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Intro

The Arctic Ocean represents 34% of the world’s coastline (Lantuit et al. 2012), yet is

among the least studied marine ecosystems in the world due to inclement weather and

inaccessibility. The shallow, broad coastal shelves in the Arctic comprise a much higher

proportion of the coast compared to other oceans (Eakins and Sharman 2010), and are not

accessible by deep-drafted, ocean-research vessels, causing nearshore ecotypes in Arctic regions

to be under-studied. The nearshore regions of the Arctic support a robust fish community

comprised of marine, freshwater, and diadromous species of all life stages that subsist in the

seasonally estuarine conditions. There are approximately 211 circumpolar marine fish species in

39 families (Mecklenburg et al. 2011), as well as approximately 99 freshwater or diadromous

fish species in 17 families (Reist et al. 2006) that inhabit Arctic waters, many of them found in

the coastal Beaufort Sea along the northern Alaskan coast. Despite this diversity, there are few

aquatic long-term studies in the Arctic (Kortsch et al. 2012), with most research focusing on

either permafrost and resulting greenhouse gas emissions from thawing or high-trophic

organisms (Fritz et al. 2017).

Justification

While the existing dataset has been used to answer many basic questions on ecological processes, much more remains undetermined. As one of the few long-term studies in the region, we can use these data to appropriately determine and contextualize any changes in Arctic fish communities. Long-term ecological studies are necessary to determine changes that are subtle, especially when the phenomena are slow and/or complex or when interannual variability is large compared to the magnitude of the effect (Strayer et al. 1986). In particular, long-term ecological studies are valuable to help quantify how ecosystems react to changes or disturbance (Lindenmayer et al. 2012). We anticipate that as the Arctic warms (IPCC 2014), this would be reflected within subtle shifts in Arctic fish species composition. The existing 17-year dataset would be more likely to allow detection of significant changes occurring in the ecosystem.

Several species of fish common in the study area, particularly Arctic cod, are keystone species of the Arctic ecosystem, serving as the main forage prey base for higher-trophic animals (Majewski et al. 2016; Thorsteinson and Love 2016). The amphidromous whitefish species also provide key linkages between marine and freshwater ecosystems. Changes to these stocks could have widespread effects upon several Arctic aquatic ecosystems. As a result, finding evidence of the influence of global forcing factors upon local fish stocks could be beneficial to understanding how to mitigate effects upon the entire ecosystem. For example, if my study were to find that temperature is an important factor influencing species composition, this could help the next step of identifying potential future trends in species abundances. Further, changes within lower trophic levels can manifest as bottom-up trophic cascades with dynamic effects felt throughout the species community ecological web (Ware and Thomson 2005), highlighting the importance of having advance knowledge of coming changes.

Both marine and freshwater fishes overlap spatially and temporally in the estuarine habitat of Prudhoe Bay. Such migratory life histories cause reliance upon multiple habitats and locations, thus increasing the number of areas that may experience changes in environmental conditions. Changes to any one of these habitats could result in shifts in abundance or distribution, increasing the likelihood of detecting shifts in species assemblages. Migratory fishes, such as diadromous species, are particularly vulnerable to a change in one of their reliant habitats (McDowall 1992). Many of the most common species in the study area are diadromous (e.g., amphidromous or anadromous) and habitat changes in freshwater, marine, or estuarine environments could manifest as either recruitment failures of early life stages or a reduced abundance of adults.

Quantifying species assemblage responses to abiotic shifts would allow for increased predictive abilities in an increasingly dynamic ecosystem. Detectable changes in community indices are likely indicative of broader, regional trends, possibly global in scale. Wind patterns are known to be the largest drivers of cisco abundance in the study area (Fechhelm and Fissel 1988; Fechhelm et al. 1994, 1999). Therefore, many of the changes within the Prudhoe Bay estuarine ecosystem are likely attributable to changes in environmental conditions. Understanding the relative importance of such environmental variables can allow for the identification of future habitats that will increase in ecological value as the underlying system changes. Future environmental scenarios planning has identified likely outcomes from changes in climate but is typically limited to abiotic predictions (SNAP 2012). Modeling how the current fish assemblage structure responds to environmental factors would allow for insight into how this assemblage structure might be expected to respond.

Even if climate change were not threatening the region, the extensive industrial development of northern Alaska for oil and gas extraction means that determining reference points for community indices is imperative. The establishment of the baseline of species assemblages sets up this study as a precursor to a future before-after control-impact study, in the unlikely event of future catastrophic effects (e.g., accidental oil or natural gas discharge, causeway removal, continued seismic work, etc.). These results could then be used to quantify potential anthropogenic disturbances to the study area in terms of effects to the species assemblage structure.

Local indigenous communities directly depend upon the fish species investigated and also upon the higher trophic levels of the marine ecosystem for which the fish provide a forage base (Moerlein and Carothers 2012). Subsistence fisheries take place yearlong but are especially important during winter months when alternative food sources are difficult to obtain. It is important for local Iñupiat cultures to maintain a subsistence lifestyle in order to preserve local traditions and communities. Understanding how fish assemblages shift given environmental changes assist natural resource managers and subsistence users to plan and adapt accordingly. Predictions of how fish assemblage structure responds to environmental shifts would allow for powerful advance awareness of the coming changes to the ecosystem. Climate change within the Arctic is often difficult to pinpoint and harder to predict, and this study aims to quantify how the important fish resources of Prudhoe Bay will respond to such changes.