Environmental Studies Program: Ongoing Study

Title	Exploring radium isotopes as tracers of groundwater inputs, flushing rates, and produced water in Cook Inlet (AK-19-02-08)
Administered by	Alaska Regional Office
BOEM Contact(s)	Dr. Heather Crowley (heather.crowley@boem.gov)
Procurement Type(s)	Cooperative Agreement
Conducting Organization(s)	University of Alaska Coastal Marine Institute
Total BOEM Cost	$152,770, plus joint funding ($152,770)
Performance Period	FY 2020–2023
Final Report Due	January 2023
Date Revised	September 16, 2022
PICOC Summary	
Problem	The carbon and nutrient budgets in Cook Inlet and Kachemak Bay are not well understood. It remains unclear whether the primary source of carbon and nutrients to these areas is the marine environment (i.e. advected in from the Alaska Coastal Current), or localized inputs from seafloor sediments and land-based sources (i.e. rivers and groundwater).
Intervention	This study will evaluate radium isotopes as tracers for carbon and nutrient inputs in the Cook Inlet region. Field surveys will collect data to characterize groundwater carbon and nutrient fluxes, estimate water residence time, and calculate rates of offshore dispersion.
Comparison	Researchers will test hypotheses of the relative importance of different carbon and nutrient fluxes and compare water residence time estimates computed using radium isotope ratios with those from other studies.
Outcome	This project will employ novel and innovative methods for tracing the flow of water and its dissolved constituents to help to refine the carbon and nutrient budgets and water residence times for Cook Inlet.
Context	Cook Inlet Planning Area

BOEM Information Need(s): This study will lead to improved understanding of the carbon and nutrient cycles in Cook Inlet, which not only drive the primary production that supports the marine ecosystem but also help to modulate the chemical environment (e.g., ocean pH) that enables or limits growth of benthic and pelagic organisms. Better understanding of these linkages will provide insight into the existing environment for all organisms ranging from lower trophic levels to marine mammals, either directly or in relation to habitats and any changes to the cycles as result of OCS activities could cause impacts to these same analyzed resources. The study will also provide refined estimates for water residence time in Cook Inlet, which is an important consideration in BOEM's oil-spill analyses.

Background: Inputs of carbon and nutrients into coastal areas like Cook Inlet drive primary productivity, the fundamental food source for the marine ecosystem, while also modulating the chemical environment (e.g., ocean pH) that enables or limits growth of benthic and pelagic organisms. It is

unclear, however, whether the primary source of carbon and nutrients to Kachemak Bay and lower Cook Inlet is advected in from the Gulf of Alaska or localized inputs from rivers and groundwater. This uncertainty may stem from the fact that while some data are available regarding river inputs, little to no information exists to quantify inputs from groundwater and the seafloor.

Naturally-occurring radium isotopes have long been used as water mass tracers in coastal systems. Radium enters the marine water column at both the land-ocean and sediment-water column interfaces, and thus is commonly used to trace groundwater and benthic discharges into the water column. Four different radium isotopes are present in marine systems, two short-lived species (224Ra and 223Ra; 4 and 12 day half-lives respectively) and two long-lived species (228Ra and 226Ra; 5 and 1600 year half-lives respectively), therefore, this radium 'quartet' can be used to trace marine processes across a wide range of temporal scales. Multiple isotopes also facilitate the measurement of isotope ratios, which are commonly applied to estimate water residence times in coastal systems. These estimates can serve as a chemical-based approach for comparison to estimates based on traditional methods (e.g., physical data, drifters and numerical models).

Objectives: The objectives of this study are as follows:

- Construct radium, carbon and nutrient budgets for Kachemak Bay using data from a comprehensive field survey, and assess the relative importance of different land-based sources (rivers, groundwater, seafloor) as well as the marine input (from outside the bay) to regional carbon and nutrient cycles
- Estimate water residence times in Kachemak Bay using radium isotope ratios and compare and contrast results to those from an ongoing drifter-based study.
- Conduct exploratory surveys in Cook Inlet to examine the potential utility of radium-based approaches

Methods: Researchers will conduct a pilot field survey in Kachemak Bay in year 1 to build mass balances for radium, carbon, and macronutrients by establishing endmember concentrations for anticipated sources (rivers, groundwater, seafloor sediment) and measuring average concentrations in various areas of the bay. They will then analyze mass-balance and isotopic ratios to calculate groundwater fluxes, export fluxes, and residence times in Kachemak Bay. Results from the Kachemak Bay study will be used to formulate a survey in lower Cook Inlet in year 2 to obtain preliminary results that can guide and expand potential future radium-based research. This research will allow for the calculation of flushing time and the estimation for the time for any released materials to be removed from Cook Inlet.

Specific Research Question(s):

1. What are the relative contributions to the carbon and nutrient budgets from marine, riverine, sediment, and groundwater sources?
2. Can analysis of radium isotope ratios provide refined estimates of water residence times in Kachemak Bay and Cook Inlet?

Current Status: Awaiting final report.

Publications Completed: None

Affiliated WWW Sites:

http://www.boem.gov/akstudies/

https://www.uaf.edu/cfos/research/cmi/