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Date Received: 4/15/05

PROPOSAL SUMMARY PAGE
(To be filled in by proposer)

Project Title: Using otolith chemical analysis to determine larval drift of Prince William Sound Pacific herring (*Clupea pallasii*)

Project Period: Federal fiscal years October 1st 2005 to September 30th 2006 FY 06-FY07

Proposer(s): Dr. Nate Bickford, NSF Polar Programs Post-Doctoral Fellow, Host Institution: University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, PO Box 757220, Fairbanks, Alaska 99775-7220, nate@sfos.uaf.edu

Dr. Bickford's training is as a hydrogeochemical ecologist, with expertise in otolith chemistry, stock delineation, tracking fish movement and identification of essential fish habitat.

Study Location: Prince William Sound

Abstract: Chemical analyses of herring otoliths can be used to consider the effect the *Exxon Valdez* oil spill continues to have on the recovery of the herring population in PWS. Studying the regional elemental signatures within the core of the herring otolith enables researchers to identify the spawning areas (Objective 1), and the edge of the otolith will identify nursery area (Objective 2). The 3D-PWS model describing larval drift and larval retention in PWS (Norcross et al., 2001a) has never been field-tested. Comparing the two methods for describing larval drift could validate this model as a tool for understanding the impediments to herring recovery in PWS (Objective 3). With these otolith chemical data combined with the 3D-PWS model, fishery managers will have the tools necessary to better predict recruitment and estimate herring spawning habitat recovery.

Funding: EVOS Funding Requested: FY 06 $ 52,211.00 (includes GA)
(Includes University Indirect cost)
TOTAL: $52,211.00

Non-EVOS Funds to be Used: FY 06 $ 0

TOTAL: $52,211.00

Date: 12 April 2005

(NOT TO EXCEED ONE PAGE)

I. NEED FOR THE PROJECT

A. Statement of Problem

It is important to quantify the effect that oiling of specific spawning beaches had on survivorship of larval herring and successful transport to nursery grounds. To date there has been no way to validate correspondence between spawning and nursery locations for Pacific herring in Prince William Sound (PWS). A model (3D-PWS model) developed for studying the passive transport and distribution of Pacific herring (*Clupea pallasii)* larvae in Prince William Sound (Norcross et al., 2001), has yet to be field-tested. Validation of this model demands that herring larvae be physically tracked from the natal origins to fjords and compared to the prediction model. Traditional mark-recapture techniques are cost prohibitive and ill-suited to this task, while otolith elemental signature analysis offers a researcher a means of identifying the temporal and spatial migrations of larval and juvenile herring. The identification of elemental signatures from natal spawning areas could validate a larval drift model. Pacific herring have not recovered from the 1989 Exxon Valdez oil spill; the validation of a tool describing the potential transport of herring larvae from spawning sites to nursery areas would aid researchers in understanding the recovery status of herring and achieve the goals of the 1994 Restoration Plan.

The toxic effects of the 1989 *Exxon Valdez* oil spill on Pacific herring caused the fishery to be closed in 1989. The stock collapsed in 1993 due to viral hemorrhagic septicemia virus (VHSV); the fishery was closed from 1994-1996 (Marty, 2003). The herring stock was expected to recover in 1999 (Morstad, 1999) but instead it crashed again. The Sound Ecosystem Assessment (SEA) project initiated an integrated multi-investigator ecosystem approach from 1994-1998 (Cooney, et al., 2001). SEA had a component identifying impediments to recruitment during the early life history stages of Pacific herring (Norcross et al., 2001a). The established linked between spawning adults, embryo, and juveniles led to the development of a three dimensional numerical ocean current model for PWS (3D-PSW model) as a tool to study the potential transport of herring larvae from spawning sites to nursery areas (Norcross, 2001a). Although this model cannot predict the percentage of larvae retained in nursery bays it can model the retention mechanisms of PWS circulation and localized variation through time (Norcross, 2001a). Assuming that larvae advected from PWS are lost, retention of larvae in bays and fjords is central to the recovery of this species. Survival of herring in the individual rearing bays of PWS is not equal (Norcross, 2001b); therefore, validation of this model can help researchers to understand the mechanisms impeding herring recovery.

The 3D-PWS model needs to be tested using scientifically accurate means; one practical method is otolith chemical analysis. Traditional genetic methods of establishing the geographic structure of fish populations cannot directly measure or specify the origin of individuals (Thresher, 1999). The biochronological information gained from otolith chemical composition is unparalleled for its precision at creating retrospective positioning for individual fish in space and time (Campana & Thorrold, 2001). Chemical analysis of trace element concentrations in otoliths can be used to identify the geographic signatures of natal habitats used by fishes captured either as juveniles or adults.

The lifecycle of Pacific herring in PWS is conducive to otolith chemical analysis. Herring are demersal spawners that seek out kelp in sub-tidal waters to fertilize and deposit their eggs (Norcross et al., 1996). Four-year-old adult herring migrate in late March to spawn on 23 – 168 km of coastline in PWS (Norcross et al., 2001a). Spawning in mid-April, much of the herring eggs are lost to predation, wave-action, and exposure (Rooper et al., 1999). The surviving herring eggs incubate in these spawning areas for about 24 days before hatching as larvae in May (Brown et al., 1996b). After herring larvae are advected from spawning areas, the planktonic larvae drift through the open water of PWS pushed by surface currents, buoyant forces, and meteorological forces (Brown et al., 1996b). Metamorphosis of the larval herring begins to occur in June of that same year (Stokesbury et al., 2002). The herring then become nektonic and swim to favorable habitats and are no longer at the mercy of the currents. In August, the young herring begin to form schools and aggregate at the heads of bays far from coastal waters (Brown et al, 2002; Stokesbury et al., 2000). These populations stay isolated in their respective nursery bays until June of their second year (Stokesbury et al., 2000). At that time this cohort of herring leaves the bays and joins adult schools (Stokesbury et al. 2000).

Throughout the life of a herring, as it migrates among in PWS fjords and bays, the trace element content of the water is recorded in the otolith. This creates a permanent record of habitat use by an individual fish. Otolith bands are accrued during the fish's time of residence in the spawning areas, thus recording the unique spatial chemical signatures. Otoliths are single cellular crystalline deposits of $CaCO_3$, in the form of aragonite, within an otolin-1 protein matrix. There are three calcified otoliths structures found in teleosts; the sagittae is the largest and most studied (Wright et al., 2002). Otoliths are formed in the latter part of the egg stage. The initial deposition of material becomes the core of the otolith (Wright et al., 2002). As the juvenile herring grows it accretes bands of new material, which surrounds its original core deposit. Daily bands, monthly bands, and yearly bands are accrued as layers. Growth is recorded as assorted bandwidths inside the otolith, much as a tree accumulates annual rings. The daily, monthly, and annual bands have long been used as detectors of age and growth rate in fish (Campana & Thorrold, 2001). Otolith tissue is not reabsorbed by the body, as other calcified tissues are; it is this quality that makes otoliths unique in fish (Campana, 1999). Otoliths, unlike other calcified tissues, such as skeletal calcium, are not readily mobilized for homeostasis during times of stress; consequently otoliths are highly suitable for aging (Wright, 2002) and chemical analysis (Campana, 1999). Otoliths also continue to accrete after somatic growth has naturally ceased (Mugiya & Tanaka, 1992) unlike skeletal tissue.

In recent years the chemical compositions of individual bands have been used to identify past habitat use of the fish (Rooker et al., 2003; Campana & Thorrold, 2001; Thresher, 1999). During crystallization, divalent cations of similar ionic radii to calcium (e.g., Mg^{+2}, Sr^{+2}, and Ba^{+2}) can substitute for calcium in the otolith matrix or in the protein in the otolith (e.g., Campana et al., 1995). The mechanism of substitution and incorporation of trace metals into the otolith are a function of abiotic (i.e., temperature, salinity) and biotic (i.e., diet, fish growth rate) conditions (Thresher, 1999).

The mechanisms impeding herring recovery in PWS are not well understood. Having a model validated to estimate retention of larvae in PWS could help researchers to understand variations in herring survival. The validation of such a model can be accomplished effectively by identifying the regional elemental signature found in embryonic and larval herring.

B. Relevance to 1994 Restoration Plan Goals and Scientific Priorities

The Exxon Valdez Oil Spill Restoration Plan of 1994, set recovery objectives, strategies and goals for Pacific herring in PWS; our project meets these requirements and will provide information needed to improve the management and recovery of this commercial and subsistence priority fishery. Exxon Valdez Oil Spill Trustee Council has identified Pacific herring as not recovered to a healthy and productive state and the Council stated herring do not exist at pre-spill abundance. As communities are dependent on the herring fishery for the long run, the Trustee

Council has made herring a priority for recovery. Our project strategy will target the reproductive success and advective transport of herring larvae from rearing areas.

This project will contribute greatly to the knowledge of herring recovery in PWS. Our project will determine elemental signatures found in rearing and spawning areas. Migration pathways due to advection and larval drift can be determined by retrospectively examining the chronology of otolith chemistry. Through otolith chemical analysis, the spatial and temporal description of where herring spend their early life history can be described. The results of this study will be used to validate a herring drift model previously proposed (Norcross et al., 2001a). Such a model would aid managers in assessing successful recruitment by describing potential transport of larvae in PWS and estimating variations of larvae retention in the sound. If validated, implementation of this model would provide a powerful means of providing information needed to improve the management of this fishery and to monitor the recovery status of this important fish stock.

These data can also be used to consider the effect the *Exxon Valdez* oil spill continues to have on the recovery of the herring population in PWS. Using these data I can identify where juveniles were spawned (natal) and caught (nursery) in 1995, 1996 and 1997 and the survivorship between the two life stages. Survivorship of juveniles is defined here as successful transport of healthy larvae from specific spawning beaches to nursery grounds. Collection of surviving juveniles spawned on beaches that were oiled would indicate spawning habitat recovery.

This technique has the capability of being expanded to further investigate the recovery of herring in PWS. By examining otoliths of adult herring, I can identify not only survival from egg through juvenile stages, but also between juveniles and adults. Also by examining multiple cohorts of herring, e.g., collections by ADF&G in 2004, 2005 and 2006, I can identify which spawning beaches and nursery grounds contribute disproportionately higher numbers to the overall population (Dorval et al., 2002). With these otolith chemical data combined with the 3D-PWS model (Norcross et al., 2001a) fishery managers will have the tools necessary to better predict recruitment.

I. PROJECT DESIGN

A. Objectives

The overall objective of this study is to identify elemental signatures of spawning and nursery areas for Pacific herring (*Clupea pallasii*) from PWS. My specific objectives are to (1) use trace element signatures of edge portions of juvenile herring otoliths to identify the otolith chemical signature of individual rearing bays within PWS, (2) use trace element signatures of core portions of herring otoliths to identify individual spawning bays within PWS, (3) compare otolith data with the 3D-PWS model for larval drift.

My hypothesis is that otolith chemical analysis can be used to identify spawning grounds. The Sr/Ca, Ba/Ca, and Mg/Ca ratios found in the edge portions of herring otoliths will be distinct to juvenile areas (objective 1), in the core portion of otoliths will be unique to spawning habitats (objective 2), by comparing of chemical signatures of larval drift and the model for larval drift we will validate the 3D-PWS model (objective 3).

Following the *Exxon Valdez* oil spill in March 1989 and the decline of herring stocks in the 1990´s, the need to understand the biotic and abiotic factors impeding herring recovery has become more critical to the conservation of this important fisheries stock. Identification of larval drift and larval retention of herring in PWS is necessary to examine the status and recovery potential of the stock, which is a priority of fisheries managers. Otolith chemical analysis of regional signatures enables our research to identify herring habitat use temporally and spatially.

B. Procedural and Scientific Methods

Otolith processing

I intend to extract the sagittal otoliths of intact frozen juvenile herring and analyze with laser ablation – inductively coupled plasma – mass spectrometer (LA-ICP-MS). 600 Juvenile herring were previously collected during 1995-1997 by the SEA program (Norcross, et al., 2001a) and have remained in storage in the Fisheries Oceanography Laboratory at UAF. Juvenile samples exist from collections in Boulder Bay, Dangerous Passage, Eaglek Bay, Green Island, Jack Bay, Nellie Juan, Paddy Bay, Rocky Bay, Simpson Bay, Whale Bay, Zaikof Bay and other areas sampled for herring during the SEA program (Figure 1).

Sagittal otoliths will be extracted from herring in a clean environment using standard techniques (Bickford et al., 2003; Campana, 1999; Campana, et al., 1995). All tools used for extraction will be made of Teflon and acid washed prior to use to minimize contamination. Thin sectioning using a Beuhler isomet low speed saw will expose the otolith core and edge (objective 1 & 2) for chemical analysis and aging (Campana, 1999).

Otolith chemical analysis

Concentration of all trace metals in otoliths will be measured using a laser ablation (LA; New Wave UP 213nm Nd:YAG) inductively coupled plasma – mass spectrometry (ICP-MS; Agilent 7500c) on the UAF campus. These analyses will be preformed on thin sections of otoliths on a transect extending from the core across to the otolith margin. All analyses will be calibrated using the external matrix-matched standard USGS MACS-1 (carbonate standard). Each sample measurement will be preceded by a gas blank measurement with re-calibration (gas blank and MACS-1) every 10 samples. Concentrations of all elements will be calculated relative to MACS-1 after proper correction for gas blank, matrix, and drift effects. Elemental abundances will be compared to relative to Ca content among otolith samples (Campana, 1999; Campana & Neilson, 1985).

C. Data Analysis and Statistical Methods

Visually comparing the spatial plots developed from otolith chemical data to the spatial plots from the 3D-PWS larval drift model (Norcross et al., 2001) will be used to test the model and resultant distribution of juvenile herring. That model started with herring spawning locations in 1996 and produced estimated distributions of larvae to juvenile nursery grounds (Figure 2). The proposed research will examine otoliths from 1996 for a direction comparison to the model, as well as otoliths from 1995 and 1997 for interannual variation. Using UnifyPow, a SAS module for sample-size analysis, my power test has shown that we will need to analyze the chemical signature of at least 25 herring otoliths from each bay to have significant results. Statistical analysis will include analysis of variance (ANOVA α =0.05) to distinguish differences between the chemistries of the core and edges of the otoliths of juvenile herring at each site and among sites. Principle component analysis (PCA) will be used to aggregate the data to reduce dimensionality of our samples from each habitat. The PCA results will distinguish geographically distinct groups of herring. Geostatistical methods will be used to compare the spatial data.

D. Description of Study Area

Prince William Sound is a semi-enclosed sea separated from the Gulf of Alaska by a series of mountainous islands (Figure 1). The rocky coastline has numerous islands, inlets, bays, and deep fjords. About half of the locations sampled during this study, though named and referred to as bays, were classified as small fjords. These fjords are characterized as steep-sided basins with maximum depths over 100 m; entrance sills varying in depth were present in some but not all fjords. Fjords generally have slow tidal currents (< 15 cm sec^{-1}) and are stratified during periods of freshwater runoff. By late winter, the subsurface and deep waters are well mixed, but the surface layers can exhibit slight stratification. Other shallower (< 100 m) locations classified as bays are more prone to vertical mixing from both winds and strong tidal currents. Bays may exhibit partial to strong stratification briefly during the summer. In comparison to fjords, by early fall bays are typically well mixed vertically, and by late winter their water columns become homogeneous from surface to bottom. Thermal conditions from 1995 to 1998 were cold and relatively well-mixed during late winter (4-6^{o} C) followed by stratification (9–13° C) in the summer (Gay and Vaughan, 2001). At 60^{o} N, primary production in PWS is typical for high latitude neritic systems with a strong spring phytoplankton bloom (McRoy *et al.*, 1997) and a short growing season. In this northern location the combination of light and temperature restrictions create environmental conditions for Pacific herring that are somewhat different from those experienced by Atlantic herring (*Clupea harengus*) or by Pacific herring found in more southerly regions of the west coast of North America.

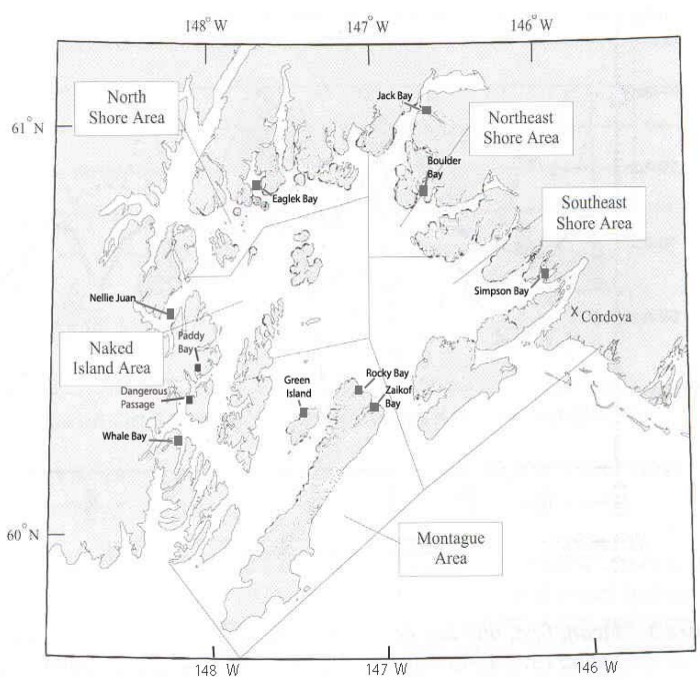

Figure 1. Juvenile sample collection sites in Prince William Sound, Alaska

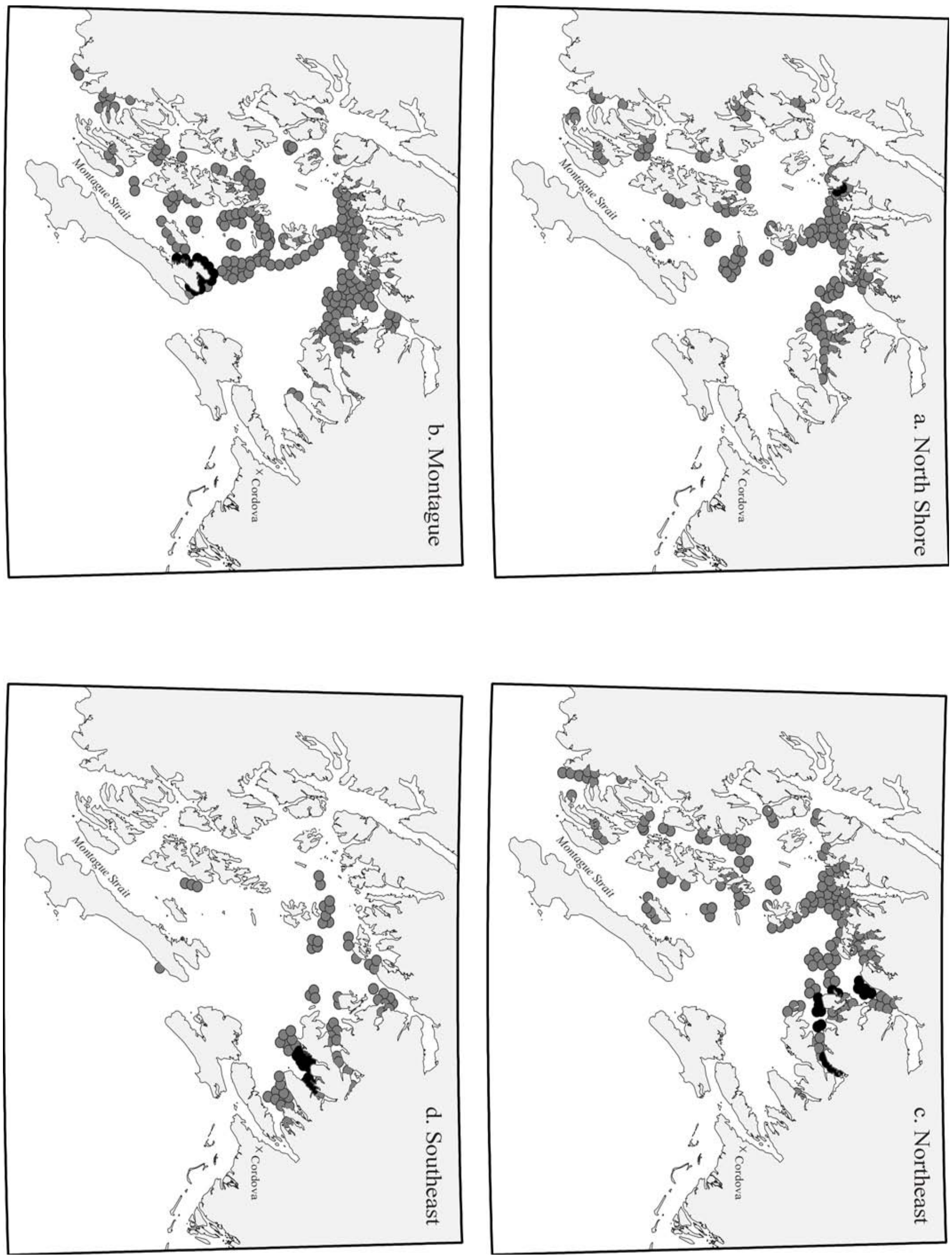

Figure 2. Herring spawning regions is 1996 and dispersal of simulated herring larvae hatched in those regions (from Norcross et al., 2001).

E. Coordination and Collaboration with Other Efforts

The proposed study will be coordinated with the EVOS Herring Synthesis project, which is to be funded under a separate Invitation. The most knowledgeable people about herring in Prince William Sound include agency scientists Jeep Rice and Mark Carls (NOAA, oil) and Fritz Funk (ADF&G, commercial), and university scientists Gary Marty (British Columbia, disease), JoEllen Hose (California, genetics), Terry Quinn (Alaska, population dynamics), Evelyn Brown (Alaska, life history) and Brenda Norcross (Alaska, fisheries oceanography). I will consult will all or most of these individuals and the individual or team contracted to do the EVOS Herring Synthesis.

III. SCHEDULE

A. Project Milestone

Objective 1. Analyze trace elements of edge portions of juvenile herring otoliths as indicator of nursery grounds.

To be met by March 2006

Objective 2. Analyze trace elements of core portions of juvenile herring otoliths as indicator of spawning area.

To be met by June 2006

Objective 3. Compare otolith data with the 3D-PWS model for larval drift.

To be met by August 2006

B. Measurable Project Tasks

FY 06, 1st quarter (October 1, 2005-December 31, 2005)

31 October:	Finish extracting SEA herring otoliths
31 December	Finish preparing otoliths for chemical analysis

FY 06, 2nd quarter (January 1, 2006-March 31, 2006)

31 March	Finish analyzing edge portion of otoliths

FY 06, 3rd quarter (April 1, 2006-June 30, 2006)

15 May	Finish analyzing core portions of Otoliths
30 June	Compare drift model to otolith data

FY06, 4th quarter (July 1, 2006-September 30, 2006)	
1 August	Preliminary Draft report
August	Peer review
10-14 September	AFS meeting Lake Placid, NY
1 October	Final Report

IV. RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

A. Community Involvement and Traditional Ecological Knowledge (TEK)

Because these are fish that were collected between 1995 and 1997 there is no direct community involvement or use of TEK in this study.

B. Resource Management Applications

The results of this study will be used to validate a herring drift model previously proposed (Norcross et al., 2001a). Such a model would aid managers in assessing successful recruitment by describing potential transport of larvae in PWS and estimating variations of larvae retention in the sound. Survivorship of juveniles is defined here as successful transport of healthy larvae from specific spawning beaches to nursery grounds. Collection of surviving juveniles spawned on beaches that were oiled would indicate spawning habitat recovery.

This study has the capability to be expanded in the future to further investigate the recovery of herring in PWS. By examining otoliths of adult herring, I can identify not only survival from egg through juvenile stages, but also between juveniles and adults. Also by examining multiple cohorts of herring, e.g., collections by ADF&G in 2004, 2005 and 2006, I can identify which spawning beaches and nursery grounds contribute disproportionately higher numbers to the overall population (Dorval et al., 2002). With these otolith chemical data combined with the 3D-PWS model (Norcross et al., 2001a) fishery managers will have the tools necessary to better predict recruitment.

V. PUBLICATION AND REPORTS

I am not requesting any funding for publication. However the results from this will provide the basis of a M.S. thesis for Sean-Bob Kelly and will be published in a refereed journal. All reports from this study will be completed as per the timeline.

VI. LITERATURE CITED

Bickford, N., Hannigan, R., & Bogdevich, O. (2003). Otolith microchemisty of freshwater fish: stock discrimination of Brown Trout and Walleye. Proceedings of the Sixth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe and the Commonwealth of Independent States Prague, Czech Republic, 132-144.

Brown, E. D., Norcross, B. L., & Short, J. W. (1996). An introduction to studies on the effects of the *Exxon Valdez* oil spill on the early life history stages of Pacific herring, *Clupea pallasi*, in Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences, 53(10), 2337-2342.

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Campana, S. E., & Neilson, J. D. (1985). Microstructure of fish otoliths. Canadian Journal of Fisheries and Aquatic Science, 42, 1014-1032.

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Academic Preparation

2004 - Present **NSF Polar Post – Doctoral Work** - University of Alaska Fairbanks. Research: Movement patterns of fish in the Bering Sea and Gulf of Alaska

2000 - 2004 **PhD** - Environmental Science (emphasis in biology and chemistry) Arkansas State University. Research: "Linkages between Hydrology and Essential Fish Habitat: Spring River, Arkansas"

1997 -2000 **M.S.** - Biology Appalachian State University. Research: "Survey of Gastrointestinal Helminths in Small Mammals in Watauga County, NC and Changes in Parasite Populations Due to Changes in Host Species and Changes in the Season"

1993 -1997 **B.S. –** Biology Lenoir-Rhyne University. Research: "The Caloric Content of Wild and Captive Bears Diet and the Difference in Calories Used by Captive Bears and Wild Bears"

Professional Experience

2004 - Present **NSF Polar Regions Post Doctoral program Post-Doc**: Identifying movement patterns and stock identification in fish from the Bering Sea and Gulf of Alaska.

2004 **Water Rock Life Lab (ASU) Post Doc**: CRUI: Environmental Life History of Freshwater Fish using Otolith Microchemistry

2003 - 2004 **Water Rock Life Lab (ASU) Project Manager**: CRUI: Environmental Life History of Freshwater Fish using Otolith Microchemistry

- Supervise undergraduate research on fish age and growth.
- Otolith Microchemistry
- Essential Habitat identification
- Community structure and assessment

Analytical Expertise

Laser Ablation Inductively Coupled Plasma - Mass Spectrometry (LA-ICP-MS)
Inductively Coupled Plasma - Mass Spectrometry (ICP-MS)
Ion Chromatography
UV-vis spectromphotometry
Atomic Absorption Spectrometer

Chemistry:

EPA Good Laboratory Practices
EPA standard methods 6020 and 200.8
Chain of Custody
APHA sample collection methods

Publications

Conference Proceedings

Bickford, N., Hannigan, R., and Bogdevich, O. 2003. Otolith Microchemistry of Freshwater Fish: Stock Discrimination of Brown Trout and Walleye. Proceedings of the Sixth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe and the Commonwealth of Independent States. Prague, Czech Republic. In Press.

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Journal Articles

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Christian, A.D., Bouldin, J., Bickford, N., McCord, S.B., Sako, A., and Ferris, J. 2003. Winter and spring water quality of Big Creek watershed, Craighead County, AR: Nutrients, habitat, and macroinvertebrates. Journal of the Arkansas Academy of Sciences 57: 27 -36

Manuscripts in Review

Bickford, N., and Hannigan, R. Stock identification of native and non-native Brown Trout in the Spring River, Ar. In review - North American Journal of Fisheries Management.

Collaborators

Jennifer Bouldin – Environmental Science - Arkansas State University
Alan Christian - Environmental Science - Arkansas State University
Robyn Hannigan – Chemistry and Physics Department – Arkansas State University
Brenda Norcross - Institute of Marine Science - School of Fisheries and Ocean Sciences University of Alaska Fairbanks
Abubakar Sako – Environmental Science - Arkansas State University

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2005 - September 30, 2006

Budget Category:	Authorized FY 2005	Proposed FY 2006						
Personnel		$18,400.0						
Travel		$6,700.0						
Contractual		$4,200.0						
Commodities		$1,000.0						
Equipment		$5,500.0	LONG RANGE FUNDING REQUIREMENTS					
Tuition		$4,500.0						
Subtotal	$0.0	$40,300.0				Estimated FY 2007		
Indirect		$7,600.0						
Project Total	$0.0	$47,900.0						
Trustee Agency GA (9% of Project Total)		$4,311.0						
Total Cost		$52,211.0						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY06

Project Number: 060782
Project Title: Using otolith chemical analysis to determine larval drift of PWS Pacific herring (Clupea pallasii)
PI: Nate Bickford
Agency: ADFG

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2005 - September 30, 2006

Prepared: 04-12-05

Personnel Costs:				Months	Monthly		Proposed
	Name	Position Description		Budgeted	Costs	Overtime	FY 2006
	Sean Bob Kelly or TBA	MS Student (Academic Year)		8.0	1100.0		8,800.0
	Sean Bob Kelly or TBA	MS Student (Summer)		4.0	2400.0		9,600.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		12.0	3500.0	0.0	
						Personnel Total	$18,400.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2006
	2 RT Fairbanks to Lake Placid NY (AFS Meeting)	1000.0	2	5	500.0	4,500.0
	2 RT Fairbanks to Anchorage (EVOS Meeting)	500.0	2	4	300.0	2,200.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$6,700.0

FY06

Project Number: 060782
Project Title: Using otolith chemical analysis to determine larval drift of PWS Pacific herring (Clupea pallasii)
PI: Nate Bickford
Agency: ADFG

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2005 - September 30, 2006

Prepared: 04-12-05

Agency: ADFG

Contractual Costs:	Proposed
Description	FY 2006
Instrument Time (100 hours @ $40 per hour)	4,000.0
Phone Tolls and Copy Charges	200.0
Contractual Total	$4,200.0

Commodities Costs:			Proposed
Description			FY 2006
Misc. Acids			
HCL	$50 L		
Nitric	$300 L		
Saw Blades	2 @ $150 each		
Misc. Project Supplies (glue, slides, etc)		$300	
			1,000.0
Commodities Total			$1,000.0

FY06

Project Number: 060782
Project Title: Using otolith chemical analysis to determine larval drift of PWS Pacific herring (Clupea pallasii)
PI: Nate Bickford
Agency: ADFG

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2005 - September 30, 2006

Prepared: 04-12-05

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2006
Beuhler Isomet Otolith Saw	1	5.5	5,500.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$5,500.0

Tuition Costs:		Proposed
Description		FY 2006
MS Student Tuition	Resident Tuition (18 credit hours)	4,500.0
	Commodities Total	$4,500.0

FY06

Prepared: 04-12-05

Project Number: 060782
Project Title: Using otolith chemical analysis to determine larval drift of PWS Pacific herring (Clupea pallasii)
PI: Nate Bickford
Agency: ADFG

University of Alaska Fairbanks Budget Justification

Salaries:
Funding in the amount of $17,956 is requested to support labor costs. A Masters student will be needed to work on the project at 20 hrs/wk during the school year and 40 hr/wk in the summer. Sean-Bob Kelly is currently selected to work on this project and will utilize this project towards his thesis research for an M.S. in Fisheries Oceanography. Brenda Norcross, UAF/SFOS, will be his advisor.

Benefits:
Staff benefits are requested in the amount of $727 and are applied according to UAF's estimated benefit rates for FY06, negotiated with the Office of Naval Research (ONR). A copy of the memo is available at:
http://www.sfos.uaf.edu/proposals/fy06_staff_benefits.pdf

Equipment:
A Buehler Isomet Otolith Saw ($5,500) is needed for thin sectioning otoliths for preparation of otolith analysis.

Travel:
Domestic:
Travel support in the total amount of $4,400 is requested for Nate Bickford and Sean-Bob Kelly to travel to the 2006 American Fisheries Society meeting in Lake Placid, NY. They will give presentations to disseminate the results of this study. Cost associated with the meeting include: registration ($300), airfare ($1035), per diem for five days ($715), and ground transportation ($150). Total travel support will be $2,200 per person.

Travel support in the total amount of $2,220 is requested for Nate Bickford and Sean-Bob Kelly to travel to the 2006 EVOS in Anchorage, AK. They will give presentations to disseminate the results of this study. Cost associated with the meeting include: airfare ($500), per diem for four days ($160), and lodging ($450). Total travel support will be $1,110 per person.

Other/Contractual/Services:
Funding in the amount of $ 4,150 is requested to support service costs associated with the project. Communication costs, i.e., toll charges and duplication/copying costs ($150).
Otolith trace elements: $40 an hour to run the LA-ICP-MS will include the associated costs of the running the ICP-MS, including electricity, water demands, micro-pipettes, sample and skimmer cones, torch, and ultra-pure Ar carrier gas and ICP-MS standards as the project dictates. We can do six otoliths an hour from start to finish. There are a total of 600 fish of which we can do six an hour for a total cost of $4,000 for elemental analysis.

Commodities:
Funds ($1100) are requested for the purchase of materials and supplies related to the proposed project. Supplies include ultra-pure acids ($350), saw blades for otolith preparation (300) and miscellaneous lab and project supplies such as crystal bond glue ($300).

Student Services (Tuition):
Funding in the amount of $4,396 is requested to support tuition costs (18 credit hours, resident) for the graduate student.

Indirect Costs:
Facilities and Administrative (F&A) Costs are calculated at 25.0% of the Total Direct Costs (TDC). TDC includes all direct costs except (1) equipment for which ownership resides with the University and (2) subcontract costs in excess of $25,000.

Data Management and Quality Assurance/Quality Control ("QA/QC") Statement

This proposal seeks the support to start a study on Pacific herring. Chemical analyses of herring otoliths can be used to consider the effect the *Exxon Valdez* oil spill continues to have on the recovery of the herring population in PWS. Studying the regional elemental signatures within the core of the herring otolith enables researchers to identify the spawning areas (Objective 1), and the edge of the otolith will identify nursery area (Objective 2). The 3D-PWS model describing larval drift and larval retention in PWS (Norcross et al., 2001a) has never been field-tested. Comparing the two methods for describing larval drift could validate this model as a tool for understanding the impediments to herring recovery in PWS (Objective 3). With these otolith chemical data combined with the 3D-PWS model, fishery managers will have the tools necessary to better predict recruitment and estimate herring spawning habitat recovery.

<u>1. Describe the study design, including sample type(s) and location requirements, all statistical analyses that were or will be used to estimate the types and numbers of physical samples required or equivalent information for studies using survey and interview techniques. Include a description of the metadata essential to interpretation of the results of your work.</u>

Visually comparing the spatial plots developed from otolith chemical data to the spatial plots from the 3D-PWS larval drift model (Norcross et al., 2001) will be used to test the model and resultant distribution of juvenile herring. That model started with herring spawning locations in 1996 and produced estimated distributions of larvae to juvenile nursery grounds (Figure 2). The proposed research will examine otoliths from 1996 for a direction comparison to the model, as well as otoliths from 1995 and 1997 for interannual variation. Using UnifyPow, a SAS module for sample-size analysis, my power test has shown that we will need to analyze the chemical signature of at least 25 herring otoliths from each bay to have significant results. Statistical analysis will include analysis of variance (ANOVA α =0.05) to distinguish differences between the chemistries of the core and edges of the otoliths of juvenile herring at each site and among sites. Principle component analysis (PCA) will be used to aggregate the data to reduce dimensionality of our samples from each habitat. The PCA results will distinguish geographically distinct groups of herring. Geostatistical methods will be used to compare the spatial data.

<u>2. Discuss criteria for determining acceptable data quality in terms of the activities to be performed or hypotheses to be tested.</u>

Data will be measured using a laser ablation (LA; New Wave UP 213nm Nd:YAG) inductively coupled plasma – mass spectrometry (ICP-MS; Agilent 7500c) on the UAF campus. These analyses will be preformed on thin sections of otoliths on a transect extending from the core across to the otolith margin. All analyses will be calibrated using the external matrix-matched standard USGS MACS-1 (carbonate standard). Each sample measurement will be preceded by a gas blank measurement with re-calibration (gas blank and MACS-1) every 10 samples. Concentrations of all elements will be calculated relative to MACS-1 after proper correction for gas blank, matrix, and drift effects. Software used for analysis also contain QA/QC measures which will halt analysis if data starts to drift.

<u>3. Discuss the characteristics of the data that your project is going to be producing. Part (a) describes the production of a minimally compliant FGDC metadata record which needs to be submitted by all proposers. Part (b) is specific to projects producing quantitative data and</u>

provides specifications for categorizing quantitative data into one of three data groups: physical measurements, species specific measurements, and taxonomic sampling.

(a) Copy of planned metadata file is attached.

(b) This project will collect chemical measurements and compare the data to previous work. The chemical measurements will consist of calcium, strontium, barium, magnesium, etc using inductively coupled plasma – mass spectrometry (ICP-MS; Agilent 7500c). Historic data will come from data used from previous publications by Norcross et al., 2001.

4. Define each algorithm to be used to convert signals from sensors to observations. Examples of algorithms of interest would be the conversion of pressure to depth and the conversion of integrated voltages to biomass at depth. When conversion algorithms are lengthy (i.e., computer programs) substitute a source location, such as an ftp site, for the full text. In the case of proprietary conversion algorithms, identify the proprietor and describe how the accuracy of conversion is verified under calibration (see #6 below).

No algorithms will be used in this project.

5. Describe the procedures for the handling and custody of samples, including sample collection, identification, preservation, transportation and storage.

All samples have been collected

6. Describe the procedures that will be used in the calibration and performance evaluation of all analytical instrumentation and all methods of analysis to be used during the project.

The instrument must be calibrated before analysis of any samples with at least a blank and multiple standards. A Linear through zero curve type is used for all analytes. The calibration blank will be run as a blank, before the analysis of any actual calibration standards. MACS-1 will be used (Table D.1; Trace Elements in calcite) as an external standard to monitor precision. In addition, a calibration gas blank monitored the process and re-calibration will be done every 6 samples. Concentrations of all elements will be calculated from the calibration curve after proper correction for control blank, matrix and drift effects using the Newwave Glitter software. Based on measurements of MACS-1 the reported values will be better than 3% error for all elements of interest. The following isotopes will be monitored with isobaric correction equations built-into the analytical method as specified by EPA 200.8. ^{24,25,26}Mg, ^{44}Ca, ^{55}Mn, ^{86,87,88}Sr, ^{135,137,138}Ba, and ^{235,238}U. Whole element concentrations will be calculated based on calibrations and relative abundance of isotopes. In the case of multi-isotope elements the reported concentration represents an average of the measured concentrations calculated independently for each isotope. All multi-isotope concentrations will be within 1% of each other.

7. Discuss the procedures for data reduction and reporting, including a description of all statistical methods, with reference to any statistical software to be used, to make inferences and conclusions. Discuss any computer models to be designed or utilized with associated verification and validation techniques.

The proposed research will examine otoliths from 1996 for a direction comparison to the model, as well as otoliths from 1995 and 1997 for interannual variation. Using UnifyPow, a SAS module for sample-size analysis, my power test has shown that we will need to analyze the chemical signature of at least 25 herring otoliths from each bay to have significant results. Statistical analysis will include analysis of variance (ANOVA α =0.05) to distinguish differences between the chemistries of the core and edges of the otoliths of juvenile herring at each site and among sites. Principle component analysis (PCA) will be used to aggregate the data to reduce dimensionality of our samples from each habitat. The PCA results will distinguish geographically distinct groups of herring. Geostatistical methods will be used to compare the spatial data.We will be using combinations of SAS, SPSS, Excel, Statview and Systat for our analyses.

Identification_Information:

Citation:

Citation_Information:

Originator: Nate Bickford

Publication_Date: 20050412

Title: Using otolith chemical analysis to determine larval drift of Prince William Sound Pacific herring (*Clupea pallasii*)

Edition: 1

Geospatial_Data_Presentation_Form: map

Publication_Information:

Publication_Place: University of Alaska Fairbanks

Publisher:

Description:

Abstract:

Chemical analyses of herring otoliths can be used to consider the effect the *Exxon Valdez* oil spill continues to have on the recovery of the herring population in PWS. Studying the regional elemental signatures within the core of the herring otolith enables researchers to identify the spawning areas (Objective 1), and the edge of the otolith will identify nursery area (Objective 2). The 3D-PWS model describing larval drift and larval retention in PWS (Norcross et al., 2001a) has never been field-tested. Comparing the two methods for describing larval drift could validate this model as a tool for understanding the impediments to herring recovery in PWS (Objective 3). With these otolith chemical data combined with the 3D-PWS model, fishery managers will have the tools necessary to better predict recruitment and estimate herring spawning habitat recovery.

Purpose:

To identify past habitat use

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 20050601

Ending_Date: 20060530

Currentness_Reference:

Status:

Progress: Planned

Maintenance_and_Update_Frequency: Monthly

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: 147

East_Bounding_Coordinate: 154.2

North_Bounding_Coordinate: 60.5

South_Bounding_Coordinate: 56.5

Keywords:

Theme:

Theme_Keyword_Thesaurus: herring

Theme_Keyword: Pacific herring

Theme_Keyword: otolith

Theme_Keyword: spawning
Theme_Keyword: nursery
Theme_Keyword: chemistry
Theme_Keyword: oil
Place:
Place_Keyword_Thesaurus: Prince William Sound
Place_Keyword: Simpson Bay
Place_Keyword: Boulder Bay
Place_Keyword: Whale Bay
Temporal:
Temporal_Keyword_Thesaurus: 2005 and 2006
Temporal_Keyword: May 2005
Temporal_Keyword: June 2005
Temporal_Keyword: July 2005
Temporal_Keyword: August 2005
Temporal_Keyword: ....
Access_Constraints: password
Use_Constraints: upon request

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Point

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Nate Bickford
Contact_Organization: Institute of Marine Science, University of Alaska Fairbanks
Contact_Address:
Address_Type: Mailing and Physical Address
Address:
245 O'Neill Bldg. University of Alaska Fairbanks
City: Fairbanks
State_or_Province: AK
Postal_Code: 99775
Country: USA
Contact_Voice_Telephone: 907-474 6469
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address: nate@sfos.uaf.edu
Distribution_Liability:

Metadata_Reference_Information:
Metadata_Date:
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:

Contact_Person: Nate Bickford
Contact_Organization: Institute of Marine Science, University of Alaska Fairbanks
Contact_Address:
Address_Type: Mailing and Physical Address
Address:
245 O'Neill Bldg. University of Alaska Fairbanks
City: Fairbanks
State_or_Province: AK
Postal_Code: 99775
Country: USA
Contact_Voice_Telephone: 907-474 6469
Contact_Facsimile_Telephone:
Contact_Electronic_Mail_Address: nate@sfos.uaf.edu
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

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