

Environmental Studies Program: Ongoing Studies

Study Area(s): Beaufort Sea, Chukchi Sea

Administered By: Alaska OCS Region

Title: Genomics of Arctic Cod: A Sentinel Species in a Changing Environment (AK-14-03)

BOEM Information Need(s) to be Addressed: To evaluate potential development effects in NEPA documents BOEM needs to understand whether Arctic cod on the OCS are part of a single pan-mictic population or part of more vulnerable sub-populations, and whether or not they exhibit genetic characteristics that will enable them to adapt to retreating sea ice and continue to feed their upper trophic predators. Thus, Arctic cod dynamics are an important consideration for NEPA analyses related to EFH.

Total BOEM Cost: \$300,000
plus Joint Funding (~\$320,000)

Period of Performance: FY 2014-2018

Conducting Organization: USGS

Principal Investigator(s): Dr. Sandra Talbot

BOEM Contact: [Rick Raymond](#)

Description:

Background: Arctic cod (*Boreogadus saida*) are estimated to funnel 93% of lower trophic energy to upper trophic predators including birds, seals, polar bears, beluga whales, and eventually to humans. Although Arctic cod are considered a sentinel species in the U.S. Arctic marine ecosystem, information about them is limited because of the difficulty of studying this ice-associated species. Despite the recognized importance of Arctic cod it is unknown whether there is a single pan-mictic population or whether there are sub-populations. This is an important distinction with respect to potential impact assessment because a sub-population limited to a smaller geographic location or a specialized habitat in the OCS would likely be more vulnerable to impact from an OCS development than a pan-mictic population spread across the circumpolar Arctic. BOEM needs a greater understanding of the ecological role this sentinel species plays as the primary pathway funneling lower trophic production to many marine mammals, birds and fish.

In 2012, a successful BOEM-funded pilot study conducted by USGS in collaboration with a Canadian genetics lab demonstrated that there is in fact a genetic break somewhere between the Chukchi/Western U.S. Beaufort and far eastern Canadian waters. This genetic break indicates that, rather than a single pan-mictic Arctic cod population, there may indeed be sup-populations. The pilot study relied on samples collected in 3 separate BOEM surveys in the northeast Chukchi and the western and central Beaufort Seas. Now that a genetic break has been identified, it is important to fill in the large spatial area between the Central U.S. Beaufort and the far eastern Canadian Beaufort with additional genetic samples and analyses to delineate sub-populations.

Additionally, a greater understanding of the ability of Arctic cod to survive and adapt as the ice retreats is needed to separate potential effects of oil and gas development on Arctic cod and its predators from the cumulative effects of climate change. Recent climate-change modeling suggests that as the arctic ice retreats Arctic cod may be at risk of extirpation in the OCS by 2030. Genetics, transcriptomes and genomics can provide insight into whether any Arctic cod lifestages are truly ice-obligate or whether they are simply ice-associated or ice-dependent and can potentially adapt to retreating ice conditions. Identifying whether there are genetically separated sub-populations, particularly near-shore and offshore populations, could provide a clue that there may be differential adaptability due to differential gene expression rather than different genes. Transcriptomes can identify differential expression of the single 'antifreeze' gene that may confer adaptability to loss of ice habitat. Genomics can facilitate transcriptomics by identifying additional genes associated with possible ice-obligation.

The large spatial gap from the eastern U.S. Beaufort Sea across the Mackenzie River Canyon into the Western Canadian Beaufort coincides with the footprint of the current field study "US-Canada Transboundary Fish and Lower Communities." That field study will collect the genetic samples needed for the work described here. The USGS Alaska genetics lab, which recently published similar groundbreaking Polar Bear genetics research, will lead the Arctic cod lab research.

Objectives:

- Identify genetic differences that would change the BOEM approach to Arctic cod effects analyses from evaluating Arctic cod as a single pan-mictic population to evaluating several geographic sub-populations of Arctic cod.
- Test hypotheses that onshore/offshore differences in the extent of ice-obligation genes may be related to differences in either genes (genetics) or gene expression (transcriptomics).
- Test hypothesis that ability to survive loss of Arctic ice may be related to differences in gene expression (transcriptomes).
- Test the ice-obligate hypothesis by identifying both differential genetic ('deep' genomic) and differential gene expression (targeted transcriptomic) pathways.
- Archive genetic specimens for future use in new hypothesis tests or with new technologies and methods.

Methods: The USGS genetics lab will analyze the field samples (supplied by the US-Canada Transboundary survey) for both mitochondrial and microsatellite DNA to identify sub-populations. Genetics results will direct how the next year's samples should be spaced to test the hypothesized dichotomies of coastal vs. continental slope populations; eastern vs. western; warm freshwater inputs vs. cold saline marine waters populations. Laboratory analyses of samples collected during 2012 and 2013 fieldwork will be used to identify optimal sampling locations for the 2014 field season. Initial profiles of the 'antifreeze' gene transcriptome will be analyzed for variation in gene expression across and within hypothesized sub-populations. A complete genomic sequence of a single

individual will be constructed to identify additional genes that may provide adaptive expression to climate change. The investigators will continue to coordinate and collaborate with a parallel Canadian collection and genetic analysis effort.

Current Status: Completed

Final Report Due: December 2018

Publications Completed: None

Affiliated WWW Sites: <http://www.boem.gov/akstudies/>
<https://marinecadastre.gov/epis/#/search/study/26926>

Revised Date: August 8, 2018