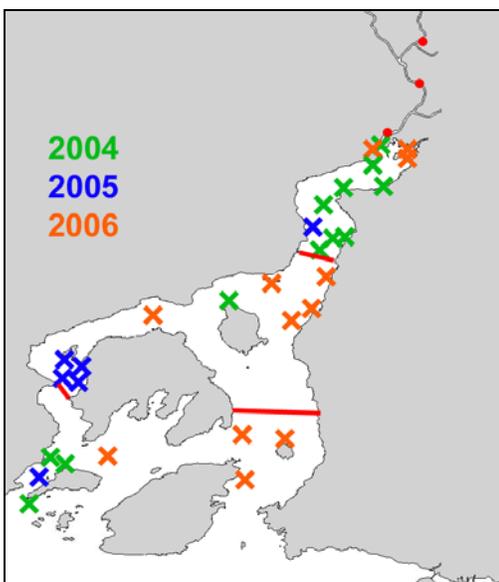


Figure 2. Locations within Howe Sound where acoustic tags stopped moving in 2004 (12 tags, green X's), 2005 (6 tags, blue X's), and 2006 (12 tags, orange X's). Tags were implanted into coho smolts at the Tenderfoot Creek hatchery, and X marks are likely reasonable approximations of where mortality occurred. 100 fish were tagged in 2004 and 2005, with 120 tagged in 2006. Locations were identified with our mobile sampling program.

## **Relevance and significance to the PSEF Recovery Plan.**

Pacific salmon are one of the most important natural resources in British Columbia, economically and culturally. In previous years, salmon sport fisheries have contributed millions of dollars annually to local and provincial economies. Coho salmon have been a main target species for decades among recreational fishermen in Howe Sound. Serious declines in stock sizes have had an immense socio-economic impact on sport fisheries on the Pacific coast and now threaten the future of salmon populations and sport fisheries alike. It is hypothesized that the problem of declining stocks is directly related to marine factors, but little attention in salmon research is focused on the marine environment or during the downstream migration after smolting. Devoting research funds to marine studies is likely to generate novel and crucial information for uncovering the problems which salmon stocks face. Before the reasons for these abundance declines can be addressed, we need a greater understanding of where and when juvenile mortality occurs in the ocean.

Educationally, the data resulting from the project will add to the existing body of scientific knowledge about migration routes of coho salmon during early ocean life. The marine phase of salmon life cycles is poorly known compared to the freshwater phase, yet marine factors are believed to be a greater contributor to the declines of these stocks. Research relating to the marine phase of salmon ecology will likely generate valuable information about patterns and possible causes of mortality. This will be a rigorous, peer-reviewed study that we hope will ultimately benefit salmon stocks, fisheries managers and users of the resource.

## **What species and life stage does this project target:**

This project targets the smolt stage of coho salmon because a large proportion of marine mortality is believed to occur early in ocean life or during the downstream migration. Mortality of smolts will be studied during their downstream migration and in their first few months of ocean life, through Howe Sound and out into the Strait of Georgia.

## **Specific objectives expected to be delivered by the end of this project:**

### **Objective # 1 – Assess in-river mortality causes during downstream migration.**

This objective is a detailed survey of coho smolt migrations down the Cheakamus and Squamish Rivers specifically with the intent of locating tags of coho that may have been eaten by predators. We used radio-telemetry with a combination of fixed station tracking and mobile tracking to monitor the downstream migrations of fish and determine the fate of individual fish with respect to predation mortality. Since the 2006 mobile tracking portion of our study was funded right before our field season, we used the PSF funding for this radio-tagging portion of our overall study, which existed in conjunction with the already-existing downstream monitoring of smolts with acoustic tags. Radio telemetry does not work well in ocean waters, so this part of the study was limited to the initial migration between Tenderfoot Creek and the Squamish River mouth.

This radio-tracking program will hopefully also help to measure the tag-related effects on survival of coho smolts tagged with acoustic transmitters. The radio tags we used are the smallest radio/acoustic tag built with sufficient battery power to last several weeks. We expect that, because they are smaller, these Lotek “Nanotags” will have less of an effect on salmon smolts than the slightly larger acoustic tags (which themselves are small by comparison to only a few years ago). By comparing the downstream survival rates of smolts with acoustic tags to those of smolts with radio tags, we will assess the difference in tagging effects between the two technologies (although our conclusions may be limited due to the lower detection rates of radio tags that we observed).

### **Objective # 2 – Continue monitoring of early marine mortality rates of Tenderfoot Creek coho salmon.**

Several researchers in the past have estimated mortality rates of juvenile salmonids during freshwater life or have followed tagged fish around on a boat to determine movement patterns. This is the first time, however, that a large tracking array has been established on the appropriate scale of the migratory ecology of these fish. In other words, the POST array occurs on a large enough scale that migration rates and routes can be traced over several hundreds of kilometres, and mortality rates can be estimated during this migration. We aim to quantify the spatial and temporal patterns of mortality in coho salmon from the Squamish River watershed during their downstream and early ocean migration through Howe Sound using a combination of POST’s stationary receiver lines and mobile sampling.

**Objective # 3 – Assess potential effects of UV radiation on survival.**

This objective is an experimental evaluation of the possible effects of UV on early ocean survival in juvenile coho salmon. UV radiation has been proposed as one possible cause for the declines in salmon survival rates that have occurred simultaneously on both coasts of North America in sunny regions (Walters and Ward 1998). The common factor in all these cases is rearing in shallow water of streams or hatcheries and hence exposure to UV-B radiation. UV may damage DNA that codes for enzymes that are needed for saltwater life, while the juveniles are still in shallow streams or hatcheries during their freshwater phase; this damage may not be naturally repaired immediately for such enzymes, since they are not induced or actively produced until ocean entry. The coho smolt mortality patterns seen in 2003-2006 were not highly concentrated in one particular area, which might have suggested a high localized predator density was responsible for high mortality in a specific area. Instead, mortality locations have been widely distributed throughout Howe Sound in various habitats, which might suggest that smolts are physiologically impaired and die at variable times during their early migration (impaired smolts are likely more susceptible to predation). Our observations of high, scattered mortality patterns in coho salmon soon after ocean entry over the past three years suggest that the possible cause of UV damage should be addressed. As UV incidence levels continue to rise at latitudes where stream-rearing juvenile salmon live, such effects could have further disastrous effects on salmon survival in the years to come.

We will be assessing whether there are differences in survival between these groups in 2006 once we receive the detection data from the stationary receivers. The experimental setup for the 2006 year was not ideal, however, since both groups received considerable shade during the day as a result of the high-walled tanks that were used in the year leading up to the 2006 release. We found different tanks to use for the fish that will be released in 2007; we are repeating the split-group experiment with UV-shading of one group, and we anticipate a greater chance at detecting a difference in survival for the 2007 groups.

**Objective # 4 – Contribute to a time-series of salmonid demographics data in the Squamish Watershed.**

The best way to develop a broad understanding of the ecology of a certain salmonid population or of populations from a specific area is to study multiple aspects of its life cycle. For example, the Keogh River on northern Vancouver Island has a comprehensive monitoring program of steelhead and coho salmon. The counting fence allows for enumeration of both outmigrating smolts and returning adults; total marine survival rates can therefore be calculated. Salmonid research programs in the Squamish River watershed have been expanding in recent years. For example, research programs for counting steelhead spawners and outmigrating salmon smolts (steelhead, coho, chinook, pink, chum) are underway in the Cheakamus River, largely funded by BC Hydro. Adding to this body of knowledge our proposed research on the downstream and early ocean mortality in Squamish watershed coho smolts would contribute to the bigger picture of understanding salmonid ecology in this region.

**Field methods and post-project monitoring and reporting plans:**

Our project team built on the 2003-2005 studies to continue our mortality and migration investigations of juvenile coho in Howe Sound. In collaboration with POST, we deployed a stationary array of acoustic hydrophone receivers in and beyond Howe Sound to determine when smolts enter the Strait of Georgia, how long they remain there, and whether they leave for offshore waters via either the Queen Charlotte Strait to the north or the Strait of Juan de Fuca to the south. We are currently waiting to receive these 2006 data for analysis. Hydrophone receivers were anchored to the seabed, arranged in 'listening lines' to monitor when individual tagged smolts swam across a line of receivers. This will allow us to reconstruct the migration pathways of these fish and estimate stock survival in the first few weeks of ocean life. To complement these data, tagged smolts were actively tracked from a boat after they leave the Squamish River and enter Howe Sound. This will reveal more detailed patterns of movement and times and locations of mortality— information that is needed before the causes for the extremely high mortality rates seen in recent years can be determined. For additional details on the methods used in these portions of the study, see our project proposal. We will describe the radio-telemetry methods in greater detail here, as this was the portion of our study funded by PSF.

***In-river radio telemetry:***

At the Tenderfoot Creek Hatchery, 20 juvenile coho were tagged with internal radio transmitters surgically implanted. These fish were held for about 1 week before releasing them with the other hatchery coho. We set up 2 fixed radio

**Pacific Salmon Foundation Strategic Salmon Recovery Plan  
2006 Interim Report**

receiver stations between Tenderfoot Creek and the Squamish River mouth, one on the North Vancouver Outdoor School grounds, and the other on the banks of the lower Squamish River to detect tagged fish as they pass by. We also used mobile radio telemetry to search for tags along the river. Radio tags can be detected whether they are in water or on land, so we walked along the river bank until a tag was detected. On foot, we found one tag in the Cheakamus River just below the confluence with Tenderfoot Creek, but were unable to decode the tag. A few days later we followed a signal slightly further downstream and were able to decode a tag. We did not recover the tag, but triangulations clearly showed that the tag location was about 50 away from the river up a shallow bank, towards the treeline. The transported tag leads us to believe that bird predation may have been involved, but this remains as speculation. We are currently analyzing the detection data from the fixed-station receivers, and will include details in our final report.

**If required, has the design been approved by a Professional Engineer and/or Biologist? YES**

**Is this project utilizing recognized or emerging technologies? YES**

The ability to track fish in the ocean with acoustic telemetry has been around for decades and is well-recognized as a valuable tool. Recent advances in the technology, however, have made it possible to implant transmitters into small fish like salmon smolts. Further, the large-scale design of the POST project has provided a common tracking array allowing scientists to tag fish from several different stocks in order to study their mortality and migration patterns with the same set of acoustic receivers. This is the first time such a large-scale telemetry array has been used in the ocean to quantify mortality rates of several populations of migrating fish.

**Will this project require long-term maintenance? NO**

Howe Sound will hopefully be a principal study area for acoustic tag and tracking research over the next several years. Using the same study area, we will be able to quantify year-to-year variability in mortality and migration rates. Existing arrays of receivers outside of Howe Sound deployed by the POST project will allow coho smolts to be detected if and when they migrate out of the Strait of Georgia system. Additional funding from other sources is secured for this larger-scale acoustic tracking array in the Straits of Georgia, Queen Charlotte, and Juan de Fuca, as well as off the coasts of Washington State and South-east Alaska in 2006 and 2007. This project has specifically been concerned with continuing the Howe Sound portion of the overall study, which has generated important results over the initial few years.

## **Performance Expectations**

### **Measures of Success**

We consider success to be achieved when locations and times of mortality of coho salmon are quantified during their downstream and early ocean mortality through Howe Sound. This will allow us to determine the proportion of total marine mortality that occurs in the first few weeks of ocean life in coastal areas, or during the downstream migration. Being able to partition mortality levels into different phases of downstream migration and ocean life will assist fisheries managers to make more reliable stock assessments, which in turn will inform management decisions for this valuable resource. The patterns of mortality we find may hint at likely causes for high mortality rates, and in-river we attempted to evaluate this with our radio telemetry program. Our combination of active and passive acoustic tracking in Howe Sound has allowed us to gain much information on the fate of individual smolts. This will be especially important in 2007 for detecting differences in mortality patterns between UV-exposed and UV-shaded groups of tagged coho smolts. Thus our third measure of success, and potentially our most important finding, will be in determining whether UV exposure during freshwater life affects survival during early ocean life. If this is found to be a cause of mortality this would become a major concern across North America, especially as the incidence of UV radiation reaching Earth continues to rise. There could then be a reasonable explanation why survival in various salmon populations separated by large distances has declined simultaneously over the past two decades. The experimental setup for the 2006 release group was not adequate enough to provide large differences in UV exposure (one of two tanks was shaded from above, but both tanks had high walls and were thus largely shaded by sunlight during most daylight hours in winter sunlight). We changed the experimental setup for the 2007 release group so both groups receive more sunlight and the treatment group continues to be shaded from UV radiation.

**Pacific Salmon Foundation Strategic Salmon Recovery Plan  
2006 Interim Report**

**Milestones**

All work for this project will be completed in 2006. We used all available project funding for our 2006 field season, specifically for the radio-tracking component outlined in our proposal. We intend to hopefully continue our study into 2007, especially to assess survival differences between UV-exposed and shaded fish, but that work will fall under the proposal which we will soon submit for our proposed 2007 field study.

<b>Task</b>	<b>Completion Date</b>
Set up UV-shading experiment at Tenderfoot hatchery for fish that will be released in 2007	June 1, 2006; <i>completed</i>
Complete all radio tracking and acoustic mobile tracking field work for 2006	August 2006; <i>completed</i>
Retrieve stationary receivers for POST project	Oct. 2006; <i>completed</i>
Analyze detection data, migration routes, and mortality patterns of radio-tagged and acoustic-tagged coho salmon	November 2006
Complete analysis and assist in POST write-up of overall summary of 2006 work for disseminating results to public in form of a newsletter mailed out	December 2006
Write a final report of 2006 field season and submit to Pacific Salmon Foundation/Squamish Watershed Salmon Recovery Plan	December 2006

**Project Budget**

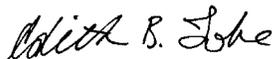
Through the POST project, 2006 funding from other sources was secured for the tagging of 100 coho salmon smolts from Tenderfoot Creek Hatchery as well as deployment, retrieval, and equipment costs of stationary lines of VR2 receivers outside of Howe Sound and one line within Howe Sound (UBC is paying for the second Howe Sound line in 2006). This project budget is not concerned with those expenses, but only the expenses for this Squamish watershed & Howe Sound portion of the overall study. To reduce total costs, we borrowed equipment from various colleagues, which we considered to be in-kind expenses in our attached budget. The POST project provided the acoustic receivers for the Howe Sound lines; colleagues in Seattle loaned the mobile acoustic receiver; and colleagues at UBC loaned their radio tracking equipment for fixed-station and mobile tracking. Several researchers and volunteers from the UBC Fisheries Centre were involved in the Howe Sound project. The Vancouver Aquarium Marine Science Centre is also involved, through raising public awareness of the ongoing research and disseminating the results to the general public (see link on POST website). Please see the interim budget enclosed in the accompanying file, "Melnychuk\_2006\_grant\_SSRP\_interim\_Budget.xls".

**Certification**

**I certify that the information provided in this application, including all attachments, is accurate to the best of my knowledge and that I am authorized to sign on behalf of the stated organization.**

**Signature:**

**Date:** Nov. 5, 2006



**for Michael Melnychuk (electronic signature)**

**Name:** Michael Melnychuk  
(Print Name)

**Please attach proposal, maps and other relevant document**