

Pacific herring, past and present

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Herring are important to predators





Images by Ian McAllister, Pacific Wild, Hope Rutledge

Herring are important to human communities









Gathering herring roe on hemlock and kelp

Herring in the archaeological record



McKechnie et al. 2014. Archaeological data provide alternative hypotheses on Pacific herring distribution, abundance and variability. PNAS.

Historical fisheries

In the early 20th century, large reduction fisheries for herring

 1930's: stocks in southeast Alaska overfished (Rounsefell, 1930)



Alaska State Library - Historical Collections



Commercial harvests of Pacific herring (1914-2012) Prince William Sound

Muradian ML, Branch TA, Moffitt SD, Hulson PJF (2017) Bayesian stock assessment of Pacific herring in Prince William Sound, Alaska. PLOS ONE 12(2): e0172153

Traditional ecological knowledge

"So many places had their own big bodies of herring. Crawfish Bay was one of the places...One year they seined down in that area [for the commercial sac roe fishery] and there hasn't been anything that way in a long time."

- Harvey Kitka





Harvey Kitka drops hemlock branches into the turquoise spawn. (Bethany Goodrich)

Biological diversity in herring







Photo from fishbio.com

Are herring that spawn at different places and at different times from genetically distinct populations?



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Photo by Ian McAllister.





Video by Mary Fisher

TGCAGGGCACACAAACACGACGGCAT...

TGCAGGGCACACAAACATGACGGCAT...



Population structure: WA

Samples cluster ٠ by spawn timing

> "March-April spawners" "January-





Data for ~7,000 DNA markers

Population structure: WA + BC





38% variation

Population structure: WA + BC + AK

June

May

April

Region

Δ

٠

March

Alaska





- Populations with different spawn times are genetically distinct
- Pattern of geographic differentiation

Isolation by distance within spawn groups



How important was herring spawn timing diversity to the food systems of Coast Salish ancestors?

Robert Kopperl (WCRA), Dana Lepofsky (SFU), Antonia T. Rodrigues (SFU), Dongya Yang (SFU), Madonna L. Moss (UO), Camilla F. Speller (UBC), Lorenz Hauser (UW)



Illustration by Bernie Lyol

Study system



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Coast Salish archaeological sites

Received permission to use herring bones from two sites:

- 1. Burton Acres Shell Midden
- 2. Bay Street Shell Midden





Sustained use of herring over multiple centuries





Methods



Zooarchaeologist Bob Kopperl

Identified herring bones



The suits are uncomfortable



Analyzed each sample at variable DNA markers

Estimated the ancestry of each sample



Antonia Rodrigues extracts ancient DNA

What can ancient DNA tell us about the food systems of Coast Salish ancestors?

- Coast Salish ancestors depended on diverse herring populations
- Consistent use of winter and earlyspring spawners through time





Population-specific consumption of Pacific herring in juvenile and adult Chinook salmon in the Salish Sea

Josh Chamberlin (NOAA), Will Duguid (UVIC), Russel Barsh (Kwiaht), Francis Juanes (UVIC), Jessica Qualley (UVIC),

and Lorenz Hauser (UW)

The importance of herring in Chinook diets

• Juvenile Chinook have high growth rates where small herring are abundant (*Chamberlin et al. 2017*)



Implications of biological diversity in herring

- Prolongs foraging opportunities for predators
- For example:
 - Wide distribution of prey sizes → more options for Chinook of different sizes and life stages

Hypothetical distribution of herring sizes in summer



Research questions

- Which populations of herring do Chinook salmon prey upon?
- Does the proportion of different herring populations in salmon diets vary based on season, geography, or salmon life stage?



Image by Whalebone Studio



From 2014 – 2019, we sampled 544 Pacific herring from the gut contents of 256 Chinook salmon









Isolated herring from gut contents





- DNA was degraded
- But present in large quantities!



TGCAGGGCACACAAACACGACGGCAT...

TGCAGGGCACACAAACATGACGGCAT...

TGCAGGGCACACAAACACGACGGCAT...



Genetic variation is a "natural tag"

Results



spring (N= 47) 1.00 1.00 0.75 0.50 0.25 (a) juvenine sainton summer (N= 40) Summer (N= 40)

T

(b) adult salmon

0.00



(a) juvenile salmon

Estimated relative proportions of spawning groups in Salish Sea



Total estimated Pacific herring biomass in the Salish Sea.

Questions for future research

- What are stock-specific distribution and movement patterns of herring throughout the year?
- Is there local retention of herring larvae near spawning grounds, and might those sites also function as nursery grounds?

Parting thoughts



Herring spawning in Sitka. Photo by Patrick J. Endres

- Forage fish like herring are very important to marine food webs
- Diverse herring populations support marine predators and human communities – now and in the past
- Biological diversity in herring is worth conserving