# Preliminary Cruise Results on Assessment of Rockfish Species in Untrawlable Habitat in the Gulf of Alaska Using Advanced Acoustic, Optical, and Trawl Technologies, October 2009 (DY09-12)

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December 2009

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## INTRODUCTION

Rockfish constitute an important component of marine ecosystems and commercial fisheries in Alaska and are difficult to assess using standard acoustic and bottom trawl surveys due to their propensity to aggregate in rocky high relief (untrawlable) areas. Estimating rockfish biomass is difficult for many species but is a specific problem for the commercially important northern (*Sebastes polyspinis*) (Clausen and Heifetz, 2002) and dusky rockfish (*S. variabilis*) (Clausen *et al*. 2003) assemblages found in rocky outcrops on the Gulf of Alaska (GOA) shelf. Use of non-traditional sampling methods may improve rockfish stock assessments by providing a more complete and accurate biomass estimate of rockfish populations (Starr *et al*. 1995). In this NPRB funded field experiment we evaluate the possibility of improving rockfish biomass estimates in untrawlable habitat by using advanced remote sensing acoustic and optical instruments and a specialized semi-pelagic trawl. Two research vessels were involved in the study working simultaneously and in close contact with each other. Results from each vessel, the NOAA ship *Oscar Dyson* (cruise DY0912) and the F/V *Epic Explorer*, are reported separately below.

## OBJECTIVES

The primary objective was to evaluate whether different remote sampling tools can be used to improve assessment and abundance estimations of rockfishes in untrawlable habitat in the GOA. Additionally, objectives were to discern whether rockfish in the GOA exhibit diel vertical movement or schooling behavior, whether consistent or unique school morphology patterns exist, and finally to provide information on the general types of habitat that are associated with rockfishes in the GOA. Preliminary results will be used to evaluate the success of detecting, mapping, and quantifing rockfishes using tools such as splitbeam echosounders, multibeam echosounders, a remotely operated vehicle (ROV), a stereo-video camera system, and a modified semi-pelagic trawl in the GOA.

# METHODS

## Study Site

Two initial sites were chosen along the GOA shelf break south of the Trinity Islands and Kodiak Island at Albatross bank and at "Snakehead", another shallow bank located on the shelf break (Fig. 1). Site selection was based on commercial and bottom trawl survey catches of northern rockfish and an abundance of rough bottom designated as untrawlable in the GOA bottom trawl survey region. Due to adverse weather conditions, survey time was lost resulting in reduction of the original experimental design comparing two sites to a more thorough survey of a single site. After exploratory acoustic observations, the Snakehead site was chosen as the study site. All survey-related activities took place from 4-12 October 2009 (Appendix I).

## Acoustic Equipment

### EK60

The large-scale acoustic survey was conducted aboard the NOAA ship *Oscar Dyson*, a 64 m stern trawler equipped for fisheries and oceanographic research. System electronics were housed inside the vessel in permanent laboratory spaces dedicated to acoustics. Echosounding was conducted with a Simrad EK60 using 18, 38, 70, 120, and 200 kHz split-beam transducers (Simrad 1997, 2004; Bodholt and Solli 1992). EK60 system settings and parameters during the survey are listed in Table 1. The transducers were mounted on the bottom of a retractable centerboard, positioning the transducers 9 m below the surface when fully extended. A 0.512 ms pulse length and 1 sec ping rate was used for all EK60 data collection. To prevent interference between the EK60 and ME70, the ME70 was set to ping 333 ms after the EK60 (thus, after a 666 ms delay the EK60 would ping again). Other acoustic instruments on the vessel were turned off (e.g. navigational fathometer, Doppler speed log) during acoustic data collections. Data were logged to files using Simrad ER60 (version 2.1.2) and Myriax EchoLog 500 (version 4.40) software. Myriax Echoview (version 4.70.48) was used for all post-processing and analyses of the acoustic data. The 38-kHz echo sounder was the primary source for the quantitative rockfish backscatter measurements presented here.

ES60

Supplemental acoustic data collection was conducted aboard the F/V *Epic Explorer*, a 40 m catcher vessel used primarily for commercial bottom trawling in the Pacific cod, walleye pollock, and shelf rockfish trawl fisheries. This acoustic data were collected with a Simrad ES60 using a 38 kHz split-beam transducer. The transducer was mounted on the hull approximately 5 m below the waterline. A pulse length of 0.512 ms was used for all ES60 data collection, and auxiliary bottom sounders were turned off during the cruise to avoid interference. Data were logged to files using Simrad ES60 software (version 1.5.2.76). The data collected with the ES60 were also used by the vessel captain to determine trawlability of the seafloor.

ME70

Multibeam acoustic data were collected during the large-scale surveys as well as several dedicated small-scale surveys onboard the *Oscar Dyson* using a Simrad ME70 multibeam echosounder. The multibeam system has a user selectable frequency range (70-120 kHz) and number of beams (up to 45), and was configured for this work to have 31 beams at frequencies ranging from 73 kHz to 117 kHz. The beams were arranged in a fan providing athwartship coverage between +/-65 degrees, with a pulse length of 1.536 ms. When configured in this manner, the ME70 can be used to characterize fish schools, seafloor habitat, and can also be set up as split beams to provide data for single target analysis such as target strength measurements. Narrow split beams with low side lobes and short pulse lengths allow insonification of targets close to bottom. The ME70 is mounted on the hull forward of the centerboard about 6m below the waterline. The ME70 was slaved to the EK60 to ping sequentially and avoid acoustic interference of the two echo sounders.

Standard sphere acoustic system calibration of the ME70 was conducted to measure acoustic system performance of the ME70. The ship was anchored at the bow and stern and tungsten carbide sphere (25 mm diameter) was suspended below the transducers during the calibration.

The presence of fish and technical delays prevented data collection in all 31 beams, although a successful calibration was completed in June 2009.

Drop-TS

Initial plans included deployment of a lowered transducer system (38 kHz) aboard the *Oscar Dyson* for acquiring accurate *in situ* target strength (drop-TS) data from individual fish. Activities involving the drop-TS system were eliminated from cruise activities due to weather and time constraints. Subsequent drop-TS data collection at the Snakehead site are planned during the GOA pre-spawning pollock acoustic-trawl survey in March 2010.

ROV

A Phantom DS4 (2004) Remotely Operated Vehicle (ROV) was deployed from the *Oscar Dyson* to ground truth acoustic observations, identify dominant rockfish species and their relationship with the substrate, and verify bottom topography. The ROV was deployed from the starboard side sampling station when weather permitted (Beaufort < 6). The ROV was tracked with an Ultra-Short Base Line hydrophone system manufactured by ORE (TrackPoint II). The directional hydrophone was mounted on a retractable arm deployed over the aft-starboard rail. The ROV tether was attached with a swivel to a clump weight, which was connected to the cable on the starboard CTD winch. The ROV and clump weight were lowered in unison until the ROV and clump weight are ~10 m above the seafloor. Once the ROV and clump weight were 10 m from the bottom, the cable to the clump weight was secured, monitored, and adjusted to maintain a clump-weight-elevation of >10 m (to avoid hitting the seafloor), while the ROV more closely approached the seafloor to identify rockfishes and substrate type. Specific locations for investigation were provided to the bridge and the ship's position was adjusted to drift or slowly navigate over the site.

The ROV was equipped with a forward-looking 12:1 zoom color video camera and a high resolution Nikon Coolpix digital still camera (Insite Pacific Inc.). Video footage was continuously recorded on digital tapes and overlaid with temperature, depth, heading, and time

information displayed on the monitor. All navigation data were recorded using WinFrog software (Fugro Inc.). Two pairs of lasers were mounted near the front of the ROV in parallel: one pair to measure fish lengths (20 cm apart), and one pair to estimate the search field of view (60 cm apart). A fifth red laser was oriented to cross the inner pair of green lasers at 1 m and 2.5m.

Drop Camera

The stereo-video drop camera was used aboard the F/V *Epic Explorer* to identify acoustic backscatter to fish species and to measure fish size using paired still images collected from the two video cameras. The stereo-video drop camera system used a quick-responding winch and camera sled with a protective frame that minimized the potential damage due to collision with seafloor objects. The winch motor was a ¾ horsepower and winch speed ranged from 43 m/min (with a bare drum) to approximately 58 m/min (with a full drum). The approximate footprint of the winch was 48 $in^2$ and the weight was 155 lbs. The drum was filled with 400 m (1312 ft) of 4.72 mm (3/16 in) armored conducting wire (with a breaking strength of 3,300 lbs). The video feed from the camera sled was passed through a 4 conductor slip ring mounted on the winch and into a junction box where it was connected to a monitor for real-time viewing.

The camera housings were constructed of titanium tubing, with a clear plastic dome port (rated to 3000 m depth). The underwater video was recorded by camcorders located inside the camera housings. The cameras were two identical Sony TRD-900 units capable of collecting 720p progressive scan video images. The video camera housings were mounted on the aluminum frame within the housing and the lens was keyed to a port. This prevented the camera from being inserted into the housing in a position other than the exact keyed position. This also maintained the relative position of the cameras as stable from deployment to deployment, an important consideration for accurate measurement of targets using the principles of stereo vision. Illumination was provided by two lights mounted above the camera housings inside the aluminum frame. The camera sled and stereo video analysis features are fully described in Rooper et al. (in prep).

Trawl Gear

Trawl hauls (Fig. 2) were performed aboard the F/V *Epic Explorer* and were used to collect rockfish specimens and to classify observed backscatter layers to species and size composition. The trawl was a modified four-seam Poly'Noreastern bottom trawl similar to the net used in the Gulf of Alaska bottom trawl survey (Stauffer 2004). The major modifications to the physical structure of the net were heavier (5 mil) netting material in the belly of the net, a footrope with tire gear through the center and continuous cookie cutter gear through the sweeps. The doors used were 3 $m^2$ Series 2000 V-type trawl doors from NET systems designed to fish in the midwater. A major difference during this study from the GOA bottom trawl survey was in the procedure for fishing the net. A wireless MARPORT net sounder was attached to the headrope of the net and allowed the vessel captain to observe the footrope position relative to the seafloor in real-time during the trawl haul. This allowed for precise control of the location of the net during fishing operations, allowing the vessel captain to fish as close to the seafloor as possible given the untrawlable nature of the substrate. Average trawling speed was approximately 3 knots. The weight of each species in the trawl haul catch was determined, and fish captured in the trawl were sampled to determine sex and fork length (FL). Additionally, a sample of select rockfish species were measured for fork length and body weight and their ovaries removed for a rockfish maturity study. All fish were measured to the nearest centimeter.

Oceanographic Equipment

Physical oceanographic data collected during the cruises included temperature profiles obtained with a Sea-Bird Electronics temperature-depth probe (SBE-39) attached to the ROV, trawl and stereo-camera, expendable bathythermographs (XBT - Sippican Deep Blue) deployed at small-scale survey locations, and conductivity-temperature-depth (CTD) observations collected with a Sea-Bird CTD system at calibration sites. Sea surface temperature and salinity data were measured using the ship's SBE-21 (Sea-Bird Electronics) probes located mid-ship, approximately 5 m below the water line. These and other environmental data were recorded using the ship's Scientific Computing Systems.

Survey Design

The survey design consisted of a large-scale (course) grid and a smaller-scale (fine) grid. The large-scale survey was intended for general mapping of rockfish distribution and bottom type and for evaluation of any diel vertical movement or schooling behavior. The large-scale survey consisted of a series of parallel line transects spaced 1.2 nmi apart (Fig. 2) and from 5 to 8 nmi in length (Table 2). Bottom depths did not exceed 326 m along any transect, and transects generally did not extend into waters less than 60 m depth. Attempts were made to complete a pass of all transects during daylight hours and again at night four different times resulting in four replicate day/night survey pairs. Each Pair of transects, comprised of a day and night pass, were conducted in the same direction, however, transects for different survey pairs were sometimes run in the reverse direction. The number and length of transects surveyed was similar within each day/night pair but varied between days depending on weather conditions and other research activities being performed.

Seven small-scale (fine) surveys were conducted within the larger survey bounds to focus on small-scale patterns in fish aggregation structure, distribution, and association with specific bottom type (Table 2). The smaller grids were designed primarily for more detailed ME70 data collection. Transect spacing was dependent on bottom depth and determined so that the outer beams of the multibeam echosounder would generally overlap on adjacent transects for full area coverage. Transects were 1 nmi in length and 0.1 nmi apart except grids C and D which had transects 0.2 nmi apart and grid E which had transects of 2 nmi length (Fig. 2).

EK60 Data Analysis

Rockfish abundance was estimated by combining echo integration, trawl information, and information acquired from the ROV and drop camera systems. Acoustic backscatter identified as rockfish, and an undifferentiated mixture of primarily macro-zooplankton between depths from 16 m of the surface to 0.5 m above the detected bottom, was binned at 0.1 nmi horizontal by 10 m vertical resolution using an $S_V$ threshold of –70 decibels (dB).

## PRELIMINARY RESULTS

***Oscar Dyson***

Physical Oceanography

Surface water temperatures from the shipboard sensors ranged from 8.7° to 9.8° C with a mean of 9.0° C (Fig. 3). Thirteen XBTs were launched during the survey and 3 CTDs were deployed during the calibration work. Surface temperatures from XBTs averaged 9.2° C. Bottom temperatures from XBTs ranged from 5.4º to 7.0º C with an average of 5.6° C over the depth range 77 to 219 m. Temperature-depth profiles (SBE-39) were collected from 3 of the 6 ROV deployments (Fig. 4), 9 stereo drop camera deployments, and 6 trawl hauls.

EK60

The initial large-scale survey pass consisted of 14 transects each about 5 nautical miles long in the Snakehead area. While running the first pass it was decided to lengthen several lines where backscatter continued beyond the endpoint (Fig. 2). Also, poor weather conditions requiring reduced vessel speeds, time needed for other research activities, and vessel mechanical problems (overheating diesel-generator), made it necessary to drop several transects from areas with low fish abundance to complete an entire pass during daylight hours (~10.5 hours; Table 2).

Seven of the transects (5-11) comprising a total of 44.5 nmi were generally covered on all eight passes (Table 2). Two lines (4 & 12), comprising 13 nmi, were surveyed both night and day on two more occasions. Lines 1 and 14 were only run once each on the initial pass. Preliminary results of backscatter attributed to rockfishes are plotted in Figure 5.

ME70

ME70 data were routinely collected during the cruise from both large-scale and more localized small scale-surveys. These data are being processed to characterize both seafloor habitat (e.g., trawlable or untrawlable) and fish aggregations. Preliminary results describing both bathymetry and seafloor backscatter (a proxy for bottom type) from one of the large-scale surveys are shown

in Figure 6. The data can ultimately be used to explore associations between seabed types and rockfish abundance.

Water column data collected during the large-scale surveys showed evidence of several fish aggregations throughout the survey site (Fig. 7). As expected, some of these occurred off the vessel trackline and were not observed by the EK60. In these situations, the wider field of view of the ME70 enables a more comprehensive description of the fish aggregation dimensions in addition to an increased sample size.

Observations of fish aggregations collected with both the ME70 and the EK60 during the large scale surveys were used to select localized areas for smaller, high resolution surveys. Seven small scale surveys (A-G) were conducted in these areas of special interest with each small survey covering from 7–12 nmi (Fig. 2, Table 2). Raw results from a fine scale survey conducted at the north end of line 4 are shown in Figure 8. This site was of interest because of the persistence of rockfishes in this area based on the large-scale surveys, and because the apparent bubble plumes (methane?) were later observed at this site by the ROV.

ROV

The ROV was deployed a total of 6 times (Fig. 2, Table 3). The first deployment was a test deployment in Unalaska Bay in an area that bubble seeps or vents were detected earlier with acoustics. Bubbles emanating from the sea floor were seen with the ROV. The second deployment was at the north end of transect 4. The substrate was primarily soft particulates covered with brittle stars. At the end of the dive some boulders and rockfishes were seen. The third deployment was at the north end of transect 10 and was on boulders with lots of rockfishes, prowfish, and lingcod. The majority of the rockfish observed were very close or in contact with the substrate. The fourth deployment was on cobble substrate with boulders at the north end of transect 12. Many juvenile rockfishes were seen. The fifth deployment was at the extreme north end of line 10 in deep water. *Sebastolobus* and 2 pollock were seen but, surprisingly, no *Sebastes* spp. were observed. Acoustic backscatter measured with the EK60 decreased during

the time the ROV was in the water indicating possible avoidance to the vehicle. When the ROV cable and clump weight were observed on the ship sounder, it appeared that relatively greater backscatter was detected between the clump weight and sea floor. Deployment 6 at the north end of line 4 was an area where the EK60 data suggested the occurrence of several bubble seeps. Bubbles were observed with the ROV rising from several areas in the substrate (see next section). Mostly dusky rockfish were seen in large numbers several meters off the bottom.

During all ROV deployments where rockfish were encountered, the reaction to the vehicle was generally minimal. Most dusky and northern rockfish would hold position until the ROV was within approximately 2 meters and then slowly swim away. Yelloweye rockfish appeared to have no reaction to the presence of the ROV. Juvenile rockfish and harlequin rockfish were more skittish and tended to dart away or into rocky cracks as the ROV approached. Prowfish and lingcod appeared curious of the ROV and prowfish were seen investigating the clump weight as the ROV descended during deployment 3.

Bubble Plumes

Numerous sites within the study area were observed with backscatter having a different frequency response than what is expected for rockfishes (e.g. De Robertis *et al.* in review). The backscatter was visible at all EK60 frequencies and often extended from the sea floor vertically through at least half the water column (Fig. 9). EK60 backscatter that was attributed to bubbles for the entire survey is plotted in Figure 10. Large aggregations that appeared to be fish were noted at the base of the echosign at the northern end of transect 4. The area was subsequently surveyed using the ME70 (Fig. 8). ROV deployment 6 in this area verified the presence of bubbles seeping from the ocean floor. Rock formations, possibly calcium carbonate as carbonate pavements, were often present in association with the bubble seeps indicating possible methane gas production in the area (Suess *et al.* 1998). Rockfishes appeared to be associated with the hard substrate adjacent to the area of the plumes in the NW corner of the study site. It is not clear whether this apparent attraction of rockfish to the area is due to the particular seabed type in the vicinity of the plumes or the bubble plumes themselves. More information is needed to

characterize this association and to determine whether it exists at each plume site to better understand the importance of these plumes to marine organisms and to the environment.

## F/V *Epic Explorer*

ES 60

ES 60 data were collected throughout the cruise aboard the F/V *Epic Explorer*. During the first two days of the cruise data were collected at both Albatross bank and the Snakehead sites to determine bathymetry and presence of acoustic fish sign. At the Snakehead site, ES 60 data were also collected during two nighttime periods over the survey transects (during one of which the vessel followed the *Oscar Dyson*). The ES 60 data were used by the vessel captain to determine "trawlability" of the seafloor and to locate the exact target schools of fish to conduct bottom trawl hauls and camera drops. A sphere calibration of the ES 60 echosounder was conducted on October 7 in Three Saints Bay, Kodiak, Alaska using a standard copper sphere.

Drop Camera

Most stereo drop camera deployments and trawl hauls were made in locations where the *Oscar Dyson* had identified aggregations of fish while running their large-scale survey transects. In total, nine deployments of the stereo drop camera system were made (Fig. 2, Table 3). Five of these deployments were linked to trawl hauls following the camera deployment. Three of the remaining four deployments were made on fish sign observed over generally untrawlable seafloor. The final deployment was made to identify a large school of Pacific ocean perch lurking at deeper depths over trawlable sandy seafloor. The most commonly observed fish species during all of these dives were dusky rockfish. There were also significant numbers of juvenile POP, northern rockfish, lingcod and halibut observed.

Trawl Samples

Trawl hauls were conducted at six locations where fish schools were observed on the echosounder. Five of the trawl hauls directly followed drop camera deployments to compare

species and size data collected from the stereo video camera system. All trawl hauls were made in areas that would have been determined to be “untrawlable” using the standard Gulf of Alaska bottom trawl survey gear. The skipper was extremely proficient at fishing the trawl gear over rough seafloor. The distance of the trawl off the seafloor was monitored in real-time and only one significant hang-up occurred during the six deployments. The trawl hauls were short, usually consisting of only 2-6 minutes of on-bottom time. In total 9 species of rockfish were captured. The catches were comprised of primarily dusky rockfish and harlequin rockfish, although a number of non-rockfish species were also captured (Table 3).

## ACKNOWLEDGMENTS

The authors would like to thank the officers and crew of the NOAA ship *Oscar Dyson* and F/V *Epic Explorer* for their dedication and contribution to the successful completion of this work.

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## APPENDIX I - ITINERARY

*Oscar Dyson*

| | |
|---|---|
| 3 Oct. | Depart Dutch Harbor, AK |
| 4 Oct. | Test ROV deployment near Dutch Harbor |
| 4-6 Oct. | Transit to survey site |
| 6-9 Oct. | Acoustic survey and ROV deployment at Snakehead site |
| 10 Oct | Weather delay |
| 11 Oct. | ME70 calibration in Three Saints Bay, Kodiak, AK. |
| 11-12 Oct. | Acoustic survey and ROV deployment at Snakehead area |
| 13 Oct. | Transit to/In port Kodiak, AK. |

F/V *Epic Explorer*

| | |
|---|---|
| 2 Oct | Vessel setup and dockside gear testing |
| 3 Oct. | Depart Kodiak, AK. Transit to survey site |
| 4-5 Oct | Exploratory investigation of Albatross and Snakehead sites |
| 6 Oct | Drop camera, trawl and acoustic survey activities at Snakehead site |
| 7 Oct | ES 60 sphere calibration in Three Saints Bay, Kodiak, AK. |
| 8-9 Oct | Weather delay in Three Saints Bay, Kodiak, AK. |
| 10 Oct | Transit to Snakehead site, acoustic survey activities |
| 11-12 Oct | Drop camera, trawl, and acoustic survey activities at Snakehead site |
| 12 Oct. | Transit to Kodiak, AK. |
| 13 Oct. | In port Kodiak, AK. |

## APPENDIX II - SCIENTIFIC PERSONNEL

### *Oscar Dyson*

| Name | Position | Organization |
|---|---|---|
| Chris Wilson | Chief Scientist | AFSC |
| Alex De Robertis | Fishery Biologist | AFSC |
| Darin Jones | Fishery Biologist | AFSC |
| Scott Furnish | I. T. Specialist | AFSC |
| Tom Weber | Acoustician | UNH |
| John Butler | Fishery Biologist | SWFSC |
| Scott Mau | Fishery Biologist | SWFSC |
| David Murfin | Electrical Engineer | SWFSC |

### F/V *Epic Explorer*

| Name | Position | Organization |
|---|---|---|
| Chris Rooper | Chief Scientist | AFSC |
| Michael Martin | Fishery Biologist | AFSC |
| Mark Zimmerman | Fishery Biologist | AFSC |
| Christina Conrath | Fishery Biologist | AFSC |

AFSC – Alaska Fisheries Science Center, Seattle, WA

SWFSC – South West Fisheries Science Center, San Diego, CA

UNH – University of New Hampshire

Table 1. -- Simrad EK60 38 kHz acoustic system description and settings during the Fall 2009 Rockfish untrawlable habitat survey of the Snakehead site on the Gulf of Alaska shelf.

| | | Survey system settings |
|---|---|---|
| Echosounder: | | Simrad ER60 |
| Transducer: | | ES38B |
| Frequency (kHz): | | 38 |
| Transducer depth (m): | | 9.15 |
| Pulse length (ms): | | 0.512 |
| Transmitted power (W): | | 2000 |
| Angle sensitivity: | Along: | 22.76 |
| | Athwart: | 21.37 |
| 2-way beam angle (dB): | | -20.74 |
| Gain (dB): | | 22.29 |
| Sa correction (dB): | | -0.64 |
| $S_v$ gain (dB): | | 21.65 |
| 3 dB beamwidth (deg) | Along: | 6.76 |
| | Athwart: | 7.19 |
| Angle offset (deg): | Along: | -0.10 |
| | Athwart: | -0.09 |
| Absorption coefficient (dB/m)*: | | 0.0100 |
| Sound velocity (m/s)*: | | 1470 |

Note: Gain and Beam pattern terms are defined in the "Operator Manual for Simrad ER60 Scientific echo sounder application (2004)" available from Simrad AS, Strandpromenaden 50, Box 111, N-3191 Horten, Norway.
* Absorption coefficient and sound velocities were measured using conductivity-temperature-depth (CTD) probes.

Table 2. -- Summary of date, activity light level, number of transects, and total milage surveyed in Snakehead site passes. Replicate 1-8 are larger coarse scale survey and replicate A-G are smaller fine scale survey.

| Survey | Date (GMT) | Night/Day | Transects (#) | nautical miles |
|---|---|---|---|---|
| 1 | 6-Oct | Night | 1-14 (14) | 68.3 |
| 2 | 6-7 Oct | Day | 2-11 (10) | 53.6 |
| 3 | 7-Oct | Night | 3-13 (11) | 67.7 |
| 4 | 7-8 Oct | Day | 4-13 (10) | 64.7 |
| 5 | 8-Oct | Night | 5-12 (8) | 52.4 |
| 6 | 8-9 Oct | Day | 5-12 (8) | 52.6 |
| 7 | 11-12 Oct | Day | 4-13 (10) | 64.6 |
| 8 | 12-Oct | Night | 4-13 (10) | 64.7 |
| | | | | |
| A | 9-Oct | Night | 10(8) | 8.0 |
| B | 9-Oct | Night | 4(8) | 8.0 |
| C | 9-Oct | Night | 7(7) | 7.0 |
| D | 9-Oct | Night | 10(7) | 7.0 |
| E | 11-Oct | Dawn | 4(6) | 12.0 |
| F | 12-Oct | Day | 10(9) | 9.0 |
| G | 12-13 Oct | Day | 4(8) | 8.0 |

Table 3. -- Summary of ROV, Drop camera, and Trawl activities by date, time and position with dominant species observed and estimated percentage or weight

| | Event | Date | Time (GMT) | Duration | Day/Night | Start Lattitude (N) | Start Longitude(W) | Depth | Comments |
|---|---|---|---|---|---|---|---|---|---|
| ROV | 1 | 4-Oct | 0:56 | 1.5 hours | Day | 53° 58.69' | 166° 29.35' | 132 | 09-277A - Test deployment Dutch Harbor vent area |
| | 2 | 6-Oct | 3:39 | 3 hours | Night | 56° 03.93' | 153° 58.13' | 140 | 09-279A - Line 4 flat muddy, Many Brittlestars, Dusky (85%) |
| | 3 | 6-Oct | 18:32 | 1.5 hours | Day | 56° 02.25' | 153° 45.47' | 72 | 09-279B - Line 10 boulders, rockfish, prowfish, lingcod |
| | 4 | 12-Oct | 3:35 | 3 hours | Night | 56° 01.99' | 153° 40.01' | 65 | 09-285A - Line 12 Many Juveniles, cobble and boulders, harlequin (40%) |
| | 5 | 12-Oct | 17:58 | 2 hours | Day | 56° 04.96' | 153° 40.01' | 225 | 09-285B - Line 10 deep Pollock (2) |
| | 6 | 13-Oct | 1:09 | 2.5 hours | Night | 56° 04.50' | 153° 57.41' | 143 | 09-286A - Line 4 boulders, bubbles, Dusky (80%) |
| Drop Camera | 1 | 5-Oct | 23:37 | 40 min | Day | 56° 01.372' | 153° 49.068' | 83 | Boulders, gravel dunes, some Dusky rockfish (80%) |
| | 2 | 5-Oct | 2:24 | 40 min | Day | 56° 01.686' | 154° 01.746' | 143 | Boulders and sand, some Dusky rockfish (80%) |
| | 3 | 5-Oct | 4:42 | 34 min | Night | 55° 58.754' | 153° 54.047' | 198 | Sloped sand, huge POP schools (95%) |
| | 4 | 6-Oct | 17:02 | 27 min | Day | 56° 01.314' | 154° 06.559' | 144 | Boulders, big Dusky & northern rockfish school (60%) |
| | 5 | 11-Oct | 21:47 | 23 min | Day | 55° 59.916' | 153° 51.548' | 82 | Boulders and sand, few juvenile rockfish (80%) |
| | 6 | 11-Oct | 1:27 | 41 min | Day | 56° 01.876' | 153° 50.221' | 78 | Boulders and sand, few juvenile rockfish (80%) |
| | 7 | 12-Oct | 17:52 | 18 min | Day | 55° 59.988' | 153° 53.555' | 134 | Flat sand, no rockfish |
| | 8 | 12-Oct | 19:49 | 43 min | Day | 55° 57.955' | 153° 41.087' | 108 | Rocks and boulders, juvenile rockfish (80%) |
| | 9 | 12-Oct | 22:40 | 43 min | Day | 56° 02.049' | 153° 45.512' | 77 | Boulders and sand, Dusky rockfish (90%) |
| Trawl | 1 | 6-Oct | 18:25 | 6 min | Day | 56° 01.377' | 154° 06.667' | 150 | Dusky rockfish (3.75 t), harlequin rockfish (0.5 t), northern rockfish (0.24 t) |
| | 2 | 11-Oct | 19:51 | 3.5 min | Day | 56° 04.309' | 153° 58.462' | 144 | Dusky rockfish (140 kg), harlequin rockfish (17 kg), northern rockfish (11 kg) |
| | 3 | 11-Oct | 22:33 | 4 min | Day | 56° 00.067' | 153° 51.637' | 86 | Dusky rockfish (1.0 t), lingcod (24 kg), northern rockfish (2 kg) |
| | 4 | 11-Oct | 2:41 | 4.5 min | Day | 56° 01.784' | 153° 50.174' | 81 | Harlequin rockfish (184 kg), dusky rockfish (115 kg), prowfish (30 kg) |
| | 5 | 12-Oct | 21:10 | 5 min | Day | 55° 58.467' | 153° 40.381' | 108 | Lingcod (13 kg), kelp greenling (1 kg), northern rockfish (0.5 kg) |
| | 6 | 12-Oct | 23:57 | 4 min | Day | 56° 02.264' | 153° 45.340' | 74 | Dusky rockfish (3.0 t), dark rockfish (58 kg), prowfish (16 kg) |

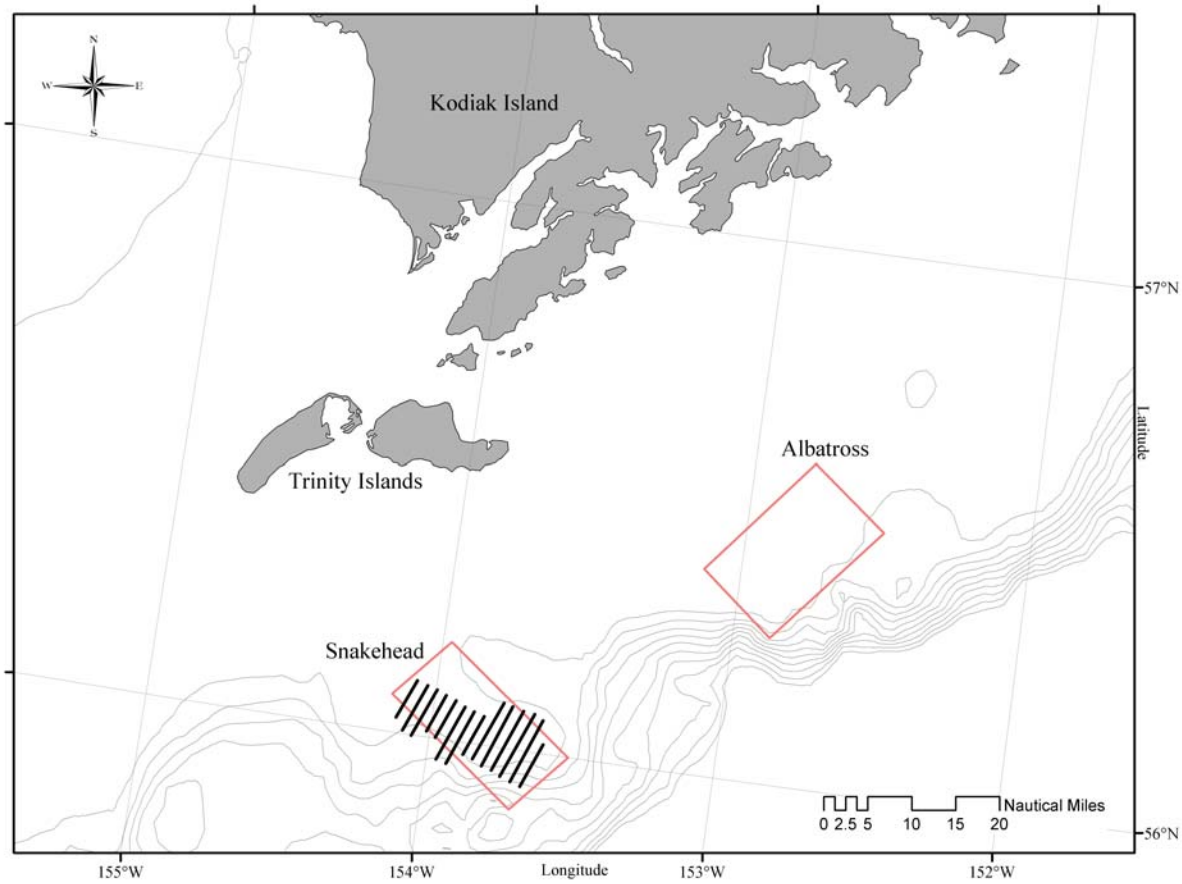



Figure 1. Location of untrawlable habitat survey sites for rockfish. Red boxes represent Albatross and Snakehead sites in the Gulf of Alaska south of Kodiak and the Trinity Islands. Parallel lines in Snakehead site represent the full extent of large scale tracklines surveyed.

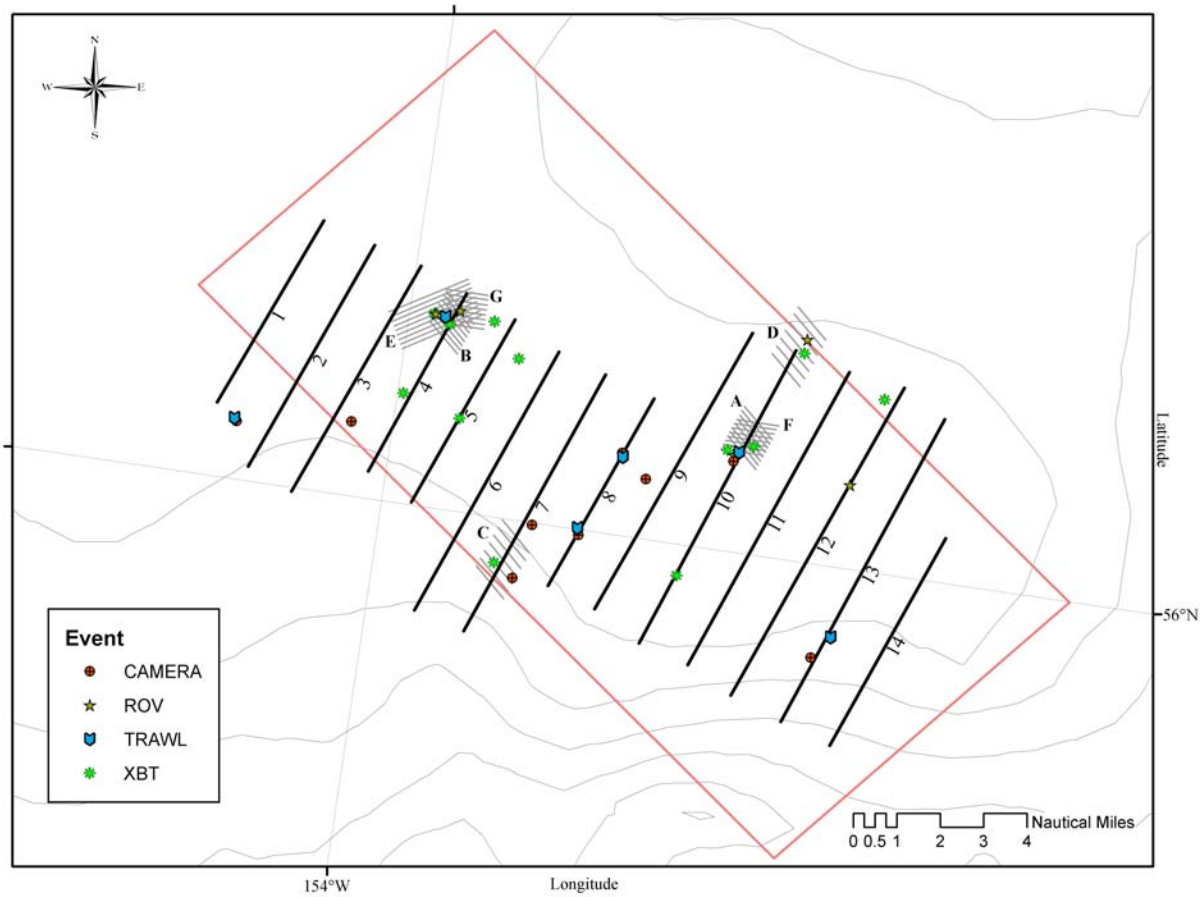



Figure 2. Snakehead survey area transects with drop camera, ROV, trawl, and XBT deployment locations. Transects are numbered according to the sequence run on survey 1. Subsequent surveys contained various combinations of transects. Several transects were increased in length due to echosign at the original endpoints. Small scale ME70 surveys are grey parallel lines labeled A-G.

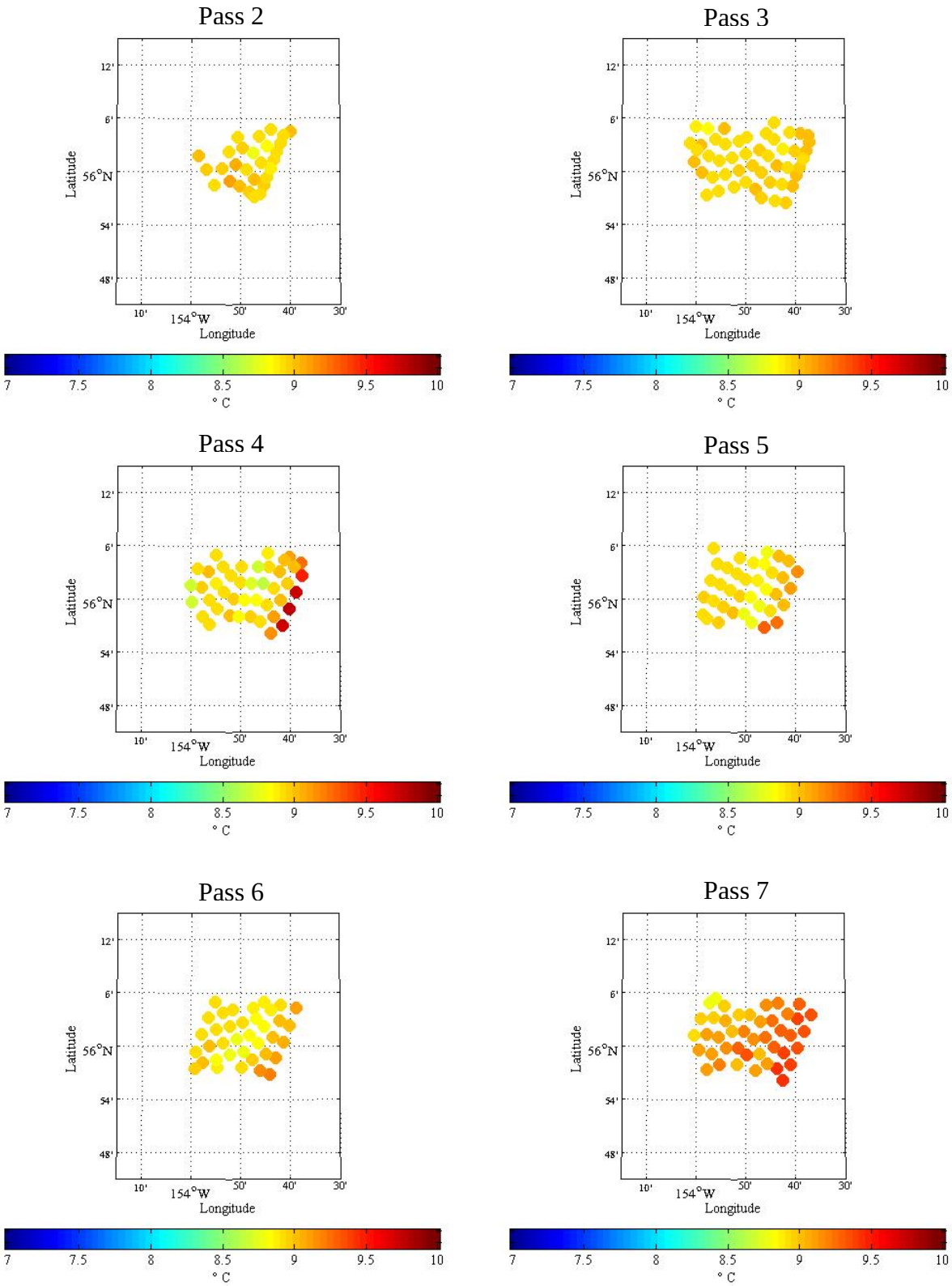



Figure 3. Temperature plots from shipboard mid-ship SBE-21 temperature sensor (5 m below surface) from each pass. Data were not collected for pass 1 and part of pass 2.

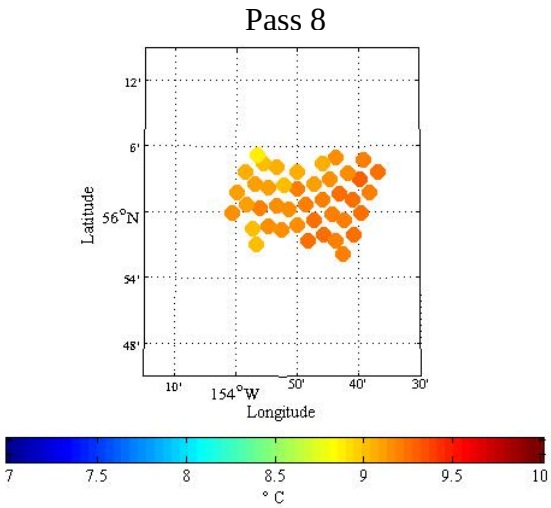
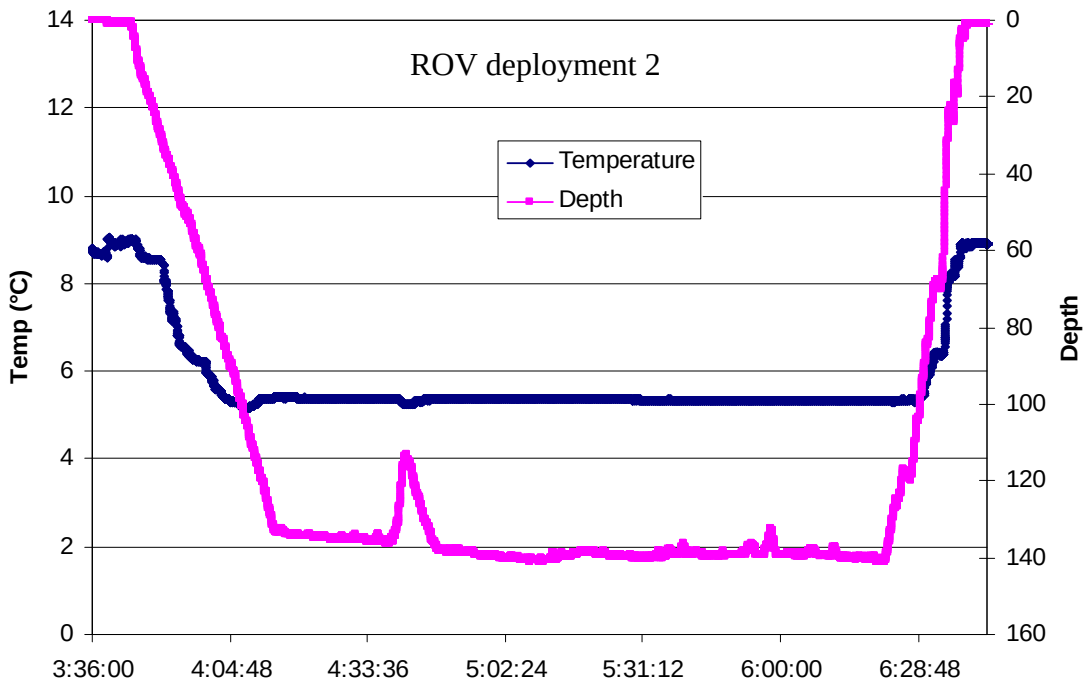



Figure 3 (cont.). Temperature plots from shipboard mid-ship SBE-21 temperature sensor (5 m below surface) from each pass. Data were not collected for pass 1 and part of pass 2.



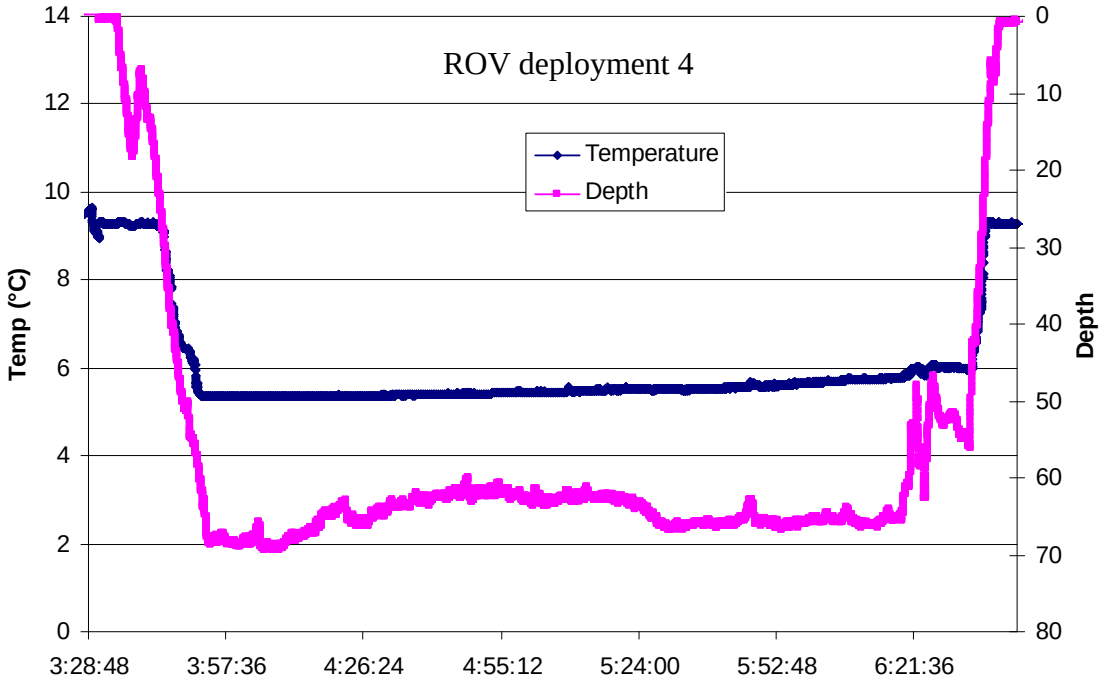




Figure 4. Plot of temperature and depth recorded during ROV deployment 2, 4 and 5.

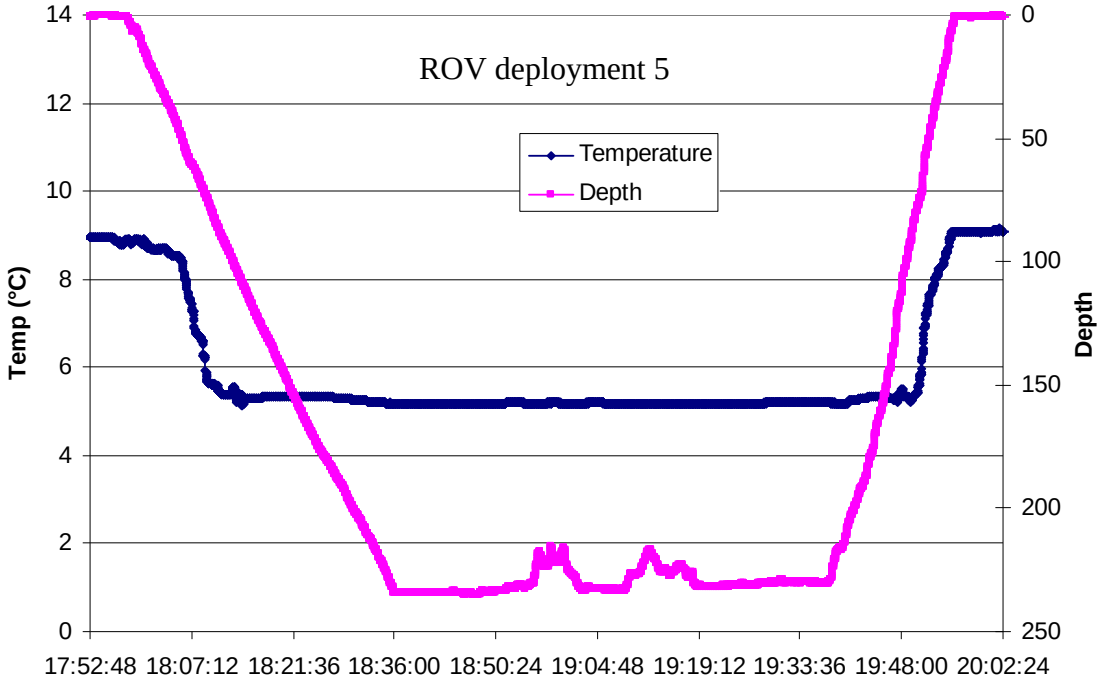
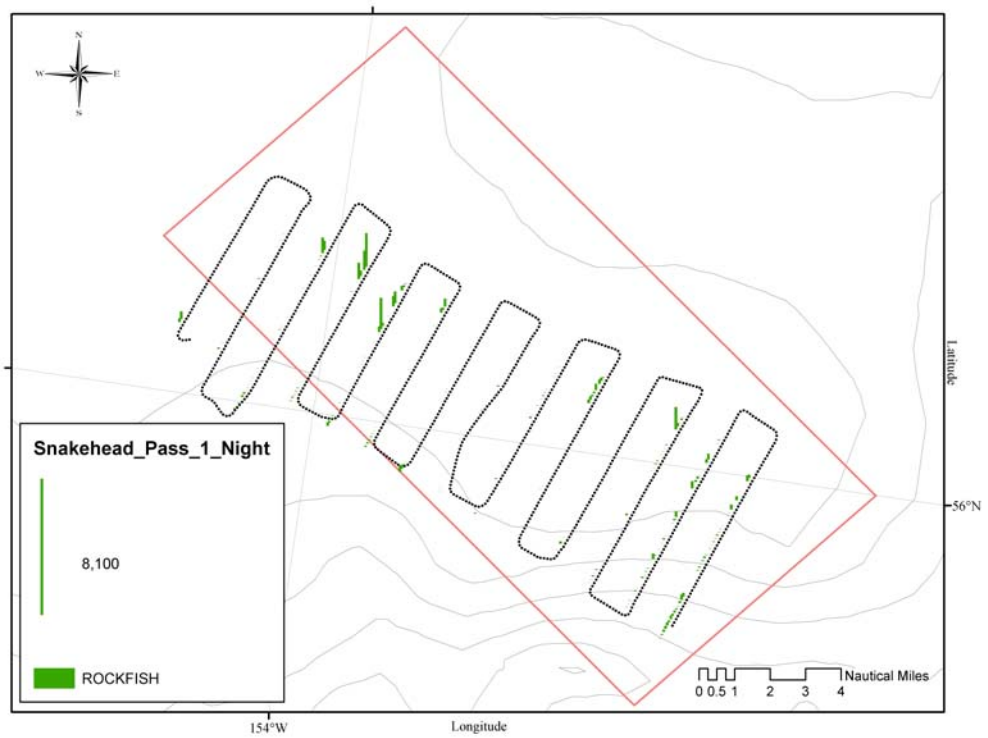



Figure 4 cont. Plot of temperature and depth recorded during ROV deployment 2, 4 and 5.



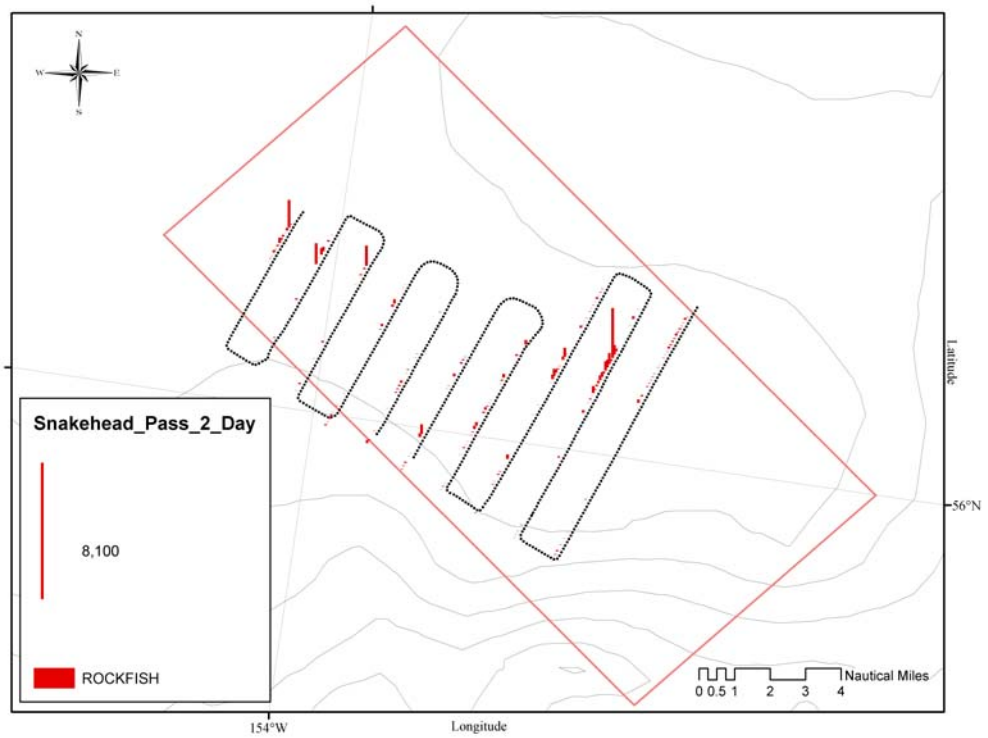
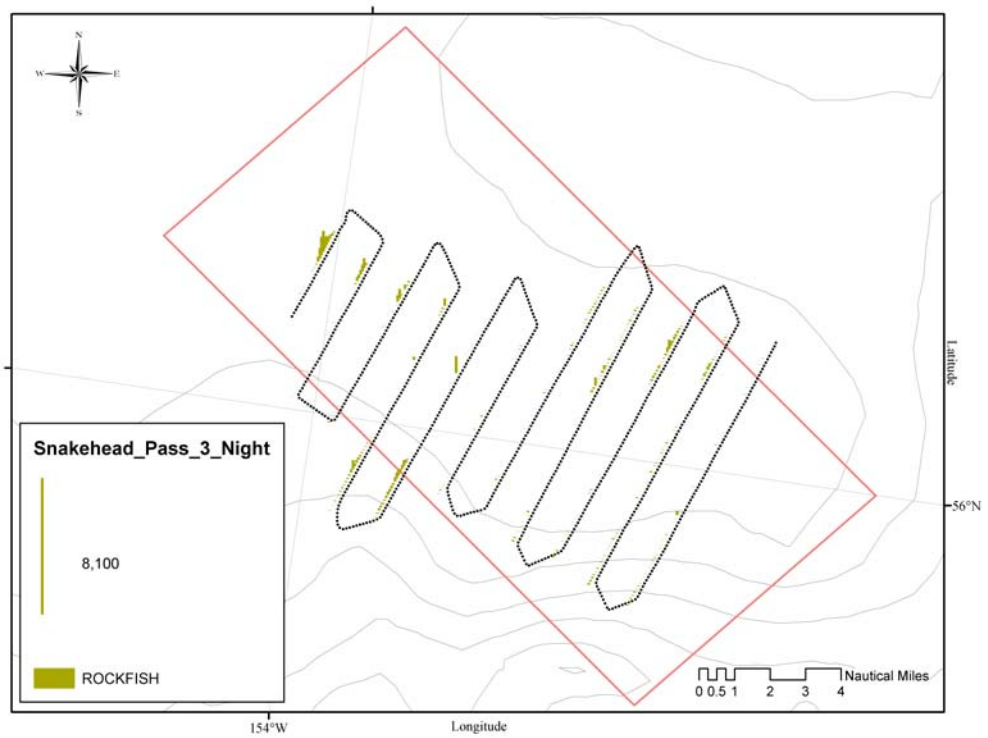




Figure 5. Survey tracklines and Sa for large scale passes 1-8 within Snakehead survey site.



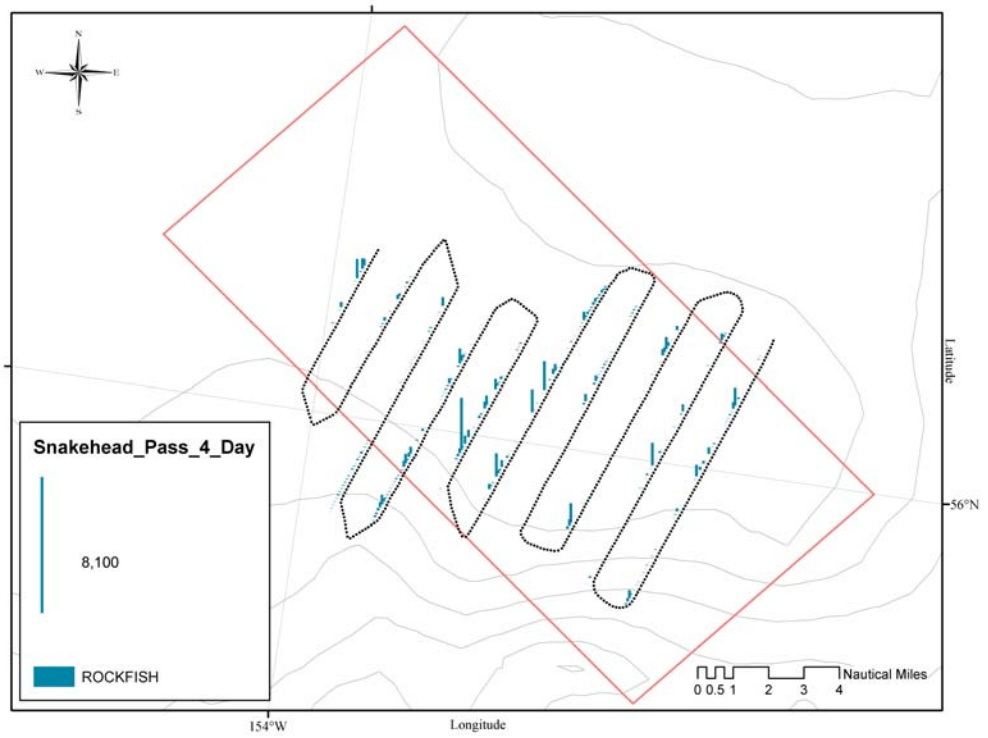
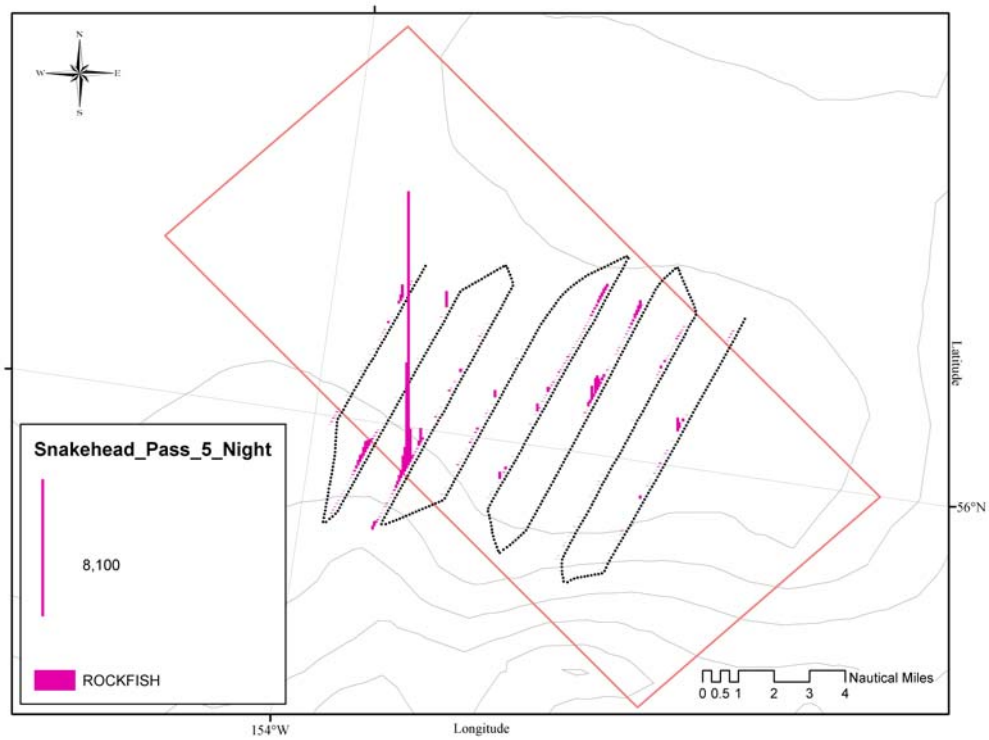




Figure 5 cont. Survey tracklines and Sa for large scale passes 1-8 within Snakehead survey site.



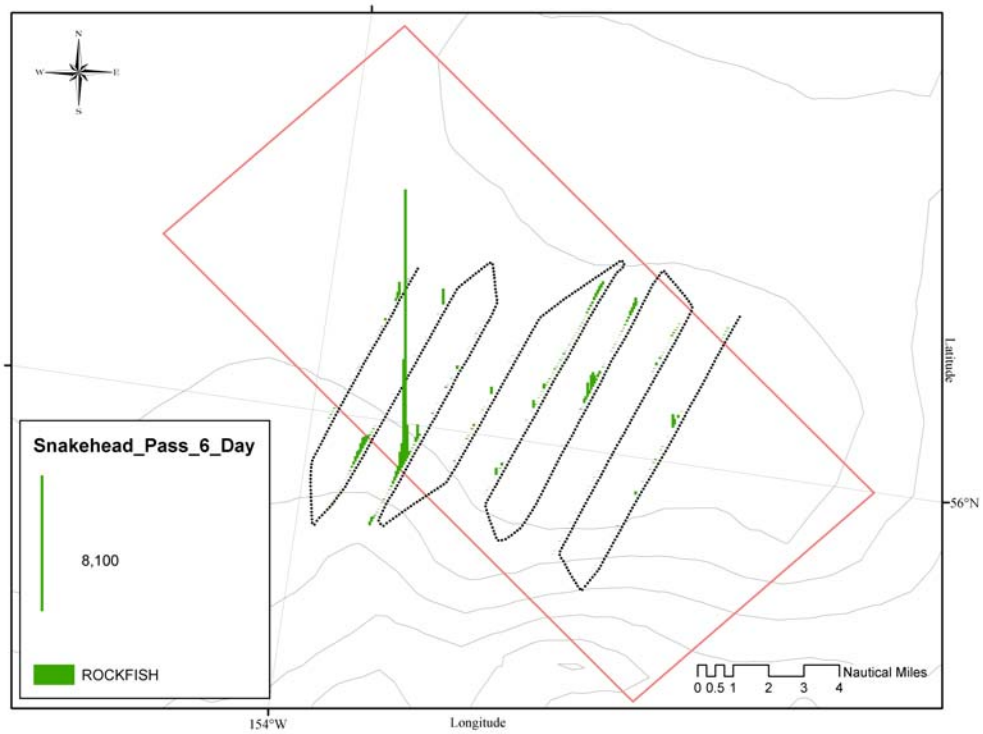
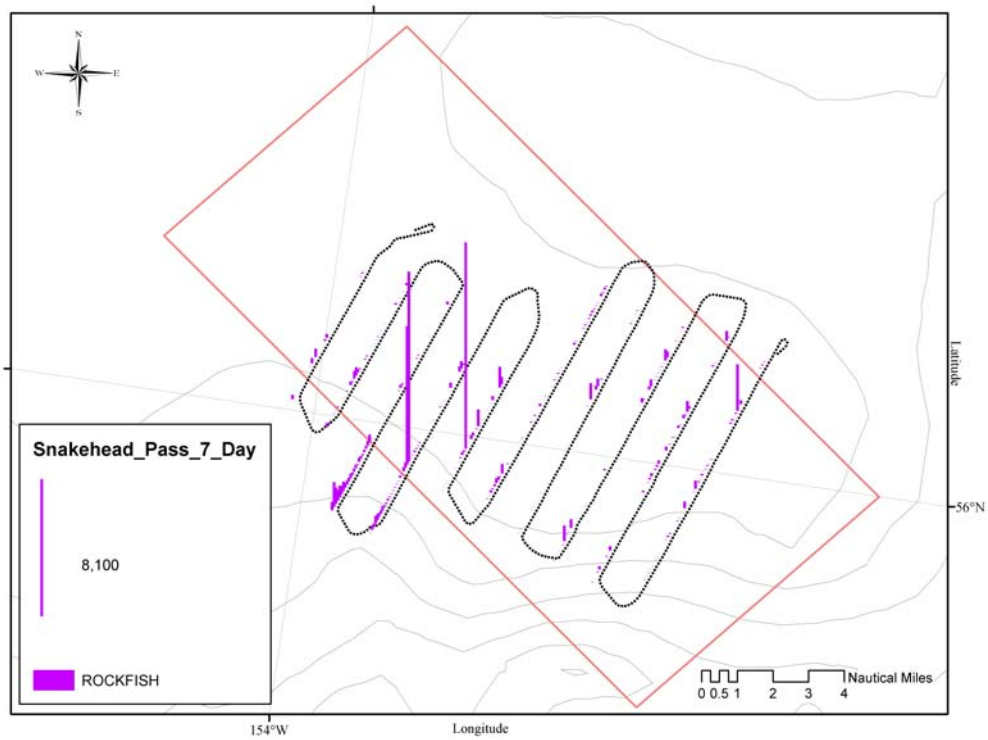




Figure 5 cont. Survey tracklines and Sa for large scale passes 1-8 within Snakehead survey site.



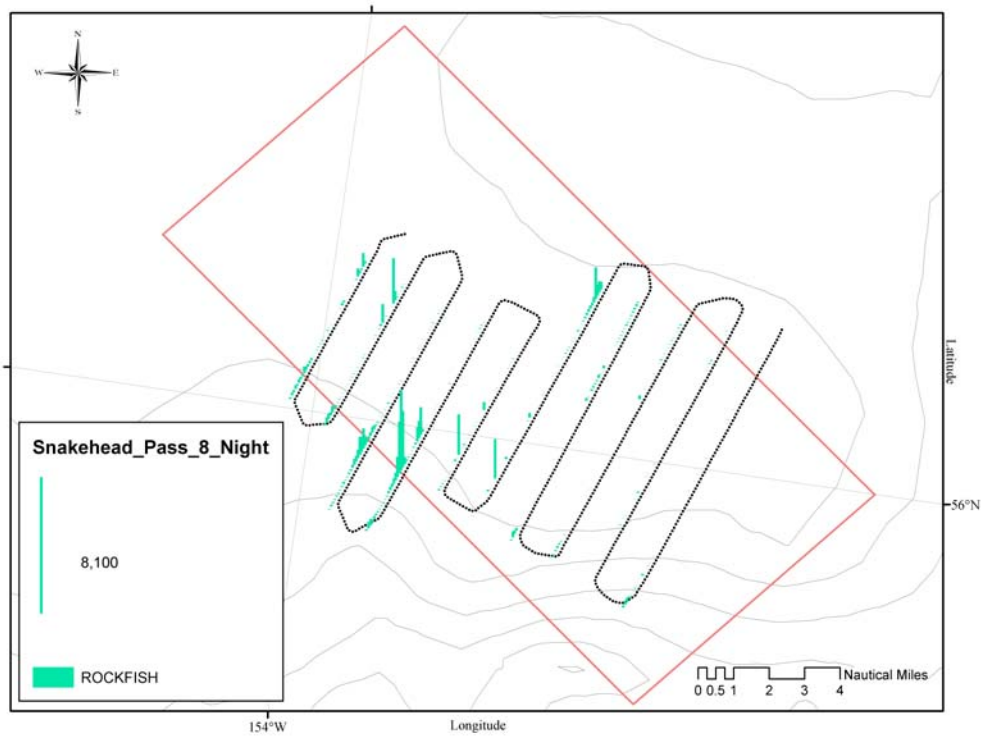




Figure 5 cont. Survey tracklines and Sa for large scale passes 1-8 within Snakehead survey site.

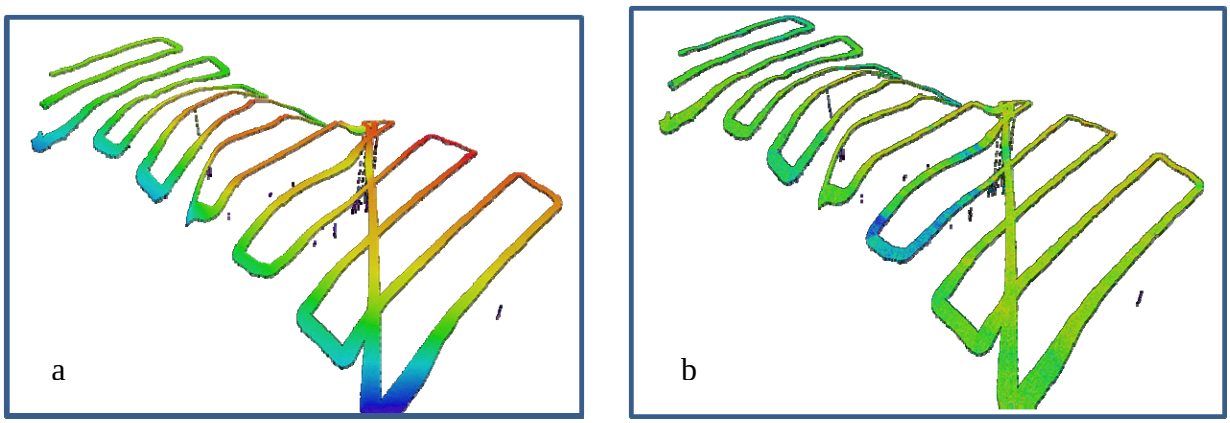



Figure 6. ME70 large scale survey data showing a) bathymetry (red is shallow, blue is deep) and b) seafloor backscatter (red/yellow indicates higher backscatter, blue indicates lower backscatter), which may be useful in classifying the bottom as untrawlable vs. trawlable.

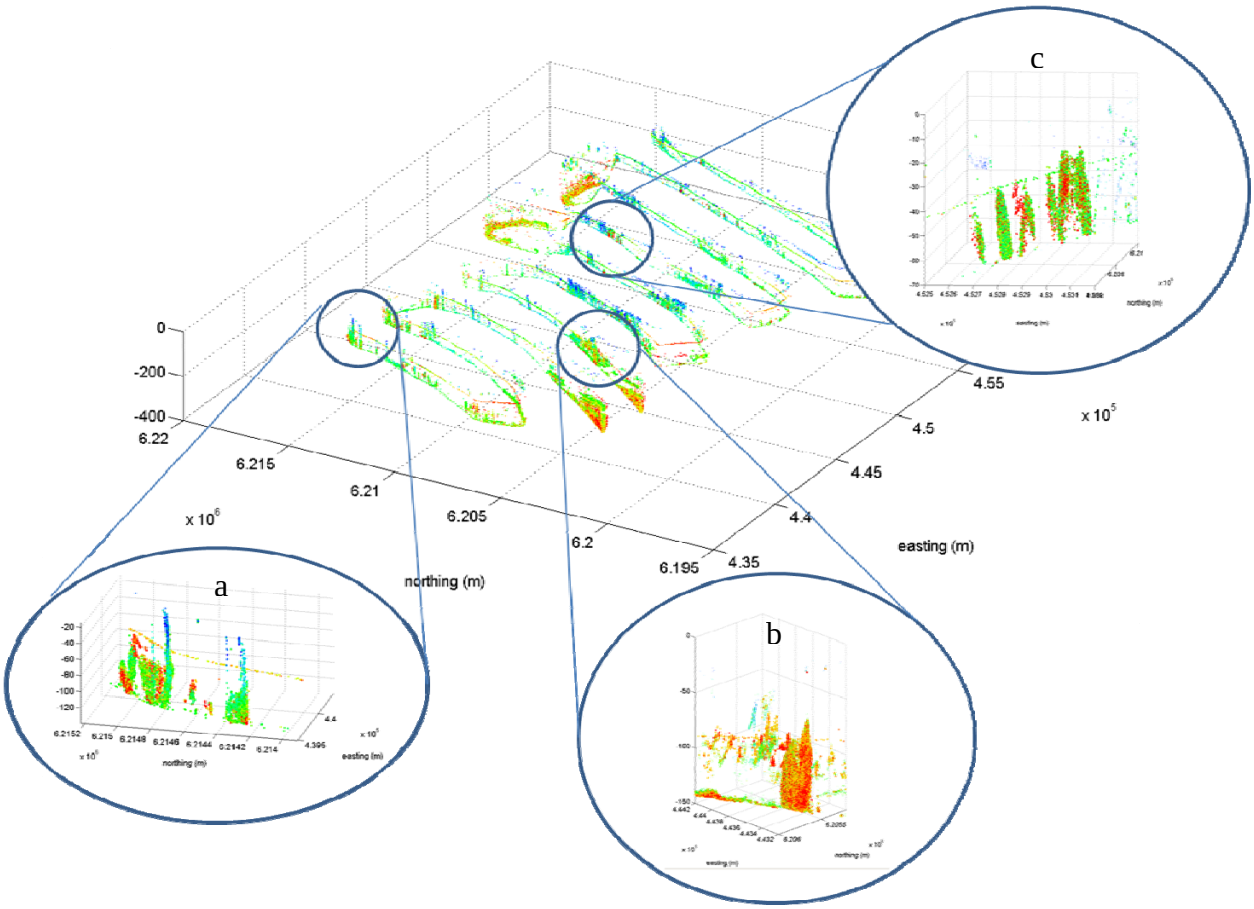



Figure 7. Water column backscatter collected with the ME70 during one of the large scale surveys. Color corresponds to Sv values (red is high, blue is low). Highlighted regions show a) what appears to be rockfish aggregated around the base of several bubble plumes (possibly methane), b) a dense aggregation of fish in 150 m water depth, and c) several smaller aggregations of rockfish.

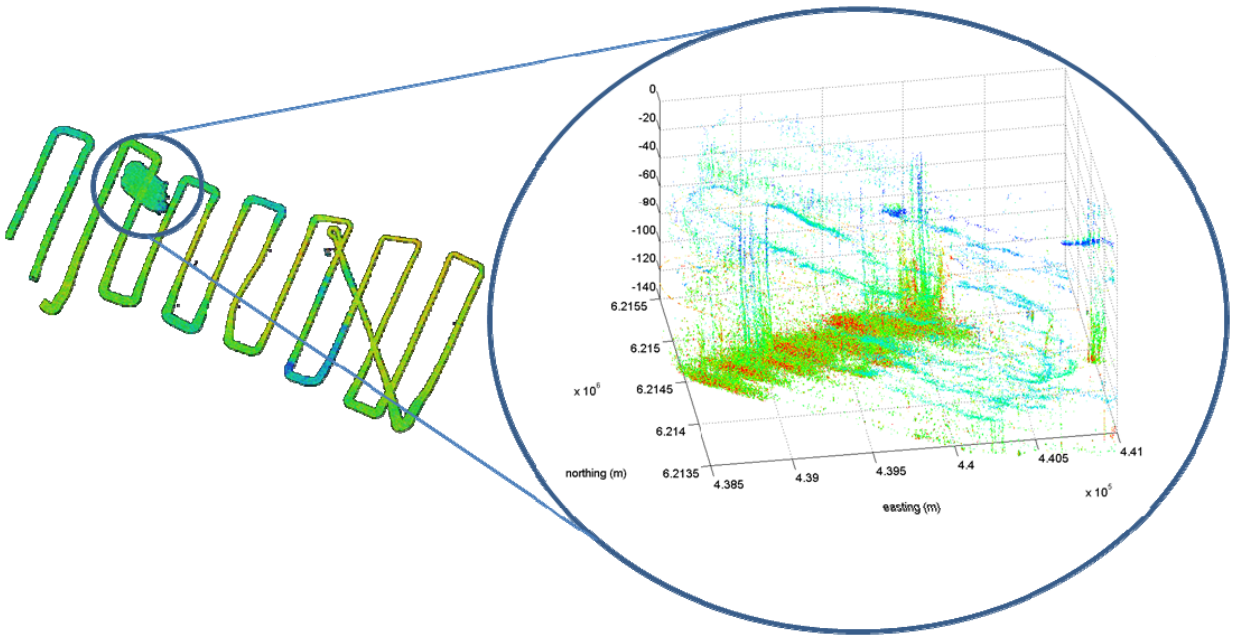



Figure 8. Seafloor backscatter (a proxy for bottom type) collected along 14 parallel transects comprising a large-scale survey on the left. The small scale illustration shows, apparent bubble plumes (light blue) characterized by high vertical extent and narrow cross section. Rockfishes appear aggregated near and on the seafloor around the base of the plumes in this region of the study area, based on acoustic and ROV data.

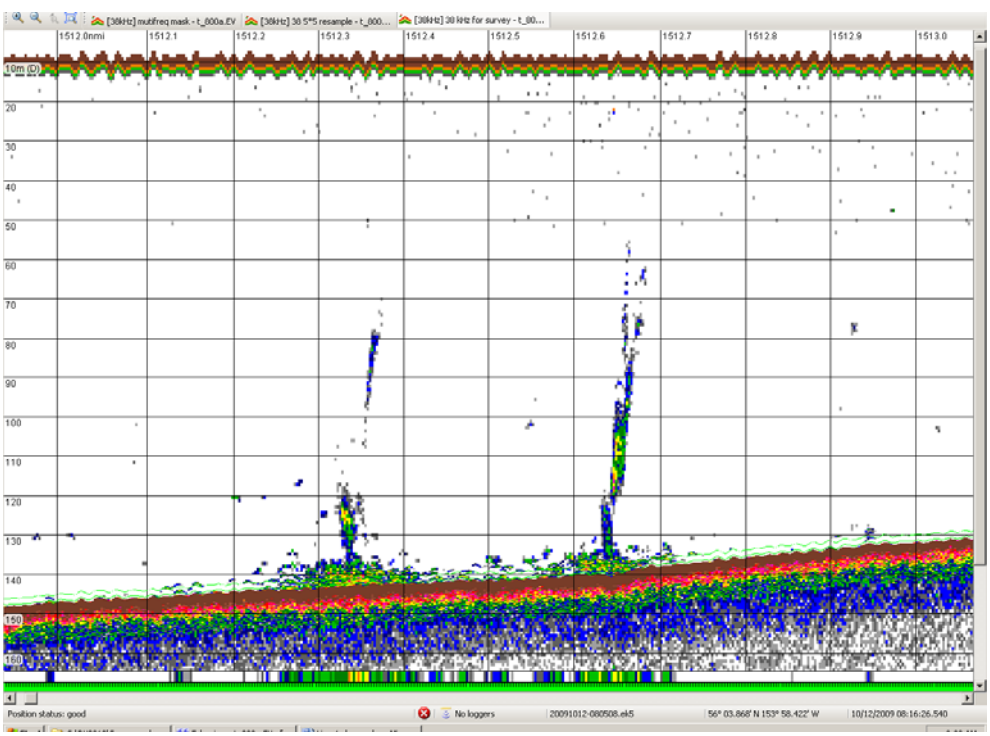


Figure 9. EK60 echogram of bubble plumes with fish associated at base.

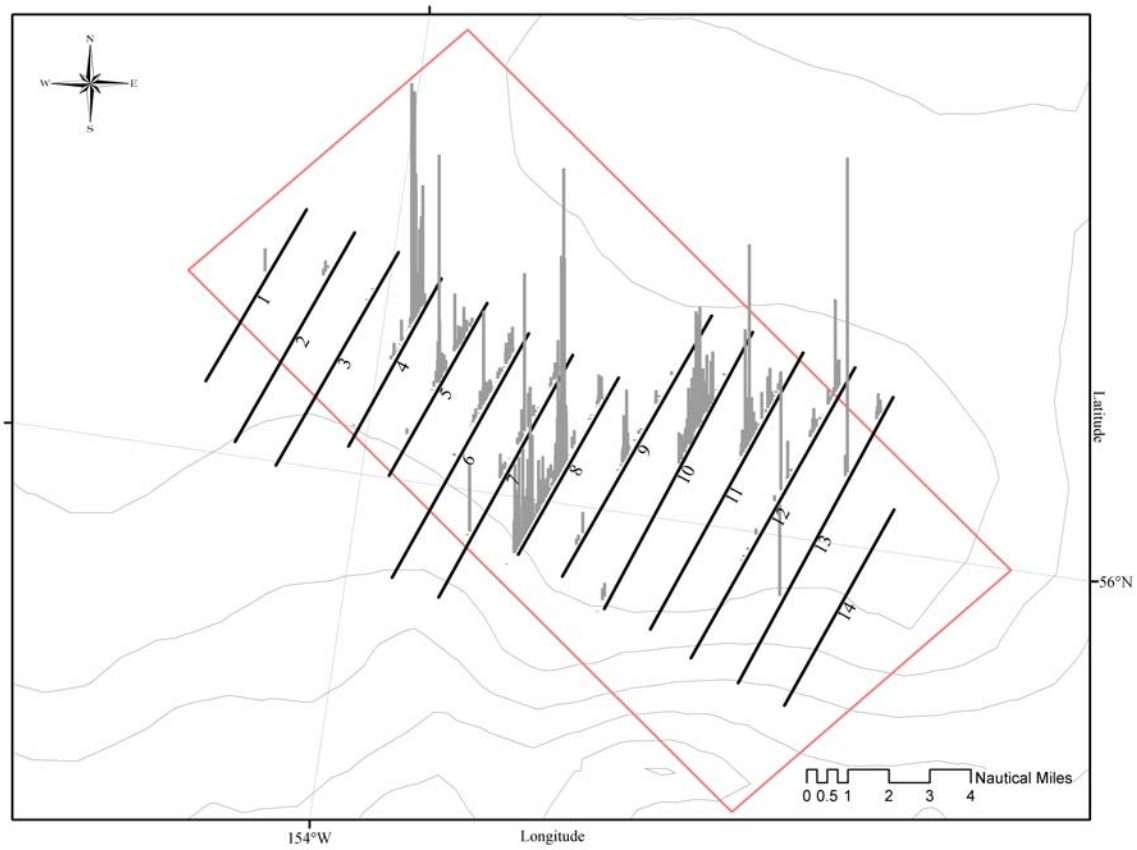



Figure 10. Combined backscatter attributed to bubbles along all transects of Snakehead survey.