Cruise Plan
NGA LTER and GWA
SKQ2022-10S

R/V Sikuliaq
7 - 27 July 2022

Northern Gulf of Alaska
Long Term Ecological Research

Funding Sources: NSF, NPRB, EVOS, AOOS, UAF

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Co-Chief Scientist: Russ Hopcroft, UAF, Zooplankton

Scientific Personnel (22)

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Bright	Kelley	WWU	Phytoplankton & Microzooplankton
Cohen	Jacob	UAF	Microbes & Genetics
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Cushing	Dan	USFWS	Seabirds & Marine Mammals
Danielson	Seth	UAF	Physics
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Webster	Nicole	UAF	Chemistry & Physics

Scientific Purpose

This cruise continues observations and sampling that begun in fall 1997 under the NSF/NOAA NE Pacific GLOBEC program, and subsequently via a consortium of the North Pacific Research Board (NPRB), the Alaska Ocean Observing System (AOOS), and the Exxon Valdez Oil Spill Trustee Council's (EVOSTC) Gulf Watch. The region covered was extended by the NSF's Northern Gulf of Alaska Long-term Ecological Program (NGA-LTER). This cruise is the 5th consecutive summer cruise for the NGA-LTER, it marks the 25th consecutive spring cruise for the Seward Line in the NGA, including Prince William Sound (PWS), and the 51th year of observations at GAK1. The scientific purpose is to contribute towards the development of an understanding of the response and resiliency of this marine ecosystem to climate variability.

Special Note: This cruise will be conducted during the COVID-19 Pandemic and will follow established protocols by UNOLS and *Sikuliaq* as outlined in the "Science Party Covid-19 Embarkation Check List" document.

Cruise Objectives

1. Conduct process experiments and mapping activities in the vicinity of the Copper River outflow plume
2. Determine thermohaline, velocity, light, and oxygen structure of the NGA shelf.
3. Determine macro- and micro-nutrient structure of the NGA shelf.
4. Determine particle structure and flux rates of the NGA shelf.
5. Determine carbon cycling parameters.
6. Determine phyto- and microzooplankton composition, biomass distribution, and productivity.
7. Determine the vertical and horizontal distribution and abundance of zooplankton species.
8. Conduct surveys of Seabirds and Marine Mammals
9. Provide at-sea experience for UAF and WWU graduate students
10. Share the experience through outreach/media activities.
11. Recover mooring GEO1
12. Deploy mooring GEO2
13. Seward Line DPI transect (~ 30 hrs, possibly moorings in the middle of this tow).
14. Deploy and recover drifting Sediment Traps (~24hr deployments).
15. Recover a Slocum glider

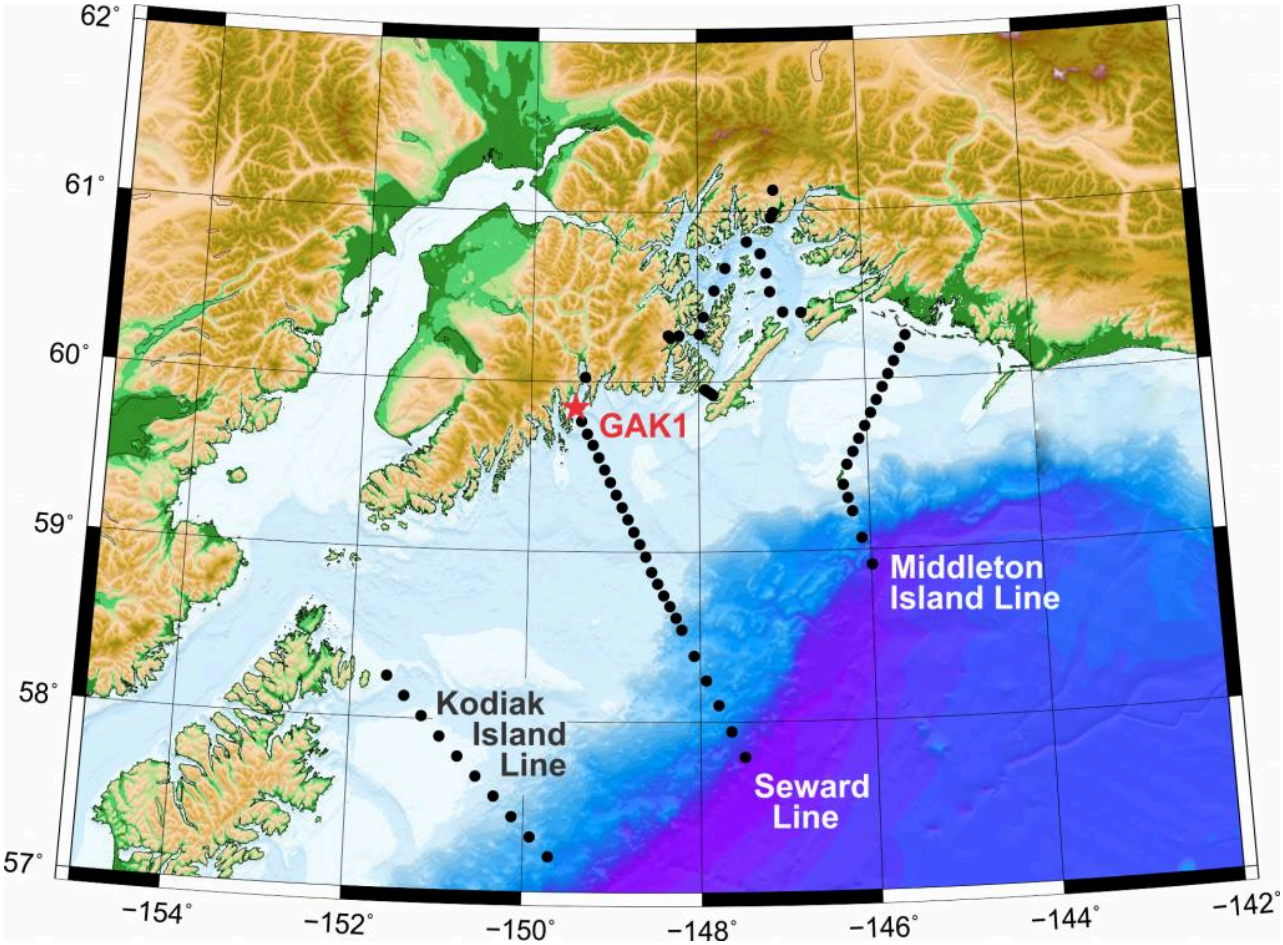

Figure 1. NGA-LTER sampling stations along the stations sets for the Seward Line (GAK), Middleton Island (MID), Kodiak (KOD) and Prince William Sound (PWS, MS, KIP, IB, CG).

Station naming convention and referencing etiquette note: The NGA hydrographic and biological sampling station transects have both transect names and station acronyms. These include the Seward Line with GAK stations (***not* the GAK Line!**). The Middleton Island Line with MID stations. The Kodiak Island Line with KOD stations. And Prince William Sound stations with PWS, MS, KIP, CG and IB stations, which stand for Prince William Sound, Montague Strait, Knight Island Passage, Columbia Glacier and Icy Bay, respectively. The Seward Line naming convention was adopted for consistency with the Newport Hydrographic line (with NH stations) and other long-established hydrographic transects.

Cruise Activities

The primary focus of SKQ2022-10S is on gaining a better understanding of the Copper River Plume. The Copper River portion of the cruise will involve a sequence of mapping activities, targeted water mass sampling, the occupation of time series stations, and sampling from a small boat.

The overall approach of the cruise is to occupy the Seward Line, Kodiak Line and Middleton Line transects across the shelf and a string of stations within western PWS. Operations are generally divided into distinct day and night tasks, thus requiring each station to be occupied twice. This structure avoids each discipline needing to supply 2 shifts of scientists and ensures all organisms – especially larger diel-migrating zooplankton – are captured with minimal time-of-day bias. During each morning we will typically occupy a selected "intensive" station that involves a greater number and range of collections than the other stations occupied that day. Station profiles are supplemented by underway measurements.

Order of operations may be modified at sea based on sampling considerations and weather conditions. Note that the "normal" schedule of Daytime and Nighttime activities will be disrupted during the plume survey, which includes different activities and follows a different order of operations.

PLUME STUDY:

Approximately 6 days of the cruise will be dedicated to high-resolution sampling of the Copper River discharge plume.

1. Station work. We will target low-salinity stations having a spread of surface salinities for the sample collections that will enable plankton experimental work.
2. DPI and Iron Fish mapping activities. In-between the station work, mapping will include characterizing the plume extent and depth using an undulating towed sensor system (the DPI Deep Plankton Imager) and towing a surface sampler (the Iron Fish) that collects uncontaminated water for trace metal analyses.
3. Small boat sample collections. To collect samples from the low-salinity end member of the Copper River, on one or more day during the plume study we will deploy a small boat that will collect CTD and water samples on a transect that extends into the mouth of the river.
4. Time series stations. Based on the MID transect hydrography, we will occupy two 36-hour time series stations at each of one low-salinity site and one high-salinity site. The time series stations will involve regular (~hourly) CTD profiles and net tows.

DAYTIME ACTIVITIES:

1. Occupy the various hydrographic stations (no "intermediate" stations on cruises with the DPI) and collect vertical CTD-fluorescence-PAR-nitrate-oxygen and particle profiles
2. Collect from the ship's rosette system discrete bottle samples at hydrographic stations for nutrients,chlorophyll, plankton community composition, and carbon cycle parameters,. Chlorophyll Size Fractionation (20 µm) will be done at all whole-numbered Seward Line stations and most other stations. Macronutrients samples will be pre- filtered prior to freezing. Chlorophyll will be extracted on fresh filters without prior freezing. Community composition will be measured through a variety of filtered or preserved samples.
3. Collect samples for molecular microbial analysis along all three lines (GAK, KOD, MID) and PWS from bottle casts at selected stations and depths. On this cruise, samples will be

analyzed live via an on-board flow cytometer.

4. Collect oxygen samples at selected depths from all CTD bottle stations. Analysis will be carried out onboard.
5. At intensive stations an additional CTD cast will collect water to be used for primary production incubations and (at GAK-1 only) gas samples. Seawater dilution experiments will be set up on most days from one of the two intensive station CTD casts.
6. Two daily trace-metal clean CTD cast will also be undertaken, one at the intensive station, and one at another selected station. (GAK 1, 3, 5, 7, 9, 11, 13, 15; MID 2, 5, 8, 10; KOD 2, 5, 8, 10; and PWS 2 and IB 1).
7. To complete the TM CTD cast, the Fe-fish will be deployed from the starboard crane as the ship departs from (or arrives to) the station. The Fe-fish will not be deployed in-between all stations as in other cruises.
8. CalVet Net casts will be deployed from the starboard crane (CalVet frame has 4 nets) after most of the CTD casts to 100m. (NO CALVETs at the "i" stations).
9. At intensive stations there will be an extra Calvet collection, and along the Seward Line plus PWS2 there will be a vertical deployment of the 150 µm Multinet to 200m. Some of this material will be used for live sorting as well as post-cruise molecular analysis.
10. We will do one deep tandem vertical 150- µm Multinet tow (to maximum 1200 m) near the end of the Seward Line and one at PWS2 (800m). This normally happens during days but may be done at night in conjunction with Multinet work at those stations if time permits.
11. We will deploy drifting sediment traps at a subset of the intensive stations, the number to be determined by how they fit into daily logistics (6 to 8). Traps will ideally be deployed for 24 (or 48) hrs as time permits.
12. We will deploy 1 mooring and recover 1 mooring at the GEO site (near GAK6i). See diagrams attached to this cruise plan below.
13. Seabird and mammal observations from the Bridge.
14. Ailiak Bay sampling: an ongoing NSF-funded ASLC project is collecting hydrographic and bird distribution data in a number of Kenai fjords. There exists potential to leverage NGA data with this project (and vice-versa), particularly if we were able to connect our closest shelf stations to this project's transect in Ailiak Bay. Stations to be occupied only if time permits.
15. We will recover one Slocum Glider. Glider progress can be followed at this website:

    https://portal.aoos.org/#platform/1c7101d6-2e01-5150-97a1-70493e372769/v2?tab=glider

NIGHTTIME ACTIVITIES:

1. A towed 505-µm Multinet will be used to collect depth-stratified samples along the Seward Line, and at selected PWS Stations to 200m. (A multinet will be available as backup). Potentially an additional bongo at each station for NOAA samples.
2. On the Middleton and Kodiak Lines bongo net collections to 200 m. We hope to complete bongo nets along the Seward Line, dependent upon logistics.
3. Multinet tows may occur during the night shift as time permits (see #11 above).

4. A second 505- µm Multinet tow occurs at intensive station along the Seward Line and in PWS.
5. Methot net tows at selected stations.

Estimated durations and sampling timing requirements

- In general, we estimate 1.5 days for PWS, 5-6 days for the Copper River Plume study, 5 days for the Seward Line, and two days for each of the Middleton and Kodiak transects.
- We allocate 30 hrs for the DPI tow and 8 hours for the mooring activities.
- It is important that all Multinet collections (with the exception of those to 600m) be completed during darkness to allow comparison to prior years.
- We anticipate that 4-5 Multinets and/or Bongos can be conducted per night: sampling starts just after dusk and stops just before dawn, and can be extended slightly when overcast. There is always typically a greater period of light available than of darkness, so execution of daytime stations and activities are designed around being in position to commence night sampling as soon as it is sufficiently dark.
- Intensive station sampling must begin before local apparent noon and after dawn (ideally 8:30-12, but deep CTD casts or MultiNet casts could occur prior to 8).
- Sediment traps are flexible in their deployment timing.

Sampling personnel requirements and sample protocol overview

- **CTD:** Winch operator, Marine Technician (launch and recovery), 30m/min in upper 100m, 60m/minbelow 100m. Depending on schedule, casts may be limited to 1000m at deep-sea stations.
- **DPI:** A-frame and winch operator, Bosun, Marine Technician, 2 scientists for launch & recovery. 1-2 scientiststo communicate with bridge during towing operations. Sikuliaq's winch#1 with 0.322 EO cable will be used for towing the DPI. Ship speed 6 kts through water.
- **TMC CTD:** Crane operator, Bosun, Marine Technician, 2 scientists (launch and recovery and winch operation), 30m/min in upper 100m, 60m/min below 100m. Casts are limited to 1000m at deep-seastations.
- **TMC towfish:** Crane operator, 2 scientists for launch and recovery (~15-20 min), Bosun and Marine Technician to communicate with the bridge/science to ensure sample is collected as close tostation as possible. Ship speed 3 kts through water. Arriving or departing fish at stations with TMC CTD.
- **Multinet & Bongo:** Winch operator, Bosun, Marine Technician, 2-3 scientists (launch, recovery, wash-down, re-cock). Ship speed: 2 knots, Wire speed: ~1 m/sec down, 0.5-1m/sec up (typically 30-40min per deployment). Stern A-frame deployment. Maximum depth on tows 200m. 0.322 EO cable (same as used for DPI). Both systems will have depth transducers to ensure we getclose to, but not on the bottom when depths are less than 200m.
- **Calvets & Ring nets:** Crane operator, Bosun, Marine Technician, 1-2 scientists (launch, recovery, wash-down) – Ship speed: station keeping, Wire speed: ~1 m/sec for Calvet, 0.5m/sec for Ring net (10min/cast)**.**
- **Methot Net:** Crane operator, Bosun, Marine Technician, 1-2 scientists (launch, recovery, wash-down) – Ship speed: 2.5 knots. Deploy on starboard crane.
- **Acoustics:** Martech support for acoustics setup. We will trigger acoustics from the K- sync system to provide an interference-free time interval for each ping type. Over shallow waters (< 1000 m depth) all acoustic instruments can be run simultaneously. In deep water (>1000 m depth) we have two modes of operation. In "night operations mode" we secure the EM302 multibeam during night station work and operate only the ADCP and EK-60 so as to have concurrent acoustics data alongside the nighttime trawl operations. In "day operations mode" we will secure the EK-60 and run the EM-302 so as to map the seafloor along our trackline. As time allows, regions previously unmapped by multibeam acoustics should be preferentially selected for ship routes in order to map uncharted areas of the seafloor.
- **Drifting Sediment Traps:** 1 person to operate the TSE spooler, 2 scientists for deployment/recovery of equipment, 1 person (deck crew) for A-frame operation. Recovery via grapple hook on starboard side. Total length of line (top to bottom) is ~ 200 m. Operational time required is approximately 30 minutes for recovery or deployment.
- **Moorings:** Prior to mooring operations the mooring lead (Danielson) will meet with Captain, Mar Techs, Bosun, Deck Crew and Mate on Watch to assess risk factors and clarify the plan for recoveries and deployments. The bosun, deck crew, marine tech and 2-3 scientists are needed for deployment/recovery. Mooring GEO2 is deployed anchor-first using the A-frame and TSE spooler. Mooring to be recovered: GEO2 (See attached deployment sheets.)

Equipment and Supplies

Ship's Science Equipment Needed:

- CTD Rosette
- Science Freezer in wet lab for chlorophyll extraction.
- -80 freezer for macro-nutrient, DOC, and genetic samples (x2).
- -20 freezer for organic iron ligand samples
- Forward walk-in incubator set at low temperature (somewhere near ~6 C).
- Aft walk-in incubator set at surface ambient temperature (somewhere near 13 C).
- 300 and 75 KHz acoustic Doppler current profilers
- EK60 fisheries acoustics
- Underway sampling system (TSG, nav, met, etc)
- Access to uncontaminated seawater system & debubbler system
- Access to Ultra-pure water systems
- Access to bridge & NMEA GPS feed for seabird observer
- Hoods in wet, analytical and main labs
- Large volume seawater 'paws for safety" manifold for three deck-based incubators
- TSE spooler for mooring deployment/recovery
- Ship's A-frame & starboard side crane
- Under-crane winch & line counter
- Access to compressed air for the Fe-fish pump
- DPI fiberoptics winch & cable
- Mustang suits as needed for some scientists
- MapServer with ocean color, true color and sea surface temperature data feeds
- Small boat for river water sampling and glider recovery

Scientist's Equipment Needed:

- Trace-metal clean CTD system (Baltic room storage), dedicated block, winch and line.
- Trace-metal clean towfish system (Deck storage) and spare
- Wall-mounted racks for keeping TMC niskins during subsampling
- Positive pressure enclosure in the analytical lab. A cylinder of ultra clean nitrogen gas will be secured in the analytical lab.
- ISUS unit attached to flow-through system water
- Deep SUNA, UVP and LISST to install on ships CTD system
- 300 KHz Teledyne RDI Workhorse ADCP mounted in centerboard
- 2-pi PAR sensor mounted on ship's superstructure
- CalVet and ring nets [nets, flow-meters, frames, swivels, weights, spares]
- 2 Multinet system (coarse and fine nets, spare cod ends/nets)
- Bongo nets, & depressors
- Methot net
- Large deckboard incubators plumbed to flowing seawater system
- Filtration systems
- Fluorometers & Centrifuge
- Oxygen titration system
- Laptop computers

- 16 cases (24/cs) of 16-oz zooplankton sample bottles
- 5 cases (12/cs) of 32-oz zooplankton sample bottles
- Several coolers with nutrient and TMC bottles
- Microscopes (4) and supplies for handling and incubation of copepods
- Incubators: 2 x 4 cu ft. required near zooplankton work area
- Refrigerated Circulators
- Liquid nitrogen dewars (2)
- Mooring instruments, tools, anchors and line
- Dynacon CTD winch
- Optical flow-through system
- DPI towed system stored on back deck
- Drifting sediment traps

Hazardous Materials:

See Hazmat Manifest for quantities, responsible scientist for point of contact, and MSDS archive.

Common Name of Material	Chemical Composition
Hydrochloric Acid	3N HCl
Mercuric chloride	HgCl2
Manganese Chloride	MnCl2
Potassium Iodate	KIO3
Sodium Hydroxide (1N)	NaOH
Sodium Iodide	NaI
Sodium Thiosulfate	Na2S2O3
Sulfuric Acid (1N)	H2SO4
Formaldehyde	COH2
Glutaraldehyde	HCO(CH2)3CHO
Liquid Nitrogen	N2
Ethanol	70% Denatured C2H5OH
Hydrochloric Acid	HCl
Acetone	CH3CHO
Acid Lugol's	I,KI,CH3COOH in water
DAPI stain	C16H15N5 . 2HCl
Liquid Nitrogen	N2
Paraformaldehyde	OH(CH2O)nH(n=8-100)
Ethanol (190 proof)	CH3-CH2-OH
RNAlater	50-70% Ammonium Sulphate ((NH4)2SO4)
Lithium Metal Batteries contained in equipment	Li-SOCl2

Deck Layout:

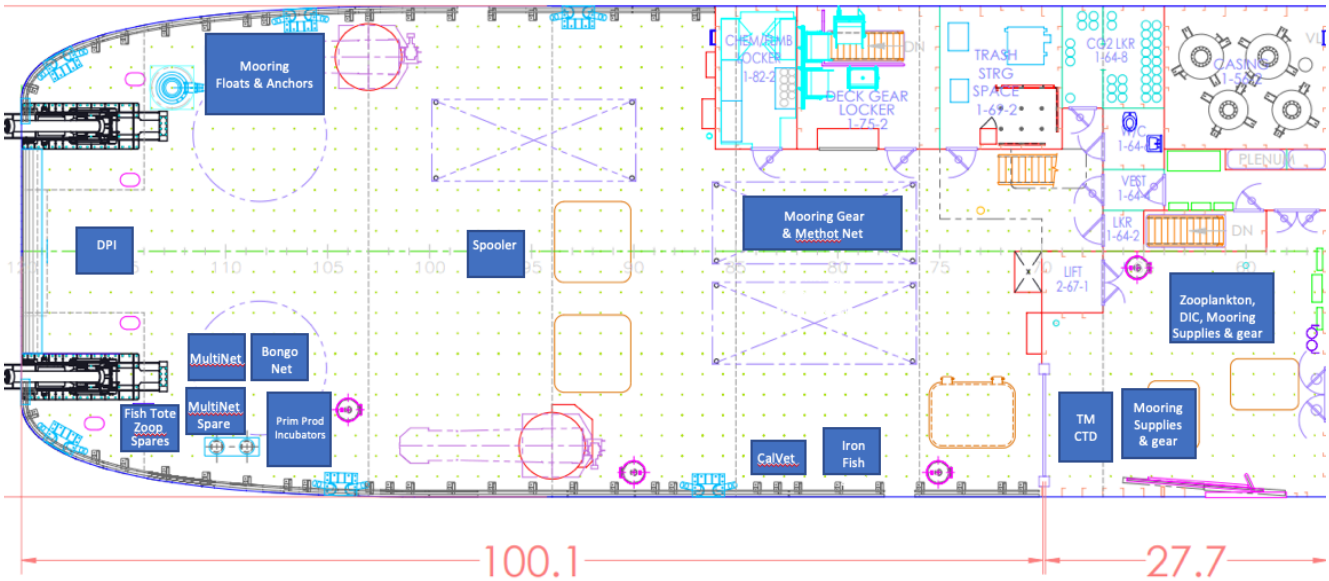

Figure 2. Draft layout of gear on deck

Cruise Activity Schedule

Note: all dates are approximate and subject to change based on weather, operations, supply of coffee and chocolate, broken banjo strings, and other factors.

7/4	Science Party travels toward Seward, overnight in Anchorage or Moose Pass.
7/5	Ship loading begins at 8am. Setup of labs, Science party sleeps on board.
7/6	Set up labs.
	Sikuliaq sails after dinner if possible (~19:00 on 7/6 or by ~06:00 on 7/7)
	First shakedown station (RES 2.5) is under 1 hour from dock.
	Sample station RES 2.5
	Sample station GAK1 (CTD profile only?)
	Transit to Prince William Sound
7/7	PWS sampling activities begin, with day and night splits
7/8	Finish PWS sampling and transit to MID Line
7/9	MID Line Stations
7/10	MID Line Stations
7/11	Copper River Plume: Stations (day) and DPI transect (night)
7/12	Copper River Plume: Stations (day) and DPI transect (night)
7/13	Copper River Plume: Stations (day) and DPI transect (night)
7/14	Copper River Plume 36-hr Time Series (#1 start)
7/15	Copper River Plume 36-hr Time Series (#1 end, #2 start)
7/16	Copper River Plume 36-hr Time Series (#2 end)
7/17	Transit to KOD Line, collect HNLC waters offshore en route
7/18	KOD Line
7/19	KOD Line
7/20	Transit to Seward Line station GAK15, recover glider
7/21	Seward Line stations
7/22	Seward Line stations
7/23	Seward Line stations & GEO moorings
7/24	Seward Line stations
7/25	Seward Line stations
7/26	Seward Line stations
7/27	Ailiak Stations (time permitting), return to Seward by 4 pm, begin demobilization
	Science party sleeps on board
7/28	Finish demobilization
	Science party departs

Transport of Personnel and Gear and Lodging:
See spreadsheets at this Google Sheet:
https://docs.google.com/spreadsheets/d/1nOGb4KHtxEfXfas_QfqjUGlZwvisCz9WoH1KzIJ99AI/edit#gid=0

Station Locations

The maps and tables below provide an overview for the NGA LTER station locations. See the Way Point Tool spreadsheet with the stations that will be visited during this cruise.

Table 1: Stations along the Seward Line (GAK Line) and in Prince William Sound. Highlighted in green are intensive stations. In grey are stations not visited during this cruise.

Latitude N (degrees, minutes)		Longitude W (degrees, minutes)		Station Name
Resurrection Bay Station				
60	1.5	149	21.5	RES2.5
Seward Line				
59	50.7	149	28	GAK1
59	46	149	23.8	GAK1I
59	41.5	149	19.6	GAK2
59	37.6	149	15.5	GAK2I
59	33.2	149	11.3	GAK3
59	28.9	149	7.1	GAK3I
59	24.5	149	2.9	GAK4
59	20.1	148	58.7	GAK4I
59	15.7	148	54.5	GAK5
59	11.4	148	50.3	GAK5I
59	7	148	46.2	GAK6
59	2.7	148	42	GAK6I
58	58.3	148	37.8	GAK7
58	52.9	148	33.6	GAK7I
58	48.5	148	29.4	GAK8
58	44.6	148	25.2	GAK8I
58	40.8	148	21	GAK9
58	36.7	148	16.7	GAK9I
58	32.5	148	12.7	GAK10
58	23.3	148	4.3	GAK11
58	14.6	147	56	GAK12
58	5.9	147	47.6	GAK13
57	***56.6***	***147***	***39***	***GAK14***
57	***47.5***	***147***	***30***	***GAK15***
Prince William Sound Stations				
60	7.5	147	50	KIP0
60	16.7	147	59.2	KIP2
60	22.78	147	56.17	PWS1
60	32.1	147	48.2	PWS2
60	40	147	40	PWS3
60	49..25	147	24	PWSA

60	45	147	14	PWSB
60	38.1	147	10	PWSC
60	31.5	147	7.6	PWSD
60	24.3	147	58.3	PWSE
60	24	146	45	PWSF
Columbia Glacier				
61	7.4	147	3.8	CG0
60	59.5	147	4.2	CG1
60	57.6	147	5.9	CG2
Icy Bay				
60	16.3	148	21.7	IB0
60	14.5	148	20.1	IB1
60	16.3	148	14	IB2
Montague Strait Line				
59	57.257	147	55.602	MS1
59	56.6	147	53.7	MS2
59	55.9	147	51.4	MS3
59	55.2	147	49.7	MS4

Table 2. New LTER Stations. Highlighted in green are intensive stations.

Latitude N (degrees, minutes)		**Longitude W (degrees, minutes)**		**Station Name**
Kodiak Line				
58	14.7	151	35.4	KOD1
58	7.8	151	23.07	KOD2
58	0.9	151	10.74	KOD3
57	54	150	58.17	KOD4
57	47.1	150	45.6	KOD5
57	40.26	150	32.97	KOD6
57	33.42	150	20.34	KOD7
57	26.37	150	7.95	KOD8
57	19.32	149	55.56	KOD9
57	12.27	149	43.17	KOD10
Middleton Island Line				
60	15	145	30	MID1
60	10.5	145	34.5	MID1i
60	6	145	39	MID2
60	1.5	145	43.5	MID2i
59	57	145	48	MID3
59	52.5	145	52.5	MID3i

59	48	145	57	MID4
59	43.5	146	1.5	MID4i
59	39	146	6	MID5
59	34.5	146	10.5	MID5i
59	30	146	15	MID6
59	25.7	146	10	MID6i
59	23	146	18	MID7
59	18.267	146	15	MID7i
59	13.534	146	12	MID8
59	4.067	146	6	MID9
58	54.6	146	0	MID10