

Update Report

Period: 2/1/2014 - 1/31/2015

Project: R/HCE-3 - Shifting baselines in Puget Sound: population abundance of Pacific herring and its use by Native Americans over the millennia

STUDENTS SUPPORTED

Petrou, Eleni, elpetrou@uw.edu, University of Washington, Aquatic and Fishery Sciences, status: new, field of study: Population genetics / social sciences, advisor: Lorenz Hauser, degree type: PhD, degree date: 2017-12-01, degree completed this period: No

Student Project Title:

Population diversity of Pacific herring and its significance for Native Americans

Involvement with Sea Grant This Period:

Fellowship

Post-Graduation Plans: *none*

Skirvin, Matthew, matthew.skirvin@gmail.com, University of Washington, Biology, status: new, field of study: Biology, advisor: Lorenz Hauser, degree type: BS, degree date: 2015-06-01, degree completed this period: No

Student Project Title: *none*

Involvement with Sea Grant This Period: *none*

Post-Graduation Plans: *none*

CONFERENCES / PRESENTATIONS

Petrou EL, Lepofsky D, Yang D, Kopperl R, Hauser L. (2014) Shifting baselines in the Pacific Northwest: the story of Pacific herring. San Juan County Marine Resources Council (MRC), public/profession presentation, 20 attendees, 2014-11-10

Hauser L & Petrou E (2014) Herring Populations in Space and Time: a genetic perspective. Island Marine and Aquatic Working Group, Nanaimo, BC, public/profession presentation, 20 attendees, 2014-10-15

Petrou EL, Lepofsky D, Yang D, Kopperl R, Hauser L. (2014). Shifting baselines in the Pacific Northwest: the story of Pacific herring. SAFS Graduate Student Symposium, University of Washington, Seattle, WA. Awarded the price for the best PhD oral presentation, public/profession presentation, 50 attendees, 2014-11-20

Petrou EL, Lepofsky D, Yang D, Rodrigues A, Kopperl R, Lewarch D, Hauser L. (May 2014). Shifting baselines in Puget Sound: population abundance of Pacific herring and its use by First Peoples over the millennia. Poster presentation. Salish Sea Ecosystem Conference, Seattle, WA, USA., public/profession presentation, 1000 attendees, 2014-05-01

ADDITIONAL METRICS

P-12 Students Reached: 100 **P-12 Educators Trained:** 0

A significant number of kids visited our exhibit at the Discover Science

weekend in the Seattle Aquarium, 8 Nov 2014

Participants in Informal Education Programs:

200

Volunteer Hours:

0

Estimated number of visitors to our exhibit at the Discover Science weekend in the Seattle Aquarium, 8 Nov 2014

Acres of coastal habitat protected, enhanced or restored:

0

Resource Managers who use Ecosystem-Based Approaches to Management:

0

Annual Clean Marina Program - certifications:

0

HACCP - Number of people with new certifications:

0

ECONOMIC IMPACTS

No Economic Impacts Reported This Period

SEA GRANT PRODUCTS

Description	Developed?	Used?	ELWD?	Number of Managers	Names of Managers
Pacific herring tissue samples for genetic analysis	Yes	No	No	0	
Method for cleaning herring contaminated by sperm for next generation sequencing	Yes	No	No	0	

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Number of stakeholders modifying practices:

Sustainable Coastal Development

of coastal communities:

PARTNERS

Partner Name: Dept of Anthropology, University of Oregon, type: Academic Institution, scale: Regional

Partner Name: Dept of Archaeology, Simon Fraser University, type: Academic Institution, scale: International

Partner Name: Haida First Nation, BC, type: Other, scale: International

Partner Name: Heiltsuk First Nation, BC, type: Other, scale: International

Partner Name: Port Gamble S'Klallam Tribe

Partner Name: Suquamish Tribe

Partner Name: Washington Department of Fish and Wildlife

IMPACTS AND ACCOMPLISHMENTS

Title: **Washington Sea Grant research combines traditional ecological knowledge and genetic analysis to chart trends in declining herring stocks**

Type: accomplishment

Description:

Relevance: Herring are a foundation of the Salish Sea food web and a cultural touchstone for Northwest tribes. A sizable herring fishery began in the 19th century and concerns about herring abundance arose in the early 20th, but biomass records date back only to the 1970s. Little is known about herring distribution and migration outside the spawning season or about adaptive genetic differences in herring stocks. Addressing this knowledge gap would enable resource managers and the fishing industry to better understand long-term trends in abundance and ecosystem implications.

Response: Traditional ecological knowledge can provide valuable information on long-term trends. Washington Sea Grant-sponsored researchers interviewed several generations of tribal and nontribal fishermen about past herring abundance, seasonality, and distribution. They also examined herring bones from two Puget Sound archeological sites and collaborated with state and Canadian partners to develop genetic markers for identifying populations of origin and tracking adaptation to various environmental conditions.

Results: Initial interviews revealed a long decline in herring abundance, with diminishing returns forcing one generation to quit the fishery and the next entering with lower expectations. Researchers indicated that initial genetic results confirmed their approach and they applied a new protocol to detect sample contamination in sequence data. As differentiating current and ancient populations continues, the results will assist management in Puget Sound and could lead to closer integration of tribal and state resource management.

Recap:

Recap:

Washington Sea Grant research is exploring genetic differentiation in Salish Sea herring and incorporating traditional ecological knowledge to assess long-term population decline.

Comments:

Primary Focus Area: HCE

Secondary Focus Area: SFA, RCE

Associated Goals: Ocean and coastal resources are managed using ecosystem-based approaches. (HCE)

Fisheries are safe, responsibly managed, and economically and culturally vibrant. (SFA)

Coastal communities and economies are vibrant and resilient. (RCE)

Partners:

Dept of Anthropology, University of Oregon

Dept of Archaeology, Simon Fraser University

Haida First Nation, BC

Heiltsuk First Nation, BC

Port Gamble S'Klallam Tribe

Suquamish Tribe

Washington Department of Fish and Wildlife

Related Partners: Dept of Archaeology, Simon Fraser University

PUBLICATIONS

No Publications Reported This Period

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

Type: influenced Period: 2014-01-01: : 2014-12-31 Amount: \$36000

Purpose:

Support for graduate student

Source: NSF IGERT on ocean change

Type: influenced Period: 2012-07-01: : 2015-06-30 Amount: \$171637

Purpose:

Funding for a complementary project on Alaskan herring - The Archaeology of Herring: Reconstructing the Past to Redeem the Future

Source: NSF

Type: influenced Period: 2014-02-01: : 2015-01-31 Amount: \$189333

Purpose:

Funding for complementary study on population genetics of herring in British Columbia.

Source: NSERC, Canada

UPDATE NARRATIVE

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Shifting baselines in Puget Sound: population diversity of Pacific herring and its use by Native Americans over the millennia

Lorenz Hauser, Dana Lepofsky, Dongya Yang and Robert Kopperl

Introduction

The PhD student of the project, Eleni Petrou, started her position in January 2014 – the project has therefore been underway for just over a year. Progress was made in all areas of the project, but in particular regarding acquisition of permits, establishment of contacts, sampling, collection of traditional ecological knowledge, and the analysis of extant data.

Leveraged funds

The project received considerable support from related projects over the reporting year, which not only provide additional funds, but also allow a coast-wide analysis of population diversity in herring, and reduce sequencing costs from the Genomics Core Facility of the University of Oregon:

- NSF IGERT on Ocean Change: Eleni Petrou was supported entirely from the NSF IGERT program headed by Terrie Klinger, SMEA, UW. The program not only provided financial support for graduate student salary and tuition, but also valuable social science education for Eleni.
- Canadian NSERC grant (PI Tony Pitcher, UBC): *Understanding the ecosystem role of Pacific herring in coupled social- ecological systems: advancing forage fish science* (2014-2017). Even though Lorenz Hauser cannot be PI and cannot receive money from this project, we are active participants in this project and lead one of the four modules. The NSERC funds are primarily being used for sampling trips of Eleni Petrou to the British Columbia coast, and for the ancient DNA work in co-PI Dongya Yang's lab. The subcontract for Dongya Yang can therefore be used for analysis of extant samples and identification of suitable genetic markers. Most importantly, the project allows an international approach to the cross-boundary issue of herring conservation and management in the Salish Sea.
- NSF: *The Archaeology of Herring: Reconstructing the Past to Redeem the Future* (PIs: Madonna Moss, University of Oregon, and co-PI Dongya Yang). This project allows us to extend the project to the Gulf of Alaska, thus providing a coast-wide survey of genetic diversity in Pacific herring. The project has similar aims as the WSG project – our role will be to provide genetic markers from our population survey. Importantly, the official collaboration with the University of Oregon provides access to much cheaper internal rates for sequencing by the Genomics Core Facility of the University of Oregon.
- Department of Ecology: The WDFW received a grant from the Department of Ecology to assess the isolation of herring spawning in Port Gamble from adjacent populations. We agreed with the WDFW that the UW will discover suitable markers for this analysis, and that WDFW will develop and optimize an amplicon-sequencing approach for high throughput screening of extant and archaeological samples. If successful, the big advantage for our project is that the development of high throughput markers is a time-intensive and costly undertaking, which now will be carried out by our partners. We therefore will be able to use more markers than anticipated on these samples, increasing the resolving power of our approach.

Progress

Synthesis of traditional knowledge

We received permission (“exempt status”) to conduct interviews from the University of Washington’s Human Subjects Division on October 30, 2014. Eleni Petrou and Andrea Weiser (research

technician from Dana Lepofsky's lab) interviewed a total of 15 fishers and scientists (Table 1). We collected qualitative data on abundance trends, spawning locations, and cultural uses of herring.

These interviews, especially those of non-tribal fishers, revealed strong evidence for shifting baselines, with a continuing decline in perceived herring abundance (Fig 1) and a repeated pattern of cessation of herring fishing by older fishers because of perceived abundance reduction and a reentry into the fishery by subsequent generations. Interviews, especially of tribal partners, will be continued in 2015.

Quantification of herring bones in existing archaeological collections

Co-PI Robert Kopperl worked with archaeologists from the Burke Museum, University of Washington, to subsample archaeological herring bones from their collections. Samples from two strata at each Burton Acres (Vashon Island) and Xaxtl'abish (Puyallup River Delta, Tacoma) were sent to Dongya Yang's laboratory to optimize DNA extraction and amplification protocols.

Quantification of extant population diversity

Sampling of extant population is progressing extremely well. Lorenz Hauser and Eleni Petrou coordinated sharing of samples with our research partners (Washington Department of Fish and Wildlife, Port Gamble S'Klallam Tribe). Almost 600 samples were collected in Puget Sound in 2014, all from spawning fish on their spawning beaches. In addition, we collected samples from the BC coast ranging from south Vancouver Island to Haida Gwaii in the north (Fig 2). Many of these sites were selected by our tribal partners and we continue to interact with them regularly regarding population structure expected from local ecological knowledge.

Samples provided by Terry Beacham, DFO, used in a preliminary project showed clear evidence for contamination, a problem which we also encountered in our previous microsatellite project (Mitchell et al. 2008). We tackled this issue from two sides: Eleni Petrou spent considerable time this year developing a protocol for decontamination. The protocol described by Mitchell et al. (2008) was suitable for microsatellites but not for next generation sequencing because the bleach treatment resulted in DNA degradation. Using magnetic beads, Eleni managed to select for non-degraded DNA and initial genomic libraries have been sent for sequencing.

The second approach for dealing with the contamination issue was its detection and consideration in the bioinformatics analysis. An undergraduate student, Matt Skirvin, who previously worked for Microsoft, found that a protocol developed for human samples could detect contamination in herring

Region	Number of fishers
Lummi Nation	2
Samish Nation	1
Nooksack Tribe	1
Quileute Nation	1
Non-tribal fishers from San Juan archipelago	8
Scientists	2

Table 1: Numbers of people from particular communities interviewed so far.

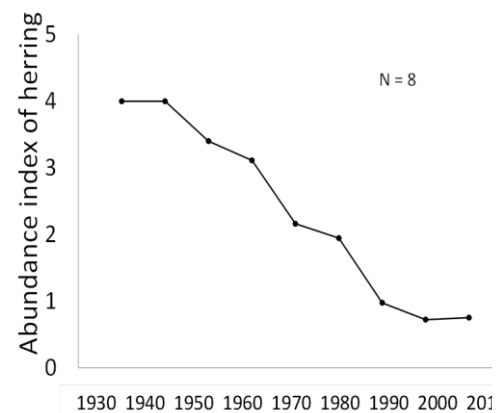


Fig. 1: Qualitative estimates of herring abundance over the past decade from San Juan interviews.

Location Name	Sampling date	N
Cherry Point	12 May 2014	99
Holmes Harbor	16 April 2014	27
Port Gamble	19 Feb. 2014	128
Port Orchard	27 Jan. 2014	100
Quilcene Bay	26 March 2014	70
Semiahmoo	4 March 2014	91
Squaxin Pass	24 Feb. 2014	77

Table 2: Samples collected by WDFW and Port Gamble S'Klallam tribal biologists from Puget Sound and available for this project

sequence data. He is currently testing the sensitivity of this approach and avenues for correcting for contamination in the analysis. At the very least, this approach will be a powerful way to confirm the efficiency of the laboratory protocols for removing contamination from samples, and thus prove the validity of resulting data.

Comparison of extant and pre-industrial population diversity

Samples have been sent to co-PI Dongya Yang's laboratory for optimization of DNA extraction protocols. Efforts are currently underway to discover suitable genetic markers for the ancient DNA work. The ongoing collaboration with WDFW will greatly facilitate the development of assays to screen these markers in the archaeological material.

Outreach

In addition to the outreach event at the Seattle aquarium (Discover Science weekend), we presented our research to the Island Marine Aquatic Working Group (IMAWG) in Nanaimo, BC on October 15, 2014. IMAWG is a Canadian organization that helps facilitate discussions with government and stakeholders regarding the recognition of First Nations rights with respect to the management of fisheries. Pacific herring are a species of high conservation concern to coastal First Nations in Canada and leaders from those communities were interested in learning more about using genetic methods to study the stock structure of herring. Eleni Petrou presented our research to the San Juan County Marine Resources Committee (MRC) in Friday Harbor, WA on November 5, 2014. The San Juan MRC has been an enthusiastic research partner and introduced us to fishers from San Juan County who participated in our interviews. Recently, and in part based on this event, Eleni was invited to provide a public lecture in the Marine Science Lecture Series organized by the SeaDoc society. We have also discussed potential activities for the Suquamish tribal school with Dennis Lewarch, and will further pursue this opportunity.

Next steps

We plan to use the next few months primarily to establish a baseline of genetic diversity and differentiation in extant herring populations from Washington, British Columbia and Alaska. We will here primarily concentrate on inlet spawners and spring spawners, which are differentiated at microsatellites markers, but we will also sample populations spawning in areas influenced by freshwater, as salinity has been shown to be an important environmental factor driving selective differentiation in Atlantic herring. Once genetic patterns in extant populations are established, we will identify suitable markers for ancient DNA analysis. We will also continue our efforts to collect local traditional knowledge and provide outreach activities.

References

Mitchell DM, McAllister PM, Stick K, Hauser L (2008) Sperm contamination in archived and contemporary herring samples. *Molecular Ecology Resources*, **8**, 50-55.

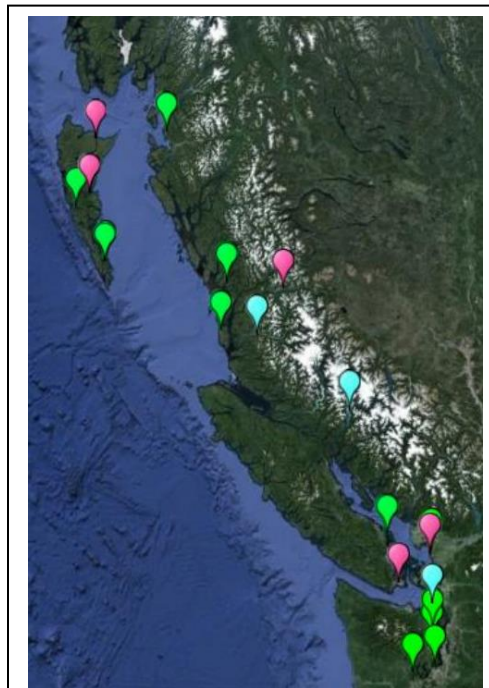


Fig 2: Map of the Salish Sea, Central coast and Haida Gwaii with sample sites available for this project. Green markers represent winter spawners, blue markers inlet winter spawners and purple markers spring spawners.