University of Alaska

Coastal Marine Institute

Annual Report 20

Calendar Year 2013

Submitted by:
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University of Alaska Coastal Marine Institute

To:
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University of Alaska Fairbanks

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Contents

Introduction

The University of Alaska Coastal Marine Institute (CMI) is a cooperative agreement between the University of Alaska and the U. S. Department of the Interior Bureau of Ocean Energy Management (BOEM, formerly Minerals Management Service) to study coastal topics associated with the development of natural resources in Alaska's outer continental shelf. Under this cooperative program, BOEM supports highly qualified scientific expertise at the University of Alaska to conduct research used to inform management of oil, gas, and marine mineral resources. The initial agreement began in June 1993. CMI is pleased to present this 2013 Annual Report, our 20th annual report and the first annual report under a new five year administrative cycle under BOEM Cooperative Agreement M13AC00003.

Under BOEM, the Environmental Studies Program (ESP) is formally directed to provide information in support of the decisions involved in the planning, leasing, and management of exploration, development, and production activities. The BOEM research agenda is driven by the identification of specific issues, concerns, or information needs by federal decision makers and the state and local governments that participate in the process. Within that framework, the University of Alaska Coastal Marine Institute partners with BOEM and the State of Alaska to develop regional research goals and execute an annual request for proposals that initiates up to two million dollars of new research every year.

CMI Funded Student Support

In 2013, seven students were supported in part or whole by CMI funded research projects. It is not unusual for a CMI project to be the major source of dissertation or thesis work for graduate students, and summer field work often employees a variety of graduate and undergraduate level students for hands on training and invaluable experience working in the Arctic region. The following table shows current and recent student support through the CMI programming:

Project Title (year project started)	*Number of Students*		
	PhD	Master	Under-graduate
Population Assessment of Snow Crab, Chionoecetes opilio, in the Chukchi and Beaufort Seas including Oil and Gas Lease Areas (2011)			1
Dispersal Patterns and Summer Ocean Distribution of Adult Dolly Varden from the Wulik River, Alaska, Evaluated using Satellite Telemetry (2012)	1*		
Evaluating Chukchi Sea Trace Metals and Hydrocarbons Sourced from Nearby Coastal Rivers (2012)	1*		
A Year in the Life of the Bowhead Whale (2012)			1
Analysis of Benthic Communities on Weathervane Scallop Beds in Shelikof Strait (2013)		1*	
Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas (2013)	1*		

* Denotes project is primary dissertation or thesis effort

CMI Funding and Cost Share Partners

In 2013, BOEM committed $1 million to new projects under the Coastal Marine Institute partnership; making the total BOEM funding committed to CMI since inception in 1993 approximately $19.5 million. All CMI funded projects require a one-to-one cost share with non-federal monies. The following list of current cost share partners demonstrates the breadth of support for CMI-funded programs:

Alaska Department of Fish and Game
Alaska SeaLife Center
Arctic Supercomputing Center, UAF
Center for Global Change, UAF
Institute of Northern Engineering, UAF
International Arctic Research Center, UAF
JAMSTEC
Naval Research Laboratory
North Slope Borough
Oregon State University
PenAir
School of Fisheries and Ocean Sciences, UAF.
Seward Marine Center
Teck Alaska

Coastal Marine Institute Program Administration 2013-2017

Dr. Rolf Gradinger

School of Fisheries and Ocean Sciences
University of Alaska, Fairbanks

Cooperative Agreement Number: M13AC00003
Period of Performance: 04/09/13-03/31/18

Project Overview

The CMI is guided by a Technical Steering Committee (TSC) with members from the University, BOEM and State of Alaska. With TSC input, the University of Alaska Fairbanks School of Fisheries and Ocean Sciences provides administrative oversight of the CMI as a special project under the Office of the Dean. Specific administrative responsibilities include:

1. Facilitating annual research funding cycles from initial call to award
2. Technical Steering Committee support/coordination
3. Program support for researchers; liaison with BOEM regarding projects and reporting
4. Monitoring cooperative agreements and assisting with funding issues
5. Study publications and coordination of a public Annual Research Review seminar

2013Administrative Update

Calendar year 2013 marked the 20th anniversary of the University of Alaska Coastal Marine Institute. Dr. Rolf Gradinger, CMI Director, presented a review of the program at BOEM Environmental Studies Program 40th Anniversary celebration in Anchorage, Alaska.

In 2013, CMI supported ten active research projects targeting research in the Chukchi Sea and Beaufort Sea region where BOEM has active lease sales. This included six ongoing projects and the following new projects funded in federal fiscal year 2013:

1) Analysis of Benthic Communities on Weathervane Scallop Beds in Shelikof Strait
Investigator: Dr. Gordon Kruse

2) Distribution and Abundance of Trace Metals in Chukchi and Beaufort Sea Ice
Investigators: Dr. Robert Rember; Dr. Ana Aguilar-Islas

3) Development of Accurate Model of the Beaufort and Chukchi Ice Drift and Dispersion for Forecasting Spill Trajectory
Investigators: Dr. Anton Kulchitsky; Dr. Jennifer Hutchings

4) Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas
Investigator: Dr. Tuula Hollmén

The Coastal Marine Institute administrative office initiated the federal fiscal year 2014 funding cycle beginning with a call for Letters of Intent in June. This request was publicized and sent to researchers at the University of Alaska and various state agencies and stakeholders, including profit and non-profit organizations. Twenty-one project concepts were received in response to the call, and the TSC selected seven concepts for full proposal development. Full proposals were received in October and sent for external peer review and assessment by the TSC and BOEM staff.

Due to a shift in annual CMI programming cycles, there was no CMI Annual Research Review in calendar year 2013. The public research seminar and annual TSC project funding meetings will continue to be held at the University of Alaska campus, but will likely move to a regular January schedule.

Publications Pending

At close of calendar year 2013 there were three project final reports pending BOEM review and CMI publication:

1) Trophic Links: Forage Fish, Their Prey, and Ice Seals in the Northeast Chukchi Sea
   Investigators: Dr. Brenda Norcross, Dr. Lara Horstmann
   Cooperative Agreement: M09AC15432

2) Biogeochemical Assessment of the North Aleutian Basin Ecosystem: Current Status and Vulnerability to Climate Change
   Investigator: Dr. Jeremy Mathis
   Cooperative Agreement: M08AX12760

3) Satellite-Tracked Drifter Measurements in the Northeast Chukchi Sea
   Investigator: Dr. Thomas Weingartner
   Cooperative Agreement: M11AC00001

Population assessment of snow crab, *Chionoecetes opilio*, in the Chukchi and Beaufort Seas including oil and gas lease areas

Dr. Bodil Bluhm
Dr. Katrin Iken

School of Fisheries and Ocean Sciences
University of Alaska, Fairbanks

Cooperative Agreement Number: M11AC00003
Period of Performance: 06/01/11-11/30/14

Project Overview

The snow crab, *Chionoecetes opilio*, is a widely distributed and abundant epibenthic species on the Bering and Chukchi Sea shelves. It also occurs regularly on the western Beaufort Sea shelf and slope, but is rare in the eastern Beaufort Sea. While the Bering Sea stock is regularly surveyed and the stock characteristics and biology are comparatively well known, knowledge about the crab stock structure in the Chukchi and Beaufort seas was very limited until now. The recent northward contraction of the species in the Bering Sea, and the general trends for northward shifts in species distributions in the Bering and Chukchi Seas combined with the increased interest in the Chukchi and Beaufort Seas for oil and gas-related exploration activities motivated this study.

A number of research cruises to the Chukchi and Beaufort Seas in recent years have afforded the opportunity to study the snow crab populations in the Pacific Arctic. Specifically, this study addresses the following objectives: (1) To estimate abundance and biomass and assess distribution of snow crab in the Chukchi and Beaufort seas, (2) to determine stock structure (size, sex, shell condition) and reproductive potential (female fecundity, sperm reserves), (3) to identify diet from stomach contents and trophic position from $\delta^{15}N$ and $\delta^{13}C$ stable isotopes, and (4) to compare our findings to the few available earlier studies in the study area. Material for this study was collected during five cruises to the Chukchi Sea (RUSALCA 2009 and 2012, COMIDA 2010, CSESP 2010, Arctic Eis 2012), and four cruises to the Beaufort Sea (Ocean Explorer 2008, BeauFish 2011, Transboundary 2012, 2013).

2013 Project Update

The focus of our work in 2013 – and of this report – was on the trophic ecology of snow crab across the Chukchi and Alaskan Beaufort seas, a joint objective between this CMI project and our component of the Arctic Eis study. The related lab work was primarily conducted by PhD student Lauren Divine as part of her dissertation. The crabs used covered a size range of 32-144 mm carapace width (CW) (Figure 1) and came from bottom trawls collected during the following field campaigns: Arctic Eis 2012, BeauFish 2011, and US-Canadian Transboundary project 2012.

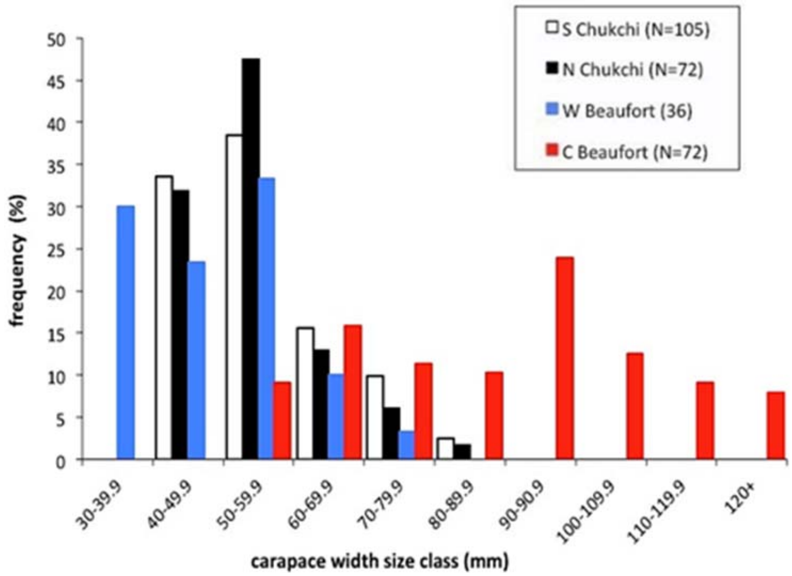

Figure 1. Size frequency distribution of snow crabs used for stomach content and stable isotope analysis by region. Few small crabs were available from the central Beaufort Sea, hence larger crabs were used. In the Chukchi Sea, no crabs larger than ~80 mm CW were found.

Approach

We employed two methods. First, stomach contents analysis was used to determine prey items to the lowest possible taxonomic level to provide a snap shot of short-term diets. Second, stable carbon and nitrogen isotope analysis of muscle tissue was used to identify time-integrated trophic positions of snow crabs. $\delta^{13}C$ increases by ~1 ‰ and $\delta^{15}N$ by ~ 3.4 ‰ with each trophic level.

The samples for stomach content analysis were spatially distributed as follows: n=105 crabs from the southern Chukchi (66.0-70.0°N and 164.1 to -168.5°W, 40.2- 89.2 mm CW); n=72 from the northern Chukchi (70.1- 73.1°N and 157.2 to -168.5°W, 40.1-88.5 mm CW); n=36 (i.e., all available) from the western Beaufort (70.1- 70.9°N and 144.95 to -147.07°W, 32.6-75.8 mm CW), and n=72 crabs from the central Beaufort Sea (70.5- 71.3°N and 147.28 to -151.34°W, 50.5-129.6 mm CW). Stomach fullness was determined in % categories. All prey items were identified to lowest practical taxonomic level under a microscope, photographed, and patterns analyzed using frequency of occurrence as the metric.

$\delta^{13}C$ and $\delta^{15}N$ stable isotopes were analyzed from muscle tissue collected from 347 crabs (n=114 each for the southern and northern Chukchi Sea, 32 for the western Beaufort Sea, and 87 for the central Beaufort Sea; regional definitions as above). Crab muscle tissue was dissected, dried, lipid extracted, re-dried and analyzed for $\delta^{13}C$ and $\delta^{15}N$ stable isotope composition at the Alaska Stable Isotope Facility in Fairbanks.

Results

Crab stomach fullness and diet composition ranged widely and varied regionally. Stomach fullness ranged from 0-70%. Some of the most common diet items included detritus, various types of animal soft tissue, polychaetes, and bivalves (Figure 2). Ophiuroids, amphipods, decapods, and fishes were less common, but in some cases regularly occurred in a particular region. Regional differences were most conspicuous for polychaetes, which were more common in the Beaufort than Chukchi Sea, and for bivalves that were more common in the northern Chukchi and western Beaufort than the other two regions (Figure 2).

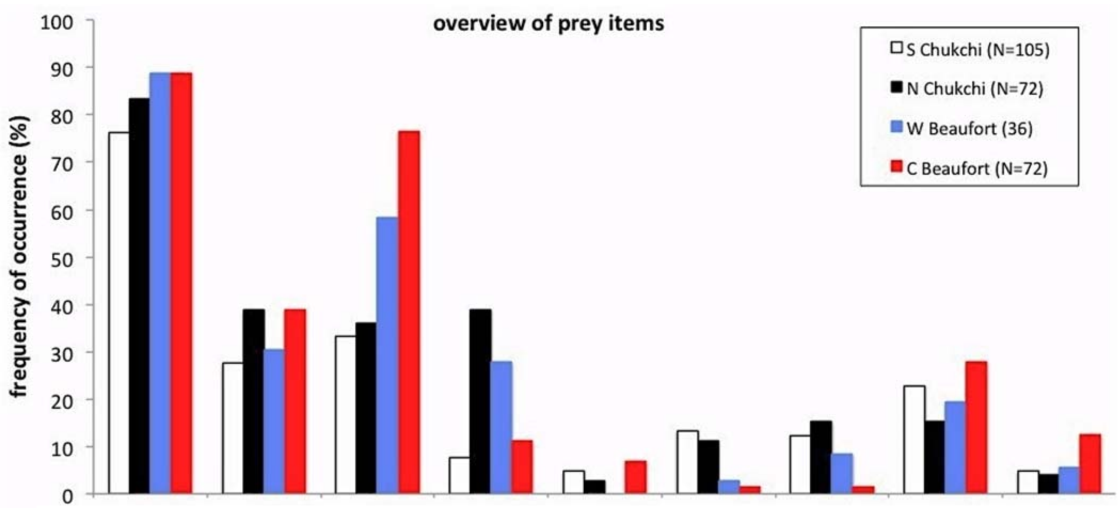

Figure 2. Frequency of occurrence of dominant prey items in Pacific Arctic snow crabs by region.

$\delta^{15}N$ and $\delta^{13}C$ varied widely across the entire study area with much of the variability explained by sex and region (Figure 3). Male crabs overall had higher $\delta^{15}N$ values than females from the same region. Crabs from the central Beaufort Sea were more depleted in $\delta^{13}C$ than crabs from the other regions, which in part could be related to the larger body size (few crabs of the same size as used in the other regions were available). Overall, the range of $\delta^{13}C$ was narrower in Beaufort Sea crabs than in Chukchi Sea crabs. Further data analysis is ongoing and will lead to preparation of a thesis chapter in form of a manuscript for a peer-reviewed journal this year.

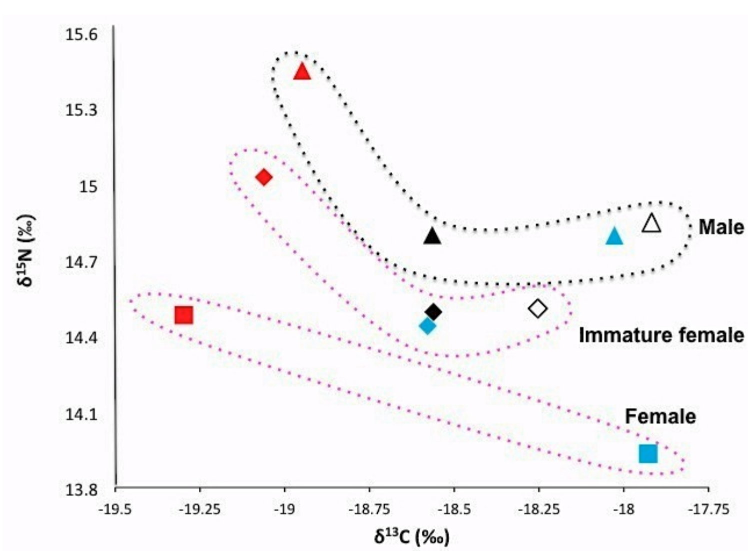

Figure 3. $\delta^{13}C$ and $\delta^{15}N$ isotopic composition of Pacific Arctic snow crab (muscle tissue) by region and sex.

Problems, project status and changes

We encountered problems with one of our freezers and thereby lost some crabs from the Chukchi Sea. Trophic samples for mature females are, therefore, missing from both the northern and southern Chukchi Sea.

We are a bit delayed with the processing of spermathecae for the reproductive aspect of our project. This work will assess to what extent female crabs in the Pacific Arctic store sperm for the potential production of clutches in years where they do not mate. We have now begun that work and anticipate finishing it by the spring to conclude the lab work for this project.

Project Related Presentations and Publications

We gave three oral and three poster presentations about this project in 2013, plus a poster at the recent Alaska Marine Science Symposium in January 2014. A student-led manuscript is in preparation that focuses on the entire benthic food web of the Beaufort Sea, including snow crab as part of the benthic communities.

Bluhm B. and K. Iken. Population assessment of snow crab, *Chionoecetes opilio*, in the Chukchi Sea: preliminary findings. Alaska Marine Science Symposium, Anchorage AK, 21-24 January 2013 (poster).

Bluhm B. and K. Iken. Population assessment of snow crab, *Chionocetes opilio*, in the Chukchi and Beaufort Seas: preliminary findings. 28th Lowell Wakefield Symposium, Anchorage AK, 26-29 March 2013 (talk).

Divine L., B. Bluhm and K. Iken. Arctic snow crab (*Chionoecetes opilio*) diets: comparison of stable $\delta^{15}N$ and $\delta^{13}C$ isotope and stomach content analyses. Alaska Marine Science Symposium, Anchorage AK, 20-24 January 2014 (poster).

Divine L., B. Bluhm and K. Iken. *Chionoecetes opilio* population assessment in the Chukchi and Beaufort Seas: Trophic ecology. Coastal Marine Institute Annual Review, Fairbanks AK, 15 January 2014 (talk).

Divine L., K. Iken and B. Bluhm. Arctic snow crab (*Chionoecetes opilio*) diets: a comparison of stomach content and stable $\delta^{13}C$ and $\delta^{15}N$ isotope analysis. American Fisheries Society Meeting, Alaska Chapter, Fairbanks Alaska, 7-11 October 2013 (talk).

Divine L., K. Iken and B. Bluhm. Can you stomach it? Preliminary diet and stable isotope analysis of snow crab (*Chionoecetes opilio*) in the Alaskan Arctic. 28th Lowell Wakefield Symposium, Anchorage AK, 26-29 March 2013 (poster) – *earned best student poster award.*

Divine L., K. Iken and B. Bluhm. Regional benthic food-web structure on the Alaskan Beaufort Sea shelf. Alaska Marine Science Symposium, Anchorage AK, 21-24 January 2013 (poster).

Dispersal patterns and summer ocean distribution of adult Dolly Varden from the Wulik River, Alaska, evaluated using satellite telemetry

Dr. Andrew C. Seitz

School of Fisheries and Ocean Sciences
University of Alaska, Fairbanks

Cooperative Agreement Number: M12AC00006
Period of Performance: 05/02/12 - 09/30/14

Project Overview

In northwest Alaska, Dolly Varden is highly valued as a subsistence fish and local residents harvest thousands of these fish each year. For example, in Kivalina and Noatak, Dolly Varden landings regularly exceed the combined landings of all species of salmon combined. These Dolly Varden undertake oceanic migrations during summers, which may exceed 1500 km. Although these fish may be broadly distributed, there have been no studies that examined oceanic ecology of Dolly Varden in the Chukchi Sea. We hypothesize that Dolly Varden that overwinter in northwest Alaska will feed during the summer in offshore areas of the Chukchi Sea. Because these fish are a critical subsistence resource in northwestern Alaska, it is imperative to understand their current spatial and temporal use patterns in the Chukchi Sea to assess their vulnerability to development and extraction activities. Therefore, in 2012 and 2013, we attached 52 Pop-up Satellite Archival Transmitting tags to adult Dolly Varden overwintering in the Wulik River to describe 1) timing of outmigration from the Wulik River to the Chukchi, Bering and/or Beaufort Seas, 2) summer dispersal in the ocean and 3) depth and temperature occupancy in the ocean.

2013 Project Update

Student update

Michael Courtney, an undergraduate Fisheries student at the University of Alaska Fairbanks (UAF), completed preliminary analyses of temperature and depth data from the tags deployed in 2012 for his Senior Thesis. Additionally, Michael was awarded a two year Rasmuson Fisheries Research Center Graduate Student Fellowship to pursue a Master's of Science degree at UAF that will focus on complete analyses of temperature, depth and light data from tags deployed in both 2012 and 2013.

Fieldwork

From 13–14 June 2013, 32 adult Dolly Varden were captured with gillnets in Kivalina Lagoon (near the mouth of the Wulik River), approximately 40 km downstream from the 2012 tagging location. There were two main reasons for the new tagging location: 1) To increase the participation of Dolly Varden subsistence users in Kivalina, AK in the project, 2) to reduce the amount of tagged fish incidentally captured in subsistence and recreational fisheries before leaving the Wulik River (20% in 2012). During this sampling period, project investigators worked closely with local residents from Kivalina and monitored three subsistence gill nets in

Kivalina Lagoon. Upon capture, large Dolly Varden (>60 cm) were carefully removed from the net and placed in a holding pen (1.2 x 2.4 m, 70 cm water depth) where their health was monitored. Pop-up satellite archival transmitting (PSAT) tags (Microwave Telemetry X-tags) were attached to healthy Dolly Varden (n=32) using a wire harness back pack system (Figure 1). After a PSAT tag was secured, the tagged fish was returned to the mesh holding pen for observation. After it was determined that it was swimming satisfactorily, it was released.

Figure 1. Pop-up Satellite Archival Transmitting (PSAT) tag attached to a Dolly Varden in Kivalina Lagoon in June 2013.

Preliminary results

Of the 32 tags deployed in June 2013, three were recovered while still attached to fish, 25 transmitted data to project investigators via Argos satellites, and four failed to report and are considered missing. For the three tags recaptured in subsistence fisheries, all were recaptured near Sheshalik in the Noatak River delta (Figure 2). For the 25 tags that reported to satellites, 19 provided accurate (±250m) end locations determined by Argos satellites. Of these tags, two reported in the lower reaches of the Wulik River, three reported in nearshore waters near Kotzebue Sound, eight reported from other rivers in northwestern Alaska, and three reported from the Russian Chukchi Sea (Figure 2).

Similar, to tagged fish in 2012, three fish tagged in 2013 reported from the Russia Chukchi Sea approximately 450 km from the Wulik River (Figure 2). Based on occupied temperature and depth, these fish exhibited similar behaviors to fish tagged in 2012 including ocean entry, marine transit, and feeding (Figure 3), although several interesting differences were noticed in these behaviors. First, the presumed feeding grounds from which these tags reported in 2013 is approximately 150 km northeast of presumed feeding grounds in 2012 (Figure 2). Additionally, these fish experienced much warmer water temperatures during ocean entry (2–3°C) in 2013 compared to the sub-zero temperatures experienced by many tagged fish in 2012. Finally, the fish tagged in 2013 occupied much shallower mean and maximum depths while in the ocean compared to those tagged in 2012. Specifically, for Dolly Varden that dispersed to offshore areas of the Chukchi Sea, they occupied the top 5 and 15 m of the water column approximately 65 and

92% of the time in 2012 (n=5), and 89 and 100% of the time in 2013 (n=3; Figure 4). When 2012 and 2013 fish are combined (n=8), they spent an average of 74 and 95% of the time in the top 5 and 15 m of the water column (Figure 4).

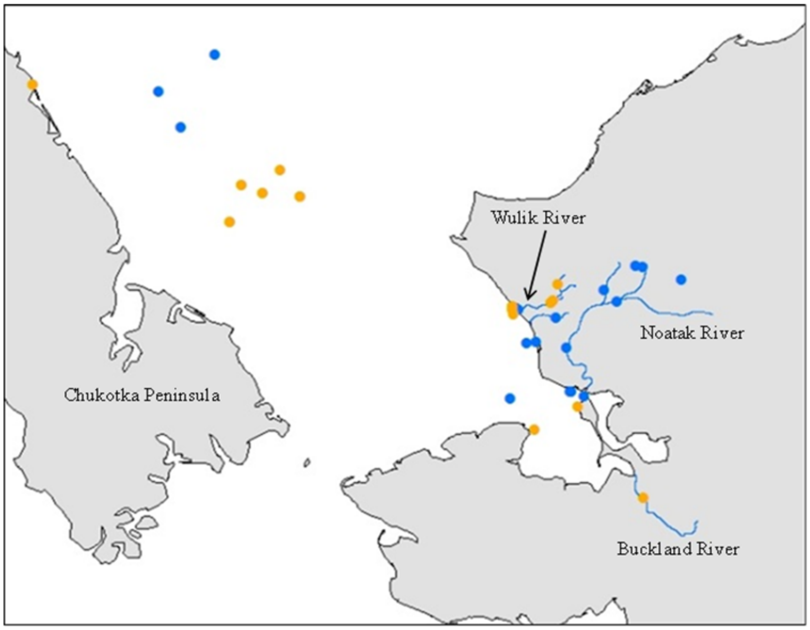

Figure 2. End locations of Dolly Varden tagged in the Wulik River in summers of 2012 (orange dots) and 2013 (blue dots). End locations may be where a fish was physically recaptured while the tag was still attached to a fish, or where a tag popped-off a live fish and reported to satellites.

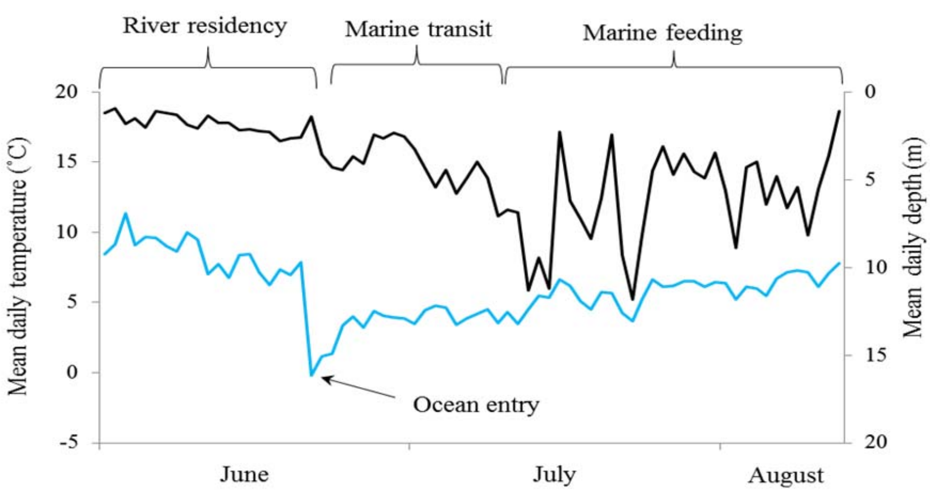

Figure 3. Proposed dispersal phases of Dolly Varden that occupied offshore waters of the Chukchi Sea during summer. Daily average depth (black line) and water temperature (blue line) occupied by one PSAT tagged Dolly Varden whose tag popped-up in the Chukchi Sea north of Russia on 15 August 2012 are shown for illustrative purposes. River residency is characterized by relatively warm water temperatures. Ocean entry is characterized by a sudden drop in water temperature. Marine transit is characterized as the brief period after ocean entry during which there is little variability in depth, which is followed by marine feeding during which variability in depth increased.

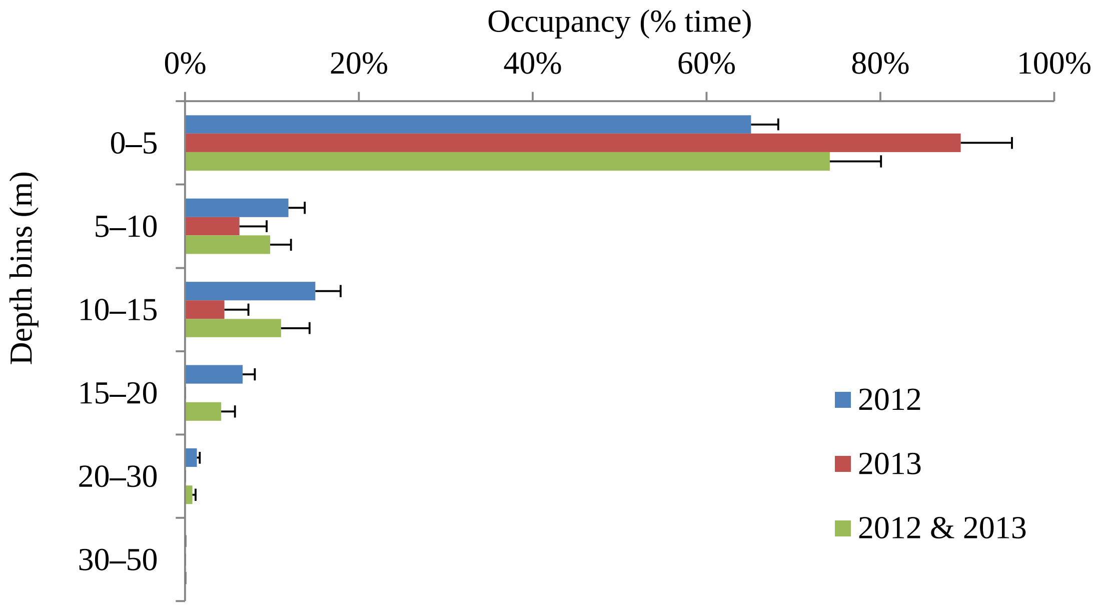

Figure 4. Mean percent of time (±SE) spent in depth bins by Dolly Varden that dispersed to offshore areas of the Chukchi Sea in 2012 (n=5) and 2013 (n=3).

As previously mentioned, 12 fish showed southerly alongshore movements to Alaskan rivers and the nearshore areas adjacent to Kotzebue Sound. While most of these tags failed to transmit any archived data, three tags were recaptured near Sheshalik, AK by subsistence fishermen. These fish, similar to tagged fish in 2012, experienced highly fluctuating daily water temperatures, shallow depths, and little oscillatory diving behavior for their entire time at liberty. Interestingly, by correlating nearshore water temperatures obtained from sea surface temperature images to temperatures experienced by tagged fish, preliminary results indicate that this nearshore transit of ~150 km occurs rapidly over a period of 2–3 days. During this nearshore transit, tagged Dolly Varden spent >99% of the time in the top 5 m of the water column in both 2012 and 2013.

Preliminary discussion

This study documents the first use of an archival or PSAT tag on Dolly Varden, and has produced new insights into their ecology and behavior. While this study does not have the sample size needed to draw quantitative population-level conclusions, it does show that Dolly Varden do undertake a variety of dispersal types, including relatively long, offshore movements in the Chukchi Sea. Because all eight fish whose tags reported from offshore areas of the Chukchi Sea were located in a relatively small area where they displayed feeding behavior for up to 45 days, it is likely that this location is an important feeding area for Dolly Varden in the Chukchi Sea for most of the summer. While in the ocean, these Dolly Varden spent the vast majority of time near the surface of the water, which may lead to interactions between this fish species and human activities in the surface waters of the Chukchi Sea.

Future data analyses

To further understand the oceanic ecology and behavior of Dolly Varden in the Chukchi Sea, we are currently conducting additional analyses to: 1. identify break points in the depth and temperature time-series data, 2. describe interannual variability in diving behavior in tagged fish, and 3. to explore the feasibility of estimating daily geoposition of tagged fish using auxiliary data, such as sea surface temperature.

Project Related Presentations and Publications

Scientific presentations titled “Dispersal of adult Dolly Varden from the Wulik River, Alaska, evaluated using satellite telemetry” were given by Michael Courtney, Andy Seitz and Brendan Scanlon at the following venues:

Alaska Chapter of the American Fisheries Society Annual Meeting, Fairbanks, AK, 9 October 2013

Annual Meeting of the Arctic Division of the America Association for the Advancement of Science, Kodiak, AK, 26 September 2013

University of Alaska Fairbanks Research Day, Fairbanks, AK, 30 April 2013

University of Alaska Fairbanks Fisheries Division Seminar, Fairbanks, AK, 24 April 2013

University of Alaska Fairbanks Fisheries Division Undergraduate Experiential Learning Seminar, Fairbanks, AK, 19 April 2013

Western Alaska Interdisciplinary Science Conference, Nome, Alaska, 22 March 2013

Pollock Conservation Cooperative Research Center Annual Research Review, Anchorage, AK, 24 January 2013

Alaska Marine Science Symposium Anchorage AK, 22 January 2013

Evaluating Chukchi Sea Trace Metals and Hydrocarbons Sourced from the Yukon River

Dr. Paul McCarthy
John Perreault

Geophysical Institute
University of Alaska, Fairbanks

Cooperative Agreement Number: M12AC00001
Period of Performance: 06/04/12-08/31/14

Project Overview

The goal of this project is to develop a modern and historical database of the transport of polycyclic aromatic hydrocarbons (PAH) and trace metals in the Yukon River sediment. The Yukon River contributes significant sediment load to the Chukchi Sea, making it a likely source for potential contaminant input. This project complements the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) program, also funded through BOEM, which is assessing baseline environmental status in the Chukchi Oil Lease areas. The specific goals of the project are to:

1. Analyze PAH and trace metal concentrations in active dissolved, suspended and bed load sediment samples from the lower Yukon River.
2. Date sediment cores from the Yukon River delta and analyze for PAH and trace metal concentrations to establish a temporal pattern of sedimentation and potential contaminant input.
3. Assess grain size distribution of trace metals in sediment samples to determine trace metal bioavailability and likelihood of transport.

2013 Project Update

A primary focus of project effort in 2013 was to accomplish seasonal sampling with the intention of capturing temporal variations in the river’s environmental conditions. Sampling was successfully completed in March, under the late winter ice; June, during spring break-up and flooding; and September, during a low, late summer flow. In each expedition, water and suspended sediment samples were taken at five sites established in 2012 (Figure 1). Bed load samples, large collections of sediment from the river bed, usually from a sandbar or beach, were collected at random points across the sampling area in June and September.

We were pleased to find that our carefully timed excursions over both sampling years coincided with the flow levels we expected. We expect to see variations in suspended sediment content reflected in contaminant profiles and possibly identify a picture of the annual changes in PAH and trace metal concentrations.

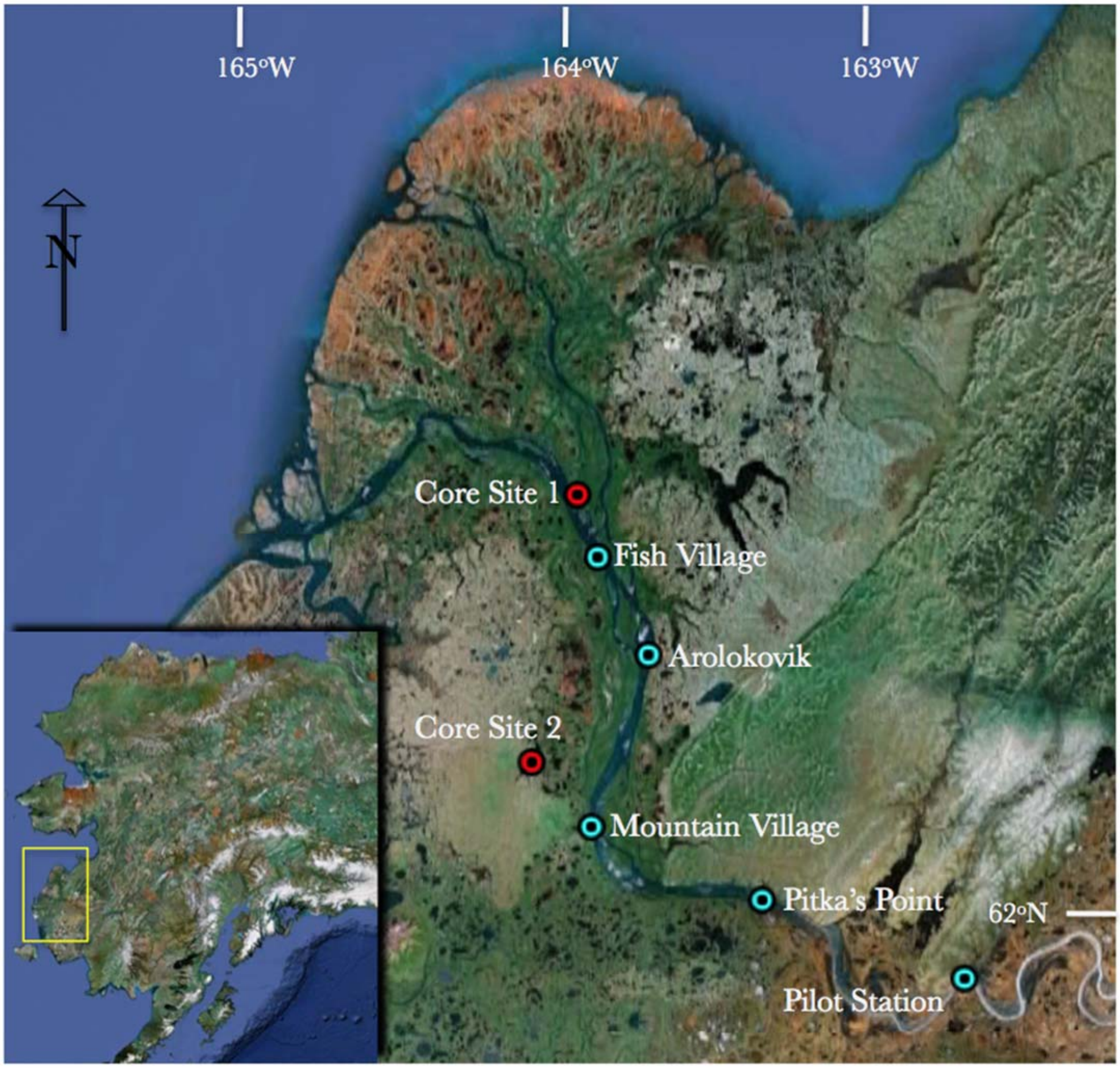

Figure 1: Yukon River sampling sites. Core sites in red were extracted in 2012 and 2012-13 water and suspended sediment sampling locations are in blue.

Sampling

In March, traveling on snow machines, we collected samples from the five suspended sample sites established in 2012. We believe these sampling stations capture the character of the river before it experiences marine influences in the delta. In winter, the river carries little to no surficial flow and water under the ice is groundwater from unfrozen hydraulic zones in the Yukon drainage basin. To sample, we drilled through 1-1.4 meters thick river ice using a hand held power drill with an ice drill bit (Figure 2). Silicon tubing was secured to a Teflon rod and inserted through the hole to 0.5-1 meter below the bottom of the ice. Water was pumped into sample jars, which were separated into samples to be frozen (PAH, carbon) and samples to be filtered before freezing (trace metals). Keeping the pump line from freezing due to wind and cold temperatures was a challenge. The issue was largely solved by running tubing through the sampler's coat and using body warmth to prevent freeze up. Due to winter conditions, bed load samples were not safely accessible during the March sampling.

Figure 2: UAF Geology graduate student John Perreault (right), and Stan Shepard of Mountain Village, Alaska drill through the Yukon River ice in March 2013.

June sampling was scheduled in order to sample effects of spring thaws and flooding. The river was very high from precipitation and snowmelt, and flooding was widespread along the normal river course. A great deal of flood debris, including large logs, was on the river during sampling and a very heavy sediment load would be expected. Water for dissolved contaminants and suspended sediment was collected at all five sampling sites and several bed load samples collected. Clear weather and an intrepid guide made this summer sampling effort fast and efficient.

Water for dissolved contaminants and suspended sediment was gathered at all five sites for this study in September. During this period, precipitation and groundwater both contributed to river volume, but there had been no flooding. A low suspended sediment load would be expected given the lower, late summer season flow. Bed load samples were also collected.

Preliminary Results

In January of 2013, preliminary PAH analyses were conducted on the nine suspended sediment samples collected in 2012. Analyses took place at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University (OSU), under the guidance of Dr. Fred Prahl and Margaret

Sparrow. Interpretation of initial data suggests a very low contamination profile for PAH levels. All significant PAH signatures observed in the primary analyses corresponded to natural products such retene, a derivative of tree bark and coal tars.

We were concerned that difficult field processes might introduce opportunity for sample contamination. However, initial analyses offered no evidence that samples were contaminated from our unique sampling procedures. We were pleased with this seemingly successful result and confident in using similar sampling methods during the 2013 sampling seasons.

Project Status

All field sampling has been completed for this project and analysis of all samples is commencing. Due to staff changes at OSU, analysis of PAH samples will be moved to the Water and Environmental Research Center at the University of Alaska Fairbanks. However, Dr. Prahl will remain involved on the project, assisting with interpretation of results and advising on best practices to ensure comparability between the different laboratories.

Two sediment cores were extracted from the presently active and historically active Yukon River in 2012. The cores provide discrete sampling intervals up to 2 meters deep, and are currently stored in a core depository at Woods Hole Oceanographic Institution (WHOI). A trip is scheduled for early April 2014 to take samples from these cores for analysis and dating of deposition. Dating is expected to be a combination of Cesium-147 and radiocarbon dating techniques, which will be dependent on the age of the cores. Dating work will be done by WHOI staff, under the direction of Dr. Liviu Giosan of the Institution. Sampling for PAH and trace metals from the cores will then be done from distinct age horizons along the cores and transported back to UAF by graduate student John Perreault for analysis and interpretation.

Project Related Presentations and Publications

Perreault, J.M. and P. McCarthy. 2012. Evaluating Chukchi Sea Trace Metals and Hydrocarbons Sourced from Nearby Rivers. Coastal Marine Institute 2012 Annual Review, Fairbanks AK, December, 2012.

Perreault, J.M. 2013. In: University of Alaska Coastal Marine Institute Annual Report No. 19. OCS Study BOEM 2013-0112. University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region, 29-30 p.

Perreault, J.M. and P. McCarthy. 2014. Evaluating Chukchi Sea Trace Metals and Hydrocarbons Sourced from Nearby Rivers. Coastal Marine Institute 2013 Annual Review, Fairbanks AK, January, 2014.

A Year in the Life of a Bowhead Whale: An Animated Film

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University of Alaska Museum of the North
University of Alaska Fairbanks

Dr. Steven Okkonen
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Cooperative Agreement Number: M12AC00005
Period of Performance: 06/04/12-05/30/14

Project Overview

This project seeks to create a 20-25 minute 3D computer animated film telling the story of bowhead whale annual migration and their zooplankton prey. The film takes its basic narrative and title from the 2013 calendar previously produced by Steve Okkonen: A Year in the Life of the Bowhead Whale. The purposes of the film are to improve public understanding of the marine ecosystem, with emphasis on the whales and the zooplankton. Specific topics covered include whale taxonomy, physiology, diet, behaviors, and overall movement through subarctic and arctic waters, as well as the current tagging and aerial observation programs, and work with Inupiat whalers. All principle production and post-production services are being carried out by University of Alaska Museum of the North staff and University of Alaska Fairbanks student employees. The visual elements of the film center around 3D photorealistic animation of whales, copepods, and krill in arctic waters, as well as hemispheric-level interpretation of bowhead annual movement using MODIS satellite imagery, and orthogonal graphic imagery interpreting science dive data and generalized current regimes near Barrow, Alaska.

2013 Project Update

The Project team conducted a full review of the footage rendered to date both for technical hurdles made and yet to be accomplished, and for an evaluative look at film nearly finished. The results are listed below.

a. Film Script
   The film script has gone through a second round of science review. We have acquired all data sets were hoping to for the film, excepting one, and that is forthcoming after additional processing (MODIS Chlorophyll-A). We have modeled, textured, and fully rigged two of the three major animals to be seen in the film. We have begun shot set-up and review on a wide sweep of film sequences.

b. Hiring
   The museum hired a project lead animator as a full time staff member. Formerly a student employee, Hannah Foss is now working full time on the film and running through object texture maps, model remediation, and animation shots.

c. Data Imaging and Graphics
Hemispheric scale imaging of whale and krill provided by Steve Okkonen, position data (tagged and simulated) are complete with final images ready for grading as the film is cut together this spring. Visualization of hydrophone recordings provided by Kate Stafford is in question and may require revisions as we see the clips annotated and incorporated into the edit. Similarly for the IWC map. The completed chlorophyll imagery provided by Rachel Potter, has been composited with the earth-view renders. Cladogram and mammalian age charts are not yet complete. Similarly, the diving whale plot and the representation of Barrow Canyon have yet to be visualized. Illustrations of whale caloric intake have been rendered and include a clip featuring 5 gallon buckets and a clip featuring chocolate kisses swimming as a krill swarm.

d. Vehicles
Limited vehicles are represented in the film. All shots including the Twin Otter are complete excepting minor image bugs that will be removed this spring. Limited use of an oceanographic research ship model has begun with decent results. Methods have been used that do not depend on fluid simulations.

e. Humans
Shots in the film involving humans are rendered as animated paintings then further graded and treated with both an artificial depth of field and a water effect to abstract the representation. The film is more from the whale's perspective than a human perspective. This is both a major cost-saving measure and an artistic one.

f. Annotations
Annotations exist in only the barest sense in the completed footage. It is our intent to keep to a minimum the on-screen text. While the film will demand a fair amount, we hope to minimize the hardness of the text by both animated and handwriting the annotations to maintain the largely organic feel of the film. The process for this has been tested and approved. If we realize this, there will be no commercial fonts used in the film. The drawback will be increased staff time and so these elements are being held back for now.

g. Krill and Copepods
Both krill hero objects and krill in flocks have been animated and rendered for the film. Additional shot angles will be required but can be based on the first run of shots. Krill look and textures have been reviewed by partnering scientists. The latest round of krill rendering has focused on creating krill layers for compositing with other footage, primarily of the whales. The copepods have been modeled and rigged, and preliminary animations have been reviewed by partner researchers. Animation of the copepods requires significant retooling to achieve a realistic look and motion for these animals.

h. Whales
A large percentage of the required whale shots have been completed, mostly in the category of shots where the whales do not intersect the plane of the water. Shots with

water intersection largely fall under the classification of fluid simulations. Whales have been rendered under ice and under open water, at depth and near the surface. Additional shots of this nature will be required, but like the additional krill shots, do not require new setups and are built upon existing work. Craig George, Senior Wildlife Biologist from the North Slope Borough visited UAMN in June to work with the Project Lead Animator reviewing animation clips and sharing photographic references for whale texturing and movement. Images produced through December have been reviewed by Craig George and Inupiat whale hunters in Barrow.

i. Fluid Simulations
The films fluid simulations are the most technically difficult part of the film and have seen the largest number of issues with software wrangling, re-simulating, and memory management. A single 15 second fluid simulation shot chews up some 500GB of hard-drive space for the particle field data and some 16-32GB of RAM during processing and rendering. A significant amount of time has been spent honing the process on the initial fluid simulations. We are now at a point where we have defined the process sufficiently to run our backlog of animated whales requiring simulation through the process. This will continue through the spring.

j. Sound
We have recorded the latest version of the film in English as a temporary narration, which will be replaced once the visual elements of the film are cut together. It is fully expected that the narrative will change in at least small ways at that time, and there is little value in pursuing a distribution quality narration of the film in English until those final reviews have been completed. Similarly, the Inupiat and St. Lawrence Island Yupik translations and narrative tracks also require all edits to be final before proceeding.

k. Additional
Additional shot and object types being worked include a collection of ice objects for a significant number of shots, and phytoplankton models, which are all completed and awaiting shot setup and rendering. Laser scans of the museum's bowhead whale specimens were turned into a 3D model by the Idaho Visualization Laboratory, which the project is now using to illustrate whale characteristics in the film.

2013 Publications and Presentations

The museum began a blog detailing progress on the project. The blog is updated as notable events happen. It can be accessed at: http://arcticcurrents.wordpress.com

UAMN Head of Production, Roger Topp, traveled to Barrow in April to speak with scientists and hunters during the Spring Whaling season. Informal presentations of animations in progress we made to many individual, resulting in the further sharing of audio and video footage of ice and whales by both the scientists and whalers.

Analysis of Benthic Communities on Weathervane Scallop Beds in Shelikof Strait

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Jessica R. Glass

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University of Alaska, Fairbanks

Cooperative Agreement Number: M13AC00004
Period of Performance: 06/15/13 - 12/31/14

Project Overview

We are conducting an analysis of benthic fish and invertebrate communities in areas targeted by Alaska's commercial weathervane scallop *(Patinopecten caurinus)* fishery in Shelikof Strait. Fish and invertebrates are incidentally caught in the commercial scallop fishery and subsequently sampled by onboard observers. Using observer bycatch data collected during 1996-2012, we are examining spatial patterns in community composition on weathervane scallop beds, as well as changes in community composition over time. Observed differences will be evaluated with respect to environmental conditions (e.g., depth, substrate type, temperature) and anthropogenic factors (e.g., dredge and trawl fishing intensity). Results from this study will provide baseline data on benthic communities in a region potentially impacted by oil and gas development. Also, benthic community compositions on scallop beds may also serve as useful indices of climate change and bottom fishing effects in Alaska. Finally, results will yield valuable information to fishery managers on benthic community composition and associated habitat to improve essential fish habitat (EFH) definitions for federally managed species of groundfish, scallops and crabs.

2013 Project Update

Since our cooperative agreement was approved in June 2013, the graduate student, Jessica Glass, has completed error checking of scallop fishery observer data, which she obtained from the Alaska Department of Fish and Game (ADF&G). Due to changes in, and complications with, the observer dataset, we were not able to receive scallop observer data for 1993-1995. However, we were able to obtain observer data from 2012, an extra year which we did not anticipate when we submitted our original proposal. Jessica also obtained data on pelagic and bottom trawling fishing effort during 1996-2012 from the National Marine Fisheries Service's Catch in Areas Database. Jessica completed her coursework and advanced to candidacy during fall 2013. She met with her graduate committee in mid-November to review her progress, and is expecting to defend her thesis in May 2014.

Using nonparametric analyses, we observed subtle, yet significant, spatial and temporal differences in biological communities associated with weathervane scallop beds in Shelikof Strait. Spatial differences became more apparent once we aggregated data by bed and sample year. Nonmetric multidimensional scaling, an ordination technique used for data visualization, indicates separation of benthic community composition among the three scallop beds in the northern part of the strait (off the Alaska Peninsula between Cape Douglas and Kukak Bay) and the four beds in the southern part of Shelikof Strait (off of Kodiak Island near Karluk, Fig. 1).

Although there is quite a bit of overlap in benthic community composition, an analysis of similarity test confirmed that these differences are statistically significant at the bed scale.

One scallop bed in Shelikof Strait, between Cape Douglas and Hallo Bay, has been sampled more consistently than the rest. We performed preliminary analyses on that bed to identify detailed specific changes in species composition over time. We found statistically significant changes in communities over time (1996-2012), including significant differences during 1996-1999. These differences might be real or they could be an artifact of changes in the observer program or altered fishing behavior after the formation of fishing cooperatives. Changes during 2000-2012 have been observed, but are less identifiable. We will further investigate the observed temporal changes by incorporating environmental (bottom water temperature) and anthropogenic (fishing effort) variables.

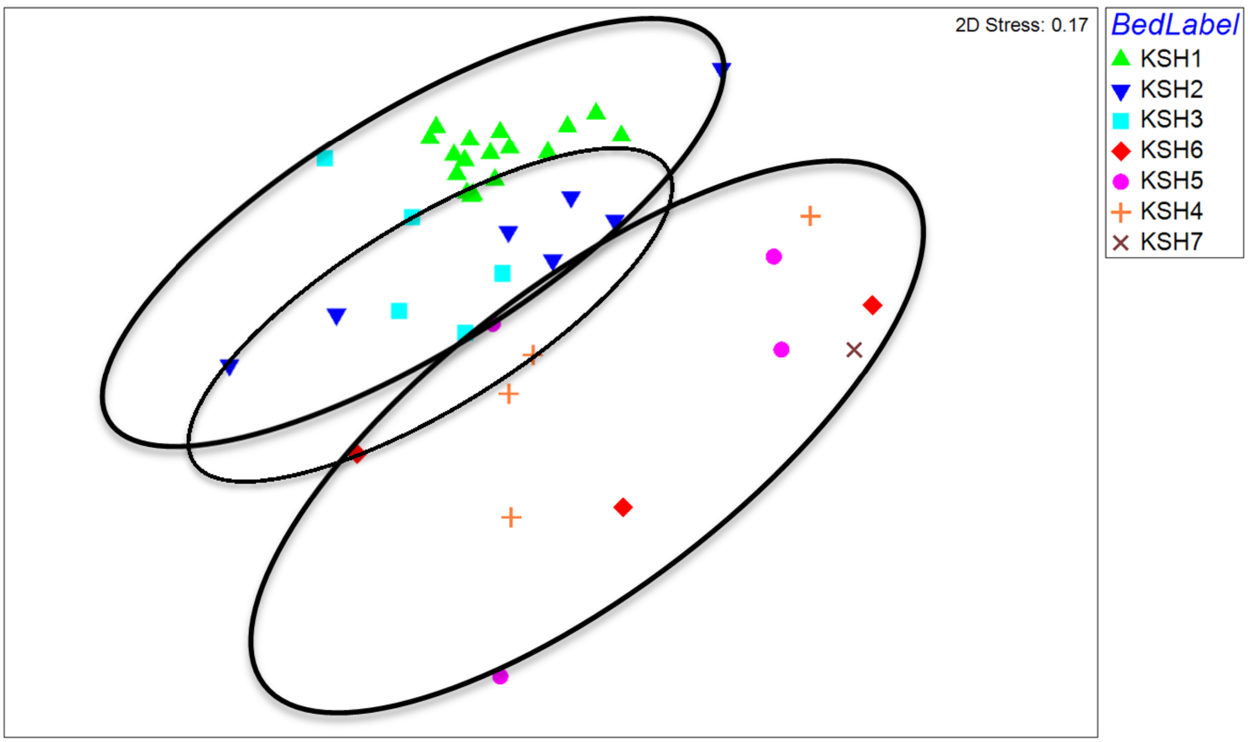

Figure 1. Visualization of similarities in haul composition samples between seven scallop beds in the Kodiak Shelikof Management District using nonmetric multidimensional scaling. Data were aggregated by bed and year. Points that are closer together are more similar to each other than those further away. KSH1-3 are in the northern part of Shelikof Strait, and appear to cluster separately (as indicated by the ovals) from beds KSH4-7, which are in the southern part of Shelikof Strait.

Overall, the project is progressing well and we are on target to meet our objectives within the planned time frame. A five-month delay in receiving the observer data from ADF&G set Jessica's progress back slightly, but she still expects to meet project deadlines. We have obtained the required datasets and have conducted preliminary analyses related to all of our project objectives. We have presented these preliminary results at professional meetings, as well as through outreach events for the public. As the project continues, we will be completing the analyses and formatting results for publication, in addition to presenting results at professional meetings attended by a broad scientific community.

Scientific Outreach

Jessica Glass created a five-minute video about her research, directed towards a public audience, which is available on YouTube (search on "Alaska Scallop Research") and was screened at the First Annual Sitka WhaleFest FilmFest on October 31, 2013. Jessica co-organized and participated in a scientific outreach event for Big Brothers Big Sisters of Alaska in Juneau on December 7th, 2013. This included hands-on, interactive activities related to studying fish and invertebrates in Alaska. Ten kids between 8-14 years old and their big brothers/sisters attended. Jessica also serves as a mentor for a high school student for the Southeast Alaska Regional Science Fair. This student comes from an underrepresented background in the sciences, and Jessica assists with project design, carrying out the experiment, data analysis and presentation of results at the science fair.

Project Related Presentations and Publications

Glass, J. R. Fish and invertebrates living on Alaskan weathervane scallop beds. Alaska Coastal Rainforest Center Brown Bag Lecture Series, September 4, 2013, Juneau, AK.

Glass, J. R., G.H. Kruse and G. E. Rosenkranz. Differences in community composition between Alaskan weathervane scallop beds within state fishery registration areas. 40th Annual Meeting of the Alaska Chapter of the American Fisheries Society, October 10, 2013, Fairbanks, AK.

Glass, J. R., G. H. Kruse and S. A. Miller. Strengths, Weaknesses, Opportunities and Threats: A SWOT analysis of the Alaskan weathervane scallop fishery. 40th Annual Meeting of the Alaska Chapter of the American Fisheries Society, October 10, 2013, Fairbanks, AK.

Distribution and Abundance of Select Trace Metals in Chukchi and Beaufort Sea ice

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Cooperative Agreement Number: M13AC00002
Period of Performance: 05/09/13 - 05/30/16

Project Overview

Though limited in number, the studies addressing dissolved trace metals in sea ice indicate that the concentrations of some metals (cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn), lead (Pb), and zinc (Zn)) are significantly elevated in sea ice when compared to the underlying seawater [*Aguilar-Islas et al.*, 2008; *Grotti et al.*, 2005; *Holemann et al.*, 1999; *Lannuzel et al.*, 2007]. As a result, natural sea ice dynamics have the potential to alter the concentration of dissolved trace metals in surface Arctic waters during the melting season. Anthropogenic contaminants from local, regional, or global sources can contribute to the abundance and distribution of trace metals in sea ice and therefore could significantly affect the distribution of dissolved trace metals in surface waters. Offshore exploration and development products (e.g. drilling muds, produced water or oil) are potential local and regional sources, while atmospheric emissions from industrialized regions captured in winter snow are potential regional and global sources. This type of information could play a role in future management decisions with respect to the discharge of produced water or other by-products of oil and gas exploration in the Arctic.

Concentrations of trace elements in seawater and sediments in the near-shore Beaufort Sea development area have been well constrained by numerous studies during the last 20 years [*Crecelius et al.*, 1991; *Trefry et al.*, 2003; *Trefry et al.*, 2009]. In contrast, there are no data for dissolved trace metals in Alaskan Arctic sea ice and a very limited number of unpublished data points for particulate metals. Sea ice samples were collected during the cANIMIDA projects, but contamination issues stemming from the type of corer used precluded the measurement of dissolved trace elements.

2013 Update

In 2013, the primary goal of was to research, design and build an ice corer capable of collecting sea ice cleanly for trace metals. Design took longer than expected as we have added features not found in other corers and the materials used for construction are challenging to machine (Figure 1). The primary purpose of the corer is to simplify core processing for the determination of trace elements and therefore be as clean as possible. We decided that cores would be collected inside the barrel in a polyethylene sleeve. This will allow us to remove the core in the sleeve from the barrel, cap it quickly and not open the core until we are in a clean environment. We also greatly simplified the way the corer detaches from the electric power head by making the pins larger and easier to manipulate in the cold.

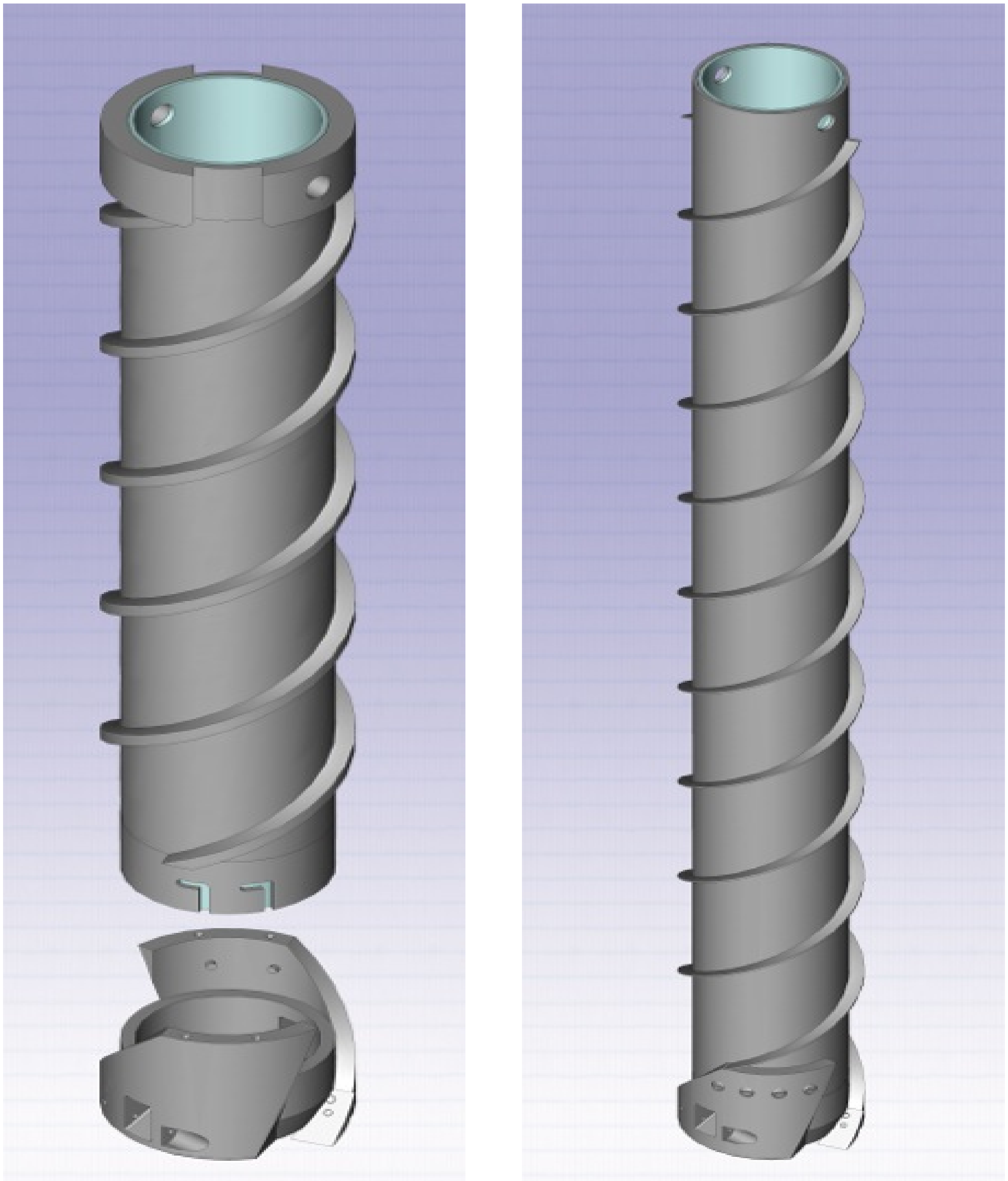

Figure 1. CAD drawings of the newly designed ice corer. The detachable head is manufactured from commercially pure Titanium (CP2) and the body of the corer is made of low-density polyethylene. The cutting blades are also CP2 titanium. The light green shading inside the corer is a sleeve designed to capture the whole core which can be quickly capped preventing any further exposure of the core to the environment before being opened in a clean laminar flow hood.

Laboratory activities

Preliminary results obtained using a prototype of the final corer design (with stainless steel blades) are very encouraging. We were able to collect, filter and freeze 150 l of seawater in a 50 gallon low-density polyethylene container. Water samples were drawn from the container as the water froze to assess any changes in the concentrations of dissolved metals. When the ice was fully formed three cores were collected over a two-day period. Concentrations of dissolved metals in water subsampled from melted cores agreed well with concentrations of metals in the water samples collected during as the container of water froze (Figure 2). One notable exception was the sample of shavings collected from the surface of the ice after a core had been drilled. Results show that the shavings, in this case cut with stainless steel blades, were highly contaminated for Al, Cu, Pb and Zn. These results prompted used to redesign the blades and we are currently testing the possibility of using CP2 titanium for the blades. It was originally thought that titanium was too soft for cutting purposes but after a slight modification to the design of the blades, we will begin testing during the month of February 2014. We believe we now have a good understanding of the problems we encountered when collecting sea ice samples in the past and will be able to collect clean whole samples in the future.

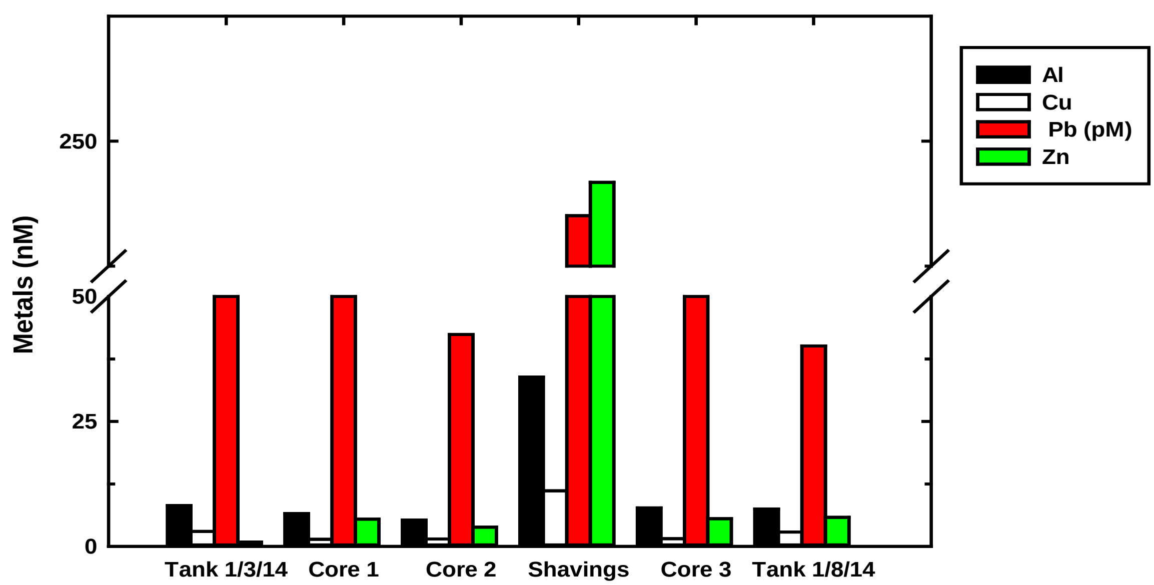

Figure 2. Results from preliminary testing of sea ice cores collected in the laboratory with the newly designed ice corer.

Field activities

We participated in the Japanese Marine-Earth Science and Technology (JAMSTEC) Mirai cruise in the Chukchi Sea during the months of September and October 2013. Seawater samples were collected using a "clean" 12-position rosette water sampling system. The system consists of a powder-coated aluminum frame, titanium exposed metal surfaces, a Sea-Bird Electronics, Inc. 19plus unit, a Wet Labs EcoView fluorometer, a Wet Labs C-Star transmissometer, and a Sea-Bird Electronics Inc. auto fire module (AFM) which is programmed to fire bottles at desired depths. The 5-liter bottles used were Teflon-coated with external-springs. These were washed with phosphate-free detergent and 0.5 M Trace-Metal Grade hydrochloric acid, and were rinsed and stored with Milli-Q water prior to use. The rosette was deployed using the ship's Kevlar wire. A maximum of 9 bottles were deployed during casts due to weight restrictions on the Kevlar wire. A total of 21 vertical profiles were collected from 11 stations (Figure 3). Eleven of the 21 profiles were collected from the stationary point observation main station (Stn 41). Station 48 was a re-occupation of Station 34. Select profiles collected during this cruise will be used to assess the contribution of dissolved trace metals to the mixed layer from sea ice when compared to profiles where no sea ice was present. Analysis of these samples is scheduled to begin in March 2014.

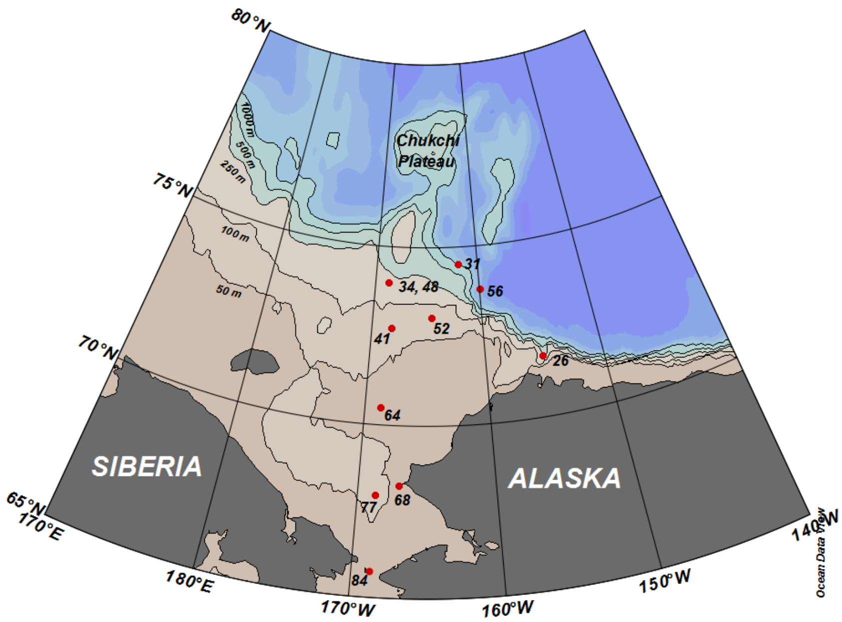

Figure 3. Map detailing the trace metal stations occupied by our group during the 2013 Mirai cruise to the Chukchi Sea.

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Project Related Presentations and Publications

Rember R. and Aguilar-Islas, A. Distribution and behavior of select trace metals in Beaufort Sea ice: preliminary findings. CMI Annual Review oral presentation, January 15, 2014.

Development of an Accurate Model of the Beaufort and Chukchi Ice Drift and Dispersion for Forecasting Spill Trajectories and Providing Decision Support for Spill Response

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Dr. Jennifer Hutchings
Oregon State University

Cooperative Agreement Number: M13AC00001
Period of Performance: 05/09/13 - 05/30/16

Project Overview

The main goal for this work is to create a new discrete element method (DEM) model of polar sea ice with an emphasis on Beaufort and Chukchi seas areas for the purpose of improving forecasting of ice drift and dispersion. A more accurate prediction of the ice drift and dispersion will help to forecast possible oil spill or other contaminant trajectories and provide decision support for a response team. This project also aims at creating new validation metrics, tools to compare the simulation results with actual measurements of the ice drift and dispersion from different sources as well as with other models.

The project was motivated by the lack of sea ice forecast models that can simulate sea ice drift and dispersion accurately. There are several different approaches to simulate sea ice dynamics. First, there are elastic-visco-plastic (EVP) models (Hunke and Dukovicz 1997) that consider sea ice as a continuum media, with isotropic relations between ice stress and strain rate. For this method, partial differential equations representing the main conservation laws are solved numerically. These models have problems with representing discrete phenomena in sea ice such as leads and ridges. Second, there are statistical or phenomenological models that use years of observations and link observed forces that drive sea ice such as winds and currents with observations of the sea ice. This approach cannot provide information about dispersion. There are a group of models that have been developed to simulate the anisotropic nature of the ice pack stress and strain rate field, that have potential to improve simulation of drift, divergence and shear. These include the elastic decohesive model (Schreyer et al. 2006) and a variety of models developed by Daniel Feltham's research group (Wilchinsky and Feltham 2006; Tsamados et al. 2012). None of these models have been validated to demonstrate that they simulate realistic sea ice dispersion. Finally, there are DEM models that represent ice floes by discrete elements that are initially coalesced together. Each element is considered to be a rigid body and is driven by physical laws while interaction forces with other discrete elements act on them as well as driving forces such as winds, currents, and Coriolis forces. This method was initially developed by Mark Hopkins (2004), and extended by Alexander Wilchinsky, Daniel Feltham and Mark Hopkins (2010). Although, DEMs are used extensively to describe solid material and granular media mechanics, they were not well studied for sea ice modeling. It was shown by Antonio Munjiza (2011) that DEM is a superset of finite element methods, thus is a more general approach than any continuous method. However, while DEM models appear to represent the physical processes of sea ice dynamics well, a strong caution needs to be maintained when using DEM to ensure solution of the right physical problem is achieved.

In this project, a new DEM spherical model will be developed that satisfies the following guiding principles:

1. A well-tuned model, using field data for forecasting/hind-casting needs in a software environment that is easy for an environmental response team or industry regulators to implement and operate for the Chukchi and Beaufort seas.
2. Improved model parameters over previous DEM models by tuning the model to field data.
3. Improved sea ice interaction mechanics over previous DEM models.
4. An open source user-friendly DEM sea ice modeling capability to the user community with scripting language for setting up simulation “scenarios”.

2013 Project Update

The project has been active for about one half of a year. First, our effort was to create the model framework, to choose and use the right tools to implement the model, split the programming tasks into smaller sub-tasks and start implementing them. Second, our effort was to establish the sources for our input data such as wind and currents data as well as boundary conditions data (land fast ice). We have fostered collaborative links with Navy laboratories that operationally run and develop sea ice forecasting models, towards using ocean and atmosphere from these models as forcing in out model. Third, we are working to identify and implement the correct ice dynamics equations to represent physics of sea-ice dynamics with the DEM properly.

The framework for our new sea ice DEM model named Siku is set up. A Git-bare repository with all version history of the model code is located at Arctic Region Supercomputing Center storage facility. The model uses a subset of C++ and Lua (Python is considered as an alternative) scripting language for setting up model “scenarios”: a generalized initialization set ups of the model and coupling interface. NCL/NCAR tools are used currently for pre- and post-processing of the data. GNU autotools are used as a model build system to make sure that model is portable and compilation and installation of the model is not a difficult task for people whose profession is not directly related to the computers.

The model imports shorelines as polygons from the Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG). It randomly fills the sea area in the Arctic with polygons using Voronoi tesselation (Figure 1). Each polygon in the Voronoi tesselation represents a discrete element in the model.

As a next step we will write the equations for a free ice drift on a sphere and will simulate a single ice cell free drift. After this is done and tested, a sea ice interaction will be included and many cells will be simulated with different driving forces. These simulations will be merged with the actual shore line boundary.

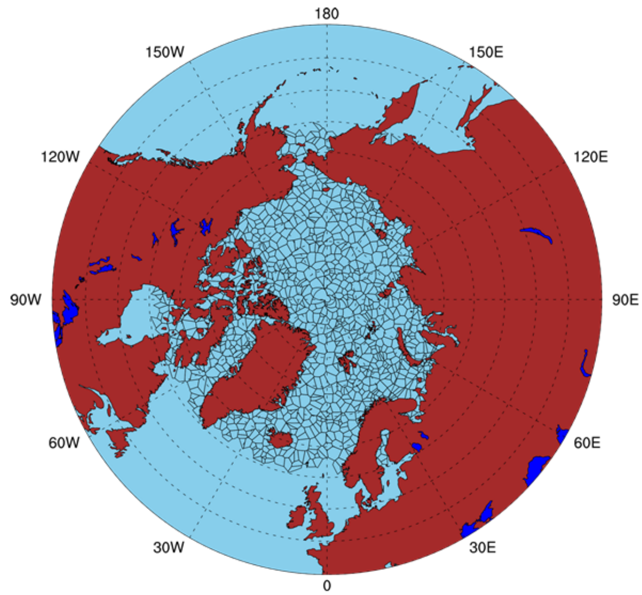

Figure 1. Voronoi tesselation of points randomly seeded in the polar region to use as initial set of polygons for sea ice representation.

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Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas

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Ann Riddle-Berntsen

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Cooperative Agreement Number: M13AC00005
Period of Performance: 05/02/12 - 04/30/16

Project Overview

A taxonomically diverse group of marine birds rely on the Beaufort and Chukchi Seas and near-by coastal habitat for breeding, nesting, brood rearing, and migration staging. Among these Arctic marine birds are species important for subsistence use and species listed as a conservation concern due to population declines. With plans for increasing oil and gas development in the Beaufort and Chukchi Seas, establishing current levels of exposure and determining sensitivity of marine birds to hydrocarbons will provide essential information for monitoring of populations, risk assessments, and, if needed, restoration efforts. To establish a reference of current baseline exposure, we will measure liver cytochrome P450 (CYP1A) enzyme induction using 7-ethoxyresorufin-*O*-deethylase (EROD) enzyme activity. Cytochrome P450 and EROD together have been widely used biomarkers of hydrocarbon exposure in wildlife, including marine waterfowl. To establish current levels of exposure we will measure EROD activity in liver samples collected from hunter killed marine birds (common eider, king eider, and white-fronted goose) near Barrow, AK in collaboration with the North Slope Borough. Sensitivity to hydrocarbons will be determined using primary liver cell culture for the previously listed species, in addition to a broader group representing Arctic marine bird species (Steller's eider, spectacled eider, long-tailed duck, brant, common murre, tufted puffin, black guillemot. or surrogate pigeon guillemot). After dosing liver cell cultures with hydrocarbon controls and Alaska North Slope crude oil, EROD responses and cytopathic effects (CPE) will be compared against reference species (mallard and chicken) to compare marine bird sensitivity to doses. Target species for both baseline and sensitivity assessments were chosen based on subsistence importance and variation in life histories, foraging strategies, and trophic positions. This diverse species group represents a variety of potential hydrocarbon exposure pathways. Once complete, our project will identify key candidate Arctic marine bird species for monitoring of hydrocarbon exposure and risk in the Beaufort and Chukchi Seas.

2013 Project Update

Cell Culture Sensitivity to Hydrocarbons

Hepatocyte cell culture laboratory work started this year focusing on laboratory validations. One hundred ten eggs were incubated from six species; Steller's eider, spectacled eider, common murre, brant, and control species mallard, and chicken. Eggs were artificially incubated and monitored every 3-5 days for development by candling. Of those eggs, 49 were viable/fertile and used in 13 extractions at day 12-17 of incubation. Cells were seeded at 30,000 cells/well with low glucose media containing antibiotics and incubated at 37ºC in 5% CO_2 atmosphere, and monitored for viability and morphology for 24-48 hours using light microscopy. Chicken cultures will be repeated in 2014 due to low viability in 2013. We conducted a total of 12 EROD assays and assessed cytopathic effects (CPE) using liver cells cultured from the four marine bird species and using mallard as a reference responder. Cells for each species were dosed in triplicate with assay reagents (dimethyl sulfoxide; DMSO, and media) to test for non-specific toxicity and the hydrocarbon control reagent chrysene with a 24 hour dose exposure (brant example; Figure 1). Preliminary results for 1.0µM chrysene at 24 hour dose exposure are shown in Figure 2. Initial results suggest that the four tested marine bird species are more sensitive to the dose concentration and exposure time than the control mallard. All tested species showed no pathological response (CPE) differences between control wells and the 1.0µM chrysene dose. An initial test for repeated dose exposure over 72 hours was attempted on mallard liver cells. This test will be repeated in 2014 to confirm dose response.

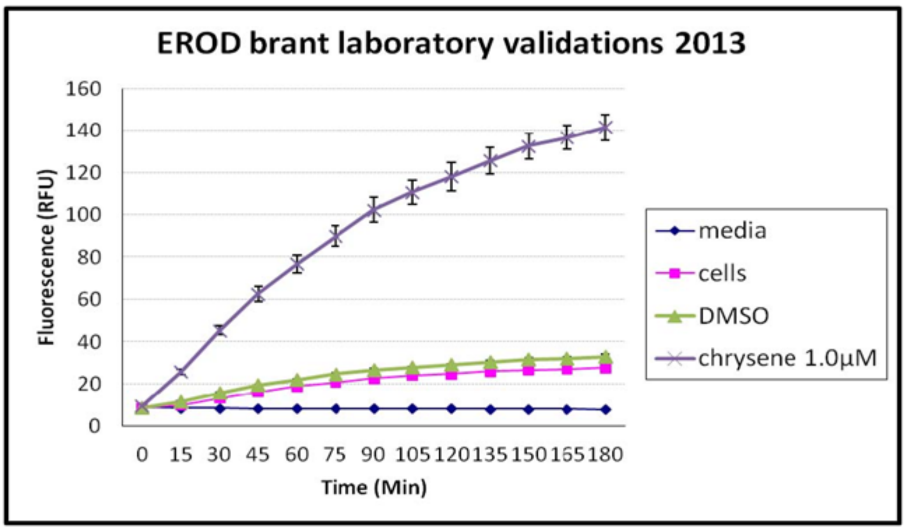

Figure 1: An example of laboratory validations for brant: EROD responses with standard error to 1.0µM chrysene dose, assay reagent DMSO, cell control, and media control with 24 hour dose exposure.

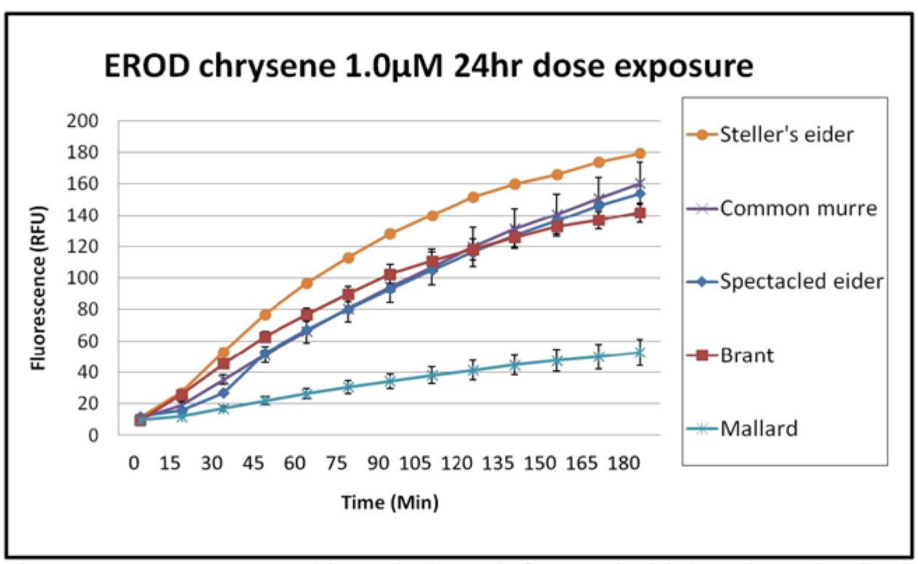

Figure 2: EROD responses with standard error in four marine bird species and mallard control to 1.0µM chrysene dose with 24 hour dose exposure.

Project Related Presentation and Publications

Riddle A.E. and T.E. Hollmén. 2014. Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas. Coastal Marine Institute Annual Review, Fairbanks AK, January 15, 2014.

Riddle A.E., T.E. Hollmén, R. Suydam and R Stimmelmayr. 2014. Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas. Alaska Marine Science Symposium, Anchorage AK, January 20-24 2014 (poster).

2013 CMI Program Related Publications

Carothers, C., S. Cotton and K. Moerlein. 2013. Subsistence Use and Knowledge of Salmon in Barrow and Nuiqsut, Alaska. Final Report. OCS Study BOEM 2013-0015, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region. 52 p.

Gradinger, R. 2013. University of Alaska Coastal Marine Institute Annual Report No. 19. OCS Study BOEM 2013-0112. University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region. 45 p.

Gradinger, R. 2013. University of Alaska Coastal Marine Institute Program Administration 2008-2012 Final Report. OCS Study BOEM 2013-0128. University of Alaska Fairbanks and USDOI, BOEM Alaska OCS Region, 12p.

Konar, B. and A. M. Ravelo. 2013. Epibenthic Community Variability on the Alaskan Beaufort Sea Continental Shelf. Final Report. OCS Study BOEM 2013-01148, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region, 43 p.

Norcross, B. L., B. A. Holladay and C. W. Mecklenburg. 2013. Recent and Historical Distribution and Ecology of Demersal Fishes in the Chukchi Sea Planning Area. Final Report. OCS Study BOEM 2012-073, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region, 210 p.

The Department of the Interior Mission
As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

The Bureau of Ocean Energy Management
As a bureau of the Department of the Interior, the Bureau of Ocean Energy (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEM Environmental Studies Program
The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.