Environmental Studies Program: Ongoing Study

Title	Changing Relationships among Climate Variables and Cumulative Climate Stress on the Gulf of Alaska Ecosystem (AK-19-02-06)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$149,440 plus Joint Funding ($149,440)
Performance Period	FY 2019–2021
Final Report Due	June 2021
Date Revised	October 3, 2019
PICOC Summary	
Problem	The Gulf of Alaska (GOA) ecosystem is currently experiencing an extended climate anomaly that challenges existing understanding of the factors regulating population variability in commercially and ecologically important fish species. More information is needed about the possible ecological responses to changing relationships among basic oceanographic variables such as temperature, salinity, and stratification.
Intervention	This study will evaluate the ecological consequences of nonstationary environmental relationships through analysis of spawner-recruit dynamics for wild populations of pink, sockeye, and chum salmon throughout the GOA.
Comparison	The project will test the hypothesis that relationships among environmental variables have changed in ways that must be accounted for in any analysis of system dynamics under climate change.
Outcome	This research will improve understanding of the cumulative effects of change in multiple physical variables and contribute to the scientific knowledge of the GOA ecosystem.
Context	The northern Gulf of Alaska and Cook Inlet.

BOEM Information Need(s): BOEM needs an improved understanding of the ecological implications of observed increases in climate variability and changing relationships among oceanographic parameters. This information will improve understanding and provide insight to support cumulative effects analyses for NEPA assessments related to lease sales and potential exploration plans and development and production plans in Cook Inlet.

Background: Since 2014 the Gulf of Alaska (GOA) ecosystem has experienced unprecedented warm temperature anomalies, both on the surface and at depth (Walsh et al. 2018). These warm conditions are part of a North Pacific heatwave that began in 2014 and which, in terms of spatial scope, temporal duration, and magnitude of observed warm anomalies, is the largest marine heatwave ever observed (Hobday et al. 2018). Persistent warm anomalies outside the envelope of pre-2014 conditions have

continued through at least March 2019. The extent and magnitude of this warm event suggest the potential for strong and potentially long-lasting effects on GOA populations. Initial responses to the warm event included extreme mortality events for whales and seabirds, and unprecedented outbreaks of neurotoxin-producing dinoflagellates and pelagic tunicates. In addition to these acute responses, a number of potentially more persistent effects have become apparent as affected cohorts begin recruiting to populations of a variety of commercially-important fish species.

Recent observations suggest that relationships between SST and other ecologically-important environmental variables may have strengthened. Density profiles, stratification, and alongshore transport in the Alaska Coastal Current are largely driven by coastal freshwater discharge and water column salinity (Stabeno et al. 2004, Weingartner et al. 2005), and these processes are in turn linked to survival and productivity in a number of economically/ecologically important fish populations (Mueter et al. 2002, Doyle et al. 2009). Further, statistical effects of temperature on GOA populations, and the cumulative level of stress from multiple environmental processes, may be increasing.

Objectives:

- Examine evolving effects of changing environmental conditions on biological resources throughout the Gulf of Alaska (GOA) using statistical models of changing patterns of association among ecologically-important GOA climate processes.
- Evaluate the cumulative climate stresses on economically important salmon populations in the GOA by testing the hypothesis that increasing (decreasing) collinearity among climate variables predicts increasing (decreasing) strength of biological responses to primary climate variables, such as SST.

Methods: Researchers will collaborate with Gulf Watch Alaska (GWA) to examine changing collinearity among climate variables and impacts on a restricted set of populations. Physical (temperature, salinity, density, fluorescence, freshwater discharge, sea level pressure, wind stress, etc.) and biological (spawner-recruit time series for wild runs of pink, sockeye, and chum salmon) data from the 1970s through the present will be analyzed using standard approaches to understand basin-scale atmosphere-ocean interactions, such as regression of sea level pressure and wind stress fields onto GOA SST values, and empirical orthogonal function analysis to elucidate leading axes of spatial and temporal variability in atmospheric drivers of GOA physical variability.

Specific Research Question(s):

1. Is the collinearity of environmental parameters in the Gulf of Alaska changing over time?
2. What are the ecological effects of such changes?

Current Status: In procurement

Publications Completed: None

Affiliated WWW Sites: http://www.boem.gov/akstudies/
http://www.sfos.uaf.edu/cmi/

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