Deepwater Sidescan Sonar and Camera Surveys for Derelict Fishing Nets and Rockfish Habitat

Prepared for:
THE NORTHWEST STRAITS FOUNDATION
www.nwstraits.org

Prepared by:
NATURAL RESOURCES CONSULTANTS, INC.
4039 21st Ave West, Suite 404
Seattle WA, 98199

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NRC
NATURAL RESOURCES CONSULTANTS, INC.

4039 21st Ave West, STE. 404
SEATTLE, WASHINGTON 98199-1252, U.S.A.
TELEPHONE: (206) 285-3480
TELEFAX: (206) 283-8263
E-Mail : jjune@nrccorp.com (corporate)

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Abstract

This study tested the feasibility of employing sidescan sonar surveys to locate derelict nets in deepwater (105 – 350 ft) rockfish habitat, verify the findings with camera surveys, and assess potential threats to the rockfish populations. Two days of sidescan sonar surveys were conducted off south San Juan and Lopez islands, covering 20.27 linear nautical miles and identifying 31 potential derelict net targets. Six days of drop camera surveys were conducted, capturing video over a total length of 3.84 linear nautical miles, verifying derelict nets at 11 of 13 targets, and identifying an additional 55 derelict nets near the original net targets. This study proved that sidescan sonar surveys are capable of identifying derelict net targets in rockfish habitat, with some limitations: (a) vertical hard bottom substrate reflects nearly all acoustic sidescan sonar energy, masking derelict net features and (b) geologic patterns in vertical rock walls such as cracks and crevices can display characteristics similar to derelict nets. Drop camera video imaging provided the ability to characterize habitat, observe rockfish behavior and assess feasibility of net removal. However findings concluded that due to limitations in the mobility and range of drop camera surveys, the use of a remote operated vehicle (ROV) would better serve to accomplish these goals.

Purpose

The study tested the feasibility of surveying for deepwater derelict fishing gear (DG), particularly derelict nets, with sidescan sonar, verifying that sidescan sonar targets were actually derelict nets using a drop camera, assessing the derelict net's potential threat to deepwater rockfish and collecting information necessary to develop a removal plan.

Background

Yelloweye rockfish, *Sebastes ruberrimus*, canary rockfish, *Sebastes pinniger*, and bocaccio rockfish, *Sebastes paucispinis*, were recently listed under the Endangered Species Act in Puget Sound. There is an increasing interest from resource managers in understanding the extent of impacts of derelict fishing gear on rockfish populations in the Puget Sound. Derelict net removals performed by the Northwest Straits Initiative (NWSI) in Puget Sound have been ongoing since 2002 and the entanglement and mortality of rockfish have been documented in derelict fishing gear, particularly derelict gillnets. Due to diver safety regulations, the NWSI net surveys and removals focus only in water depths less than 105 feet, leaving the extent and impact of derelict nets in waters deeper than 105 feet virtually unknown. The three ESA listed rockfish species (and many others) are known to commonly reside in water deeper than 105 feet being common in depths between 200 and 350 feet. Therefore, identifying the extent of the derelict nets and assess their level of impact on these species is needed in order to implement effective methods for future management of the rockfish in Puget Sound.

The use of sidescan sonar has proven to be an effective method to locate derelict fishing nets in shallow water (< 105 feet.). Previous to the use of sidescan sonar, drop camera and diver surveys were the most common methods for finding derelict nets in Puget Sound. Diver and drop camera surveys have many limitations in their effectiveness, most of all through a lack of area covered and problems with poor visibility. However, camera surveys can be effective in characterizing the size and condition of nets when in the field of view. From past drop camera surveys and diver reports, we know that there are derelict nets in water over 100 feet deep. The study tested the feasibility of using sidescan sonar to detect derelict

nets in deepwater and using a drop camera, characterize the risk of the nets to rockfish and develop a plan for net removal with a remote operated vehicle (ROV).

Funding from the National Fish and Wildlife Foundation and NOAA, Department of Commerce was provided to the Northwest Straits Foundation (NWSF) to conduct deepwater sidescan sonar and camera surveys in areas of known rockfish critical habitat. NWSF contracted with Natural Resources Consultants, Inc (NRC), to manage the deep water surveys. NRC contracted with Fenn Enterprises to conduct the survey work.

Scope of Work

Two days of sidescan sonar surveys were conducted, as well as one half day of data post-processing. The surveys focused on locating deepwater derelict fishing nets and rockfish habitat on the southeast tip of Lopez Island and the west side of San Juan Island, from Small Pox Bay to Salmon Bank (Exhibit 1). Six days of drop camera surveys were conducted in areas where derelict net targets and rockfish habitat was found using the sidescan sonar surveys.

Methodology

Sidescan Survey

Fenn Enterprises conducted sidescan sonar to locate deepwater derelict fishing nets and rockfish habitat on the southern tip of Lopez Island and the west side of San Juan Island. The surveys on San Juan Island focused on the area between Small Pox Bay and the western side of Salmon Bank (Exhibit 1). The surveys were conducted using a Marine Sonics® 300 kHz transducer, mounted in a Fenn Enterprises heavy stainless-steel towfish. A Trimble® differential global positioning system antennae (DGPS) mounted on a davit over the stern of the vessel was used to geo-reference the track line of the vessel during the survey that was recorded by the Marine Sonics sidescan system. Nobletec®, a marine navigation software system, was also used to track the progress of the vessel during the survey.

The towfish was deployed off the stern of the 40-foot research vessel R/V *Surveyor II.* A hydraulic winch with cable controlled the altitude of the towfish. The survey image was displayed on a video monitor onboard the vessel and recorded onto a computer hard drive for later processing. Generally, the sidescan sonar survey was conducted at 2.5 knots (4.63 km/hr). Due to the steepness of the underwater terrain in the survey areas, the majority of the sidescan surveys were conducted using only one side channel, with the signal covering the base of the rock structures and up the structure a calculated distance. This distance varied depending on depth and terrain, with the majority (approx. 78%) of the survey swath width of 328 feet (100 meters) with the remaining survey swath width of 490 to 650 feet (150 to 200 meters). Survey depths ranged from 105 feet (32 meters) to 351 feet (107 m), as per contract specifications, although surveys at deeper depths are certainly feasible.

The sidescan sonar images were examined in detail during post-survey processing and counts and precise locations of derelict nets and rockfish habitat were recorded. The products from the sidescan sonar survey included a track line file of the area surveyed, calculation of the amount of the seabed area covered and the positions (latitude and longitude) of likely derelict net targets found.

Drop Camera Survey

Fenn Enterprises conducted six days of drop camera surveys to ground truth the targets found during the sidescan survey. In addition to the sidescan sonar targets, existing deepwater targets in the NWSI Derelict Fishing Gear Database and targets reported by WDFW from a 2008 fish habitat ROV survey were also investigated.

A Canon® Vixia HFS11 recording in 1920 x 1080 full high definition (HD) video combined with two Deep Sea Power & Light® Mini C Series underwater lights each with a 250 watt frosted bulb with 4500 lumens and a color temperature rating of 2900 were used for lighting of the cameras field of view. A custom titanium housing with wide-angle lens was built for the camera including a telemetry system for video control in the vessel cabin via an RS485 connection to a laptop. This allows control of features such as power to the camera, record, zoom and focus. The camera system was tethered to the boat by a 1,000-foot long Falmat Xtreme-Cat® ruggedized umbilical with six 18awg copper wires and four pairs of Cat5e with a breaking strength of 1,200 lbs. This cable provided power to the camera and lights, telemetry and onboard analog video cable. The location of the vessel was geo referenced using a Trimble survey grade DGPS antenna mounted above the string block that fed the drop camera umbilical from the winch over the stern of the vessel. The GPS was connected to a GeoStamp+® system that allowed the latitude and longitude of the vessel location to be overlaid on the analog video output. Generally the drop camera remained vertically under the GPS antennae so the position of the vessel was an accurate estimate of the position of the drop camera. Nobletec® and the Trimble® DGPS antennae recorded the track line of the vessel and drop camera during each net target survey.

Video was stored on its internal 64GB flash drive or onto SD memory cards for easy transferability. Frame grabs of captured video were taken at 2 megapixels. The camera system had the ability to record in either digital HD or analog video. For instance, the analog capture was used real-time and when an item of interest occurred, the digital HD record was initiated. Analog video can be encoded in a variety of formats such as .avi, .wmv, .mpg, .mp4 and .mov. A stainless steel crash frame was built for maximum protection of the camera and lights and provided minimal snag points of underwater hazards.

A net target was chosen for investigation and the survey vessel was stationed directly over the target and the vessel was allowed to drift in the wind and current, while keeping track of the drift on the navigation program. Once the drift expected vessel pattern was plotted, a primary anchor was set approximately 490 feet (150 meters) up current and about 165 feet (50 meters) to starboard of the net target. The boat was then allowed to drift back over the target, the vessel motored out to the port 325 feet (100 meters), and a secondary anchor was set. The vessel again was allowed to settle back onto the target. Positioning the anchors in this way allowed for control over the X and Y position of the vessel relative to the net target. The drop camera was then lowered to the seafloor to image the target. The anchor lines were taken in or let out to maneuver the vessel and camera over the target while keeping track of the search pattern with the Nobletec® navigation program.

The video footage was examined in detail during post-survey processing. Video images were edited to choose items of interest, including rockfish, rockfish habitat and derelict fishing gear. The locations of derelict nets found during the drop camera survey that were not identified in the sidescan sonar survey images were marked on the navigation program and entered into the final list of derelict nets identified. When a derelict net was observed during post-survey processing, the real-time geographic coordinates from the GeoStamp+® system were displayed in the top left corner of the video image allowing precise

location of the derelict net for comparison to the locations from the sidescan sonar system. In general, the vessel was maneuvered using the two-point anchor system in an attempt to document video images of the entire derelict net. However, in some cases time and changing weather and sea conditions did not allow complete documentation of all derelict nets encountered.

Results

During the two days of sidescan survey, 31 targets judged to be derelict nets or lines were identified along the survey length covering 20.75 nautical miles (38.44 km) of deepwater rockfish habitat (Exhibit 1). A total of 13 net targets (nine sidescan sonar targets and four other reported targets) were investigated during the six days of drop camera surveys, of which 11 targets were identified as derelict net or line and two were not found. The nine targets found with sidescan sonar surveys were all found with the drop camera and proved to be leadline, net or purse seine rope. Video footage of net and rockfish habitat was recorded at an additional two target locations from previous derelict gear surveys. Two targets investigated but not found during the drop camera survey were identified from previous camera surveys and dive removals for derelict nets. Drop camera surveys recorded images of nets, rockfish habitat, rockfish and other organisms over a total length of 3.84 nm (7.11 km) and identified 55 additional derelict nets in close proximity to the original sidescan sonar targets. Twenty-two of the sidescan targets were not investigated (Exhibits 2, 3 and 4).

Drop camera survey efforts on October 27, 2010, focused on a net location beyond 105 feet deep, reported during previous derelict net removal operations (Gear ID: 9145 in DG database). No net or line was found at this location, however, the drop camera survey identified an extensive amount of prime rockfish habitat, such as steep rock structures with intermittent valleys and caverns. Rockfish, Sebastes sp. were observed at this location, as well as other fish species such as lingcod, *Ophiodon elongates*, and kelp greenling, *Hexagrammos decagrammus*. This survey covered 1.185 linear nautical miles (nm) and 0.00234 nm^2 (Exhibit 4, Appendix A, Figure 1).

Drop camera survey efforts on October 28, 2010, focused on two derelict net target locations, reported during previous derelict net removal operations (Gear ID: 6826 and 6827 in DG database). Both net and lead line were found at these locations. The net was tubed up and wrapped around the face of a rock pinnacle and stretched across a flat area at the base of the structure. The camera survey also identified an extensive amount of prime rockfish habitat, such as steep rock structures with intermittent valleys and caverns. This survey covered 0.193 linear nm and 0.000381 nm^2 (Exhibit 4, Appendix A, Figure 2).

Drop camera survey efforts on October 29, 2010, focused on a net target location reported during previous derelict net removal operations (Gear ID: 6900 in DG database). No net or line was found at this location, however, the camera survey identified an extensive amount of prime rockfish habitat such as steep rock structures with intermittent valleys and caverns. Rockfish were observed at this location, as well as other species such as lingcod and kelp greenling. The survey covered 0.351 linear nm and 0.000462 nm^2 (Exhibit 4, Appendix A, Figure 3).

Drop camera survey efforts on November 10, 2010, focused on five derelict net target locations located during sidescan sonar surveys conducted during the study (Gear ID: DW4, DW15, DW9, DW2 and DW14 in the DG database). Lead line was found at all 5 locations. Eight other derelict gear targets (lead lines) were also identified with the drop camera in this area. While only lead line was captured on video,

it is very likely that the web is buried under the sand. Depending on sea state conditions and the season, this web may be exposed during part of the year, similar to observations of other derelict nets during dive removals on nearby Salmon Bank. This area had a sandy bottom with boulders ranging in size from 1.5 to 6.5 feet (0.5 to 2 meters) and ranging in height to 3 feet (1 meter). The total drop camera survey coverage was 0.860 linear nm and 0.001698 nm^2 (Exhibit 4, Appendix A, Figures 4, 5 and 6).

Drop camera survey efforts on November 10, 2010, focused on four derelict net target locations, located during sidescan survey (Gear ID: DW16, DW18, DW31 and DW 30 in DG database). Lead line was found at the first three of these areas. These areas had a sandy bottom with boulders ranging in size from 1.5 to 6.5 feet (0.5 to 2 meters) and ranging in height to 3 feet (1 meter). While only lead line was captured on video, it is very likely that the web is buried under the sand. Depending on sea state conditions and the season, this web may be exposed during part of the year. While surveying for DW30 an increase in current made it impossible to effectively cover the area. The total coverage was 0.699 nm and 0.001381 nm^2 (Exhibit 4, Appendix A, Figures 7, 8 and 9).

Drop camera survey efforts on November 28, 2010, focused on a derelict net target location, located during the sidescan sonar survey (Gear ID: DW 30 in DG database). Lead line and net were found at this location. In addition, 26 other nets were observed and recorded during the drop camera surveys that were not seen in the sidescan sonar images. The majority of these additional derelict nets were hung up on ridges in the rock and draped down through the valleys, in some places causing suspensions of the net above the seabed. The camera survey also identified an extensive amount of prime rockfish habitat, such as steep rock structures with intermittent valleys and caverns. Lingcod and rockfish were found in close proximity to the derelict nets although no fish were observed entangled in the nets. The survey covered 0.556 nm and 0.001098 nm^2 (Exhibit 4, Appendix A, Figures 10 and 11). Video and still photos from the drop camera surveys are available on DVD.

Conclusions

This study proved the feasibility of locating derelict nets in deepwater with sidescan sonar and ground truthing images, habitat and associated marine fauna with a drop camera. A total of 31 probable derelict fishing gear targets were identified over 20.75 nm of linear deepwater coastline surveyed during the project for a target density of 1.5 targets per nautical mile or 0.8 targets per kilometer. Of the 31 DG targets imaged with sidescan, nine were investigated during the drop camera survey and all proved to be either derelict gillnet, lead line or purse seine rope. However, 26 additional derelict nets or lead line not observed by sidescan sonar were found at one of the nine locations indicating sidescan sonar detection of derelict nets was difficult in areas with steep, hard bottom substrate. The nearly vertical hard bottom substrate reflected nearly all of the acoustic energy from the sidescan sonar and masked the patterns in the image characteristic of derelict nets (Exhibit 5). The study also demonstrated that cracks and crevices in vertical rock walls may look like derelict nets or lines on sidescan sonar images. Sidescan sonar surveys are capable of cost effectively surveying large amounts of seabed habitat for derelict fishing gear but some derelict gear may not be detected on steep hard bottom substrate. ROV video surveys may be more appropriate for these hard bottom areas that can be located during the sidescan sonar surveys.

Video imaging provided the opportunity to characterize the habitat, observe rockfish behavior near nets, and assess the feasibility of net removal. Exhibit 6 provides an example of typical image of a quillback rockfish, *Sebastes maliger*. The camera surveys proved that sidescan sonar surveys were capable of

imaging and distinguishing deepwater rockfish habitat as well as derelict fishing gear. Exhibit 7 provides an example of a drop camera image of derelict leadline and scraps of net on a deepwater reef face. Sidescan sonar surveys also proved capable of imaging schools of fish, assumed to be rockfish, congregated at the edge of vertical rock walls (Exhibit 5). Although no rockfish were observed entangled in the derelict net observed during the study, rockfish were observed in the vicinity (300 feet or 100 meters) of the nets at five of the nine target derelict net locations and at two of the target derelict net locations (DG #s 6826/6827 and DW 30), the suspended derelict nets (gillnets) presented a significant risk of entanglement to rockfish and other marine animals.

After conducting these surveys using the drop camera technique, we believe ground truthing surveys would be improved by the use of an observational ROV. The use of an ROV would dramatically increase productivity, as an ROV can easily image more than a hundred times the same amount of area as a drop camera over a given period of time. An ROV can drive the length of a net at speeds of 1.5 to 2 knots imaging the net while plotting its position onboard the vessel in real time. The ROV has the ability to change its cameras aspect or attitude to view a rock face or see under a ledge where the rockfish are likely to be, whereas a drop camera cannot. Also, an ROV equipped with a scanning sonar could image and navigate through high relief habitat over 100 feet (30 meters) ahead while simultaneously viewing suspended nets and schooling fish. In addition, anchoring on or near a rock face or shear 300 feet (100 meter) wall is impractical for a drop camera survey since the vessel must be anchored directly over the survey area. However, for ROV operations the vessel can be anchored 150 to 250 feet (50-75 meters) away while efficiently surveying the entire study area. Hence, an ROV would be better suited than a drop camera for surveying the sheer rock walls that are associated with rockfish habitat and probable derelict net locations.

Sufficient information on the length, width and configuration of the derelict fishing gear in the habitat was gained during the drop camera survey to prepare a derelict gear removal plan. Although a specific protocol for removal of deepwater derelict nets has yet to be developed and is beyond the scope of this study, the derelict fishing gear encountered during the survey appeared to be capable of removal by one or more ROVs.

Exhibit 1: Sidescan sonar survey track lines, area covered and derelict fishing gear targets identified, 2010.

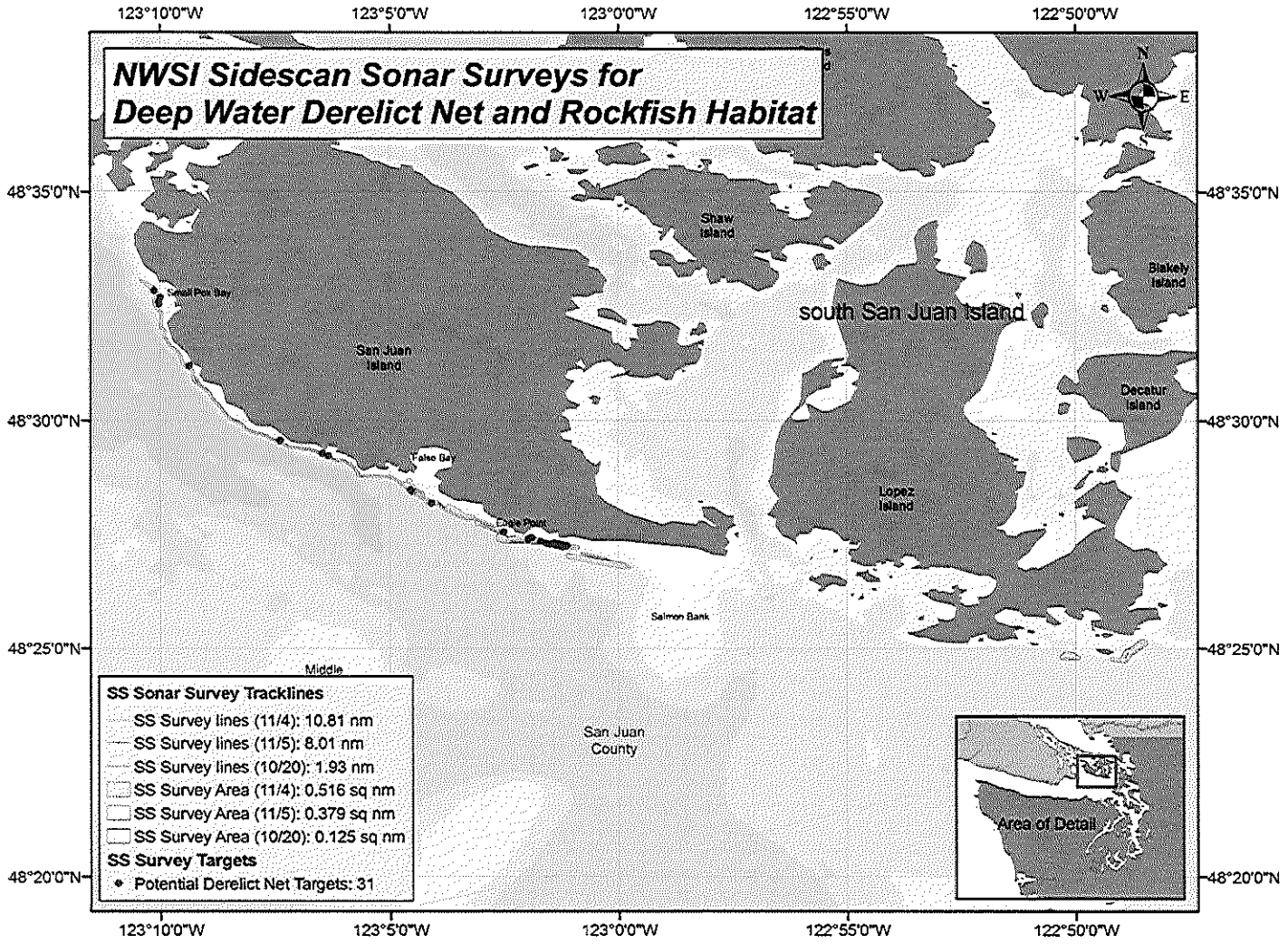


Exhibit 2: Locations and track lines of drop camera surveys of derelict fishing gear targets conducted, 2010.

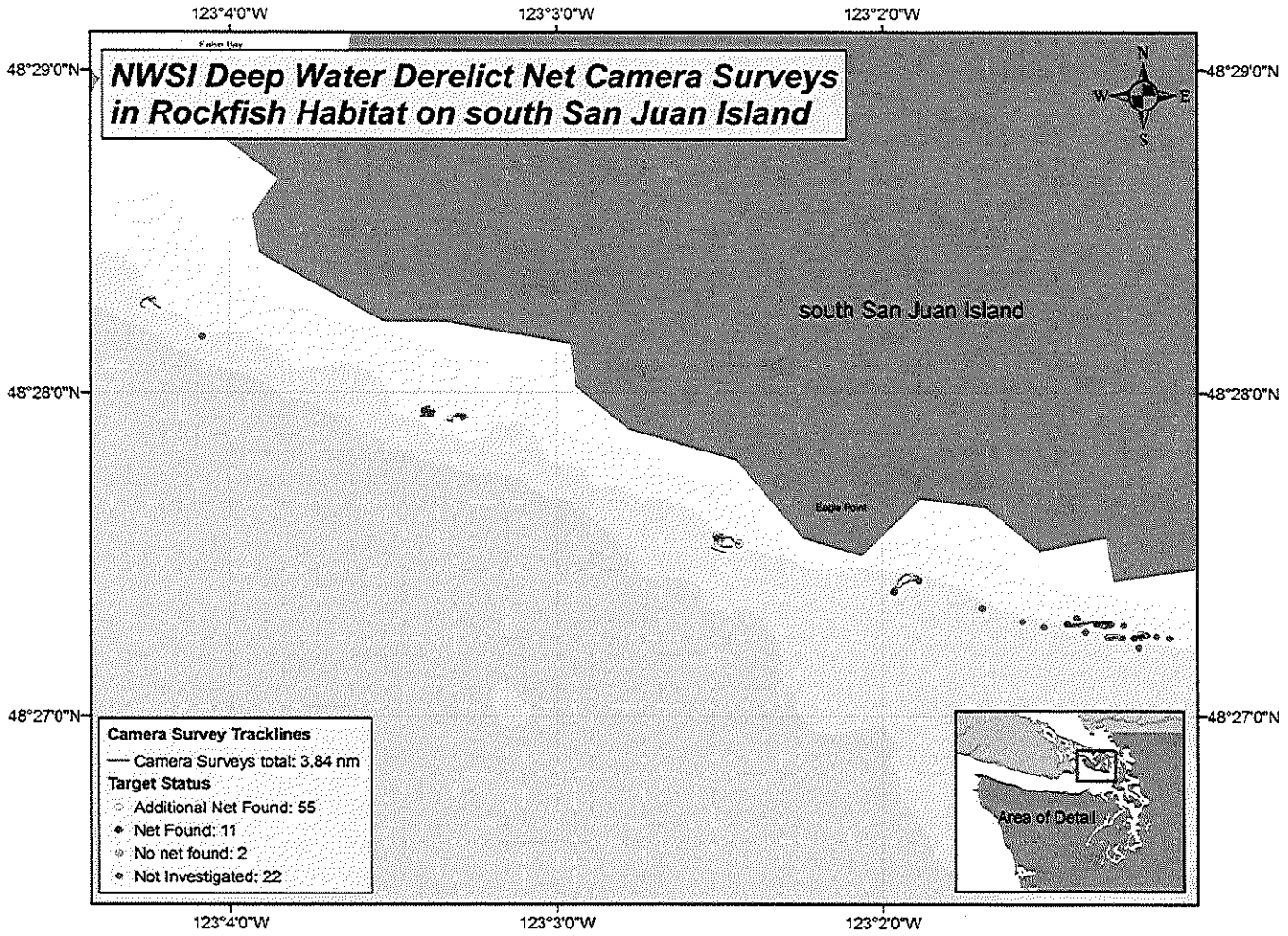


Exhibit 3: Derelict fishing gear target status (found, not found, not investigated) after completion of the drop camera survey, 2010.

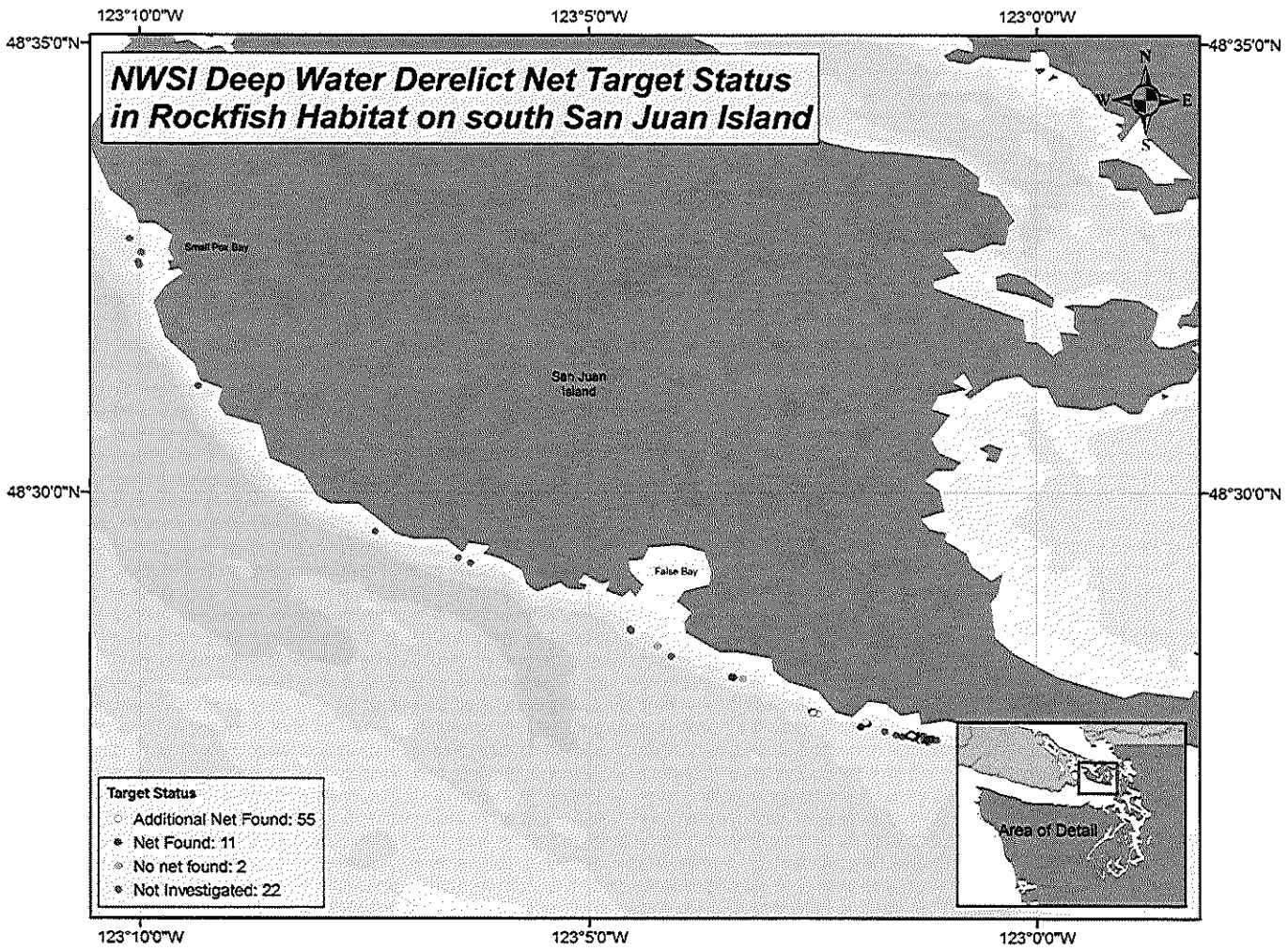


Exhibit 4. Characteristics of the derelict targets investigated during drop camera survey, 2010.

Target ID	Gear Type	Min Depth (ft)	Max Depth (ft)	Investigation Status	Location	Latitide	Longitude	Date of Drop Camera Investigation	Additional Targets Found	Habitat type	Rockfish Habitat	Rockfish Present	Rockfish Risk	Comments
dw2	Gillnet	112	130	Net Found	Eagle Point	48 27.250	123 01.189	11/10/10	6	Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw4	Gillnet	121	126	Net Found	False Bay	48 27.284	123 01.321	11/10/10	8	Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw9	Gillnet	118	128	Net Found	Eagle Point	48 27.242	123 01.301	11/10/10	9	Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw14	Gillnet	114	127	Net Found	Eagle Point	48 27.241	123 01.227	11/10/10		Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw15	Gillnet	117	130	Net Found	Eagle Point	48 27.284	123 01.341	11/10/10		Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw16	Gillnet	111	127	Net Found	Eagle Point	48 27.284	123 01.432	11/12/10	5	Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw18	Gillnet	113	124	Net Found	Eagle Point	48 27.419	123 01.886	11/12/10	1	Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
dw30	Gillnet	115	220	Net Found	Eagle Point	48 27.550	123 02.500	11/28/10	26	Large Rock Structure with sand/shell base	Yes	Yes	High	Rockfish, lingcod, kelp greenling, Puget Sound king crab, red sea urchins, sea cucumbers
dw31	Gillnet	118	128	Net Found	Eagle Point	48 27.382	123 01.962	11/12/10		Sand Bottom with boulders	Nearby	No	Low/Mod	Only lead lines observed by net may be buried in sand
6826	Gillnet	115	126	Net Found	False Bay	48 27.936	123 03.383	10/28/10		Sand/shells at base of rock structure	Yes	No	High	Rockfish within 100 meters, but not at net
6827	Gillnet	115	127	Net Found	False Bay	48 27.942	123 03.403	10/28/10		Sand/shells at base of rock structure	Yes	No	High	Rockfish within 100 meters, but not at net
9145	Gillnet	112	130	No net found	False Bay	48 27.925	123 03.285	10/27/10		Rock Pinnacle with vertical walls	Yes	Yes	N/A	Rockfish, Puget Sound king crab
6900	Gillnet	120	300	No net found	False Bay	48 28.288	123 04.235	10/29/10		Rock Pinnacle with valleys	Yes	Yes	N/A	Rockfish, lingcod, kelp greenling

Exhibit 5. Sidescan sonar image showing rockfish habitat, derelict nets and fish aggregations, 2010.

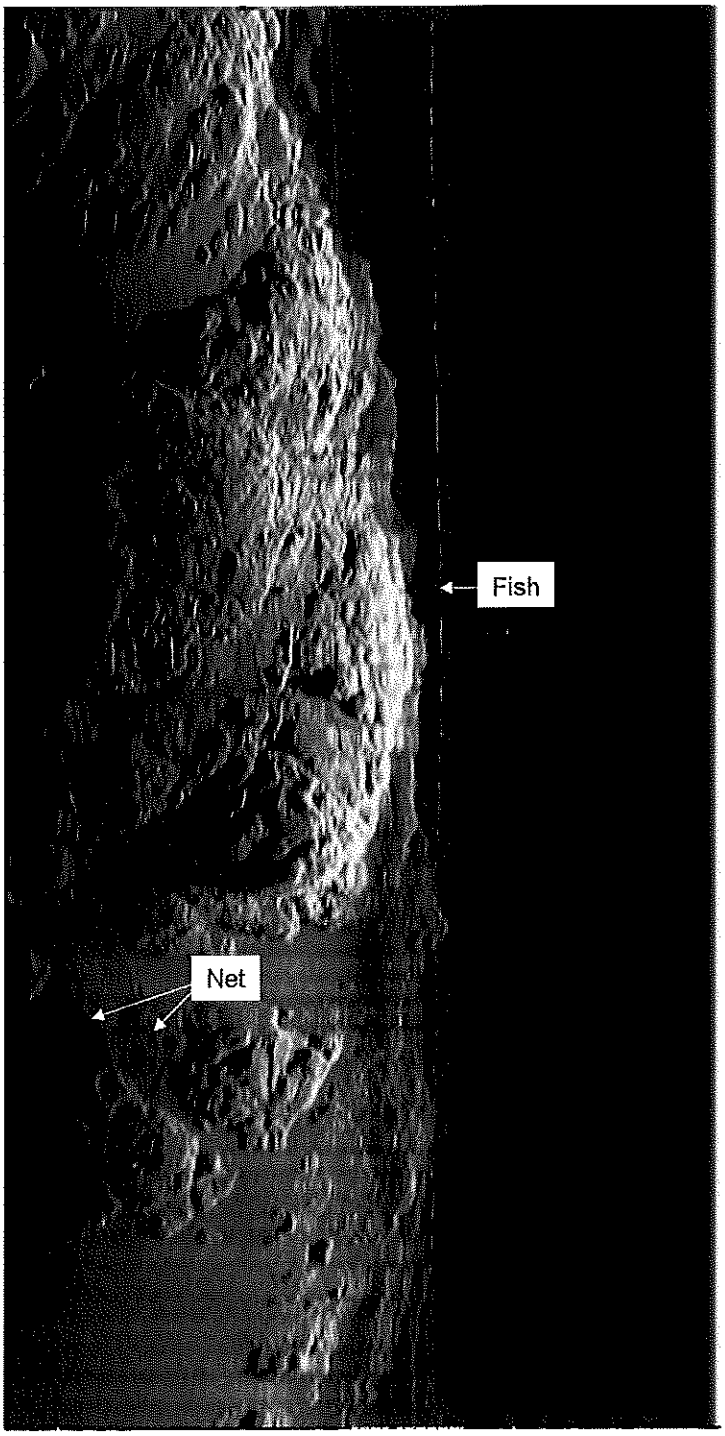


Exhibit 6. An example of a typical image of a rockfish taken in deepwater with a drop camera during the project. The image shows a quillback rockfish, *Sebastes maliger*, on a reef face at 120 feet (36 meters) off the west coastline of San Juan Island.

Exhibit 7. An example of a typical image of derelict gillnet leadline and net scraps taken in deepwater with a drop camera during the project on a reef face at 120 feet (36 meters) off the west coastline of San Juan Island.

APPENDIX A:

Screen shots of Nobeltec® navigation software track lines collected during drop camera surveys

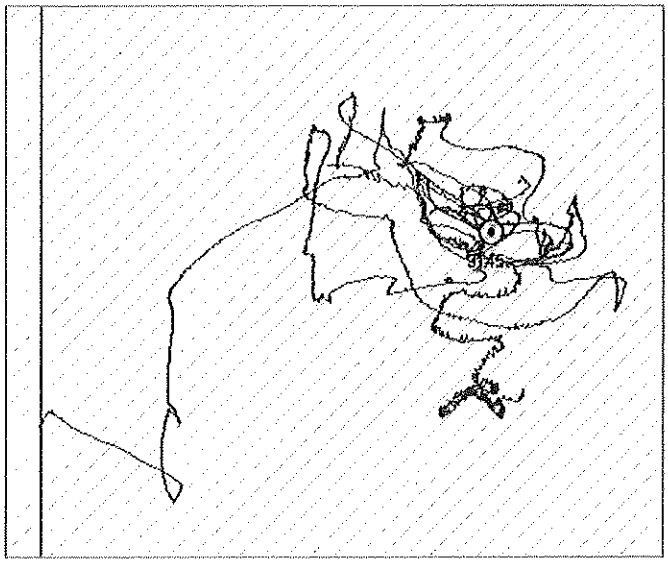


Figure 1: Date: 10/27/2010 Target: 9145

Total track line length: 1.185 nm (7,200 ft.)
Area surveyed: 0.00234 nm^2 (86,000 ft^2)

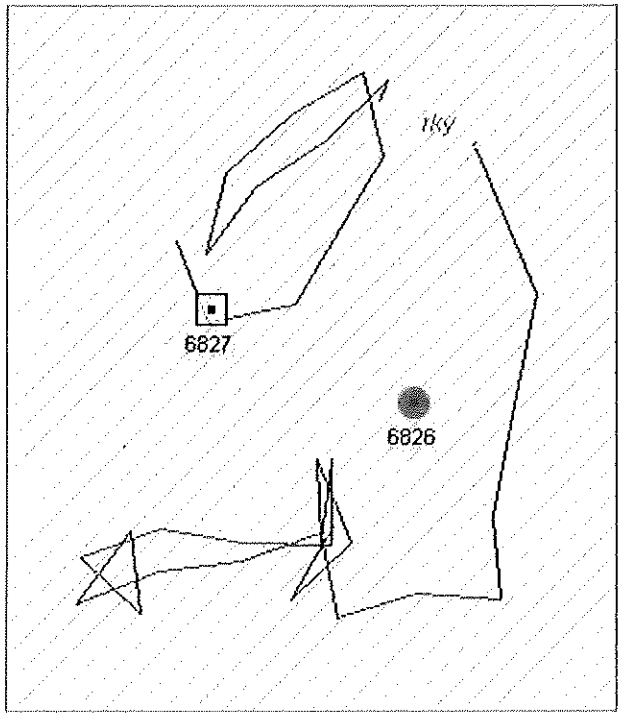


Figure 2: Date: 10/28/2010 Targets: 6826 & 6827

Total track line length= 0.193 nm (1,173 ft.)
Area surveyed: 0.000381 nm^2 (14,072 ft^2)

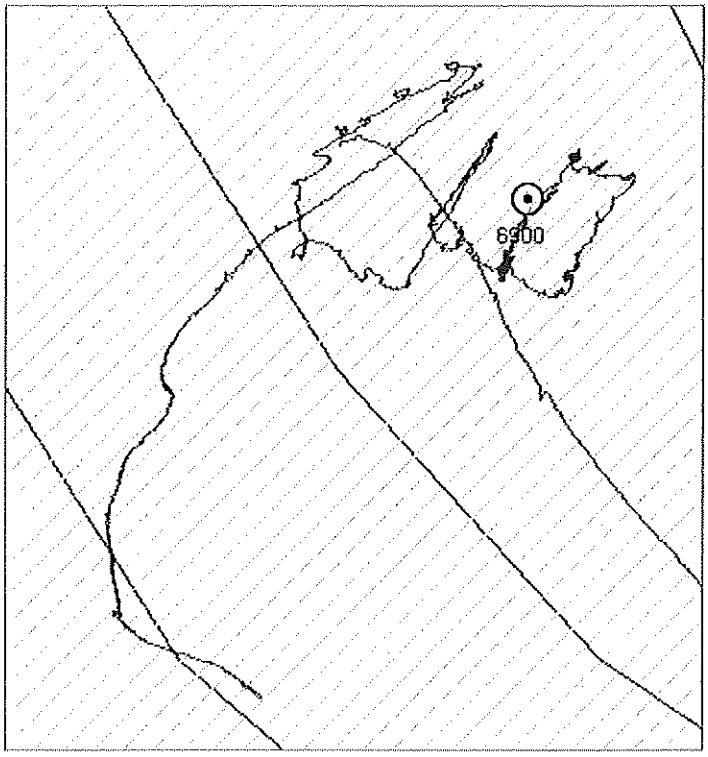


Figure 3: Date: 10/29/10 Target: 6900

Total track line length: 0.351 nm (2,133 ft.)
Area surveyed: 0.000462 nm^2 (17,061 ft^2)

Figure 4: Date: 11/10/10 Targets: DW4 & DW15.

Track line length: 0.311 nm (1,890 ft.)
Area surveyed: 0.000614 nm^2 (22,676 ft^2)

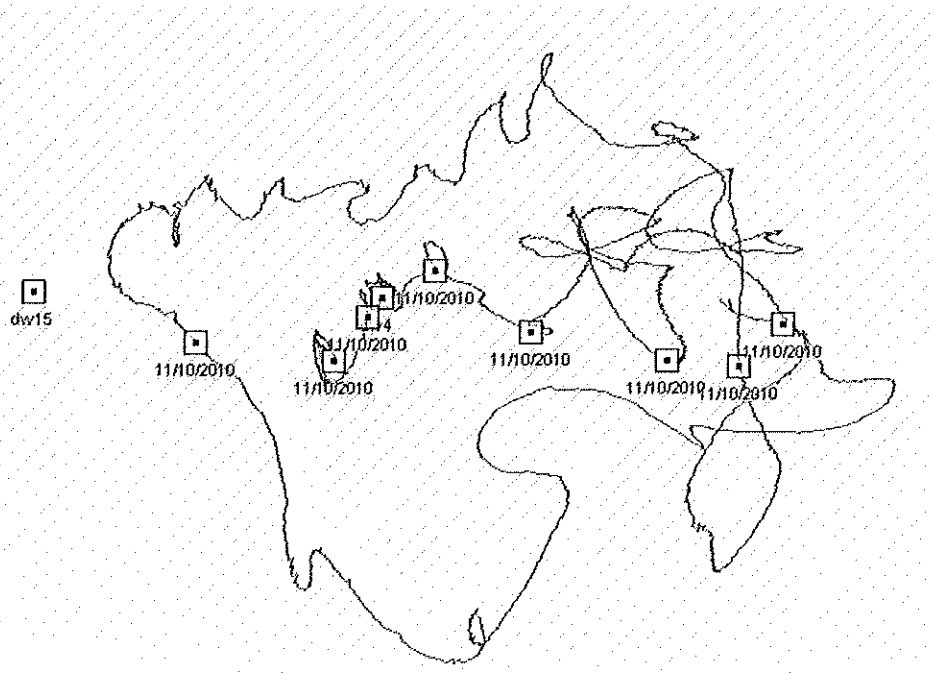


Figure 5: Date: 11/10/10 Target: DW9.

Track line length: 0.406 nm (2,467 ft.)
Area surveyed: 0.000802 nm^2 (29,602 ft^2)

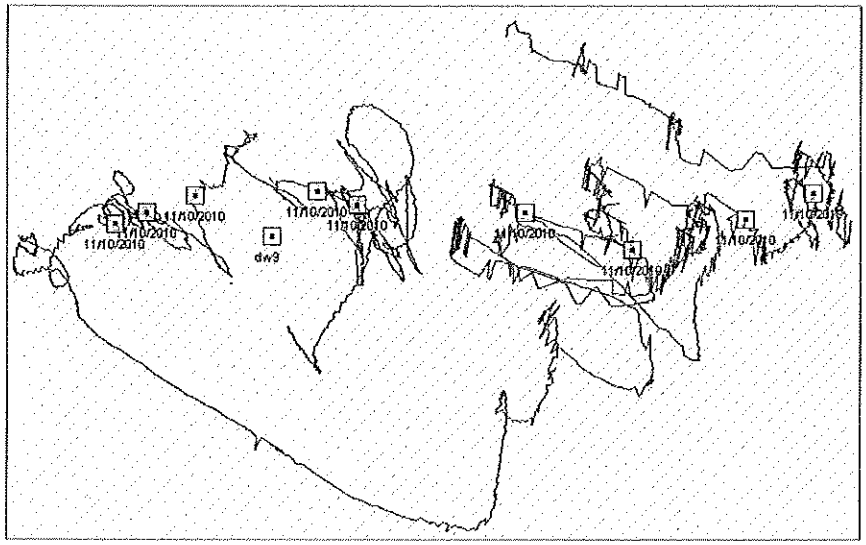


Figure 6: Date: 11/10/10 Targets: DW2 and DW14.

Track line length = 0.143 nm (870 ft.)
Area surveyed: 0.000282 nm^2 (10,426 ft^2)

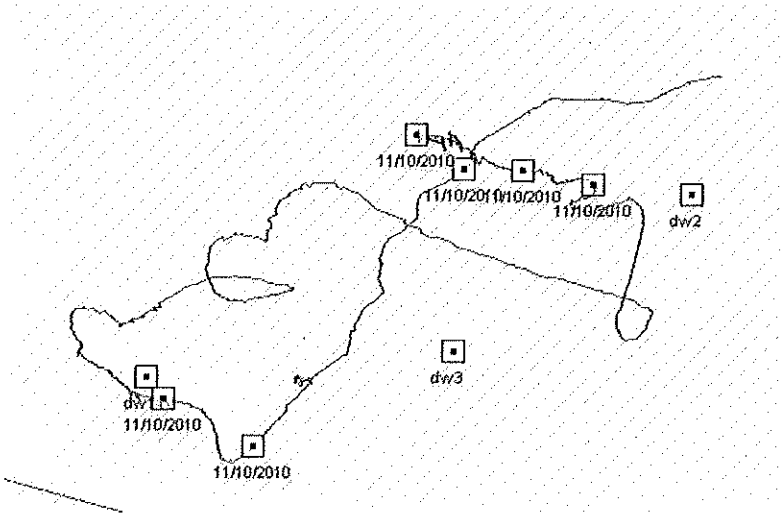
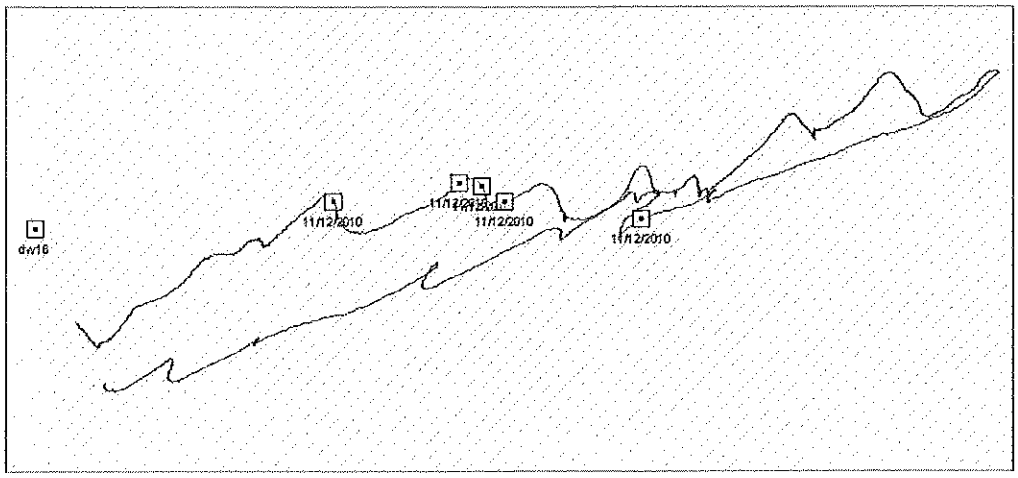


Figure 7: Date: 11/12/10 Target: DW16.

Track line length = 0.193 nm (1,173 ft.)
Area surveyed: 0.000381 nm^2 (14,072 ft^2)



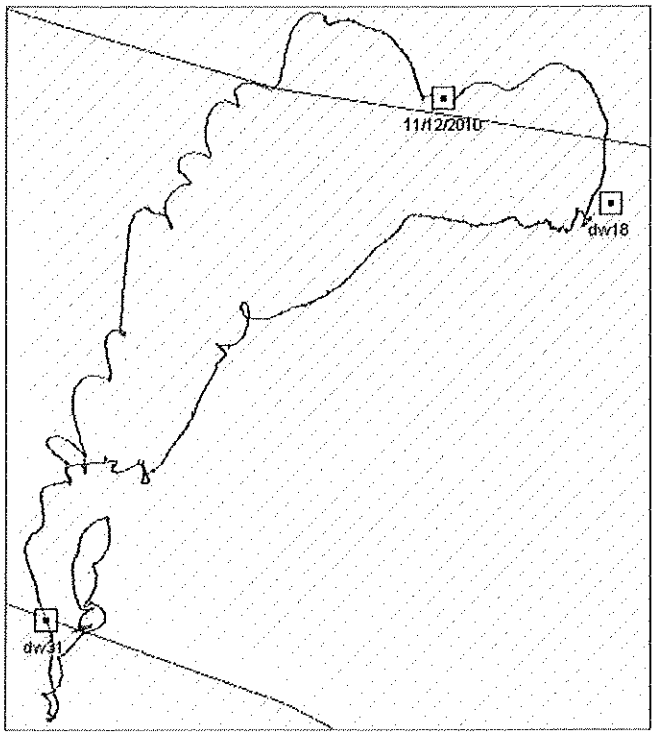


Figure 8: Date: 11/12/10 Targets: DW18 & DW31

Track line length: 0.378 nm (2,297 ft.)
Area surveyed: 0.000747 nm^2 (27,561 ft^2)

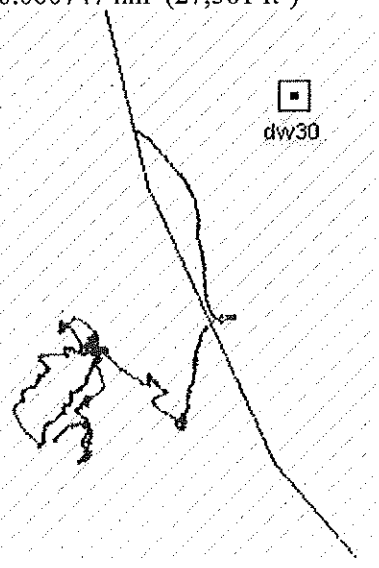


Figure 9: Date: 11/12/10 Target: DW30

Track line length: 0.128 nm (778 ft.)
Area surveyed: 0.000253 nm^2 (9,333 ft^2)

Figure 10: Date: 11/28/10 Target: DW30

Track line length: 0.556 nm (3,378 ft.)
Area surveyed: 0.001098 nm^2 (40,539) ft^2

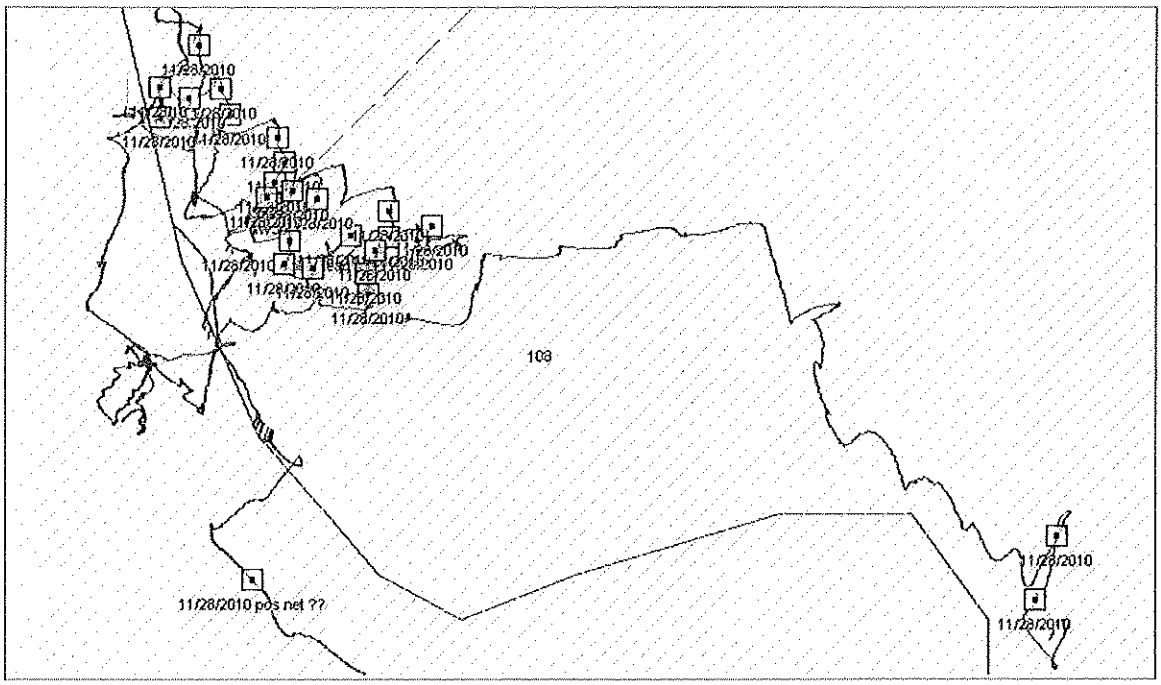


Figure 11: Close-up of additional derelict gear targets identified with the drop camera at DW30.