University of Alaska

Coastal Marine Institute

Annual Report 19
Calendar Year 2012

Submitted by:
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University of Alaska Coastal Marine Institute

To:
U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region
Anchorage, Alaska

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OCS Study BOEM 2013-0112

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 2012 Annual Report, our 19th annual report and the final annual report under our five year administrative cycle under BOEM Cooperative Agreement M08AX12644.

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.

The proposal process is initiated each summer with a request for proposals to addressing one or more of the research goals. This request is publicized and sent to researchers at the University of Alaska, to various state agencies, and to relevant profit and non-profit corporations. The proposals are reviewed both externally and by BOEM internally. The CMI technical steering committee then decides which proposals should be recommended to BOEM for funding.

2012 Administrative Update

In 2012, CMI supported twelve active research projects targeting research in the Chukchi Sea and Beaufort Sea region where BOEM has active lease sales. This included three new projects funded in 2012:

1) Dispersal Patterns and Summer Ocean Distribution of Adult Dolly Varden from the Wulik River, Alaska.
   Investigator: Dr. Andrew Seitz

2) Evaluating Chukchi Sea Trace Metals and Hydrocarbons Sourced from the Yukon River.
   Investigator: Dr. Paul McCarthy

3) A Year in the Life of a Bowhead Whale: An Animated Film
   Investigators: Mr. Roger Topp, Dr. Steve Okkonen

The Coastal Marine Institute administrative office successfully completed the 2012 funding cycle which was modified in 2012 to add an initial call for Letters of Intent (LOI) in May. The LOI process supported a more targeted Notice of Availability of Funding Opportunity posting in August. Fourteen concept proposals were received as LOI with eight concepts identified for full proposal development. Six projects were recommended for funding for FY13.

Dr. Rolf Gradinger, Associate Dean, School of Fisheries and Ocean Sciences became CMI Director in July, 2012. Technical Steering Committee changes included the addition of University of Alaska representative Dr. Larry Hinzman, and retirement from the committee by Alaska Department of Fish and Game representative Dr. Douglas Woodby, and UAF representative Dr. Carol Lewis.

The 2012 public CMI Annual Research Review was held in December 2012 at the University of Alaska campus. The seminar event featured ten project reviews and was broadcast to Anchorage BOEM offices and UAF Juneau Center campus.

Project Reporting

Reports Published in 2012

Castellini, M.A. 2012. University of Alaska Coastal Marine Institute Annual Report No. 18. OCS Study BOEM 2012-10. University of Alaska Fairbanks and USDOI, BOEM Alaska OCS Region, 59 p.

Konar, B. 2012. Recovery in a High Arctic Kelp Community. Final Report. OCS Study BOEM 2012-011, University of Alaska Fairbanks and USDOI, BOEM Alaska OCS Region, 24p.

Mahoney, A., H. Eicken, L. Shapiro, R. Gens, T. Heinrichs, F. Meyer, and A. Graves-Gaylord. 2012. Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas. Final Report. OCS Study BOEM 2012-067, University of Alaska Fairbanks and USDOI, BOEM Alaska OCS Region, 154 p.

Final Reports Pending

Current and Historic Distribution and Ecology of Demersal Fishes in the Chukchi Sea Planning Area
Cooperative Agreement: M07AC13416
Investigator: Brenda L. Norcross

Subsistence Use and Knowledge of Salmon in Barrow and Nuiqsut, Alaska.
Investigator: Dr. Courtney Carothers
Cooperative Agreement: M09AC15378

Epifaunal Communities in the Beaufort Sea
Investigator: Dr. Brenda Konar
Cooperative Agreement: M11AC00002

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

Biogeochemical Assessment of OCS Arctic Water: Current Status and Vulnerability to Climate Change

Dr. Jeremy Mathis
Ms. Jessica Cross

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M08AX12760
Period of Performance: 6/01/2008 – 12/31/2013

Project Overview

Highly productive, high-latitude continental shelves, such as the North Aleutian Basin (NAB) and the Beaufort and Chukchi seas, are naturally more vulnerable to ocean acidification (OA), a widely-recognized reduction in ocean pH resulting from the absorption of anthropogenically produced carbon dioxide (CO2), as well as other drivers such as sea ice melt, respiration of organic matter, upwelling and riverine inputs. The suppression of calcium carbonate mineral saturation states (CaCO3 Ω) induced by a decrease in seawater pH could have potentially negative consequences for individual organisms. Compounding detrimental effects for the associated food webs and ecosystems could adversely impact both the regional and national economy, as well as subsistence communities in Alaska that rely on these fisheries as their primary source of protein.

Of particular concern is the rate at which OA and CaCO3 Ω suppression is progressing. Our observations from the NAB have already revealed areas of seasonal carbonate mineral undersaturations, attributed to the synergistic reductions in pH from both natural and anthropogenic sources. As a continuation of our assessment of the NAB, we have delved more deeply into the potential chemical impacts of undersaturated conditions, and the areas where they may be most prevalent.

The biogeochemical assessment of the NAB has included repeat observations of the carbonate system of the Southeastern Bering Sea shelf, including seasonal observations of CO2 gas fluxes, pH, and CaCO3 Ω as well as quantification of annual net community production (NCP). We identified a number of factors that naturally influence the carbonate system. Most control is annually exerted by NCP via the Phytoplankton-Carbonate Saturation State (PhyCaSS) Interaction, where phytoplankton primary production consumes CO2 and increases pH and CaCO3 Ω in surface waters, but accumulation of CO2 in bottom waters resulting from the remineralization of this vertically exported production reduces pH and CaCO3 Ω. The species composition of these blooms, the annual formation and melt of sea ice, the seasonal discharge of river waters, the penetration of basin waters onto the shelf, and seasonally cycling sea surface temperatures also contribute to additional CaCO3 Ω suppression on seasonal timescales. However, we have shown that none of these natural processes or any observed combination thereof would produce seasonal undersaturations of carbonate minerals without the influence of anthropogenic CO2.

Observations from across the Beaufort and Chukchi seas show that there is a sharp gradient in aragonite saturation states between the Chukchi Sea region and areas of the Beaufort Sea to the east. These spatial differences reveal the varying degree of impacts that primary production, ice melt and river water can have on carbonate mineral concentrations and ocean acidification in the region. High rates of primary production over the Chukchi shelf consume dissolved inorganic carbon at the surface and cause a significant increase in pH and carbonate mineral saturation states (i.e., anti-ocean acidification) during spring and summer; these effects can be seen throughout the open-water season. Rates of primary production are much lower in the Beaufort Sea due to nutrient limitations; accordingly, the saturation states near the surface are lower. In the Canada Basin, where ice melt is most prevalent and rates of primary production are minimal, the surface waters are near undersaturation ($\Omega < 1$) with respect to aragonite. Low Ω waters were also observed north of the Bering Strait, where the Alaska Coastal Current (ACC) brings low salinity, carbonate-poor waters northward from the Bering Sea.

2012 Project Update

In 2012, we continued our efforts towards the quantification of the intensity of undersaturation events and the processes that contribute to their occurrence. Water column measurements confirmed previous observations that subsurface waters over the Chukchi shelf, particularly in the region of Barrow Canyon, can become undersaturated due to the accumulation of remineralized dissolved inorganic carbon. The waters on the western side of the canyon were highly undersaturated with respect to aragonite, which is consistent with our understanding of patterns of primary production and export of organic matter in the region. The data shows that the eastern part of Barrow Canyon is dominated by ACC water that is warmer, fresher and has lower total alkalinity. This riverine water is also low in inorganic nutrients and therefore limits primary production at the surface. However, observations on the western side of the canyon are indicative of central Chukchi Sea waters that are replete with nutrients and support high rates of primary production. The respiration signal is present near the bottom, with high dissolved inorganic carbon concentrations on the western side of the canyon.

Understanding that the export of phytoplankton primary production is the most prominent natural process contributing to carbonate mineral suppression on a seasonal scale, we have developed a carbon budget that describes the lateral movement of organic matter following production. Near the coast, focused deposition of organic matter produced further offshore results in net heterotrophy on the annual scale. Through this lateral import of organic matter and its subsequent remineralization, bottom water CO2 accumulation and carbonate mineral suppression may be more prominent at the coast than previously expected. Additionally, we also more deeply examined the carbonate chemistry of undersaturated waters, and have uncovered evidence that carbonate mineral dissolution resulting from ocean acidification may already be occurring in the NAB. Each of these advances is discussed in more detail below.

Carbon Budget

During the primary field program for the Bering Ecosystem Study (2008-2010), independent estimates of net primary production (NPP), net community production (NCP), vertical export production (Cexp) and benthic carbon consumption (BCM) were used to construct a shelf-wide carbon budget for the NAB. Near the coast of the southern Bering Sea shelf, lateral transport was a source of carbon to the bottom layer, with estimated input of carbon exceeding NPP by as much as 54 g C m-2 yr-1, or ~7.9 Tg C yr-1. While the source of this additional carbon is unconfirmed, the only adjacent reservoir known to have a large enough export of carbon is the middle Bering Sea shelf, where lateral transport of NPP can be as high 8.7 Tg C yr-1.

Previously, we considered the PhyCaSS interaction to be most prominent along the 100m isobath, where NCP rates and bottom water carbonate mineral suppression is highest. However, the spatial disconnect between carbon production and carbon deposition caused by lateral transport may indicate that the PhyCaSS interaction also strongly impacts other areas of the shelf. While we have observed carbonate mineral undersaturations near the coast, these have been attributed to the discharge of carbonate-poor river waters typical of the region. However, it is possible that focused deposition of organic matter also contributes to these undersaturations.

Nonconservative Production of Alkalinity

As part of the BEST-BSIERP Bering Sea Project, seasonal observations of total alkalinity (TA) were made between 2008 and 2010. TA concentrations are typically related very closely to salinity, as both are major constituents of seawater. Often, this relationship also allows alkalinity to be used as a conservative tracer of water mass mixing. However, some non-conservative processes also affect alkalinity concentrations. Corrosive conditions can induce the dissolution of carbonate minerals, causing non-conservative increases in alkalinity that can be identified by the deviation from the typical relationship between salinity and alkalinity. We defined this typical relationship for the bottom waters of the Bering Sea, and also showed that in areas of undersaturation, alkalinity concentrations were higher than expected. Because undersaturations in the Bering Sea have been shown to result only from ocean acidification pressures despite other natural mechanisms of carbonate mineral suppression, these data thus provide the first evidence that ocean acidification is presently causing $CaCO_3$ mineral dissolution on the Bering Sea Shelf. Increasing carbonate dissolution in these waters could have potentially disruptive consequences for the region, as many calcifying marine species are present in this ecosystem and provide critical links in the regional food web (Fabry et al., 2008, 2009; Chilton et al., 2010; Boveng et al., 2008).

Project Related Publications and Presentations

2012 Publications:

Cross, J.N., Mathis, J.T., and Bates, N.R., 2012. Hydrographic controls on net community production and total organic carbon distributions in the eastern Bering Sea. *Deep-Sea Research II*, 65-70, 98–109.

Cross, J.N., Mathis, J.T., Bates, N.R., and Byrne, R.H., 2013. Conservative and non-conservative variations of total alkalinity on the Southeastern Bering Sea Shelf. *Marine Chemistry*, Submitted Nov. 2012.

Cross, J.N., Mathis, J.T., Lomas, M.W., Moran, S.B., Baumann, M.S., Shull, D.H., Mordy, C.W., Bates, N.R., Stabeno, P.J., and Grebmeier, J., 2013. Integrated assessment of the carbon budget in the Southeastern Bering Sea. *Deep-Sea Research II.* Submitted Jan. 2013.

Prior Publications:

Mathis, J.T., Cross, J.N., Bates, N.R., Moran, S.B., Lomas, M.W., Mordy, C.W., and Stabeno, P.J., 2010. Seasonal distribution of dissolved inorganic carbon and net community production on the Bering Sea shelf. *Biogeosciences*, 7, 1769 – 1787.

Mathis, J.T., Cross, J.N., and Bates, N.R., 2011. Coupling primary production and terrestrial runoff to ocean acidification and carbonate mineral suppression in the eastern Bering Sea. *Journal of Geophysical Research*, 116, C02030.

Bates, N.R., Mathis, J.T., and Jeffries, M.A., 2011. Air-sea CO_2 fluxes on the Bering Sea shelf. *Biogeosciences*, 8, 1237 – 1253.

Mathis, J.T., Cross, J.N., and Bates, N.R., 2011. The role of ocean acidification in systemic carbonate mineral suppression in the Bering Sea. *Geophys. Research Letters*, 38, L19602.

Prior Presentations:

Cross, J.N., and Mathis, J.T., 2011. Controls on Carbonate Mineral Saturation States and Ocean Acidification on the Southeastern Bering Sea Shelf. Woods Hole Oceanographic Institution Ocean Carbon Biogeochemistry Workshop, Woods Hole.

Cross, J.N., Mathis, J.T., and Bates, N.R., 2011. Controls on Carbonate Mineral Saturation States and Ocean Acidification on the Southeastern Bering Sea Shelf. North Pacific Marine Science Organization (PICES) ESSAS Ocean Sciences Meeting, Seattle, 2011.

Cross, J.N., Mathis, J.T., Bates, N.R., Moran, B., Lomas, M.W., and Stabeno, P.J., 2010. The seasonal distribution of DIC and NCP on the Bering Sea Shelf. American Geophysical Union Ocean Sciences Meeting, Portland, OR, 2010.

Cross, J.N., and Mathis, J.T., 2009. "The Southeastern Bering Sea Shelf: seasonal distribution of dissolved inorganic carbon and net community production." Woods Hole Oceanographic Institution Ocean Carbon Biogeochemistry Workshop, Woods Hole.

2012 Presentations

Cross, J.N., Mathis, J.T., Lomas, M.W., Moran, S.B., Baumann, M.S., Shull, D.H., Mordy, C.W., Bates, N.R., Stabeno, P.J., and Grebmeier, J. "Integrated assessment of the carbon budget in the southeastern Bering Sea: from the atmosphere to the sediment." Alaska Marine Science Symposium, Anchorage, AK, 2013.

Cross, J.N., and Mathis, J.T., Biogeochemical assessment of the North Aleutian Basin ecosystem: current status and vulnerability to change. CMI Annual Review, Fairbanks, AK, 2012.

Cross, J.N., and Mathis, J.T. "Controls on carbonate mineral saturation states and ocean acidification on the Southeastern Bering Sea Shelf." Third International Symposium on the Ocean in a High CO_2 World, Monterey, CA, 2012.

Cross, J.N., Mathis, J.T., and Bates, N.R. "Controls on Carbonate Mineral Saturation States and Ocean Acidification in the Southeastern Bering Sea." American Geophysical Union Ocean Sciences Meeting, Salt Lake City, UT, 2012.

Cross, J.N., and Mathis, J.T. "Ocean Acidification and Carbonate Mineral Saturation State Suppression in the Eastern Bering Sea." Woods Hole Oceanographic Institution Ocean Carbon Biogeochemistry Workshop, Woods Hole, 2012. Poster.

Cross, J.N., and Mathis, J.T. "Nonconservative Variation of Total Alkalinity in the Subarctic Pacific (Southeastern Bering Sea Shelf)." Bering Sea Project Principle Investigator Meeting, Anchorage, AK, 2012. Poster.

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: 6/01/2011-11/30/2014

Project Overview

The snow crab, *Chionoecetes opilio*, is a widely distributed and abundant epibenthic species on the Bering and Chukchi Sea shelves, extending at least into the western Beaufort Sea. While the Bering Sea stock is regularly surveyed and the stock characteristics and biology are reasonably well known, until recently knowledge about the crab stock structure in the Chukchi and Beaufort Seas was limited to abundance and biomass estimates for parts of the region and some aspects of the reproductive biology (Jewett 1981, Paul et al. 1997). The recent northward contraction of the species in the Bering Sea (Orensanz et al. 2004), the assumed biomass increase in the Chukchi Sea (Bluhm et al. 2009), and the increased interest in the Chukchi and Beaufort Seas for oil and gas-related exploration activities motivated this study.

Recent research cruises to the Chukchi and Beaufort Seas afforded the possibility to collect new snow crab population data. 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 three cruises to the Beaufort Sea (Ocean Explorer 2008, BeauFish 2011, Transboundary 2012). 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 and reproductive potential, 3) to identify diet and trophic position, and 4) to compare our findings to the few available earlier studies in the study area.

2012 Project Update

Field Activities
In addition to earlier collections, crabs for this project were collected during three expeditions in the summer and fall of 2012. All three expeditions had other primary objectives. Both PIs participated in the NOAA-funded RUSALCA expedition (27 Aug-16 Sept 2012), supported by graduate student Lauren Bell. We collected abundance, biomass, body size and body weight data of ~1500 snow crab (with over 1000 being juveniles); including ~150 mature females for analyses for the reproductive objective of this project. In addition, SFOS graduate students Lauren Divine and Benjamin Gray collected approx. 120 mature females crabs for the reproductive biology objective during the BOEM-funded Arctic EIS expedition (14 Aug-24 Sept 2012). Crabs were also collected for a crab energetics objective funded through Arctic EIS. During the BOEM-funded Transboundary cruise (20 Sept – 1 Oct), PI Iken was able to add 50 crab samples to the much smaller sample pool from the Beaufort Sea compared to the Chukchi Sea.

Crab Processing

Lab work in 2012 concentrated on two tasks with a regional focus on the Chukchi Sea: (1) For all crabs, we conducted morphometric measurements (carapace width, chela height for males, body wet weight), determined sex and shell condition, and – for the majority of crabs - dissected stomachs for future stomach content analysis. (2) For mature females, we determined clutch fullness, ovary color (the latter on frozen specimens only) and fecundity, i.e., egg counts. All procedures were based on methods outlined in Jadamec et al. (1999), and updated and complemented by the ADF&G Kodiak lab under the guidance of crab biologists Laura Slater and Doug Pengilly. Lab work conducted in 2012 was supported by undergraduate students Colton Lipka and Kelsie Maslan and summer technician Carlos Serratos (all task 1), and by Elizabeth Kandror (task 2). All 50 crabs collected during the Transboundary cruise 2012, all body measurements were taken on board, stomachs and stable isotope samples dissected, and eggs from the single mature female collected were counted. For the crabs collected during BeauFish 2011, graduate student Lauren Divine conducted and completed the stable isotope analysis. In total, over 4000 crabs were processed for task 1, and the lab portion of this task has recently been completed. Egg counts (task 2) have so far been completed for ~250 females and are ongoing.

Results

Morphometric measurements revealed that snow crabs in the Chukchi Sea were overall smaller than those from the Beaufort Sea. The latter were reported on in last year's annual report. The majority of male Chukchi Sea crabs were smaller than 65 mm carapace width (CW) (Figure 1).

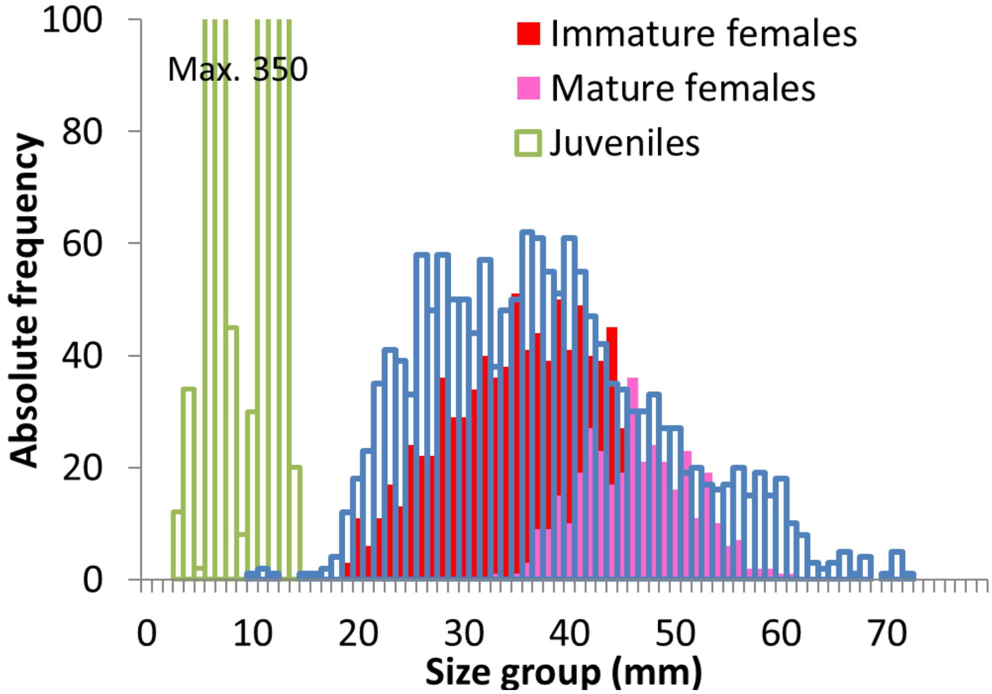


Figure 1. Size-frequency distribution of snow crab in the Chukchi Sea for all crabs measured with collections from 2009-2012. N=4100.

Most immature females measured between 30 and 45 mm CW with the majority of mature females falling into the range of 40-55 mm CW. Male and immature crabs were found throughout the locations sampled, while mature females were absent from Bering Strait and sparse in the Herald Canyon area, at least in 2009, the year for which our sample size was largest (Figure 2).

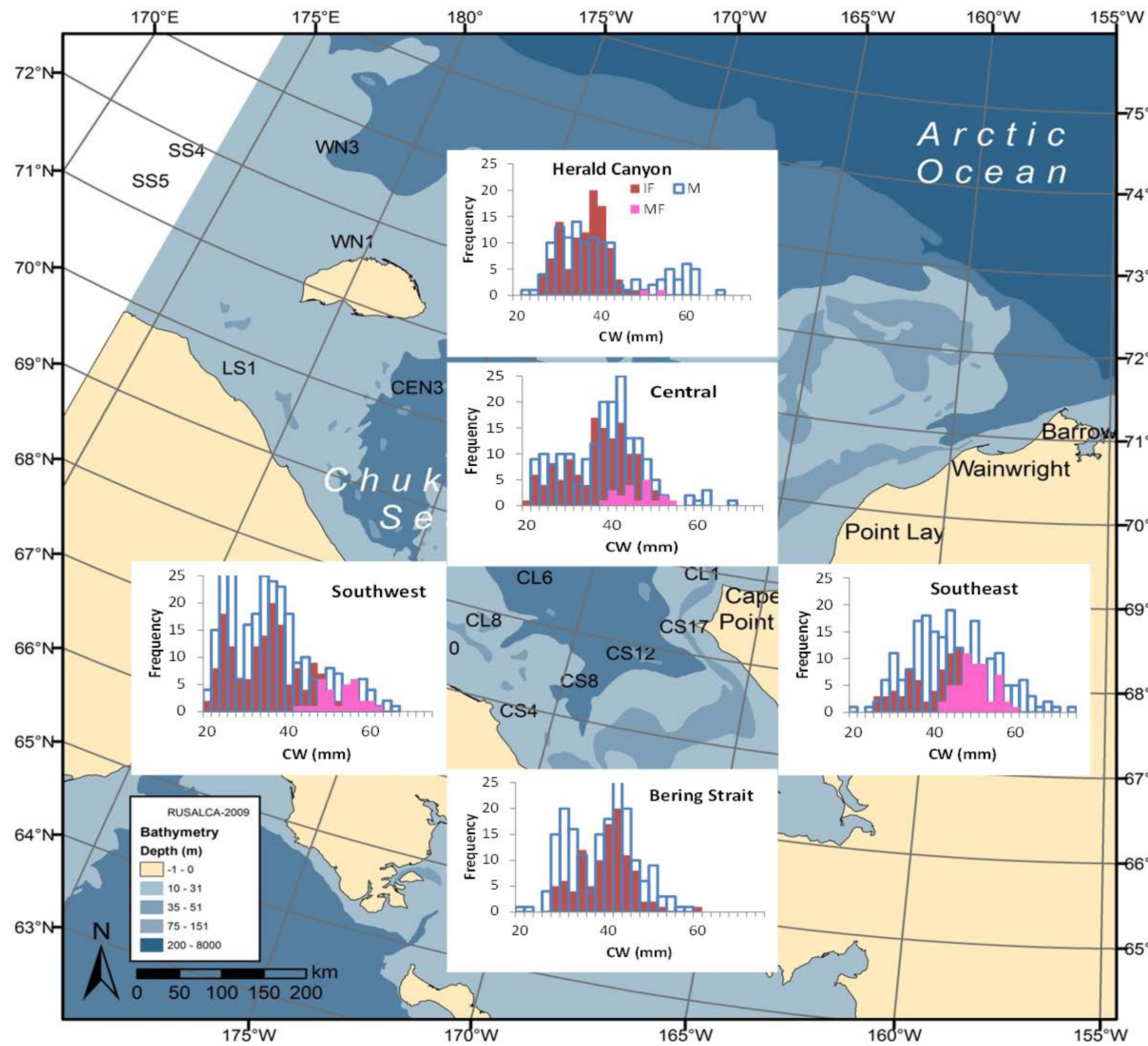


Figure 2. Size-frequency distribution of snow crab in the Chukchi Sea in 2009, by sub-region.

Juvenile crabs (~5-14 mm CW) were primarily encountered in the southern Chukchi in 2012. Immature females and male crabs occurred throughout the depth range sampled on the Chukchi shelf (~30-150 m), with mature females sparse shallower than 40 m and juveniles concentrated on the 30-60 m range (Figure 3).

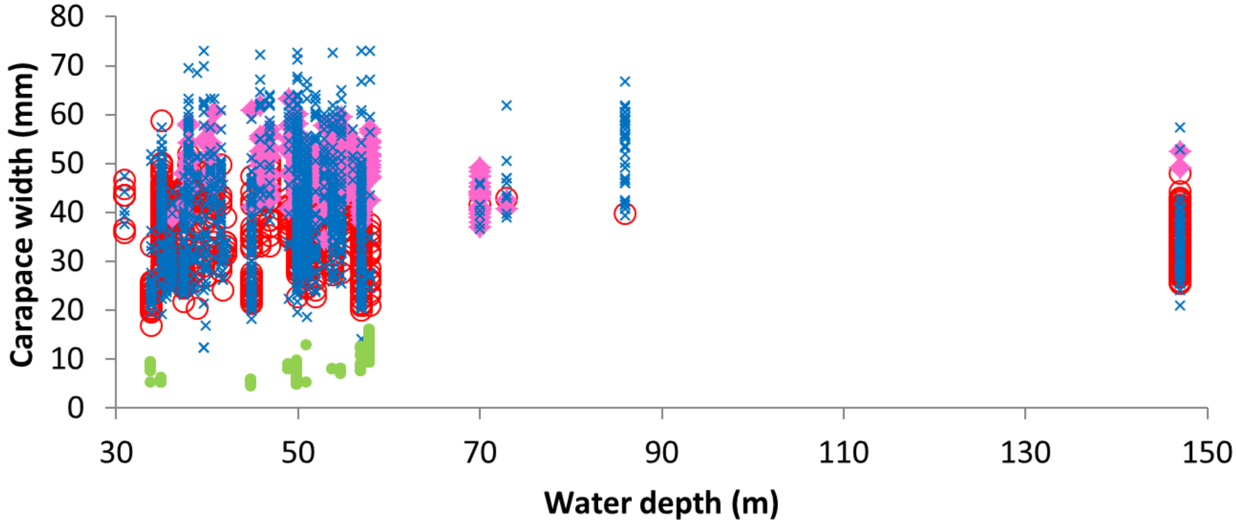


Figure 3. Occurrence of snow crab in the Chukchi Sea by water depth. N=4100, 2009-2012. Blue-males, red-immature females, pink-mature females, green-juveniles

Female fecundity ranged from <5000 to >50,000 eggs per female over a size range of 36-64 mm CW. Most females had full clutches corresponding to clutch fullness indices 5 and 6, and most were new shell crabs. So far, fecundity for ~160 crabs has been matched to female body size and latitude showing that egg number per female is correlated with body size, but not with latitude (Figure 4). Next we will relate fecundity to bottom temperature.

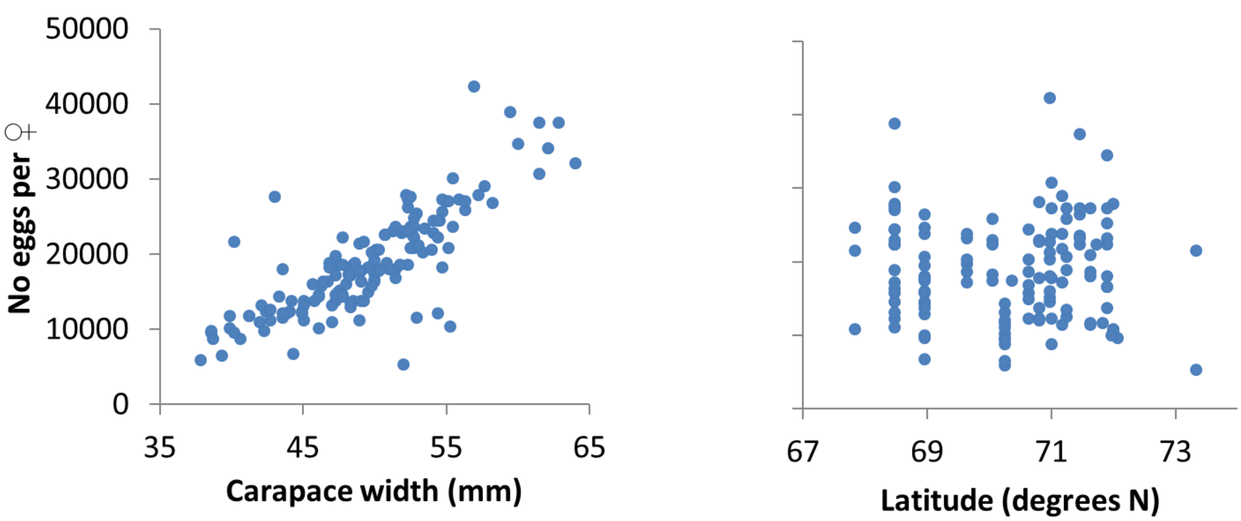


Figure 4. Fecundity (eggs per female) of mature female snow crab in the Chukchi Sea by (a) body size and (b) latitude. N=267.

Progress and Problems

So far, sample collections and sample processing has mostly been conducted in agreement with the timeline stated in the proposal. Collections during Arctic Eis and Transboundary were not anticipated when the CMI proposal was submitted and efforts for crab collections were not charged to CMI, but the material is a welcome addition to earlier collections. Arctic Eis samples contribute to the reproductive biology objective of this grant (part of objective 2 in introduction) and objective 3. Diet analysis is now scheduled for spring through summer of 2013 as part of Lauren Divine's PhD thesis. The preparation of the web site was moved to 2013. The travel costs for the presentations listed below were primarily covered through other sources.

Outreach / Education

Colton Lipka's involvement in the project fulfilled his requirement for the 'experiential learning' credit that is part of the School of Fisheries and Ocean Sciences' undergraduate fisheries degree. All students involved in the project have received training and gained experience that will be useful in their future careers. Part of the tasks (stomach content analysis) will be part of a PhD dissertation (L. Divine).

References

Bluhm BA, Iken K, Mincks SL, Sirenko BI, Holladay BA (2009) Community structure of epibenthic megafauna in the Chukchi Sea. Aquat Biol 7:269-293

Jadamec LS, Donaldson WE, Cullenberg P (1999) Biological field techniques for *Chionoecetes* crabs. Alaska Sea Grant College Program AK-SG-99-02

Jewett SC (1981) Variations in some reproductive aspects of female snow crabs *Chionoecetes opilio*. J Shellfish Res 1:95-99

Orensanz J, Ernst B, Armstrong DA, Stabeno P, Livingston P (2004) Contraction of the geographic range of distribution of snow crab (*Chionoecetes opilio*) in the Eastern Bering Sea: An environmental ratchet? CalCOFI Report, p 65-79

Paul JM, Paul AJ, Barber WE (1997) Reproductive biology and distribution of the snow crab from the northeastern Chukchi Sea. Am Fish Soc Sym 19: 287-294

Project Related Publications and Presentations

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

Divine L, Iken K, Bluhm B. Snow crabs (*C. opilio)* in the Alaskan Arctic: contributing to stock assessment data for the AFMP. Interagency Crab Meeting. Kodiak, AK, December 2012 (oral)

Bluhm BA, Iken K. *Chionoecetes opilio* population structure in the Pacific Arctic: preliminary results. CMI Annual Review, November 2012 (oral)

Bluhm BA, Iken K. Population assessment of snow crab, *Chionoecetes opilio*, in the Chukchi and Beaufort Seas: preliminary findings. Institute of Marine Science Seminar Series, Fairbanks, 7 November 2012 (oral)

Divine L, Iken K, Bluhm B. Population structure and trophic positioning of snow crabs (*Chionoecetes opilio)* in the Alaskan Arctic. Alaska Chapter of the American Fisheries Society. Kodiak, AK, October 2012 (oral)

Bluhm BA, Iken K. Population assessment of snow crab, *Chionoecetes opilio*, in the Beaufort Sea including oil and gas lease sale areas – first results. BOEM UAF campus visit (K. Wedemeyer), July 2012

Divine L, Iken K. Snow crab (*Chionoecetes opilio*) stock characteristics and trophic dynamics in the Alaskan Arctic. University of Alaska Fairbanks chapter of the American Fisheries Society. Fairbanks, AK, February 2012 (oral)

Bluhm BA, Iken K. Population assessment of snow crab, *Chionoecetes opilio*, in the Beaufort Sea: preliminary findings. Alaska Marine Science Symposium, Anchorage, 16-20 January 2012 (poster)

Divine L, Iken K, Bluhm B. Fitting snow crabs (*Chionoecetes opilio*) into the benthic food web of the central Alaskan Beaufort Sea. Alaska Marine Science Symposium. Anchorage, AK, January 2012 (poster)

Satellite-tracked Drifter Measurements in the Northeast Chukchi Sea

Dr. Thomas Weingartner

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M11AC00001
Period of Performance: 3/08/2010 – 3/31/2014

Project Overview

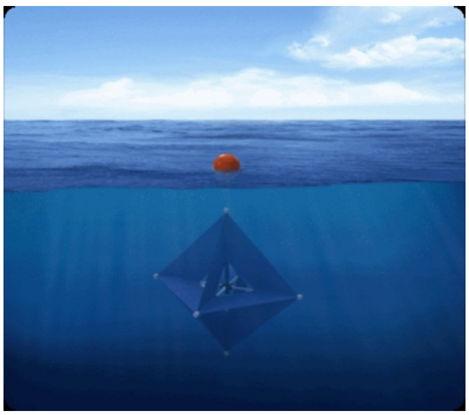
Fundamentally, the dynamics of the Chukchi Sea shelf circulation are controlled by a mean pressure gradient and the winds. The mean pressure gradient is a body force acting on the fluid column which, in the mean, propels water northward from Bering Strait toward the Arctic Ocean. On average this flow parallels the isobaths as it crosses the Chukchi shelf. The winds impart momentum at the sea surface, with this momentum then diffused downward by turbulence. The mean winds over the Chukchi shelf are from the northeast so that the wind stress tends to oppose the mean flow driven by the pressure field. Since the net force is not distributed uniformly over the water column, the current structure may be considerably sheared in the vertical. Historically, our understanding of ocean circulation on the Chukchi Sea shelf has come from current meter measurements obtained from subsurface moorings. While these devices have been and will remain an important tool for understanding ocean circulation processes, the instruments cannot easily measure the top few meters of the flow field. The overall goal of this program is to evaluate the near surface currents and their response to winds in the northeast Chukchi Sea where hydrocarbon exploration is underway and future development may take place. In particular, we sought to determine if:

1. The surface (upper 1 m) and near-surface (10 -15 m) circulation field diverges and differs from the sub-surface circulation as captured by current meter measurements, and
2. The differences in the surface and sub-surface flows are related to the bathymetry, seasonally-varying winds, stratification, and/or ice-edge fronts.

2012 Project Update

Methods

The sampling approach used two different types of satellite-tracked drifters; the CODE-type and the SVP-type (Figure 1). Drifter performance characteristics [*Davis*; 1985a] indicate that drifter slippage is ~1 cm s^{-1} and thus small compared to the expected magnitudes of the 10 – 50 cm s^{-1} current velocities typical of the Chukchi Sea. CODE drifters measure the upper 1 m of the water column and the SVP drifter's drogue is set at 10 m depth. These drogue depths were chosen to address our 2 goals and because these depths are the standard designs by the manufacturer (Technocean and Pacific Gyre). (Deeper drogues depth could have been chosen, but these would have been more costly.) Each drifter also included a surface thermistor. Drifter positions were determined by satellite GPS fixes and recorded hourly along with sea surface temperatures. The data were stored aboard the drifter and then transmitted via Service Argos (2011) twice per day and by Iridium link (2012) hourly. In both years the drifters were deployed from research vessels operating south and/or east of Hanna Shoal in approximately 40 m water depth. In 2011 these deployments were made by research vessels under charter to Shell, Conoco-Phillips, and Statoil as part of their Chukchi Sea Environmental Studies Program. In 2012, the drifter deployments were made from the USCG Healy and from the Norseman II. In addition, this program was supplemented by additional drifter deployments conducted by the North Slope Borough (NSB). They used a combination of the CODE-type and iSphere (Figure 2; manufactured by Metocean) drifters and conducted their deployments within 10 miles of the coast in water depths of < 20m offshore of Icy Cape, Wainwright, and Barrow. Unlike either the SVP or CODE drifter, the iSphere drifter sits half in and half out of the water. Hence, the iSphere drifter trajectories will be subject to considerable wind drag.



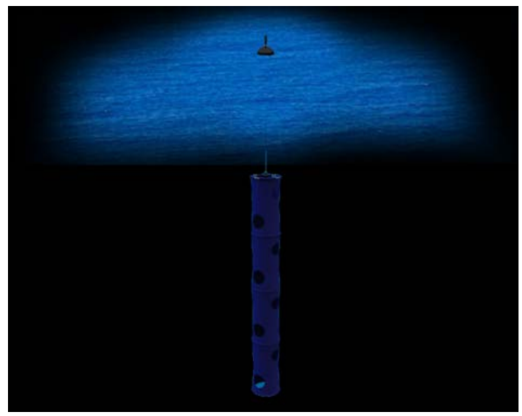


Figure 1. The CODE-type 1-m drogued Microstar drifter (left) and the SVP-type 10-m drifter (right). Both drifter types shown are manufactured by Pacific Gyre.

Figure 2. The iSpehere surface drifter manufactured by Metocean.

The drifter deployments were made in the area shown in Figure 3 with red circles indicating deployments in 2011 and blue circles those conducted in 2012 and green triangles the nearshore deployments. As indicated in the figure the drifter deployments were executed in regions providing supplementary data that included shipboard and/or towed CTDs, subsurface moorings, and surface velocities. The latter were obtained from shore-based high-frequency radars (HFR) located in the communities of Barrow, Wainwright, and Pt. Lay. Regional wind data used in the analyses were obtained from the National Center for Environmental Prediction, North American Regional Re-analysis (NCEP-NARR). The NARR winds are provide at 3-hourly intervals on a 35 km grid.

Drifter trajectories were updated daily and posted to websites available to the public at: http://dm.sfos.uaf.edu/chukchi-beaufort/data/drifters/. Animations of the drifter trajectories can be found at: http://mather.sfos.uaf.edu/drifters/Chukchi2012/Plots/DrifterMovieC.html.

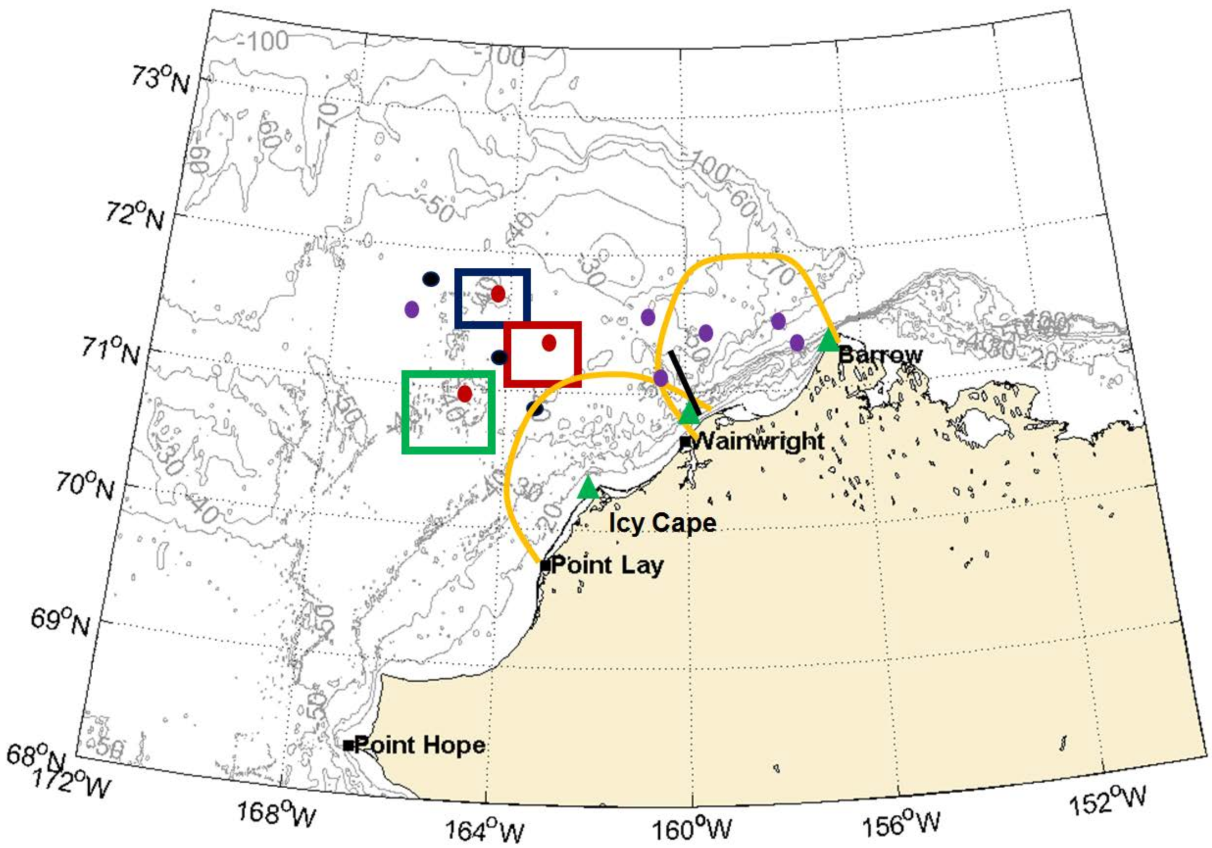


Figure 3. Bathymetric map of the Chukchi Sea showing the approximate location of the Statoil (dark blue box), Burger (red box), and Klondike (green box) prospects. The black dots show the location of NOAA's subsurface oceanographic moorings. The orange arcs show the approximate radar masks for HFRs at Pt. Lay, Wainwright, and Barrow. The solid black line extending northwest from Wainwright is an array of 6 subsurface moorings. Approximate locations of UAF drifter releases in 2011 (red dots) and 2012 releases (purple dots) are shown. The approximate locations of NSB drifter deployments in 2011 and 2012 are shown by green triangles.

Results

As mentioned in previous annual reports, the 2011 drifter study was highly problematic given the 80% failure rate of the drifters. Those drifters, manufactured by Technocean, had several flaws, including the lack of thermistors and, in our opinion, flawed seals on the pressure canister that housed the electronics. As a consequence, many of the drifters failed shortly after deployment. Another problem encountered was that we were initially unable to decode the data string according to Technocean's instructions. Repeated efforts to do so based on their advice also failed. Eventually Seth Danielson was able to decode the data string through his own efforts. For the same reasons, the NSB experienced similar failure rates with their drifters. Thus the 2011 resulted in only a limited set of data and insufficient to address many of our goals. Figure 4 shows the trajectories of drifters deployed in mid-August 2011 (and whose lifetimes exceeded 4 days). There are several general features that emerge:

1. most of the drifters moved eastward from south of Hanna Shoal toward Wainwright, and
2. then moved northeastward down Barrow Canyon to the shelfbreak, before
3. proceeding westward along the Chukchi shelfbreak (under the influence of strong westward fall winds)

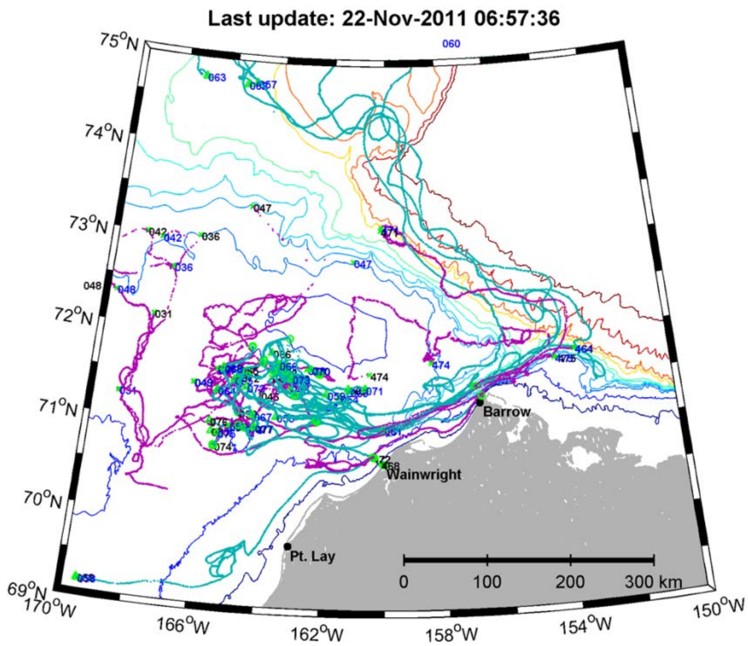


Figure 4. Combined trajectories of all drifters released in 2011 in the central Chukchi Sea.

However, several of the drifters moved southwestward toward Hanna Shoal (when winds were strong and from the northeast) and into the Central Channel. Thereafter they moved northward toward the Chukchi shelfbreak in accordance with historical current meter data from the Central Channel (Weingartner et a., 2005).

Deployments in 2012 were staggered in time and space. Figure 5 shows the deployment distribution times and locations for the UAF and NSB drifters. Figure 6 shows the eventual data distribution over the Chukchi Sea in terms of number of observations in each 15' x 15' grid cell. The various panels show the data distribution for all drifters as well as for each drifter type. It is evident from the figure that the iSphere drifters had a distribution quite different from the Microstars and SVPs. For example, almost all the drifter observations south of 70°N were iSpheres. Many of these initially drifted northeastward into Barrow Canyon, then turned westward over the Chukchi shelfbreak before being blown back onto the shelf and southward (Figure 7).

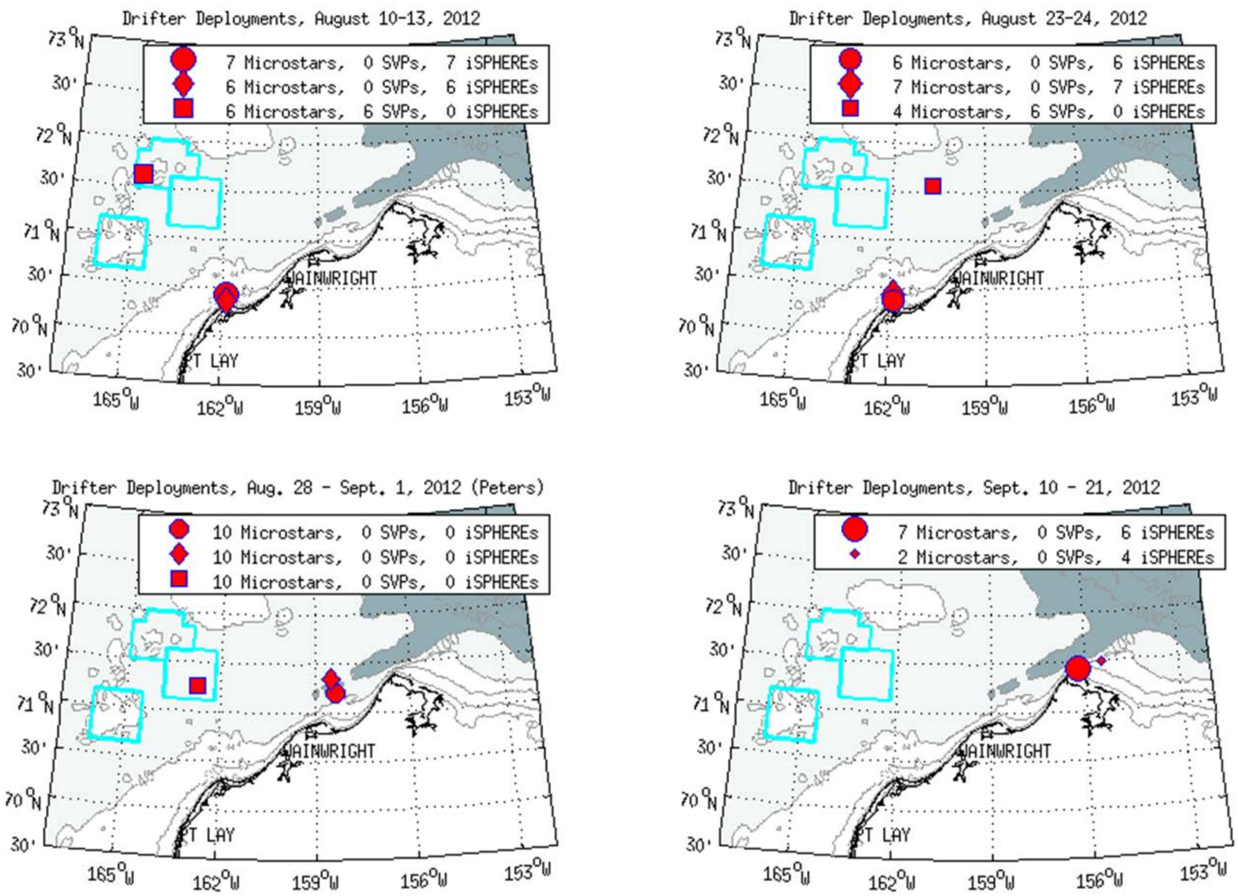


Figure 5. Deployment times, locations, and drifter types for the UAF and NSB drifters used in 2012.

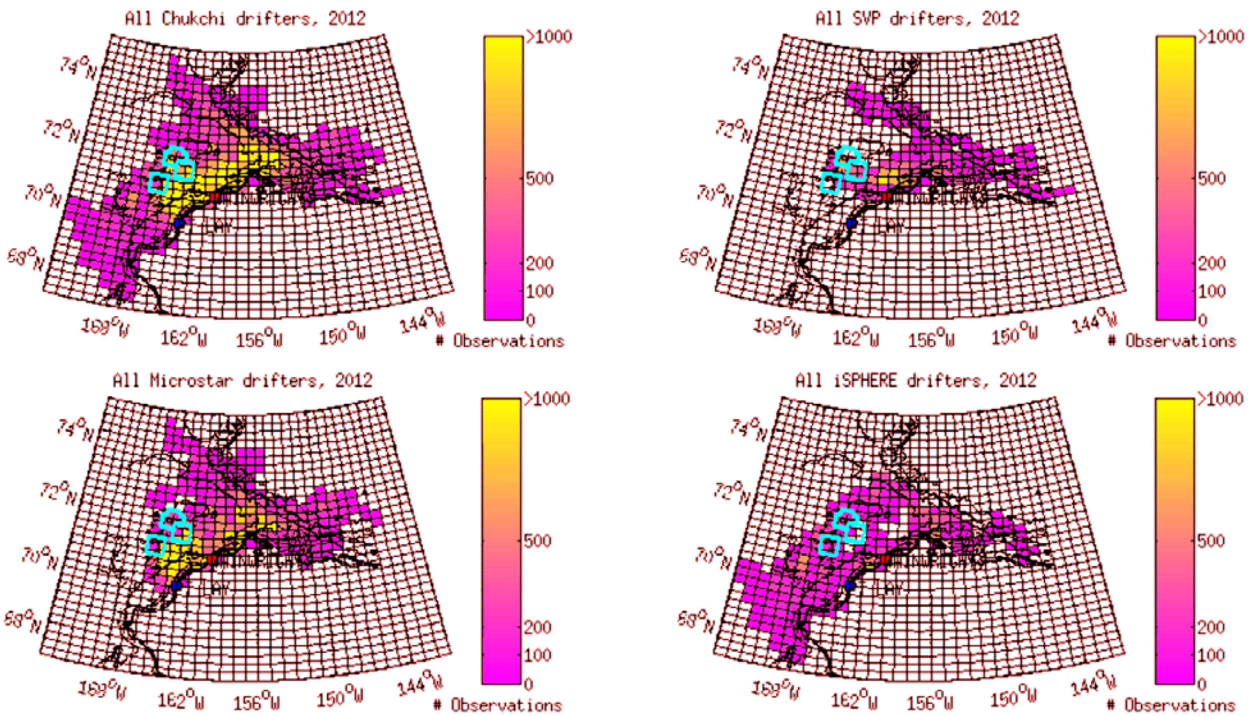


Figure 6. Data distribution over the Chukchi Sea in terms of number of observations in each cell.

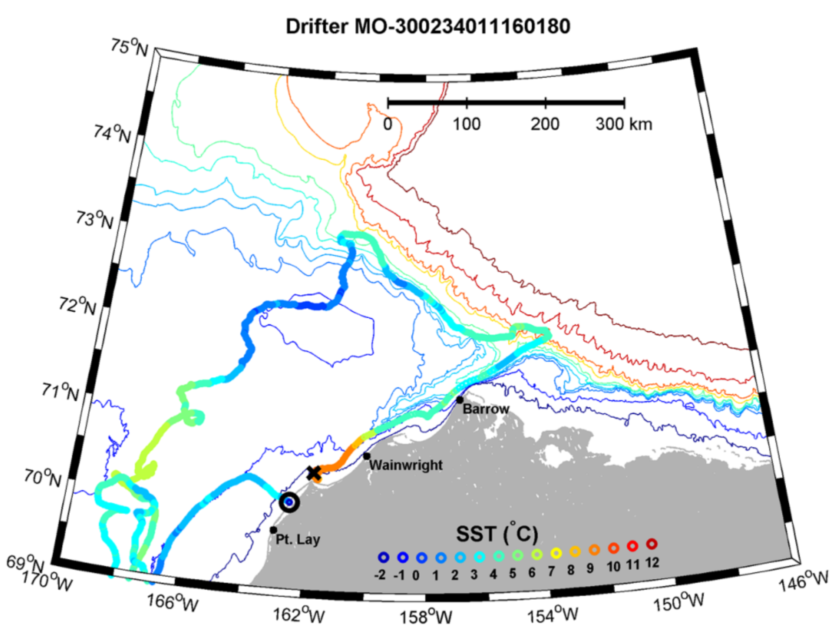


Figure 7. An example iSphere trajectory that was released at Icy Cape (x) moved down Barrow Canyon, then westward along the shelfbreak, before being blown southward as far as Cape Lisburne. This drifter eventually turned northward and became beached near Pt. Lay. Color coding along the trajectory indicates the SST.

In a preliminary examination of the bulk data we have averaged all velocities in grid cells which contain more than 200 drifter observations (Figure 8). Although this results is colored to some degree by the ambiguous iSphere drifter responses to winds and currents, several patterns emerge, which bear similarity to previous measurements. For example few drifters remained in Regime I, suggesting that drifters either avoided this region or swept through it rapidly. Regime II denotes the nearshore area between Wainwright and Point Lay and suggests a recirculation zone, with southward flow inshore and northeastward flow offshore. This pattern has emerged from the HFR data set as well. Regime III contains the swift northeastward flows within Barrow Canyon. Regime IV, at the mouth of the canyon, suggests a bifurcation zone, in which some drifters continue east and others west after exiting from the canyon. Regime V is an anticyclonic eddy which carried some drifters offshore and into the basin. Regime VI includes the shelf east of Hanna Shoal and west of Barrow Canyon. Here, the flow is weak and confused, which is also consistent with HFR measurements. Examples of individual drifters that characterize some of these flow regimes are shown in Figures 9 – 12.

Most of the drifters released in 2012 have been crushed in ice. However, five are still transmitting. One, which is about 200 km north of Wrangel Island and another is trapped in the landfast ice on the Mackenzie shelf. A third is trapped in the landfast ice of Peard Bay, and two others are drifting slowly westward in the pack ice over the Alaskan Beaufort shelf. All of these drifters are SVP-type, but now moving with the ice and so no longer moving with the water. We have decided to continue monitoring these trajectories in order to determine battery lifetime in this cold environment and out of general interest.

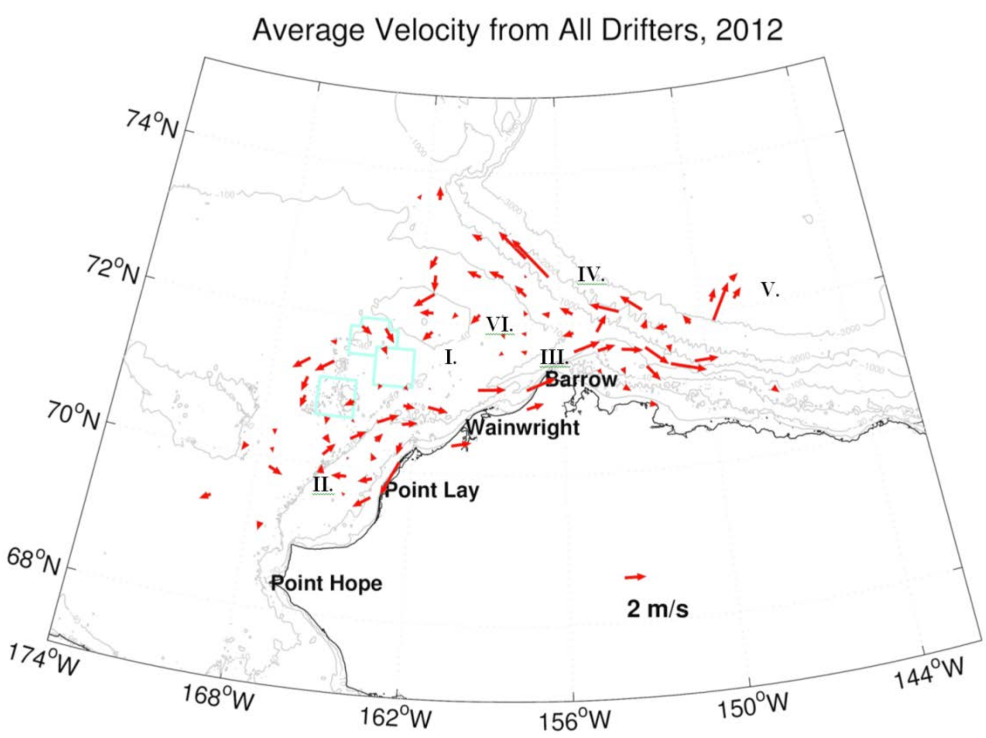


Figure 8. Mean current velocities in grid boxes in which there are more than 200 drifter observations of any kind. The Roman numerals refer to particular flow regimes discussed in the text.

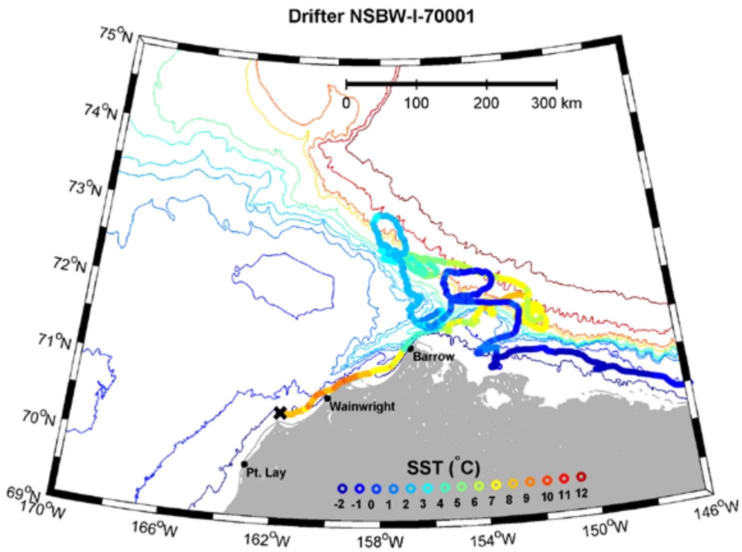


Figure 9. A Microstar trajectory illustrating the bifurcation mode Regime IV, after which it continued eastward along the Beaufort shelfbreak.

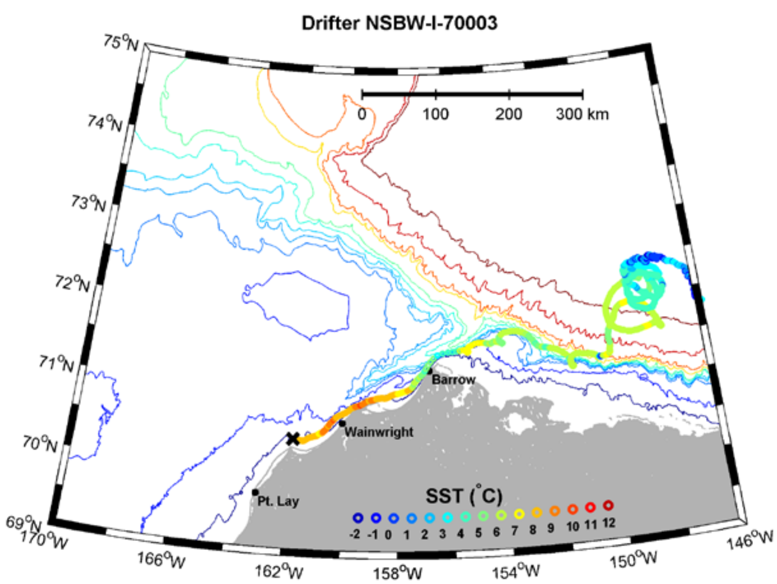


Figure 10. A Microstar trajectory illustrating Regime IV in which the drifter was caught in an anticyclonic eddy that carried it into the basin.

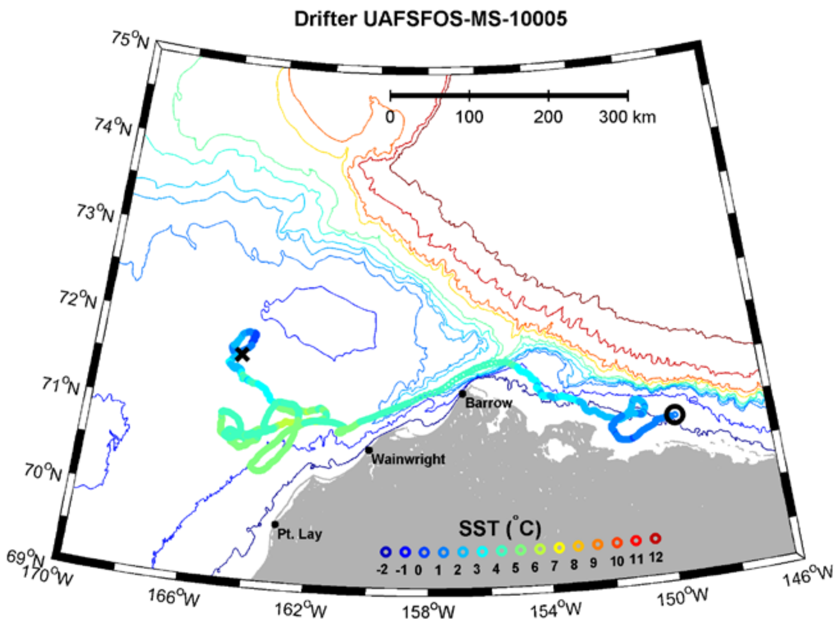


Figure 11. An SVP drifter released to the southwest of Hanna Shoal the drifted eastward toward the coast before moving down Barrow Canyon (Regime III). Note that this drifter (and the others released at the same spot did not enter Regime I.

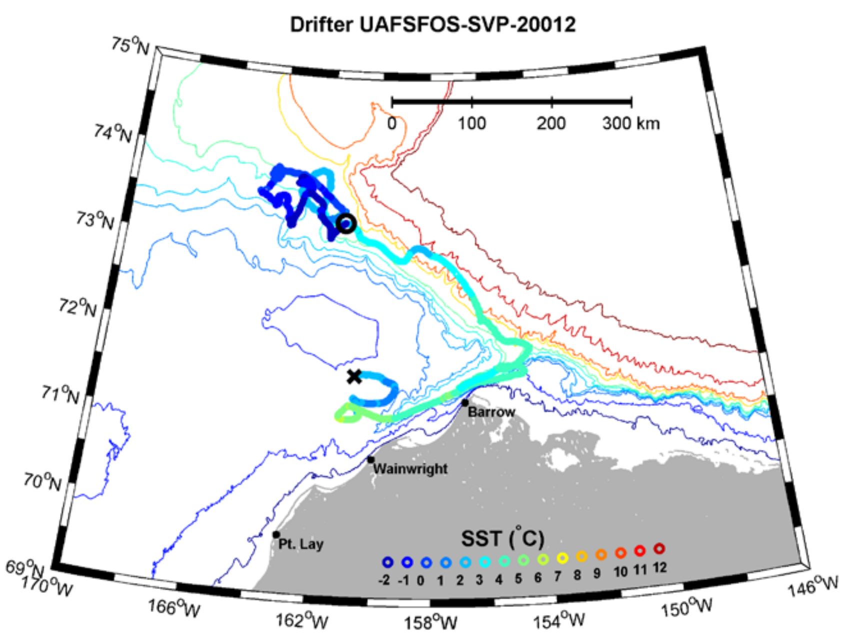


Figure 12. An SVP drifter released to the southeast of Hanna Shoal (in Regime I) which eventually moved down Barrow Canyon (Regime III) and then westward at the mouth of the canyon (Regime IV) and along the Chukchi shelfbreak.

Project Related Publications and Presentations

Weingartner, T., S. Danielson, P. Winsor, and E. Dobbins, Satellite-tracked drifter measurements in the Northeast Chukchi Sea, presented at the CMI Annual Review November 20, 2012, Fairbanks, AK

Portions of these data were presented in: Winsor, P., T. Weingartner, T., H. Statscewich, R. Potter, E. Dobbins, K. Martini, and S. Danielson, High-Resolution Observations of Hydrography and Circulation of the Chukchi Sea, oral presentation, Alaska Marine Science Symposium, January 22, 2013, Anchorage, Alaska.

In addition, informal presentations that included some of these data were made to the oil industry.

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: 5/02/2012 – 09/30/2014

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 marine areas that may be explored and developed for oil and gas in outer continental shelf areas in 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 these areas to assess their vulnerability to development and extraction activities. Therefore, in 2012, we attached 20 Pop-up Satellite Archival Transmitting tags to adult Dolly Varden 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.

2012 Project Update

From 3–5 June 2012, adult Dolly Varden were captured with a beach seine in the Wulik River, approximately 30 km from Red Dog Mine. After each seine haul, large Dolly Varden (>75 cm) were carefully removed from the seine net and placed in a holding pen (1.2 x 2.4 m, 70 cm water depth) where their health was monitored. After collecting seven fish that were deemed appropriate for tagging (i.e., large, healthy, and appeared to have spawned previous year), collections were ceased for the day in preparation for attaching satellite tags to the fish.
Pop-up satellite archival transmitting (PSAT) tags (Microwave Telemetry X-tags) were attached to Dolly Varden (n=20) using a novel and minimally invasive “tag backpack” system recently refined by a Norwegian scientist. After a PSAT tag was secured (Figure 1), the fish was returned to the mesh holding pen for observation while the remaining fish were tagged. After tagging and determining that all fish were swimming satisfactorily, it was decided to release them concurrently rather than holding them overnight and risk unnecessary stress to the fish and bear predation.

While at liberty, the tags measured and archived depth, temperature and ambient light intensity data every two minutes. Four tags were programmed to release from the fish on each of the following dates: July 1, July 15, August 1, August 15, and September 1. After releasing from the fish, the tags floated to the surface of the ocean and transmitted their archived data to Argos satellites passing overhead. While transmitting, the position of the tag was determined by the satellites. Dispersal was examined by plotting end locations of tags (i.e., location of physical recovery of tag while attached to fish or location from which the tag transmitted to satellites) in two week intervals in a GIS framework. Depth data were examined for behavioral patterns and temperature data were examined for patterns indicating freshwater and marine residence.

Preliminary Results and Interpretation

Figure 1. Pop-up Satellite Archival Transmitting (PSAT) tag attached to a Dolly Varden.

Tagged fish ranged from 75.5 to 91.5 cm (82.5±4.3 cm, mean±SD). Of the 20 tags deployed, data were recovered from 18 of them, of which 12 released from the fish and transmitted data via Argos satellites and six were recovered while still attached to fish. The remaining two tags are considered "missing."

A total of 12 tags reported to satellites and transmitted their depth, temperature and ambient light intensity data. Although formal analyses of these data are not finished, a cursory examination of depth data indicated that two fish, one whose tag reported from the Chukchi Sea and one from north of Barrow, likely died before the scheduled pop-up date of 1 September and sunk to the sea floor. After the fish laid on the seafloor and decomposed, the tags were freed from the fish, floated to the surface of the ocean and drifted for up to five weeks before reporting to satellites. Three other tags reported to satellites, but no fine-scale position estimates (±100 m) were obtained, likely because the tags were in freshwater, preventing proper transmission of the tags. However, coarse position estimates (±100 km) are currently being generated by the satellite provider. Seven tags remained attached to the fish until their scheduled pop-up date at which time they reported to satellites. These fish were located in the Chukchi Sea north of Russia (n=4), north of Cape Espenberg on the Seward Peninsula (n=1), Kivalina Lagoon (n=1), and in the Wulik River upstream of the tagging site (n=1). These seven tags successfully transmitted depth, temperature and ambient light intensity data to satellites.

Recovery of tags still attached to the fish occurred at the tagging site by recreational anglers (n=2), in Kivalina Lagoon by subsistence fishers (n=2), in nearshore marine waters adjacent to Kotzebue (n=1) and in the lower reach of the Buckland River (n=1). These six tags have been sent to the manufacturer and are in queue for downloading of the depth, temperature and ambient light data.

When end locations (i.e., recovery locations of tags that were attached to the fish (n=6) and tags that transmitted to Argos satellites after popping-up from live fish (n=7)), were examined in two-week intervals, potential distribution patterns were observed. In June, fish were located near the tagging site and in the mouth of the Wulik River (Figure 2). By July, fish were more widely distributed, ranging from the Chukchi Sea north of Russia to the lower reach of the Buckland River and northeast of Cape Espenberg (Figure 2). No end locations were obtained between 1 and 15 August. In late August and early September, fish were located near the tagging site and in the Chukchi Sea north of Russia (Figure 2). The fish whose final tag locations were located at the mouth of the Wulik River were likely preparing to leave the area as these end locations were only provided early in the summer and no other tags provided evidence that fish remain in this area throughout the remainder of the summer. We believe three general summer dispersal patterns of Dolly Varden exist: remaining at the tagging site for the summer, southerly alongshore dispersal, and perhaps the most interesting is northwesterly offshore dispersal to the Russian Chukchi Sea.

From a cursory examination of the temperature records of the four fish that dispersed to the Russian Chukchi Sea, all of them experienced a period of relatively warm water (4–14°C) which we believe corresponds to freshwater residence (Figure 3). After this freshwater residence, each fish experienced a brief period (<12 hr) of very cold water (approximately-1.7°C) which we believe corresponds to exiting the mouth of the Wulik River and swimming under the landfast ice in the coastal zone of the Chukchi Sea (Figure 3). Therefore, we propose to use this period of cold water (<0°C) as a proxy for entry into the Chukchi Sea. As such, all four fish entered the Chukchi Sea between 25 June and July 1.

After entering the ocean, each fish experienced relatively cool water (1–8°C) for the remainder of the tag deployments (Figure 3). During the early period of ocean occupancy, the tagged Dolly Varden experienced relatively shallow depths with very little variability (Figure 4) which we hypothesize is transiting behavior from the Wulik River to the offshore feeding area in the Russian Chukchi Sea. The straight-line distance between the mouth of the Wulik River and the area where all four tags popped-up is approximately 350 km, which one fish transited in five days before its tag popped-up. This observation demonstrates the ability of Dolly Varden to disperse over relatively large expanses of outer continental shelf regions.

After a relatively short transit period (approximately 7 days), the tagged Dolly Varden changed swimming behavior from relatively constant shallow depths to oscillatory diving behavior between 0 and 15 m, with dives to 50 m (Figure 5). We believe that this behavior corresponds to feeding. It appears that two of the fish occupied the outer continental shelf region north of Russia for at least 45 days, therefore, we speculate that this offshore area of the Chukchi Sea may be an important feeding "hotspot" and that the outer continental shelf of the Chukchi Sea may be a critical feeding area for Dolly Varden. Additionally, the frequent occupation of shallow ocean water demonstrates that Dolly Varden may be exposed to human activities conducted near the surface of the Chukchi Sea.

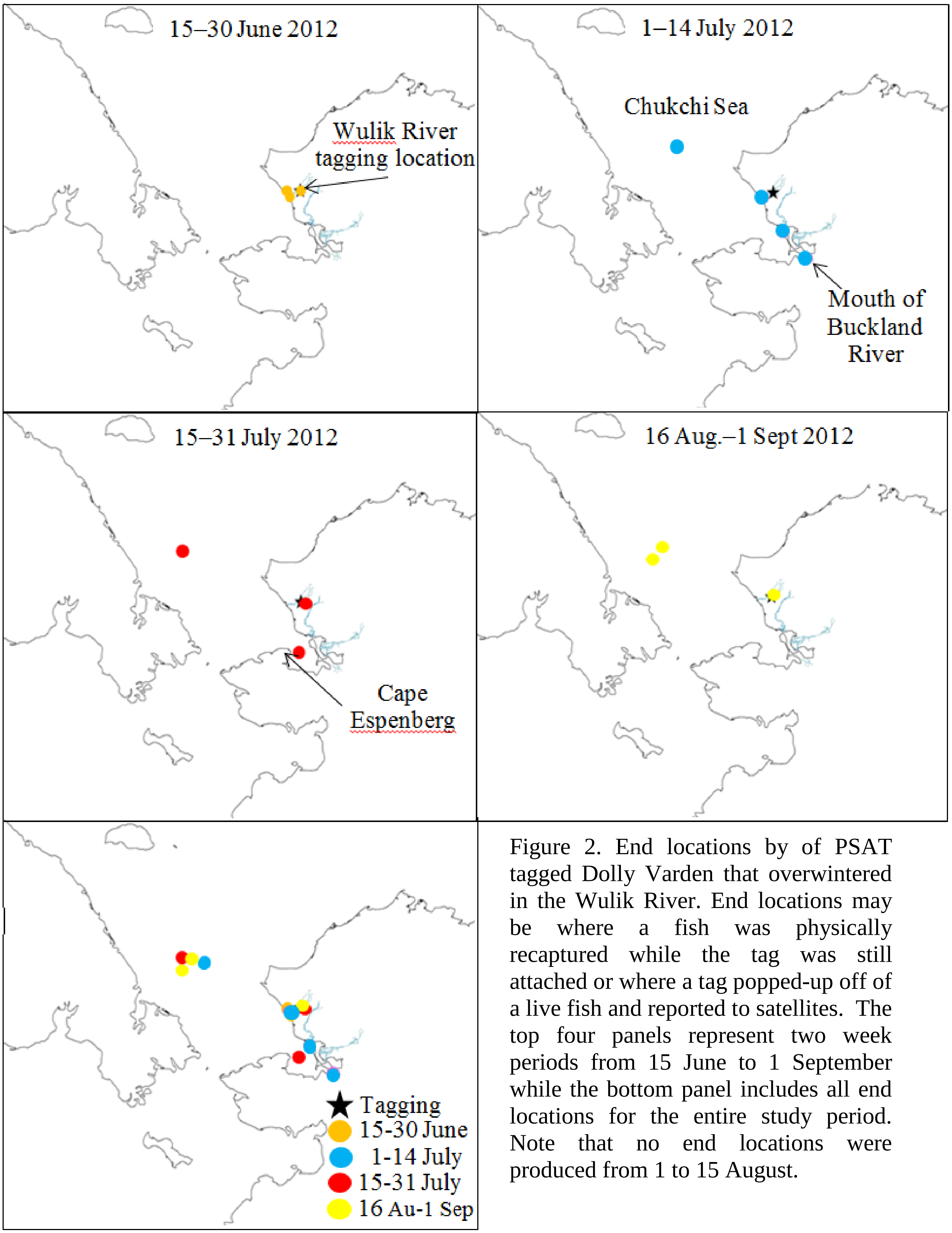


Figure 2. End locations by of PSAT tagged Dolly Varden that overwintered in the Wulik River. End locations may be where a fish was physically recaptured while the tag was still attached or where a tag popped-up off of a live fish and reported to satellites. The top four panels represent two week periods from 15 June to 1 September while the bottom panel includes all end locations for the entire study period. Note that no end locations were produced from 1 to 15 August.

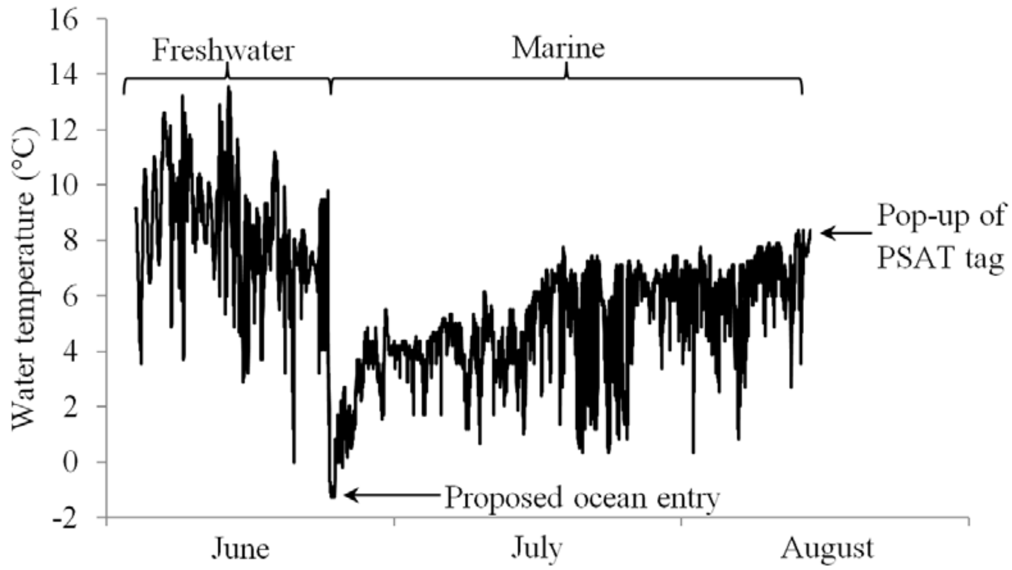


Figure 3. Example of a water temperature record from one Dolly Varden whose tag popped-up in the Chukchi Sea north of Russia on 15 August 2012. Temperature was measured and recorded every 15 minutes. Proposed periods of freshwater and marine occupancy are noted along with entry into the Chukchi Sea and the date that the tag popped-up.

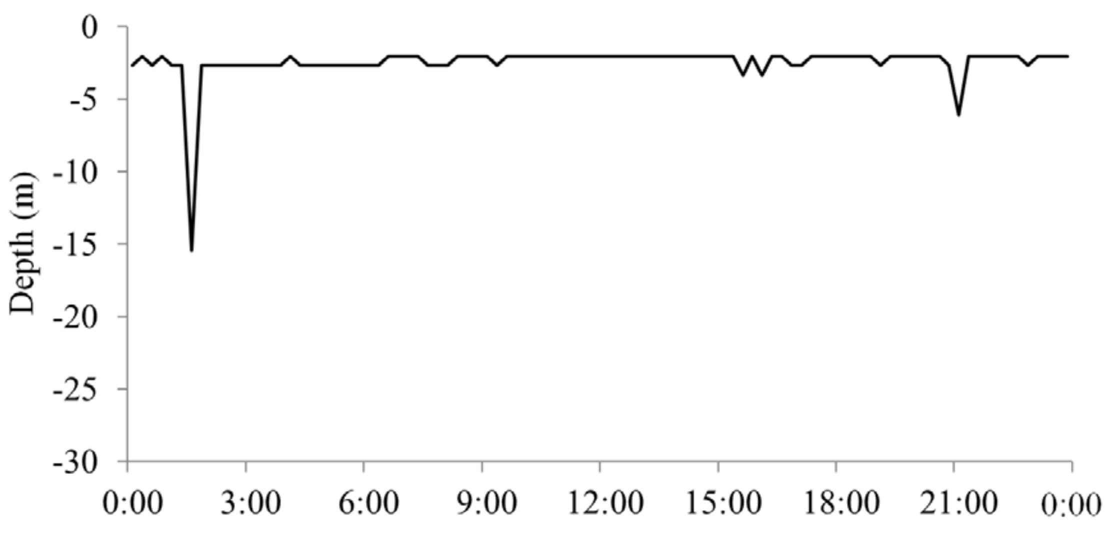


Figure 4. Example of hypothesized transiting behavior of one Dolly Varden whose tag popped-up in the Chukchi Sea north of Russia on 15 August 2012. Depth was measured and recorded every 15 minutes.

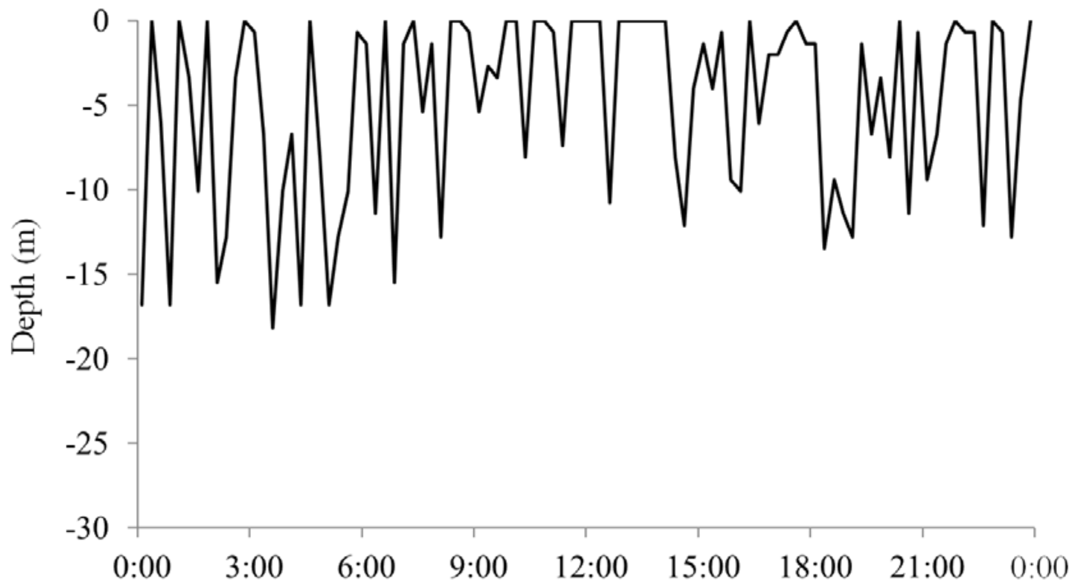


Figure 5. Example of hypothesized feeding behavior of one Dolly Varden whose tag popped-up in the Chukchi Sea north of Russia on 15 August 2012. Depth was measured and recorded every 15 minutes.

Future analyses

We will undertake a full analysis of temperature, depth and light intensity records that should provide additional information about behavior and temperature occupancy of Dolly Varden and should improve resolution of movements. An undergraduate student majoring in Fisheries at UAF SFOS is conducting the data analyses and will assist in reporting. This student, who is supervised and mentored by Principle Investigator Seitz, will be conducting these activities in fulfillment of his Senior Thesis in Fisheries at UAF.

Project Related Publications and Presentations

Seitz, A.C., M.B. Courtney and B. Scanlon. 2012. Dispersal of adult Dolly Varden from the Wulik River, Alaska, evaluated using satellite telemetry. Alaska Chapter of the American Fisheries Society Annual Meeting. Kodiak, AK, 25 October 2012.

Seitz, A.C., M.B. Courtney and B. Scanlon. 2012. Dispersal of adult Dolly Varden from the Wulik River, Alaska, evaluated using satellite telemetry. Coastal Marine Institute Annual Review. Fairbanks, AK, 20 November 2012.

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

Dr. Paul McCarthy
Mr. John Perreault

Geophysical Institute
University of Alaska Fairbanks

Cooperative Agreement Number: M12AC00001
Period of Performance: 6/04/2012 – 8/31/2014

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 associated with Yukon River sediment. These sediments contribute much of the overall sediment in the Chukchi Sea oil lease area, and this project is a compliment to the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Chemical and Benthos (CAB). The specific goals of the project are to:

1. Collect and analyze active suspended and bed load sediment samples from several points in the lower Yukon River for PAH and trace metal concentration measurements.
2. Collect and analyze historical data from sediment cores gathered from the Yukon River delta for PAH and trace metal concentrations.
3. Assess grain size dependent fractionation of PAHs and trace metals to determine their distribution.

2012 Project Update

2012 was the inaugural year for this project, and the primary focus was obtaining core samples for historical data and the initial active sediment samples while establishing protocols for sampling and analysis in this unique, logistically challenging environment.

The first field season was conducted during the summer of 2012. Field work included collection of the largest set of samples for this project in July 2012. Nine suspended sediment samples were taken at five locations along the lower Yukon River from Pilot Station to Fish Village near the start of the modern, active Yukon delta. Six bedload samples were taken along this part of the river from sandbars and sediment near shore. Separate water and sediment samples were taken at each location for trace metals, PAH and, organic carbon.

Two sediment cores were extracted from the presently active and historically active Yukon River during this field campaign using a percussion coring system flown to the sample location by floatplane. The cores provide discrete sampling intervals up to 2 meters deep and will be analyzed in 2013-14.

Preliminary analyses on the nine PAH samples from 2012 were conducted with the help of Dr. Fred Prahl and Margaret Sparrow at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, Corvallis, OR. These analyses show a very low contamination profile and a successful sampling procedure. Development of analytical protocols for the trace metal analysis were begun in Fall, 2012 with the help of Dr. Ana Aguilar-Islas, UAF School of

Fisheries and Ocean Sciences, and results are expected in early 2013 before additional field work resumes in March 2013.

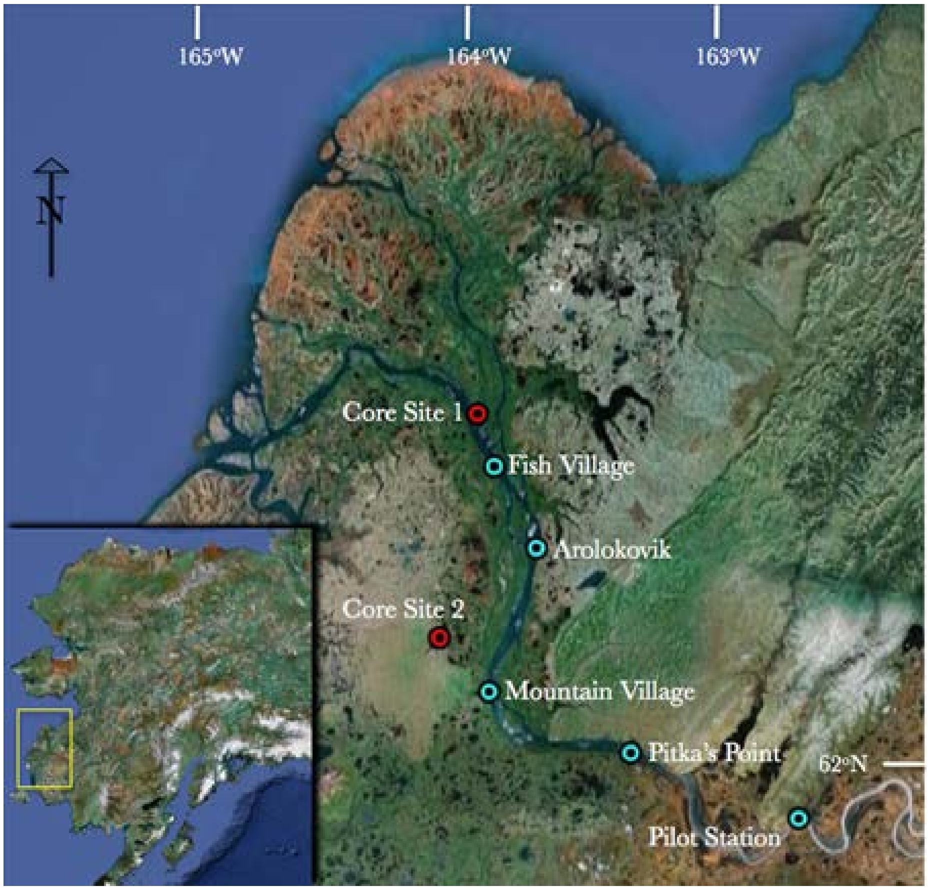


Figure 1. Locations of core sites and water-sediment sampling.

Project Related Publications and Presentations

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

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

Mr. Roger Topp
Dr. Steve Okkonen

University of Alaska Museum of the North
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M12AC00005
Period of Performance: 6/04/2012 – 5/30/2014

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.

2012 Project Update

Narrative
The project team completed the first and second drafts of the spoken and text-onscreen narrative. The narrative was reviewed by project scientists including Steve Okkonen, Carin Ashjian, and Lori Quakenbush. The narrative was charted (Figure 1) and revised product was forwarded to the visual design team. We anticipate a complete project picture by end of first quarter 2013. The narrative process extended about a month longer than planned due to museum project conflicts. A draft narrative exists in shooting-script format broken down by scene, but not by shot, which is determined more by the visual nature of the film than the narrative.

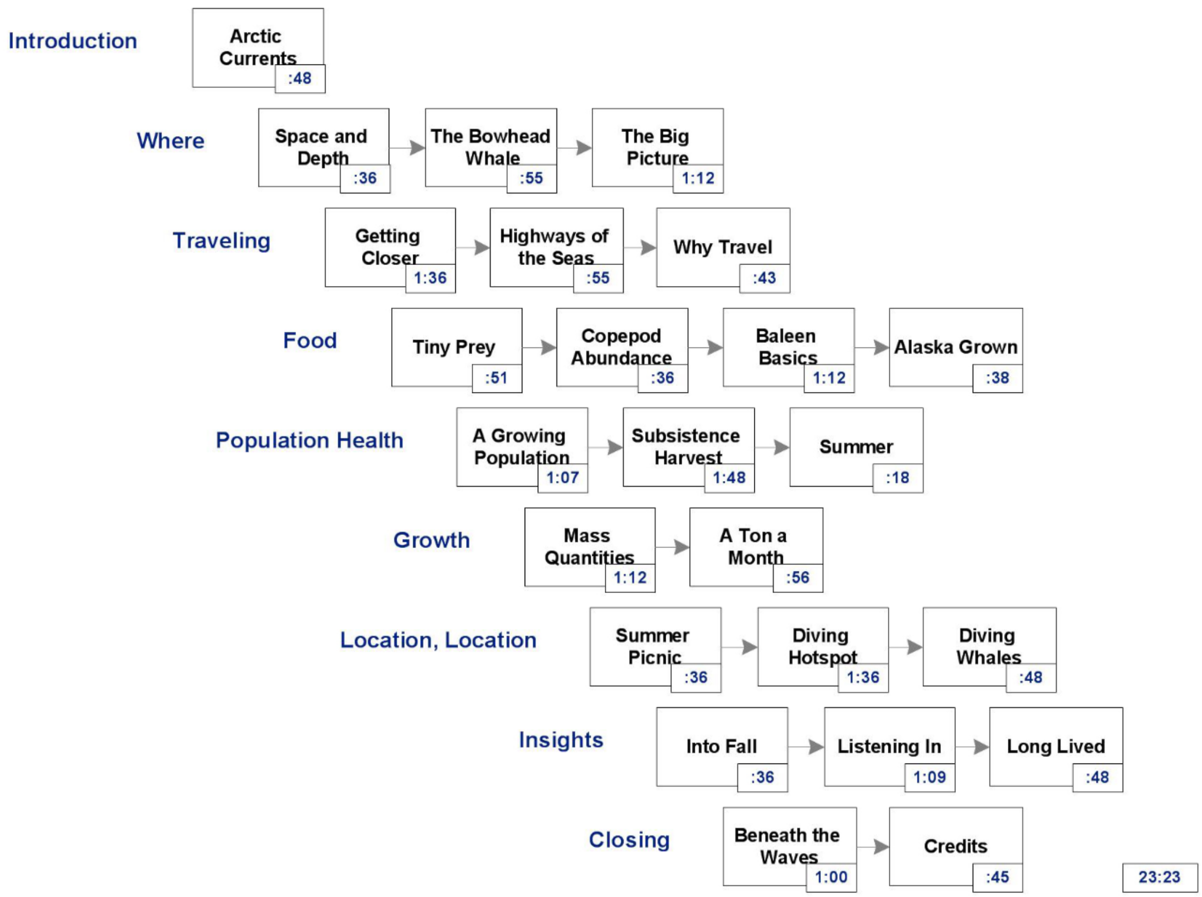


Figure 1. Film narrative structure.

Visual Design

Project visual design has begun with production team meetings identifying the 3D model needs for the project, stylistic differences to be tackled for animal and human animated components, and ways to integrate scientific data and illustration into an otherwise photorealistic presentation. Previous UAMN projects including the recent Power Play and Hibernation exhibitions, the auditorium show You are Here, and a short film depicted Interior Alaska fishwheel operation are being used as starting points for basic water environments, water FX and to inform the projects use of camera depth of field and fog FX styles. Human – largely Inupiat hunter perspective shots for the film are intended to be tackled in a more stylized manner, conceptually dividing human from animal perspective with a very different visual style. First draft style imagery for the human perspective is being based on sketch FX techniques created for the museum's You Are Here show, there used as a means to integrate HD video and photographic elements.

Data Collection

The project team has completed collection of satellite imagery required for the film, predominantly MODIS imagery from the AQUA and TERRA satellites, with additional imagery from Landsat and bathymetry data converted to geoTIF. Mark Baumgartner has provided Dive data from short duration whale tags. This data was featured in the calendar and will be re-presented in the film as an animated graphic coupled with the photorealistic animation.

The project team is still seeking to determine the best way to include data or pre-rendered imagery for the computer-modeled krill dispersal in the Bering, Chukchi, and Beaufort seas.
John Citta has provided the project with 2011 and 2012 bowhead tagged whale maps. We are currently exploring the possibility of acquiring the original lat-long data from the whale tags. If this is not available, we will use the generated plots to create a new plot for the purposes of the film.

Sound Design
Team sound-designer, recordist and editor Theresa Bakker has begun collecting ambient audio and FX audio for the project, including a large quantity of sound donated by Kate Stafford. Additional sound needs are being logged either for on-site recording, donation by scientists, or purchase from sound libraries. Preliminary music design for the film has also begun, with several draft recordings conducted in October of 2012 for used in project development. These recordings are not expected to be used in the final film, but serve to give the team an early feel for the complete film including some 'finished' visual and audio elements.

Theresa Bakker will be scouting for English and Inupiat voice talent in early 2013, as well as approach Inupiat translators to work with us on the project. A change from the original proposal, we intend to invite volunteer Inupiat speakers to review/edit the formal translation as means of correcting for different Inupiat dialects.

Modeling
The team was fortunate to find UAF art student Hannah Foss in her senior year at the University and willing to work part-time on the project. Hannah began modeling whales, krill, and copepod models as early as summer 2012, far ahead of the proposed schedule. Modeling work was curtailed late in 2012 to allow for Hannah's thesis defense, with her returning to work on the project in early 2013.

Rigging & Animation
Rigging and animation of the computer models will largely begin in first quarter 2013. Rigging tests on commercially purchased objects was conducted in November 2012 to identify where the rigs require adjustments or amendments to meet the film's needs (Figure 2). For example, in one purchased whale model, whereas the greater part of the rig is adequate for the animation, a lack of tongue and eye controls means we will need to amend the existing rig, as well as create a close-up substitute model of the whale mouth and baleen plates. If amending the rig proves difficult in January of 2013, we will schedule an original replacement construction in February.

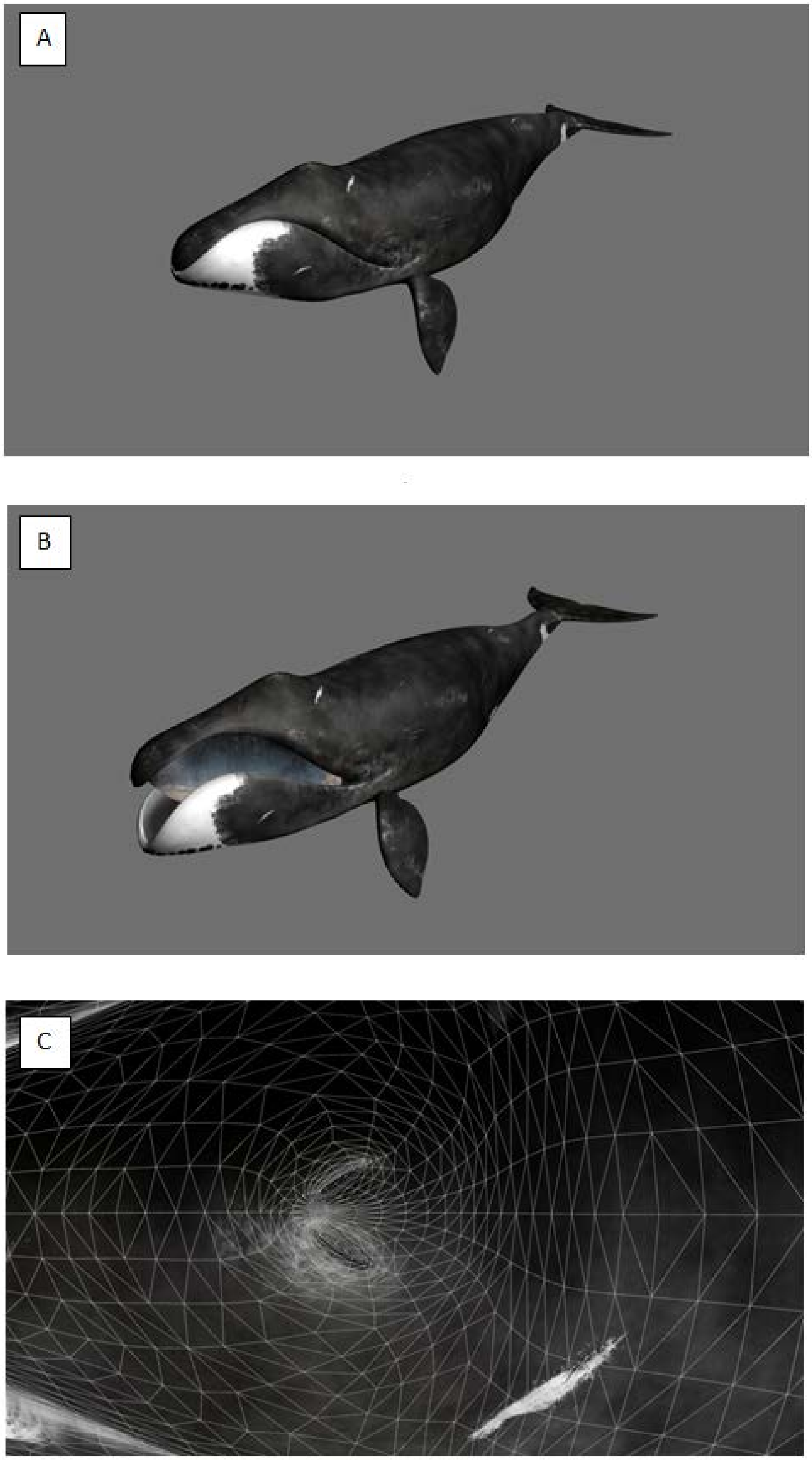


Figure 2. Whale model renders generated as part of the integrated rig testing in November 2012; shown as movies at the 2012 CMI annual review.
A. Bowhead joints B. Bowhead mouth C. Bowhead blowhole

Budget and Timeline Revisions
Funding for staff was reallocated to increase student time on the project. Minor changes were made to the timeline including extending narrative writing, shortening storyboarding time and aligning computer modeling tasks with modeler/animator availability. Overall timeline remains the same (Figure 3).

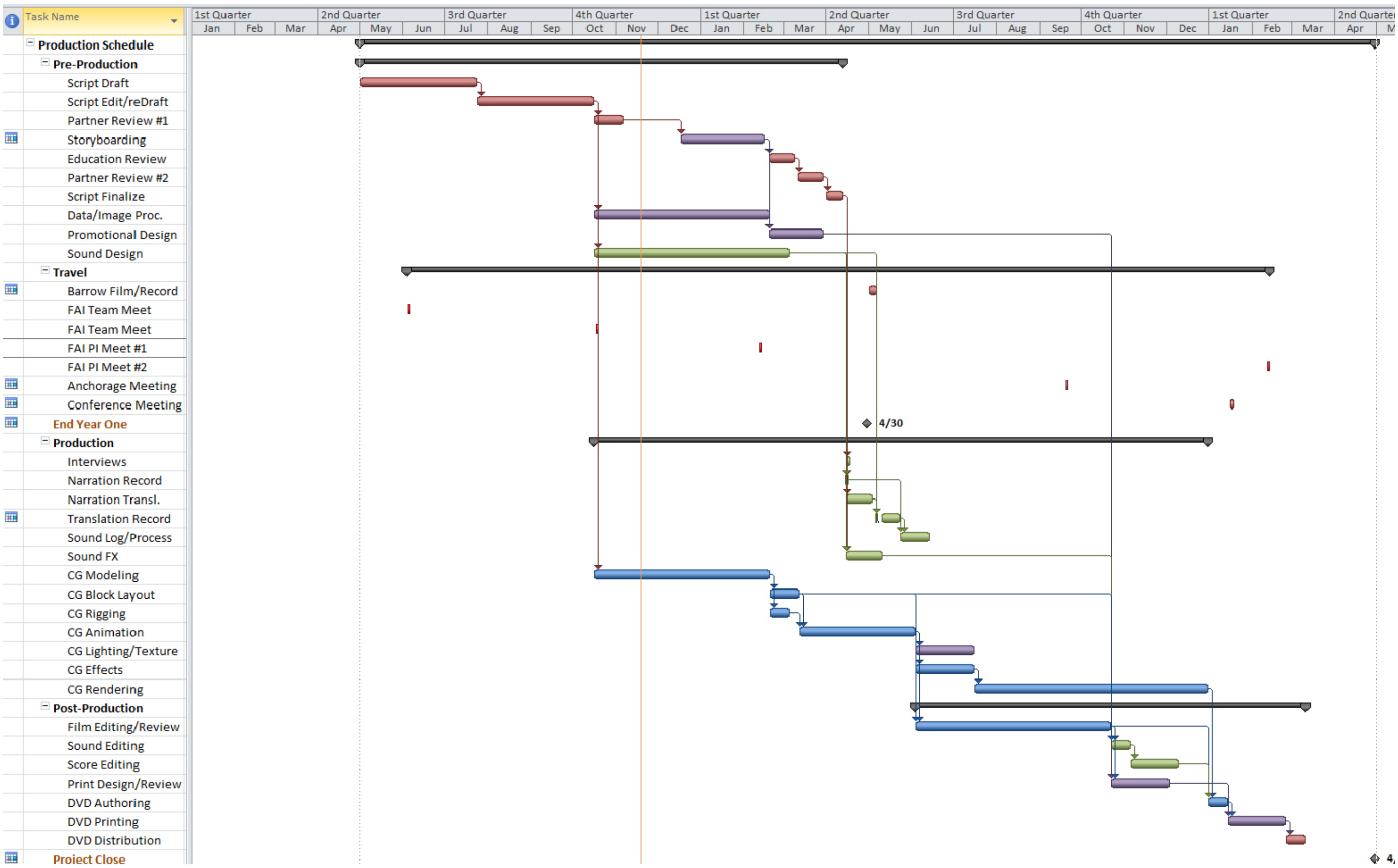


Figure 3. Project timeline as of January 2013.

Project Related Publications and Presentations

Roger Topp, 2012 CMI Annual Research Review, November 20, 2012. Mr. Topp summarized work to-date including narrative structure and scientific review of the verbalized story; demonstrated 3D computer models, textures, and generated riggings; to date, reviewed changes to the project timeline, and talked about how scientific data and satellite imagery would be employed in the project.

CMI Funding and Cost Share Partners

The total BOEM funding committed to Alaska CMI projects since inception in 1993 through calendar year 2012 is approximately $18.5 million. All CMI funded projects require a one-to-one cost share with non-federal monies. The following partial list of cost share partners demonstrates the breadth of support for CMI-funded programs:

Alaska Beluga Whale Committee
Afognak Native Corporation
Alaska Department of Environmental Conservation (ADEC)
Alaska Department of Fish and Game (ADF&G)
Alaska Department of Transportation and Public Facilities
Alyeska Pipeline Service Company
BP Amoco
Canadian Wildlife Service
Cominco Alaska, Inc.
Cook Inlet Regional Citizens Advisory Council
Department of Fisheries and Oceans Canada
Frontier Geosciences, Inc.
Japanese Marine Science and Technology Center (JAMSTEC)
Littoral Ecological & Environmental Services
Oil Spill Recovery Institute
Pollock Conservation Cooperative Research Center
Simon Frasier University
University of Alaska Fairbanks
Frontier Research System for Global Change, IARC
Institute of Marine Science
School of Agriculture & Land Resources Management
School of Management
University of Alaska Museum
University of Alaska Southeast
University of Northern Iowa
Wadati Fund
Woods Hole Oceanographic Institution
ADF&G – Kachemak Bay Research Reserve
Alaska Science and Technology Foundation
Ben A. Thomas Logging Camp
BP Exploration (Alaska) Inc.
CODAR Ocean Sensors
ConocoPhillips Alaska, Inc.
Cook Inlet Spill Prevention & Response, Inc.
Exxon Valdez Oil Spill Trustee Council
Golden Plover Guiding Co.
Kodiak Island Borough
North Slope Borough
Red Dog Mine
Phillips Alaska, Inc.
Prince William Sound Aquaculture Corporation
University of Alaska Anchorage
College of Science, Engineering & Mathematics
Institute of Arctic Biology
International Arctic Research Center (IARC)
School of Fisheries and Ocean Sciences
School of Mineral Engineering
University of Alaska Natural Resources Fund
University of California, Los Angeles
University of Texas

CMI Funded Student Support

Year	Number of Students		BOEM Funds	Matching Funds
1994	PhD	1	$22,558	$9,220
	M.S.	6	$65,107	$37,411
	Undergrad	1	$4,270	$0
	Total	**8**	**$91,935**	**$46,631**
1995	PhD	4	$53,061	$9,523
	M.S.	8	$90,367	$64,380
	Undergrad	5	$4,297	$13,933
	Total	**17**	**$147,725**	**$87,836**
1996	PhD	5	$75,499	$8,499
	M.S.	5	$80,245	$18,661
	Undergrad	2	$4,644	$0
	Total	**12**	**$160,388**	**$27,160**
1997	PhD	2	$37,714	$0
	M.S.	2	$22,798	$0
	Undergrad	2	$2,610	$0
	Total	**6**	**$63,122**	**$0**
1998	PhD	2	$17,109	$17,109
	M.S.	2	$26,012	$7,200
	Undergrad	2	$0	$2,548
	Total	**6**	**$43,121**	**$26,857**
1999	PhD	6	$66,750	$38,073
	M.S.	4	$31,650	$8,730
	Undergrad	4	$0	$10,704
	Total	**14**	**$98,400**	**$57,507**
2000	PhD	6	$61,383	$30,551
	M.S.	2	$5,868	$10,135
	Undergrad	7	$0	$21,299
	Total	**15**	**$67,251**	**$61,985**
2001	PhD	2	$19,159	$22,019
	M.S.	1	$0	$5,800
	Undergrad	3	$10,983	$5,761
	Total	**6**	**$30,142**	**$33,580**
2002	PhD	3	$48,476	$0
	M.S.	5	$66,676	$7,500
	Undergrad	0	$0	$0
	Total	**8**	**$115,152**	**$7,500**
2003	PhD	3	$45,032	$12,000
	M.S.	5	$79,448	$7,500
	Undergrad	1	$1,349	
	Total	**9**	**$125,829**	**$19,500**

Year	Number of Students		BOEM Funds	Matching Funds
2004	PhD	4	$55,365	$15,000
	M.S.	2	$34,715	$0
	Undergrad	0	$0	$0
	Total	**6**	**$90,080**	**$15,000**
2005	PhD	2	$30,942	$0
	M.S.	2	$6,385	$0
	Undergrad	1	$1,398	$0
	Total	**5**	**$38,725**	**$0**
2006	PhD	2	$21,132	$6,667
	M.S.	1	$0	$0
	Undergrad	2	$0	$0
	Total	**5**	**$21,132**	**$6,667**
2007	PhD	0	$0	$0
	M.S.	1	$82,635	$0
	Undergrad	0	$0	$0
	Total	**1**	**$82,635**	**$0**
2008	PhD	0	$0	$0
	M.S.	2	$124,086	$27,423
	Undergrad	0	$0	$0
	Total	**2**	**$124,086**	**$27,423**
2009	PhD	0	$0	$0
	M.S.	2	$0	$0
	Undergrad	0	$0	$0
	Total	**2**	**$0**	**$0**
2010	PhD	1	$66,332	$17,288
	M.S.	3	$97,740	$82,114
	Undergrad	1	$34,620	$0
	Total	**5**	**$198,692**	**$99,402**
2011	PhD	0	$0	$0
	M.S.	1	$6,841	$0
	Undergrad	1	$2,979	$0
	Total	**2**	**$9,820**	**$0**
2012	PhD	1	$60,327	$0
	M.S.	1	$40	$0
	Undergrad	1	$6,000	$0
	Total	**3**	**$66,367**	**$0**

Totals	Students	BOEM	Matching
	132	$1,574,602	$517,048

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