

NGA LTER & Gulf Watch Alaska Cruise SKQ2019-15S

Seward Line Cruise Plan
29 June to 18 July, 2019

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

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10 Gwenn Hennon	Microbes & genetics, UAF
11 Suzanne Strom (LTER PI)	Phytoplankton/Microzoop, WWU
12 Kerri Fredrickson	Phytoplankton/Microzoop, WWU
13 Clay Mazur	Phytoplankton/Microzoop, WWU
14 Hana Busse	Phytoplankton/Microzoop, WWU
15 Delphina Walker-Phelan	Phytoplankton/Microzoop, WWU, REU
16 Russ Hopcroft (LTER Lead PI)	Zooplankton (days), UAF
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20 Adrianna Hernandez	Zooplankton (nights), UAF, REU
21 Kate Mayer	Zooplankton (days), UAF, REU
22 Kira Monell	Zooplankton (days), UHawaii
23 Daniel Cushing	Seabirds/Mammals, US Fish & Wildlife Service
24 Catherine Fuller	Teacher at sea (Particle Flux team member)
25 Ethan Roth	SKQ Marine technician, Lean
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Synopsis

The scientific purpose of this research is to monitor ecosystem conditions and to develop an understanding of the responses and resiliency to climate variability. This cruise represents a continuation of ecosystem sampling begun in 1997 under the NSF/NOAA NE Pacific GLOBEC program. From 2005-2017 sampling was supported by a consortium that included the North Pacific Research Board (NPRB), the Alaska Ocean Observing System (AOOS), and the Exxon Valdez Oil Spill Trustee Council's (EVOSTC) Gulf Watch Alaska (GWA) program. From 2018 to the present an expanded consortium also includes the NSF Northern Gulf of Alaska (NGA) Long-Term Ecological Research (LTER) program. In 2019 we are now in the 50th consecutive year of samples taken at oceanographic station GAK1 (begun December 1970) and the 23rd consecutive year of Seward Line physical-chemical-phytoplankton-zooplankton-seabird sampling.

Cruise Objectives

1. Determine thermohaline, velocity, light, and oxygen structure of the NGA shelf.
2. Determine macro- and micro-nutrient structure of the NGA shelf.
3. Determine particle structure and flux rates of the NGA shelf.
4. Determine phyto- and microzooplankton composition, biomass distribution, and productivity.
5. Determine the vertical and horizontal distribution and abundance of zooplankton species
6. Record multi-frequency acoustics for estimation of nekton
7. Conduct surveys of seabirds and marine mammals
8. Conduct shipboard experimental work on phytoplankton and zooplankton.
9. Determine carbonate chemistry (i.e. ocean acidification parameters) at selected stations
10. Deploy drifting sediment traps at select stations.
11. Conduct process studies in the vicinity of the Copper River discharge plume
12. Deploy GEO moorings.
13. Provide at-sea research experiences for graduate and undergraduate students.
14. Share the experience through outreach/media activities.

Sampling

Cruise SKQ201915S will have two distinct components that each require multiple days of activity (Plume Study and Monitoring Transects) and two shorter components that will require something less than one day each to accomplish (Mooring Operations and a High-Nutrient Low-Chlorophyll (HNLC) experiment).

1. Plume Study

Approximately 5 days of the cruise will be dedicated to high-resolution sampling of the Copper River discharge plume. Activities will include mapping of the plume extent and depth using an undulating towed Acrobat CTD system and towing a surface sampler (Iron Fish) that collects clean water for iron analyses. We will pause mapping activities approximately once per day (probably in the morning between 8 and 12) in order to collect water and plankton samples using the CTD and nets. We will deploy a number of satellite-tracked drifters (4 PacificGyre MicroStar and 16 Oceanetic SCT drifters) and a light, short-term mooring that is recovered at the end of the plume study.

An important facet of the plume study involves the simultaneous towing of the **Iron Fish** (abeam starboard) and the **Acrobat** undulating vehicles (astern). Two packages over the side is always cause for taking extra care. The Iron Fish package is towed just below the surface away from the vessel by the starboard crane, and does not have enough line paid out to ever foul with Sikuliaq's propulsion system. The Acrobat is towed 170 to 230 meters astern from the A-frame. Because of the tow locations of these two packages and their tow cable lengths, they have no ability to foul with each other or the vessel while maintaining forward motion or even sharp turns. However, because we will be making cross-shelf transects into shallow water, it will be important to make wide and slow turns to keep the Acrobat from sinking toward the seafloor during a heading change maneuver, and to allow for adjusting the IronFish tubing and line to prevent damage by either excessive pulling or hitting the hull.

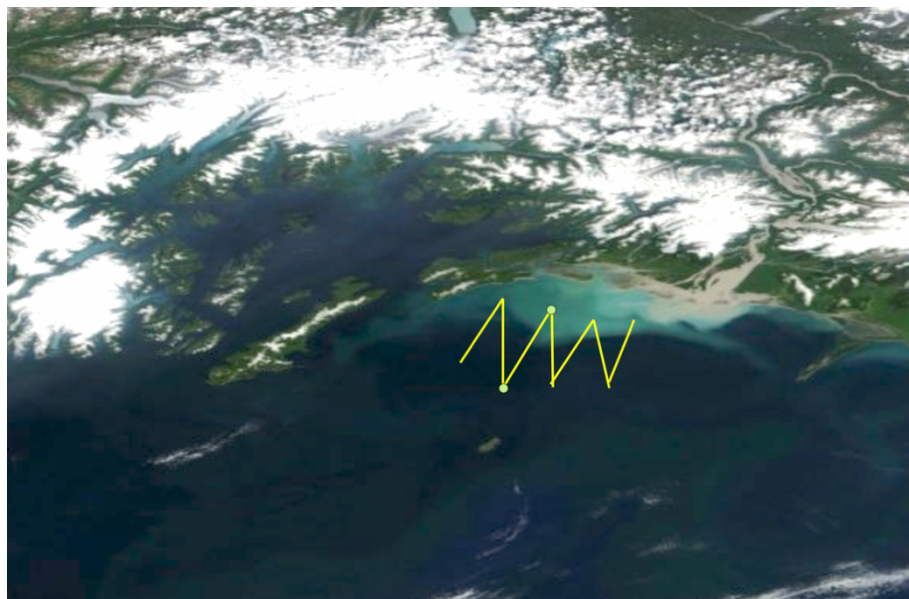


Figure 0. Satellite image of the NE Gulf of Alaska shelf and the Copper River sediment plume. Image from July 2018. Transect endpoints will be determined at sea based on available satellite imagery and results of the Middleton Island hydrographic transect.

Acrobat/Iron Fish tows will involve zig-zags across the river plume frontal region (Figure 0). We will spend one 24-hour diurnal tidal cycle doing repeat tows back-and-forth along one of these lines in order to characterize tidal straining of the frontal zone.

2. Station Transects

Approximately 15 days of the cruise will be dedicated to transect station work. The overall approach of the transect component of the cruise is to occupy 3 transect lines across the shelf and additional stations within PWS. While occupying transect lines, 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 other stations occupied that day. Stations profiles are supplemented by underway measurements.

For this cruise we anticipate spending 2 days to complete the Kodiak Line, 2 days for the Middleton Island Line, 1 day for PWS and 4 days for the Seward Line. 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 stations conducting both Multinet and Methot trawls will be conducted per night: sampling starts ~dusk and stops ~dawn, and can be extended slightly when overcast. The Methot deployments are less light dependent and typically are conducted coming into or leaving station. In July, there is a greater period of light available than of darkness, so execution of daytime stations and activities are designed around being in position to commence Multinet sampling as soon as it is sufficiently dark.

TRANSECT COMPONENT DAYTIME ACTIVITIES:

- Occupy the various hydrographic stations and collect vertical CTD-fluorescent-PAR and particle profiles (see **Figures & Tables**).
- Collect discrete bottle samples at these stations for nutrients, dissolved organic carbon (DOC), chlorophyll, and microzooplankton. Chlorophyll Size Fractionation (20 μ m) will be done at all whole numbered Seward Line and most other stations. Macronutrients samples will be prefiltered prior to freezing. Chlorophyll will be extracted on fresh filters without freezing.
- Measure the dissolved carbonate chemistry along the Seward Line and within Prince William Sound from bottle casts at selected intensive stations (GAK1, GAK5, GAK9, GAK13, PWS2).
- CalVet Net casts will be done (CalVet frame has 4 nets) after most the CTD casts to 100m. (NO CALVETs at the “i” stations).
- At intensive stations an additional CTD cast will collection water to be used for primary production incubations. Samples for molecular analysis, HPLC-pigments, and particulate organic carbon (POC) will also be collected.
- At intensive stations at trace-metal CTD cast will collect water for determination of iron concentration (a key micronutrient in NGA). Because a clean surface sample cannot be collected with the CTD rosette, this will be done with the IronFish (see next point)
- We will deploy the Iron Fish during the day (and possibly on long transits). Sampling will occur just prior arriving to or just after departing a station. Last year, we left the IronFish in the water while on station rather than constantly retrieving it and deploying it. The exception was Intensive stations, when the trace-metal CTD cast took place. During high wind conditions or choppy seas, the Iron Fish will not be deployed so as not to impact transit speed.

- At intensive stations there will be an extra Calvet collection, as well as a vertical deployment of the 150 μ m Multinet to 200m. Some of this material will be used for live sorting as well as post-cruise molecular analysis.
- We will do one deep Multinet tow (to maximum 1200 m) near the end of the Seward Line and two at PWS2 (800m). This may be done at night in conjunction with Multinet work at those stations if time permits.
- We will identify additional opportunities for concurrently towing the Acrobat and the iron fish. Priority regions for tows are along the Seward Line, and over Albatross Bank.
- We will deploy drifting sediment traps at select stations and then recover following a 6 to 24 hour soak period. Aligning deployments and recoveries to avoid extra transit might involve deployment during daytime activities and recovery during nighttime activities or vice-versa.

TRANSECT COMPONENT NIGHTTIME ACTIVITIES:

- A towed 505- μ m Multinet will be used to collect depth-stratified samples along the Seward Line, and at selected PWS Stations to 200m. Tandem Bongo nets will be used at all other stations to 200m. At intensive stations along the Seward Line and in PWS an additional collection will be taken with a Bongo net. When either entering or leaving all stations, a Methot Trawl will be deployed by crane for ~20 minutes while in route at 2.5-3 knts to the next station.
- Deep-multinet tows may occur during the night shift as time permits.

3. HNLC Experiment

Sometime during the plume study, time will be required to collect a carboy of plume water from the IronFish. Following the Plume Study, we will transit to offshore HNLC waters to collect carboys of filtered and unfiltered surface water for an incubation growth experiment that combines river plume waters with offshore waters. Once offshore waters are located, water collection and experimental set-up will take ~ 4 hrs. Incubators for this and other process experiments need to be located in a relatively unshaded deck location.

4. Moorings

This cruise involves the initial commissioning of the moored Gulf of Alaska Ecosystem Observatory (GEO) mooring set, which will be located in the vicinity station GAK7. It is comprised of one subsurface mooring, one instrumented mooring with a surface expression and one guard mooring with a surface expression (see Figure 3 below). The two surface buoys have radar reflectors, flashing lights and real-time telemetry. Prior to deployment we will map the seafloor with the SKQ multibeam system in order to know the region within which we will have an acceptable seafloor depth (230 m +/- 1m) at the time of anchor release. Moorings will be deployed surface float first, slowly towed into location, and released with a free-falling anchor. The three moorings will be deployed in a line with Mooring GEO2 located directly between GEO1 and GEO3.

Sampling personnel requirements and sample protocol overview

- **CTD:** winch operator, 1-2 scientists (launch and recovery), 30m/min in upper 100m, 60m/min below 100m. Depending on schedule, casts may be limited to 1000m at deep-sea stations.
- **Acrobat:** A-frame & winch operator, 2 scientists for launch & recovery. 1-2 scientists to communicate with bridge during towing operations. Ship speed 6-8 kts through water.
- **Moorings & Drifting Sediment Traps:** A-frame/crane/TSE spooler operators, martec, mooring technician, 2-3 scientists to mark deployment locations, assist on deck, and communicate with bridge.
- **TMC CTD:** winch operator, 2 scientists (launch and recovery), 30m/min in upper 100m, 60m/min below 100m. Casts are limited to 1000m at deep-sea stations.
- **TMC towfish:** 1 Deck person and 1 scientist for launch and recovery (~15-20 min), A deck person, martec, or scientist to watch towfish during towing and communicate with the bridge/science.
- **Multinet & Bongo:** winch operator, 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. Both systems will have depth transducers to ensure we get close to, but not on the bottom when depths are less than 200m.
- **Calvets & Ring nets:** winch operator, 1-2 scientists (launch, recovery, wash-down) – Ship speed: station keeping, Wire speed: ~1 m/sec for Calvet, 0.5m/sec for Ring net (10 min/cast).
- **Methot Trawl:** winch operator, 1-2 scientists, launch, recovery, wash-down) – Ship speed: ~2.5-3 kts., Duration 20 minutes. This will be a shallow subsurface tow – if time permits we will try to tow-yo the upper 20-30 m at a subset of stations.
- **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.

Equipment and Supplies

Ship's Science Equipment Needed:

- CTD
- Science Freezer for chlorophyll extraction.
- -80 freezer for macro-nutrient, DOC, and genetic samples.
- -20 freezer for organic iron ligand samples
- First walk-in incubator set at surface ambient temperature (somewhere near 10 C).
- Second walk-in incubator set at a subsurface temperature TBD (~ 4 C)
- 150 and 75 KHz acoustic Doppler current profilers
- EK60 fisheries acoustics
- Underway sampling system (TSG, nav, met, etc)
- Access to uncontaminated seawater system
- Access to Ultra pure water systems
- Access to bridge & NMEA GPS feed for seabird observer
- Large seawater manifold for deck-based incubators
- TSE spooler for mooring cable payout
- Access to and hookup of one phase of the deck 208V 3-phase supply for driving the Acrobat Winch
- Raspberry Pi for splitting NMEA GPS and SKQ depth strings into Acrobat flight computer.

Scientist's Equipment Needed:

- Trace-metal clean CTD system (Baltic room storage), dedicated block, winch and line.
- Trace-metal clean towfish system (access to compress air) (Deck storage 3 palettes)
- Wall-mounted racks for keeping TMC niskins during subsampling
- Positive pressure enclosures. A large one in the analytical lab, and a small one in the Wet lab. Both enclosures need to be near a sink. 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
- CalVet and ring nets [nets, flow-meters, frames, swivels, weights, spares]
- 2 Multinet system (coarse and fine nets, spare cod ends/nets)
- Bongo nets, Methot nets & depressors
- Large deckboard incubators plumbed to flowing seawater system
- Filtration systems
- Fluorometers & Centrifuge
- 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 dewar
- Mooring instruments, tools, anchors and line
- Acrobat instrument, spares, and winch
- Coffee

- Formaldehyde – 2x20L carboy (Hopcroft)
- Rose Bengal Stain 50g (Hopcroft)
- Ethanol – 40L (Hopcroft)
- Oxygen Fixation (Sodium hydroxide. Sulphuric acid, Manganous Chloride) (O'Daly)
- Mercuric Chloride (for DIC fixation) (O'Daly)
- 3N HCl (25% v/v) (500 ml) (Aguilar-Islas)
- 1 N HCl (1 L) (Strom)
- 12N HCl (2 L) (Strom)
- Acetone – 16L (Strom)
- DAPI stain – 10 mg (Strom)
- Glutaraldehyde (10%) – 2 L (Strom)
- Lugol's solution (1L) (Strom)
- Glutaraldehyde (25%) – 10mL (Hennon)
- Ethanol (70%) – 1L (Hennon)
- 1N HCl - 500mL (Hennon)
- Liquid nitrogen- ~5L (Hennon)
- Lithium batteries in instruments (Shipton)

48.0

100.1

27.7

2

Draft Cruise Activity Schedule

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

- 6/27 Science party arrives in Seward, overnight at Breeze Inn.
Clean bubble install begins if possible.
- 6/28 Science party boards Sikuliaq @ 8am, sets up.
Science party sleeps on board.
- 6/29 Sikuliaq sails at approximately 8 am
First station is under 1 hour from dock.
Sample stations RES2.5 and GAK1.
Transit to Prince William Sound, sample Station KIP2.
- 6/30 Sample station PWS2
Transit to Middleton Island Line
Begin MID Line stations
- 7/1 MID Line stations
- 7/2 Finish MID Line stations, begin Plume Study
- 7/3 Plume Study
- 7/4 Plume Study
- 7/5 Plume Study
- 7/6 Plume Study
- 7/7 Finish Plume Study
Transit to Seward Line
- 7/8 HNLC Experiment
- 7/9 Seward Line stations
- 7/10 Seward Line stations
- 7/11 Deploy GEO moorings
- 7/12 Seward Line stations
- 7/13 Seward Line stations
- 7/14 Transit to Kodiak Line
- 7/15 KOD Line stations
- 7/16 KOD Line stations
- 7/17 Assess remaining time.
Tow Acrobat on Seward Line?
Sample eddy at end of Kodiak Line?
Montague Strait stations?
- 7/18 Transit to GAK1
Sample GAK1 & RES2.5
Return to Seward by 4 pm, begin demobilization
Science party sleeps on board
- 7/19 Finish demobilization, science party departs Seward

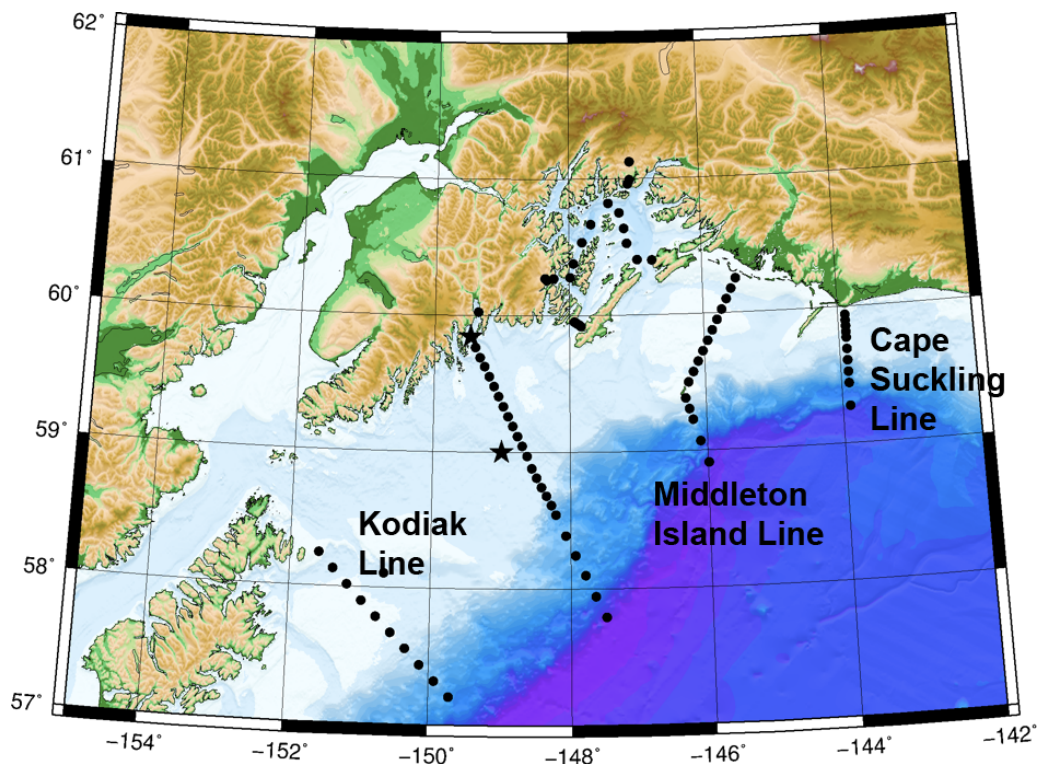


Figure 2. NGA-LTER sampling stations. The Cape Suckling Line will not be occupied on SKQ2019-15S. Only a portion of the Prince William Sound stations will be occupied (TBD at sea).

Table 1. STANDARD STATIONS (intensive stations highlighted)

Table Columns:

1. Degrees North,
2. Minutes North,
3. Degrees West,
4. Minutes West,
5. Decimal Degrees North,
6. Decimal Degrees West,
7. %,
8. Station Name

Resurrection Bay Stations							
60	1.5	149	21.5	60.02500	-149.35833	%	RES2.5

Seward Line Stations							
59	50.7	149	28	59.84500	-149.46667	%	GAK1
59	46	149	23.8	59.76667	-149.39667	%	GAK1I
59	41.5	149	19.6	59.69167	-149.32667	%	GAK2
59	37.6	149	15.5	59.62667	-149.25833	%	GAK2I
59	33.2	149	11.3	59.55333	-149.18833	%	GAK3
59	28.9	149	7.1	59.48167	-149.11833	%	GAK3I
59	24.5	149	2.9	59.40833	-149.04833	%	GAK4
59	20.1	148	58.7	59.33500	-148.97833	%	GAK4I
59	15.7	148	54.5	59.26167	-148.90833	%	GAK5
59	11.4	148	50.3	59.19000	-148.83833	%	GAK5I
59	7	148	46.2	59.11667	-148.77000	%	GAK6
59	2.7	148	42	59.04500	-148.70000	%	GAK6I
58	58.3	148	37.8	58.97167	-148.63000	%	GAK7
58	52.9	148	33.6	58.88167	-148.56000	%	GAK7I
58	48.5	148	29.4	58.80833	-148.49000	%	GAK8
58	44.6	148	25.2	58.74333	-148.42000	%	GAK8I
58	40.8	148	21	58.68000	-148.35000	%	GAK9
58	36.7	148	16.7	58.61167	-148.27833	%	GAK9I
58	32.5	148	12.7	58.54167	-148.21167	%	GAK10
58	23.3	148	4.3	58.38833	-148.07167	%	GAK11
58	14.6	147	56	58.24333	-147.93333	%	GAK12
58	5.9	147	47.6	58.09833	-147.79333	%	GAK13
57	56.6	147	39	57.94333	-147.65000	%	GAK14
57	47.5	147	30	57.79167	-147.50000	%	GAK15

Prince William Sound Stations							
60	7.5	147	50	60.12500	-147.83333	%	KIP0
60	16.7	147	59.2	60.27833	-147.98667	%	KIP2
60	22.78	147	56.17	60.37967	-147.93617	%	PWS1
60	32.1	147	48.2	60.53500	-147.80333	%	PWS2
60	40	147	40	60.66667	-147.66667	%	PWS3
60	49.25	147	24	60.82083	-147.40000	%	PWSA
60	45	147	14	60.75000	-147.23333	%	PWSB
60	38.1	147	10	60.63500	-147.16667	%	PWSC
60	31.5	147	7.6	60.52500	-147.12667	%	PWSD
60	24.3	147	58.3	60.40500	-147.97167	%	PWSE
60	24	146	45	60.40000	-146.75000	%	PWSF
61	7.4	147	3.8	61.12333	-147.06333	%	CG0
60	59.5	147	4.2	60.99167	-147.07000	%	CG1
60	57.6	147	5.9	60.96000	-147.09833	%	CG2
60	16.3	148	21.7	60.27167	-148.36167	%	IB0
60	15.5	148	20.1	60.25833	-148.33500	%	IB1
60	16.3	148	14	60.27167	-148.23333	%	IB2
60	11.57	147	42	60.19283	-147.70000	%	HB1
60	10.754	147	38.5	60.17923	-147.64167	%	HB2
60	9.855	147	34.508	60.16425	-147.57513	%	HB3
60	8.807	147	30.04	60.14678	-147.50067	%	HB4
59	57.257	147	55.602	59.95428	-147.92670	%	MS1
59	56.6	147	53.7	59.94333	-147.89500	%	MS2
59	55.9	147	51.4	59.93167	-147.85667	%	MS3
59	55.2	147	49.7	59.92000	-147.82833	%	MS4

Kodiak Island Stations							
58	14.7	151	35.4	58.24500	-151.59000	%	KOD1
58	7.8	151	23.07	58.13000	-151.38450	%	KOD2
58	0.9	151	10.74	58.01500	-151.17900	%	KOD3
57	54	150	58.17	57.90000	-150.96950	%	KOD4
57	47.1	150	45.6	57.78500	-150.76000	%	KOD5
57	40.26	150	32.97	57.67100	-150.54950	%	KOD6
57	33.42	150	20.34	57.55700	-150.33900	%	KOD7
57	26.37	150	7.95	57.43950	-150.13250	%	KOD8
57	19.32	149	55.56	57.32200	-149.92600	%	KOD9
57	12.27	149	43.17	57.20450	-149.71950	%	KOD10

Middleton Island Stations							
60	15	145	30	60.25000	-145.50000	%	MID1
60	10.5	145	34.5	60.17500	-145.57500	%	MID1i
60	6	145	39	60.10000	-145.65000	%	MID2
60	1.5	145	43.5	60.02500	-145.72500	%	MID2i
59	57	145	48	59.95000	-145.80000	%	MID3
59	52.5	145	52.5	59.87500	-145.87500	%	MID3i
59	48	145	57	59.80000	-145.95000	%	MID4
59	43.5	146	1.5	59.72500	-146.02500	%	MID4i
59	39	146	6	59.65000	-146.10000	%	MID5
59	34.5	146	10.5	59.57500	-146.17500	%	MID5i
59	30	146	15	59.50000	-146.25000	%	MID6
59	25.7	146	10	59.42833	-146.16667	%	MID6i
59	23	146	18	59.38333	-146.30000	%	MID7
59	18.267	146	15	59.30445	-146.25000	%	MID7i
59	13.534	146	12	59.22557	-146.20000	%	MID8
59	4.067	146	6	59.06778	-146.10000	%	MID9
58	54.6	146	0	58.91000	-146.00000	%	MID10

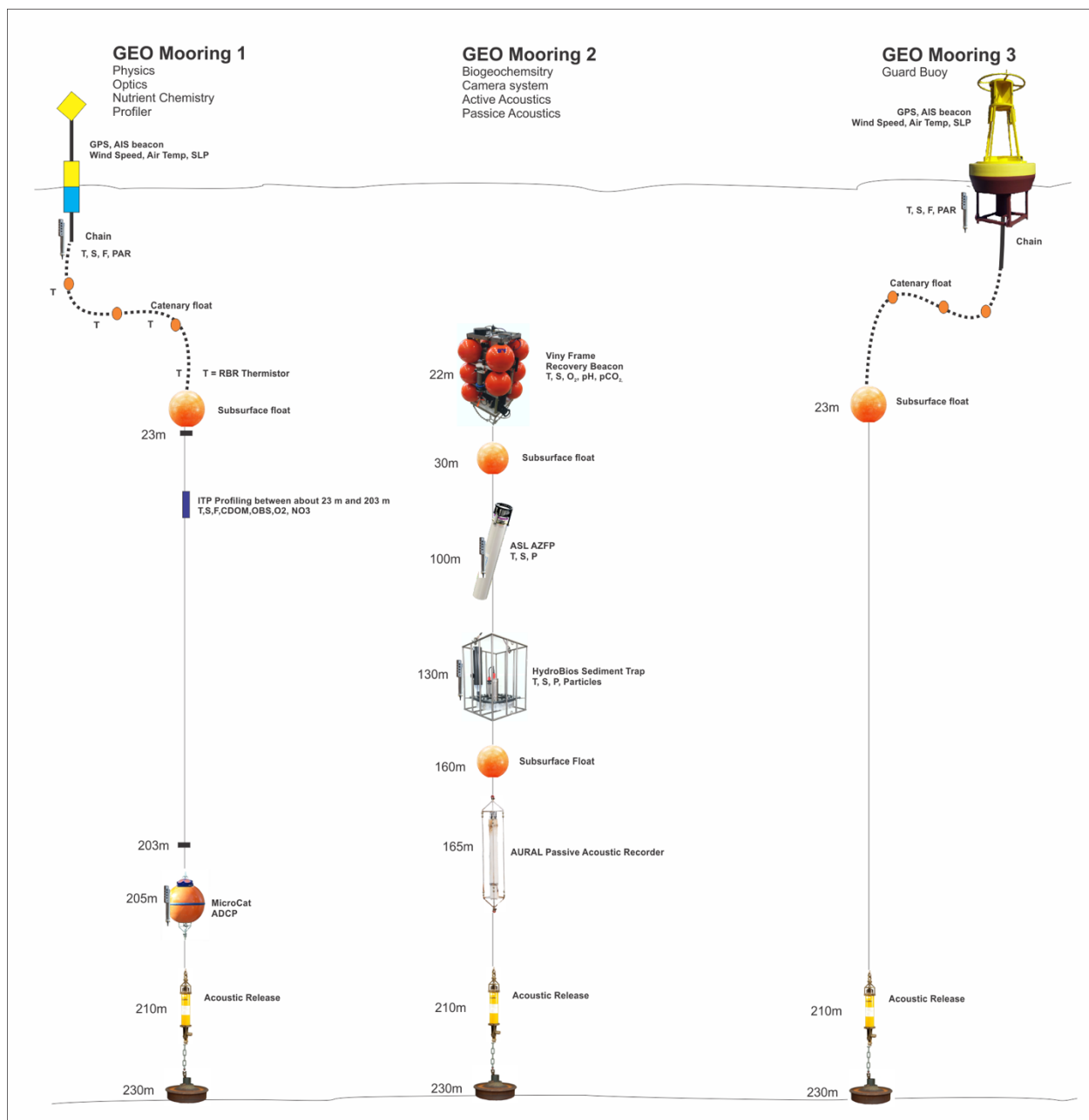


Figure 3. GEO mooring cluster. These moorings will be deployed in 230 m water depth west or southwest of station GAK7.