Essential Fish Habitat project status report

Reporting date: 31 October 2012

Project number: 1

Title: Low-cost multibeam mapping to support habitat based groundfish assessment and deepwater coral research in the Gulf of Alaska

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Funding year: FY11

Funding amount: $67,400

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: January 2013

Reporting: A final project report and peer-reviewed manuscript will be prepared describing the results of this study. A final protocol for continuing collection of ME70 multibeam data aboard the *Oscar Dyson* will be developed and used by future survey and research activities in the Gulf of Alaska (GOA). Maps will be provided of particular ME70 multibeam derived metrics that will ultimately be used to build a comprehensive acoustic-based predictive model to assess seafloor trawlability.

Results:

Simrad ME70 multibeam echosounder (ME70) data were collected during several surveys to characterize trawlable and untrawlable areas of the seafloor. The information will ultimately improve efforts to determine habitat-specific groundfish biomass and to better describe patterns in community structure among these different habitats.

Multibeam data were collected during the summer 2011 GOA-wide biennial acoustic-trawl survey aboard the NOAA ship *Oscar Dyson*. This cruise was completed from 14 June – 12 August from the Islands of Four Mountains in the Aleutian Islands (169°59'0"W 52°43'11"N) to the eastern side of Kodiak Island (151°5'25"W 57°20'46"N) (Fig. 1). Additional ME70 data were also collected during an acoustic-trawl survey in the winter 2012 from 13–22 February and 17–27 March between Sanak Island in the Aleutians (163°14'42"W 54°48'37"N) and the eastern side of Kodiak Island (Fig. 1). The ME70 multibeam data were collected opportunistically during the winter surveys using protocols developed in 2011 and described in Appendix 1.

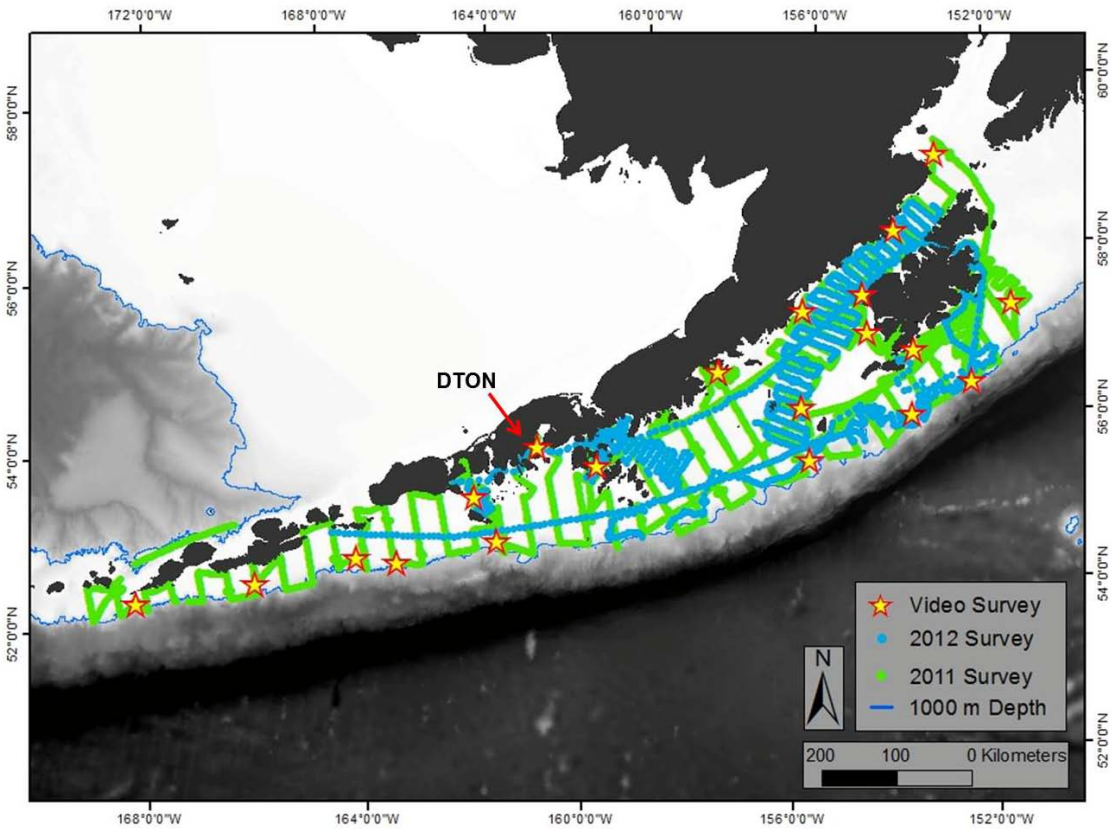

Figure 1. Oscar Dyson GOA ME70 survey footprint, including 2011 (green), 2012 (blue), and the locations of fine-scale surveys with groundtruth video conducted in 2011. An uncharted Danger to Navigation (DTON) was identified from the 2011 survey in Pavlof Bay.

ME70 data were collected continuously during the surveys along the ship trackline (Fig. 1). In addition, several ME70 fine-scale surveys were conducted in 2011 over localized areas having no groundtruth seafloor data, but which were suspected of being untrawlable (e.g., high relief) or characterized by some other unique habitat features (e.g., canyon, bank) based on historical information from AFSC groundfish surveys. The fine-scale ME70 surveys also targeted localized areas where seafloor information had been collected earlier with other devices (e.g., cameras, submersibles), which could be used to groundtruth the ME70 data. A total of 42 of these previously sampled video dive locations were intersected by the 2011 *Oscar Dyson* trackline or fine-scale ME70 surveys (n = 21; Table 1). An uncharted Danger to Navigation (DTON) was identified from the June 25 survey in Pavlof Bay and charts were updated for the area (Fig. 1, Table 1).

Single (Drop; n = 44) or stereo drop camera (SDC; n = 3) deployments were conducted at stations in the fine-scale survey areas to characterize the seafloor for comparison with ME70 data. Substrate observed in the underwater video from these deployments was classified as trawlable or untrawlable, where untrawlable areas were defined as any substrate containing boulders reaching higher than 20 cm off bottom or any substrate with exposed bedrock that was so rough that the standard bottom trawl footrope would not pass easily over it (*sensu* Weber et al.

accepted). A total of 27 Drop and SDC camera stations were characterized as trawlable and 20 stations were characterized as untrawlable (Table 1), including areas of Albatross Bank on the south Kodiak Shelf with rock ridge, boulders, sponges and corals, and associated rockfishes (*Sebastes spp.*) (Fig. 2).

Table 1. Fine-scale ME70 survey locations, survey date in 2011, camera deployments, vehicle used (Drop = single drop camera, SDC = stereo drop camera), seafloor type (T = trawlable, U = untrawlable), and untrawlable substrate types encountered (B = boulders, R = rock) with sponges (s) and corals (c) indicated when present. An uncharted Danger to Navigation (DTON) was identified from the June 25 survey.

Location	Date	Camera Deployments	Vehicle	Seafloor Type	Untrawlable Substrate
Aleutian Islands	06/18	-	-	-	-
Aleutian Islands	06/19	-	-	-	-
Aleutian Islands	06/20	1	Drop	T	-
Aleutian Islands	06/21	1	Drop	T	-
Aleutian Islands	06/21	2	Drop	U	B (s, c)
Aleutian Islands	06/21	3	Drop	T	-
Shumagin Islands	06/23	1	Drop	T	-
Shumagin Islands	06/23	2	Drop	U	B (s, c)
Shumagin Islands	06/23	3	Drop	T	-
Shumagin Islands	06/23	4	Drop	T	-
Shumagin Islands	06/24	1	Drop	U	B (s, c)
Shumagin Islands	06/24	2	Drop	U	B, R (s, c)
Shumagin Islands	06/25	1	Drop	T	-
Shumagin Islands	06/25	2 (DTON)	Drop	U	R (s)
Shumagin Islands	07/07	1	Drop	T	-
Shumagin Islands	07/07	2	Drop	U	B (s)
Nakchamik Island	07/12	1	Drop	T	-
Nakchamik Island	07/12	2	Drop	T	-
Chirikof Island	07/13	1	Drop	U	B (s)
Chirikof Island	07/13	2	Drop	U	B (s)
Snakehead Bank	07/14	-	-	-	-
Shelikof Strait	07/16	1	Drop	T	-
Shelikof Strait	07/16	2	Drop	T	-
Shelikof Strait	07/17	1	Drop	T	-
Shelikof Strait	07/17	2	Drop	U	R
Shelikof Strait	07/17	3	Drop	T	-
Shelikof Strait	07/18	1	Drop	T	-
Shelikof Strait	07/18	2	Drop	T	-
Shelikof Strait	07/18	3	Drop	T	-
Shelikof Strait	07/19	1	Drop	T	-
Shelikof Strait	07/19	2	Drop	T	-
Shelikof Strait	07/19	3	Drop	T	-
Chirikof Island	07/21	1	Drop	T	-
Chirikof Island	07/21	2	Drop	T	-
Chirikof Island	07/21	3	Drop	T	-

Table 1. Continued.

Location	Date	Camera Deployments	Vehicle	Seafloor Type	Untrawlable Substrate
Kodiak Island Shelf	08/08	1	Drop	U	B, R (s)
Kodiak Island Shelf	08/08	2	Drop	T	-
Kodiak Island Shelf	08/08	3	Drop	U	B, R (s)
Kodiak Island Shelf	08/08	4	Drop	U	B, R (s)
Kodiak Island Shelf	08/08	5	Drop	U	B (s)
Albatross Bank	08/09	1	Drop	U	B, R (s, c)
Albatross Bank	08/09	2	Drop	U	B (s, c)
Albatross Bank	08/09	3	Drop	U	B (s, c)
Kodiak Island Shelf	08/10	1	Drop	T	-
Kodiak Island Shelf	08/10	2	Drop	U	B
Kodiak Island Shelf	08/11	1	Drop	T	-
Kodiak Island Shelf	08/11	2	Drop	T	-
Albatross Bank	08/12	1	SDC	U	B, R (s, c)
Albatross Bank	08/12	2	SDC	U	B, R (s, c)
Albatross Bank	08/12	3	SDC	U	B (s)

Figure 2. Stereo Drop Camera image collected on August 12, 2011 at Albatross Bank (152°25'25"W 56°21'36"N) with Sebastes spp. associating with untrawlable habitat composed of rock ridge, boulders, corals, and sponges.

ME70 data were matched to the spatial location of previously conducted AFSC bottom trawl survey hauls from 1996-2011 to discriminate between trawlable and untrawlable seafloor types in the region of overlap between the trawl path and ME70 data (Fig. 3). Hauls had been previously classified as successful, marginally–successful, or unsuccessful (failed) by AFSC researchers based on the level of gear damage sustained from contact with the seafloor. The ME70 survey data corresponded with the location of 582 hauls, including 487 successful hauls and 95 marginal or failed hauls (Table 2).

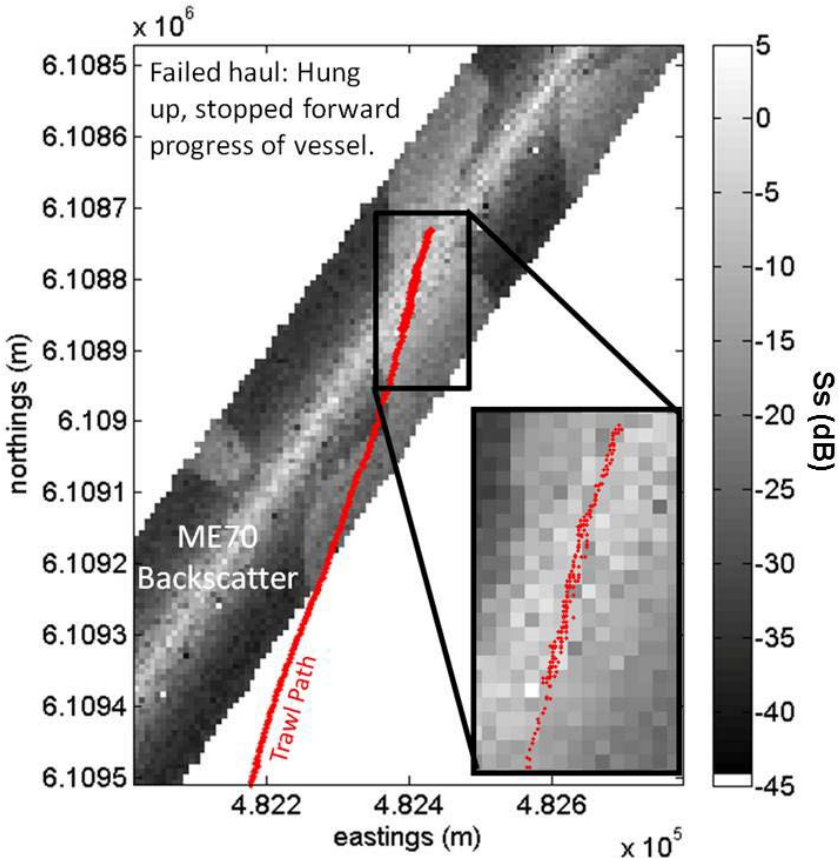

Figure 3. Angle-dependent seafloor backscatter strength (S_s) from the Oscar Dyson ME70 survey and a corresponding failed trawl haul path location.

Table 2. Number of AFSC 1996-2011 bottom trawl survey trawl haul locations encountered by the Oscar Dyson ME70 surveys in the GOA in 2011 and 2012. Hauls are listed by performance category as successful or marginally-successful and failed due to gear damage.

Survey Year	Successful	Marginal/Failed	Total
2011	294	24	318
2012	193	71	264
Total	487	95	582

Angle-dependent seafloor backscatter strength (S_s) from the ME70 data were extracted at haul locations for the area that the trawl contacted the seafloor, taking into account the trawl warp length, trawl width, and the positional uncertainty of the survey vessel. S_s was also determined at the Drop and SDC camera stations of the fine-scale survey sites in 2011. Areas of untrawlable seafloor generally exhibited higher S_s than areas with trawlable seafloor. The three haul performance categories show separation in S_s across incidence angles, with successful haul locations having lower values overall, corresponding to finer grainsize, or the lack of strong scatterers on the seafloor such as boulders and rock (Fig. 4). Likewise, areas of trawlable seafloor at camera stations generally have lower S_s values across the range of incidence angles sampled by the ME70 (Fig. 5).

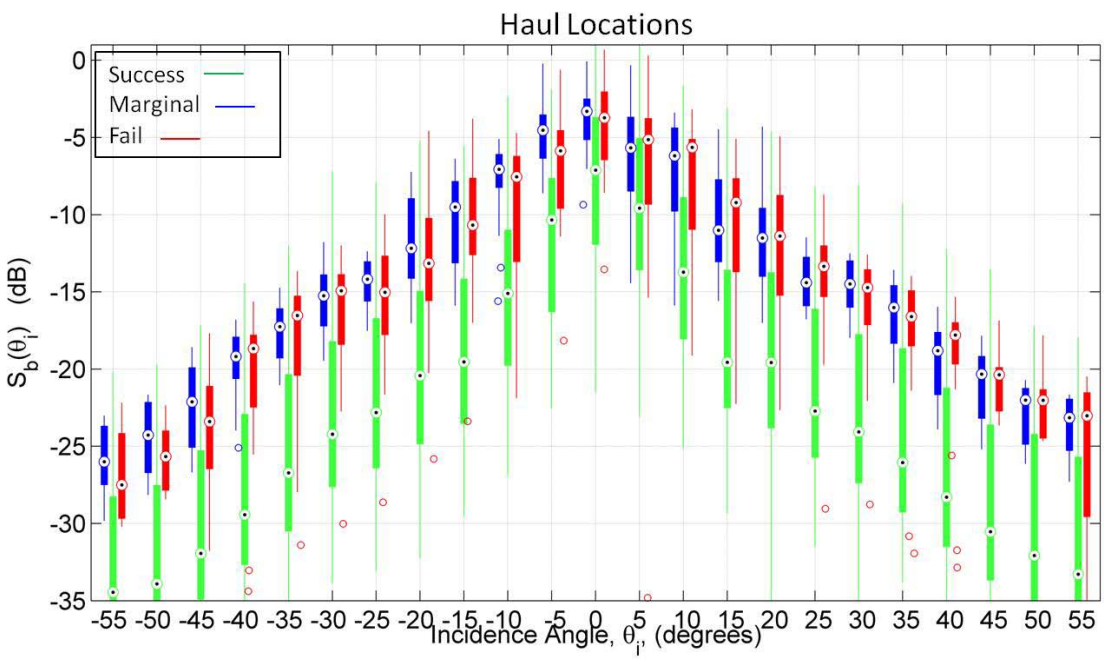

Figure 4. Angle-dependant seafloor backscatter strength (S_s), representing the ME70 beam configuration used in the GOA, sampled at haul locations from the AFSC bottom trawl survey (1996-2011) and classified by performance as successful, marginally–successful, or failed due to gear damage.

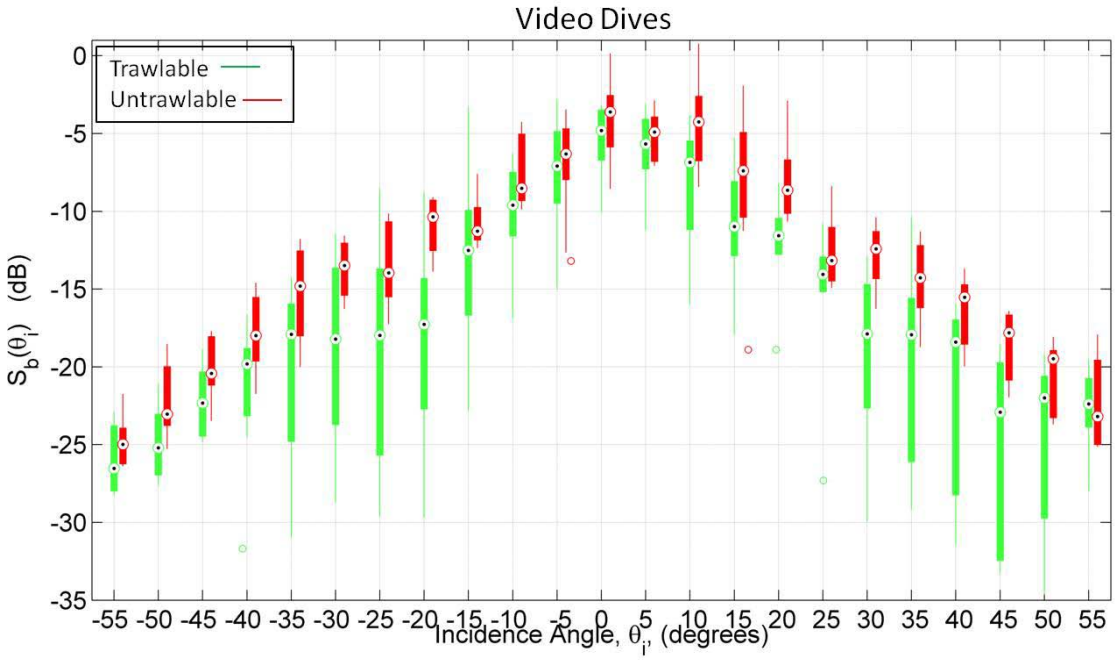

Figure 5. Angle-dependent seafloor backscatter strength (S_s), representing the ME70 beam configuration used in the GOA, at camera stations sampled in 2011 and characterized from video as trawlable or untrawlable.

Backscatter mosaics are commonly used in seafloor habitat studies and have the potential to simplify interpretation of seafloor properties (as opposed to retaining and analyzing the full angle dependent S_s). Mosaics were generated by normalizing values across the swath to the range of observed values at oblique angles from 30-50°. We analyzed the maximum S_s from the mosaics at haul locations (e.g., Fig. 3 inset) and camera stations based on performance. The distributions of maximum normalized S_s at successful and failed haul locations begin to deviate near -20 dB (Fig. 6). A similar pattern was observed for trawlable and untrawlable camera stations (Fig. 7).

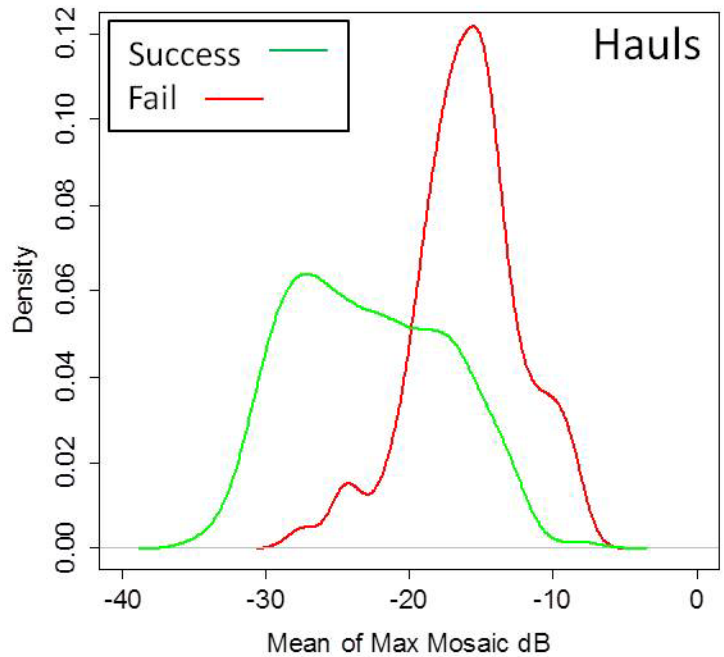

Figure 6. Histograms describing the distribution of seafloor backscatter strength (S_s) (mosaic values normalized to oblique incidence angles of 30-50°) at locations in the GOA previously sampled (1996-2011) by the AFSC bottom trawl survey and classified by performance as successful (success) or marginally-successful and failed due to gear damage (fail).

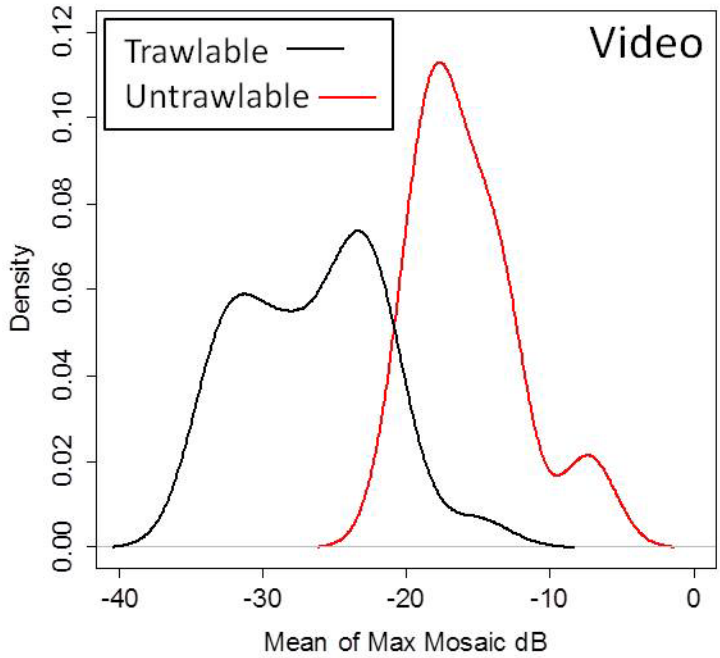

Figure 7. Histograms describing the distribution of seafloor backscatter strength (S_s) (mosaic values normalized to oblique incidence angles of 30-50°) at camera stations in the GOA sampled in 2011 and characterized from video as trawlable or untrawlable.

In addition to the backscatter mosaics, we have extracted other metrics from the multibeam data to determine if we can improve discrimination between trawlable and untrawlable seafloor (Table 3). Oblique incidence S_s is the average S_s measured at an incidence angle to the seafloor between 30° and 50° degrees. S_s slope near normal incidence is the difference in the slope of the angular response curves between 0° and 10°. Normal incidence S_s is measured directly under the transceiver at an incidence angle of 0°. In addition, four measures of seafloor roughness were extracted from the bathymetry data, where the bathymetry was binned at a scale of 0.25, 0.5, 1, and 2 m. The scintillation index (SI) was calculated, as the fourth moment of the S_s envelope, which measures how the backscattered acoustic intensity fluctuates over an area of the seafloor (Abraham and Lyons, 2002; Weber et al. *accepted*). The SI may be useful to identify areas of the seafloor that are untrawlable due to the presence of isolated rock outcrops and boulders surrounded by otherwise trawlable seafloor.

We will determine whether or not there is a stochastic difference between angle dependent S_s at oblique incidence angles and S_s mosaics at trawlable and untrawlable locations and identify the best descriptors for seafloor trawlability among metrics using stepwise logistic regression (GLM). The model results will be applied to map predicted seafloor trawlability of the ME70 survey footprint in Arc GIS, by characterizing ME70 mosaics as untrawlable or trawlable based on thresholds of the best descriptors identified by the model. These results may also be applied to redefine or reassign areas within the AFSC bottom trawl untrawlable/trawlable sampling grid cells using new information based on ME70 data. Continued opportunistic collection of ME70 multibeam data during *Oscar Dyson* operations in the GOA will provide more information to develop and test seafloor trawlability metrics over a potentially broader range of seafloor types as well as to collect this information in new areas throughout the GOA to help refine existing classifications of untrawlable and trawlable areas.

Table 3. Multibeam metrics derived from the ME70 data, and the angle of incidence (degrees) or scale (m) for calculation, and a brief description of the potential for discriminating between untrawlable and trawlable seafloor types.

Metric	Angle of Incidence or Scale (m)	Discriminatory Potential
Normal Incidence S_s	0°	Separation among seafloor types, may be greater for larger grain sizes
S_s Slope Near Normal Incidence	0-10°	Change in S_s slope is inversely proportional to grain size at these angles
Oblique Incidence S_s	30-50°	Separation among seafloor types may be greater at these angles
S_s Mosaic	Normalized to 30-50°	Angle dependency is largely removed across the swath
Seafloor Roughness	0.25 m	Roughness at the scale of small boulders
Seafloor Roughness	0.5 m	Roughness at the scale of medium boulders
Seafloor Roughness	1 m	Roughness at the scale of large boulders
Seafloor Roughness	2 m	Roughness at the scale of large boulders
Scintillation Index	30-50°	Isolated features (e.g. bedrock outcrop)

References:

Abraham, D., and A. Lyons. 2002. Novel physical interpretations of K-distributed reverberation. IEEE J. Oce. Eng. 27(4):800-813.

Applied Physics Laboratory (APL). 1994. APL-UW High-frequency ocean environment acoustic models handbook, TR9407, APL, University of Washington.

Foote, K.G., H.P. Knudsen, G. Vestnes, D N. MacLennan, and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. No. 144, 69 p.

Weber, T.C., C. Rooper, J. Butler, D. Jones, and C. Wilson. *provisionally accepted.* Seabed classification for trawlability using the Simrad ME70 multibeam echosounder on Snakehead Bank in the Gulf of Alaska. Fish Bull NOAA.

Appendix 1: ME70 data collection protocols developed and implemented for the *Oscar Dyson*, summer 2011 survey, and subsequent surveys.

The ME70 was slaved to the Simrad EK60 echosounder system to eliminate cross talk between the two systems.

Beam Configuration:

The ME70 is configurable for number of beams, frequencies, and steering angles. The ME70 has a different frequency for each beam within a range of 70 kHz to 120 kHz. The following table contains specifications for the beam configuration used on the *Oscar Dyson*.

Beam Number	Frequency (kHz)	Beam Steering Angle (Forward / Athwartship)	Beam Size (Forward / Athwartship)
0	73.2	0 / -65.9	4.5 / 11.0
1	76.1	0 / -56.7	4.3 / 7.9
2	78.9	0 / -49.7	4.2 / 6.4
3	81.8	0 / -43.8	4.0 / 5.6
4	84.7	0 / -38.5	3.9 / 5.0
5	87.5	0 / -33.8	3.8 / 4.5
6	90.4	0 / -29.5	3.6 / 4.2
7	93.2	0 / -25.5	3.5 / 3.9
8	96.1	0 / -21.7	3.4 / 3.7
9	99.0	0 / -18.2	3.3 / 3.5
10	101.8	0 / -14.8	3.2 / 3.3
11	104.7	0 / -11.5	3.2 / 3.2
12	107.5	0 / -8.4	3.1 / 3.1
13	110.4	0 / -5.4	3.0 / 3.0
14	113.2	0 / -2.4	2.9 / 2.9
15	116.8	0 / 0.4	2.8 / 2.8
16	114.7	0 / 3.2	2.9 / 2.9
17	111.8	0 / 6.1	2.9 / 3.0
18	109.0	0 / 9.1	3.0 / 3.1
19	106.1	0 / 12.2	3.1 / 3.2
20	103.2	0 / 15.4	3.2 / 3.2
21	100.4	0 / 18.8	3.3 / 3.5
22	97.5	0/ 22.3	3.4 / 3.6
23	94.7	0 / 26.1	3.5 / 3.9
24	91.8	0 / 30.0	3.6 / 4.1
25	89.0	0 / 34.3	3.7 / 4.5
26	86.1	0 / 39.0	3.8 /4.9
27	83.2	0 / 44.1	4.0 / 5.5
28	80.4	0 / 50.0	4.1 / 6.4
29	77.5	0 / 57.0	4.3 / 7.8
30	74.7	0 / 66.0	4.4 / 10.8

Beam Calibration:

The ME70 beams were calibrated in Three Saints Bay on Kodiak Island (153°30'54"W 57°10'30"N) prior to the start of the summer 2011 survey, using the standard target method (Foote et al., 1987).

Positioning:

The positioning and attitude sensor aboard the *Oscar Dyson* was from a survey quality POS M/V version 4 with DGPS from a CNAV satellite signal receiver. In general, and with good satellite coverage, positioning from such a system would maintain horizontal control within the 5m specification.

Heave and Attitude:

Real time heave from the POS M/V was logged in the raw sonar files during acquisition and applied in post processing. Pitch and Roll are provided to the sonar at a rate of 200 Hz and are applied by the sonar through real-time beam steering.

Sound Speed Profiles:

Sound speed profiles were largely determined through XBTs casts, taken approximately every 3-6 h while underway, and nightly CTD casts. Noise was present in the XBT casts, likely due to the conductive wire contacting the vessel hull. These spikes were removed graphically and the profile limited to the water depth in the area. The temperature profile was then extended using the average profile for the month in the world ocean database, and sound speed was calculated using an average salinity profile from the world ocean data base.

Processing:

Soundings were extracted from the raw ME70 data, using the bottom detection algorithm developed by Dr. Tom Weber at the Center for Coastal and Ocean Mapping at the University of New Hampshire. The Hare Uncertainty Model was implemented during the conversion process to provide estimates of uncertainty for the soundings, which includes tidal, sound velocity and vessel offset uncertainty estimates. These bottom detections were written to a Generic Sensor Format (GSF).

The GSF files were imported into CARIS HIPS to correct for tide, sound velocity, and vessel offsets. Cursory cleaning was conducted to remove obvious fliers affecting the surface. Corrected GSF files were exported from CARIS HIPS.

The corrected GSF files were imported into Fledermaus FMGT to generate backscatter mosaics, using custom settings for the ME70.