NGA LTER & Gulf Watch Alaska
Cruise SKQ202010S

Seward Line Cruise Plan
2 to 16 July, 2020

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

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4	Will Burt	Plankton/Optics, UAF
5	Hana Busse	Phytoplankton/Microzooplakton, WWU
6	Daniel Cushing	Seabirds/Mammals, US Fish & Wildlife Service
7	Russ Hopcroft (LTER Lead PI)	Zooplankton (days), UAF
8	Savannah Sandy	Physics (Moorings/CTD/Acrobat), UAF
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12	Ethan Roth	SKQ Marine technician, Lead
13	Bern McKiernan	SKQ Marine technician

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 2020 we are now in the 50th consecutive year of samples taken at oceanographic station GAK1 (begun December 1970) and the 23nd consecutive year of Seward Line physical-chemical-phytoplankton-zooplankton-seabird sampling.

COVID-19

Expedition SKQ202010S is taking place in the era of the Covid-19 novel coronavirus global pandemic and as a result of this, the cruise is operating under safety protocols for R/V Sikuliaq. Adjustments to normal operations include pre-cruise isolation for ship's crew and science party, reduction of personnel to one per stateroom for social distancing, and twice daily temperature and oxygen vital signs monitoring (see attachment for additional details).

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 phyto- and microzooplankton composition, biomass distribution, and productivity.
4. Determine the vertical and horizontal distribution and abundance of zooplankton species
5. Record multi-frequency acoustics for estimation of nekton
6. Conduct surveys of seabirds and marine mammals
7. Conduct shipboard experimental work on phytoplankton and zooplankton.
8. Determine carbonate chemistry (i.e. ocean acidification parameters) at selected stations.
9. Map structure of the Copper River discharge plume.
10. Recover mooring GEO2 and deploy moorings GEO2 and GEO3.
11. Provide at-sea research experiences for graduate students.
12. Share the experience through outreach/media activities.

Sampling

Cruise SKQ202010S will have three distinct components that each require dedicated ship time (Mooring Turn-Around, Plume Study and Monitoring Transects).

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 may deploy a satellite-tracked drifters (PacificGyre MicroStar and Oceanetic SCT drifters) and a light, short-term mooring that would be 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 relatively 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. Slow turns will also allow for adjusting the IronFish tubing and line to prevent damage by either excessive pulling or hitting the hull.

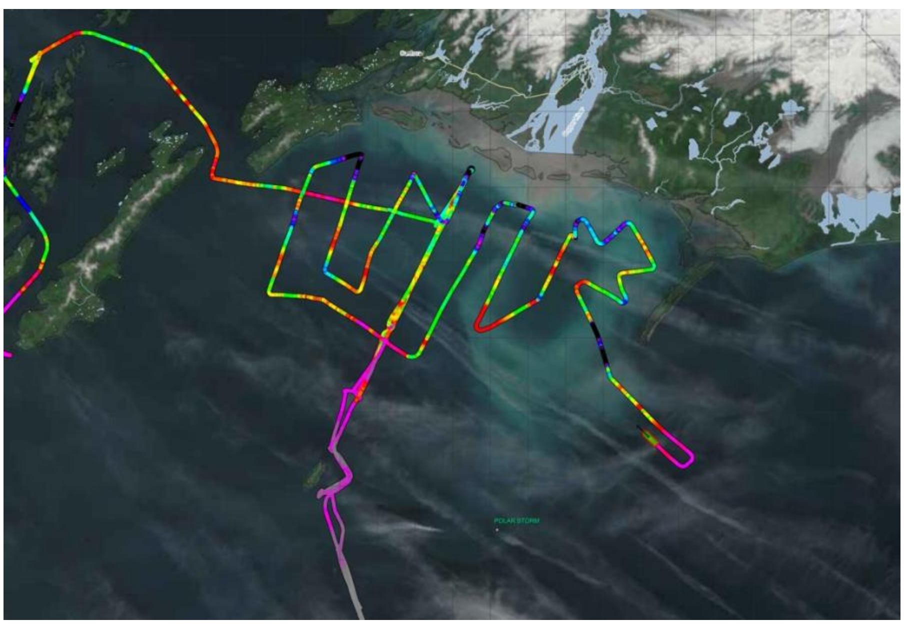

Figure 1. July 2019 satellite image of the NE Gulf of Alaska shelf, the Copper River sediment plume, and the shiptrack of cruise SKQ201915S. Acrobat mapping locations for 2020 will be determined at sea based on available satellite imagery and results of the Middleton Island hydrographic transect.

Acrobat/Iron Fish tows will involve zig-zags across the river plume frontal region (Figure 1). We may 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 7 days of the cruise will be dedicated to transect station work. The overall approach of the transect component of the cruise is to occupy the Seward and Middleton Island transect lines 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 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 µm) 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 µm 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.
- For winch maintenance, we will spool out ~1500m of wire from the large Seward Line winch normally used on R/V Tiglax and grease the cable as the wire is recovered.

TRANSECT COMPONENT NIGHTTIME ACTIVITIES:

- A towed 505-µm 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. We will focust Methot sampling on the odd-numbered Seward Line stations.
- Deep-multinet tows may occur during the night shift as time permits.

3. Moorings

This cruise involves servicing the Gulf of Alaska Ecosystem Observatory (GEO) moorings, which are located mid-shelf in the vicinity of GAK6. It is comprised of two subsurface moorings, and one surface mooring (see Figures 4 and 5 below). The surface buoy has radar reflectors, flashing lights and real-time telemetry. The surface mooring will be deployed top-float first, slowly towed into location, and released with a free-falling anchor (layback of 20 m). Mooring GEO2 located directly between GEO1 and GEO3 and will be deployed anchor-first with the vessel holding position in DP mode.

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.
- **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. Odd Seward Line 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 12 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
- Seawater manifold for two 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
- Dynacon CTD winch
- Optical flow-through system

Hazardous Materials (See Hazmat manifest and MSDS archive):

- Formaldehyde – 2x20L carboy (Hopcroft)
- Rose Bengal Stain 50g (Hopcroft)
- Ethanol – 40L (Hopcroft)
- Oxygen Fixation (Sodium hydroxide, Sulphuric acid, Manganous Chloride) (Aguilar-Islas)
- Mercuric Chloride (for DIC fixation) (Aguilar-Islas)
- 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)
- Lithium batteries in instruments (Shipton)

Deck Layout:

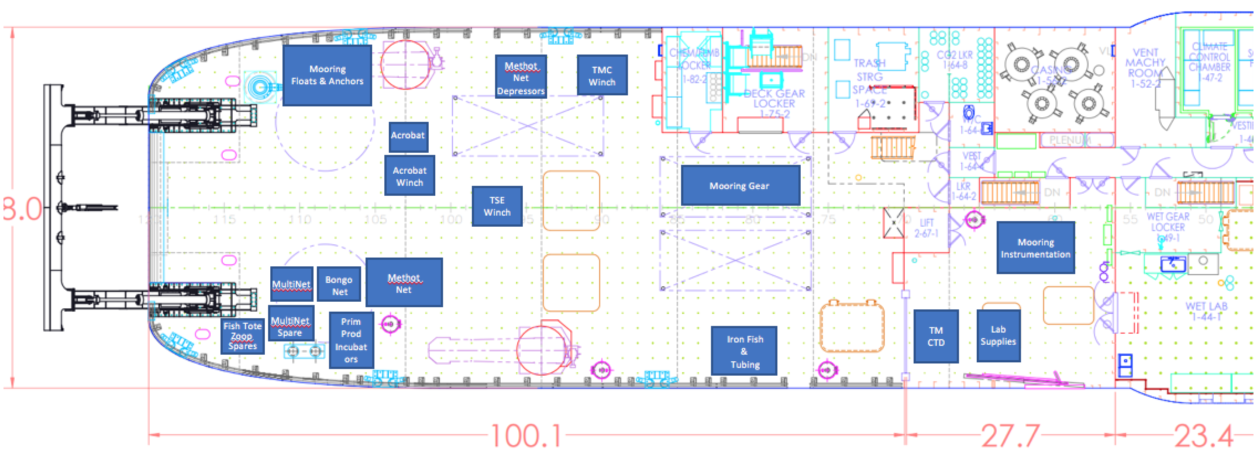

Figure 2. Draft layout of gear on deck.

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.

6/16	Danielson arrives in Seward
6/17	Strom Phytoplankton team arrives in Seward (3 Scientists)
6/29	Aguilar-Islas Chemistry team arrives (2 Scientists), overnight on board SKQ
6/30	Science party arrives in Seward, All scientists overnight on board SKQ. Setup of clean lab bubble begins (Ana A-I)
7/1	Set up labs.
7/2	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. Depending on time, test Acrobat system while on transit or after station PWS2
7/3	Sample station PWS2 Transit to Middleton Island Line Begin MID Line stations
7/4	MID Line stations
7/5	Finish MID Line stations, begin Plume Study
7/6	Plume Study
7/7	Plume Study
7/8	Plume Study
7/9	Plume Study
7/10	Finish Plume Study Transit toward GAK15 Grease Dynacon winch cable over deep water.
7/11	Seward Line stations
7/12	Seward Line stations
7/13	Recover and deploy GEO moorings
7/14	Seward Line stations
7/15	Seward Line stations Assess remaining time. Tow Acrobat on Seward Line?
7/16	Transit to GAK1 Sample GAK1 & RES2.5 Return to Seward by 4 pm, begin demobilization Science party sleeps on board
7/17	Finish demobilization, science party departs Seward

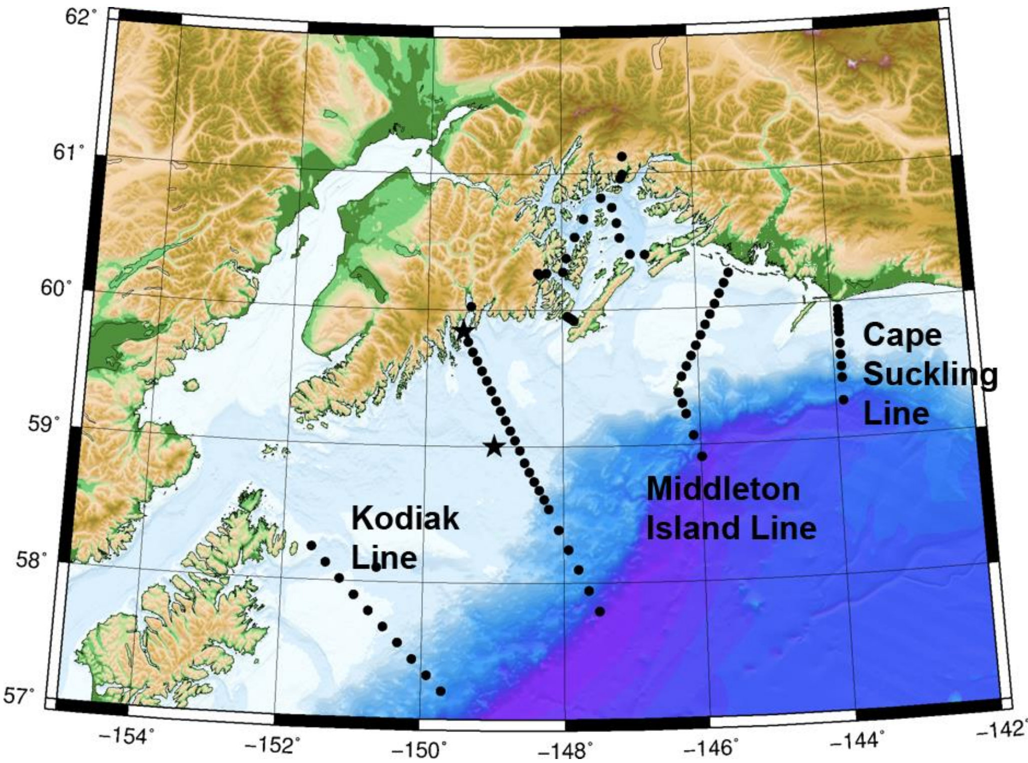

Figure 3. NGA-LTER sampling stations. The Cape Suckling Line and Kodiak Line will not be occupied on SKQ202010S. Only a portion of the Prince William Sound stations will be occupied (TBD at sea). Star indicates approximate location of the GEO site.

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	58.8816	-148.56000	%	**GAK7I**

				7			
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	57.6710	-150.54950	%	**KOD6**

				0			
57	33.42	150	20.34	57.5570 0	-150.33900	%	**KOD7**
57	26.37	150	7.95	57.4395 0	-150.13250	%	**KOD8**
57	19.32	149	55.56	57.3220 0	-149.92600	%	**KOD9**
57	12.27	149	43.17	57.2045 0	-149.71950	%	**KOD10**

Middleton Island Stations							
60	15	145	30	60.2500 0	-145.50000	%	**MID1**
60	10.5	145	34.5	60.1750 0	-145.57500	%	**MID1i**
60	6	145	39	60.1000 0	-145.65000	%	**MID2**
60	1.5	145	43.5	60.0250 0	-145.72500	%	**MID2i**
59	57	145	48	59.9500 0	-145.80000	%	**MID3**
59	52.5	145	52.5	59.8750 0	-145.87500	%	**MID3i**
59	48	145	57	59.8000 0	-145.95000	%	**MID4**
59	43.5	146	1.5	59.7250 0	-146.02500	%	**MID4i**
59	39	146	6	59.6500 0	-146.10000	%	**MID5**
59	34.5	146	10.5	59.5750 0	-146.17500	%	**MID5i**
59	30	146	15	59.5000 0	-146.25000	%	**MID6**
59	25.7	146	10	59.4283 3	-146.16667	%	**MID6i**
59	23	146	18	59.3833 3	-146.30000	%	**MID7**
59	18.267	146	15	59.3044 5	-146.25000	%	**MID7i**
59	13.534	146	12	59.2255 7	-146.20000	%	**MID8**
59	4.067	146	6	59.0677 8	-146.10000	%	**MID9**

58	54.6	146	0	58.9100 0	-146.00000	%	**MID10**

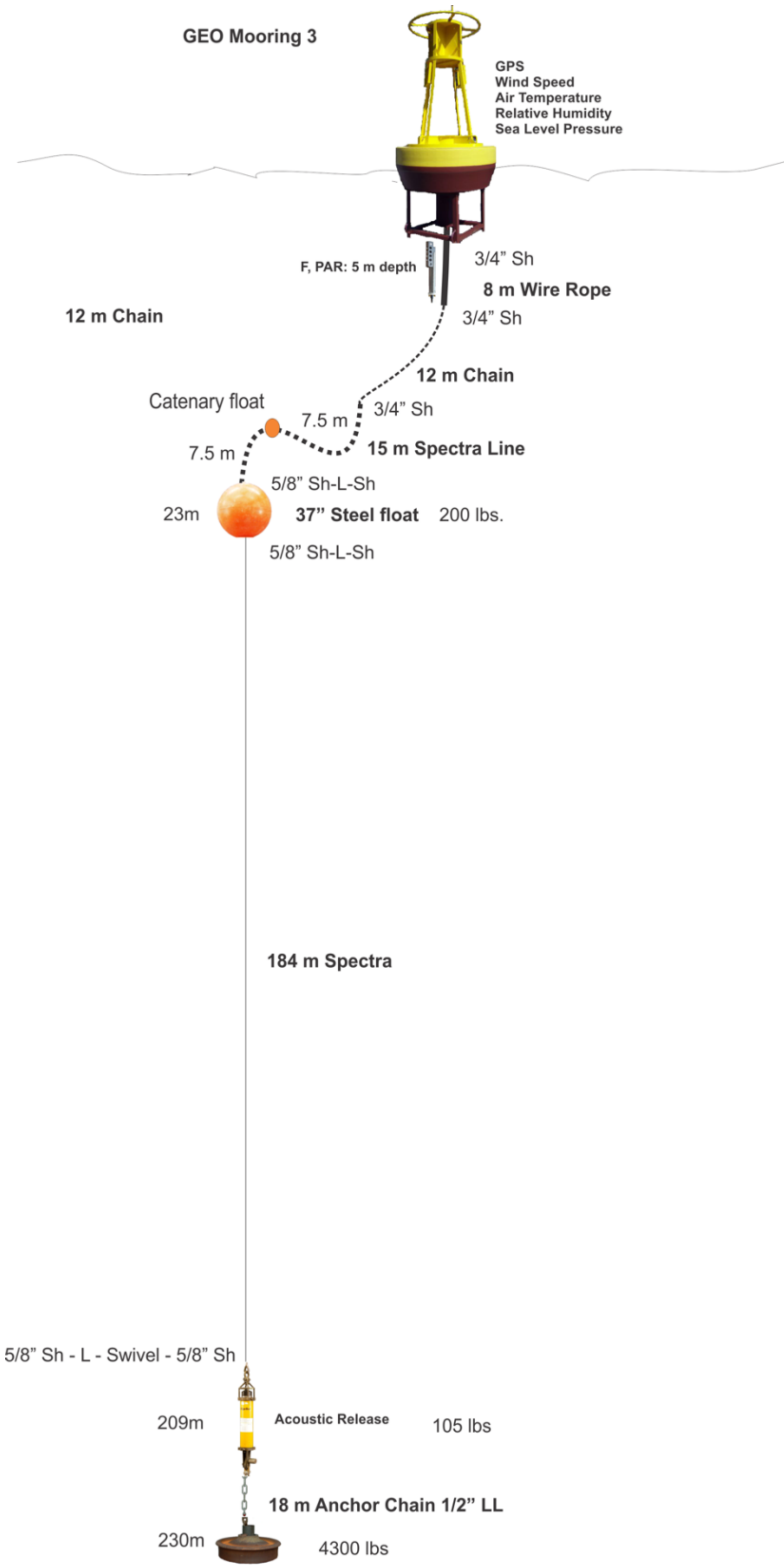

Figure 4. Mooring GEO3 configuration.

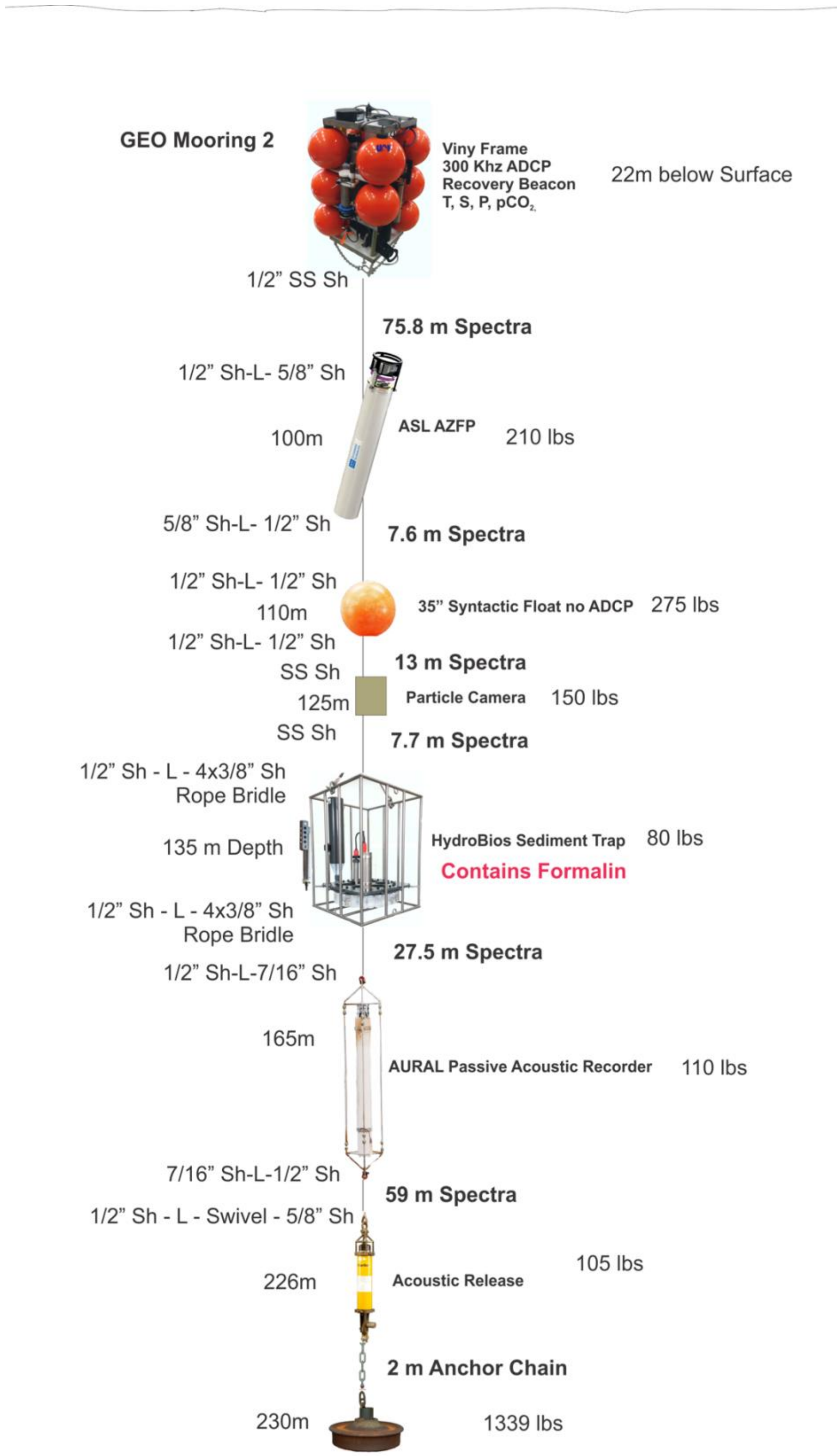

Figure 5. Mooring GEO2 configuration.