ARCTIC NEARSHORE IMPACT MONITORING IN DEVELOPMENT AREA – III (ANIMIDA III)

2015 Field Report

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1.0 Introduction

As part of the four-year *Arctic Nearshore Impact Monitoring in Development Area* (ANIMIDA III) contract with the Bureau of Oceans and Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE), Olgoonik Fairweather (OF), in conjunction with a team of sub-contractors, conducted a 7-day sampling cruise in the Beaufort Sea during August 2015. Forty-seven (47) stations were originally slated for sampling as per the ANIMIDA sampling plan. Thirty four (34) stations were sampled. Due to ice, many of the planned stations were unreachable and other secondary and /or opportunistic stations were occupied and various samples collected, depending on the particular discipline (see discipline specific sections contained herein). Samples collected include sediment for physical, chemical, and biological analysis, water for physical and chemical analysis, biota for chemical and taxonomic analysis, and water column sensor data for physical oceanographic analysis (e.g., conductivity, temperature, current velocity; as well as Acoustic Doppler Current Profiler (ADCP) measurements.

The subcontractors brought a wide variety of discipline expertise to the project and include Battelle (hydrocarbon chemistry), Florida Institute of Technology (FIT, metals chemistry and geochemistry), University of Alaska – Fairbanks (UAF, epibenthic and physical oceanography), University of Texas at Austin (UT-A, benthic taxonomy, data management, and website development). OF's role served primarily as project management, safety, and vessel operations and logistics.

The following tasks are included in this field report:

- Task 1 – Sediment chemistry monitoring for hydrocarbons and metals
    - Task 1A – Field Logistics (additional detail can be found in the Logistics Plan, a separate deliverable)
    - Task 1B – Establishing baseline for benthic biomass, species composition, and oil industry anthropogenic chemicals to detect changes that may result from future oil and gas activities
    - Task 1C – Supporting water column and physical oceanographic information
    - Task 1D – Reconstruct historical trend for anthropogenic chemicals
    - Task 1E – Identify and sample natural or other anthropogenic sources of contaminants to the study area
- Task 2 – Initiate and develop a conceptual food web related to bioaccumulation and risk of trophic transfer of oil industry anthropogenic chemicals
- Task 3 – Collaboration with entities
    - Task 3A – Coordination
- Task 4 – Project and data management
    - Task 4A – Project management
    - Task 4B – Data management
    - Task 4C – Quality control and quality assurance
- Task 5 – Local and scientific outreach

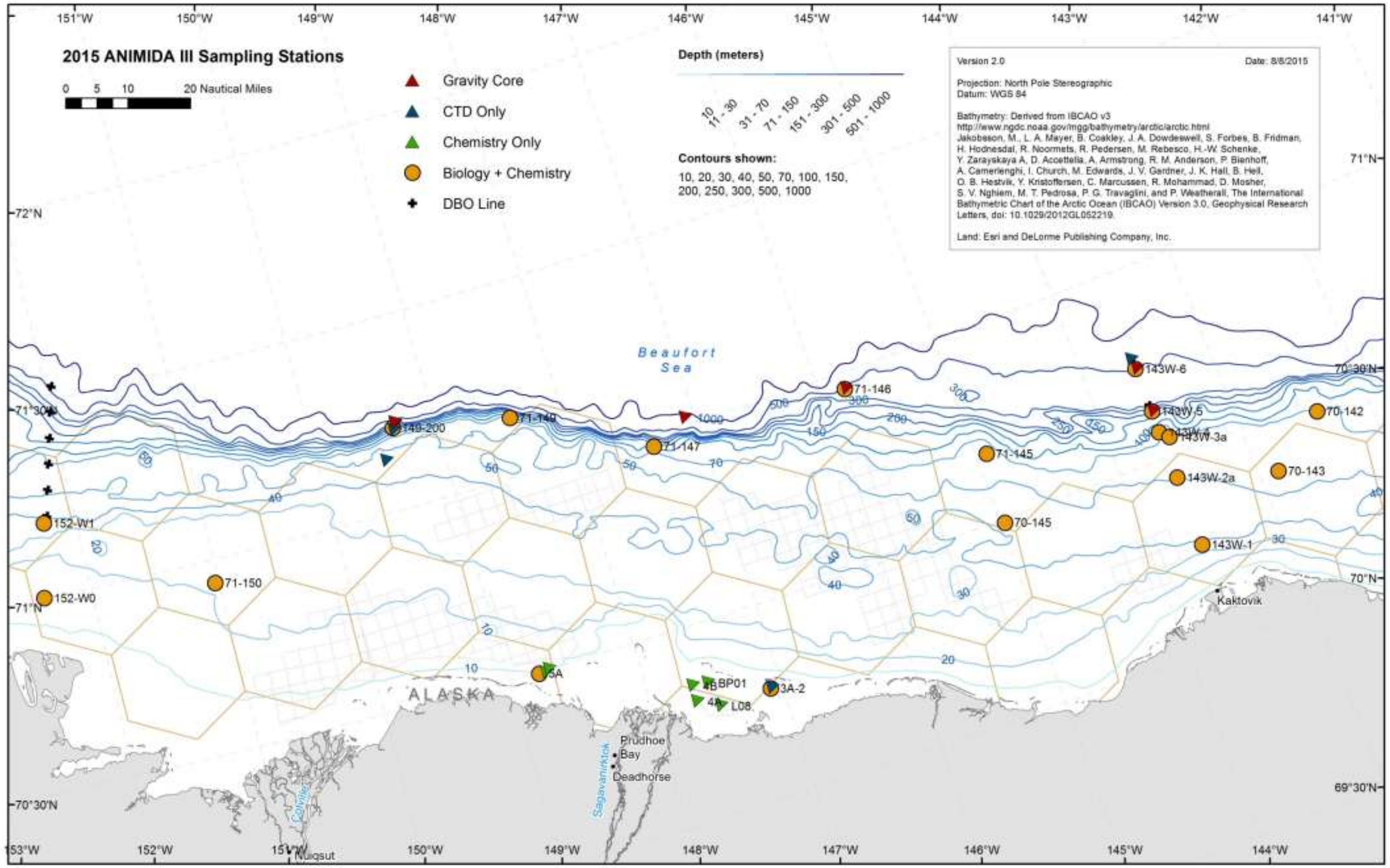
The ANIMIDA III project augments, with new stations, many of the stations included during ANIMIDA I and ANIMIDA II (previously called ANIMIDA (1999-2003) and cANIMIDA ("continuation" of ANIMIDA (2004-2007), respectively).

The objectives of the 2015 ANIMIDA III field sampling work in support of the specific tasks outlined above were:

(1) Collect sediment, tissue (for biological and chemical analysis), and water samples (a combination of sensor only data and discrete water samples) at 12 former Beaufort Sea Monitoring Program (BSMP) stations (see Figure 1). Five (5) former BSMP stations were sampled.
(2) Collect sediment, tissue (for chemical analysis only), and water column sensor data at 10 Camden Bay stations. None of these stations were sampled.
(3) Collect sediment, tissue (for biological and chemical analysis), and water samples (a combination of sensor only data and discrete water samples) at 2 random, deep-water stations. None of these stations were sampled.
(4) Collect at least 5 sediment cores at targeted stations. Five (5) sediment cores were collected.
(5) Coordinate sampling between offshore and nearshore locations.
(6) Streamline sampling efforts, wherever possible, to reduce duplicative collections at the same stations.
(7) Sample the newly defined Beaufort Sea Distributed Biological Observatory (DBO) lines at 152W and 143W.
(8) Continue outreach efforts in the community of Kaktovik.

The objectives were met, for the most part, during the 2015 sampling cruise. The nearshore stations accessible by the Norseman II were sampled, although ice created other challenges in accessing some sites. Specific sampling locations are outlined in the discipline-specific summaries.

Figure 1. Station Locations for the 2015 ANIMIDA III Field Sampling Program.



2.0 Logistics – Actual Cruise Schedule

The ANIMIDA III cruise began on July 31, 2015 with the attempted recovery of a physical oceanography mooring and ended on August 8, 2015 with the completion of all sampling activities. This cruise timing is specific to the offshore vessel (the *Norseman II*) only, as the nearshore vessel (Launch 1273) not used in 2015. The team was mobilized to Anchorage/Fairbanks by July 29 with travel to Deadhorse on July 31 for mobilization to the Norseman II and August 8 served as the demobilization day for the team to return to shore. The actual mobilization day was delayed slightly due to ice around Pt. Barrow while the Norseman II was transiting from Nome. All crew changes occurred in and out of Prudhoe Bay. Table 1 summarizes the actual cruise schedule.

Table 1. Summary of Actual Cruise Schedule.

Date (2015)	Activity / Stations Sampled
Tue - Thur, Jul 28 -30	Team traveled to either Fairbanks or Anchorage
Fri Jul 31	Team traveled to Deadhorse and loaded on NII
Fri Jul 31	Norseman II left West Dock and began scientific operations by attempting to retrieve mooring (not successful)
Sat Aug 1	Completed: 152W0, 152W1, and 71-150 (ice on northern part of DBO line too thick for safe transit)
Sun Aug 2	Completed: 5A, N06, N03, 3A 2nd attempt at mooring (still unsuccessful)
Mon Aug 3	Completed: 143W-1, 143W-2, 143W-3, 143W-6, 143W-5
Tue Aug 4	Completed: 143W-4, 143W-3, 70-142, 70-143
Wed Aug 5	Completed: 70-145, 71-145, 71-146, 71-147a Continued ice issues in between stations
Thur Aug 6	Completed: 71-147, 71-149, 149-350, 149-250, 149-200, 149-100, 149-46
Fri Aug 7	Completed packing and traveled to West Dock
Sat Aug 8	Completed crew change with crew and samples; team transited to Fairbanks/Anchorage on Ravn charter and on to final destination
Sun Aug 9	Continued travel to final destination

2.1 Offshore Vessel

The offshore research vessel used in both 2014 and 2015 was the R/V Norseman II (Figure 2). The *Norseman II* is owned by Norseman Maritime (Seattle, WA). The *Norseman II* conducted field activities to completion from July 31 through August 8. The vessel is described in more detail in the 2015 ANIMIDA III Sampling Plan, previously provided to BOEM.

Figure 2. Photo of R/V Norseman II.

2.2 Scientific Field Teams

The 2015 field team was comprised of scientists on the offshore vessel. Table 2 summarizes the field personnel and the approximate shift schedule for the *Norseman II*.

Table 2. Scientific Field Personnel on R/V Norseman II during the 2015 ANIMIDA Program.

	Scientific Personnel	Affiliation/Discipline	Shift
1	D. Holiday	BOEM, COR (Epibenthic/Fish)	Day
2	J. Kasper	UAF (Phys O)	Day
3	P. Shipton	UAF (Phys O)	Night
4	P. Libby	BAT (Chem)	Day
5	P. Curran	BAT (Chem)	Night
6	J. Trefry	FIT (Chem)	Day
7	S. Fox	FIT (Chem)	Day
8	A. Fox	FIT (Chem)	Night
9	B. Bluhm	UAF (Epibenthic)	Day
10	L. Edenfield	UAF (Fish)	Night
11	K. Walker	UAF (Epibenthic)	Day
12	T. Schollmeier	UAF (Epibenthic)	Night
13	S. Schonberg	UTA (Benthic)	Day
14	C. Bonsell	UTA (Benthic)	Night
15	C. Harris	UTA (Benthic)	Day
16	K. Dunton	UTA (Benthic)	Night
17	N. Wolf	OF (OPM)	Day

3.0 Field Report Discipline Summaries

The following sections present brief summaries of the sampling activities completed for each discipline during the 2015 ANIMIDA III field cruise.

3.1 Physical Oceanography

- Dr. Jeremy Kasper, PI, UAF
- Dr. Jeremy Kasper and Peter Shipton, shipboard team

A total of 29 conductivity temperature and depth (CTD) casts were taken (Table 3) between July 31 and Aug. 8, 2015 on the eastern and central sections of the Alaskan Beaufort Sea shelf (ABS). The stations included a mix of full, partial and physical oceanography only stations. The latter generally consisted of a CTD cast with no water samples (Table 3, Figure 3). Full CTD stations included bottle samples collected at discrete depths (surface, bottom and chlorophyll max, sampled for nutrients, chlorophyll *a* as well as chemical analysis). Approximately 110 samples were collected for analysis of major and trace nutrients (Whitledge et al., 1981). An additional ~44 samples were collected for analysis of stable oxygen isotopes (δO^{18}). The chlorophyll *a* and chemical analysis are described in more detail in separate reports. In addition to the CTD stations, data from the vessel mounted ADCP were logged for the duration of the cruise as well as a "flow through" thermosalinograph (TSG) that sampled at approximately 1 meter (m) below the surface at 1 Hertz (Hz) during the cruise.

The physical oceanography only CTD transects provide a snapshot of shelf conditions. The analysis of salinity and potential temperature from these transects should provide a map of water masses on the shelf including whether nutrient rich "Pacific Water Masses" are present on the shelf. These water masses are typically advected by the shelfbreak jet which forms the northern boundary of the ABS (e.g. Pickart 2004) and are transported onto the shelf by upwelling favorable winds.

References

Pickart, R. S., 2004. Shelfbreak circulation in the Alaskan Beaufort Sea: Mean structure and variability. Journal of Geophysical Research, 109, (C4), C04024 10.1029/2003JC001912.

Whitledge, T.E., Malloy, S.C., Patton, C.J., Wirick, C.D., 1981. Automated nutrient analyses in seawater. Brookhaven National Laboratory Technical Report BNL 51398

Figure 3. Map Indicating ANIMIDA 2015 Station Locations and Type.

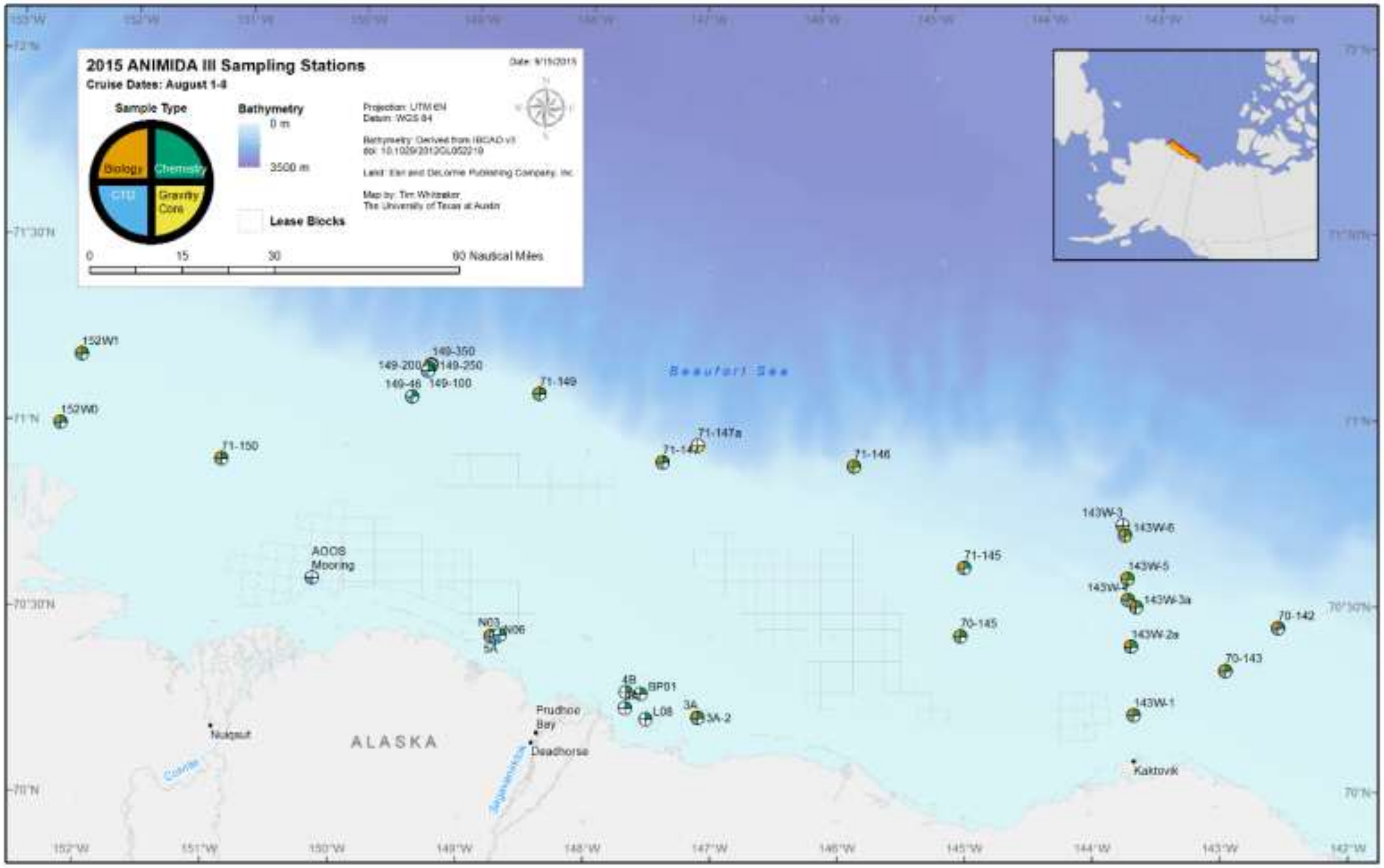


Table 3. Summary of Stations Occupied During the 2015 ANIMIDA III Cruise.

Measurement Key: A=Amphipod, C = CTD, W = Niskin water samples, P = plankton net tow, V = Van Veen Grab, T = Trawl, B=Bivalve Rake,

Measurement Key: A=Amphipod, C = CTD, W = Niskin water samples, P = plankton net tow, V = Van

Station Name	Measurements	Station Type	Latitude (N) Decimal °	Longitude Decimal °	Depth sounder reading	depth (corrected for sounder placement on ship)
152W0	ACWPVTBA	DBO	71.0042	152.38	12.9	15.9
152W1	ACWPVTBA	DBO	71.1939	152.25	35	38
71-150	CWPVT	Ken Bio	70.9404	151.03	15.2	18.2
AOOS Mooring	C	CTD only	70.6331	150.23	10	13
5A	ACWPVTBA	BSMP	70.4947	148.76	8.8	11.8
N06	CV	BSMP	70.4924	148.72	8.9	11.9
N03	CV	BSMP	70.4991	148.69	10	13
3A (cast #1, redo)	C	BSMP	70.2829	147.09	3.4	6.4
3A-2	ACWPVTBA	BSMP	70.2824	147.09	3.4	6.4
143W-1	ACWPVTBA	DBO	70.2573	143.61	35.8	38.8
143W-2 (wire angle too steep, redo)		DBO				
143W-2a	ACWPVTBA	DBO	70.4425	143.6	45	48
143W-3	CTD only		70.7714	143.61	195	198
143W-6	CWPGT	DBO	70.7445	143.59	499	502
143W-5	CWPVGT	DBO	70.6260	143.59	300	303
143W-4	CWPVT	DBO	70.5691	143.6	151	154
143W-3a	CWPVT	DBO	70.5482	143.54	100	103
70-142	ACWPVTBA	Ken Bio	70.4658	142.4	62.5	65.5
70-143	ACWPVTBA	Ken Bio	70.3614	142.85	54	57
70-145	ACWPVTBA	Ken Bio	70.4912	144.97	42.8	45.8
71-145	ACWPVTBA	Ken Bio	70.6753	144.92	100	103
71-146	CWPVGT	Ken Bio	70.9569	145.8	392	395
71-147a	G	Gravity Core (p	71.0181	147.09		
71-147	CWPVTB	Ken Bio	70.9716	147.38	101	104
71-149	ACWPVTBA	Ken Bio	71.1525	148.41	65.4	68.4
149-350	CVG	NOPP Line	71.2236	149.33	322	325
149-250	C	NOPP Line	71.2199	149.33	262	265
149-200	CWPVT	NOPP Line	71.2123	149.34	204	207
149-100	CW	NOPP Line	71.2058	149.35	105	108
149-46	CW	NOPP Line	71.1340	149.47	45.1	48.1

3.2 Trace Metal Chemistry

- Dr. John Trefry, PI, FIT
- Dr. John Trefry, Austin Fox, Stacey Fox onboard team

Trace metals in sediments and biota serve as sensitive indicators of anthropogenic inputs to the Beaufort Sea from industrial activities (Trefry et al. 2003, 2013). Baseline concentrations of 16 metals (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Tl, V and Zn) in sediments and biota from the coastal Beaufort Sea were previously determined during the ANIMIDA project (Trefry et al. 2003; Brown et al. 2010). Now that a baseline is established for sediment and biota metals in the coastal Beaufort Sea, future monitoring can proceed with defined limits for identifying contamination.

During the 2015 survey, surface sediments (0-1 cm) were collected for metal analysis using a double van Veen grab at 26 stations (Table 4). Sediment gravity cores were obtained for metal analysis at 5 stations (Table 4). The lengths of the sediment cores ranged from 112-137 cm as noted in Table 4. The cores were sub-sectioned aboard ship in 1-cm thick layers over the top 10 cm and in 2-cm thick layers at depths >10 cm. These sediments will be analyzed for selected trace metals. Some cores will be age-dated using ^{137}Cs and excess ^{210}Pb geochronology.

During the 2014 survey, surface-rich layers with arsenic and mercury were found and explained by natural diagenetic processes. To follow-up on the 2014 work, sediment profiles for dissolved oxygen, redox potential (Eh) and pH were obtained. Figures 4 and 5 show that dissolved oxygen extended to depths of 10-20 mm (1-2 cm). We will integrate the amount of oxygen (in nmole/cm^2) to help interpret sediment trace metal profiles. Redox potentials (on a different scale of centimeters) were quite variable with values at depth that ranged from 200 to 0 mvolts. Again, these data also will be used to help interpret sediment metal profiles.

Sampling for amphipods and clams was carried out at most stations; sufficient quantities were obtained at 6 stations for amphipods and six for clams. These samples will be analyzed for mercury (Hg), lead (Pb) and several other metals.

As a preview of 2015 results to be forthcoming, 2014 data for Hg in clams and Pb in amphipods show no evidence of any enhanced concentrations since the previous sampling in 2006.

We also will be determining sediment accumulation for the sediment cores collected during 2015. Again, as a preview, results from station 6.1 sampled in 2014 show the low sediment accumulation rate of 0.08 cm/yr.

Table 4. Summary of Samples Collected in the Beaufort Sea for Trace Metal Analysis.

Station ID	Station Date	Latitude (°N)	Longitude (°W)	Surface Sediment	Sediment O_2, Eh	Sediment Core[2]	Biota[3]
L08	26 Jul 2015	70.278	147.506	1			
4A	26 Jul 2015	70.308	147.671	1			
4B	27 Jul 2015	70.350	147.667	1			
BP01	27 Jul 2015	70.346	147.549	1			
152W0	1 Aug 2015	71.002	152.381	1	1		A
152W1	1 Aug 2015	71.194	152.251	1	1		A, C
71-150	1 Aug 2015	70.940	151.029	1	1		
5A	2 Aug 2015	70.495	148.765	1	1		
N06	2 Aug 2015	70.493	148.722	1	1		
N03	2 Aug 2015	70.499	148.691	1	1		
3A	2 Aug 2015	70.282	147.090	1	1		C
143W1	3 Aug 2015	70.260	143.601	1			A, C
143W2	3 Aug 2015	70.440	143.603	1			
143W6	3 Aug 2015	70.744	143.591	1	1	137 cm (39)[2]	
143W5	3 Aug 2015	70.626	143.590	1	1	109 cm (35)[2]	
143W4	4 Aug 2015	70.569	143.600	1	1		
143W3	4 Aug 2015	70.548	143.536	1			
70-142	4 Aug 2015	70.466	142.396	1	1		C
70-143	4 Aug 2015	70.362	142.850	1			A
70-145	5 Aug 2015	70.494	144.960	1			A
71-145	5 Aug 2015	70.674	144.916	1	1		C
71-146	5 Aug 2015	70.957	145.801	-	-	136 cm (30)[2]	
71-147A	5 Aug 2015	71.088	147.392	1	1	137 cm (31)[2]	
71-147	6 Aug 2015	70.972	147.384	1			
71-149	6 Aug 2015	71.153	148.415	1	1		C
149-350	6 Aug 2015	71.224	149.328	1	1	112 (30)[2]	A
149-200	6 Aug 2015	71.212	149.343	1			
				Total	**26**	**5 (165)**	**6A, 6C**

[1]BC = Biology and Chemistry, C = Chemistry."
[2]Sediment core length in cm (number of sections sampled).
[3]A= amphipod, C = clam.

Figure 4. Vertical Profiles for Sediment Dissolved Oxygen and Redox Potential (Eh) for Stations 152W1 and 143W5.

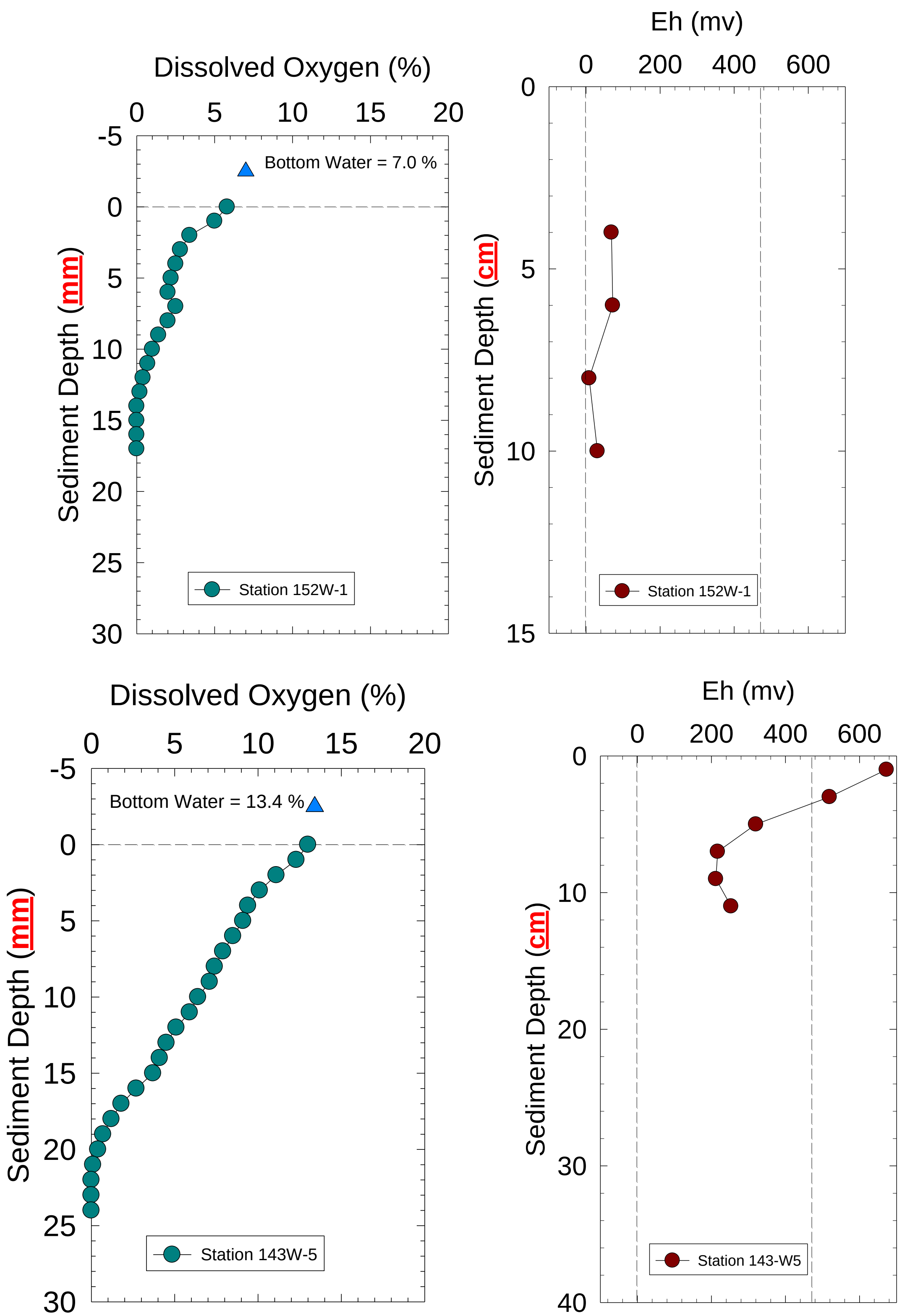


Figure 5. Vertical Profiles for Sediment Dissolved Oxygen and Redox Potential (Eh) for Station 71-149.

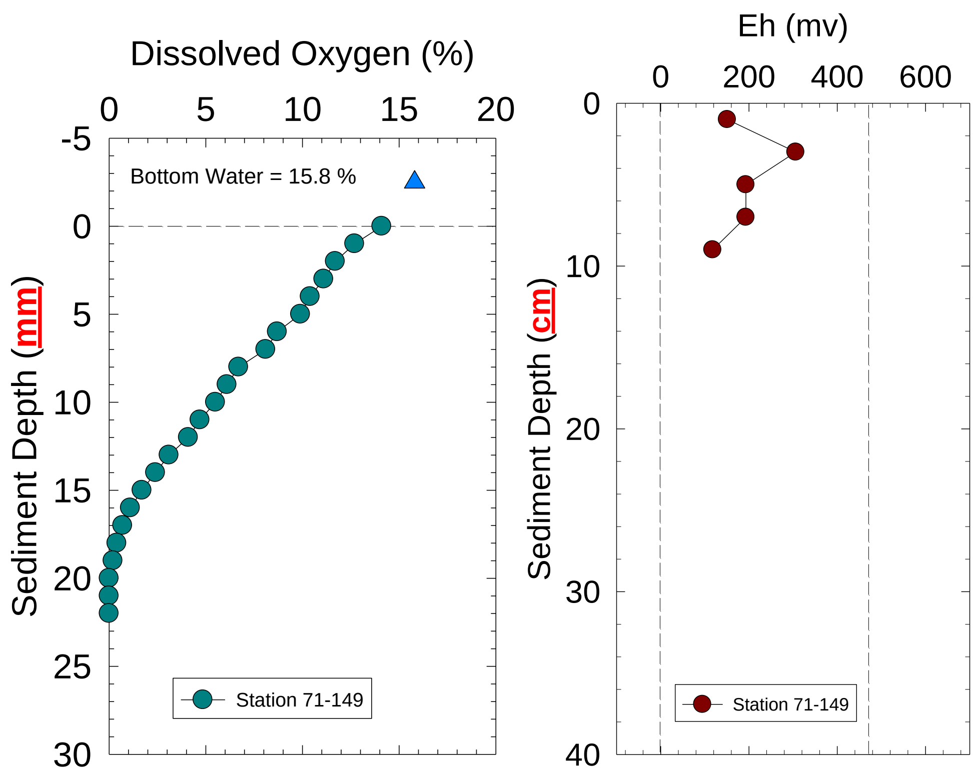


Figure 6. Concentrations of Mercury (Hg) in Clams and Lead (Pb) in Amphipods from 2014 ANIMIDA III, ANIMIDA I, and cANIMIDA projects.

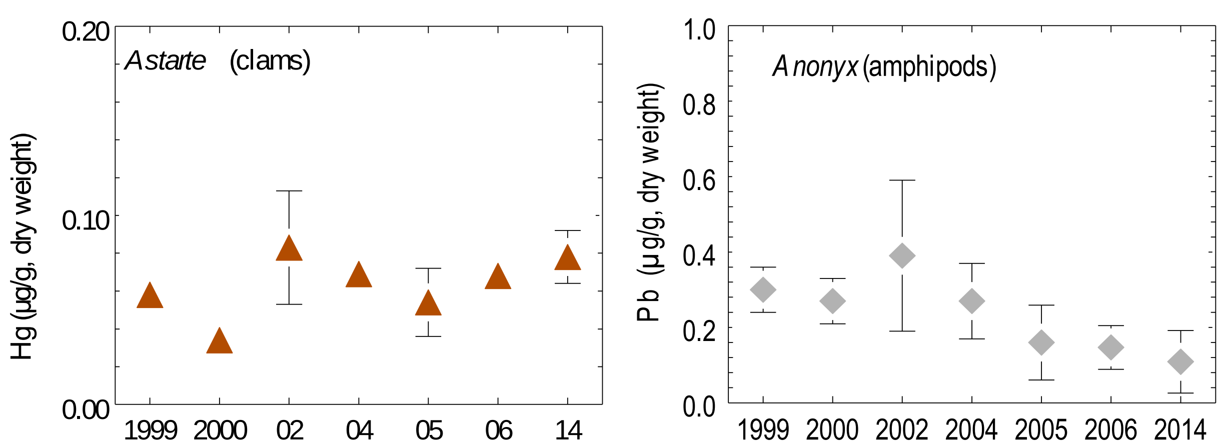
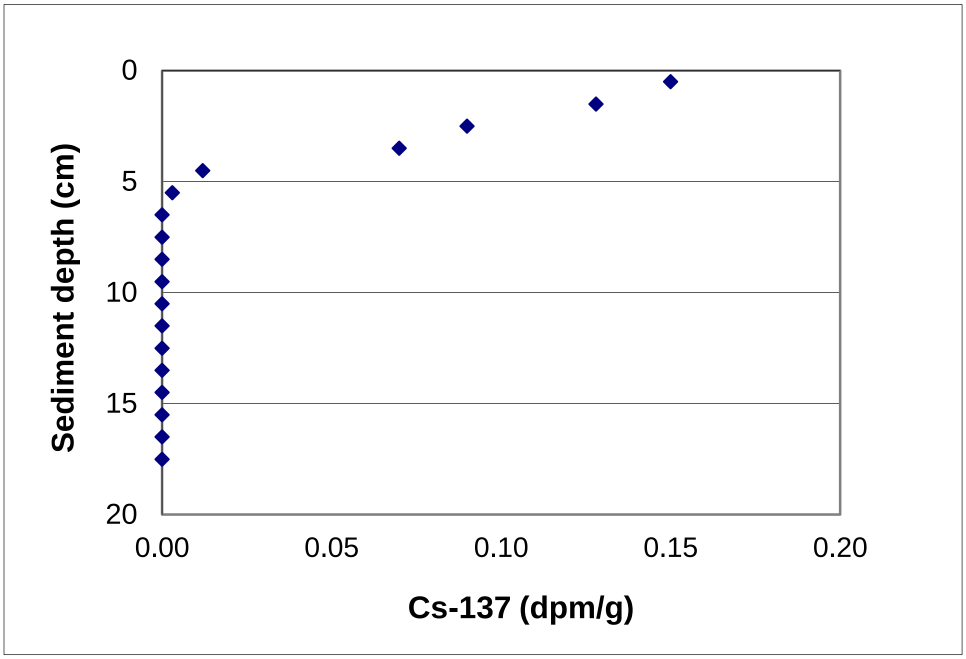


Figure 7. Vertical Profile for Cs-137 in Sediment Core from ANIMIDA III Station 6.1, Sampled in 2014. Activity of Cs-137 Goes to Zero at About 1950; Therefore, the Sedimentation Rate is (5 cm/ 64 yrs) = 0.08 cm/yr.



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Brown J, Boehm P, Cook L, Trefry J, Smith W, Durell G. 2010. Hydrocarbon and metal characterization of sediments in the cANIMIDA study area. OCS Study MMS 2010-004, US Dept. Interior, Anchorage.

Trefry JH, Rember RD, Trocine RP, and Brown JS. 2003. Trace metals in sediments near offshore oil exploration and production sites in the Alaska Arctic. Environ Geol 45149–160.

Trefry JH, Dunton KH, Trocine RP, Schonberg SV, McTigue ND, Hersh ES, and McDonald TJ. 2013. Chemical and biological assessment of two offshore drilling sites in the Alaskan Arctic. Mar Environ Res 86:35-45.

3.3 Epibenthic Invertebrates and Fish Community Structure

- Dr. Bodil Bluhm, PI, University of Alaska Fairbanks (UAF) and The Arctic University of Norway (UiT)
- Dr. Bodil Bluhm, Lorena Edenfield, Kelly Walker, Tanja Schollmeier onboard team

Objectives

Our objective during the ANIMIDA III 2015 cruise was to continue the survey of the epibenthic invertebrate and demersal fish community in the ANIMIDA III study area at nearshore and central/eastern Beaufort Sea shelf stations and at the newly established DBO lines. On Pacific Arctic shelves, trawl hauls tend to be composed of ~ 90% invertebrates by biomass and ~10% fish. Epibenthic invertebrates include prey items for fish and marine mammals and contribute substantially to total benthic biomass, carbon recycling and biodiversity. Fishes are key organisms in the energy flow on Arctic shelves, as predators of the invertebrate fauna, and as food for higher trophic levels such as ice seals. Bottom-feeding fish can also be important in structuring the benthic invertebrate communities.

Methods

Epibenthos and fishes were sampled from trawl samples, using a modified 3-m plumb-staff beam trawl (PSBT-A) with 7 mm mesh and 4 mm cod end liner and bottom roller gear to avoid penetration of the foot rope into the often soft, muddy sediment on the shelf. Start and end time stamps of the bottom trawling were taken to later be matched with specific latitude and longitudes from the ship records. The net was also affixed with a time-depth recorder (TDR, Star Oddi) that provides a detailed profile of bottom time of the trawl. The coordinates and TDR data together with ship speed during towing will allow us to calculate towed area and calculate catch per unit effort (CPUE) for epibenthic invertebrates and fishes.

Epibenthic invertebrates of the full catch or a well-mixed subsample of the catch were sorted to lowest taxonomic level practical on board. Fishes were always collected from the entire haul. Small-bodied invertebrates were subsampled from a smaller fraction of the haul than larger invertebrates. Counts and wet weights per taxon were determined on board using digital hanging scales or spring scales. Invertebrate vouchers were preserved in 4% formalin-seawater solution buffered with hexamethylenetetramine for later confirmation of species identifications with taxonomic specialists and for long-term archiving at recognized national archives. A few organisms were preserved in molecular-grade ethanol for genetic analysis to assist in species identification (pycnogonids, select cnidarians). Several individuals of the common epibenthic invertebrates and fishes (typically n=4 per species and station) were supplied to collaborators from the University of Texas for stable isotope food web work. Most fish were identified and measured to the nearest mm, weighed as a species group, and then either transferred to UT-A collaborators for stable isotope analysis or to Battelle/FIT collaborators for contaminant analysis. Fishes superfluous to contaminant or stable isotope needs were frozen and will be transported to the UAF Fisheries Oceanography Laboratory for further analysis.

Results

Epifauna and fish were sampled at 18 stations from the PSBT-A (Table 5). Five additional hauls were deemed non-quantitative based on the TDR-profile and trawl content. A total of ~200 putative invertebrate taxa (mostly species) and 22 fish taxa were identified from the trawls. More than 200 voucher samples with typically multiple individuals per sample were taken. Epibenthic invertebrate taxa mostly belonged to Arthropoda (mostly Crustacea), Mollusca (mostly Gastropoda), Annelida (all Polychaeta), Echinodermata, Bryozoa, and Cnidaria (Figure 8). Within the Crustacea, most taxa were Amphipoda and Decapoda. Asteroidea and Ophiuroide were most species rich within the echinoderms.

Arthropods and molluscs were the most taxon-rich phyla, but echinoderms often dominated by relative abundance and/or relative biomass. Absolute abundance and biomass patterns will require proper calculation of CPUE before they can be compared among stations.

Table 5. Trawl Stations During the ANIMIDA III 2015 Cruise and Number of Putative Invertebrate and Fish Taxa Collected at Each Station.

Station Number	Date	Haul	Max Depth	No. epifauna taxa	No. fish taxa	Quant/ Non-Quant.	Fraction fish	Fraction inverts
152W0	1-Aug-15	1	13	14	3	Quantitative	1	1
152W1	1-Aug-15	2	36	17	6	Quantitative	1	1
71-150	1-Aug-15	3	15	21	6	Quantitative	1	1
5A	2-Aug-15	4	8.5			Non-Quant.	0	0
5A	2-Aug-15	5	8.6	5	1	Quantitative	1	1
3A	2-Aug-15	6	3.4			Non-Quantitative	0	0
3A	2-Aug-15	7	3.1	27	2	Quantitative	1	1
143W-1	3-Aug-15	8	37.1	48	5	Quantitative	1	all 1/6
143W-2	3-Aug-15	9	45			Non-Quant.	0	0
143W-2	3-Aug-15	10	44	29	9	Quantitative	1	mostly 1/6, 1/12 or 100% for rest
143W-6	3-Aug-15	11	500			Non-Quant.	0	0
143W-5	4-Aug-15	12	302	20	2	Quantitative	1	100% except for 1/4 small ophis
143W-4	4-Aug-15	13	151	40	6	Quantitative	1	0.60
143W-3	4-Aug-15	14	100	41	7	Quantitative	1	0.17
70-142	4-Aug-15	15	62	35	6	Quantitative	1	0.33
70-143	4-Aug-15	16	54	46	8	Quantitative	1	0.08
70-145	5-Aug-15	17	43			Non-Quant.	0	0
70-145	5-Aug-15	18	43	35	9	Quantitative	1	100% (1/6 for *Ophiocten, Similipecten)*
71-145	5-Aug-15	19	96	37	7	Quantitative	1	100%, (1/6 *Ophiocten, Similipecten)*
71-146	5-Aug-15	20	399	27	3	Quantitative	1	1
71-147	6-Aug-15	21	107	31	7	Quantitative	1	100% (1/4 *Ophiocten, Ophiopleura, Similipecten*
71-149	6-Aug-15	22	62	40	5	Quantitative	1	100% (1/3 *Ophiocten, Similipecten)*
149-200	6-Aug-15	23	200	27	7	Quantitative	1	1/35 (1/7 for large fauna)
			Total	201	22			

A total of 326 fish were captured during 2015 ANIMIDA III. Six fish were taken from the clam rake and the remaining 320 fish were captured in the benthic trawl. Fishes belonged to seven families (Figure 9) and 22 putative species (Table 6). Sculpins (Family Cottidae) dominated species richness with *Icelus spatula* being the most common fish species caught. Poachers and Eelpouts were the next most common families.

Figure 8. Epibenthic Taxonomic Composition by Phylum During ANIMIDA III in 2015.

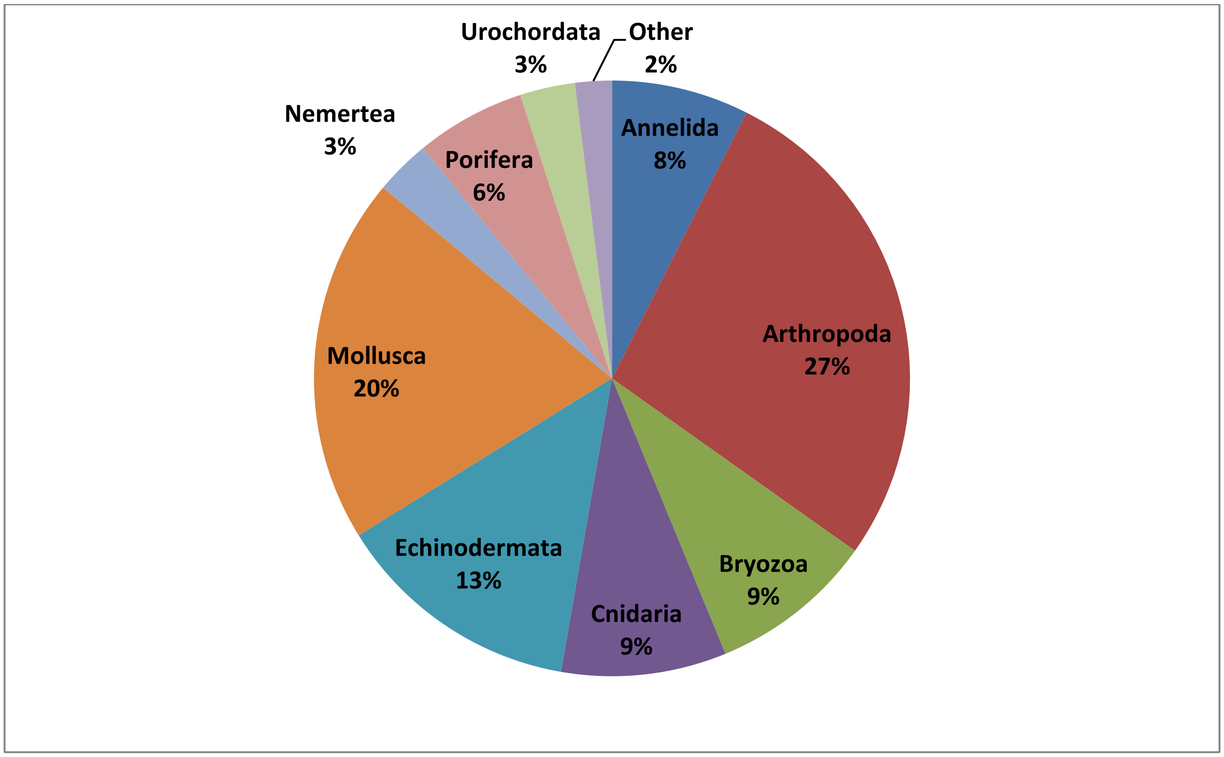


Figure 9. Fish Taxonomic Composition by Family During ANIMIDA III in 2015.

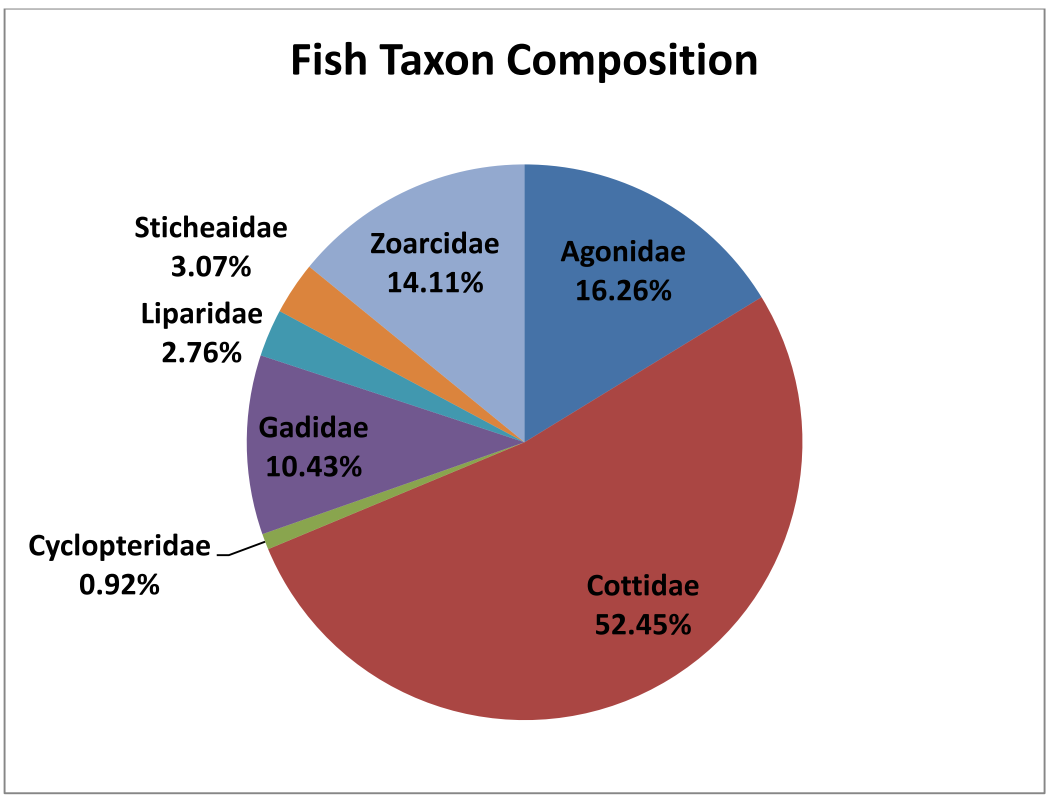
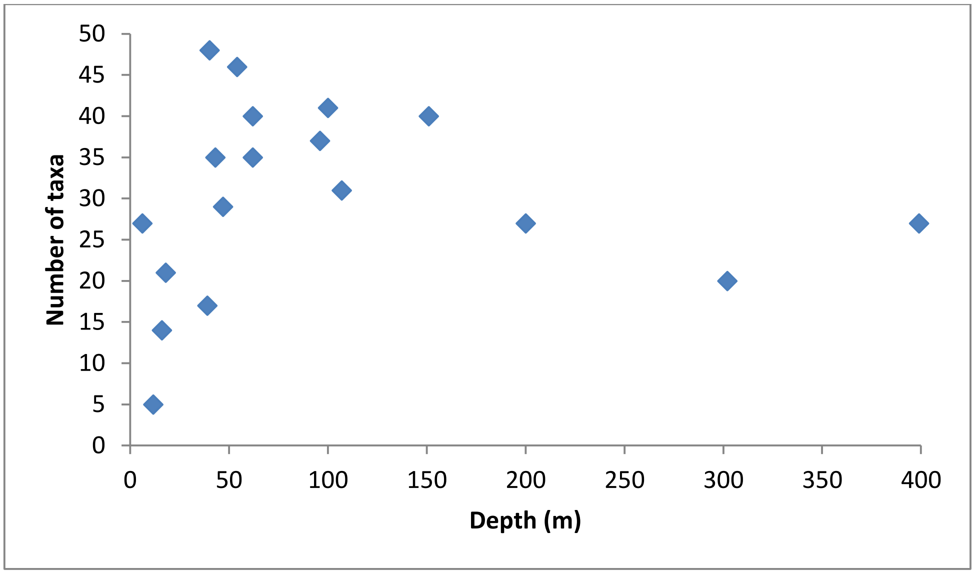


Table 6. Fish Taxon and Count of Individuals Captured in the Modified Plumb Staff Beam Trawl (PSBT-A) During ANIMIDA III in 2015.

Taxa captured in benthic trawl	**Number of Fish**
Agonidae	**53**
Aspidophoroides olrikii	52
Leptagonus decagonus	1
Cottidae	**171**
Artediellus scaber	10
Cottidae unid. (juv)	2
Gymnocanthus tricuspis	20
Icelus bicornis	50
Icelus spatula	64
Triglops nybelini	4
Triglops pingelii	21
Cyclopteridae	**3**
Cyclopteridae	3
Gadidae	**34**
Boreogadus saida	34
Liparidae	**9**
Liparis bathyarcticus	4
Liparis fabricii	4
Liparis sp.	1
Stichaeidae	**10**
Anisarchus medius	3
Eumesogrammus praecisus	1
Leptoclinus maculatus	2
Lumpenus fabricii	4
Zoarcidae	**46**
Gymnelus hemifasciatus	22
Gymnelus viridis	8
Lycodes mucosus	1
Lycodes sp.	15
PSBTA Fishes Total	**326**

Field identifications suggest that epibenthic invertebrate taxon richness was generally lowest at shallow stations (Figure 10), which were dominated by mobile crustaceans including isopods and amphipods. Highest taxon richness was found between ~50 and 150 m, and taxon richness at deeper stations was intermediate. Depth-related abundance and biomass patterns and spatially explicit community structure will be evaluated once CPUE data have been calculated.

Figure 10. Epibenthic Invertebrate and Demersal Fish Taxon Richness in Relation To Bottom Depth.



3.4 Trophic Structure, Faunal Inventory, and Sediment Biogeochemical Processes

- Dr. Ken Dunton, PI, UT-A Marine Science Institute
- Susan Schonberg, Carolynn Harris, and Christina Bonsell, onboard team

During the ANIMIDA III 2015 cruise, the UT-A component collected samples from water, hand nets, sediment grabs and bottom trawls to assess benthic infaunal inventories and food web structure of the Beaufort Sea shelf (Table 7). Results from these efforts will serve as a baseline to assess the current state of the Beaufort shelf system and future ecological changes resulting from natural and/or anthropogenic sources.

WATER FROM CTD – 20 stations (2 replicates/station)

Replicate water samples were collected from CTD bottles tripped in the chlorophyll maximum and near bottom waters. About 500 ml of seawater were filtered through duplicate non-combusted 25 mm GFF filters then frozen for future HPLC chlorophyll analyses. In addition, 2 liters off seawater were filtered onto a combusted GFF filter, dried and stored for POM stable isotope analyses.

HAND NETS – 19 stations

Phytoplankton and zooplankton nets were deployed to collect pelagic organisms for stable isotope analyses. These samples will be analyzed at the UT-A.

A 20µ phytoplankton net was lowered vertically to near the sea floor then retrieved. The collected sample was poured through a series of 3 sieves the smallest being 63µm mesh. The resulting filtrate was filtered onto two 25 mm combusted GFF filters and dried.

A 335µ zooplankton net was lowered vertically to near the sea floor then retrieved. The sample was poured through a 1mm mesh sieve. The resulting filtrate was filtered onto two 25 mm combusted GFF filters and dried.

Large calanoid copepods, *Calanus hyperboreus*, were occasionally collected in the 1 mm mesh sieve and hand-picked as an additional isotope sample.

SURFACE SEDIMENTS FROM GRABS

Surface sediment chemistry – 20 stations (1 grab/station)

Surface sediments were collected in duplicate from a double van Veen grab for four analyses: chlorophyll a, C:N and TOC, porewater ammonium, and microalgal identification. Chlorophyll a samples were collected using a 20 cc syringe, stored in a pp Falcon tube and frozen. C:N samples were also taken with a 20 cc syringe and dried. Ammonium samples were collected with a 60 cc syringe and frozen. The microalgae sample was collected with a spatula, placed in a 10 ml vial and frozen.

Quantitative Biology – 19 stations (3 grabs/station)

At each station 2 double van Veen grabs were deployed for quantitative analysis and stable isotope collections. One side from the double grab was sampled for surface sediment chemistry and the other side was used for quantitative infauna to assure that the two data types were collected from the same area. The second and third quantitative grabs came from two subsequent deployments of the double van Veen. The grab samples were washed using a slide table with a 1 mm mesh capture box at the base of the slide. Infauna was collected from the table and the screen as the sediment grab was washed then taken inside for sorting under a microscope and bottled in 100% ethanol, which is required for potential DNA analyses.

EPIBENTHIC TRAWL (19 stations/ 446 samples)

A selection of infaunal organisms from van Veen grabs and epifaunal organisms collected by the Bluhm trawling component were prepared for isotope analyses. Sample types included fish, polychaetes, echinoderms, molluscs, crustaceans and other small groups (Table 8). Large organisms were dissected to retrieve muscle tissue and smaller organisms where kept whole. Samples were frozen and shipped to the UT-A for isotope analyses using an EA-IRMS (Elemental Analyzer- Isotope Ratio Mass Spectrometer).

Table 7. Stations Where the UT-A Team Collected and Processed Samples in Summer 2015 for ANIMIDA III.

Station	Type	Latitude	Longitude	DD	MM	YY	Depth m
152-W0	DBO	71.00417	-152.37927	1	8	2015	15.9
152-W1	DBO	71.19385	-152.25312	1	8	2015	38
71-150	Ken Bio	70.94037	-151.03007	2	8	2015	18.2
5A	BSMP	70.49468	-148.76400	2	8	2015	11.8
3A-2	BSMP	70.28238	-147.09002	2	8	2015	6.4
143W-1	DBO	70.25728	-143.60658	3	8	2015	38.8
143W-2a	DBO	70.44248	-143.59570	3	8	2015	48
143W-6	DBO	70.74450	-143.59178	3	8	2015	502
143W-5	DBO	70.62602	-143.59075	3	8	2015	303
143W-4	DBO	70.56907	-143.60012	4	8	2015	154
143W-3a	DBO	70.54817	-143.53765	4	8	2015	103
70-142	Ken Bio	70.46577	-142.40260	4	8	2015	65.5
70-143	Ken Bio	70.36135	-142.85175	5	8	2015	57
70-145	Ken Bio	70.49115	-144.96818	5	8	2015	45.8
71-145	Ken Bio	70.67525	-144.91698	5	8	2015	103
71-146	Ken Bio	70.95688	-145.80058	5	8	2015	395
71-147	Ken Bio	70.97157	-147.38218	6	8	2015	100
71-149	Ken Bio	71.15253	-148.41442	6	8	2015	68.4
149-350*	NOPP Line	71.22360	-149.32690	6	8	2015	331
149-200	NOPP Line	71.21227	-149.34295	6	8	2015	207

*Sediment chemistry only

Table 8. Organisms Collected for Isotope Analyses, Identified to the Lowest Taxonomic Unit.

Species	n	Species	n	Species	n
Acanthostepheia behringiensis	4	Golfingia sp.	1	Parasagitta elegans	4
Alcyonidium disciforme	1	Gorgonocephalus sp.	2	Parathemisto libellula	2
Alcyonidium gelatinosum	3	Gymnelus hemifasciatus	5	Paroediceros lynceus	2
Allantactis parasitica	4	Gymnelus viridis	2	Phyllodoce groenlandica	6
Ampelisca macrocephala	7	Gymnocanthus tricuspis	8	Phyllodoce sp.	2
Ampelisca sp.	1	Heteromastus sp.	1	Pista cristata	3
Anonyx sp.	12	Holothuria	1	Platyhelminthes	1
Argis lar	5	Hyas coarctatus	1	Polycirrus sp.	1
Artediellus scaber	1	Hymenodora glacialis	1	Polymastia sp.	4
Aspidophoroides olrikii	1	Hypariid amphipods	1	Polynoidae	5
Astarte borealis	2	Icelus bicornis	7	Pontaster sp.	1
Astarte montagui	3	Icelus spatula	10	Pontaster tenuispinus	2
Astarte sp.	8	Lafoeina maxima	1	Portlandia arctica	2
Atylus carinatus	1	Lafoeina sp.	1	Praxillella sp.	1
Atylus smitti	2	Leitoscoloplos sp.	1	Priapulus caudatus	2
Bathyarca glacialis	1	Leptasterias groenlandica	6	Pseudosagitta maxima	1
Bathybiaster vexillifer	1	Liocyma fluctuosa	3	Psolus peronii	6
Boreogadus saida	11	Liparis bathyarcticus	1	Pteraster obscurus	4
Boreomysis sp.	2	Liparis fabricii	2	Rhachotropis aculeata	3
Boreotrophon truncatus	1	Lumbrineris sp.	1	Sabinea septemcarinata	10
Brada villosa	2	Lumpenus fabricii	3	Saduria entomon	3
Buccinum elatior	1	Lycodes sp.	2	Saduria sabini	4
Byblis sp.	2	Macoma calcarea	1	Scoletoma sp.	2
Calanus glacialis	9	Macoma sp.	1	Serripes groenlandicus	1
Calanus hyperboreus	6	Maldane sarsi	2	Similipecten greenlandicus	9
Calanus sp.	4	Marenzelleria wireni	4	Siphonodentalium lobatum	2
Ciliatocardium ciliatum	3	Margarites costalis	9	Sipuncula	2
Cistenides sp.	1	Melita dentata	2	Spirontocaris sp.	1
Cnidarian (unidentified)	1	Musculus discors	1	Sponge (unidentified)	1
Colus sabini	5	Mysis litoralis	2	Stegocephalus inflatus	3
Crossaster papposus	7	Mysis sp.	2	Stegophiura nodosa	1
Ctenodiscus crispatus	4	Nemertea	4	Sternaspis fossor	2
Ctenophore	6	Nephtys ciliata	3	Stomphia sp.	3
Cyclocardia crebicostata	1	Nephtys sp.	6	Strongylocentrotus pallidus	3
Diastylis (spinosus?)	1	Nereis zonata	7	Strongylocentrotus sp.	3
Diastylis alaskensis	8	Nicolea zostericola	1	Synidotea bicuspida	3
Diastylis goodsiri	1	Nicomache lumbricalis	1	Tachyrhynchus erosus	1
Diastylis rathkii	3	Nuculana pernula	1	Tachyrhynchus sp.	1
Diastylis scorpioides	1	Nuculana radiata	3	Terebellides sp.	2
Eualus gaimardii	9	Nuculana sp.	5	Themisto abyssorum	1
Eualus gaimardii belcheri	2	Ocnus glacialis	3	Themisto libellula	1
Eucratea loricata	1	Onisimus litoralis	1	Thysanoessa raschii	1
Eusirus holmi	1	Ophiacantha bidentata	10	Thysanoessa sp.	1
Euspira pallida	1	Ophiocten sericeum	11	Triglops nybelini	1
Filamentous material	6	Ophiura (robusta?)	2	Triglops pingelii	7
Florometra sp.	7	Ophiura sarsii	1	Tubularia sp.	1
Flustra sp.	1	Pagurus sp.	2	Urasterias lincki	1
Gersemia (voucher species 2)	3	Pagurus trigonocheirus	1	Weyprechtia pinguis	1
Gersemia rubiformis	2	Paradiopatra striata	1	**Grand Total**	**446**
Golfingia margaritacea	1	Paraeuchaeta glacialis	3		

3.5 Hydrocarbon Chemistry

- Mr. Greg Durrell, PI, Battelle
- Scott Libby and Patrick Curran, onboard team
- (John Hardin fearless field leader in abstentia)

Hydrocarbons are relevant indicator chemicals for establishing baseline environmental conditions relative to the oil and gas industry. These organic compounds have natural and anthropogenic sources in the Beaufort Sea, and it is important to understand baseline concentrations and possible sources. Aromatic and aliphatic hydrocarbons are routinely used for assessment of anthropogenic inputs to the Arctic and can provide a temporal record of changes (Macdonald et al. 2005). Other sources exist, however, and as such, we are analyzing an expanded set of alkanes, polycyclic aromatic hydrocarbons (PAH), and petroleum biomarkers. This extensive set of hydrocarbons will allow for a measure of terrestrial versus marine derived vs anthropogenic organic carbon in sediments. In work from the Chukchi and Beaufort Seas, sediments show pronounced odd carbon (e.g., C25, C27) predominance that is characteristic of terrestrial plants (Belicka et al. 2004), and also unique relative concentrations of specific petroleum biomarkers and PAH.

Distributions of n-alkanes in the nearshore and offshore Beaufort Sea environments can be useful for comparing contaminant inputs delivered from the terrestrial system, and other sources. PAHs and chemical biomarkers (steranes and triterpanes; S/T) will also be used to more specifically determine the characteristics of the hydrocarbons, and to understand their sources and fate. Certain types of PAHs found in oil have known toxic effects on some marine organisms (NRC 2003a, b). Toxicity is dependent upon the concentration and duration of exposure to the specific bioavailable PAHs. In general terms, toxicity may be acute (i.e., from an acute spill event) or sub-lethal (e.g., additional impacts following an acute spill or chronic long-term exposure). No evidence of toxic levels of organic substances have been found to date in the ANIMIDA study area (Neff et. al. 2009); therefore, this work does, at this time, not include any sediment toxicity studies and such would only be considered if contaminated sediments are discovered (i.e., above relatively uniform background conditions). However, sediment contaminant concentrations will be compared to reference effects values to assess the potential for ecological impact.

A total of 20 surface sediment (0-1cm) samples were collected for analysis from a double van Veen grab at 20 stations (Table 9). An additional four stations were sampled by Ken Dunton prior to the survey and are included in Table 9. These samples will be analyzed for an extensive suite of petroleum hydrocarbons including 54 PAHs, a set of base saturated hydrocarbons (SHC), and a series of chemical biomarkers. Additional sediment samples were collected at 20 stations from the van Veen grabs for analysis of *Alexandrium* cysts by WHOI scientist Don Anderson (Table 9). Sediment gravity cores were obtained for analysis at 5 stations (Table 9), for potential hydrocarbon analysis. The lengths of the sediment cores varied, but samples potentially to be analyzed (depending on the core dating and other characterization results) for hydrocarbons were only collected from the top 20-cm of each core as noted in Table 9. The cores were sub-sectioned aboard ship in 2-cm thick layers down to 20 cm, which resulted in a total 50 samples. The top segment from two of the sediment cores (from 143-W6 and 71-147A) was selected for chemical analysis along with the surface sediment samples, as those represented the surface sediments at locations intended for analysis but where van Veen grabs were not collected. Additionally, two peat samples collected during the spring sampling event were submitted for hydrocarbon analysis, as indicators of a potential source of hydrocarbons.

A variety biota samples were collected throughout the study area via van Veen grab, beam trawl, plankton net, clam dredge, and amphipod traps. Of the different biota that were sampled, a set of seven amphipod samples, eight clam samples (including one field duplicate), and six arctic cod samples were selected for hydrocarbon analyses (Table 9). In addition, 10 of the amphipod and clam samples that had sufficient biomass were submitted for methylmercury analysis. These biota samples were collected over a wide distribution of stations in the survey area.

References:

Belicka, L.L., Macdonald, R.W., Yunker, M.B., and Harvey, H.R. 2004. The role of depositional regime on carbon transport and preservation in Arctic Ocean sediments. Marine Chemistry 86, 65–88.Belicka et al. 2004

Macdonald, R.W., T. Harner, and J. Fyfe. 2005. Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. Sci. Tot. Environ. 342:5-86.

Neff JM, Trefry JH, Durell GS. 2009. cANIMIDA Task 5. Integrated biomonitoring and bioaccumulation of contaminants in biota of the cANIMIDA study area, OCS Study MMS 2009-037. U.S. Department of Interior, Anchorage.

NRC (National Research Council). 2003a. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. National Academy Press, Washington, DC. 304 pp.

NRC (National Research Council). 2003b. Oil in the Sea III. Inputs, Fates, and Effects. National Academy Press, Washington, DC. 265 pp.

Table 9. Summary Of Samples Collected in the Beaufort Sea for Hydrocarbon Analysis. Zeros Indicate That Sampling Was Done, But No Sample Was Obtained.

Date	Station	Sediment	Amphipod	Clam	Sediment Core	Arctic Cod	*Alexandrium*
26-Jul-2015	L08[a]	1					
26-Jul-2015	4A [a]	1					
27-Jul-2015	4B [a]	1					
27-Jul-2015	BP01 [a]	1					
1-Aug-2015	152W0	1	1	0			1
1-Aug-2015	152W1	1	1	1			1
1-Aug-2015	71-150	1		0			1
2-Aug-2015	5A	1	0	0			1
2-Aug-2015	N06	1					1
2-Aug-2015	N03	1					1
2-Aug-2015	3A	1	0	2[d]			1
3-Aug-2015	143W-1	1	1	2[e]			1
3-Aug-2015	143W-2	1	0	0			1
3-Aug-2015	143W-6	0[b]			10		0
3-Aug-2015	143W-5	1			10	1	1
4-Aug-2015	143W-4	1				1	1
4-Aug-2015	143W-3	0 [b]					0
4-Aug-2015	70-142	1	0	1			1
4-Aug-2015	70-143	1	1	0			1
5-Aug-2015	70-145	1	2 [d]	0		1	1
5-Aug-2015	71-145	1		1			1
5-Aug-2015	71-146	1			10	1	1
5-Aug-2015	71-147A[c]				10		
6-Aug-2015	71-147	1		1		1	1
6-Aug-2015	71-149	1	1	0			1
6-Aug-2015	149-350	1			10		1
6-Aug-2015	149-200	1				1	1
Total	**27**	**24**	**7**	**8**	**50**	**6**	**20**

[a] Sampled by Ken Dunton

[b] Van Veen not successful, surface sediment from the core collected at 143-W6 was used for hydrocarbon analysis.

[c] Only collected a gravity core at this station, surface sediment from the core collected at 71-147A was used for hydrocarbon analysis.

[d] Replicate samples collected

[e] Two different species of *Astarte* (*A. borealis* and *A. crenata*) collected as separate samples

3.6 Kaktovik Outreach Report

The annual Kaktovik Summer Oceanography Program was taught at the Kaktovik Community Center in Kaktovik, AK from 10-15 August 2015. The University of Texas Marine Science Institute (UTMSI), the U.S. Fish and Wildlife Service (USFWS), and OF sponsored the camp. Cliff Strain, an ocean sciences middle school teacher from Port Aransas, TX served as the lead instructor. Professor Ken Dunton, UTMSI graduate student Carolynn Harris, and Greta Burkart, an Aquatic Ecologist from USFWS, coordinated the program. They were assisted by several other instructors, William Daniels (Brown-MBL grad student), Allyssa Morris (ANWR Outreach Coordinator), Christina Bonsell (UTMSI grad student), and Levi Simmons (undergraduate volunteer from Toolik Field Station).

Students
Doe Doe Sittichinli
JD Tikluk
Kim Burns
Maddy Gordon
Melanie Tikluk
Thea Lampe
Tracy Burns
Wayne Akootchook

Our program theme was "Life as an Oceanographer". We hoped to give students first-hand experiences of how an oceanographer might spend their days as well as teach them basic oceanographic techniques. Our goal was to demystify a career in science and show students that it is a viable career path for them. We took advantage of our unique location on an Arctic barrier island and used Kaktovik lagoon as a natural classroom. We focused our program on upper middle school and high school level students. As we discovered in 2014, it is difficult to engage this age range because many of them work jobs during the summer or wanted to enjoy their last few days of vacation before the start of the school year. As an attendance incentive, all students who attended the camp at least 3 days were entered into a drawing to win a handheld Etrex GPS (which the students learned to use during the week). On average, 5 students attended the camp each day and 4 were eligible to enter the GPS drawing. Eight students in our target age range (12+) attended the program for at least one day.

	Main Activities
Monday	Biology + Chemistry Day – fieldwork at lagoon; aquarium set up, lab tests and discussion in classroom
Tuesday	Geology Day – coring at lagoon, core descriptions Eider group guest lesson
Wednesday	Comparison Day – field work on ocean side of lagoon Bluff erosion survey
Thursday (afternoon only)	Ground water guest lesson, Lagoon vs. ocean comparison discussion
Friday (afternoon only)	Fish-printing on program t-shirts
Saturday	Culture Day – taste testing and spoon craft

4.0 Field Documentation / Data Management

Sample collection in the field was documented using station logs, field forms and/or field notes, depending on the particular discipline. Station coordinates, water depth, and other pertinent information was logged at each location. All samples were held and transferred under custody at all times.

Data management on this multi-faceted program is extremely important and the standard of care exercised for the COMIDA-CAB and Hanna Shoal projects was followed here. The data management program provides persistent and sustainable information which will be (once processed and finalized) readily accessible to the target audience and features a GIS-enabled project database. Data management on this project will be handled in three phases: collection, analysis, and reporting (to NODC), ostensibly the collection and analyses phases are most relevant to this document. In the collection phase, datasets will be authored by individual co-PIs as Excel files. In the analysis phase, observations will be integrated geographically using ArcGIS in a similar manner to that used by Dunton et al. (2005) for historical surveys of the Chukchi Sea.

During the data analysis phase, the observational data and interpolations of their values over the domain of interest will be generated using ESRI's ArcMap and its geostatistical capabilities. A digital base map of the Alaskan Beaufort Sea with shelf bathymetry was created for this project at UTMSI. The basemap includes sample sites of previous station locations in the study area and a tessellated grid created for ANIMIDA III sample sites. We will use GIS software to manage, analyze, and display spatially referenced point samples, and interpolate surfaces for data types collected on this project.

Data archiving at NODC for the proposed project will follow a similar procedure as that of the COMIDA-CAB project. Data will be submitted to NODC (or any site selected by BOEM) for data repository on a yearly basis as part of the annual report. Each year's report to BOEM will contain a description of field and lab methods, results, discussion and comparisons to other findings in the literature or from concurrent projects. Co-PIs will be given a set of standards for reporting that follow Digital Geospatial Metadata (CSDGM), Vers. 2 format for date, latitude, longitude, datum, etc. Each Co-PI will be responsible for submitting a chapter of the annual report which will be compiled under the direction of the project coordinator.

A project website has been developed for PIs to share results with each other, with other scientists, with regulators, and with stakeholders. The website will be linked to a password-protected data management system for project members to securely share preliminary results, while final results will be made publicly available both on the website and via the NODC archives. The project website will be used for sharing geographic data and mapping support will be provided via a project geodatabase. Project website is at:
http://www.arcticstudies.org/animida_iii/index.html

5.0 Quality Assurance/Quality Control

A rigorous QA/QC program was implemented. For example, SOPs were followed, field documentation was completed, instruments were properly calibrated, and QC samples were collected in the field (and will be included with relevant sample analysis in the laboratory) to demonstrate accuracy, precision, representativeness, and, where applicable (i.e., chemical analysis) to ensure there is no field or laboratory-based sample contamination.

6.0 Permit Information

The following permits (Table 10) were obtained by OF or other team members to conduct the ANIMIDA sampling program in 2015. Deliverables required by each permit were addressed by OF.

Table 10. Summary Of Permits Obtained for the 2015 ANIMIDA Field Sampling Program.

Permit Name	Date Submitted and/or Signed	Reason for Permit
North Slope Borough Land Use Permit	Submitted: 6/10/15 Approved: 6/16/15	Authorization from North Slope Borough to conduct research/sampling in the nearshore area of the Beaufort Coastal Area (Permit No. 15-819).
National Marine Fisheries Services (NMFS) Letter of Acknowledgement (LOA)	Submitted: 6/10/15 Approved: 6/16/15	Acknowledgement that certain activities on a research vessel (the NII in this case) that are defined as fishing but are scientific in nature, are exempted from broader requirements under the Magnuson-Stevens Act. (LOA: 2015-05).
AK Fish & Game Fish Resources Permit	Submitted: 6/10/15 Approved: 6/17/15	Permit authorizing sample collection of fishes and other organisms in the Beaufort Sea for scientific purposes. Anticipated species list provided by Bluhm's group at UAF (Permit No. CF-15-113).
IACUC Permit	Submitted: 6/2/14, Approved: 6/10/14	Institutional Animal Care and Use Committee permit authorizing laboratory facility to conduct research using animals based on animal welfare/ethical treatment (601331-2).

APPENDIX A – DAILY FIELD REPORTS FROM THE NORSEMAN II