Arctic Integrated Ecosystem Survey
Cruise Report to the Arctic Integrated Research Program

August 1 to October 3, 2019

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Photo by Brendan Smith.

Introduction:

The Arctic Integrated Ecosystem Survey (Arctic IES) is funded as part of the North Pacific Research Board's (NPRB's) Arctic Integrated Ecosystem Research Program (IERP; http://www.nprb.org/arctic-program/). Funding for the program is provided by NPRB, the Bureau of Ocean Energy Management (BOEM), the Collaborative Alaskan Arctic Studies Program (formerly the North Slope Borough/Shell Baseline Studies Program), and the Office of Naval Research Marine Mammals and Biology Program. Generous in-kind support for the program has been contributed by the National Oceanic and Atmospheric Administration (NOAA) Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory, the University of Alaska Fairbanks, the U.S. Fish & Wildlife Service, and the National Science Foundation. Research on this expedition was sponsored by NPRB and BOEM. In-kind support for this research cruise is contributed by NOAA.

Our objective is to understand how reductions in Arctic sea ice and the associated changes in the physical environment influence the flow of energy through the ecosystems of the Chukchi and Beaufort seas. Two research expeditions in the Beaufort and Chukchi seas during late summer and early fall 2017 and 2019 were designed to address our objective. Our survey takes measurements of the: 1) physical environment (temperature, salinity, nutrients); 2) seasonal composition, distribution and production of phytoplankton (plants); 3) distribution and standing stocks of zooplankton (bird, whale, and fish food); 4) assemblages, distributions, abundances, size, diet, and fitness of larval, early juvenile, and adult fishes; and 5) distribution and relative abundances of seabirds and marine mammals.

These Arctic IES measurements are designed to quantify the physical and chemical environments; water mass, heat, salt, and nutrients; phytoplankton communities and growth rates; the composition, abundance, biomass, and energy content of zooplankton and benthic (ocean floor), pelagic (mid water) and surface fishes, and the composition and relative abundance of seabirds and marine mammals. Year-round biophysical moorings provide temporal context of these measurements as well as fish movement and marine mammal calls.

This year's survey was notable for a number of reasons. First, there was no sea ice within our survey region from 72.5N in the Chukchi Sea, into the nearshore regions of the Beaufort Sea and south to the Bering Strait. Ice was present in the northern regions of our survey area during previous surveys that occurred in 2012 and 2013. Second, sea surface temperatures were warmer than previous years ranging from 5.3°C (42°F) to 10.9°C (52°F). Coldest sea surface temperatures were found at the offshore Chukchi Slope stations with the warmest found inshore between Icy Cape and Ledyard Bay. Third, zooplankton abundances were very low this year compared to previous years. Fourth, the acoustic backscatter for age 0 Arctic cod indicated fewer fish in this region when compared to 2017. We captured large numbers of Arctic sand lance within each of the midwater tows which constituted a significant percentage of the catch in the western portion of the survey area. Arctic sand lance were not found in large numbers during 2017 and were typically only caught south of Cape Lisburne. Of note were the large numbers of age 0 walleye Pollock caught on the 70.25N transect. Age-0 walleye pollock (mean length 61 mm) were the most abundant fish within the trawl samples, with a small number of Saffron and Pacific cod in the catch. We did not catch large numbers of age 0 walleye Pollock in the midwater north of Kotzebue Sound during 2017. Fifth, we recorded 30 dead birds, all in the Chukchi Sea. The majority were alcids (n = 11), followed by six shearwaters, two sandpipers (*Scolopocidae spp*.), one kittiwake, and nine unidentified birds. Most of the dead birds were encountered south of Point Hope and offshore of Point Lay.

Daily radio calls at 6:00, 12:00, and 18:00 on channel 16 were done to update and inform nearby listeners on the status of the survey operations. Daily emails that displayed our progress and planned operations for the day were sent each morning to a distribution list.

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PARTICIPATING INSTITUTIONS

AFSC – Alaska Fisheries Science Center, Seattle, WA and Juneau, AK

PMEL – Pacific Marine Environmental Laboratory, Seattle, WA

USFWS – US Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK

UAF – University of Alaska Fairbanks, Juneau, AK

NPRB – North Pacific Research Board, Anchorage, AK

BOEM – Bureau of Ocean and Energy Management, Anchorage, AK

OA – Ocean Associates (contract agency for AFSC)

OSU – Oregon State University, Corvallis, OR

NC – North Carolina State University, Raleigh, NC

JISAO – Joint Institute for the Study of the Atmosphere and Ocean, Seattle, WA

NRC – National Research Council

TINRO – Russia's marine research center in Vladivostok

VNIRO – Russia's marine research center in Moscow

UW – University of Washington, Seattle, WA

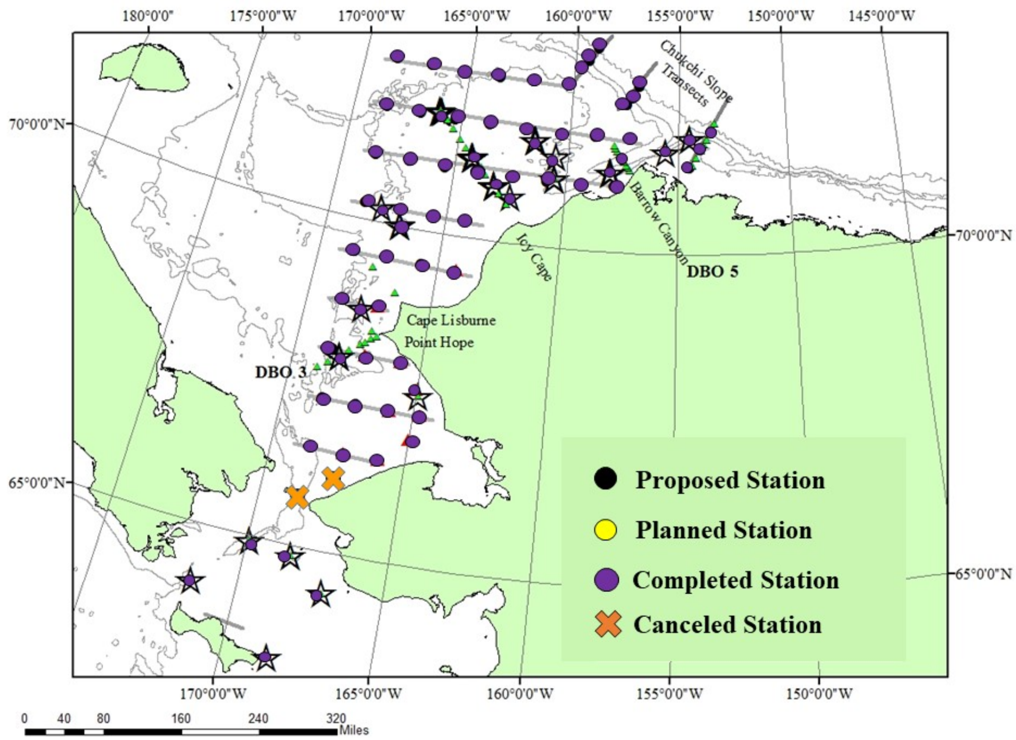
BLOS – Bigelow Laboratory for Ocean Sciences, Boothbay, ME

SCIENCE PARTY CRUISE PERSONNEL

(Last, First)	Title	Date Aboard	Date Disembark	Affiliation
Leg 1				
Ryan McCabe	Chief Scientist	8/1	8/24	JISAO/UW
Pete Shipton	Mooring Tech	8/1	8/24	UAF
Jordi Maisch	Mooring Tech	8/1	8/24	UAF
Lisa Eisner	Phytoplankton	8/1	8/24	AFSC
Haley Cynar	Underway	8/1	8/24	OSU
Catherine Berchok	Oceanographer	8/1	8/24	AFSC
Libby Logerwell	Zooplankton	8/1	8/24	AFSC
Sarah Donohoe	Ocean Mooring	8/1	8/24	PMEL
David Strausz	Oceanographer	8/1	8/24	PMEL
Brendan Smith	outreach	8/1	8/24	NPRB
Marty Reedy	Seabird Observer	8/1	8/24	USFWS
Heather Crowley	physical Oceanographer	8/1	8/24	BOEM
Anna Mounsey	HABs	8/1	8/24	Warren-West
Leg 2				
Ed Farley	Chief Scientist	8/24	9/14	AFSC
Robert Levine	Acoustician	8/24	9/14	AFSC
Alex Andrews	Fish Bio (CLAMS)	8/24	9/14	AFSC
Natalia Kuznetsova	International Specialist	8/24	9/14	TINRO
Sarah Donohoe	Oceanographer	8/24	9/14	PMEL
Dave Kimmel	Oceanographer / Zoo	8/24	9/14	AFSC
Jens Nielsen	Phytoplankton	8/24	9/14	NRC
Libby Logerwell	Beam Trawl	8/24	9/14	AFSC
Miranda Irby (Schnetzer)	Phytoplankton	8/24	9/14	NC State
Marty Reedy	Seabird Observer	8/24	9/14	USFWS
Igor Grigorov	International Specialist	8/24	9/14	VNIRO
Matt Baker	Fish Bio	8/24	9/14	NPRB
Anna Mounsey	HABS	8/24	9/14	Warren-West
Dan Cooper	Zooplankton	8/24	9/14	AFSC
Jared Weems	Special projects	8/24	9/14	UAF
Leg 3				
Kristin Cieciel	Chief Scientist	9/14	10/3	AFSC/ABL

Robert Levine	Acoustician	9/14	10/3	UW
Todd Miller	Energetics	9/14	10/3	AFSC
Dan Cooper	Beam Trawl	9/14	10/3	AFSC
David Strausz	Oceanographer	9/14	10/3	PMEL
Natalia Kuznetsova	International Specialist	9/14	10/3	TINRO
Mike Lomas	Phytoplankton	9/14	10/3	BLOS
Adam Spear	Zooplankton	9/14	10/3	AFSC
Esther Goldstein	Oceanographer/Zoo	9/14	10/3	AFSC
Charlie Wright	Seabird Observer	9/14	10/3	USFWS
Igor Grigorov	International Specialist	9/14	10/3	VNIRO
Zane Chapman	Student	9/14	10/3	UAF
Linnaea Wright	Seabird Observer	9/14	10/3	USFWS
Andrew Dimond	CLAMS Bio	9/14	10/3	AFSC
Miranda Irby (Schnetzer)	Phytoplankton	9/14	10/3	contractor

R/V OCEAN STARR ARCTIC IES PHASE II CRUISE TRACK & STATION LOCATIONS



Research survey stations (purple dots), moorings (stars), oceanographic transects (green diamonds), and acoustic transects (grey lines) for the August 1 to October 4, 2019 Arctic Integrated Ecosystem Survey (Arctic IES) on board the Research Vessel, **OCEAN STARR**. Two stations were canceled (orange cross) due to weather.

CRUISE NARRATIVE

19 July-22 July
Gear trials occurred in Seattle over 3.5 days. All gear and operations were given a dry run.

Leg 1 (08/01/2019-08/24/2019) (Ryan McCabe)


Captain Pete Hall on the R/V OCEAN STARR. Photo by Brendan Smith.

1 August
We pushed off the OSI dock in Dutch Harbor, Alaska, at 3:15 local time. The weather was great. Some fog arrived soon after we left, but eventually burned off. A storm is expected to arrive in a couple of days so we took the opportunity with favorable weather to test the Conductivity Temperature at Depth (CTD) and Bongo (zooplankton collection device) operations. Testing began at 4:05 pm at 53 55.2 N, 166 36.1 W. One of the oxygen sensors on the CTD provided poor data, so we will need to evaluate it. Testing of the Bongo went well. During the Bongo test, a bald eagle caught a fish near the ship and there were a few whale flukes spotted on the horizon. We also re-evaluated the Acrobat after installing a new electronics package on it. It is not reporting as expected, so we will continue to investigate why. At 5:50 pm, we finished testing operations and began steaming toward the Bering Sea 2 (BS2) mooring site, averaging 8-9 knots.

2 August
We are continuing to steam north to the BS2 mooring site. We are experiencing foggy conditions, and the seas picked up considerably today. The captain diverted off our course to the northeast a bit so that we would not be in the trough as much. Everyone is hoping that seas will calm somewhat tomorrow for our first mooring deployment. We had an all-hands science meeting today just to update everyone and to identify which team members could help with the various operations we will be conducting.

3 August
We arrived at the BS2 mooring site with reasonably good conditions. As we were preparing for a CTD cast, the wind and seas picked up considerably. We elected to cancel the CTD and instead proceed with the mooring deployment. However, the captain called to postpone that operation as well after some 35-knot wind gusts. We decided to stay on site for a couple of hours in hopes that the winds would drop. As we were discussing our options for how to proceed the captain said we were clear to attempt the deployment. After deploying the mooring, we then headed north to the next mooring site, BS1.

4 August
A science party member is severely sea sick and very dehydrated, so we are transiting to Nome. We spent much of the night and day steaming into the wind. As we got closer to the Nome, the winds and seas both calmed a bit. We expect to arrive in Nome in the afternoon of Monday, 5-August.

5 August
We continued steaming to Nome today and arrived around 2:30pm. Libby escorted our sick science team member to the medical center where they were given a clean bill of health with the ability to fly out of Nome as early as tomorrow. Great news! Libby returned to the ship after escorting the team member to a local hotel for the evening. While Libby was gone, we took advantage of our dock time and lack of rolling to shuffle items around on the ship and get some mooring anchors out of the hold. Lisa set up her incubators (used to understand how quickly plants (phytoplankton) grow in the Arctic). Most of us also got a chance to make quick phone calls to friends and loved ones, and Haley got to pet a very cute golden retriever pup while at the dock. We left Nome around 6:45 pm under mostly clear and sunny skies. The sun set at 11:57 pm today and Chris (the second mate), Marty, and Ryan, witnessed one of the most amazing green flashes from the bridge. It was more of a slow burn than a flash per se, and will very likely end up being the best one any of us will see again. What a beautiful evening! Our destination is the N1 mooring site on the eastern side of St. Lawrence Island. We should arrive there around daybreak.

6 August

Today was quite busy, we finally got our first CTD at the N1 mooring site, which meant that many people had some samples to process and analyze. Lisa conducted the first primary production experiment (phytoplankton growth rate) along with chlorophyll sampling (total and size fractionated), phytoplankton taxa from the Flowcam (imaging microscope), particulate organic phosphate, phytoplankton fatty acids, and flow cytometery. And that was just Lisa's group. We also collected oxygen, nutrient, and salt samples to help calibrate our electronic sensors. One CTD bottle didn't trip properly and the spring inside the bottle was missing upon recovery. We got that repaired quickly and then held a mooring recovery/deployment practice session with a float, some chain, and a makeshift lightweight anchor. After that, we met for a pre-recovery meeting and then finally set up to recover the N1 mooring. After the release command was sent, no one spotted the surface buoy. After a second attempt and some searching, I spotted what I thought might be the buoy in the distance. That buoy ended up being an emaciated walrus that was bloated and floating very high on the water surface. We considered collecting a sample from the animal, but its emaciated state was too advanced. We then proceeded back to the N1 mooring. After a few more tries at releasing the mooring without any luck, we gave in to the fact that we would need to drag for it. We hooked the mooring on our first attempt and moved it 100 feet, but it somehow escaped our drag gear. On the second drag attempt the mooring was snagged and the release ended up separating from the anchor just as we were pulling it to the ship. This meant that we did not have to worry with the anchor and a more dangerous situation. All of the instrumentation was recovered. The release ended up with a scrape from the grappling hook, but it was not bad at all. All in all a successful day. As we transited west toward the N2 mooring site, Marty spotted a dead seabird. Chris quickly turned the ship around and Catherine and Sarah were able to catch the bird in a hand net. It was a black-legged kittiwake. Marty put it in the freezer so that it could be analyzed later to determine what may have caused its death.

David Strausz running the winch during a mooring drag operation. Photo by Brendan Smith.

7 August

We woke up early at the N2 mooring location for a CTD with a 3.5-knot current pushing us northeast. During the CTD cast, the wire was tending off the ship quite a bit and strumming in the current. We then had a pre mooring recovery meeting on the bridge and set up for recovery. Acoustic ranging indicated that mooring was still at its deployment location, so we released it. The buoys quickly surfaced. During the recovery, the ADCP float started tending around the stern, which delayed things a bit as our team sorted it out. Regardless, all of the instruments were on the deck within 40 minutes of releasing. We then quickly turned northeast toward the N4 mooring site. Once there we took a CTD cast at that location and, despite some thick fog, quickly recovered the N4 mooring. We then took advantage of the relatively calm seas to reorganize some of our equipment. Pete, Catherine, and I discovered that we could fit a 30" steel float through the passageways on the O1 deck, meaning that we can place them on the bow of the ship. Most people would not appreciate the gravity of that discovery, but we have an enormous amount of equipment on this cruise and if things go well we will be recovering more than we are deploying, so space is at a premium. We are more than excited about the clear space for the floats! Calculations indicate that 1.5 hours could be saved by moving to the N3 mooring site overnight instead of the NM1 site. So tomorrow we will attempt to recover the N3 mooring before heading to Nome to pick up our new boson.

Peter Shipton, mooring lead, during a mooring recovery operation. Photo by Brendan Smith.

8 August

Another early morning start, but this time at the N3 mooring location off Nome. After a CTD we deployed the transponder and ranged on the mooring a few times. The release sent back seven beeps, indicating that, instead of standing upright, it was tilted or laying on its side. The current at the time was approximately 1 knot. Additional transmissions gave the same result. Pete called Seth to ask how he would like us to proceed. Seth decided to be conservative and leave the mooring, anticipating that divers could potentially help retrieve it safely since it was only in 30 m of water. We disabled the release, conducted an additional CTD cast for some more water samples and then began steaming to Nome to pick up the new boson. After the boson, John, boarded the ship, we quickly got him in the crane to help us move a few buoys and recovered instruments into the hold. After a bit more rearranging, we had a fire drill and then untied from the dock to head to the NM1 mooring site.

Lisa Eisner preparing to filter water from the CTD for chlorophyll. Photo by Brendan Smith.

9 August

With John on the crane we quickly turned around Catherine's NM1 moorings this morning at first light and then took a CTD cast. Lisa used water from the CTD bottles to set up another primary production experiment and members of the other groups collected their respective samples. The remainder of the day boiled down to a very long steam north, through Bering Strait and finally into the Chukchi Sea. Most of us kept ourselves busy during the transit by completing important tasks, such as changing out an oxygen sensor on the CTD. While steaming northeast toward the N5 mooring site, Marty spotted another dead seabird and Austin was able to retrieve it after the Captain turned the ship around. Not long after Marty nabbed another. And then another! Marty was three for three today on deceased seabirds (a common murre, and two short-tailed shearwaters) and so is now four of four on the cruise thus far. We should be at N5 in the morning to retrieve the mooring there and will then try to get to the CK-12 site for two recoveries and a deployment. Fingers crossed. Today was also Chris's birthday (our second mate). But that is not all. Chris crossed the Arctic Circle for the first time on his birthday! In addition, because of our northward transit, Chris's Arctic birthday is also a day without a sunset! Happy Arctic birthday, Chris.

Christopher Wahlers at the helm of the R/V OCEAN STARR. Photo by Brendan Smith.

10 August

Our morning started with a CTD for moored sensor calibration. We were surprised at the difference in the amount of daylight at 6am compared to latitudes in the northern Bering Sea near Nome. After a pre mooring recovery meeting we set up and ranged on the mooring. Pete then sent the command to release the mooring. It did not surface. Another release attempt also failed. We set up the deck to drag and got four new range estimates at different locations around the mooring in order to triangulate its position. Chief Mate Terry then began circling the ship around the mooring site as the mooring team deployed the grappling gear and wire. Just after completing the circle and hauling back on the dragging wire, the buoy appeared at the surface. We then hauled in the remaining wire and recovered the N5 mooring. A second CTD was completed to get water samples for a primary production experiment. We then got underway toward the CK-12 mooring site on the Distributed Biological Observatory (DBO) 3 line in hopes of being able to recover the two moorings there and replace them with a single combined mooring before the end of the work day. Those hopes eventually came true. We recovered Catherine's PH-1 mooring first and then the CK-12 mooring without any issues. It took a few minutes to clear the deck and set up the CK-12 replacement combination mooring, but the deployment went smoothly. All of this was done with humpback whales breaching in the distance, which naturally made for a very enjoyable day. The team then took a break for dinner and afterward got busy scrubbing and power washing the retrieved equipment. Brendan tried flying his drone for some interesting video footage. Marty observed a few dead seabirds today, but only had the chance to catch two of them (a crested auklet and a shearwater), one of which he then released (the shearwater) because it was too desiccated for analysis. A report from colleagues aboard the Healy suggested Alexandrium cells were in the water a bit farther offshore than we were near the DBO3 line. We took the opportunity of a relatively short transit to the N6 mooring site, to steam along the DBO3 Line for seabird observing. Unfortunately, not many were seen on the shoreward half of DBO3, but the numbers started picking up again just north of the point. At 12:25 am, Marty, Chris, and Ryan got to enjoy a second green flash. Of the two we have seen so far on this trip, Marty ranks them as first and third best in his lifetime. This one was third. The other green flash a few days ago was the best.

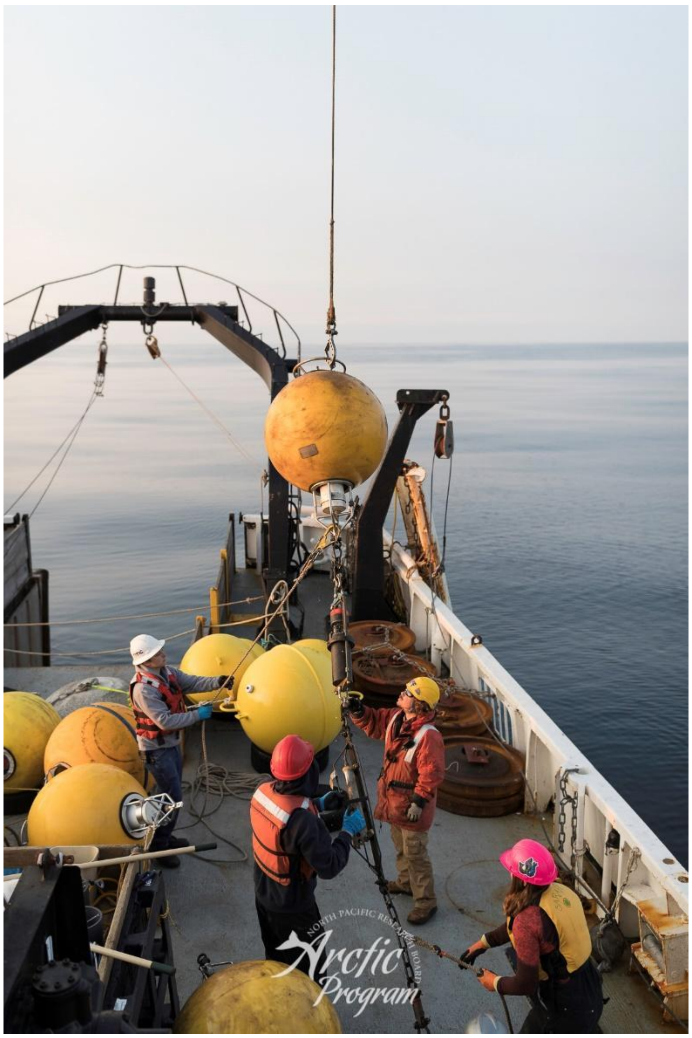
11 August

As usual, the CTD was first at the N6 location. We then moved to recover the N6 mooring. Pete got no response from the release, even after multiple range attempts. Two white floats were nearby the deployment site, so we moved over to inspect them thinking that someone may have inadvertently hooked the mooring and then left the surface markers as a warning. The line connecting them was not attached to anything, and had quite a bit of biological growth in it. From there we moved to ranging from 1 mile away, but got no definitive response. We also tried a point from 2 miles away in the direction of the most return noise, but again got no response. Oceanographers hate leaving gear and data behind, so from there we set up to drag blindly for the mooring, hoping that, at worst, the acoustic release was covered in mud. We set up a 200 m radius circle around the mooring deployment location to help guide the ship and then set the grapple and started our snare. We ended up with two failed attempts and never felt any solid tension on the drag cable. The schedule forced us to carry on, but at least we had time to give it a college try. Hopefully another ship can visit the site at some point to see if they can find the lost mooring. While we were fussing with trying to locate the N6 mooring, Brendan was getting some slick footage with his drone. Not long after leaving the N6 location in route to the CL location we came across a second deceased walrus carcass. While transiting, some science party members played a few rounds of cards in the galley. Others were busy preparing instrumentation that will be deployed in a few days. Once at the CL site we took a CTD cast and then quickly deployed Catherine’s mooring. During the night we will arrive at the CK-10 mooring site, where we will start first thing in the morning.

12 August

Once again we started with a CTD cast and quickly recovered the CK-10 mooring. We steamed southeast for approximately 2 hours to the C-11 site. Once there we collected water for a primary production experiment and then set up to release the two mooring. Both recoveries went very quickly without any problems. We then left the C-11 site steaming northeast toward the outermost point on the Icy Cape transect and our suite of CK-03 moorings. The transit proved valuable again. The mooring team cleaned the recovered equipment and then we installed two Acoustic Doppler Current Profilers (ADCP) in the two recovered buoys so that we can redeploy them on the Icy

Cape line. We also shuffled more gear and Austin and John helped up get the Acrobat (a towed oceanographic sampling device) wire and block down from the A-frame. We will not be using the Acrobat on this leg and the cable has often been in the way.
During transit there was also much discussion about the weather forecast. We have been monitoring it the last few days because a system with high winds was due to arrive around midway through the Icy Cape transect. Today's updated forecast suggests that it may die down a bit. We are also optimistic that the nice weather will continue. In an otherwise unremarkable day of sea bird observing, Marty spotted a pair of Kittlitz's murrelets east of Wainwright.


Austin, Pete, Jorie, and Sarah recovering an ice profiler mooring. Photo by Brendan Smith.

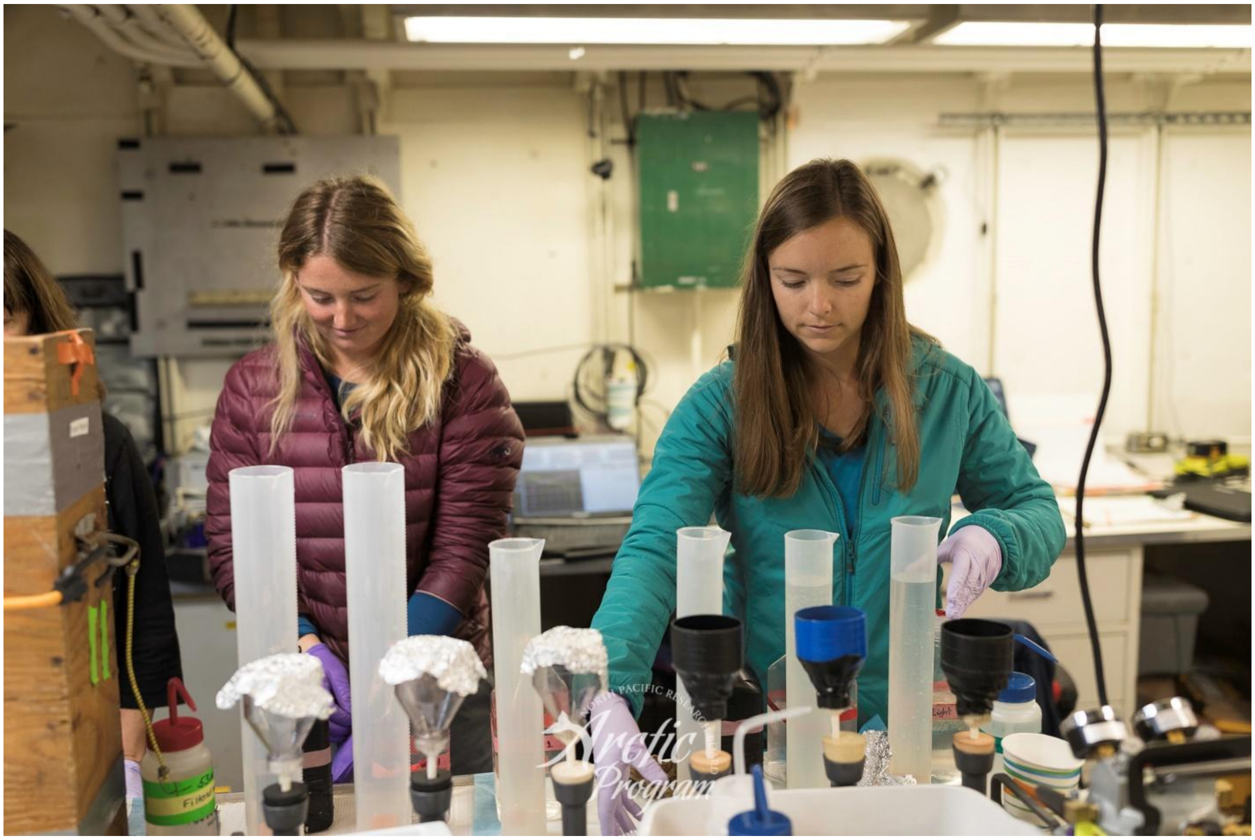
13 August
We began today at the CK-03 site where we took a CTD and then began recovering moorings. The moorings included Catherine's marine mammal mooring, an ADCP mooring, and an ice profiler mooring. We then redeployed the marine mammal mooring and the ADCP mooring. All recoveries and deployments were done within two hours without any issues. We then began

marching down the Icy Cape transect with CTD casts and Bongo net tows (our first so far for the cruise) at every other station. Libby managed to catch a small sculpin the Bongo net. Seabird observations were lackluster today, but we did happen across two different walrus along the Icy Cape line. In the late afternoon the Captain and crew graciously worked extra time to help us pick up our five moorings at the CK-02 location. The mooring team was extremely appreciative. This will set us up well for the coming days.

Libby, Sarah, Jordie, and Catherine recovering the Bongo net. Photo by Brendan Smith.

14 August

We started at the CK-02 site early this morning, where we were planning to redeploy a suite of four moorings including a large surface mooring that will sink before the winter ice arrives and then inflate itself after the ice has melted in the spring. The sea state had risen during the night. The mooring team met to evaluate working conditions with the Captain as large waves were washing water up the trawl ramp. We decided to postpone the mooring deployments and instead finish the Icy Cape transect of CTDs and Bongos. The plan would be to then double back with mooring operations the next day. The day went well and we finished the Icy Cape transect. A few walrus were seen nearby. After the transect was completed we had just enough time to jog over to pick up our CK-14 mooring on the northeast side of the transect. Tomorrow we plan to recover and redeploy our CK-01 moorings and then deploy the CK-02 moorings.



Anna and Haley helping Lisa with water samples. Photo by Brendan Smith.

15 August

More setbacks. As usual, we started with a CTD at the CK-01 mooring site. We then set up to recover the moorings. Catherine's marine mammal mooring was first up. Catherine enabled the release, ranged (200 m away), and released the mooring. It popped up quickly just out in front of the ship. Terry brought the ship alongside the mooring and Catherine hooked it. Just as John started to pull with the crane, I heard a noise that I assumed was the buoy smacking the side of the hull given the significant swell we were experiencing. It was not. It turned out to be the buoy being sucked into the propeller because the retrieval line was caught. We woke Brendan who had a couple of Go-Pro cameras and he quickly got to work fixing a camera to a boat hook and trying to take some blind video so that we could assess. This went on for a while, but each time Brendan kept getting better and better views for us. In the end it appeared that the poly-pro retrieval line was wrapped around the propeller with the buoy pinned against the hull and Catherine's Aural device and release dangling below. The starboard propeller was free. After much discussion, various phone calls, and a few emails a plan quickly formed. We limped over to Wainwright to set anchor and await a team of divers to free our propeller and assess any potential damage. We all have our fingers crossed that the divers will arrive tomorrow and that we can be on our merry way. If we can somehow be back at the CK-01 site by 17 August, there are no other mishaps, and the weather holds, there would be just enough time to finish up the highest priority items before needing to return to Nome.

16 August

We limped along through the night at around 3 knots and finally arrived off Wainwright this morning. We set anchor at 09:10 at 70 36.075 N, 160 09.956 W. Brendan took another video after we arrived to see if the mooring equipment was still dangling from the port side propeller. The water was quite murky so close to shore, but the video showed that the mooring equipment survived the slow transit. No science operations were conducted today. We waited for the dive team and at 17:00 we were informed that they would not arrive today due to too low cloud ceiling for the aircraft. We expect them to arrive tomorrow.

17 August

The dive team arrived in Wainwright during the late morning and got on a local boat out to our ship. The divers did not take long to free the buoy and other equipment from beneath the ship. Catherine's Aural device was damaged, but it did not leak, and she had a full hard drive of data. The divers then inspected the propeller, shaft, bearings, and everything else under the ship, and happily gave us a clean bill of health. We hauled back the anchor just before 7 pm and set off toward CK-01 where we will begin tomorrow. We saw at least three seals as we departed Wainwright.

18 August

Because we already had a CTD at CK-01, we simply began this morning by quickly recovering the remaining two moorings and then deploying their replacements. We then took a post-deployment CTD cast before heading off to CK-02. We arrived at CK-02 around 11:30, but still had some rigging to do before deploying the large surface mooring with the Prawler. Once our rigging was configured the Captain and everyone involved in the deployment met on the back deck to run through everything and make sure everyone was clear about how the deployment would proceed. We then repositioned the ship to about 1 nm away from the epicenter of our normal mooring cluster and began slowly steaming towards it. First in was the acoustic release, that we let dangle in the water just off the trawl ramp. We then launched the surface buoy over the starboard side and let it go with the quick release, paying out line as it slowly bobbed past our stern. Once the buoy was trailing along nicely behind us, we released the large subsurface chain down the trawl ramp. It was not as explosive as we had anticipated. We then started inching the anchor back to the edge of the deck next to the trawl ramp with the A-frame. Once it was mostly centered, we picked it up and then began moving the A-frame back to get the anchor out over the water. We then lowered to it to just beneath the water surface and then pulled the pin on the gravity release. We then started lowering the anchor into the water. The wire we were using on our drag winch was tight against one side and kept hitting the winch break. Therefore, we just kept lowering as we could and soon enough the anchor was on the bottom and our wire was slack. We then retrieved the gravity release and got busy setting up for the remaining three moorings. Those were standard fare, and the deployments went quickly. We ended the day by moving items around in the hold and on deck in preparation for our final days at sea. We dug out more anchors and moved our ice profilers into the hold. Overall, it was an extremely successful day. Everyone is happy to finally be rid the large surface mooring that has been weighing on our minds since we first left Dutch Harbor.

19 August

We began at the CEO site, located on the flanks of Hanna Shoal, early this morning. We did a CTD for mooring instrument calibration and then recovered the two CEO moorings. After clearing the deck, we quickly redeployed their two replacements and then took a CTD cast for primary production. We then headed to our CK-04 site and repeated process: a CTD followed by recovery of two moorings and then deployment of their replacements. Because we are severely pressed on time, the Captain agreed to let us carry on to the CK-05 site to also turn around those two moorings. We were extremely thankful to him and the crew that rallied to help us. We did the CTD, recoveries, and deployments of the CK-05 moorings in 1 hour and 10 minutes. We then set our sights to the Beaufort Sea region with a plan to bypass the BF1 Aural mooring and instead have an early 05:30 start at the BF2 site. We will then try to get three stations on the Beaufort Line.

Catherine Berchok preparing for a mooring deployment. Photo by Brendan Smith.

20 August

Many of us got very little sleep after the late night of working and the 5:30 am start. I checked in on the bridge just after 5:00 am and we had just gotten to the BF2 marine mammal mooring site after bypassing the BF1 site earlier in the morning. Perfect timing! We quickly set up, ranged, released, and recovered the mooring and then deployed its replacement. All of that in less than 30 minute. We then resumed steaming toward an outer station on the Beaufort Line just east of Point Barrow. When we arrived at station BFA8 we couldn't get an accurate depth reading with the depth-sounder, but knew it was somewhere near 300 m depth. Libby and a group of us set up the beam trawl. This took a while as it was the first time we had done that during this cruise. After finally deploying the beam trawl and recovering it, Libby essentially ended up with a net full of brittle stars. The CTD and Bongo were next, before moving to the next site and repeating the same operations. The next site was around 53 m deep and Libby's beam trawl found quite the variety of organisms including crabs, shrimp, and different fish. Upon reaching the third site, we had to cancel the beam trawl because the bottom appeared very rough on the depth-sounder. Instead, we completed just the CTD and Bongo tow. That gave us just enough time to get one additional CTD / Bongo station in before leaving toward Nome. On the way out of the Beaufort Sea region we stopped by the BF1 mooring site and recovered it in less than 15 minutes. We are now bound for Nome!

Libby Logerwell with crabs from the beam trawl. Photo by Brendan Smith.

21 August

We have simply transited south today toward Nome. Most of us slept in after the long day yesterday. Haley organized a root beer float party that we all enjoyed and it was Gregory's birthday too. After the party, the science members met on the ship's bow for a photo. Marty observed 15 walruses today, some Arctic terns, Sabine's gulls, Jaeger species, and an unidentified eider species. We also found out that the position for the N6 mooring that we could not find earlier in the cruise might have been somewhat off. So tomorrow we will try to find it at the updated position and then attempt to recover it if it is there.

22 August

Our transit south continues! The seas had picked up somewhat today as the southward winds kicked in overnight. We transited most of the day, discussing logistics and trying to plan for our arrival at the dock in Nome. I thought we would be able to get some of the DBO3 Line done today. However, the timing simply did not work out because the Line itself is composed of a 7-hour transit without stopping for stations. Starting at the nearshore station would mean getting to the mooring site too late. Starting from the mooring site meant only just enough time for a single station. Therefore, we ended up canceling any DBO3 sampling beyond that being done at the mooring site. We finally caught another break at the updated N6 mooring site. The other site we visited days ago had no sign of the N6 mooring. With a corrected N6 position, however, it did not take long to hone in on the mooring. We collected a few ranges to get an even more accurate position and then dunked the CTD to collect water for moored sensor calibration and for Lisa's primary production experiment. After the CTD, it did not take long to get the mooring on board. Not losing those data (or the equipment!) means lots to the two projects. Near the N6 site, Marty observed four whales, one of which was a confirmed Humpback. There was also a significant phytoplankton bloom. Shortly after leaving the N6 site, while we were still cleaning the mooring instruments, the boat turned quickly and we were able to collect a deceased common murre for Marty. We then continued heading south toward Nome.

The Leg 1 mooring team aboard the R/V Ocean Starr after successfully completing the final mooring operation. From left to right: David Strausz, Sarah Donohoe, Jordie Maisch, Peter Shipton, Catherine Berchok, Jose Valentin, Ryan McCabe, and Vaoatea "John" Ioane. Photo by Brendan Smith.

23 August

Today we continue transiting south toward Nome. The sea state had picked up considerably and this meant we could not safely open the hold to start staging items for the offload of Leg 1. We had planned to visit the N3 mooring on our way in, but given the sea conditions we first had to find shelter. We ended up making our way to the lee side of Sledge Island near Nome. We spent a few hours this evening moving items around and making room for spare fishing doors and nets that may be needed on Legs 2 and 3. No science operations were completed today.

The Leg 1 science party aboard the R/V Ocean Starr. From left to right: Peter Shipton, Lisa Eisner, Haley Cynar, Marty Reedy, Anna Mounsey, Jordie Maisch, Sarah Donahue, Libby Logerwell, David Strausz, Ryan McCabe, and Catherine Berchok. Photo by Brendan Smith.

Leg 2 (08/24/2019-09/14/2019) (Ed Farley)

24 August

We left Nome at 9 pm to get started on our way toward the northern most transect line. The sun was out and the weather was great. Science team and ship's crew were in great spirits! A CNN film crew and the lead journalist for their climate division was at the pier and interviewed several of the outgoing scientists from the first cruise of the 2019 NPRB Arctic IERP, including chief scientist Ryan McCabe.


CNN film crew documenting and interviewing NPRB Arctic IERP scientists following their work at sea. Photo by Matthew Baker.

25 August

Transit day, new crew ready to get to work.


Crew and research team of the R/V OCEAN STARR survey leg 2. Photo by Matthew Baker

26 August

Today we were close by one of our moorings that contained an upward looking fish finder that was recording continuously for one year. We successfully retrieved the mooring in the early afternoon and Robert Levine downloaded the data. These data will be used to determine when fish pass by to see if there are migratory patterns during the year when sea ice arrives and retreats. There were a number of small blue king crab on the mooring apparatus. We then continued north toward the first station.

Retrieval of an upward-facing acoustic mooring. Photo by Matthew Baker.

27 August

We arrived! We started taking samples at our first station at 72.5N and 168.5W at 7:30am. Sampling at a station includes temperature and salinity measurements from near surface to near bottom depths. Samples for nutrients, phytoplankton (marine plants), and the plant associated with harmful algal blooms (HABs) are taken at a variety of depths. We then take samples of the zooplankton to document the species and relative abundance of these important components of the food web. A sample of the mud/sand from the bottom is also taken to document the presence or absence of HABS in the bottom mud/sand. Next, we tow a small beam trawl along the bottom to understand the community of fishes and invertebrates (snails, brittlestars, crabs, and others). Finally, we tow a midwater net to understand the fish community within the water column. Fish typically found in the water column include very small Arctic cod, sand lance, and saffron cod. Fish are collected to take back to the laboratory to determine their fat content (a measure of their fitness) and to identify them to species. We also conduct on board stomach content analyses to determine what the fish are eating.

Deployment of the beam trawl for bottom sampling. Photo by Matthew Baker.

28 – August

We continue east along the 72.5N transect line. Our bottom beam trawl captured a number of small snow crab and a few older Arctic cod. Other fish on the bottom include eelblennies, and sculpins, and a small Bering Flounder. The midwater tow captured many age-0 Arctic cod, small sandlance, and a few age-0 saffron cod.


Sample from the midwater Marinovich trawl, including Arctic sand lance and Arctic cod. Photo by Matthew Baker.

29 – August

We continue east along the 72.5N transect line. Much of the operations remain the same and the weather continues to be great. The crew and scientists continue to work on efficiencies and safety while on deck. We know our weather days are numbered, so we are to trying to get as efficient as possible to prepare for the potential longer days ahead. At the end of the day, we transited along the 100 m depth line and documented more seabirds in that region of water depth. Most of the seabirds were shearwater.


Shearwater coasting on surface winds. Photo by Matthew Baker.

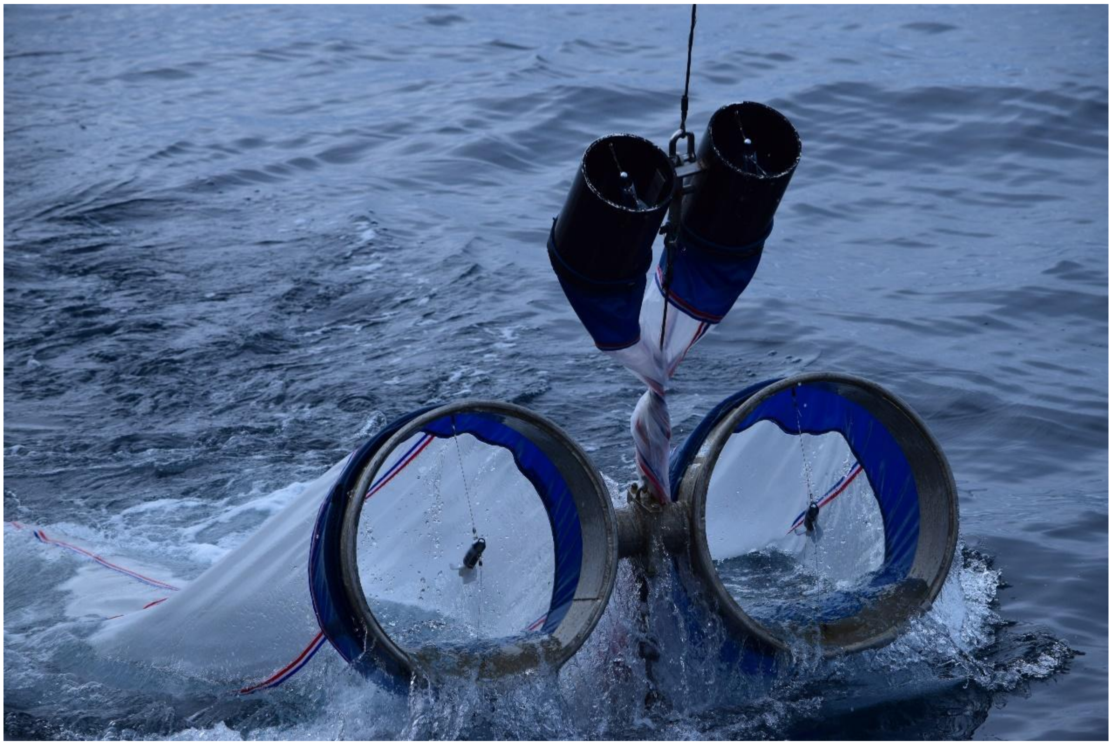
30 - August

Today we started our first offshore transect. The depths are much greater than on the shelf and the operations are taking longer as we are collecting information from the surface to the greater ocean depths. Our first bottom beam trawl caught a large snow crab and an adult Arctic cod. Depth of the tow was at 100m (328 feet). We continued to collect sediment grabs and take samples for potential presence of the plant species related to harmful algal blooms. The depth at the last station was greater than 1,000 m (3,280 feet)! We also caught a handful of myctophids.

Myctophid fishes documented on the Arctic Ocean continental shelf. Photo by Matthew Baker.

31 - August

We continued with the Chukchi slope transects today starting at the deepest station. Midwater tow found numerous age 0 Arctic cod within the top 50 m of the water column. Temperature and salinity profiles at 200 to 300 m indicated the presence of Atlantic water. We deployed the beam trawl at 200 m depth and caught a large polar eelblenny and a couple of snow crab. There was quite a bit of mud that came up with the trawl sample and it took the science crew a while to wash it away. On the last station (approx. 100m depth), the wind started to pick up considerably; we completed the CTD but our winch used to deploy the bongo stopped functioning…while the bongo was out! We were able to retrieve the gear and made the decision to head to shelter to wait out the coming storm.



Retrieval of the bongo net used to sample the water column for zooplankton and larval fishes. Photo by Matthew Baker

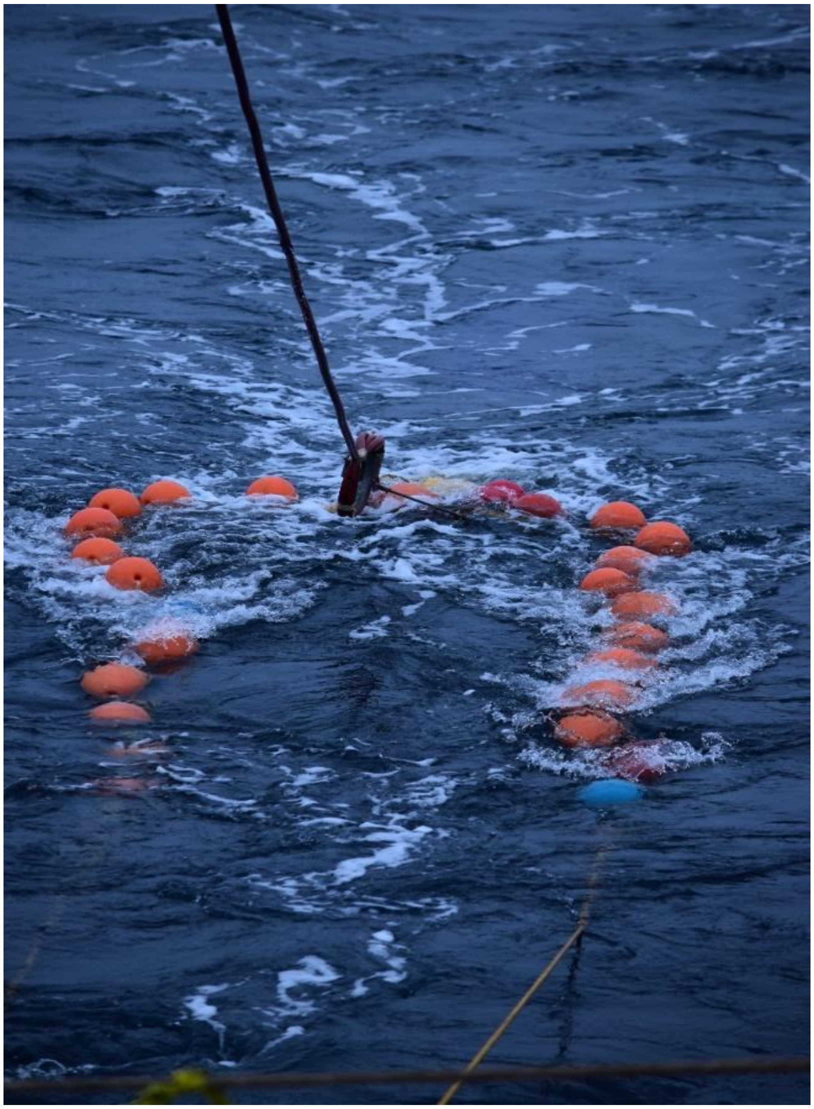
1 – September

Today we waited out the high winds near shore at 71N 157.8W. The wind continued all day, so the decision was to hold off sampling until the next day.

Crew of the OCEAN STARR (John and Austin) anchoring the vessel to wait out rough seas. Photo by Matthew Baker.

2 – September

Winds had died down considerably overnight, and we started our first station along the 71°N transect at the eastern most point (157.8°W). Catch in the beam trawl was diverse with invertebrates and fishes. The midwater net continued to catch small age 0 Arctic cod along with other small fishes and jellyfishes. We retrieved the second acoustic mooring and found many small blue crab within the meshes of the mooring platform.



Retrieval of the midwater net. Photo by Matthew Baker.

Retrieval of the Van Veen grab (right). Photo by Matthew Baker.

3 – September

Today we continued west along the 71°N transect sampling two stations and two midwaters. We encountered 10 to 15 gray whales at 71°N 161 19.14°W that were feeding. There were large plumes of mud in the surface water. Marty was able to get a few pictures as we moved past the pod. After sampling was complete, we transited south and retrieved the final acoustic mooring. We again encountered 15 to 20 blue crab hiding out within the mesh on the platform. Robert was pleased to note that all moorings had data.


Jellies with biomass dominated by *Chrysaora melanaster*. Photo by Matthew Baker.

4 - September

The days are becoming routine now with two stations and two midwaters. The bottom beam trawls were filled with larger Arctic cod and other fishes as well as a diverse array of invertebrates. The midwater trawl captured more jellyfishes than the previous day along with some saffron cod, capelin, and Pacific sand lance. Sea surface temperatures are warm offshore at around 10C. Dave mentioned that there were few to no copepods this day, more small jellyfishes and chaetognaths in the bongo nets. The day was foggy and air temperatures were in the low 50s!

NPRB Arctic IERP science team processing beam trawl samples. Photo by Matthew Baker.

5 – September

Today we completed the last two stations and two midwaters along the 71°N transect. One walrus was sighted while transiting between stations. Our weather continues to hold with winds around 10 knots and cloudy skies. Sea temperatures remain relatively warm at around 10°C or 52°F.

UAF graduate student Jared Weems processing bongo net samples. Photo by Matthew Baker

Water sample collection from Niskin bottles on the CTD rosette. Photo by Matthew Baker.

6 – September

We are continuing on a steady pace of completing two stations and two midwaters. Still finding age 0 Arctic cod in our midwater samples. We did not see any marine mammals this day. Sea surface temperatures ranged from 7 to 8°C or 46 to 48°F.

7 – September

Each day is very similar to the previous day. We are continuing to complete two stations and two midwaters. Age-0 Arctic cod and Arctic sandlance are dominating the fish catches. No marine mammals were seen today and sea temperatures remain warm at 8°C (48°F).

NOAA Corp officer and PMEL researcher Sarah Donahue directing the deployment of the CTD array. Photo by Matthew Baker

8 – September

Today we were having trouble sending information as the internet connection was not up. We have four more stations to complete on this transect before heading south. The beam trawl sampling the sea floor continues to catch large numbers of brittlestars and a handful of older Arctic cod while the midwater net continues to catch age-0 Arctic cod and Arctic sandlance. There were no marine mammals sighted today.


UW postdoc and JISAO scientist Jens Nielsen processing water chemistry data. Photo by Matthew Baker.

9 – September
Today we completed the 71.75°N transect line. Our weather continues to cooperate, however fog hampered some of the seabird observations. Sea surface temperatures continue to be quite warm hovering around 9.5°C (48°F).

Fog on the water in the northern Chukchi Sea, combining cold air temperatures with relatively warm surface waters. Photo by Matthew Baker.

10 – September

After completing the last station on 71.75° N, we ran southwest to the 70.25°N line. Our first station of the day was on the nearshore side of the transect. After completing the station operations, we ran for a while then conducted our first midwater trawl set on this line. There were many age-0 fishes, most were larger and looked much different that the age-0 Arctic cod we had been capturing further north. After looking at the fish characteristics, it was determined that these fish were age-0 walleye pollock! This was not expected, as we did not capture age-0 walleye pollock in numbers like this at these northern stations during 2017 or in the previous years of 2012 and 2013. The next midwater trawl set 30 miles further offshore also found large numbers of age-0 walleye pollock.

Arctic cod shown here were sampled extensively north of 71°N. In transects south of this latitude Arctic cod were replaced by walleye pollock. Photo by Matthew Baker.

11 – September

Our final day of sampling! The midwater tow further offshore along the 70.25°N line continued to capture large numbers of age-0 walleye pollock. However, these were smaller than yesterday. At the last trawl of the day at 70.25°N 168.5°W we caught numerous age-0 walleye pollock along with two adult (>70cm) walleye pollock! These adult pollock appeared to be in very good condition with full stomachs of small fishes and krill.


Krill and Arctic fishes sampled in the midwater tow. Krill were abundant in many of the southern lines of the northern portion of the Chukchi Sea shelf sampled in leg2. Photo by Matthew Baker.

12 – September

We continue our transit to Nome.

13 - September

We arrived in Nome at 2:00pm! Several reporters came to the vessel to discuss research results from Leg 2. Reporters included JoJo Phillips with KNOM and Sandra Medearis with the Nome Nugget. Jared Weems provided tours or the ship to students with the Anvil Academy on September 14.


Sunlight on the ocean swell on the return to Nome. Photo by Matthew Baker.

Leg 3 (09/14/2019-10/3/2019) (Kristin Cieciel)

14 September

First day of transit for the new science crew, leg 3 officially begins. We departed Nome at 1500 after a safety review and ship orientation to make our way north towards the first station at 69.5°N 164°W. The planned transit is 30 hours to the first sampling location. There is a possibility of weather picking up and a delay may occur in our tentative start day of Monday September 16. Time by new crew was spent restocking the supplies and trying to repair a winch for deployment of the zooplankton bongo.

15 September

Our plans have been delayed, and we are now heading for Point Hope to ride out some unfortunate weather. This will push back our sampling start to at least Tuesday morning. The inline sensor that samples water temperature, salinity and chlorophyll was found to have a burned out pump. With the help of the OCEAN STARR, engineering crew and Dave Strausz lead oceanographer they were able to get it back up and running by lunch.

The OCEAN STARR anchored off Point Hope to avoid foul weather. Photo by NOAA

16 September

The scientists and crew enjoyed a partly sunny but windy day avoiding the weather anchored up off Point Hope. A meeting was held to get all sampling protocols lined out prior to tomorrow's start. Leg 3 will add in the final operation of the surface trawl, which fishes the top 18m.

17 September

The first day of sampling on transect line 69.5°N began at 8:00 am with a Juday net which is towed vertically, followed by a benthic grab that pulls a chunk of mud out of the ocean floor, a Bongo net towed obliquely for zooplankton, a Plumb-staff Beam trawl which samples the benthic organisms and a CTD with water samples that measures temperature, salinity, chlorophyll and oceanographic characteristics. That series of operations occurs twice daily and can include up to two midwater trawls. The final trawling operation is a Nordic surface trawl and only occurs near the coastal areas to target juvenile (first ocean year after leaving freshwater) salmon and forage fish in the top 20 meters of the water column. Today's operations included all of the above except the surface trawl. Our final midwater trawl occurred today after dinner and consisted of age-0 walleye pollock, five species of jellyfish and a number of Pacific Herring. Samples from the oceanography and zooplankton group included sea surface temperatures of 10-11°C (52 to 54°F), and many shelled pteropods (*Limacina helicina*).

Picture of midwater trawl net, with scientists sampling the “pocket nets”. Photo courtesy of Kris Cieciel.

18 September

The day started out as usual along transect line 69.5°N with a beam trawl, bongo nets, Juday net, benthic grab and CTD, and then midwater trawl. No marine mammals or unusual seabird sightings. All equipment has been functioning. The zooplankton sample did not have many small copepods, which was different than expected. The midwater trawl has been catching pollock, sandlance, and saffron cod; there not much acoustic sign to target for those tows. Today was the first surface trawl on the second station of the day. It had a catch of two Chinook salmon and one pink salmon with a small amount of small pollock, sandlance, saffron cod and many jellyfish. The salmon was an unexpected surprise. The beam trawl was dominated by sea stars and shrimp. These operations completed line 69.5°N.

19 September

Two stations today with all operations plus, two surface trawls at each station, and two midwaters. Catches were heavy with jellyfish for the trawls but we did see a couple of squid, some sandlance, salmon, pollock, age-1 plus Arctic cod and some larval fish. In between transits, the bird observers from US fish and Wildlife noted a lone orca. The beam trawl caught a large amount of nickel-sized sand dollars this morning and many brittle stars for the afternoon tow. Sea surface temperatures remained around 10.6°C (53°F) and 28.5 for salinity. The zooplankton contained a notable amount of the shelled pteropods. These operations completed line 68.75°N.


Cyanea (jellyfish) caught in the southern Chukchi Sea. Photo by Kris Cieciel.

20 September

We started with an offshore station at 68°N and worked our way east, spotting land on the horizon with our second station. There were two stations with complete oceanography and zooplankton operations and beam trawls, two midwaters and a surface tow at the second station. The weather is feeling a bit more like fall, the crew reported it snowed last night for a brief moment and today we have been experiencing on and off rain and hail. The sea surface temperatures at the offshore station were 6.9°C (44°F) with 31.9 salinity and slightly warmer at the second station with 8.2°C (47°F). The zooplankton samples contained bits of algae mats, the beam trawls caught little snailfish, there were sandfish in the midwater, and the surface trawl with a pink salmon.

21 September

Clear skies and sunny weather for the entire day while we completed two stations. First station ended transect line 68°N and the second station was the first in-between station to specifically target salmon with the surface trawl. Both stations included all operations, plus 2 midwaters and 2 surface trawls. Sea surface temperatures were 9.5°C (49°F) in the morning and 10.2°C (50°F) in the afternoon. Zooplankton net tows contained larval fish; some were identified as greenling and flatfish. The second in-between station SF01 with the surface trawl had catches of juvenile pink salmon and when the diets were examined were shown to have larval greenling, limacina sp (shelled pteropod), and flatfish larvae in some of the stomachs. All diets are being done on board by visiting scientist Natalia Kuznetsova. The juvenile salmon will be frozen and sent back to the laboratory for genetics (to determine stock identification), otoliths (ear bones – to look at growth and chemical makeup of the otolith), scales (to also measure growth) and energetics (amount of fat for fitness measure).

22 September

The day started dark with cold heavy rain. We started and completed the two off shore stations along transect 67.25°N, there were two midwaters, and the usual zooplankton and oceanography with benthic work. No surface trawls were done and no marine mammals were observed. Mid-day today, we had some engine issues on the starboard engine that resulted in loss of speed from 8 to 5 knots. It was fixed only causing a slight delay. The midwater trawl catches were high in jellyfish; the first catch was not only mostly jellyfish but almost all *Chrysaora melanaster*. The second catch of the day was more mixed but still dominated by the northern sea nettle and had some age-0 pollock.

Scientists sorting through the catch. Photo by Todd Miller.

23 September

In anticipation of weather headed our way, we were able to complete three stations, three surface trawls and one midwater. Transect line 67.25°N was completed, along with station SF0S2 a nearshore in-between station. Sea surface temperatures for the day ranged from 9-10°C (48 to 50°F). The flow cam, which takes pictures of individual plant cells from a sample of water, had chain diatoms and ciliates present. The beam trawls overall seemed to have a high number of purple orange sea stars brittle stars. The surface trawls were almost completely jellyfish at all three stations.

24 September

Two stations were completed today on transect line 66.5°N. The first station of the day was located at 66.5°N 165.7°W was less than 15m (49 feet) in depth which made it too shallow to do any trawling other than the beam benthic sampling. During the transit to the next station, snow flurries were observed but only lasted for less than 5 minutes. The second station at 66.5°N 167.1°W included the oceanographic sampling along with the beam, surface and midwater trawls. No marine mammals were observed.

25 September

We ran into Kotzebue to drop off a science member and back out to the grid.

26 September

The final section of the last acoustic transect was completed during the early morning of the 26th and ended with a midwater tow just 6 miles short of our final station. It yielded the most diverse catch of the third leg including age-1 and older saffron Cod, walleye pollock, and Pacific cod, and younger age-0 pollock and saffron cod, and an assortment of jellyfishes. Sampling operations were carried out at the final station but the benthic grab was not deployed as the boat was drifting over 2 knots due to strong currents. After the final station was completed, we ran to hide from incoming weather.

27 September

The morning and early afternoon was spent on anchor waiting out strong winds coming from the south- southeast. The morning and afternoon were spent cleaning and disassembling the sampling equipment and securing them for transit. Our on board fish measuring equipment (CLAMS) was cleaned and stored away in pelican cases. Oceanography filtering stations were disassembled and packed away. Zooplankton nets were stored and samples packed away. Captain Pete held a meeting at 12:30 to brief the science crew for the weather for the upcoming run to Dutch Harbor. Anchor was pulled at 18:00 to begin the run. There are a few more mooring operations to complete on the transit south.

28 September

The first mooring was deployed at approximately 11:30am this morning. The transit thus far has been carried out with no issue.

29 September
Transiting back to Dutch Harbor.

30 September
Transiting Back to Dutch Harbor.

1 October
We arrived in Dutch Harbor and carried out the acoustic calibration.

2 October
All gear has been offloaded from the ship and scientists have begun to depart. The vessel leaves today to try and beast the Seattle loch closure. The cruise is complete.

3 October
Zane Chapman, Miranda Irby, and Esther Goldstein conducted 4^{th} grade classroom visits in Dutch Harbor and spoke about the survey.

DISCIPLINARY SUMMARIES

Physics and nutrients *(Phyllis Stabeno, Carol Ladd, Calvin Mordy, Ryan McCabe, David Strausz, Sarah Donohoe)*

Hydrographic profiles and bottle samples:
The NOAA PMEL EcoFOCI and University of Washington groups conducted a total of 91 (Leg 1: 41, Leg 2: 32, Leg 3: 18) CTD casts over the course of the cruise. The EcoFOCI CTD package consisted of a Sea-Bird Electronics 911*plus* instrument with dual pumped conductivity, temperature, and oxygen (SBE 43) sensors. In addition, a WETLABs fluorometer and turbidity sensor, a PAR sensor, and an altimeter were installed on the rosette frame along with 12 10-liter Niskin bottles. The majority of stations consisted of a single CTD profile, but occasionally an additional cast was taken at one station to collect enough water for on-deck phytoplankton primary productivity incubation experiments. Standard CTD profiles included the collection of water at nominal depths of near-bottom, 500 m, 200 m, 100 m, 75 m, 50 m, 40 m, 30 m, 20 m, 10 m, and near-surface. The majority of casts over the shallow Chukchi Sea shelf were limited to approximately 40 m depth, and the CTD was lowered to within 3–5 m of the bottom. The rosette was held in place for at least 30 seconds prior to bottle trips. Filtered nutrient (cruise total = 496) and chlorophyll samples (cruise total = 447) were taken from each Niskin. In addition, salinity (cruise total = 24) and oxygen bottle samples (cruise total = 108) were collected for use in post-cruise data correction. Oxygen samples were initially saved and then processed onboard during each Leg of the cruise. The nutrient samples were frozen onboard in a -20 C freezer. All samples other than the oxygen samples will be processed in laboratories on land. Preliminary processing

of CTD data was conducted onboard and hydrographic cross-sections for each transect as well as spatial maps were compiled (Figures 1 and 2). Final processing of the CTD data will occur after bottle samples have been analyzed.

Underway flow-thru system:

The NOAA PMEL EcoFOCI group installed an underway system on the ship's seawater intake line (~3.5 m depth) that included a Sea-Bird Electronics thermosalinograph (Stabeno/Ladd), a WETLABS fluorometer (McCabe), an Aanderaa optode (Stabeno/Mordy), a Pro-Oceanus Total Dissolved Gas Pressure (TDGP, Mordy), and a Satlantic In Situ Ultraviolet Spectrophotometer (ISUS, Mordy); the ship's Global Positioning System (GPS_ information was also fed into the data stream. Filtered chlorophyll, nutrient, and salinity samples were taken approximately twice per day. These samples will be used along with the near-surface CTD samples for post-cruise correction of the underway data.

Towed instrument:

The NOAA PMEL EcoFOCI group planned multiple transects with a Sea Sciences Inc. Acrobat towed instrument. Unfortunately, during the sea trials the instrument flooded. Replacement parts were sourced before the cruise began, but we could not get the instrument to function properly. Thus, the planned Acrobat tows were canceled.

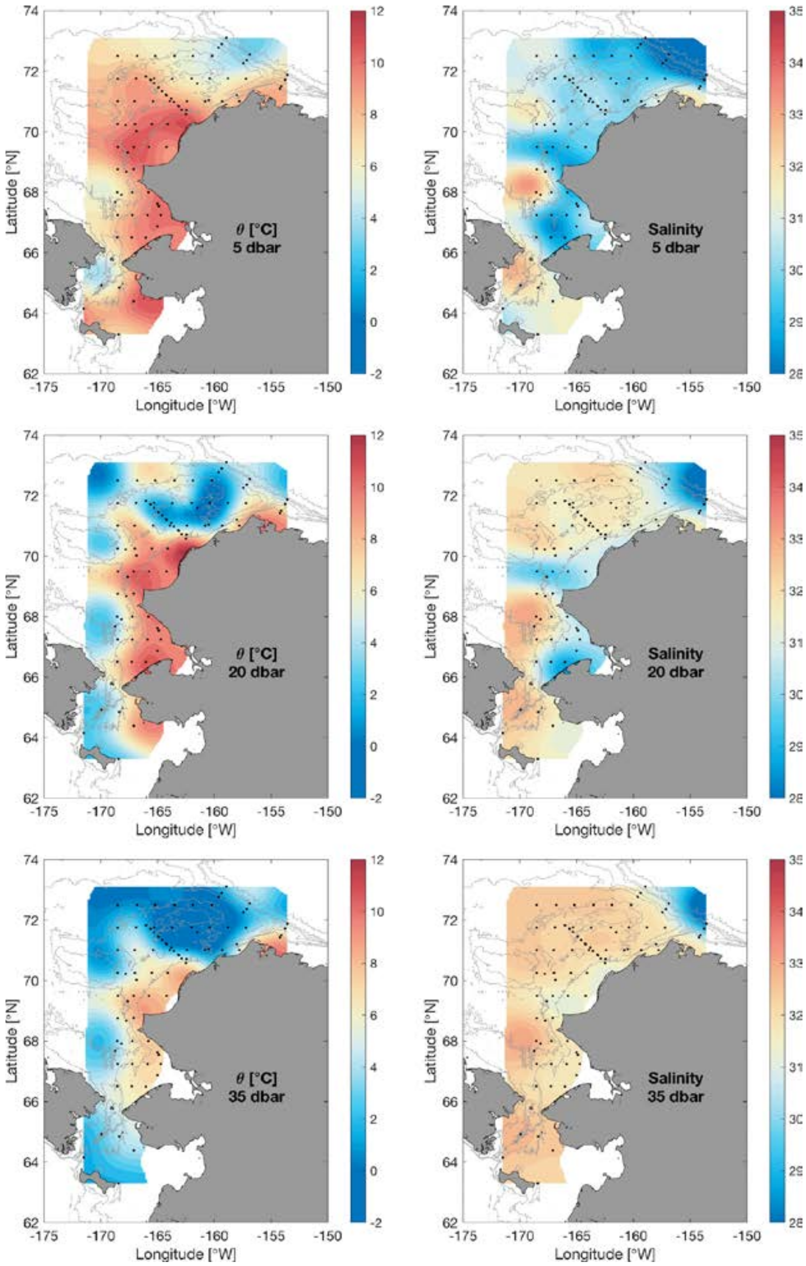


Figure 1: Plan view maps of potential temperature (left column), and salinity (right column) at three depths (5, 20, and 35 dbar; top to bottom, respectively) over the Chukchi Sea shelf from hydrographic profiles collected Aug–Sep 2019 aboard the R/V *Ocean Starr*. Data are not yet quality controlled.

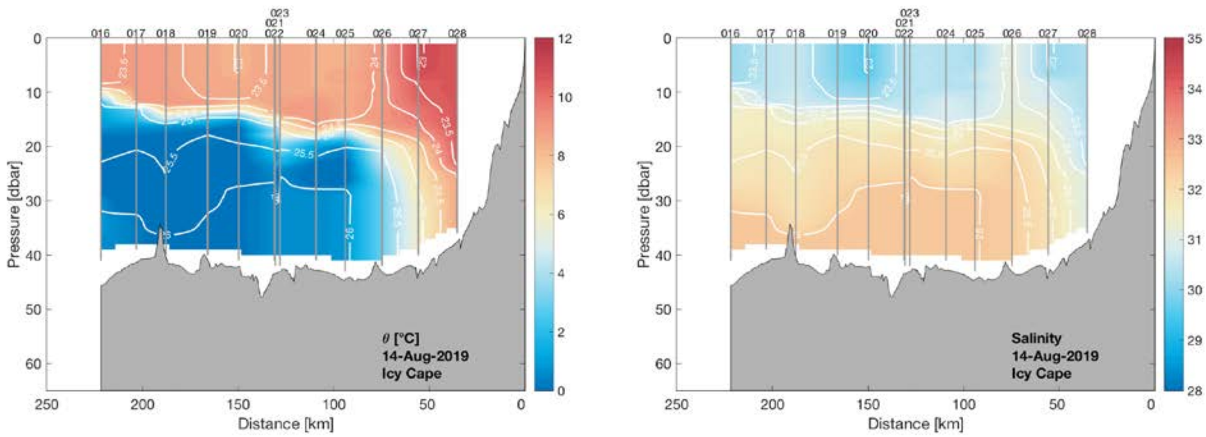


Figure 2: Potential temperature (left) and salinity (right) from the hydrographic transect off Icy Cape. Data are not yet quality controlled.

Primary production *(Lisa Eisner, Michael Lomas, Haley Cynar, Anna Mounsey, Brendan Smith, Miranda Irby)*

Sample Collection. Samples were collected for chlorophyll and particulate organic phosphate concentrations, phytoplankton taxonomic abundance analysis by flow cytometry (pico and nanoplankton) and a Fluid Imaging Technologies FlowCAM (microplankton), fatty acid analysis of seston and zooplankton, and rates of net primary productions in the northern Bering, Chukchi and Beaufort seas. Samples for Chlorophyll, flow cytometry and FlowCAM were collected at all stations, with the former at all depths and the later at 2-3 depths (Figure 3). Samples for microzooplankton biomass were collected at two depths at 26 stations. Incubations for rates of net primary production were conducted at one station per day, which for legs 2 and 3 were roughly every other station. In addition, 132 samples for 18S DNA analysis were collected. Samples were collected in a variety of water masses in the northern Bering, Chukchi and Beaufort seas. During the cruise, both surface and subsurface blooms were encountered. In areas with subsurface blooms (e.g., Icy Cape Line), the 1% light level was often near the sea floor, indicating light for photosynthesis was likely available throughout the water column. A summary of samples collected is provided in Table 1.

Many thanks go to Brendan Smith (NPRB), Haley Cynar (OSU), Ed Farley (AFSC), Anna Mounsey (NWFSC, NOAA), and Miranda Irby (NCSU) for their cheerful and relentless assistance with sampling and filtering thousands of liters of water! This help is greatly appreciated and ensured the success of the phytoplankton sampling component.

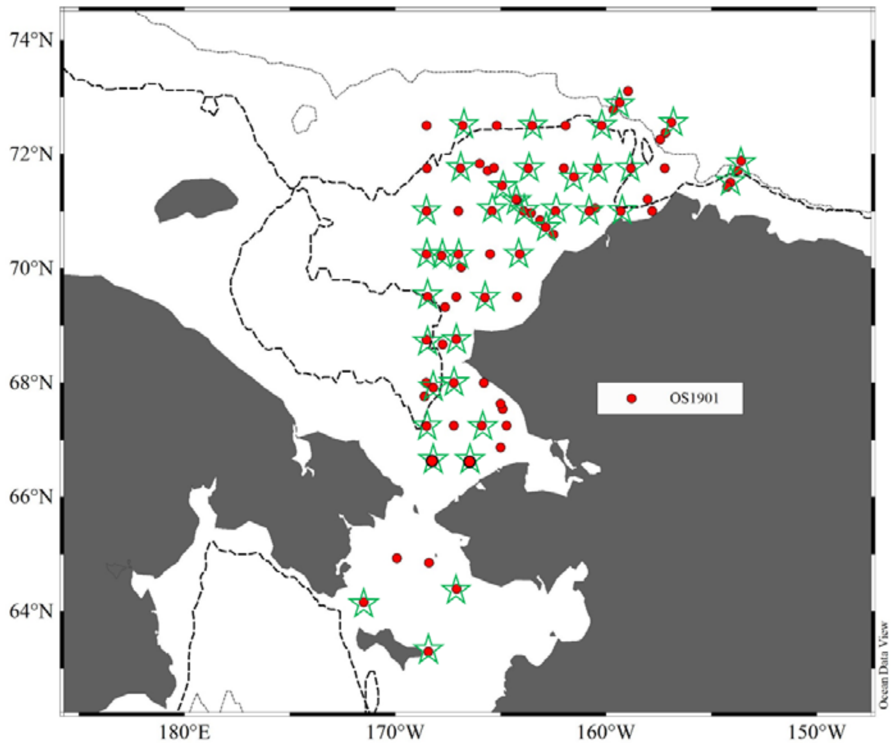


Figure 3. Station map showing which stations were sampled for parameters relevant to this report.

Table 1. Summary statistics for samples collected and incubations conducted.

Parameter	Number of stations	Number of samples/incubations	Scientist responsible for sample/data processing
Chlorophyll (whole)	81	511	L. Eisner / J. Nielsen / M. Lomas
Chlorophyll (<, > 5um)	41	198	L. Eisner / J. Nielsen / M. Lomas
Chlorophyll (>20, 5 to 20, <5um)	40	316	L. Eisner / J. Nielsen / M. Lomas
Chlorophyll TSG	33	33	L. Eisner / J. Nielsen / M. Lomas
Flow cytometry (pico/nanoplankton	81	437	M. Lomas
FlowCAM	81	344	L. Eisner / J. Nielsen
Seston Fatty Acids	31	184	L. Eisner

Zooplankton Fatty acids	51	99	L. Eisner
Microzooplankton biomass	18	52	A. Schnetzer / M. Irby
18S DNA	9	132	A. Schnetzer / M. Irby
Particulate Organic Phosphorus	38	157	M. Lomas
Primary Production	40	789	M. Lomas

Sample Details.

Primary Production. We sampled 40 stations for total primary production, with size fraction production collected at roughly half of the sites, to estimate phytoplankton carbon fixation for the whole community and small (<5 µm) and large (>5 µm) size fractions. Stable isotopes of carbon, nitrate and ammonium were added to 1L incubation bottles to measure uptake at 4 light levels between 100-1.5% surface irradiance. Water samples were incubated in on-deck incubators cooled with surface seawater for 6 hours, filtered and filters stored frozen until isotope ratio mass analysis at Bigelow Laboratory for Ocean Sciences. For seven of the primary production stations (18 sample depths) on leg 1, we matched the depths that data were collected for Oxygen-17 (estimate of gross photosynthetic oxygen production) by Haley Cynar (OSU). This will provide an estimate of gross primary production, oxygen-17, to compare with our estimate of net primary production from stable isotope carbon uptake. This adds a new and exciting component to our project.

Chlorophyll. Total chlorophyll a (an approximation of phytoplankton biomass) was collected at all depths at all (80) CTD stations. Size fractionated chlorophyll a (3 fractions: < 5, 5-20, > 20 µm) were collected at all primary production stations at 3 depths; at all other stations we collected 2 fractions (> 5, < 5 µm) at 2 depths. For the smaller fractions, <5um, we will be able to compare an estimate of carbon biomass (via flow cytometry) in these cells to the chlorophyll biomass estimate.

Particulate Phosphorus Samples. Particulate organic phosphate samples were collected to use with the estimates of particulate organic carbon and nitrogen (obtained during the analyses of primary production samples) from the primary production stations to calculate the seston elemental stoichiometry. This ratio can provide information on the general quality of sestonic material available to grazers. Particulate organic phosphorus samples were collected at all production stations and at the four depths selected for primary production incubations.

Flow Cytometry. Flow cytometry samples for numeric quantification of pico- and nanophytoplankton (<10um) were collected at 80 stations at all depths to match chlorophyll. From each sample, we will provide estimates for the abundance of four different phytoplankton groups: the picocyanobacteria *Synechococcus*, picoeukaryotes (<3um), nanoeukaryotes (3-10um) and eukaryotic cryptophytes. Using a method developed in Lomas' lab, these analyses will also provide an estimate of carbon per cell for each cell type and when multiplied by cell abundance provides an estimate of particulate carbon in each population.

FlowCAM. FlowCAM analysis for identification of microphytoplankton and microzooplankton (~10 – 200 µm) was conducted at all 80 stations (1-3 depths). Preliminary data suggest that dinoflagellates, cilliates and small cells were dominant at some sites with diatoms, primarily *Chaetoceros* spp., dominant at others (Figure 4). High numbers of diatoms *Chaetoceros* spp. and *Thallasiosira* spp. (Figure 4) were observed at the mooring site N6 at the offshore end of the Pt. Hope (DBO 3) transect.

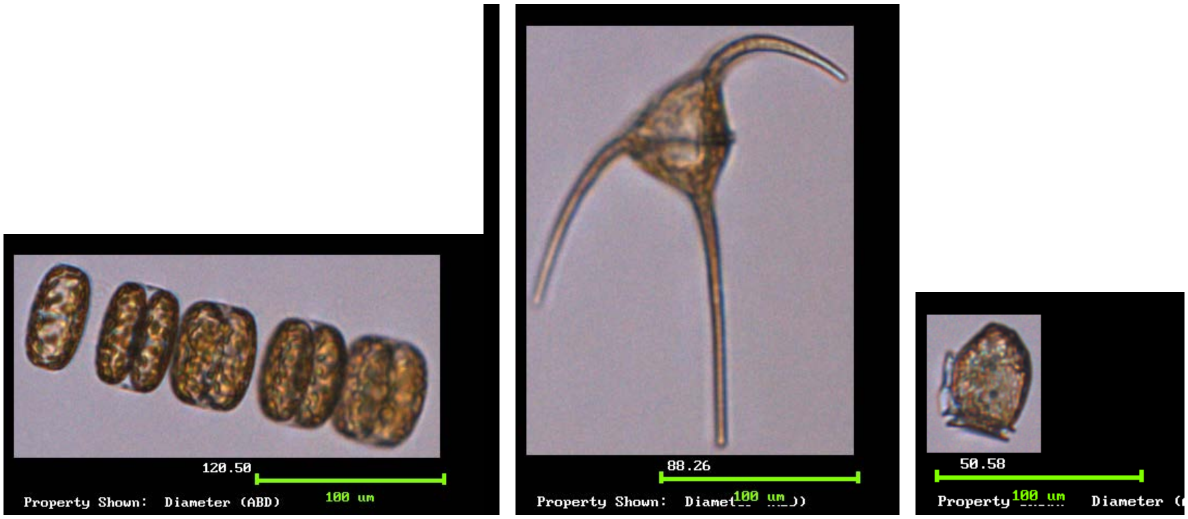


Figure 4. Examples of FlowCAM images of the diatoms *Chaetoceros (top*), *Thallasiosira* (bottom left) and dinoflagellates *Ceratium* (bottom middle), and *Dinophysis* (bottom right) from leg 1.

Microzooplankton Biomass. Samples were collected from 2-3 depths (minimum of surface and chlorophyll maximum) at all production stations for the estimation of microzooplankton biomass by microscopic image analysis. Samples were fixed in Lugol's solution and will be returned to Dr. Astrid Schnetzer's lab at North Carolina State University for analysis by her Ph.D. student Miranda Irby.

18S DNA analysis. A total of 132 samples were collected for 18S DNA analysis to identify phylogeny of dominant microzooplankton groups at these depths/stations. Samples were filtered and stored frozen at -80oC and will be returned to Dr. Astrid Schnetzer's lab at North Carolina State University for analysis by her Ph.D. student Miranda Irby.

Fatty Acid Analysis. Fatty acid samples were collected for zooplankton (51 stations) and seston (particles < 200 µm such as microzooplankton, phytoplankton and detritus, 31 stations at the surface and chlorophyll maximum). Samples for large zooplankton were kindly provided by Libby Logerwell, David Kimmel and Adam Spear (NOAA EcoFOCI) from bongo net tows (505-µm mesh). Large zooplankton (individuals) and seston samples (filters) were stored frozen at minus 80 for later analysis of fatty acids and lipid classes. These data will be used to determine what types of fatty acids (e.g. markers for different phytoplankton) are found in different water masses and if and where these fatty acids move up the food web to zooplankton and potentially higher trophic levels. In addition, these data will complement the fish FA samples to understand FA transfer in the food web.

Biological Production by Equilibrator Inlet Mass Spectrometry (EIMS) *(Haley Cynar, Lauren Juranek)*

Underway flow-through seawater was continuously measured by an equilibrator inlet mass spectrometer (EIMS) for O2/Ar (oxygen to argon) ratios while in transit, which provides information on biological productivity. At least three events where dissolved oxygen was greater than 130% were observed with concurrent elevated O2/Ar ratios, indicating a recent or current bloom of phytoplankton. Forty discrete samples were collected from the surface underway seawater system, and 53 seawater samples were collected from CTD casts to resolve depth profiles. These samples will be analyzed by an isotope ratio mass spectrometer at OSU for oxygen isotopes and O2/Ar ratios as an estimate of biological production in the surface mixed layer.

Pseudo-nitzschia and Alexandrium abundance and domoic acid and saxitoxin concentration *(Anna Mounsey, Kathi Lefebrve)*

Samples were taken from both CTD rosette and in-line water. At each depth, 3 liters of water were collected (1m, 10m and Chlorophyll Max). Other samples of water were taken from the in-line service hose in the lab. Three protocols were performed to ultimately quantify cell densities of two HAB (harmful algal bloom) species (*Psuedo-nitzschia* and *Alexandrium)* and concentrations of the corresponding algal toxins (domoic acid and saxitoxin) in Arctic and subarctic Alaskan waters. For *Alexandrium*, two liters of water from each depth was sieved through a 15uM mesh in order to concentrate *Alexandrium* for cell counts. The concentrated two liters were backwashed into a 15mL falcon tube and formalin fixed for a short interval and then rapidly preserved in ice-cold methanol. 15mL falcon tubes were sealed with para-film and stored in the -80°C freezer. Later, subsequent whole cell hydrobidaztion and enumeration of *A. Catenella* and *A. Ostenfeldii* cell abundances will be performed using ribosomal RNA probes. Another 2 liters from each depth was collected from the CTD for *Psuedo-nitzschia* counts. 300ml from each depth was filtered on an HA filter for toxin analysis, and another 300ml from each depth was filtered on an HV filter for species identification. HA filters and HV filters were placed in their respective cryovials and stored in the -80°C freezer. Another 125ml was preserved in Lugol’s and kept at room temperature.

The underway seawater system was used for collection saxitoxin samples. 10 liters of water from the in-line hose was filtered through a 20uM net. The filtrate was concentrated and then sieved similar to the *Alexandrium* whole cell protocol. The 15mL of backwash was then filtered onto an HA filter for saxitoxin analyses. Underway filters were placed in a cryovial and stored in the -80°C freezer.

Opportunistic sediment samples were taken from bottom trawls. Samples were taken by spooning sediment into amber vials and kept in the refrigerator at 4°C. One hundred ten whole-cell samples were taken, 202 *Psuedo-nitzschia* samples were taken, and 51 underway samples were taken.

Microzooplankton *(Dave Kimmel, Mike Lomas, Lisa Eisner)*

Microzooplankton were sampled from the Niskin bottles at three depths (surface mixed layer, chlorophyll maximum, below chlorophyll maximum) when the water column is stratified. Microzooplankton were preserved in acid Lugol's solution at every grid station, in glutaraldehyde at every other grid station. Microzooplankton samples for molecular analysis were also taken at six stations in the northern Chukchi Sea. Microzooplankton samples will be shipped to the Schnetzer laboratory at North Carolina State University for enumeration and identification.

Large zooplankton and ichthyoplankton *(Dave Kimmel, Adam Spear, Esther Goldstein)*

Zooplankton: Meta- and mesozooplankton were sampled using a paired bongo net frame with two 60 cm diameter, 505-µm mesh nets and two 20 cm, 153 µm mesh nets. Bongo tows were processed in the following manner. Net 1 of both the 505-µm mesh and 153-µm mesh was preserved in formalin for later sorting at the Plankton Sorting and Identification Center in Poland. Net 2 of the 505-µm mesh was first sorted for larval fish and these were preserved in ethanol for later identification or genetic analysis (see below, *Ichthyoplankton*). Next, the rapid zooplankton analysis (RZA) was performed to generate rough counts of the zooplankton abundance and community composition. During the RZA, specific taxa of interest were picked from the sample and frozen at -80 °C for later harmful algal blooms (HABs), total lipid, and fatty acid analysis. A subsample of the zooplankton was also preserved for stable isotope analysis. For the 153-µm mesh sample, a similar procedure was followed. The RZA analysis was done on the sample, but no individual taxa were collected. Rather, one subsample was preserved for HABs and another for stable isotope analysis.

The RZA was performed at every grid station as well as five stations along the Chukchi slope (Figure 5). Small copepods (< 2 mm) were found in abundance throughout the Chukchi Sea. Small copepods had lower abundances in the northern portion of the grid and increased as the survey progressed southward. The small copepods were primarily represented by *Pseudocalanus* spp., *Oithona* spp., *Metridia* spp., and *Acartia* spp. Large copepod (> 2 mm) abundances were generally low (< 10 individuals m-3), particularly throughout the central portion of the grid. Abundances were highest in the northeastern (near the Chukchi Slope) and southwestern corners of the survey grid. The primary large copepod encountered was *Calanus marshallae/glacialis* (co-occurring species that are difficult to tell apart). We also observed several individual *Calanus hyperboreus*, a larger, Arctic copepod, in the net samples. This suggests that colder water from the Arctic basin was being transported into the eastern portion of the Chukchi Sea. Other rare species observed included *Neocalanus* spp. and *Epilapidocera amphitrites*. Small (< 15 mm) euphausiid abundances were highly variable throughout the grid and this was expected as euphausiids are more effective at net avoidance, particularly during the day. We observed high abundances euphausiids along two stations in the southwest portion of the survey grid.

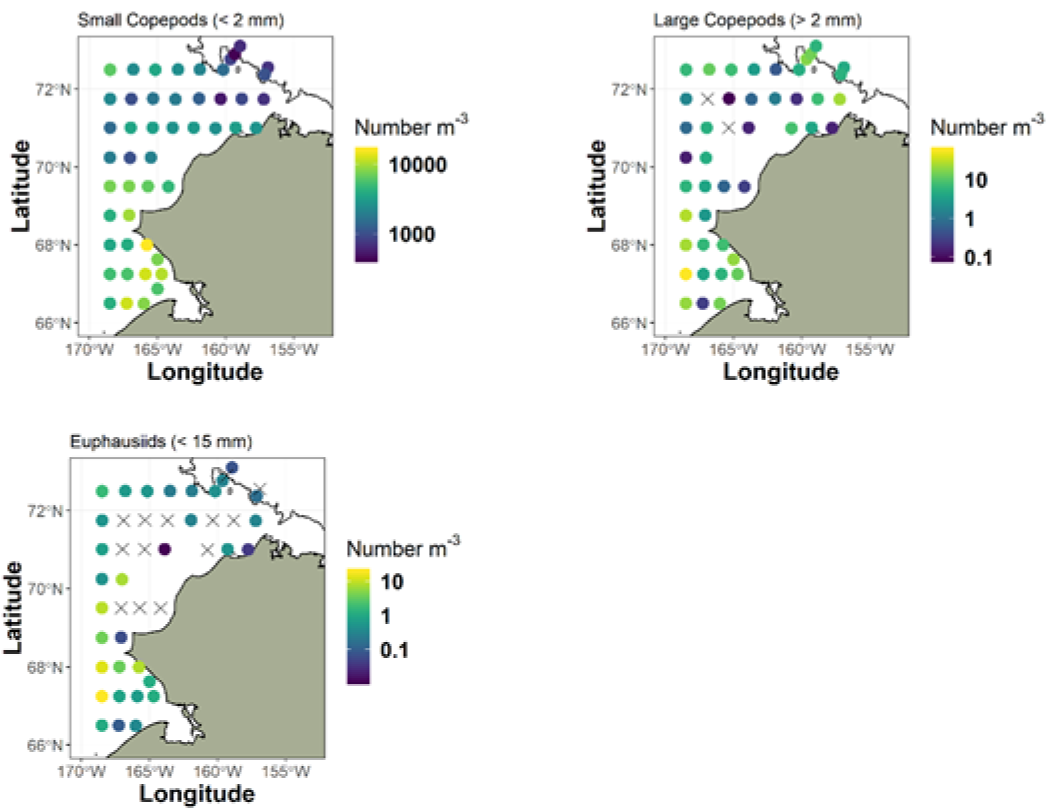


Figure 5. Zooplankton abundance as determined from Rapid Zooplankton Analysis (RZA) for three broad categories. Each dot represents a Bongo tow at a station and x represents a sample was taken, but the abundance was zero. Note the different scales.

<u>Ichthyoplankton</u>: Larval fish were collected using a paired Bongo net frame mounted with two 60-cm diameter, 505 µm mesh nets and two 20-cm, 153 µm mesh nets (see above, *Zooplankton*). Quantitative samples (quantitative sample) were preserved in formalin from one side of the paired 60-cm net at each station for later enumeration and measuring at the Plankton Sorting and Identification Center in Poland. All fish from the other side of the 60-cm (non-quantitative) were identified to the lowest taxonomic level possible and preserved for special projects. Two target species (*Boreogadus saida* and *Eleginus gracilis*) were frozen for stable isotope analyses. All other species were preserved in 95% ethanol for future studies. If fish of the target taxa were found in the non-quantitative 20 cm bongo net (153 µm mesh), then they were also frozen for stable isotope analyses. Additionally, zooplankton from net 2 of the 505 µm and 153 µm nets were frozen for stable isotope analyses.

A total of 195 fish were collected from the non-quantitative nets. Most larval fish were collected in at the southernmost stations and inshore, followed by stations in the northeast. Based on preliminary shipboard identification, flatfishes were the most abundant taxonomic group, particularly at inshore and lower latitude stations (Figure 6). *Boreogadus saida* (Arctic cod) larvae were rare and were only found at high latitudes.

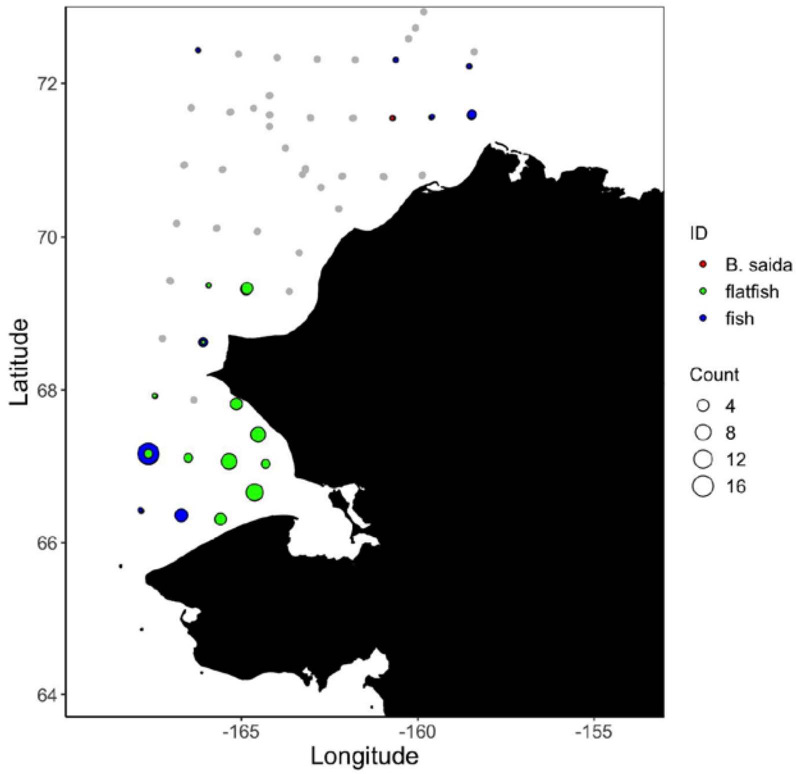


Figure 6. Distribution of larval fish samples collected from Bongo net 2 for special studies*:* *Boreogadus saida* (*B. saida*; Arctic cod), flatfish, and other fish (fish). Size represents the number of individuals collected at each station and the gray circles are stations in which no fish were caught.

Fatty acids *(Lisa Eisner, Ron Heintz, Louise Copeman, Johanna Vollenweider)*

Fatty acid and total lipid samples were collected for zooplankton and seston (particles < 200 µm (microzooplankton, phytoplankton and detritus) at all grid stations sampled. Samples for zooplankton were kindly provided by Nissa Ferm, Dave Kimmel and Adam Spear (NOAA EcoFOCI) from vertical net tows. Large zooplankton (individuals), small zooplankton bulk samples and seston from water samples (filtered onto GFF filters) were stored frozen for later analysis of fatty acids and total lipids. These data will be used to determine what types of fatty acids (e.g. markers for different phytoplankton) are found in different water masses and if and where these fatty acids move up the food web to different zooplankton and larval fish species (samples collected in the surface and midwater trawls). Samples will be analyzed by the Alaska Fisheries Science Center, Juneau, Alaska and at the Northwest Fisheries Science Center, Newport, Oregon.

FISHES

Three types of trawls were used to sample Arctic fishes:

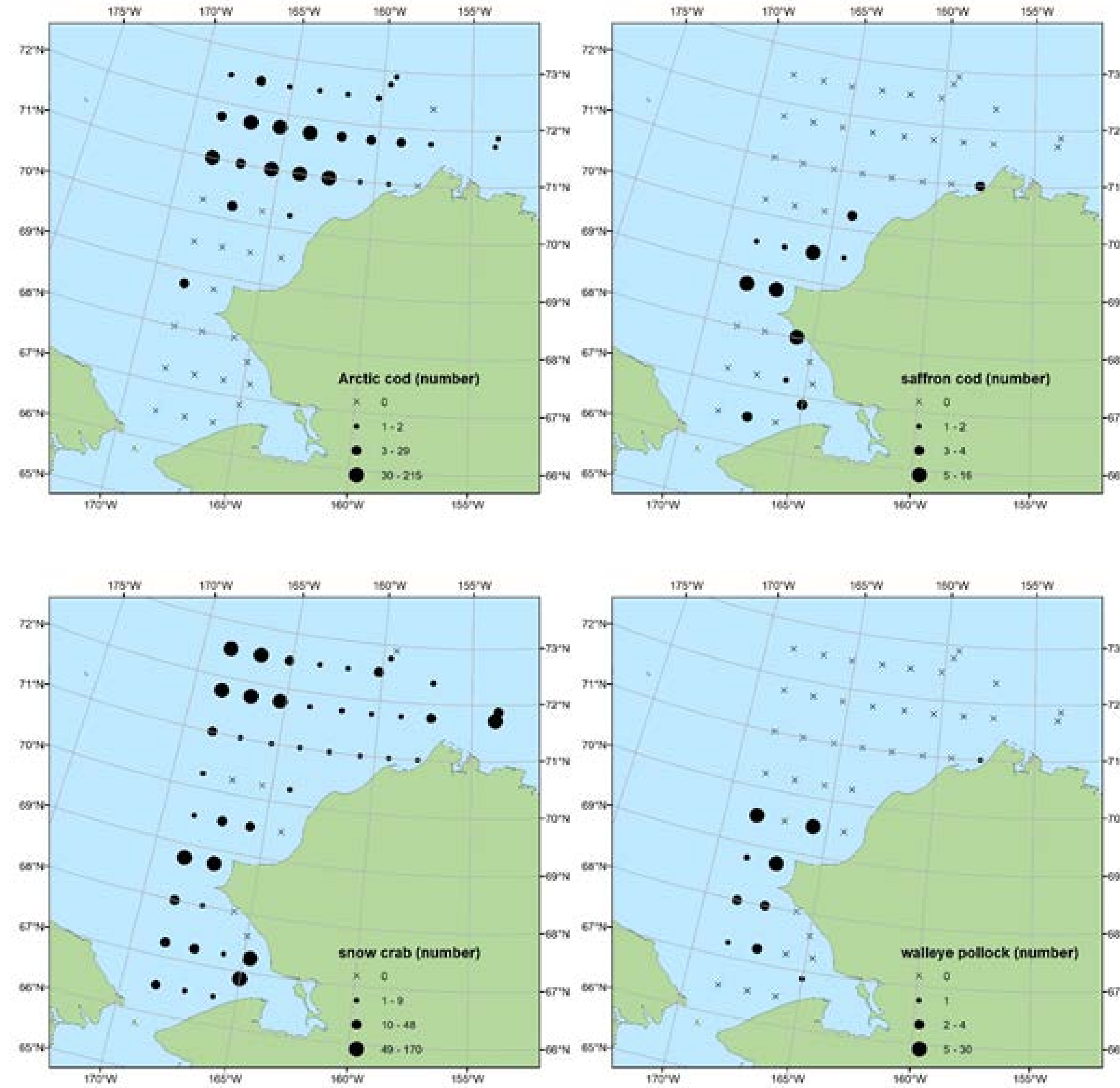
a) Surface Trawl to enumerate juvenile salmon
b) Midwater Trawl to ground truth midwater acoustic targets
c) Bottom Trawl to describe benthic communities

Tests were completed during Leg 1 to optimize fishing performance of two pelagic trawls. The larger Nordic trawl was configured to fish only at the ocean surface, and the smaller Marinovich trawl was configured to fish in midwater. Additional setback was added to the larger Nordic trawl to increase the vertical mouth opening, and modifications were made to the trawl doors' V-rigging. As the smaller Marinovich midwater trawl was fished for the first time with rope bridles and the Nordic trawl X-Lite trawl doors, substantial efforts were made to determine the appropriate weight for the footrope to obtain the specified trawl mouth opening and to reduce the amount of trawl warp needed to get the trawl to the targeted depth.

Demersal fish and invertebrates *(Libby Logerwell, Dan Cooper)*

<u>Bottom Trawls (ocean floor)</u>:

The 3m Plumb Staff Beam Trawl was deployed at 49 predetermined stations. Two stations were sampled in the Beaufort Sea. Epibenthic invertebrates dominated the catch, making up 96% of the total catch weight. The top 10 fish taxa caught (by biomass) were pricklebacks, sculpins, Bering flounder, Arctic Cod, starry flounder, Arctic shanny, walleye pollock and saffron cod (Table 2). The Pollock were 5.0 – 18.6 cm in length and thus likely immature. The top 10 invertebrate taxa caught (by biomass) were brittlestars, sand dollars, starfish, snow crab, basket stars, nut clams, urchins, and shrimps. The snow crab were smaller than commercially viable size, although ovigerous females (females with eggs) were caught at several stations. Figure 7 illustrates the distribution of Arctic Cod, saffron cod, snow crab, walleye pollock, and Bering flounder.


Arctic cod (number)
0
1 - 2
3 - 29
30 - 215
saffron cod (number)
0
1 - 2
3 - 4
5 - 16
snow crab (number)
0
1 - 9
10 - 48
49 - 170
walleye pollock (number)
0
1
2 - 4
5 - 30

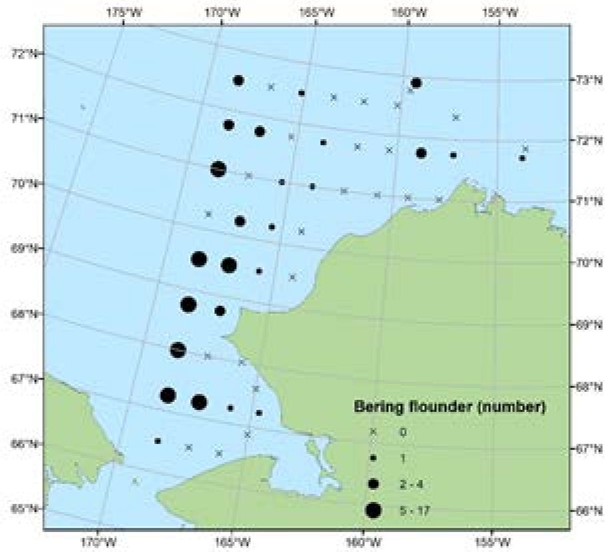


Figure 7. Preliminary numbers of Arctic cod, saffron cod, snow crab, walleye pollock, and Bering flounder caught in the beam trawl at stations within the Chukchi and Beaufort seas during August to October 2019.

Table 2. Preliminary numbers and weight (kg) of fishes (and snow crab) by species, common name, and Inupiat name caught in the 3m Plumb Staff Beam Trawl. Numbers and weight are "raw" catch and have not been standardized to distance traveled; some species identifications have yet to be confirmed.

Species	**Common Name**	**Inupiaq Name**	**Weight (kg)**	**Number**
Chionoecetes opilio	snow crab		20.193	1341
Lumpenus fabricii	slender eelblenny		5.484	1847
Hippoglossoides robustus	Bering flounder		2.405	105

Myoxocephalus scorpius	shorthorn (warty) sculpin	Kanayuq	2.122	160
Boreogadus saida	Arctic cod	Iqalugaq	2.043	743
Lumpenus medius	stout eelblenny		1.265	327
Platichthys stellatus	starry flounder		1.001	2
Gymnocanthus tricuspis	Arctic staghorn sculpin	Kanayuq	0.752	291
Stichaeus punctatus	Arctic shanny		0.667	165
Gadus chalcogrammus	walleye pollock		0.615	67
Eleginus gracilis	saffron cod	Uugaq	0.566	57
Limanda aspera	yellowfin sole		0.345	20
Lycodes polaris	Canadian eelpout		0.283	39
Pleuronectes quadrituberculatus	Alaska plaice		0.220	1
Lycodes palearis	wattled eelpout		0.177	11

Liparis gibbus	variegated snailfish		0.170	19
Artediellus scaber	hamecon	Kanayuq	0.130	19
Podothecus veternus	veteran poacher		0.126	16
Lycodes raridens	marbled eelpout		0.122	15
Myoxocephalus jaok	plain sculpin	Kanayuq	0.122	15
Ulcina olrikii	Arctic alligatorfish		0.102	104
Enophrys diceraus	antlered sculpin	Kanayuq	0.087	5
Eurymen gyrinus	smoothcheek sculpin	Kanayuq	0.071	1
Liopsetta glacialis	Arctic flounder		0.070	1
Limanda proboscidea	longhead dab		0.068	11
Blepsias bilobus	crested sculpin	Kanayuq	0.060	2
Lycodes turneri	polar eelpout		0.060	13

Liparis tunicatus	kelp snailfish		0.040	4
Gadus macrocephalus	Pacific cod		0.038	7
Lepidopsetta polyxystra	northern rock sole		0.037	2
Limanda sakhalinensis	Sakhalin sole		0.037	2
Triglops pingeli	ribbed sculpin	Kanayuq	0.037	4
Icelus spatula	spatulate sculpin	Kanayuq	0.031	9
Pleuronectiformes	flatfish unident.		0.021	21
Nautichthys pribilovius	eyeshade sculpin	Kanayuq	0.017	4
fish eggs unident.	fish eggs unident.		0.015	
Eumesogrammus praecisus	fourline snakeblenny		0.012	1
Chirolophis snyderi	bearded warbonnet		0.011	3
Cottidae	sculpin unident.	Kanayuq	0.011	3

Myoxocephalus sp.		Kanayuq	0.010	1
Pallasina barbata	tubenose poacher		0.009	2
Liparis sp.			0.006	4
Lycodes mucosus	saddled eelpout		0.005	4
Aspidophoroides monopterygius	alligatorfish		0.003	6
Lumpenus maculatus	daubed shanny		0.002	1
Pleuronectiformes larvae	flatfish larvae unident.		0.002	4
Reinhardtius hippoglossoides	Greenland turbot		0.002	2
fish larvae unident.	fish larvae unident.		0.001	3
Lycodes sp.			0.001	1

Midwater fishes/acoustics *(Robert Levine, Alex De Robertis, Chris Wilson)*

Active Acoustics:
Acoustic data were collected using a Simrad EK60 scientific echosounder operating at 38 and 120 kHz during the survey. Acoustic backscatter was detected along much of the survey trackline (Figures 8 – 11). Vertical distribution was variable, ranging from within the upper 20 m of the

ocean surface to near the seafloor depending on location. A separate deep backscatter layer was observed off the shelf in the northern Chukchi and Beaufort seas. The greatest intensity of acoustic backscatter was found in the Chukchi Sea between 71 and 71.75°N in areas where age-0 arctic cod were captured in midwater trawls. Most of the backscatter was attributed to age-0 Arctic cod. Preliminary results suggest that acoustic backscatter from Arctic cod was significantly lower than observed in 2017, with backscatter resembling levels observed during the 2013 survey (Figure 12)

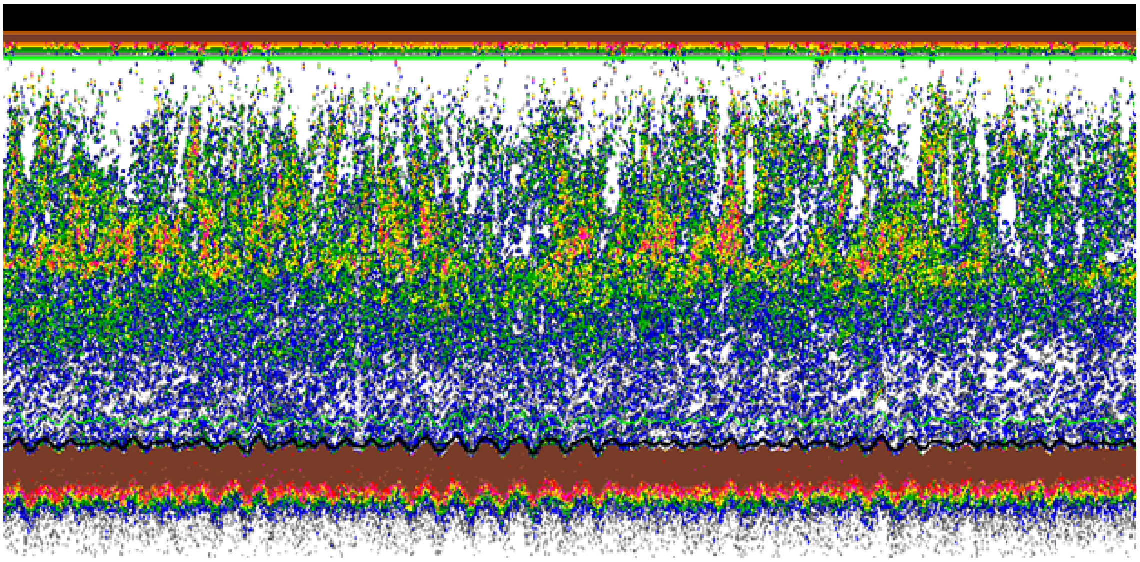


Figure 8. Water column backscatter along a transect in the North Chukchi Sea. A midwater trawl conducted in the vicinity (20 minutes duration at 1.8 kts) caught 8,544 age-0 Arctic cod, 36 jellyfish, 13 pricklebacks and 1 sculpin.

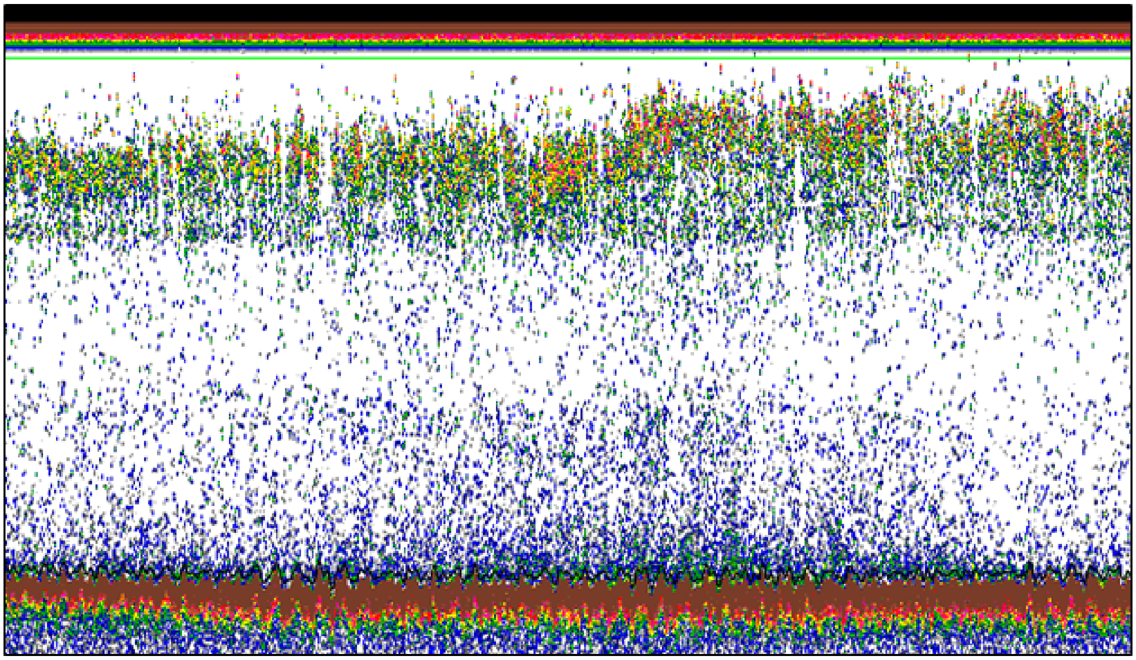


Figure 9. Water column backscatter along a transect in the Northern Chukchi Sea. A midwater trawl conducted in the vicinity (15 minutes duration at 2.6 kts) caught 11,108 age-0 Arctic cod, 178 sand lance, 16 sculpin, 8 Saffron cod, and 228 jellyfish. Age-0 Arctic cod and jellyfish comprised 14% and 82% of the catch by weight, respectively.

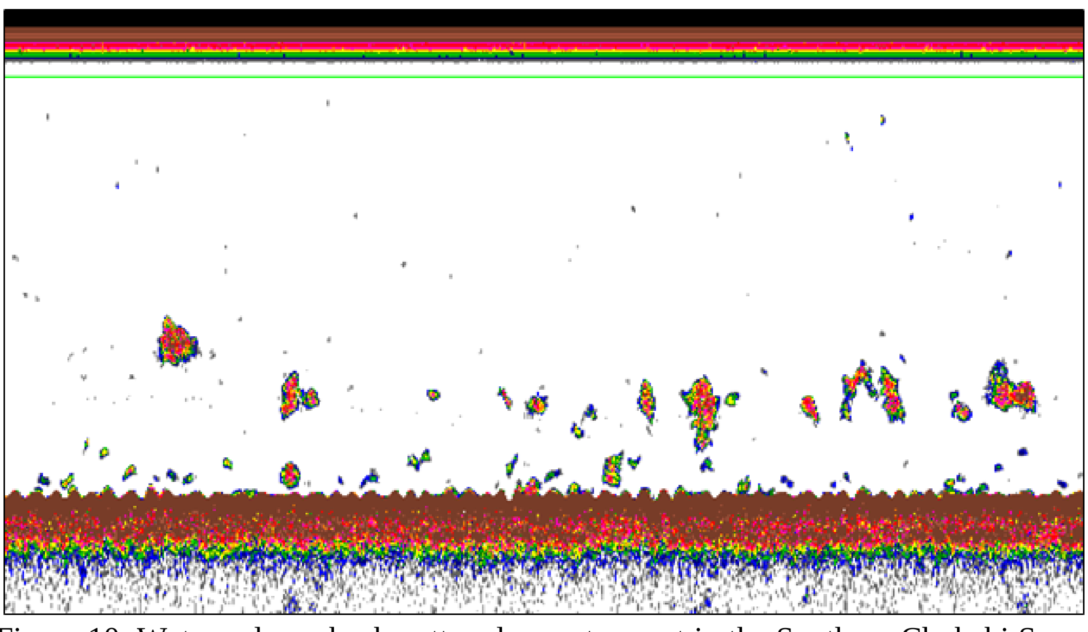


Figure 10. Water column backscatter along a transect in the Southern Chukchi Sea. A midwater trawl conducted in the vicinity (17 minutes duration at 2.8 kts) caught 4,217 Pacific herring, 31 Rainbow smelt, 7 age-0 walleye pollock, and 138 jellyfish. Herring and jellyfish comprised 38% and 56% of the catch by weight, respectively.

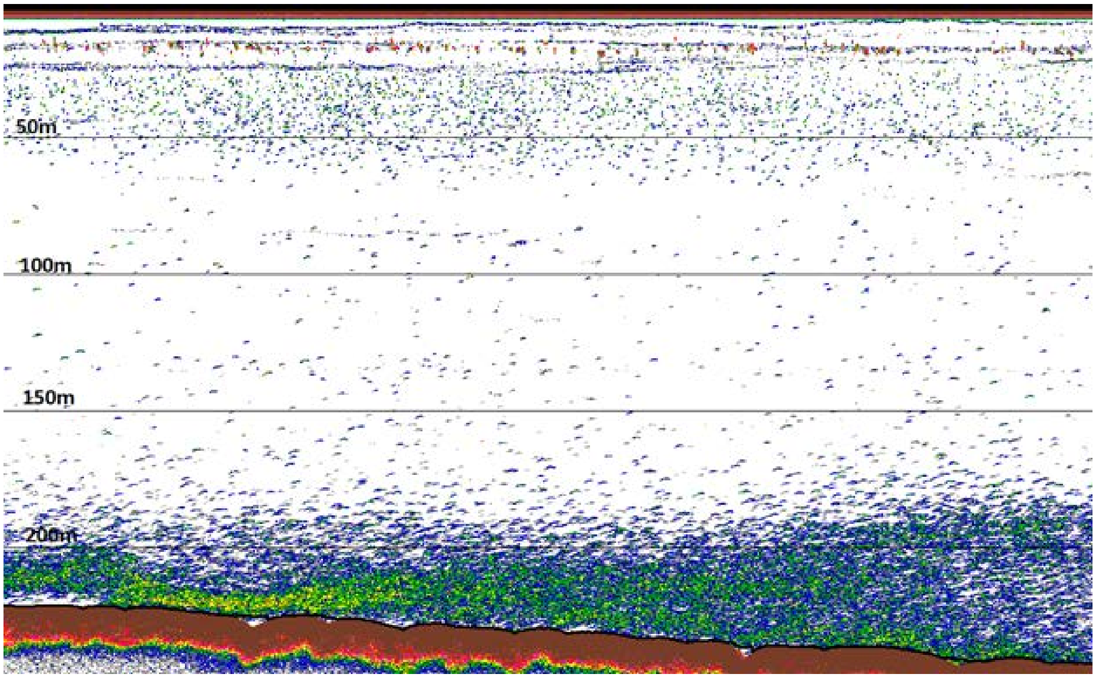


Figure 11. Acoustic backscatter in deep water of the Chukchi shelfbreak. A distinct deep scattering layer occurred at depth of approx. 150 m and persisted into deep water. A midwater trawl within the deep layer (>200m headrope depth) caught age-1+ Arctic cod with a mean length of 105 mm (range of 65 to 165 mm). Nearby sampling of backscatter in the upper 50m of the water column caught age-0 Arctic cod with a mean length of 42 mm (range of 25 to 61 mm).

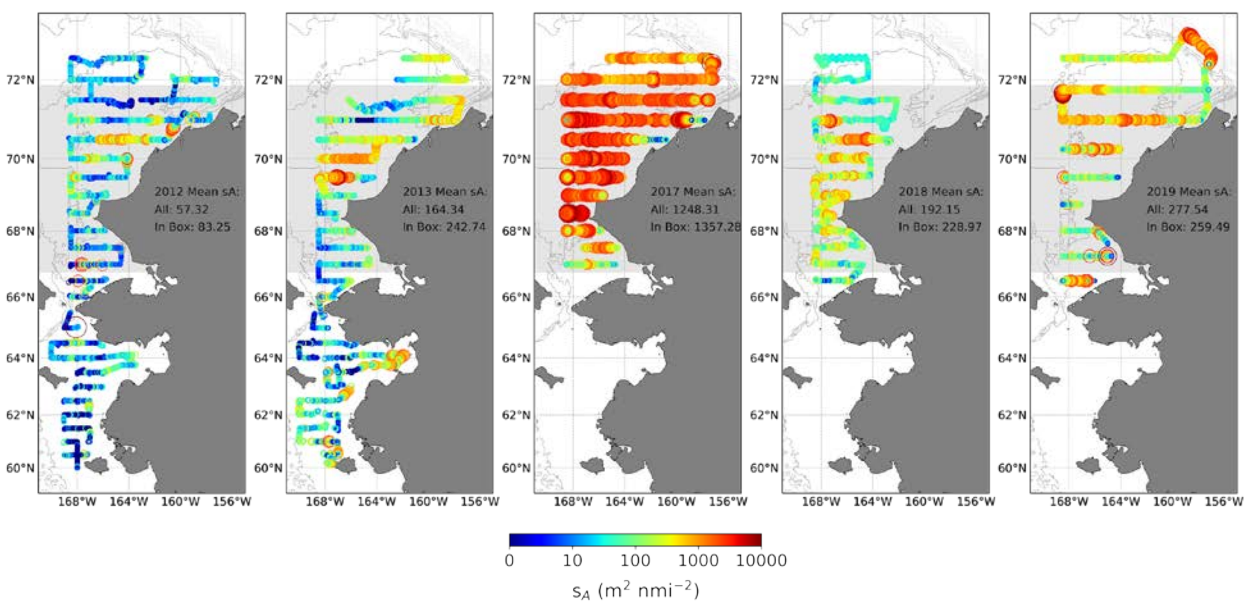


Figure 12. 38 kHz backscatter, a proxy of fish abundance, observed in five years of acoustic surveys (from left to right: 2012, 2013, 2017, 2018, and 2019). The mean integrated backscatter

of the whole survey (labeled as 'All') and between 67°N and 71.5°N (the gray-shaded area of the map, labeled as 'In Box') is indicated for each year.

Midwater Trawl Hauls:

A twice-modified Marinovich trawl with a 2x3 mm hexagonal codend liner was deployed with 3m trawl doors for midwater sampling. Nine fine-mesh (2x3 mm) recapture (pocket) nets were attached to the outside of the trawl to quantify escapement. A total of 42 midwater trawl hauls were conducted throughout the survey area to characterize the backscatter along the survey trackline. The net opening was approximately 7.7 m vertically by 7.4 m horizontally for all hauls. The average headrope depth ranged from 13.4m to 228.8 m, and average vessel trawling speed was 2.4 knots.

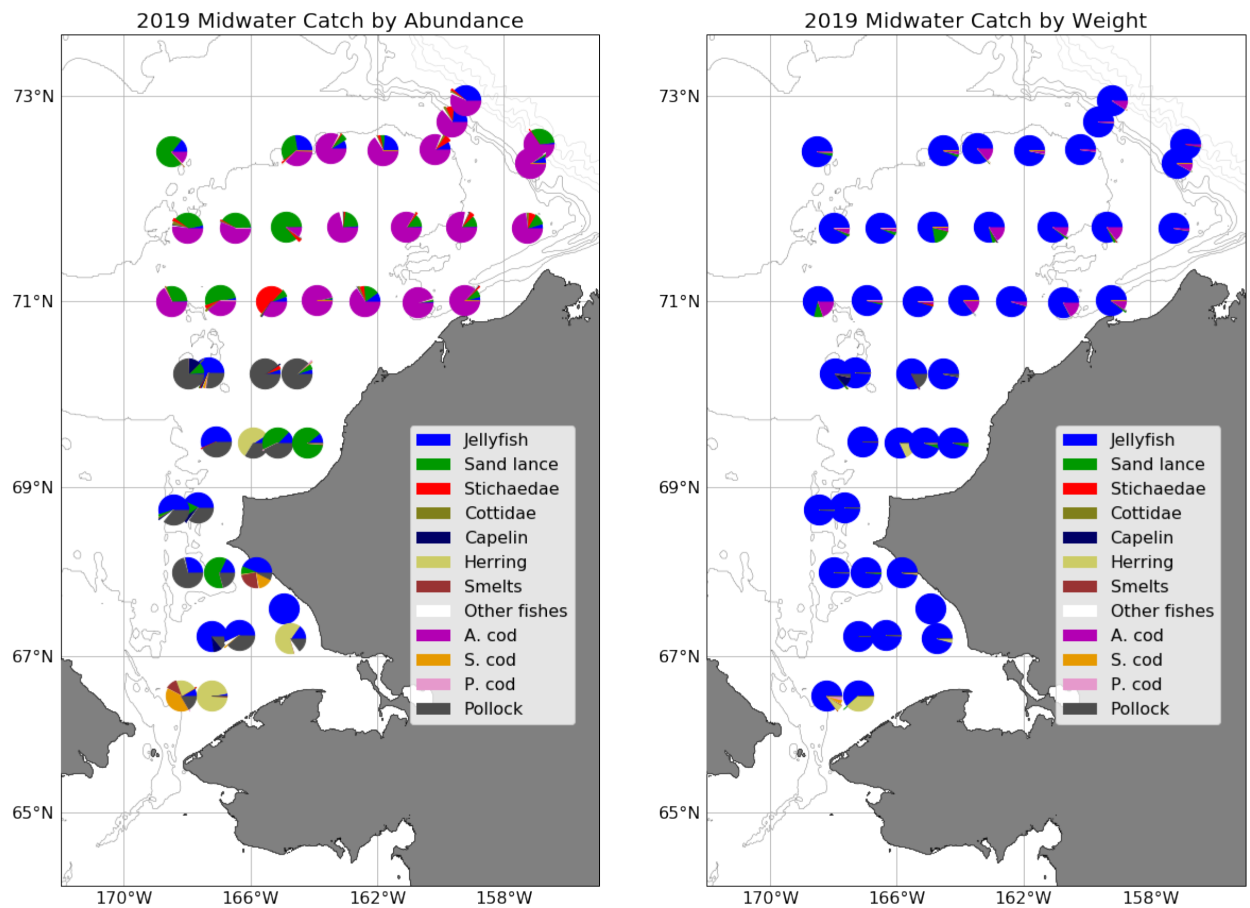


Figure 13. Midwater sampling locations indicating the catch composition as a measurement of proportion of fishes and jellyfish at each site based on abundance (left) and weight (right).

Age-0 Arctic cod (mean length 47 mm) dominated the midwater catch north of the 70.25N transect, and accounted for 45.2% of the total survey catch of fishes and jellyfish by numbers and 1.5% by weight based on all midwater trawl hauls. The age-0 Arctic cod were distributed from 71°N to 72.5°N with the largest catches occurring along the 71.25°N transect. Two trawls were conducted on fish layers deeper than 225 meters along the Chukchi Sea shelf break. Age-1+ Arctic cod with a mean length of 105 mm dominated the catch in these locations. Beginning at the 70.25°N transect and continuing south, age-0 walleye pollock (mean length 61 mm) were the dominant gadid caught, accounting for 11.8% of the total survey catch of fishes and jellyfish by numbers (Figure 13). Arctic sand lance were prevalent throughout the survey region, accounting for 22.6% of the total survey catch of fishes and jellyfish by numbers.

Stichaeids (6.8%), herring (5.1%), and *Aurelia* jellyfish (2.0%) were the next most abundant species after age-0 walleye pollock. Jellyfish dominated the catch by weight with *Chrysaora melanaster* contributing 54.4% and *Cyanea* capillata contributing 24.7%. Saffron cod and Pacific cod increased in abundance in the southern area of the survey and in midwater trawl hauls near Kotzebue Sound, but only accounted for 0.12% and 0.10% of the catch by weight, respectively (Table 3).

Table 3. Preliminary numbers and weight (kg) of fishes and invertebrates by species, common name, and Inupiat name caught in the midwater trawl. Numbers and weight are "raw" catch and have not been standardized to distance traveled.

Species	**Common Name**	**Inupiaq Name**	**Weight (kg)**	**Number**
Aequorea sp.	Aequorea jellyfish		12.31	30
Ammodytes hexapterus	Arctic Sand lance	Panmaksraq	38.23	26367
Amphipoda	Amphipod (unidentified)		0.45	2553
Anonyx sp.	Anonyx amphipod (unidentified)		0.005	5
Argis sp.	Argid (unidentified)		0.006	1
Asterias amurensis	Purple Orange sea star		0.342	6
Aurelia aurita	Aurelia jellyfish		7.55	53
Aurelia labiata	Aurelia jellyfish		8.601	9

Aurelia limbata	Brown rimmed jelly		398.44	2343
Benthosema glaciale	Benthosema amphipod		0.014	5
Blepsias bilobus	Crested sculpin	Kanayuq	0.044	1
Boreogadus saida	Arctic cod	Iqalugaq	59.65	52506
Buccinum scalariforme	Ladder whelk		0.008	2
Chaetognath	Chaetognath (unidentified)		0.01	6
Chionoecetes sp.	Tanner crab (unidentified)		0.076	2
Chrysaora melanaster	Chrysaora jellyfish		2152.7	1598
Clupea pallasi	Pacific herring		85.0	5991
Copepoda	Copepod (unidentified)		0.02	699
Cottidae	Sculpin (unidentified)	Kanayuq	0.001	1
Crangon dalli	Ridged crangon		0.001	1
Crustacea	Crustacean (unidentified)		0.1	738
Cyanea capillata	Lions mane jellyfish		975.9	2001
Echinacea	Sea urchin (unidentified)		0.2	2
Echiura	Echiuroid worm (unidentified)		0.013	4
Echiurus	Echiurus worm		0.012	2
Eleginus gracilis	Saffron cod	Uugaq	4.9	379

Enophrys diceraus	Antlered sculpin		0.066	1
Eualus gaimardi belcheri	Eualid		0.003	4
Eualus gaimardi	Eualid		0.0145	14
Euphausiacea	Euphausiid (unidentified)		24.0	
Fish larvae (unidentified)			0.1	381
Gadus chalcogrammus	Walleye pollock		55.3	13734
Gadus macrocephalus	Pacific cod		4.06	54
Gammaridae	Gammarid amphipod (unidentified)		0.294	2450
Gymnocanthus tricuspis	Arctic staghorn sculpin	Kanayuq	0.12	58
Hexagrammos stelleri	Whitespotted greenling		0.042	2
Hippoglossoides robustus	Bering flounder		0.001	1
Hyperidae	Hyperid amphipod (unidentified)		0.04	156
Limanda aspera	Yellowfin sole		0.269	2
Liparis fabricii	Liparis fabricii		0.044	3
Liparis sp.	Snailfish (unidentified)		0.03	27
Liparis tunicatus	Kelp snailfish		0.008	1
Lumpenus fabricii	Slender eelblenny		3.65	7155
Lumpenus sagitta	Snake prickleback		0.011	21

Mallotus villosus	Capelin	Panmagrak	16.8	1305
Myoxocephalus jaok	Plain sculpin	Kanayuq	0.127	2
Myoxocephalus scorpioides	Arctic sculpin	Kanayuq	0.004	6
Myoxocephalus scorpius	Shorthorn (Warty) sculpin	Kanayuq	1.2	686
Mysidacea	Mysid (unidentified)		0.1	397
Osmerus mordax	Rainbow smelt		1.7	224
Pandalus goniurus	Humpy shrimp		0.014	2
Phacellophora camtchatica	Egg yolk jellyfish		3.34	3
Pleuronectes quadrituberculatus	Alaska plaice		0.302	1
Pleuronectiformes larvae	Flatfish larvae (unidentified)		0.005	8
Pungitius pungitius	Ninespine stickleback		0.135	86
Reinhardtius hippoglossoides	Greenland turbot		0.003	1
Sclerocrangon sp.	Sclerocrangon shrimp (unidentified)		0.116	8
Scyphozoa	Jellyfish (unidentified)		1.2	66
Solaster sp.	Sea star (unidentified)		0.3	1
Squid (unidentified)			0.049	8
Staurophora mertensi	Staurophora jellyfish		126.4	287
Stichaeidae	Prickleback (unidentified)		0.47	769

Thoracica	Barnacle (unidentified)		0.049	1
Triglops pingeli	Ribbed sculpin	Kanayuq	0.0041	4
Ulcina olrikii	Arctic alligatorfish		0.0553	78

Surface fishes *(Ed Farley, Kris Cieciel, and Johanna Vollenweider)*

The 264 Nordic Rope Trawl with 3m X-Lite doors was deployed for half-hour tows at 12 pre-determined nearshore stations (Figure 14); however, only nine surface trawls were completed during the survey due to weather. The most numerous organisms caught in the surface trawl included sticklebacks (56%) that included ninespine and threespine, jellyfish (41%) that included *Chrysaora melanaster* and . Other fishes made up roughly 3% of the catch numbers including age-0 walleye pollock, saffron cod, and Pacific cod, juvenile Pacific salmon, Arctic sandlance, and Pacific herring (Table 4). By weight, jellyfish dominated the catch (99%), and was comprised of *Cyanea* (61%) and *Chrysaora melanaster* Jellyfish (38%).

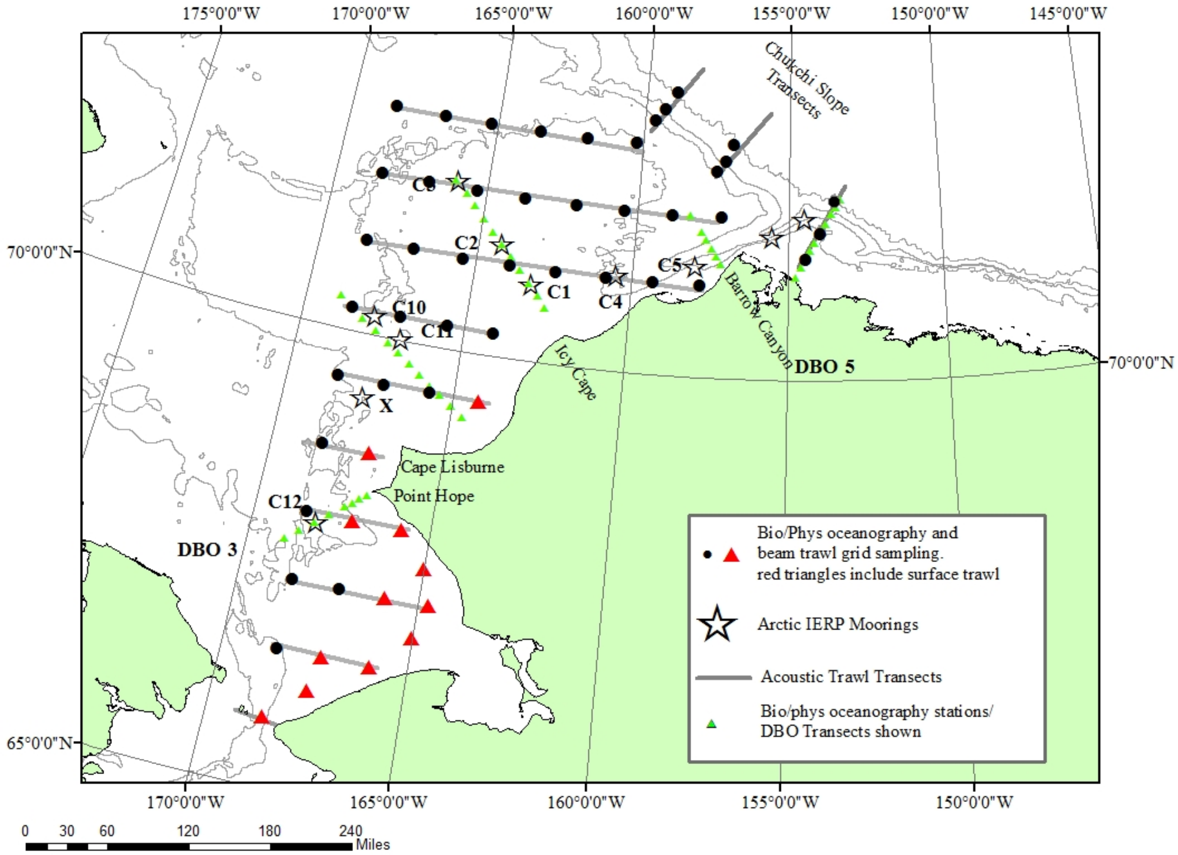


Figure 14. Map with station locations for the August – October 2019, Arctic Integrated Ecosystem Survey. Red triangles indicate stations where a surface trawl was to be performed.

Table 4. Preliminary numbers and weight (kg) of fishes by species, common name, and Inupiat name caught in the Nordic 264 surface trawl. Numbers and weight are "raw" catch and have not been standardized to net opening or distance traveled.

Family	**Species**	**Common Name**	**Inupiat Name**	**Number**	**Weight (kg)**
Aequoreidae	*Aequorea sp.*	Jellyfish		17	45.44
Ammodytidae	*Ammodytes hexapterus*	Sandlance	Panmaksraq	43	0.217
Arthropoda	*Argis* sp.	Shrimp		1	0.001

Clupeidae	*Clupea pallasii*	Pacific herring	Uqsruqtuuq	43	0.588
Cottidae	*Myoxocephalus scorpius*	Shorthorn sculpin	Kanayuq (general)	5	0.125
	Gymnocanthus tricuspis	Arctic staghorn sculpin		1	0.005
Cyaneidae	*Cyanea capillata*	Lions mane jellyfish		375	390.8
Gadidae	*Gadus macrocephalus*	Pacific cod		2	0.005
	Eleginus gracilis	Saffron cod/tomcod	Uugaq	6	0.037
	Gadus chalcogrammus	Walleye pollock		49	0.076
Gasterosteidae	*Pungitius*	Ninespine stickleback		772	1.29
	Gasterosteus aculeatus	Threespine stickleback		2355	2.54
Gonatidae	*Gonatus sp.*	Squid		1	0.012
Hemitripteridae	*Blepsias bilobus*	Crested sculpin	Kanayuk (general)	1	0.095
Laodiceidae	*Staurophora mertensi*	Jellyfish		706	14.12
Pelagiidae	*Chrysaora melanaster*	Jellyfish		258	349.32
Pleuronectidae	*Platichthys stellatus*	Starry flounder	Nataagnaq	1	0.738

Salmonidae	*Onchorynchus gorbuscha*	Pink salmon	Amaqtuuq	27	1.442
	Onchorynchus keta	Chum salmon		3	0.124
	Onchorynchus tshawytscha	Chinook salmon		5	0.508
	Onchorynchus kisutch	Coho salmon		1	0.306
Ulmaridae	*Aurelia labiata*	Jellyfish		36	33.5
	Aurelia limbata	Brown rimmed jellyfish			
	Phacellophora camtschatica	Fried egg jellyfish		3	0.96

Marine Birds and Marine Mammals ***(*****Kathy Kuletz, Liz Labunski, Marty Reedy, Charlie Wright & Linnaea Wright*****)***

The U.S. Fish and Wildlife Service (USFWS) conducted seabird surveys during the Arctic Integrated Ecosystem Survey (Arctic IES) Phase II, aboard the NOAA contract research vessel *Ocean Starr* from August 1-September 30, 2019. The seabird effort was funded through an Interagency Agreement (M17PG00017) with the Bureau of Ocean Energy Management (BOEM), Project AK-16-07c: Seabird Community Structure and Seabird-Prey Dynamics. These data will be integrated with Arctic IES data and will be archived in the North Pacific Pelagic Seabird Database (http://alaska.usgs.gov/science/biology/nppsd).

This report summarizes data collected during the Arctic IES portion of the cruise, in the Chukchi and Beaufort seas, although surveys were also conducted during transits to and from ports of call in the Bering Sea.

Methods

Marine birds and mammals were surveyed from the starboard side of the bridge using standard USFWS marine bird protocols, thus mammal observations cannot be used to calculate densities. Observations were conducted during daylight hours while the vessel was underway. The observer scanned the water ahead of the ship using hand-held 10x42 binoculars as necessary for identification and recorded all birds and mammals. We used a modified strip transect methodology with four distance bins from the center line: 0-50 m, 51-100 m, 101- 200 m, 201-300 m. Rare birds, large flocks, and mammals beyond 300 m or on the port side ('off transect') were also recorded but will not be included in density calculations. We recorded the species, number of animals, and behavior (on water, in air, foraging). Birds on the water or actively foraging were counted continuously, whereas flying birds were recorded during quick 'Scans' of the transect window. Scan intervals were based on ship speed, ranging during this cruise from 49 sec to 97 sec, with the median at 65 sec.

Geometric and laser hand-held rangefinders were used to determine the distance bin to bird sightings. Observations were directly entered into a GPS-interfaced laptop computer using the DLOG3 program (Ford Ecological Consultants, Inc., Portland, OR). Location data were also automatically written to the program in 20-second intervals, which allowed us to track survey effort and simultaneously record changing weather conditions, Beaufort Sea State, glare, and ice coverage (no ice was encountered during this cruise). Other environmental variables recorded at the beginning of each transect included wind speed and direction, cloud cover, sea surface temperature, and air temperature.

Preliminary Results and Discussion

Marine birds

Unidentified dark shearwaters (*Ardenna spp*) and short-tailed shearwaters (*Ardenna tenuirostris*) were 81% of all recorded seabird species throughout the survey area and dominated both the Chukchi and Beaufort Sea, comprising 81% and 85%, respectively (Table 5). Survey effort was very low in the Beaufort, thus the vast majority of the shearwaters were in the Chukchi Sea, with high densities south of Point Hope, offshore of Point Lay, and north of Wainwright (Figure 15).

The *Alcidae* family includes common murres (*Uria aalge*), thick-billed murres (*U. lomvia*), ancient murrelets (*Synthliboramphus antiquus*), crested auklets (*Aethia cristatella*), least auklets (*A. pusilla*), parakeet auklets (*A. psittacula*), horned puffins (*Fratercula corniculata*), and tufted puffins (*F. cirrhata*). This family comprised 8% of the birds throughout both regions, with a density of 8% in the Chukchi Sea and <1% in the Beaufort Sea. The three *Aethia* auklet species were 5% of birds in the Chukchi Sea, but were not observed in the Beaufort Sea. Among the auklets, crested auklets were most abundant, and were found north of 71.5ºN in the northern Chukchi Sea (Figure 16). Parakeet auklets were recorded offshore of Point Lay and Kivalina, while least auklets were primarily south of Point Hope.

We recorded seven species of Larids in the study area: pomarine jaeger (*Stercorarius pomarinus*), parasitic jaeger (*S. parasiticus),* long-tailed jaeger (*S. longicaudus*), black-legged kittiwake (*Rissa tridactyla*), glaucous gull (*Larus hyperboreus*), Sabine's gull (*Xema sabini*), and arctic tern (*Sterna paradisaea)* (Table 5). As a group, the *Laridae* family comprised 5% of total birds and were the most abundant group aside from shearwaters in the Beaufort Sea, comprising 13% of total birds in that region (Table 5). Black-legged kittiwakes were the majority of Larid species in the Chukchi Sea while the Beaufort Sea had equal numbers of kittiwakes and glaucous gulls (Table 5). Arctic tern was the second most abundant bird (10%) in the Beaufort Sea with the majority of birds recorded nearshore north of 70ºN (Figure 15). Most of the Sabine's gulls were recorded in a single forage flock of 21 birds near Icy Cape (Figure 17).

Phalaropus species, comprised of red phalaropes (*Phalaropus fulicarius*) and red-necked phalaropes (*P. lobatus*), have similar plumages in the fall and are difficult to distinguish at sea, thus many of the phalaropes were only identified to genus. Their relative density was 5% over both regions, although only three individuals were observed in the Beaufort Sea (Table 5). Phalarope numbers were highest in the Hope Basin along with smaller groups scattered offshore and near Wainwright (Figure 18).

Gavia species observed during this survey were pacific loon (*Gavia pacifica*), arctic loon (*G. arctica),* common loon (*G. immer*), and yellow-billed loon (*G. adamsii*). *Gavia* species were <1% of total birds in the Chukchi Sea (Table 5). Long-tailed ducks (*Clangula hyemalis*) were the most commonly encountered waterfowl, and with king eiders (*Somateria spectabilis*), and spectacled eiders (*Somateria fischeri*), comprised <1% of total birds (Table 5).

Marine mammals

We recorded marine mammals during our surveys, but because we used seabird survey protocols our observations cannot be used to calculate densities. The USFWS observer recorded 356 marine mammals of 10 identified species, including off-transect individuals. All sightings were in the Chukchi Sea with none observed in the Beaufort Sea. There were five *Mysticeti* species with 122 individuals, of which the humpback whale was the most common with 28 individuals (Table 6).

Gray whales (*Eschrichtius robustus*) were a commonly observed whale, with 11 records (Table 6). Three individuals of this species were photographed and those observations have been sent to Sue Moore, University of Washington, Seattle. These observations are part of an assessment of gray whale body condition to further the investigation of an UME (Unusual Mortality Event) declared by NOAA for this species. Walrus (*Odobenus rosmarus*) were the most frequently observed mammal (Table 6). With no ice at their normal haul out areas, walrus were congregating along the coastal waters of Point Lay.

Observations of dead birds and mammals

During the three legs of this study, we recorded 30 dead birds, all in the Chukchi Sea (Figure 19). The majority were alcids (*n* = 11), followed by six shearwaters, two sandpipers (*Scolopocidae spp*.), one kittiwake, and nine unidentified birds (Table 7). Most of the dead birds were encountered south of Point Hope and offshore of Point Lay. With the able assistance of the crew and scientists, we were able to collect 10 birds, which have been submitted to the USGS Wildlife Center in Madison, WI, for necropsies, testing for avian diseases, and tissue removal for toxin tests.

Additionally, three deceased walrus were observed, all of them headless. One seal, one unidentified cetacean, and two unidentified mammals were also found dead in the water in the Chukchi Sea. The majority of these animals were in advanced stages of decomposition. We submitted reports to the USFWS Marine Mammal office (Anchorage, AK) and to the NOAA Alaska Marine Mammal Stranding Network.

Table 5. Seabirds observed on transect during the 1 August-30 September 2019 Arctic IES cruise.

			CHUKCHI		**BEAUFORT**		**ALL REGION**	
Family	**Common Name**	***Latin name***	**No.**	**% Total**	**No.**	**% Total**	**No.**	**% Total**
Gaviidae	Unidentified loon	*Gavia spp.*	14	0.06	1	0.19	15	0.06
	Pacific loon	*Gavia pacifica*	56	0.24			56	0.24
	Arctic loon	*Gavia arctica*	1	<0.01			1	<0.01
	Common Loon	*Gavia immer*	3	0.01			3	0.01
	Yellow-billed loon	*Gavia adamsii*	5	0.02			5	0.02
Procellariidae	Northern fulmar	*Fulmaris glacialis*	107	0.47	1	0.19	108	0.46
	Unid, dark shearwater	*Puffinus spp.*	3	0.01			3	0.01
	Short-tailed shearwater	*Puffinus tenuirostris*	18435	80.64	457	84.94	18892	80.74

Hydrobatidae	Fork-tailed storm-petrel	*Oceanodroma furcata*	1	<0.01			1	<0.01
Anatidae	Unidentified waterfowl	*Anatidae family*	1	<0.01			1	<0.01
	Unidentified duck	*Anatidae spp.*	3	0.01			3	0.01
	Long-tailed duck	*Clangula hyemalis*	22	0.1			22	0.09
	Unidentified eider	*Somateria spp.*	2	<0.01			2	0.01
	King eider	*Somateria spectabilis*	14	0.06			14	0.06
	Common Eider	*Somateria mollissima*	1	<0.01			1	<0.01
	Spectacled Eider	*Somateria fischeri*	3	0.01			3	0.01
	White-winged scoter	*Melanitta fusca*	2	<0.01			2	0.01
Charadriidae	Pacific golden-plover	*Pluvialis fulva*	3	0.01			3	0.01
Scolopacidae	Unidentified shorebird	*Scolopacidae family*	13	0.06	1	0.19	14	0.06
	Unidentified turnstone	*Arenaria spp.*	1	<0.01	2	0.37	3	0.01
	Unidentified phalarope	*Phalaropus spp.*	689	3.01			689	2.94
	Red phalarope	*Phalaropus fulicarius*	492	2.15			492	2.1
Laridae	Pomarine jaeger	*Stercorarius pomarinus*	28	0.12			28	0.12
	Unidentified jaeger	*Stercorarius spp.*	10	0.04			10	0.04
	Parasitic jaeger	*Stercorarius parasiticus*	12	0.05	4	0.74	16	0.07
	Long-tailed jaeger	*Stercorarius longicaudus*	1	<0.01			1	<0.01

	Unidentified gull	*Laridae family*	4	0.02			4	0.02
	Black-legged kittiwake	*Rissa tridactyla*	822	3.6	7	1.3	829	3.54
	Sabine's gull	*Xema sabini*	54	0.24	1	0.19	55	0.24
	Glaucous gull	*Larus hyperboreus*	95	0.42	7	1.3	102	0.44
	Arctic tern	*Sterna paradisaea*	78	0.34	53	9.85	131	0.56
	Unidentified alcid	*Alcidae family*	73	0.32	4	0.74	77	0.33
Alcidae	Unidentified murre	*Uria spp.*	78	0.34			78	0.33
	Common murre	*Uria aalge*	114	0.5			114	0.49
	Thick-billed murre	*Uria lomvia*	313	1.37			313	1.34
	Unidentified murrelet	*Brachyramphus spp.*	3	0.01			3	0.01
	Kittlitz's murrelet	*Brachyramphus brevirostris*	3	0.01			3	0.01
	Ancient murrelet	*Synthliboramphus antiquus*	21	0.09			21	0.09
	Unidentified auklet	*Aethia spp.*	53	0.23			53	0.23
	Crested Auklet	*Aethia cristatella*	734	3.21			734	3.14
	Least auklet	*Aethia pusilla*	244	1.07			244	1.04
	Parakeet auklet	*Aethia psittacula*	199	0.87			199	0.85
	Horned puffin	*Fratercula corniculata*	26	0.11			26	0.11
	Tufted puffin	*Fratercula cirrhata*	16	0.07			16	0.07
Aves class	Passerine	*Passeriformes spp.*	1	<0.01			1	<0.01
	Unidentified bird	*Aves spp.*	9	0.04			9	0.04
			22862		**538**		**23400**	

Table 6. Marine mammals observed (on and off transect), 1 August-30 September, 2019 Arctic IES. No mammals were observed in the Beaufort Sea**.**

Order	**Suborder**	**Common name**	***Latin name***	**Chukchi**
Cetacea		Unidentified Whale	*Cetacea (Order)*	70
	Mysticeti	Bowhead whale	*Balaena mysticetus*	2
		Fin Whale	*Balaenoptera physalus*	6
		Minke Whale	*Balaenoptera acutorostrata*	5
		Humpback Whale	*Megaptera novaeangliae*	28
		Gray whale	*Eschrichtius robustus*	11
	Odontoceti	Killer whale	*Orcinus orca*	1
		Harbor Porpoise	*Phocoena phocoena*	1
Carnivora	**Pinnipedia**	Unidentified Pinniped	*Caniformia (Suborder)*	8
		Unidentified Seal	*Phocidae (Family)*	7
		Ringed Seal	*Pusa hispida*	1
		Walrus	*Odobenus rosmarus*	216
				356

Table 7. Dead birds observed in the Chukchi Sea, 1 August-30 September, 2019 during Arctic IES; all records in this table were observed in the Chukchi Sea. This table does not include dead birds found during transit between Dutch Harbor and the study area.

SPECIES	**No.**	**No.**
Observed	**Observed**	**Collected**
Black-legged kittiwake	1	1
Crested auklet	1	1
Northern fulmar	1	
Thick-billed murre	1	1
Unidentified auklet	1	
Tufted puffin	1	1
Horned puffin	2	
Pectoral sandpiper	2	2
Unidentified murre	2	
Common murre	3	2
Short-tailed shearwater	6	2
Unidentified bird	9	
	30	**10**

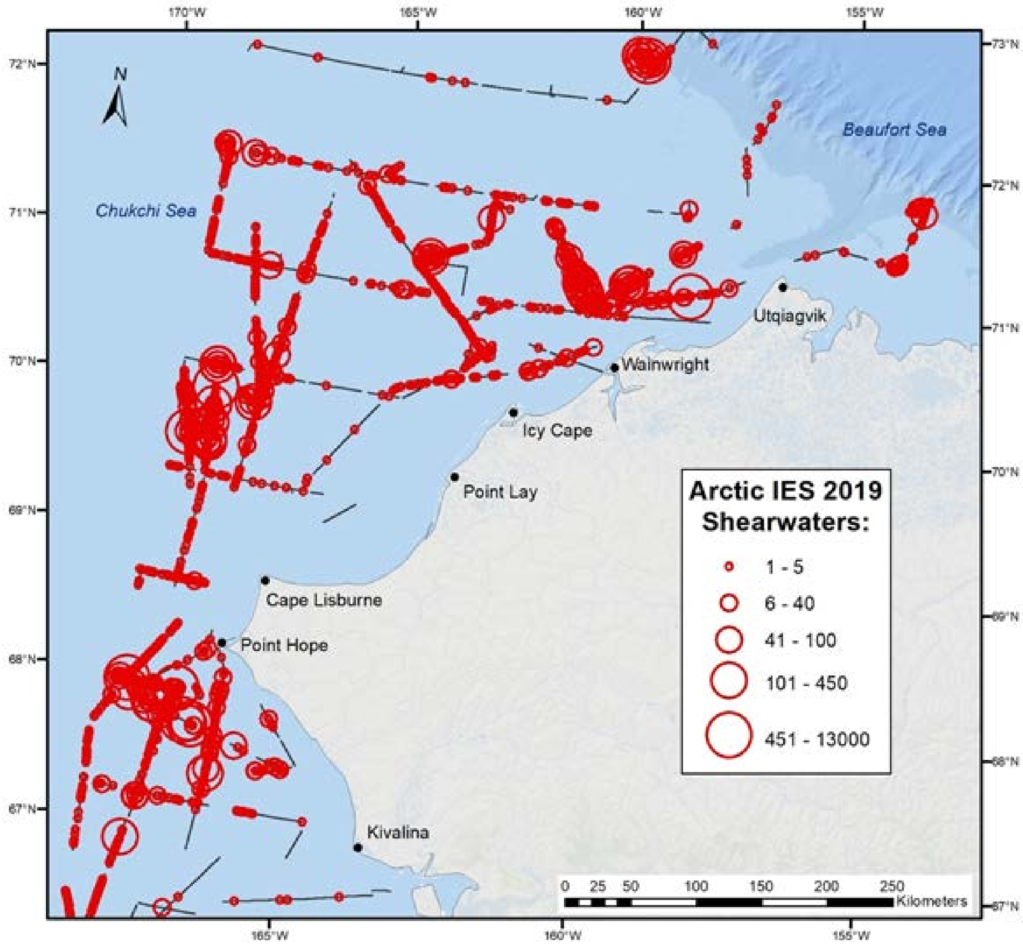


Figure 15. Distribution of shearwaters observed during the Arctic IES survey, 1 Aug – 30 Sept 2019.

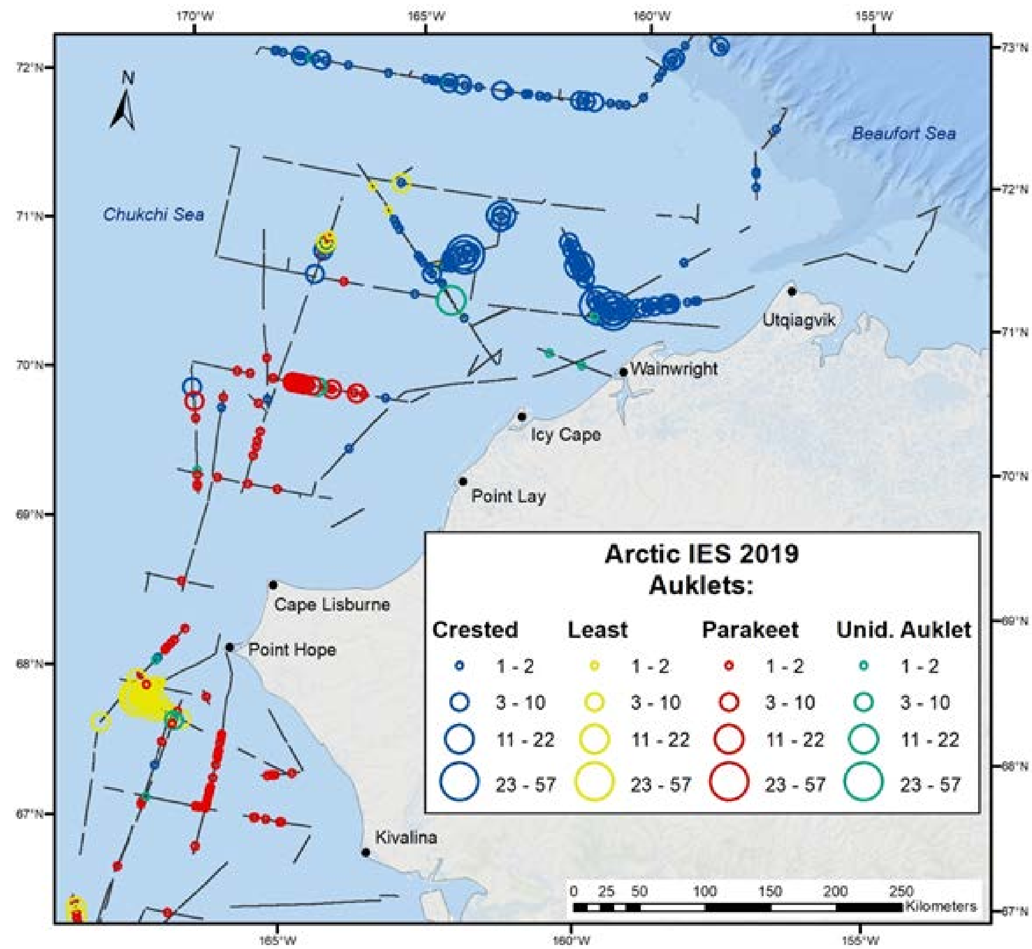


Figure 16. Distribution of auklets observed during the Arctic IES survey, 1 Aug – 30 Sept 2019.

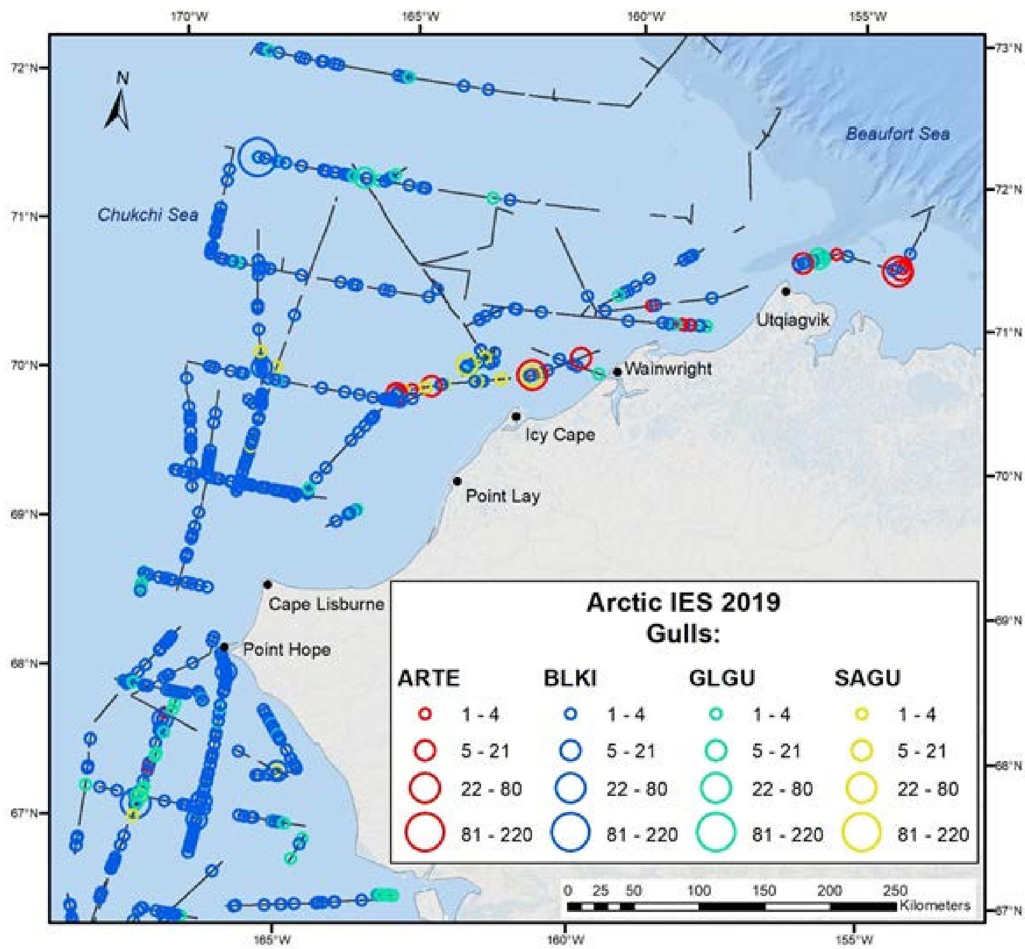


Figure 17. Distribution of Larid species observed during the Arctic IES survey, 1 Aug – 30 Sept 2019. Species Codes: ARTE (Arctic Tern), BLKI (Black-legged Kittiwake), GLGU (Glaucous Gull), SAGU (Sabine's Gull).

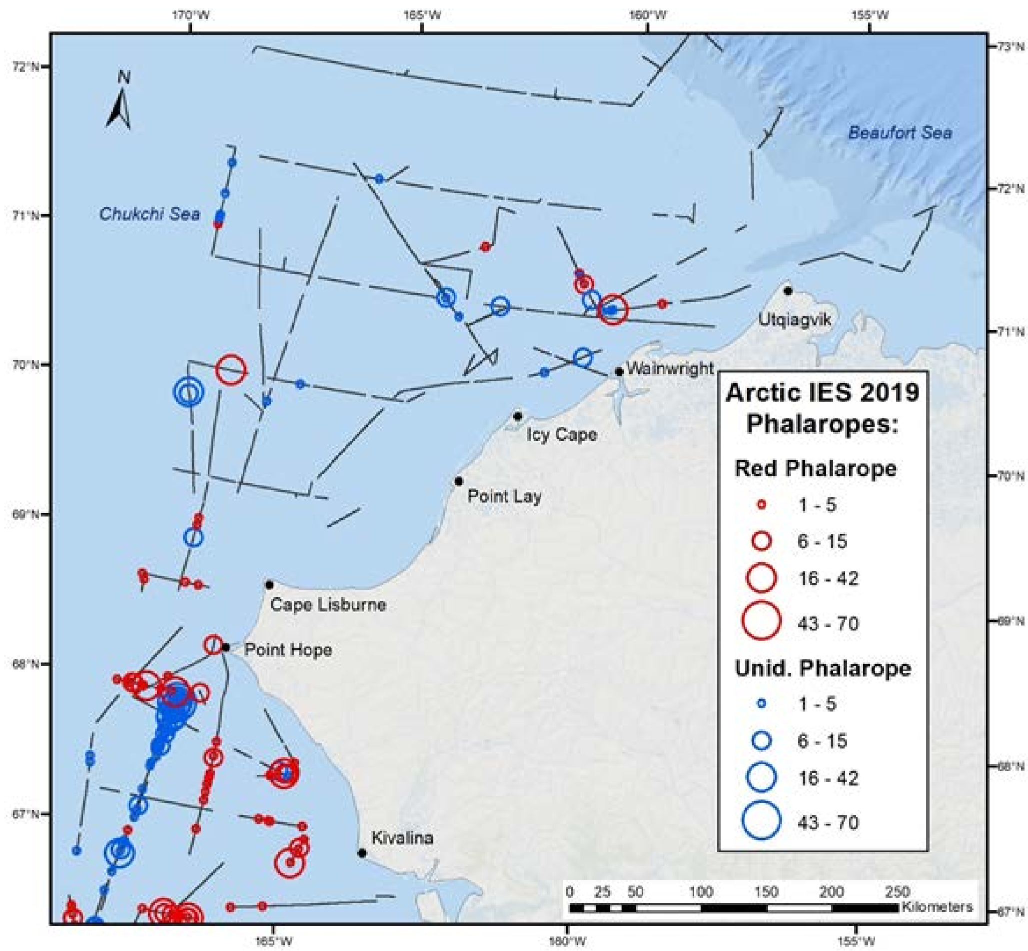


Figure 18. Distribution of phalaropes observed during the Arctic IES survey, 1 Aug – 30 Sept 2019.

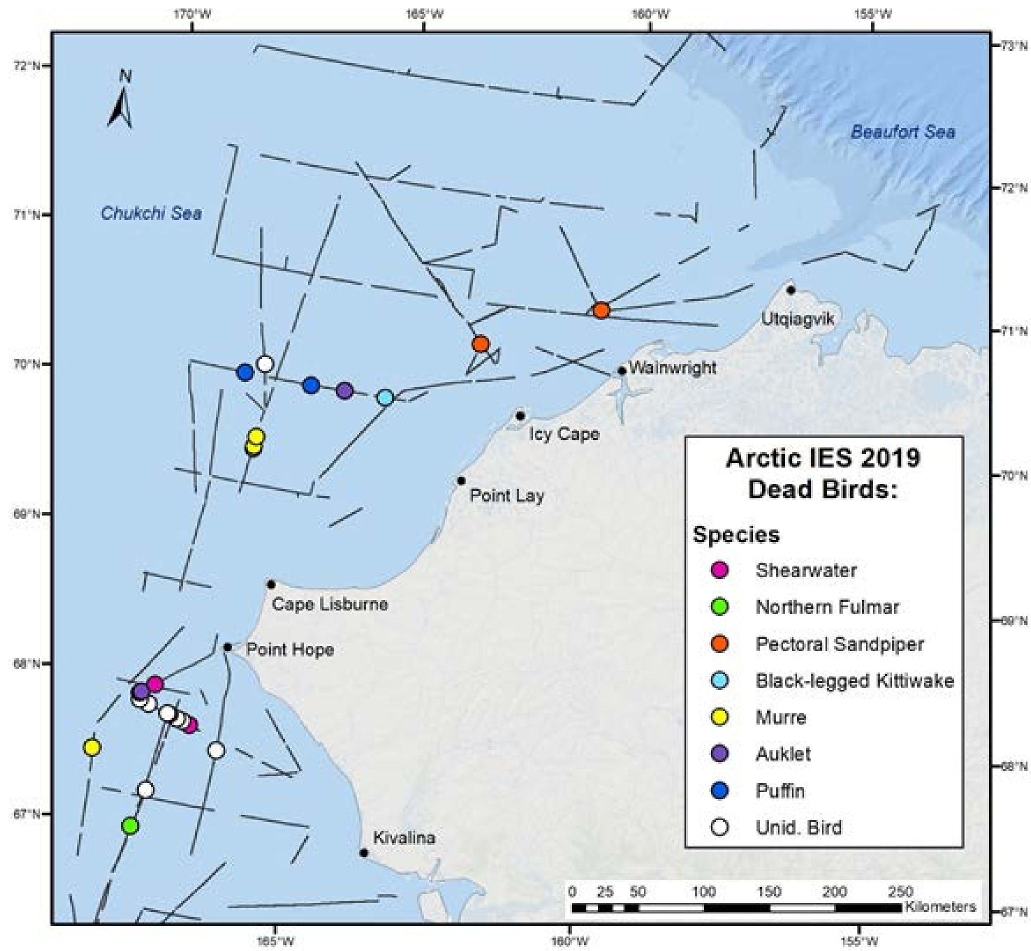


Figure 19. Distribution of dead birds observed during the Arctic IES survey, 1 Aug – 30 Sept 2019.

Moorings *(Phyllis Stabeno, Carol Ladd, Seth Danielson, Ryan McCabe, Peter Shipton, Catherine Berchok, David Strausz, Sarah Donohoe, Jordie Maisch, Robert Levine)*

Mooring operations for Leg 1 of the IERP survey consisted of 31 moorings recovered and 19 moorings deployed. Recoveries included 7 UAF moorings, 10 NOAA Marine Mammal passive acoustic moorings, and 14 NOAA PMEL moorings. Deployments consisted of two UAF moorings, nine NOAA Marine Mammal passive acoustic moorings, and eight NOAA PMEL moorings. During Leg 2 of the survey, an additional three active acoustic moorings were recovered. On Leg 3, a single NOAA Marine Mammal passive acoustic mooring was deployed.

a. Biophysical Ecosystem Moorings (Peter Shipton, David Strausz, Sarah Donahue, Jordie Maisch, Ryan McCabe)

Biophysical mooring recoveries included 3 ice profiler moorings, 15 ADCP (Acoustic Doppler Current Profiler) moorings, two water sampler moorings, a single point current meter mooring, and a sunken (by design) surface mooring . Deployments were scaled back due to restrictions on ship weight; no ice profiler moorings were redeployed. The deployed moorings consisted of seven ADCP moorings, two water sampler moorings, and one surface mooring deployed with the NOAA PMEL ITAE wire-crawling "Prawler". This surface mooring is designed to sink near the end of the ice-free season, then inflate itself, and resurface after the winter ice has melted away. Two UAF moorings were recovered by dragging (N1 and N5). The UAF N3 mooring in 30 m of water was intentionally left because the acoustic release reported that it was tilted > 45 degrees, suggesting severe biofouling or potential loss of floatation. Recovery by divers was deemed safer than dragging, for both data recovery and for avoiding damage to the instrumentation (and lithium batteries). Two incidents occurred during mooring operations on Leg 1 of the cruise. The first involved a swell-induced swinging anchor that damaged three Niskin bottles on the CTD. In the second incident a mooring recovery line was sucked into the ship's port side propeller and had to be freed by divers. Mooring recovery and deployment times and positions are listed in Tables (8-9).

b. Passive Acoustic Moorings (C. Berchok)

The passive acoustics work on Leg 1 consisted of retrieving and deploying ten moorings. Six of these moorings were located in clusters with the biophysical moorings as described above (Tables 8-9), while three were co-located with both biophysical and active acoustic moorings (see Section c below). All recovered moorings except one contained a full year of data, which was extracted from the recorders and will be brought to Seattle for future analysis as funding permits. A total of 3287 days (2.25TB) of data were successfully collected. Especially notable, the recorder (AL18_AU_IC1) that was caught in the port screw, and dragged along to the anchorage off Wainwright, continued to record until it was shut off on deck. The AL18_AU_CC2 mooring (Cluster C11) did record for 159 days, but the hard drive appears to have failed on 23 Jan 2019; attempts to extract the data from the drive have proven unsuccessful, and professional services will be sought at a later time. Of the ten moorings deployed, seven were similar redeployments in the same location, one (AL19_AU_PH1) was incorporated onto the C12 oceanographic mooring at the same location. The AL19_AU_CL1 mooring was moved to the C11 location in 2018, and was deployed back at its original long-term location off Cape Lisburne; the main mooring location for detections of minke whale boing calls. The final mooring deployment (AL19_AU_BS11) was made during the transit from Nome to Dutch Harbor in the Bering Sea. This mooring location is part of our decade-long detection array for the Critically Endangered North Pacific Right Whale; of which less than 30 remain.

All recorders were set to a sampling rate of 16 kHz, on a duty cycle of 80 minutes of recordings made every five hours. Results will consist of the long-term seasonal calling activity levels of nine species of marine mammals (bowhead, gray, humpback, minke, beluga, and killer whales, bearded and ribbon seals, and walrus), fish (work preliminary), two anthropogenic sound sources (airgun and vessel), and one environmental sound source (ice noise). Temperature and pressure data are also collected. In addition, quantitative measurements on the acoustic environment surrounding these mooring will be possible from these data.

c. ***Active Acoustics Moorings*** (R. Levine)

Three bottom-mounted upward-looking echosounders operating at 38, 70, and 200 kHz along with associated sensors (CTD, orientation) were recovered in the Chukchi Sea during Leg 2. Data from these moorings will be used to describe seasonal changes in abundance and track the movement patterns of Arctic cod to understand the role of the Chukchi as a nursery area for this species. The moorings were initially deployed in August 2017, then recovered and redeployed in August 2018. The first mooring (DAFT-1) was recovered on 26 Aug at 70° 0.838N, 166° 51.48W, the second (DAFT-2) on 4 Sept at 70° 50.102N, 163° 7.08W, and the third (DAFT-3) on 3 Sept at 71° 2.334N, 160° 30.24W.

Table 8. Moorings recovered during Leg 1 including date, time, longitude, latitude, and bottom depth.

OS1901 Mooring Recoveries									
Mooring	**PI**	**Status**	**Date [UTC]**	**Time [UTC]**	**Latitude Deg [N]**	**Latitude Min [N]**	**Longitude Deg [W]**	**Longitude Min [N]**	**Bottom Depth [m]**
N1-18	Danielson	Recovered	8/7/2019	7:22:21	63	17.789	168	25.802	46
N2-18	Danielson	Recovered	8/7/2019	15:14:43	64	9.29112	171	31.55334	46
N4-18	Danielson	Recovered	8/7/2019	23:25:40	64	55.7222	169	55.0923	49
AL18_AU_NM1	Berchok	Recovered	8/9/2019	14:20:36	64	51.080	168	23.670	45
N5-18	Danielson	Recovered	8/10/2019	14:24:57	67	32.2756	164	53.1732	36
AL18_AU_PH1	Berchok	Recovered	8/11/2019	1:17:54	67	54.652	168	11.800	61
18CKP-12A	Stabeno	Recovered	8/11/2019	1:32:29	67	54.582	168	11.392	62
18CKP-10A	Stabeno	Recovered	8/12/2019	14:27:04	70	13.158	167	47.506	49
AL18_AU_CC2	Berchok	Recovered	8/12/2019	17:57:44	70	0.963	166	51.886	49
18CKP-11A	Stabeno	Recovered	8/12/2019	18:18:33	70	1.022	166	51.202	49
AL18_AU_IC3	Berchok	Recovered	8/13/2019	14:43:34	71	29.834	166	2.404	46
18CKP-3A	Stabeno	Recovered	8/13/2019	15:00:37	71	49.491	166	3.508	47
18CKIP-3A	Stabeno	Recovered	8/13/2019	15:21:39	71	49.718	166	3.161	52
AL18_AU_IC2	Berchok	Recovered	8/14/2019	1:49:02	71	12.904	164	15.612	45
18CKP-2A	Stabeno	Recovered	8/14/2019	2:05:00	71	13.201	164	15.158	45
18CKIP-2A	Stabeno	Recovered	8/14/2019	2:28:25	71	12.828	164	15.158	46
18CKR-2A	Stabeno	Recovered	8/14/2019	2:48:47	71	13.092	164	14.404	45
18CKV-2A	Stabeno	Recovered	8/14/2019	3:04:31	71	13.01	164	14.972	46
18CKP-14A	Stabeno	Recovered	8/15/2019	1:41:52	70	42.456	162	27.053	42
AL18_AU_IC1	Berchok	Recovered	8/15/2019	14:36:16	70	50.039	163	7.002	45
18CKP-1A	Stabeno	Recovered	8/18/2019	14:09:37	70	50.141	163	7.403	45
18CKIP-1A	Stabeno	Recovered	8/18/2019	14:28:55	70	50.341	163	7.736	45
CEO CEM1-18	Danielson	Recovered	8/19/2019	15:03:41	71	35.999	161	30.406	46
CEO CEM2-18	Danielson	Recovered	8/19/2019	15:26:30	71	35.997	161	31.683	46
AL18_AU_WT1	Berchok	Recovered	8/19/2019	22:05:14	71	2.610	160	29.790	52
18CKP-4A	Stabeno	Recovered	8/19/2019	21:44:00	71	2.622	160	30.213	52
AL18_AU_PB1	Berchok	Recovered	8/20/2019	4:32:44	71	12.210	158	0.714	49
18CKP-5A	Stabeno	Recovered	8/20/2019	4:21:00	71	12.467	158	1.049	49
AL18_AU_BF2	Berchok	Recovered	8/20/2019	13:43:16	71	45.060	154	27.852	88
AL18_AU_BF1	Berchok	Recovered	8/21/2019	3:56:55	71	33.072	155	32.022	70
N6-18	Danielson	Recovered	8/22/2019	23:11:07	67	40.2573	168	44.75136	51

Table 9. Moorings deployed during Leg 1 including date, time, longitude, latitude, and bottom depth.

OS1901 Mooring Deployments									
Mooring	**PI**	**Status**	**Date [UTC]**	**Time [UTC]**	**Latitude Deg [N]**	**Latitude Min [N]**	**Longitude Deg [W]**	**Longitude Min [N]**	**Bottom Depth [m]**
AL19_AU_BS2	Berchok	Deployed	8/4/2019	0:41:00	59	14.137	169	24.800	55
AL19_AU_NM1	Berchok	Deployed	8/9/2019	15:01:34	64	51.213	168	23.630	45
19CKP-12A	Stabeno/Berchok	Deployed	8/11/2019	2:14:47	67	54.712	168	11.628	60
AL19_AU_CL1	Berchok	Deployed	8/12/2019	0:49:45	69	18.977	167	37.007	50
AL19_AU_IC3	Berchok	Deployed	8/13/2019	16:09:14	71	49.728	166	3.993	46
19CKP-3A	Stabeno	Deployed	8/13/2019	15:56:36	71	49.486	166	3.560	46
19CKP-1A	Stabeno	Deployed	8/18/2019	15:00:34	70	50.329	163	7.698	45
AL19_AU_IC1	Berchok	Deployed	8/18/2019	15:14:02	70	50.156	163	7.344	45
19CKITAEPR-2A	Stabeno	Deployed	8/18/2019	21:17:36	71	12.739	164	13.341	46
19CKP-2A	Stabeno	Deployed	8/18/2019	21:36:53	71	13.203	164	15.088	45
AL19_AU_IC2	Berchok	Deployed	8/18/2019	21:48:43	71	13.005	164	15.110	45
19CKR-2A	Stabeno	Deployed	8/18/2019	22:08:23	71	12.848	164	15.159	46
CEM2-19	Danielson	Deployed	8/19/2019	16:03:57	71	35.979	161	31.648	47
CEM1-19	Danielson	Deployed	8/19/2019	16:18:12	71	35.971	161	30.419	47
19CKP-4A	Stabeno	Deployed	8/19/2019	22:25:26	71	2.591	160	29.706	52
AL19_AU_WT1	Berchok	Deployed	8/19/2019	22:35:43	71	2.623	160	30.201	52
19CKP-5A	Stabeno	Deployed	8/20/2019	4:54:58	71	12.212	158	0.722	48
AL19_AU_PB1	Berchok	Deployed	8/20/2019	5:03:53	71	12.346	158	0.660	49
AL19_AU_BF2	Berchok	Deployed	8/20/2019	13:57:07	71	45.139	154	28.173	100

International Collaboration *(Ed Farley)*

We were fortunate to have two Russian scientists on the survey during legs 2 and 3. Natalia Kuznetsova is from the TINRO Center in Vladivostok, Russia. Natalia Kuznetsova is a Marine Biologist, specializing in zooplankton ecology and fish diet. Igor Grigorov is from the VNIRO Center in Moscow, Russia. Igor is a Research Fish Biologist, specializing in marine ecology of fishes.

Natalia Kuznetsova and Igor Grigorov (photo credit, Matt Baker)

Community Outreach *(Jared Weems)*

Outreach events associated with the 2019 Arctic Integrated Ecosystem Survey occurred during port calls in Nome and Unalaska.

September 14, 2019 - Nome, AK
Dr. Ed Farley provided the context for Arctic Integrated Ecosystem Research Program research and a summary of Arctic IES results to the Nome Nugget (Printed on 9/19/2019; see below) and KNOM Radio.
Jared Weems (UAF) hosted ship tours of the R/V OCEAN STARR and Arctic IES research to 25+, 5-8 grade students from Anvil City Science Academy (ACSA) in Nome. Teacher and parent chaperones also participated.

September 15-18, 2019 - Nome, AK
Jared Weems provided two days of ACSA science classroom instruction for 55+, 5-8 grade students from Anvil City Science Academy (ACSA) in Nome. Activities included follow up on the ship tours, creating arctic marine food webs, and startup of a Winterberry citizen science project with help from teacher Mr. Keane Richards.

September 16, 2019 - Nome, AK
Jared Weems provided a UAF Northwest Campus and Alaska Sea Grant sponsored Strait Science Series talk entitled "Arctic IES Program research update and insights on king crab recruitment". It was open to the public and well attended with 29 audience members. Arranged and advertised by Sea Grant MAP Agent Gay Sheffield.

October 3, 2019 – Unalaska / Dutch Harbor, AK
Zane Chapman (UAF), Esther Goldstein (NOAA), and Miranda Irby (NC State) visited Lucy Ortiz and Mary Heimes 4th grade classroom (35 students) at Unalaska City Elementary School to provide an overview of preliminary results from the Arctic IES. They presented photos of the different types of sampling gear, what was caught in the sampling gear, and then explained how it all fit into assessment of the Arctic ecosystem.

Nome Nugget Newspaper Article
Scientists Sample The Chukchi And Beaufort Seas For Effects Of Climate Warming
http://www.nomenugget.com/news/scientists-sample-chukchi-and-beaufort-seas-effects-climate-warming
BY: SANDRA L. MEDEARIS
FRI, 09/20/2019 - 4:31PM

The NOAA research vessel Ocean Starr tied up at the port causeway last weekend, one in a parade of vessels carrying ocean scientists and their tools to document effects of climate warming and loss of sea ice on the Arctic marine ecosystem.

Fisheries research scientist Ed Farley and his team stopped at Nome following a three-week research cruise of the Chukchi and Beaufort seas where they worked the waters for an extensive look at midwater fishes as well as the food web and physical environment in that part of the Arctic. "We're trying to understand what is happening within the water column, the changes that may be occurring as we're starting to see these big shifts in seasonal ice in terms of the loss of sea ice and the warming of the water column," Farley explained.

Farley is a program manager at the Ecosystem Monitoring and Assessment Program at Alaska Fisheries Science Center laboratory in Juneau.

The team has performed sampling at 32 stations 30 nautical miles apart and completed 27 midwater trawl tows for samples to be examined, weighed, measured and recorded in the Ocean Starr's onboard lab. The survey area lies between latitudes 70°N and 72.5°N on the Chukchi Sea shelf.
At each station the team is collecting information on zooplankton, the prey of fish and birds.
The scientists' integrated study looks at the ecosystem through the lenses of physical oceanography—temperature and dissolved oxygen, the abundance of zooplankton and larval fish for analysis in the shipboard laboratory to find out what is going on with distribution of sea life and changes in the lowest elements of the food chain; they looked at midwater fishes. Arctic cod less than a year old dominated the midwater catch.

"We captured large numbers of Arctic sand lance within the midwater tows which constituted a significant percentage of the catch abundance in the western portion of the survey area," said Farley. "That was new to us, in this northern region. This isn't the first time we've been out here." The program has performed the integrated study four times—2012, 2013, 2017 and 2019. Arctic sand lance were not found in large numbers in 2017, and were typically only caught south of Cape Lisburne.

"The only thing I'm seeing that is really different than what we saw in the past is this northern extension of age zero walleye pollock," he said. "I was surprised to see just how big they were in the nearshore area."

They are conducting benthic trawls—sampling invertebrates as snails, small snow crab, and brittle stars as well as small fishes in the bottom.

Benthic? That's anything associated with the bottom of a body of water.

“As usual for bottom trawls in this area, invertebrates dominated the catches, providing 97 percent of catch weight and only 3 percent was fish,” Farley said in a report to colleagues on the second leg of the survey.

The team took bottom grabs to examine the surface of the ocean floor. They collected mud samples, which they dumped out and sorted through in the lab, examining and recording everything in it.

Farley showed a large freezer in the lab that held hundreds of small fish and other specimens that will go to the Auk Bay Laboratory for further study.

The team uses a fine sieve apparatus—a bongo net, which looks like what? A couple of bongo drums. The net takes and strains the water column at mid-depths for plankton samples. They sampled fish for harmful algal blooms.

The scientists also use an apparatus called a CTD, an instrument that measures conductivity, temperature and depth (for pressure) of seawater. The gadget has a carousel of bottles, called Niskin bottles, which may be opened and shut by push button for sampling water at desired depths. The scientists found very warm temperatures at the bottom and on the surface of the Chukchi in the survey area. Surface areas across the shelf varied from 5.3°C to 10.9°C, or 41.5° F to 51.6°F. “Wow, that’s way up. In this region, in the Chukchi, that’s astounding,” Farley said. “We didn’t want that.”

Bottom temperatures including all stations ranged from negative 1.6°C to 7.7°C, or 29.12°F to 45.9°F. The warmest surface and bottom temperatures were recorded inshore near Icy Cape.
The next leg of the survey voyage has taken the team to the Southern Chukchi Sea where they will sample for juvenile salmon.

It is likely the rapidly warming Arctic region will continue to surprise and astound members of the science community who are trying to understand what is happening with the ecosystem. While the recession of the sea ice has not reached or exceeded the lower limits of record season 2012, it is getting close. This week, anecdotal reports from Kaktovik say the weather is in the high 50°s F; the trailing edge of the sea ice is 800 miles north of Savoonga, St. Lawrence Island, and 400 miles north of Utqiagvik (formerly Barrow).

The work is part of the Arctic Integrated Ecosystem Survey Aug. 23 to Sept. 19.

Farley’s current research is focused on addressing hypotheses that link climate change and variability to ecosystem function and to link ecosystem function to fish growth, fitness, and survival at critical life history stages.

There will be a final report on findings following conclusion of the final voyage of the survey and additional analysis.

Appendices

Appendix A: Event Activity Log

SURVEY	EVENT_ID	GEAR	Date/Time (GMT)	Latitude	Longitude
201901	2	CTD	08072019 04:17:46.014	63.2941	-168.425
201901	4	CTD	08072019 14:27:12.925	64.1566	-171.503
201901	6	CTD	08072019 22:51:46.941	64.9278	-169.92
201901	8	CTD	08082019 14:23:23.207	64.3933	-167.088
201901	9	CTD	08082019 16:18:11.815	64.3892	-167.076
201901	12	CTD	08092019 15:36:44.907	64.8504	-168.394
201901	13	CTD	08102019 14:09:26.655	67.5386	-164.886
201901	15	CTD	08102019 15:54:14.063	67.5407	-164.894
201901	16	CTD	08112019 01:03:22.038	67.9109	-168.195
201901	20	CTD	08112019 14:07:12.534	68.6725	-167.742
201901	22	CTD	08112019 19:39:57.766	68.6729	-167.747
201901	23	CTD	08122019 00:26:42.123	69.319	-167.622
201901	25	CTD	08122019 14:07:37.570	70.2177	-167.797
201901	27	CTD	08122019 17:38:50.014	70.0171	-166.866
201901	30	CTD	08132019 14:13:05.387	71.8271	-166.051
201901	36	CTD	08132019 16:39:58.937	71.8256	-165.984
201901	39	CTD	08132019 19:07:47.988	71.7067	-165.608

201901	40	CTD	08132019 20:26:54.492	71.6059	-165.305
201901	41	Bongo	08132019 20:42:46.895	71.6043	-165.3
201901	42	CTD	08132019 22:16:22.676	71.4516	-164.923
201901	43	CTD	08132019 23:47:56.286	71.3429	-164.618
201901	44	Bongo	08142019 00:07:06.152	71.3406	-164.613
201901	45	CTD	08142019 01:35:36.145	71.2162	-164.258
201901	51	CTD	08142019 14:55:18.610	71.2181	-164.264
201901	52	CTD	08142019 15:25:19.560	71.2001	-164.21
201901	53	CTD	08142019 17:08:54.105	71.09	-163.798
201901	54	Bongo	08142019 17:28:09.473	71.0893	-163.795
201901	55	CTD	08142019 18:44:15.574	70.975	-163.564
201901	56	CTD	08142019 20:27:07.238	70.8531	-163.183
201901	57	Bongo	08142019 20:44:36.980	70.8544	-163.178
201901	58	CTD	08142019 22:20:12.542	70.7225	-162.851
201901	59	CTD	08142019 23:55:51.553	70.5834	-162.486
201901	60	Bongo	08152019 00:11:23.214	70.584	-162.475
201901	61	CTD	08152019 01:24:24.093	70.7064	-162.447
201901	63	CTD	08152019 14:15:06.010	70.8424	-163.121
201901	69	CTD	08182019 15:29:42.705	70.8353	-163.124
201901	74	CTD	08182019 22:21:35.933	71.2145	-164.258

201901	75	CTD	08192019 14:09:14.796	71.6001	-161.516
201901	80	CTD	08192019 16:34:44.370	71.5965	-161.516
201901	81	CTD	08192019 21:21:29.586	71.0464	-160.495
201901	86	CTD	08202019 04:04:58.577	71.2063	-158.016
201901	93	3m Beam Trawl	08202019 16:54:54.652	71.8769	-153.602
201901	94	CTD	08202019 17:56:50.860	71.8788	-153.581
201901	95	Bongo	08202019 18:41:55.422	71.8853	-153.569
201901	96	CTD	08202019 20:27:44.264	71.7095	-153.751
201901	97	Bongo	08202019 20:50:53.755	71.7137	-153.75
201901	98	3m Beam Trawl	08202019 21:21:52.993	71.7224	-153.77
201901	99	Bongo	08202019 23:08:21.072	71.5397	-154.062
201901	100	CTD	08202019 23:38:59.499	71.5033	-154.102
201901	101	CTD	08212019 00:36:33.715	71.4284	-154.239
201901	102	Bongo	08212019 00:48:05.738	71.4264	-154.243
201901	104	CTD	08222019 22:50:27.567	67.6697	-168.738
			Leg 2		
201901	107	CTD	08272019 15:23:22.122	72.4991	-168.502
201901	108	Bongo	08272019 15:43:27.766	72.4964	-168.502
201901	109	Benthic Grab	08272019 15:53:55.208	72.4946	-168.5
201901	110	Bongo	08272019 16:03:49.934	72.4941	-168.49

201901	111	3m Beam Trawl	08272019 16:27:50.840	72.5051	-168.485
201901	112	Marinovich	08272019 19:14:32.711	72.4843	-168.513
201901	113	CTD	08282019 00:26:19.240	72.5004	-166.801
201901	114	Juday	08282019 00:36:44.096	72.5004	-166.801
201901	115	Benthic Grab	08282019 00:49:10.619	72.4997	-166.8
201901	116	Bongo	08282019 01:03:31.950	72.5013	-166.784
201901	117	3m Beam Trawl	08282019 01:23:29.258	72.5094	-166.778
201901	118	CTD	08282019 15:10:05.782	72.5015	-165.19
201901	119	Juday	08282019 15:23:40.753	72.4986	-165.181
201901	120	Benthic Grab	08282019 15:33:09.006	72.4962	-165.173
201901	121	Juday	08282019 15:42:00.849	72.4941	-165.17
201901	122	Bongo	08282019 15:52:45.293	72.4943	-165.172
201901	123	3m Beam Trawl	08282019 16:05:22.569	72.4988	-165.178
201901	124	Marinovich	08282019 16:49:46.886	72.5274	-165.175
201901	125	Marinovich	08282019 19:58:09.870	72.4954	-164.547
201901	126	CTD	08282019 23:09:41.785	72.5	-163.498
201901	127	Juday	08282019 23:10:57.799	72.4999	-163.498
201901	128	Benthic Grab	08282019 23:13:23.224	72.4999	-163.499
201901	129	Bongo	08282019 23:30:32.468	72.5051	-163.492
201901	130	3m Beam Trawl	08282019 23:41:33.977	72.5108	-163.488

201901	131	Marinovich	08292019 00:21:56.796	72.5088	-163.485
201901	132	CTD	08292019 15:03:38.354	72.5015	-161.908
201901	133	Juday	08292019 15:05:21.714	72.5014	-161.908
201901	134	Benthic Grab	08292019 15:06:52.513	72.5013	-161.907
201901	135	Bongo	08292019 15:30:48.591	72.5055	-161.919
201901	136	3m Beam Trawl	08292019 15:34:51.992	72.5066	-161.923
201901	137	Marinovich	08292019 17:05:38.848	72.4915	-161.841
201901	138	CTD	08292019 22:06:32.144	72.4982	-160.203
201901	139	Juday	08292019 22:08:10.930	72.498	-160.204
201901	140	Bongo	08292019 22:25:44.293	72.4991	-160.204
201901	141	3m Beam Trawl	08292019 22:37:43.591	72.5036	-160.193
201901	142	Marinovich	08292019 23:26:28.390	72.5014	-160.208
201901	143	Benthic Grab	08292019 22:08:10.930	72.498	-160.204
201901	144	CTD	08302019 15:05:26.278	72.7684	-159.636
201901	145	Bongo	08302019 15:36:44.737	72.7677	-159.65
201901	146	Juday	08302019 15:47:12.933	72.767	-159.671
201901	147	Marinovich	08302019 16:17:26.732	72.7673	-159.646
201901	148	Benthic Grab	08302019 17:16:25.888	72.768	-159.545
201901	149	Benthic Grab	08302019 17:36:34.352	72.7675	-159.541
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201901	151	3m Beam Trawl	08302019 18:22:44.564	72.7639	-159.6
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201901	153	Benthic Grab	08302019 20:20:57.163	72.8966	-159.341
201901	154	Juday	08302019 20:23:41.977	72.8965	-159.342
201901	155	Bongo	08302019 20:55:48.591	72.9018	-159.324
201901	156	3m Beam Trawl	08302019 21:28:58.310	72.904	-159.322
201901	157	Marinovich	08302019 23:17:04.451	72.9632	-159.212
201901	158	CTD	08312019 01:58:54.271	73.1047	-158.939
201901	159	Juday	08312019 02:00:57.002	73.1052	-158.94
201901	160	Bongo	08312019 02:44:39.145	73.1062	-158.949
201901	161	CTD	08312019 15:24:10.507	72.5519	-156.893
201901	162	Juday	08312019 15:25:35.071	72.552	-156.894
201901	163	Bongo	08312019 16:09:52.542	72.5521	-156.912
201901	164	Marinovich	08312019 16:59:59.799	72.5522	-156.895
201901	165	CTD	08312019 19:54:36.726	72.3703	-157.167
201901	166	Juday	08312019 20:21:44.624	72.3761	-157.201
201901	167	Bongo	08312019 20:34:40.114	72.3734	-157.19
201901	168	3m Beam Trawl	08312019 21:01:38.325	72.3712	-157.158
201901	169	Marinovich	08312019 22:28:30.249	72.3706	-157.175
201901	170	CTD	09012019 01:18:21.756	72.2535	-157.417

201901	171	Juday	09012019 01:39:40.980	72.257	-157.424
201901	173	CTD	09022019 15:15:33.046	71.0009	-157.798
201901	174	Juday	09022019 15:16:40.615	71.001	-157.799
201901	175	Benthic Grab	09022019 15:17:51.989	71.0011	-157.8
201901	176	Benthic Grab	09022019 15:23:08.588	71.0015	-157.806
201901	177	3m Beam Trawl	09022019 15:37:27.553	71.0023	-157.793
201901	178	Bongo	09022019 15:57:56.795	71.002	-157.77
201901	179	CTD	09022019 19:40:03.168	71.0009	-159.293
201901	180	Juday	09022019 19:42:45.616	71.0009	-159.294
201901	181	Benthic Grab	09022019 19:44:24.142	71.0007	-159.294
201901	182	3m Beam Trawl	09022019 20:01:27.850	71.0022	-159.286
201901	183	Bongo	09022019 20:19:47.848	71.0085	-159.273
201901	184	Marinovich	09022019 20:51:50.690	71.0121	-159.259
201901	186	CTD	09032019 15:05:28.352	71.0015	-160.787
201901	187	Juday	09032019 15:08:13.921	71.0013	-160.787
201901	188	Benthic Grab	09032019 15:15:29.252	71.0007	-160.787
201901	189	3m Beam Trawl	09032019 15:33:37.125	70.9971	-160.775
201901	190	Bongo	09032019 15:51:16.189	70.9927	-160.753
201901	191	Marinovich	09032019 16:18:04.653	70.9923	-160.746
201901	192	CTD	09032019 21:08:07.505	70.9995	-162.393

201901	193	Juday	09032019 21:11:54.945	70.9988	-162.394
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201901	195	3m Beam Trawl	09032019 21:32:13.455	71.0014	-162.379
201901	196	Bongo	09032019 21:48:05.215	71.0069	-162.365
201901	197	Marinovich	09032019 22:17:04.362	71.0001	-162.393
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201901	200	Juday	09042019 15:12:55.876	71.0017	-163.903
201901	201	Benthic Grab	09042019 15:14:31.530	71.0016	-163.902
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201901	203	Bongo	09042019 15:54:00.620	71.0126	-163.914
201901	204	Marinovich	09042019 16:20:25.555	71.0115	-163.907
201901	205	CTD	09042019 20:47:34.726	71.0013	-165.402
201901	206	Juday	09042019 20:49:24.585	71.0013	-165.402
201901	207	Benthic Grab	09042019 20:51:03.620	71.0013	-165.403
201901	208	Benthic Grab	09042019 20:56:30.338	71.0013	-165.404
201901	209	3m Beam Trawl	09042019 21:08:19.230	71.0015	-165.391
201901	210	Bongo	09042019 21:25:31.164	71.0046	-165.367
201901	211	Marinovich	09042019 21:54:03.504	71.0068	-165.361
201901	212	CTD	09052019 15:05:18.456	71.0012	-167.003
201901	213	Juday	09052019 15:06:24.250	71.0012	-167.004

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201901	215	3m Beam Trawl	09052019 15:24:04.751	71.0025	-167.009
201901	216	Bongo	09052019 15:41:24.757	71.0074	-166.988
201901	217	Marinovich	09052019 16:13:10.540	71.0111	-166.951
201901	218	CTD	09052019 20:23:43.433	71.002	-168.504
201901	219	Juday	09052019 20:26:28.697	71.0025	-168.506
201901	220	Benthic Grab	09052019 20:27:27.032	71.0027	-168.506
201901	221	3m Beam Trawl	09052019 20:44:19.663	71.0049	-168.503
201901	222	Bongo	09052019 21:04:54.417	71.0088	-168.473
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201901	224	CTD	09062019 15:02:41.335	71.7511	-168.488
201901	225	Juday	09062019 15:03:52.080	71.7515	-168.489
201901	226	Benthic Grab	09062019 15:08:26.354	71.753	-168.489
201901	227	3m Beam Trawl	09062019 15:24:29.506	71.7531	-168.487
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201901	229	Marinovich	09062019 17:32:55.765	71.7393	-167.994
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201901	231	Juday	09062019 21:00:26.843	71.7516	-166.891
201901	232	Benthic Grab	09062019 21:01:20.226	71.7517	-166.89
201901	233	3m Beam Trawl	09062019 21:18:10.159	71.7502	-166.895

201901	234	Bongo	09062019 21:44:39.427	71.7447	-166.923
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201901	236	CTD	09072019 15:03:39.382	71.7552	-165.312
201901	237	Juday	09072019 15:05:39.167	71.7552	-165.312
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201901	239	3m Beam Trawl	09072019 15:24:14.641	71.7547	-165.323
201901	240	Bongo	09072019 15:40:43.950	71.7532	-165.345
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201901	243	Juday	09072019 21:22:44.990	71.75	-163.695
201901	244	Benthic Grab	09072019 21:24:22.563	71.7501	-163.695
201901	245	3m Beam Trawl	09072019 21:37:20.248	71.7482	-163.693
201901	246	Bongo	09072019 21:51:54.999	71.7425	-163.681
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201901	252	Bongo	09082019 15:43:07.455	71.7561	-161.956
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201901	254	CTD	09082019 20:44:28.543	71.7509	-160.4
201901	255	Juday	09082019 20:48:02.049	71.7511	-160.402
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201901	258	Bongo	09082019 21:24:49.687	71.7504	-160.37
201901	259	Marinovich	09092019 00:18:12.180	71.7507	-159.371
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201901	261	Juday	09092019 15:04:29.704	71.7528	-158.798
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201901	267	Benthic Grab	09092019 19:31:37.009	71.7516	-157.201
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201901	269	Bongo	09092019 20:12:55.994	71.7403	-157.219
201901	270	Marinovich	09092019 20:35:25.818	71.7444	-157.281
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201901	272	Juday	09102019 16:07:57.435	70.253	-164.091
201901	273	Benthic Grab	09102019 16:09:42.305	70.2532	-164.091

201901	274	3m Beam Trawl	09102019 16:25:28.606	70.251	-164.098
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201901	276	Marinovich	09102019 18:22:59.322	70.249	-164.535
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201901	278	Juday	09102019 21:44:58.232	70.2492	-165.49
201901	279	Benthic Grab	09102019 21:46:11.290	70.2492	-165.489
201901	280	3m Beam Trawl	09102019 21:59:00.046	70.2469	-165.492
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201901	283	CTD	09112019 15:01:05.035	70.2484	-166.997
201901	284	Benthic Grab	09112019 15:05:43.855	70.2485	-166.996
201901	285	Juday	09112019 15:07:35.381	70.2486	-166.996
201901	286	3m Beam Trawl	09112019 15:24:07.756	70.2452	-167.002
201901	287	Bongo	09112019 15:42:08.015	70.2388	-167.014
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201901	289	Marinovich	09112019 20:16:45.144	70.25	-167.969
201901	290	CTD	09112019 22:30:21.467	70.2511	-168.499
201901	291	Juday	09112019 22:32:26.894	70.2513	-168.499
201901	292	Benthic Grab	09112019 22:34:39.738	70.2514	-168.5
201901	293	3m Beam Trawl	09112019 22:47:33.132	70.2497	-168.502

201901	294	Bongo	09112019 23:04:48.630	70.242	-168.501
			Leg 3		
201901	295	Juday	09172019 16:00:52.028	69.5	-168.508
201901	296	Benthic Grab	09172019 16:10:00.915	69.4983	-168.51
201901	297	Bongo	09172019 16:25:11.013	69.5025	-168.502
201901	298	3m Beam Trawl	09172019 16:39:02.993	69.5044	-168.482
201901	299	CTD	09172019 17:07:20.405	69.4991	-168.466
201901	300	CTD	09172019 21:14:35.372	69.4999	-167.097
201901	301	Juday	09172019 21:16:01.797	69.4996	-167.096
201901	302	Benthic Grab	09172019 21:19:00.453	69.4991	-167.095
201901	303	Bongo	09172019 21:31:46.827	69.5	-167.09
201901	304	3m Beam Trawl	09172019 21:43:29.792	69.5052	-167.092
201901	305	Marinovich	09172019 22:14:55.704	69.511	-167.1
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201901	307	Bongo	09182019 15:51:01.006	69.5054	-165.719
201901	308	3m Beam Trawl	09182019 16:02:59.000	69.5004	-165.714
201901	309	Juday	09182019 16:22:29.956	69.4955	-165.72
201901	310	Benthic Grab	09182019 16:34:32.946	69.4946	-165.729
201901	311	CTD	09182019 16:51:27.363	69.4935	-165.741
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201901	313	CTD	09182019 22:40:52.165	69.4991	-164.207
201901	314	Juday	09182019 22:42:08.907	69.4989	-164.208
201901	315	Benthic Grab	09182019 22:43:35.788	69.4987	-164.209
201901	316	Bongo	09182019 22:52:06.763	69.4973	-164.205
201901	317	3m Beam Trawl	09182019 23:04:24.786	69.4962	-164.19
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201901	319	Nordic	09192019 00:57:22.337	69.4962	-164.484
201901	320	Bongo	09192019 16:03:54.576	68.7608	-167.1
201901	321	3m Beam Trawl	09192019 16:18:12.077	68.7566	-167.09
201901	322	Juday	09192019 16:40:02.073	68.7554	-167.083
201901	323	Benthic Grab	09192019 16:51:23.332	68.7586	-167.085
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201901	325	Nordic	09192019 18:11:56.242	68.7669	-167.101
201901	326	Marinovich	09192019 21:06:34.412	68.7638	-167.673
201901	327	CTD	09192019 23:56:57.080	68.7507	-168.496
201901	328	Juday	09192019 23:59:17.402	68.7508	-168.495
201901	329	Benthic Grab	09202019 00:00:21.368	68.7508	-168.495
201901	330	Bongo	09202019 00:16:13.642	68.7513	-168.501
201901	331	3m Beam Trawl	09202019 00:28:35.803	68.7548	-168.509
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201901	334	Bongo	09202019 16:04:06.150	68.0021	-168.511
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201901	338	CTD	09202019 17:02:48.702	68.0032	-168.531
201901	339	Marinovich	09202019 19:45:43.164	68.0082	-168.005
201901	340	CTD	09202019 22:48:56.892	68.0035	-167.209
201901	341	Juday	09202019 22:51:28.384	68.0042	-167.21
201901	342	Benthic Grab	09202019 22:52:39.800	68.0046	-167.21
201901	343	Bongo	09202019 23:09:19.608	68.0058	-167.218
201901	344	3m Beam Trawl	09202019 23:23:41.372	68.0014	-167.231
201901	345	Nordic	09212019 00:30:40.199	68.0295	-167.249
201901	346	Marinovich	09212019 02:42:43.528	68.0146	-167
201901	347	Bongo	09212019 16:04:02.150	68.0022	-165.784
201901	348	3m Beam Trawl	09212019 16:19:01.272	68.0048	-165.772
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201901	350	3m Beam Trawl	09212019 16:43:23.881	68.0051	-165.757
201901	351	Benthic Grab	09212019 17:03:04.251	68.0053	-165.744
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201901	354	Nordic	09212019 19:14:19.532	67.9795	-165.805
201901	355	CTD	09222019 00:00:28.936	67.6259	-165.002
201901	356	Juday	09222019 00:02:30.325	67.6261	-165.003
201901	357	Benthic Grab	09222019 00:04:06.501	67.6263	-165.003
201901	358	Bongo	09222019 00:15:48.849	67.6269	-165.002
201901	359	3m Beam Trawl	09222019 00:26:45.841	67.6233	-164.997
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201901	362	Bongo	09222019 16:04:20.343	67.2501	-168.504
201901	363	3m Beam Trawl	09222019 16:16:54.706	67.2519	-168.518
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201901	365	Benthic Grab	09222019 16:42:45.376	67.2496	-168.506
201901	366	CTD	09222019 17:02:06.875	67.2449	-168.497
201901	367	CTD	09222019 21:34:02.564	67.2512	-167.208
201901	368	Juday	09222019 21:35:43.828	67.2513	-167.209
201901	369	Benthic Grab	09222019 21:37:46.766	67.2514	-167.21
201901	370	Bongo	09222019 21:52:37.523	67.25	-167.208
201901	371	3m Beam Trawl	09222019 22:01:49.339	67.247	-167.2
201901	372	Marinovich	09222019 22:26:48.432	67.246	-167.232

201901	373	Marinovich	09232019 02:25:15.891	67.2607	-166.361
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201901	375	3m Beam Trawl	09232019 16:13:15.904	67.249	-165.89
201901	376	Juday	09232019 16:29:00.529	67.246	-165.885
201901	377	Benthic Grab	09232019 16:35:01.945	67.2471	-165.883
201901	378	CTD	09232019 16:48:57.732	67.2508	-165.881
201901	379	Nordic	09232019 17:22:09.228	67.2396	-165.879
201901	380	Bongo	09232019 21:20:02.116	67.2518	-164.699
201901	381	3m Beam Trawl	09232019 21:27:59.839	67.2511	-164.709
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201901	384	CTD	09232019 21:44:50.466	67.251	-164.711
201901	385	Nordic	09232019 22:15:03.189	67.2532	-164.737
201901	386	Marinovich	09232019 23:18:28.815	67.2194	-164.735
201901	387	Nordic	09242019 03:00:55.690	66.8799	-165.028
201901	388	Bongo	09242019 04:07:58.408	66.8758	-165.003
201901	389	3m Beam Trawl	09242019 04:23:21.363	66.874	-165.015
201901	390	Juday	09242019 04:36:19.128	66.8736	-165
201901	391	CTD	09242019 04:40:22.993	66.8738	-164.997
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201901	393	Bongo	09242019 16:04:52.473	66.499	-166.012
201901	394	3m Beam Trawl	09242019 16:12:13.803	66.4963	-166.016
201901	395	Juday	09242019 16:30:20.328	66.4982	-166.021
201901	396	CTD	09242019 16:31:15.625	66.4984	-166.021
201901	397	Benthic Grab	09242019 16:31:56.989	66.4986	-166.021
201901	398	CTD	09242019 20:21:31.845	66.5016	-167.246
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201901	400	Benthic Grab	09242019 20:25:04.030	66.502	-167.245
201901	401	Bongo	09242019 20:33:36.152	66.5019	-167.248
201901	402	3m Beam Trawl	09242019 20:41:12.691	66.5013	-167.256
201901	403	Nordic	09242019 21:21:40.543	66.4995	-167.273
201901	404	Marinovich	09242019 22:27:38.265	66.5112	-167.219
201901	405	Marinovich	09262019 15:39:16.220	66.5066	-168.211
201901	406	Bongo	09262019 17:16:38.080	66.499	-168.503
201901	407	3m Beam Trawl	09262019 17:29:52.887	66.4971	-168.516
201901	408	CTD	09262019 17:59:13.858	66.5088	-168.534
201901	409	Juday	09262019 18:00:53.236	66.5097	-168.535