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The historical ecology of Pacific herring: Tracing Alaska Native use of a forage fish

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ABSTRACT

Long-term use of herring by Alaska Natives is not well-documented over space or through time, yet this information can illuminate pre-industrial patterns of herring abundance and distribution. Such information is important to understand the sustained relationships Alaska Native fishers and egg collectors have had with herring. Understanding the genetics of pre-industrial herring may also inform management of the fish and fisheries to insure their survival into the future. In this paper, we attempt a contextualized account of the long-term history of Alaska Native herring fisheries, bringing together archaeological, ethnographic, and ethnohistorical data. We tie these together as background for presenting the preliminary results of the NSF-funded project, *The Archaeology of Herring*: *Reconstructing the Past to Redeem the Future* (No. 1203868). We have now tested 84 herring bone samples from 17 archaeological sites in Alaska expanding beyond Speller et al. (2012), having tripled the earlier archaeological dataset. The oldest herring bones identified archaeologically in Alaska are dated to more than 10,000 cal BP. Early Holocene and Middle Holocene sites have also yielded herring bones, although most of the record dates to the last 2400 years. Preservation of genetic information is effectively complete for the last 2400 years, but achievable back to the terminal Pleistocene (68% success rate for samples between 10,500 and 2400 cal BP). This gives considerable confidence to the potential to expand the analyses and develop a richer pattern of biological variability. The resulting data show genetic continuity between archaeological and modern herring populations. The main technical challenge for the future is to extract adequate amounts of nuclear DNA from the ancient samples for identifying more informative DNA markers that can be used to more effectively reveal any population diversity and/or population size changes over time when compared to modern herring.

1. Introduction

Pacific herring (*Clupea pallasii*) is a cultural keystone species for many Alaska Natives, and is a critical resource in the marine food web for much of coastal Alaska (Thornton, 2015; Thornton and Hebert, 2014; Thornton and Kitka, 2015). The appearance of herring in the spring signals the start of the seasonal round after a long winter. Herring is a key dietary resource during this time, but to some, herring is an economic mainstay throughout the year. Alaska Natives, as well as a range of North Pacific species, depend on abundant and geographically widespread populations of herring. In 1989, the Exxon Valdez oil spill devastated Prince William Sound herring populations in the northern Gulf of Alaska (Thorne and Thomas, 2008; Fig. 1). The southern Gulf of Alaska has been impacted by commercial fishing, habitat degradation, and environmental changes over the past century. Bering Sea communities also depend on herring; in the words of Nelson Islander Louise Kanrilak, "herring are very important to us. When we are out of herring, we are out of food"(Barker, 1993:73). The scientific debate over the status of herring has been complicated by the lucrative commercial sac roe fishery that supplies herring eggs for Asian markets. Local and Traditional Knowledge bearers have witnessed the decline of herring (Thornton et al., 2010a) and many argue that herring are being managed in a depleted state. Alaska Native subsistence fishers and egg-collectors are sounding the alarm, while biologists debate whether herring populations are "endangered," "threatened" or "struggling" (Carls et al., 2009). Herring have already abandoned some spawning locations (Alaska Department of Fish and Game, Division of Commercial Fisheries, 2011), and several First Nations in British Columbia have been forced to stop harvesting herring and spawn altogether (Speller et al., 2012).

Archaeological assemblages from across coastal Alaska constitute an unmatched archive of environmental data. The NSF-funded project, *The Archaeology of Herring*: *Reconstructing the Past to Redeem the Future*, aims to develop a more complete understanding of the ancient Alaska Native use of herring to better assess the historical abundance, biogeography, and genetic diversity of herring in the past. We hope (ultimately) to contribute to improved herring fisheries management to benefit a

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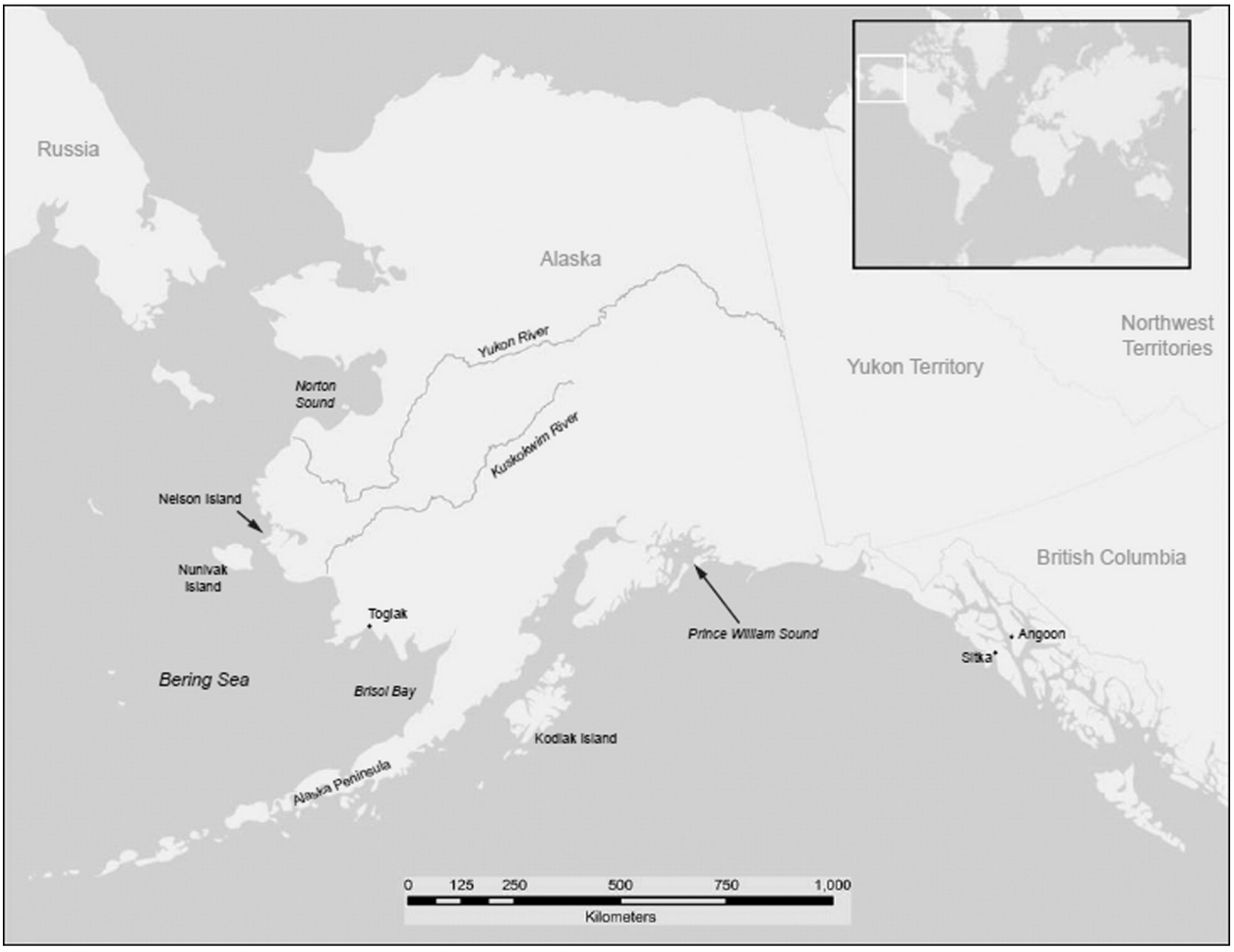

Fig. 1. Map of Alaska showing places mentioned in the text.

wide range of stakeholders in the Arctic, subarctic, and beyond. In this paper, we present preliminary results of our ancient DNA analysis and describe obstacles we currently face. Herring bones are preserved in some of the oldest sites in the region, including one that dates to more than 10,000 cal BP at Upper Yatuk Creek (Carlson, 2012). So far, 84 herring bone samples have been tested from 17 sites in southeast Alaska as part of this project. For samples less than 2400 years old, ancient mitochondrial DNA (mtDNA) is well-preserved as demonstrated by a 100% success rate for DNA recovery. The success rate for older samples is lower at 68%, but this is still promising. The next technical challenge will be to extract adequate amounts of nuclear DNA from ancient samples, targeting those more informative loci to more effectively monitor population diversity and size changes when compared to modern herring.

2. Alaska Native use of herring

Forage fish compensate for their small size by forming schools that can become immense shoals moving along coastlines and migrating across open water. Herring and other forage fish play a crucial role in ocean food webs because they feed on phytoplankton and zooplankton near the bottom of the food chain. Forage fish convert this energy into their flesh that then feeds other fish, seabirds, and mammals, including people (e.g., Anderson et al., 2009). In southeast Alaska, herring (*yaaw* in Tlingit, *iinaang* in Haida) were (and are) eaten as fresh food, dried and smoked, rendered for their oil, and used as bait (see Moss et al., 2011:282–283 for more detail). The spring arrival of herring was/is especially important because this is when eggs are harvested (Thornton et al., 2010a, 2010b; Pete, 1984, 1991). Besides eggs, schooling herring and a wide range of their predators (gulls, ducks, geese, eagles, chinook and coho salmon, lingcod, halibut, Pacific cod, hake, black cod, dogfish, harbor seals, Steller sea lions, porpoises, whales) were also taken (cf. Monks, 1987). Besides the early spring fishery, Alaska Natives also took herring later in the spring, during summer, and into the fall seasons (Moss et al., 2011; Thornton, 2010). Herring were dried and cured for storage and their oil was rendered and used to preserve other foods. Herring was an important resource used throughout much of the seasonal cycle, from March through the spring and summer and into late October for as many as eight months of the year although this varied across the coast (Emmons, 1991; Pete, 1984; Thornton, 2010).

In Prince William Sound, herring is one of only two species determined "not recovering" by the Exxon Valdez Oil Spill Trustee Council (Bernton, 2009). The fate of herring is not fully understood; some believe that the 16,000 gal of oil still buried in the region is an on-going deterrent to herring spawning. The oil spill occurred when herring had just hatched, and both the young-of-the-year and adult herring were affected. The weakened stocks may have been particularly vulnerable to disease, over-fishing, predation, or climate change, but scientists have not agreed on the relative impacts of these factors, nor can they explain why herring have not recovered. Nonetheless, Alaska Natives did use herring (*jikałux-paq* in Chugach) in Prince William Sound. Birket-Smith (1953:23, 39) reported that large numbers of herring were taken each year, and that the season extended from mid-June until November.

On Kodiak, herring (*iqalluarpak* in Alutiiq), spawn in more than 35 bays around the island, and have been historically abundant in Marmot

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