Cruise Report for the 2012 FISHPAC Project and South Arctic Reconnaissance

Prepared by: RACE Division Habitat Research Team

Cruise ID:	**FISHPAC, M-R908-FA-12**	Vessel:	**NOAA Ship *Fairweather***
Cruise Dates:	**8-28 July and 1-6 August, 2012**	Hydrographic Surveys:	**D00169 & D00170**

Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA 98115-6349

28 February 2013

Overview

The broad scope of the Essential Fish Habitat (EFH) mandate requires an efficient process for describing and mapping the habitat needs of federally managed species. Previous research indicates that the distribution and abundance of many groundfish species is related to surficial sediment properties. However, direct sampling of sediments with grabs and coring devices is impractical over areas as large as the eastern Bering Sea (EBS) shelf. Acoustic tools, on the other hand, are suitable for large-scale surveying and show great promise as a substitute for the more conventional samplers, but they have not been proven for EFH purposes.

In 2012, an acoustic seafloor survey using five different sonar systems was conducted along strong gradients of groundfish abundance, as determined from many years of Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) Division bottom-trawl-survey catches at fixed stations. The value of acoustic backscatter as a habitat-defining characteristic will be judged based on the statistical relationships between normalized backscatter and species-specific fish densities. Groundtruth samples of infauna and sediment along each trackline will provide additional biological and geological information for the analysis.

Additional work was performed outside the scope of the primary study including sonar data collection along a standard trackline near Dutch Harbor, Alaska and a reconnaissance survey into the Chukchi Sea. Details are provided in the final sections of this report.

Objectives

(1) Investigate the utility of acoustic backscatter for characterizing the EFH of EBS species using a variety of sonar and groundtruthing systems.

(2) Evaluate the mechanism of association between groundfish and surficial sediments through coordinated sampling of sediments and infaunal prey.

(3) Provide hydrographic-quality bathymetric data to the NOAA Pacific Hydrographic Branch (PHB) for updating nautical charts of areas with outdated or non-existent information.

Vessels and Gear

Operations were conducted aboard NOAA Ship *Fairweather*, a multi-mission hydrographic survey vessel capable of continuous sonar operations.

The 2012 FISHPAC project utilized five different sonar systems to acquire acoustic backscatter in the study area. These five systems included two hull-mounted multibeam echosounders (MBES) (Reson models 7111 and 8160), a towed high-resolution interferometric side scan sonar (Klein 5410), and a towed long-range side scan sonar (Klein 7180 LRSSS) equipped with an independent single beam echosounder (Elac custom 38 kHz) (Table 1). The two Reson MBES and the Klein 5410 side scan sonar are commercially available systems, whereas the Klein 7180 LRSSS was purpose-built as part of the FISHPAC effort and was included in the group of acoustic systems because its very broad swath and relatively high tow speed (maximum 12 kts) address the need for more efficient survey systems to accomplish large-scale EFH mapping. The LRSSS is also equipped with a triplet of optical scatter sensors (WET Labs ECO-Triplet Puck) to continuously measure colored dissolved organic matter (370/460 nm excitation/emission), chlorophyll-a fluorescence (470/680 nm), and turbidity by particle scattering (660 nm) in the pelagic environment. Positions of the two towed sonars (Klein 5410, Klein 7180 LRSSS) were acoustically determined using a skeg-mounted Sonardyne Fusion ultra-short baseline (USBL) system that was calibrated and interfaced to the ship's horizontal positioning sensors.

Manufacturer	Reson	Reson	Klein	Klein	Elac
Model number	8160	7111	5410	7180	Custom
Configuration	Hull-mounted	Hull-mounted	Towfish	Towfish	Towfish (7180)
Frequency (kHz)	50	100	455	180	38
Bathymetric data?	Yes	Yes	Yes	Yes	Yes
Backscatter data?	Yes (snippets)	Yes (snippets)	Yes (side scan)	Yes (side scan)	Yes
Imagery?	Yes	Yes	Yes	Yes	No
Maximum speed with 100% coverage	8 kts	8 kts	10 kts	7.7 kts	7.7 kts

Table 1. Sonar systems used in 2012.

For groundtruthing purposes, three state-of-the-art instruments sampled the biological and geological characteristics of the seafloor (Figure 1). The Seabed Observation and Sampling System (SEABOSS) grab sampler took sediment grabs and digital still photos to characterize infauna and sediment properties. The Towed Auto-Compensating Optical System (TACOS), a two-part towed camera sled, collected representative video data which were transmitted to the vessel in real-time. The Sonardyne USBL system also provided real-time positioning of both SEABOSS and TACOS. A Rolls Royce Free-Fall Cone Penetrometer-660 (FFCPT) measured geophysical properties of the seafloor, as well as sound speed within the water column. Additional casts using a Rolls Royce Single

Sensor Free Fall Fish or a Seabird SBE 19plus SeaCAT Profiler were conducted throughout the survey to complement and cross-check the sound-velocity profiles from the FFCPT.

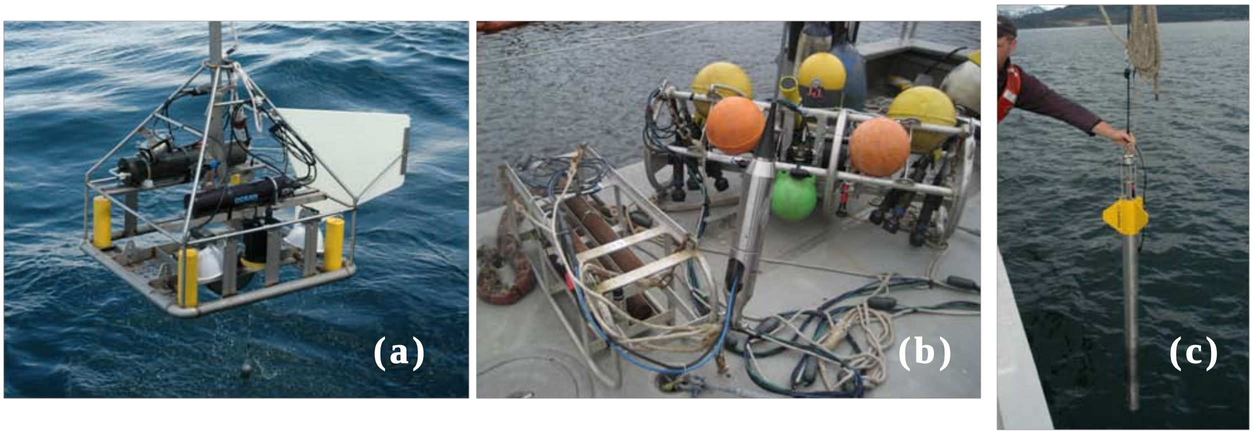

Figure 1. Groundtruthing devices used during FISHPAC 2012 cruise: (a) the SEABOSS sediment and infauna sampling system, (b) the TACOS towed video sled shown with clump weight and (c) the FFCPT sediment profiler with an integrated sound velocity and pressure sensor.

Survey Design and Methods

The original survey plan consisted of six 60 to 140 nautical mile tracklines across the EBS shelf at depths ranging from 25 to 130 meters. These tracklines were chosen to pass directly over 31 RACE bottom-trawl-survey stations at which a wide range of fish and invertebrate abundances has been observed. However, the *Fairweather's* port main engine failed during transit to the project area, prompting survey-design modifications to maintain proximity to Dutch Harbor until replacement parts arrived. The actual study area consisted of three of the original planned tracklines (numbers 1, 12 and 13), another (number 14) that was extended from 60 to almost 90 nautical miles, and an entirely new 145 nautical mile line (number 15) (Figure 2). Each trackline was navigated a total of three times. The initial pass acquired data with the Klein 5410 side scan sonar being towed at 7 kts. The return pass consisted of groundtruthing at several selected sites along the trackline. The final pass, in the same direction as the initial pass, used the Klein 7180 LRSSS towed at approximately 7 kts. Both shipboard Reson MBES systems collected multibeam backscatter and bathymetric data during all passes, including a single pass over a 118 nautical mile extension of line 14 to a point near the northeast end of Line 15 as well as during all transits to and from the study area.

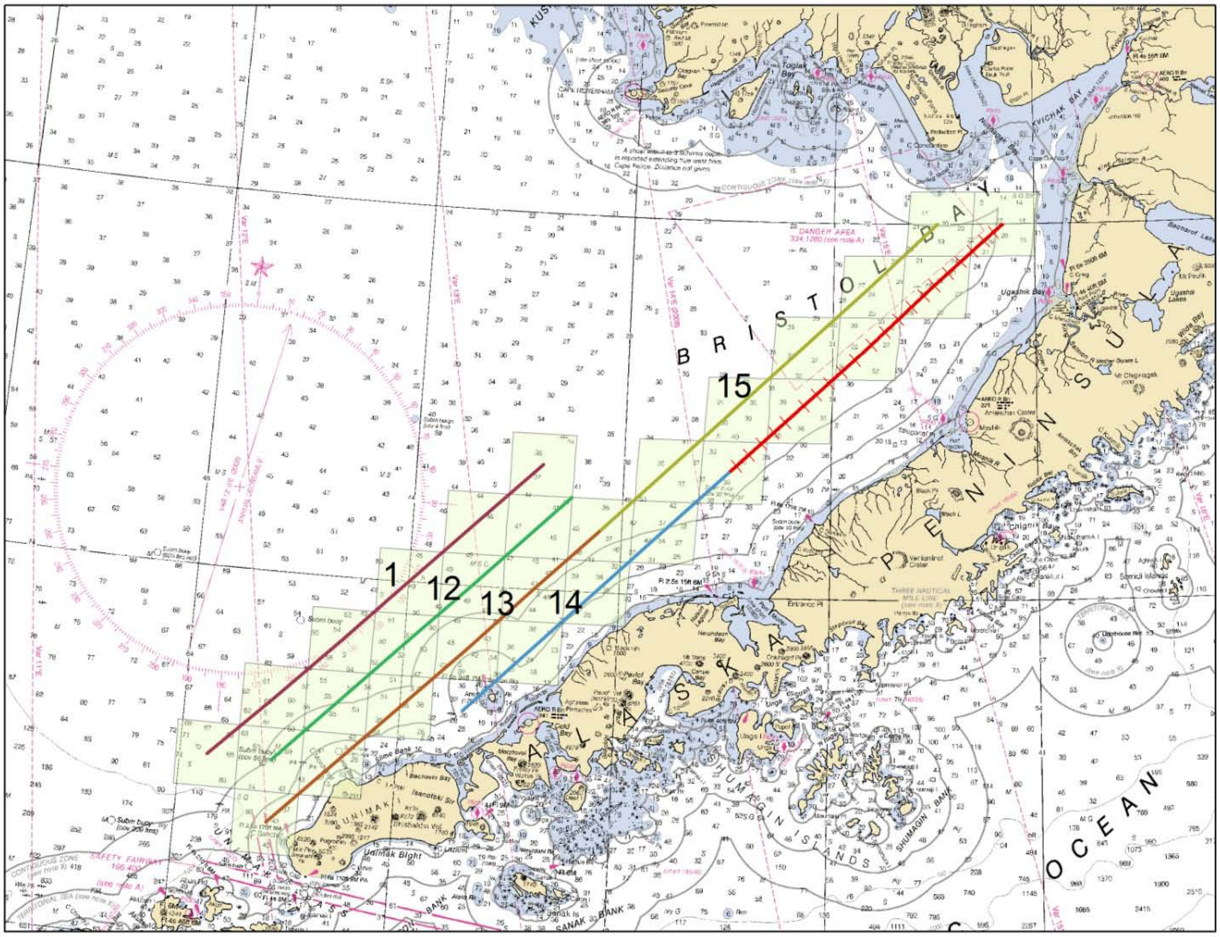

Figure 2. Completed FISHPAC 2012 survey tracklines. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom trawl survey stations for the Bering Sea shelf. The northeast section of line 14 in red with cross hashes was navigated once with MBES acquisition only.

Proper operation of the USBL system and the standard procedures for the hydrographic surveys D00169 and D00170 require sound speed profiles at least every four hours. The FFCPT deployed using the ship's Moving Vessel Profiler (MVP200) was the desired primary sound speed instrument. When used at selected groundtruthing sites or bottom-trawl-survey stations, the FFCPT was usually deployed and retrieved in three successive drops while underway at around 3 kts. The Single Sensor Free Fall Fish deployed from the MVP and the Seabird SBE 19plus SeaCAT Profiler were also utilized to provide supplemental sound-speed measurements. If transit time between groundtruth stations was greater than four hours, a sound velocity cast was taken at additional locations along each line.

SEABOSS was deployed with *Fairweather* holding position at each groundtruthing station. Prior to deployment, the SEABOSS required power-up of the still and video camera systems, and arming of the sediment grab. The video camera system was pressure-activated just below the surface and provided a landscape view of the sampling location, while the still camera was mechanically triggered shortly before bottom-contact. Using the ship's mechanical winch, SEABOSS was lowered to the seafloor at 0.5 – 1 m/s. Once on bottom, a slow pull on the winch ensured proper closure of the lever-arms on the 0.1-m^2 van Veen-style grab. Two acceptable grabs were required for separate infauna and sediment samples. Every infauna grab was measured for volume, sorted with seawater on a 1 mm screen, fixed in 10% buffered formalin with rose bengal biological stain and subsequently transferred to 50% isopropanol. The sediment sample was qualitatively described in the grab upon retrieval. A subsample from the topmost layer was collected and immediately frozen for characterizing carbon and nitrogen levels. The sediment grab was then cored and the sample stored for granulometric processing in the laboratory. Photographic records of the bottom were downloaded and stored in raw and compressed image formats (*.nef, *.jpg, *.avi).

After stationary sampling was completed, the ship would reposition for a towed video transect across the station. The TACOS video sled and clump weight were lowered over the ship's stern. Desired tow speed was < 1 kt, which required careful ship positioning for either a drift or live-boat tow. Sled altitude was actively maintained at an altitude of 1 m by remote control of the tow winch. Data from the digital camera were recorded in a proprietary format and later converted to the AVI format on a dedicated workstation.

Operations

Scientific equipment was installed in Seattle, WA prior to *Fairweather's* departure for Alaska. Surveying on the FISHPAC project began with calibration of the USBL system in Unalaska Bay on 12 July. Project activities were interrupted when the ship made a brief stop in Dutch Harbor, AK on 21 July to pick up needed parts. The cruise ended in Dutch Harbor on 28 July.

Itinerary

14 May – 15 June	Mobilization of AFSC equipment Seattle, Washington.
12, 20 June	Operational tests, equipment shakedown Puget Sound, Washington.
8 – 11 July	Transit to project area from Homer, Alaska.
12 – 27 July	Survey operations aboard NOAA Ship *Fairweather*, Bristol Bay region.
28 – 31 July	Moored Dutch Harbor, Alaska.
1 – 6 August	South Arctic Reconnaissance.

Results

Five tracklines were completed during the course of the cruise (Figure 2) using five sonar systems (Table 1) and three groundtruthing systems (Figure 1) in accordance with the modified survey plan. Operationally, the cruise was successful. All lines, other than the 118 nautical mile extension of line 14, were completely navigated three times with continuous shipboard operations. On every pass, backscatter and bathymetric data were collected using the ship's two multibeam sonars with top-side settings optimized for backscatter acquisition. Upon project completion, trackline coverage by the five sonars included 26 bottom-trawl-survey stations. The extension of line 14 to the northeast expanded MBES coverage into four additional bottom-trawl-survey stations. Scientists and crew safely performed multiple on-station deployments of sampling devices, obtaining large volumes of data and many groundtruth samples (Table 2).

Instrument	Total sampling units
Reson 8160 multibeam	1,911 nmi
Reson 7111 multibeam	1,991 nmi
Klein 5410 side scan	645 nmi
Klein 7180 LRSSS	645 nmi
SEABOSS grab (infauna)	25 stations sampled
SEABOSS grab (sediment)	25 stations sampled
SEABOSS still photos	13 stations
TACOS video	20 stations
FFCPT drops	28 stations (92 drops)

Table 2. Data collected along the 2012 FISHPAC survey tracklines.

MBES data were also acquired with the ship's systems during transits to and from the project working area (Figure 3). This resulted in an additional 428 nautical miles of acquisition with the Reson 8160 and 830 nautical miles with the Reson 7111.

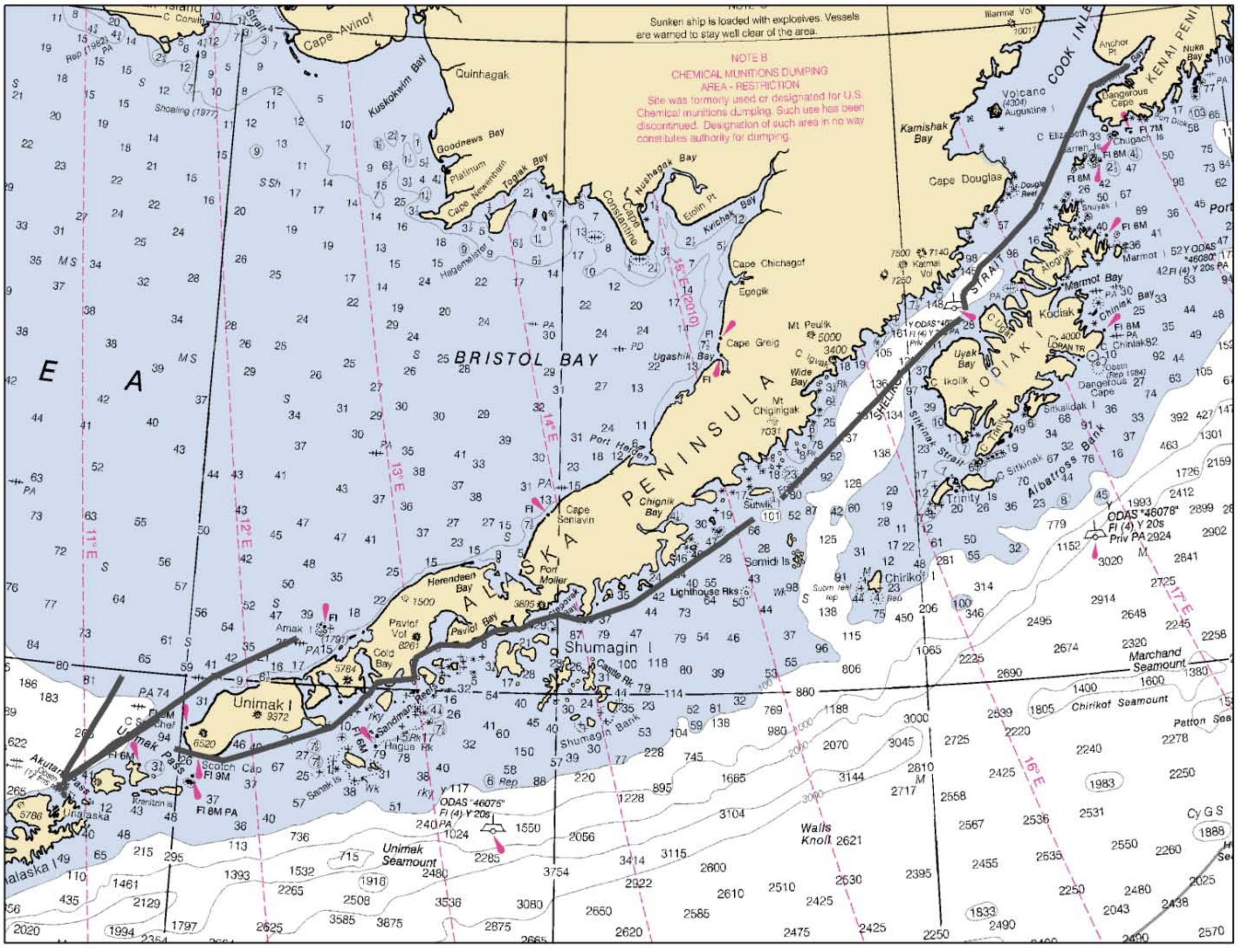

Figure 3. MBES acquisition while *Fairweather* transited to and from 2012 FISHPAC working area.

Due to a malfunctioning sound velocity and pressure (SV&P) sensor on the FFCPT, the Single Sensor Free Fall Fish deployed from the MVP was initially used as the primary sound-speed instrument, allowing measurements every few minutes while underway. During early groundtruthing operations the Seabird SBE 19plus SeaCAT Profiler was attached to the FFCPT to provide sound velocity data. A replacement SV&P sensor was installed on the FFCPT on 21 July, re-enabling the instrument for multipurpose data collections. For the remainder of the project either the FFCPT or the Single Sensor Free Fall Fish was used to obtain sound velocity data.

Generally favorable weather and seas permitted collection of sediments and infauna with SEABOSS at all of the intended groundtruthing stations. A malfunction in the integrated digital still camera limited the acquisition of still photos to 13 stations.

The TACOS device was deployed at a total of 20 groundtruth stations. Video quality was generally excellent but occasionally limited by excessive sea state and an over-abundance of jellyfish in the water column.

This was the first fully operational cruise where the skeg-mounted USBL system aboard *Fairweather* provided functional tracking of all towed instruments. During previous survey operations, the USBL transceiver had been mounted on an over-the-side pole and temporarily attached to *Fairweather*. At the commencement of the 2012 FISHPAC project, both the skeg- and pole-mounted USBL transceivers were calibrated using a moored COMPATT beacon and a standard box-in-calibration procedure. The installation corrections used in Sonardyne Ranger software and the corresponding calculated accuracies for both the skeg- and pole-mounted transceivers are presented in Table 3.

	Calculated Correction			Calculated Accuracy		
	Pitch	Roll	Heading	Pitch	Roll	Heading
Skeg-mounted Transceiver	2.87°	-0.22°	0.00°	0.01°	0.01°	0.01°
Pole-mounted Transceiver	0.82°	1.13°	0.12°	0.01°	0.01°	0.02°

Table 3. Installation corrections entered into Ranger software and the resulting accuracies obtained with a box-in calibration procedure for both the skeg- and pole-mounted USBL transceivers.

In general, positioning uncertainty is expressed as the probability that the error will not exceed a certain amount or as the percentage of all fixes that are contained in an error circle whose center is the true or correct position of the COMPATT transponder. Sonardyne routinely uses the two-dimensional 1 DRMS (radial or distance root mean squared error) as the preferred measure of accuracy:

$DRMS = \sqrt{\sigma_E^2 + \sigma_N^2}$, where σ_E^2 and σ_N^2 are the squared standard deviations (variances) for the Easting and Northings of the COMPATT fixes.

These calibrations indicated that both mounting methods would perform acceptably, but the skeg-mounted transceiver would produce slightly more accurate positioning overall (Table 4). Most notably, a skeg-mounted configuration did not require deployment and retrieval evolutions or any speed limitations on the vessel as compared to an over-the-side pole mounted setup.

	Distance (m)		Percentage	
	Before	After	Before	After
Skeg-mounted Transceiver	2.7	1.1	2.11	0.84
Pole-mounted Transceiver	1.6	1.2	1.24	0.92

Table 4. Performance statistics (at 1 DRMS) for the skeg- and pole-mounted USBL transceivers before and after the box-in calibration. Distance indicates the ± uncertainty for the specific depth at which the calibration was performed (130 m). Percentage is the generalized multiplier for uncertainty at a particular depth. For example, 0.84% at 130 m depth yields the reported 1.1 m distance for the skeg-mounted transceiver after calibration.

Data from all devices were acquired and securely archived on redundant data drives. Collaborative processing and analysis of data for EFH research, nautical charting, and other technical purposes will be undertaken by research partners on *Fairweather*, in the RACE and Resource Ecology and Fisheries Management Divisions at AFSC, and at NOAA PHB.

Additional Activities

South Arctic Reconnaissance

Following completion of the scheduled FISHPAC cruise and subsequent Dutch Harbor, Alaska in-port period, *Fairweather* embarked on the scheduled Arctic Reconnaissance Cruise on 1 August.

The first leg consisted of a northerly transit across the Bering Sea, through the Bering Strait, and into Kotzebue Sound. The initial planned trackline for this leg was a line running generally north to include 38 RACE bottom-trawl-survey stations. During the transit, the hull-mounted Reson multibeam systems and the Klein 7180 LRSSS were utilized to acquire acoustic backscatter. The FFCPT was used to collect sound-speed data as well as collect data to characterize bottom type. No other groundtruthing operations were conducted during the South Arctic Reconnaissance.

The traveled route (Figure 4) differed from initial plans in an effort to mitigate the effects of poor weather and a sizable westerly swell. The combination of poor weather and shallow water eventually prompted a suspension of LRSSS and FFCPT operations prior to arrival in Kotzebue Sound. Thereafter, sound velocity data were collected using the Single Sensor Free Fall Fish deployed from the MVP winch. LRSSS coverage included 18 RACE bottom-trawl-survey stations. FFCPT drops were completed at 9 of these. *Fairweather* transited an additional 20 RACE bottom-trawl-survey stations while acquiring MBES data with the Reson 7111 and 8160 systems. Data-collection totals for the South Arctic Reconnaissance are summarized in Table 5.

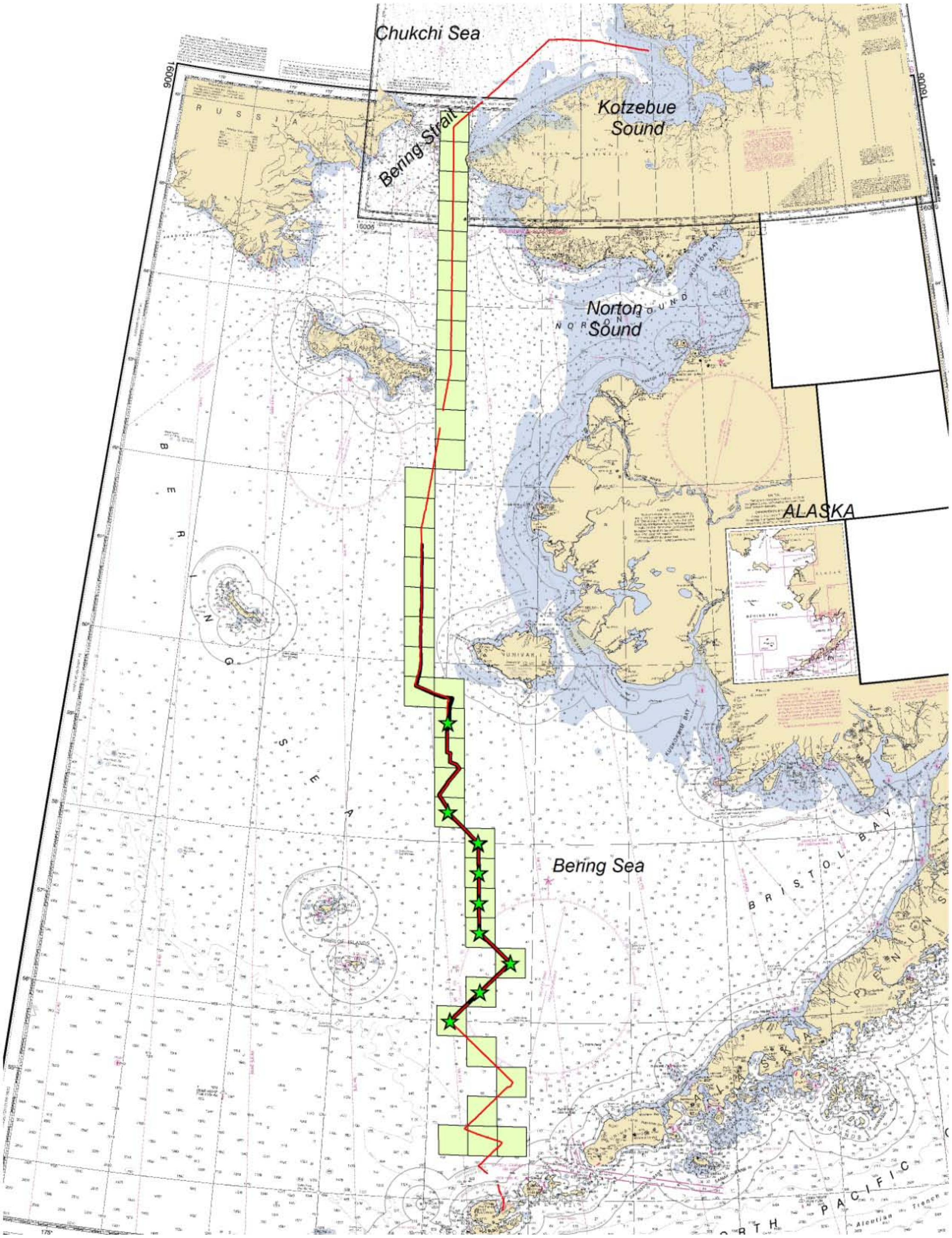

Figure 4. Completed South Arctic Reconnaissance survey trackline with black and red lines representing Klein 7180 and Reson MBES coverage, respectively. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom-trawl-survey stations and green stars represent FFCPT sample sites.

Instrument	Total sampling units
Reson 8160 multibeam	1,009 nmi
Reson 7111 multibeam	1,009 nmi
Klein 7180 LRSSS	385 nmi
FFCPT drops	9 stations (27 drops)

Table 5. Data collected during South Arctic Reconnaisance.

RACE Division standard acoustic transect

In addition to the survey operations mentioned above, *Fairweather* and the FISHPAC team acquired bathymetric and backscatter data during two passes along a short transect near Dutch Harbor (Figure 5). These hydrographic-quality data will be compared with Reson data acquired on prior FISHPAC cruises and will also be made available for evaluation of Kongsberg ME70 data collected by the RACE Division's Midwater Assessment and Conservation Enginering (MACE) program. The ME70 is a multibeam sonar configured to survey the water column rather than the seabed.

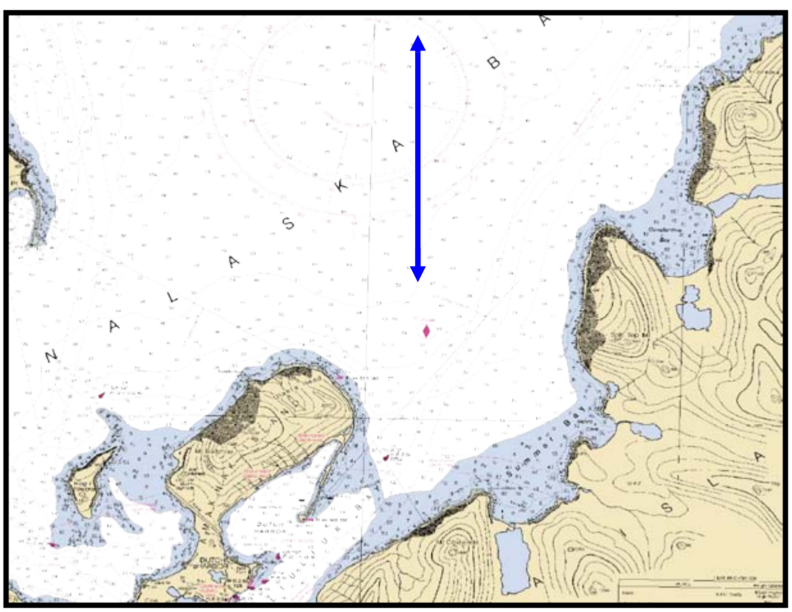

Figure 5. RACE Division transect surveyed by *Fairweather* in both north and south directions while acquiring multibeam and backscatter data with RESON 7111 and 8160 multibeam echosounders.

Scientific Personnel

AFSC RACE, Seattle, WA
Mr. Steve Intelmann*
Dr. Bob McConnaughey* – Chief Scientist
LTJG Adam Pfundt*
Mr. Keith Smith
Dr. Steve Syrjala
Dr. Cynthia Yeung

LCHUFF Consultancy
Dr. Lloyd Huff

US Navy, Naval Undersea Warfare Center, Keyport, WA
Mr. Ed Draper
Mr. Bill Heather
Mr. Jim Hosford*
Mr. Jim Husted
Mr. Mark Moody*– Navy Team Leader

*Participated in South Arctic Reconnaissance

Acknowledgements

The Scientific Party gratefully acknowledges vital support provided by the hard-working, resourceful, and dedicated officers and crew of NOAA Ship *Fairweather*.

For further information, contact the Director, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA 98115-6349. Telephone (206) 526-4170.
