NATURAL RESOURCES

REMOTELY OPERATED VEHICLE (ROV) VIDEO INVESTIGATION OF TWO LARGE SEAFLOOR MOUNDS IN SOUTHERN HOOD CANAL, WASHINGTON

by Recep Cakir, Robert L. Logan, Chris N. Johnson, Timothy J. Walsh, Todd Palzer, Robert E. Pacunski, James Beam, and Lisa Hillier

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Washington Department of FISH and WILDLIFE

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

Photo: Washington Department of Fish and Wildlife vessel 12 m [40 ft] *R/V Molluscan*.

Cover photos:
(left photo) Todd Palzer, Recep Cakir, Josh Logan, James Beam, Chris Johnson, Bob Pacunski, and Lisa Hillier, and
(right photo) remotely operated vehicle (ROV), a Saab-Seaeye Falcon.

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Attachment

ESRI shapefiles showing tracklines of the ROV and video observation points.

Remotely Operated Vehicle (ROV) Video Investigation of Two Large Seafloor Mounds in Southern Hood Canal, Washington

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NONTECHNICAL SUMMARY

Dome-shaped seafloor features have been noted near Dewatto Bay in southern Hood Canal, Washington. The Washington State Department of Natural Resources (WADNR) and the Washington State Department of Fish and Wildlife (WDFW) conducted a joint survey of these domes to determine their origin, previously thought to be drumlins. We made direct visual observations of these features using a remotely operated vehicle (ROV) operated from a small boat navigated by the WDFW crew.

The video observations revealed that these dome-shaped features are not related to any substrate gas-seep or thermal-venting activities. The shapes and sizes of these features are not consistent with those of drumlins as suggested earlier. The consensus was that the mounds are likely landslide deposits.

This pilot interagency joint effort showed that investigating and mapping seafloor geological hazards and geomorphologic conditions leads to better understanding of the seafloor environment and its relation with habitat both in water and on land. This joint venture, while focused on geologic features in Hood Canal, proved to be quite informative to the WDFW biologists who participated. Specifically, video documentation of several species of rockfish was obtained from an area that cannot be easily assessed by traditional WDFW assessment methods. This anecdotal information has provided WDFW marine fish scientists with valuable insight into the spatial distribution and habitat use by rockfish in Hood Canal that will be used to design future rockfish assessment surveys.

INTRODUCTION

Chien-Hom (2007) and Mark Holmes (Univ. of Wash., oral and written commun., 2008) reported dome-shaped seafloor features in Hood Canal and concluded that they were probably drumlins. On September 9, 2008, the Division of Geology and Earth Resources (DGER) and Division of Aquatic Resources (DAR) of the Washington State Department of Natural Resources (WADNR) and the Washington State Department of Fish and Wildlife (WDFW) conducted an investigation of these features—two topographic mounds in southern Hood Canal, west of Dewatto Bay and Little Dewatto Bay. Using a small, remotely operated (submersible) vehicle (ROV), a Saab-Seaeye Falcon equipped with a high-resolution video camera, we observed and characterized sediments exposed on the surface of the mounds. The following is a brief overview of the bathymetric and geologic setting of these mounds, including a description of sediments based on the ROV video observations.

[4] Robert 'Josh' Logan is now retired, and Chris Johnson is currently with the Washington Department of Ecology.

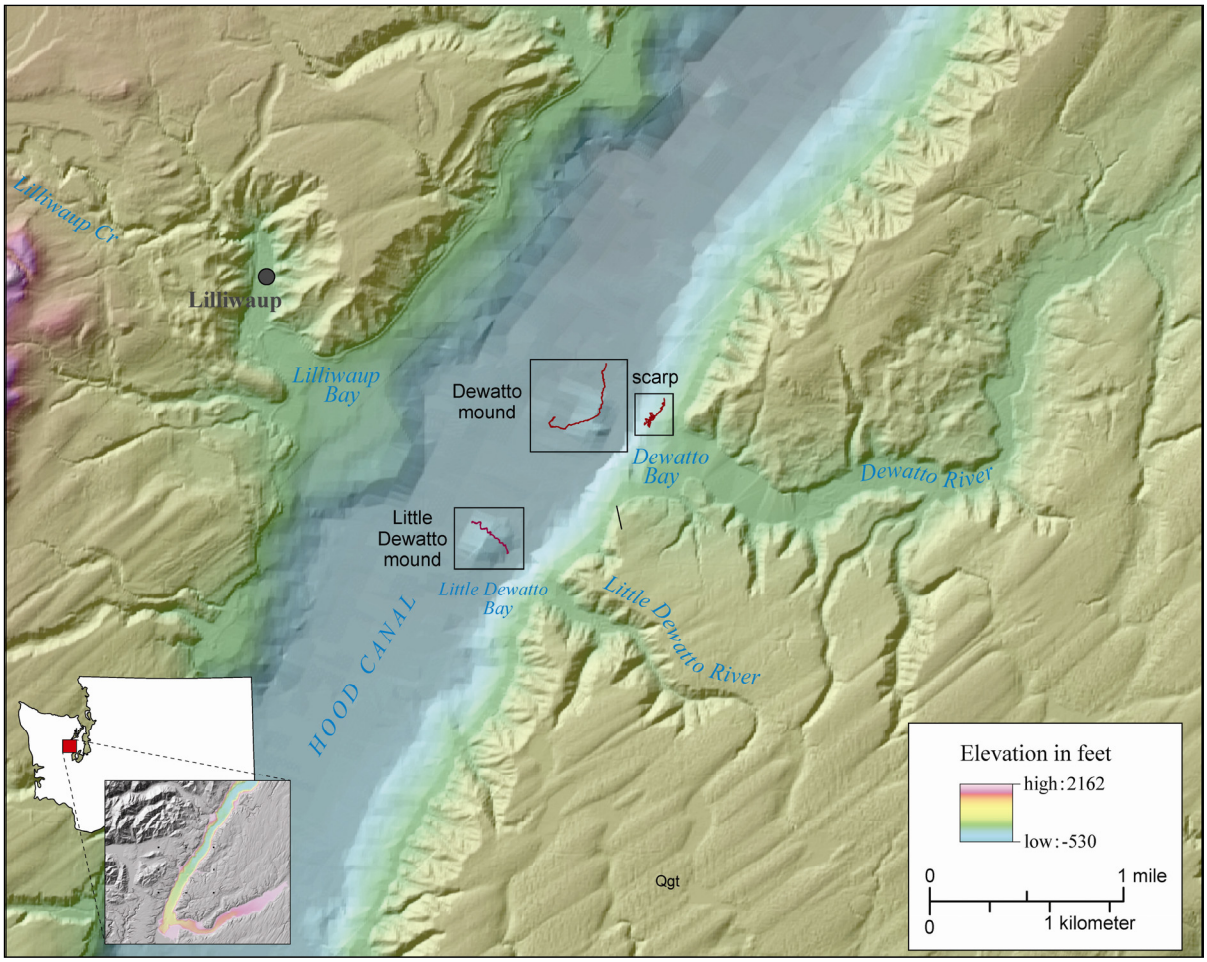

Figure 1a. Two topographic mounds in southern Hood Canal west of Dewatto Bay and Little Dewatto Bay, and a small scarp area oriented northeast to southwest between Little Dewatto Bay and Dewatto Bay. Red lines inside the boxes show the track-lines where the ROV's video observations were made. Lidar image shows on-land topography and color-ramp shows on-land elevation and bathymetry of Hood Canal (Finlayson, 2005).

LOCATION AND SETTING

Both mounds are located along the eastern side of Hood Canal within 1.6 km (1 mi) of each other (Figs. 1a and 1b). According to Chien-Hom (2007), the mounds are approximately 35 to 40 m (115–130 ft) in height and 350 to 450 m (1150–1475 ft) in width. Each mound is situated at the mouth of a drainage that discharges toward the west to the east shore of Hood Canal. The north mound is at the mouth Dewatto Bay, and the south mound is at the mouth of Little Dewatto Bay.

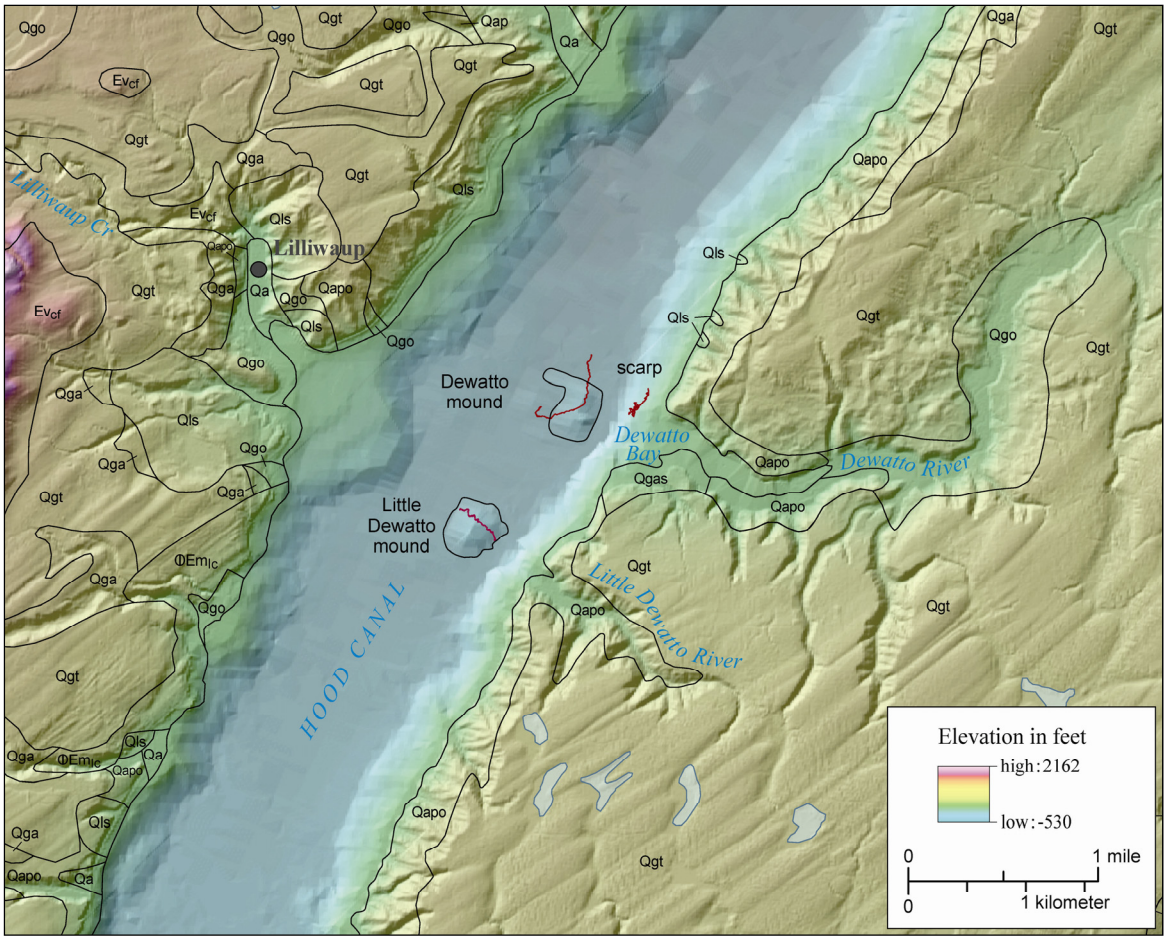

Figure 1b. The DGER 1:100,000-scale geologic map as an overlay on a lidar image. Red lines show the ROV track; the mounds are outlined in black. Both the Dewatto and Little Dewatto mounds appear to be erosional remnants of large landslide blocks of semi-consolidated glacial outwash and (or) glacial deltaic sediments (unit Qapo, pre-Fraser alpine glacial outwash). Lithostratigraphic units exposed onshore include Qa (Quaternary alluvium), Qls (Quaternary mass-wasting deposits, mostly landslides), Qgo (Fraser recessional continental glacial outwash sand), Qgt (Fraser continental glacial till), Qga (Vashon advance continental glacial outwash), Qgas (Vashon advance continental glacial outwash sand), Qap (pre-Fraser alpine glacial drift), and Ev_{cf} (Eocene basalt flows and flow breccias of the Crescent Formation). This geologic map was taken from the Washington State Geologic Information Portal at http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/geology_portal.aspx. Elevation is shown as a color ramp; bathymetry is from Finlayson (2005).

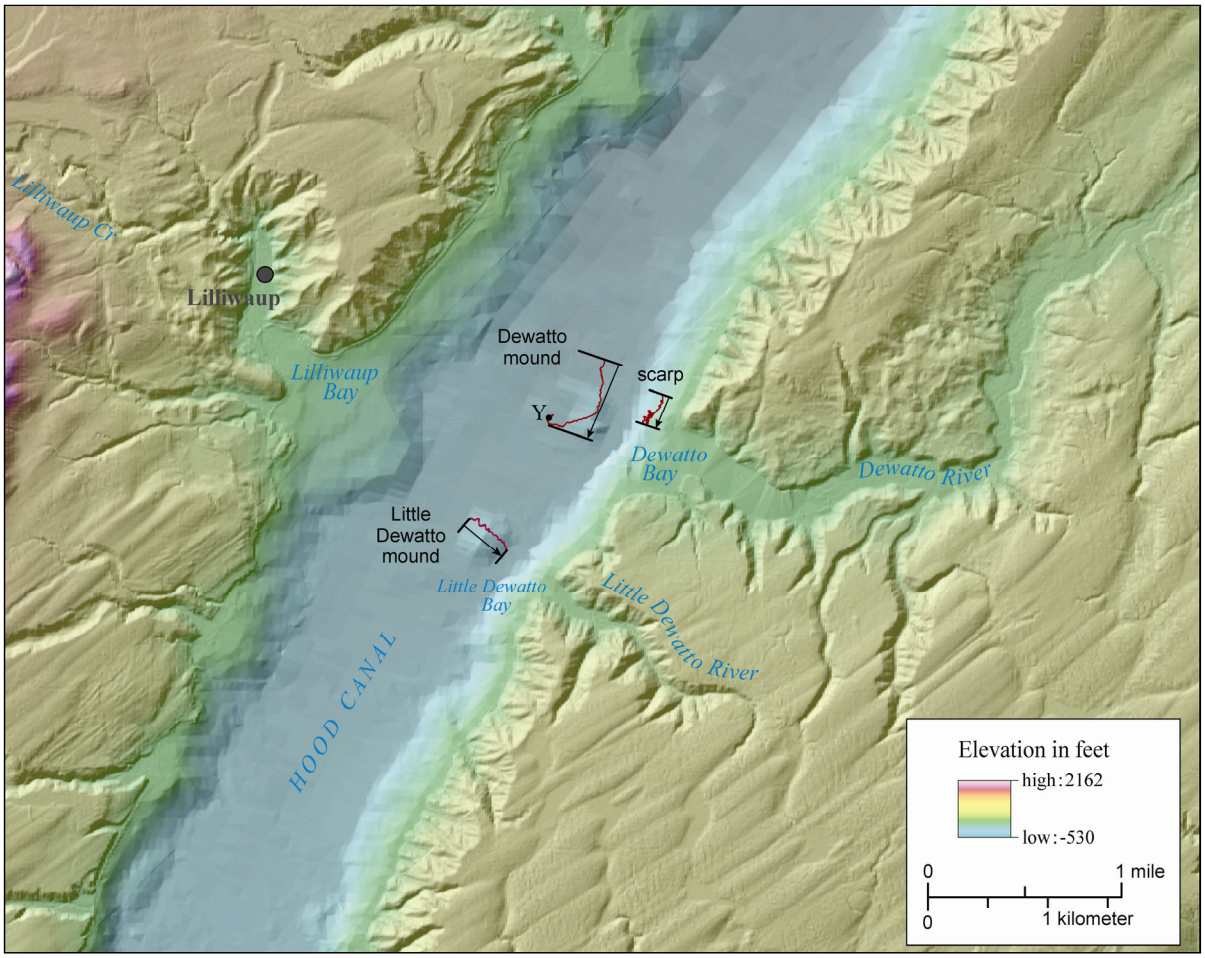

Figure 2. ROV tracklines traversing the Little Dewatto mound, Dewatto mound, and a scarp area parallel to the shoreline near Dewatto Bay. Arrows show the direction of ROV operation for each site. Y is the location of grab sampling by Chien-Hom (2007). Bathymetry (Finlayson, 2005) is shown as a color ramp.

DESCRIPTION OF SURFICIAL SEDIMENTS

Using a video camera mounted onto a remotely operated submersible vehicle (ROV), we observed and characterized sediments exposed on the surface of the mounds (Fig. 2). The ROV was piloted along NW–SE and NE–SW traverses, between 0.25 m (1 ft) and 1 m (3 ft) above the surface of the mound. The first run was from northwest to southeast over the Little Dewatto mound.

Little Dewatto Mound

Surface sediments on the lower flanks of the Little Dewatto mound consist of reddish-brown silt and clay. Accumulations of organic detritus are pervasive. This detritus is made up of fall-out from dead marine organisms descending from the photic zone (Fig. 3a). At the base of the mound, the surface sediment is very fine grained and hosts spot prawn burrows, pinch bug holes, and sea whips. Cobbles and boulders were observed near the top of the mound and on the east side of the mound, respectively; no matrix was visible (inconsistent with gas seep interpretation). At the bottom of the mound are orange-stained, dark-colored boulders similar to nearby Olympic-provenance rocks. Cloud sponges are present on top of the mounds, indicating a solid substrate, as that is what they require for anchoring.

Figure 3a. At the base of the Little Dewatto mound, the surface sediment is very fine grained and hosts spot prawn burrows, pinch bug holes, and sea whips. Time is shown at top right corner of ROV photos. Green beams are from a pair of lasers mounted on top of the video camera to provide a scalar reference (see Appendix B).

Figure 3b. Burrowing anemone (*Pachycerianthus fimbriatus*) on the lower flanks of the Little Dewatto mound.

These fine (soft) sediments are host to benthic marine fauna (epifauna and infauna). Burrowing anemone (*Pachycerianthus fimbriatus*), white sea whips (*Osteocella septentrionalis*), marine worms, ratfish (*Hydrolagus colliei)*, and flatfish species are present. This soft substrate has undergone bioturbation resulting in a pocketed and (or) undulating surface. The surface irregularities of the lower flanks of the mound may also reflect coarse substrate (cobbles and boulders) buried beneath a blanket of fine sediment (Figs. 3a and 3b).

With increasing elevation up the flanks of the mound, fine sediments are replaced by exposures of coarse sand with abundant well-rounded pebbles and cobbles. (Clasts are estimated to be about 1.0 to 10+ cm [0.5–4 in.] in length.)

The distribution patterns of benthic animals are strongly influenced by the firmness, texture, and stability of substrate. For example, sponges require a firm substrate to establish a secure attachment to the sea floor. Note that in Figure 4 a white sponge is attached to a substrate of rounded cobbles.

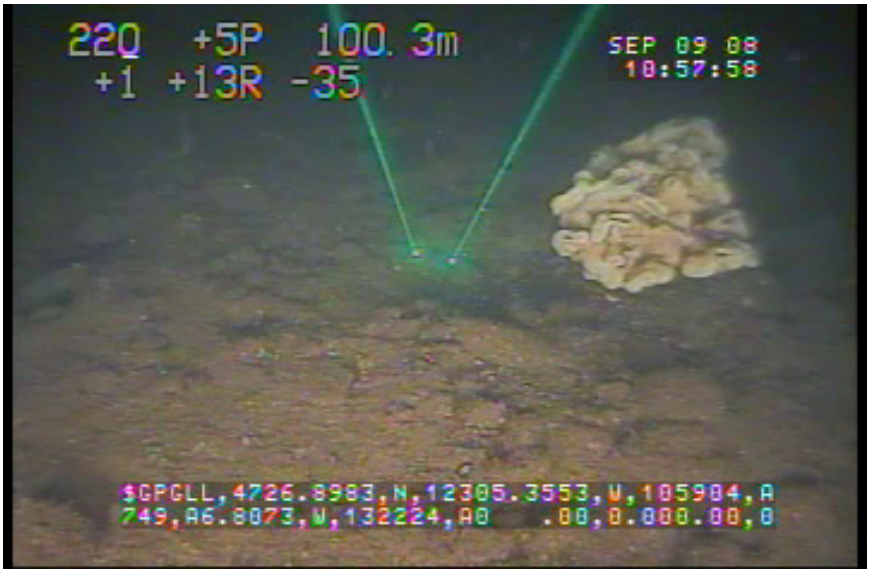

Figure 4. A white sponge is attached to a substrate of rounded cobbles.

Dewatto Mound

The second run was on the Dewatto mound (Fig. 2). The pass was made from the north side of the mound to the center of the mound then westward. The ROV hit the bottom at about 12:30 pm. The bottom consists of soft fine sediment.

Rounded cobbles and boulders make up the north side of the Dewatto mound. Some till with boulders may be present. Some clasts have fissured surfaces much like west-derived sandstone clasts. Many of the cobbles are very dark and probably basalt. Fine sediments with sea whips and burrows are on top of the mound. At about 12:53 pm (time is shown at top right corner in Figs. 3–9), the ROV began the westward traverse. At about 12:56 pm and 119 m (390 ft) depth, it began seeing cobbles again, then more fines and burrows appeared (Fig 5).

Reddish surficial colorations on both fine and coarse sediments are probably derived from red benthic plankton. More fish were observed on the Dewatto mound than on the Little Dewatto mound, possibly due to the greater proportion of cobble substrates encountered on the Dewatto mound transect. Rockfishes observed on the Dewatto mound appeared to be predominantly greenstriped rockfish (*Sebastes elongatus*), along with a few redstripe (*S. proriger*), splitnose (*S. diploplora*), and juvenile quillback rockfish (*S. maliger*). The majority of rockfish observed were on coarser substrates (pebbles and cobbles) and (or) within a field of sea whips. Other fishes observed on the Dewatto mound included gadids (Family Gadidae), ratfish, skates (*Raja spp*.), and flatfish.

At the location used for grab sampling marked as “Y” by Chien-Hom (2007)(Fig. 2), the seafloor shows more fines (Fig. 6) and the bottom has about 2 m of hummocky relief, which is typical of the toe of a landslide.

The rounded clasts on the mound likely originated in a fluvial environment (glacial outwash?). These sand and gravel deposits appear to be semi- to well consolidated and locally sustain steep slope gradients on the east flank of the mound (Fig. 7).

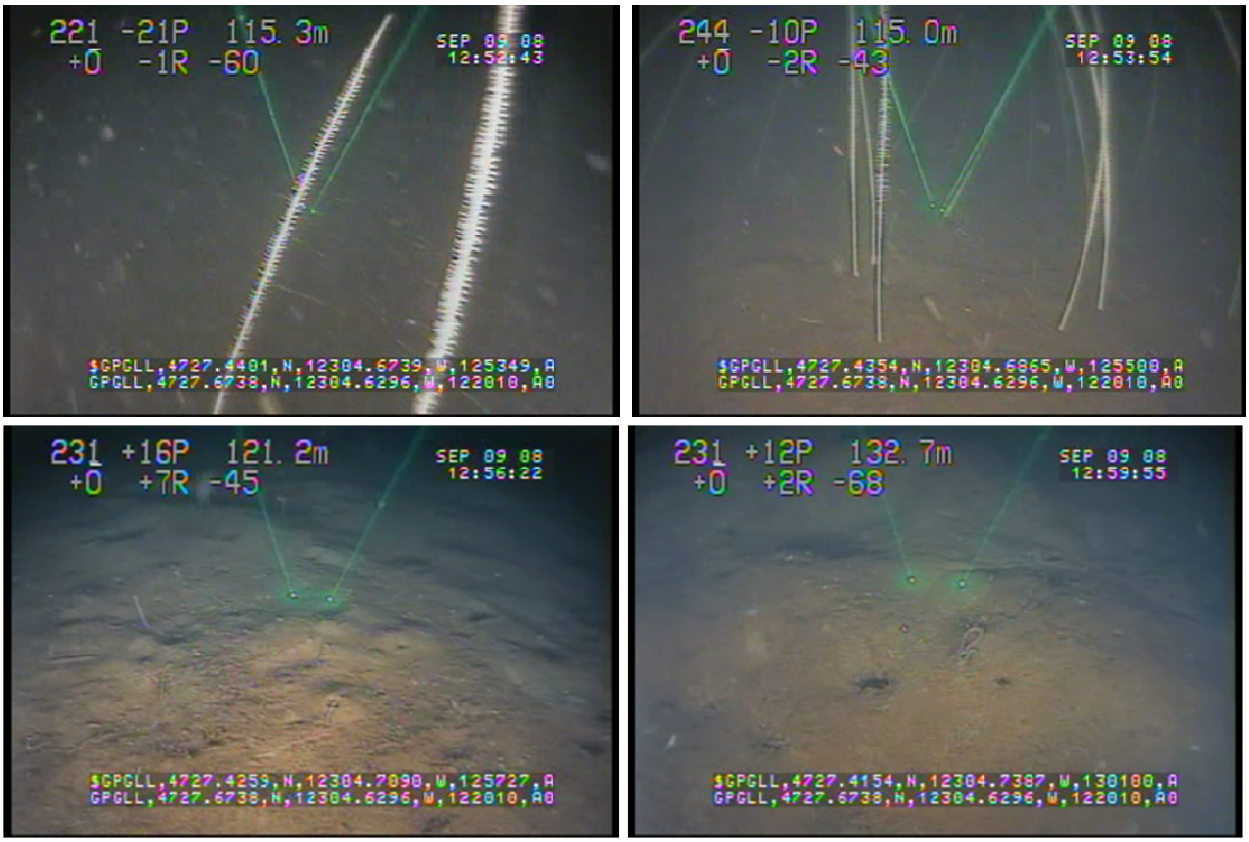

Figure 5. Sea whips and burrows toward top of the Dewatto mound.

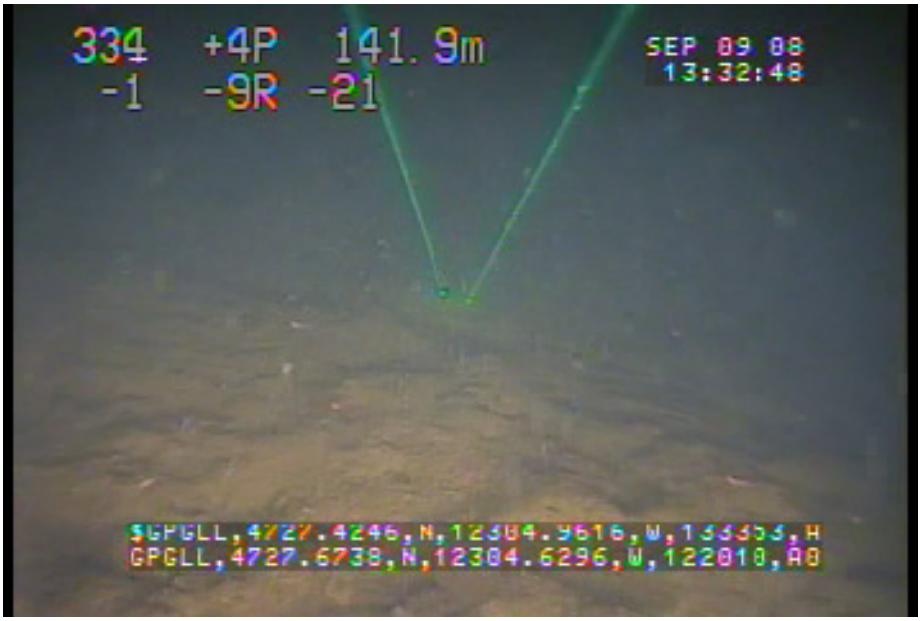

Figure 6. Seafloor shows fines and hummocky environment.

Figure 7. Semi-consolidated, well-rounded sand and gravel deposits observed on the top section of the mounds.

SCARP AT MOUTH OF DEWATTO RIVER

The third run was up the scarp (submarine cliff) at the mouth of the Dewatto River. The ROV hit bottom at 2:42 pm. The scarp wall at 105 m (345 ft) consists of abundant cobbles that appear to be *in situ* (Fig. 8). Till with protruding boulders of unknown lithology was observed at 85 m (279 ft). The ROV went back to the bottom. At 105 m (345 ft), cobbles make up the bottom and are sloped upward as in a scree or talus pile. A 0.5 m (1.5 ft) boulder was observed at 105 m (345 ft). Till was noted at 103 m (338 ft) and at 91 m (299 ft) as indicated by boulders sticking out of the scarp wall. At about 114 to 108 m (374–355 ft), a debris or submarine talus slope began and continued to the bottom of the wall. There were large blocks of till (with protruding boulders) at 83 m (272 ft). Large chunks or blocks of consolidated silt were observed at 78 to 75 m (256–246 ft)(Fig. 9). The top of the slope was at 62 m (203 ft).

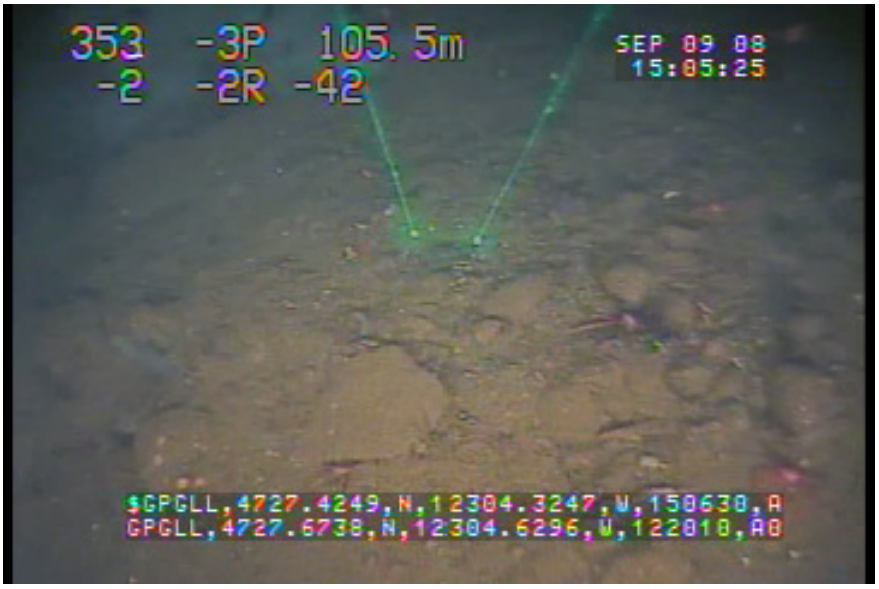

Figure 8. The scarp wall at 105 m (345 ft) consists of abundant cobbles that appear to be *in situ*.

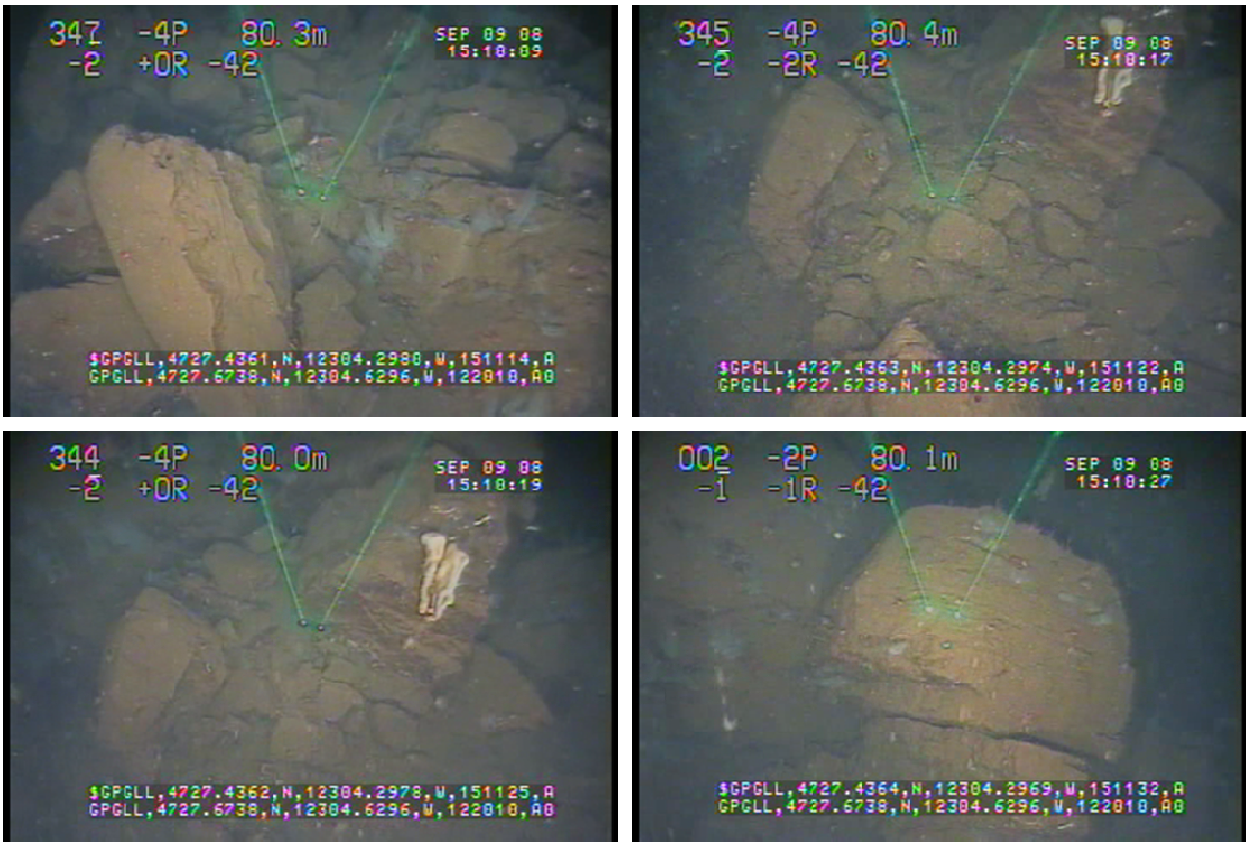

Figure 9. Large chunks or blocks of consolidated silt were observed at 78 to 75 m (256–246 ft).

No vents were observed in the substrate, nor were there indications of ascending gas bubbles or aqueous discharge. No epigenetic mineral deposits were observed anywhere on the mounds.

DISCUSSIONS AND CONCLUSIONS

Our initial hypotheses were that these features could be drumlins, gas seeps, or landslides. Our overall interpretation of the origin of the mounds is that they are both submarine landslide deposits, due to the fact that they are composed of well-rounded, cobble- to boulder-size clasts that appear much like Olympic-provenance outwash gravels and tills found just above sea level in the bluffs of Dewatto Bay. These are likely to be very thick deposits, suggesting that they are present in submarine exposures as well. The similar appearing cobble- and boulder-rich submarine headwall areas at the mouth of Dewatto support this suggestion. Because of the coarseness of the deposits, they are definitely not caused by natural gas seeps. Furthermore, their shapes and sizes are not consistent with those of drumlins as suggested by Chien-Hom (2007). Also, submarine drumlins are rare in Puget Sound.

The video observations visually show that the mounds are likely landslide deposits due to:

- The coarseness of the deposits (no gas seeps were observed);
- Their apparent cohesiveness—the mounds appear to be large cohesive blocks of clasts similar to well-cemented coarse gravel deposits in the headwall and surrounding areas;
- Their color—the orange staining and dark color of the clasts is consistent with outwash and till from the Olympic Mountains;
- The texture of some clasts—the fissured surface of many of the clasts is consistent with textures of clasts that are scattered along beaches derived from adjacent bluffs;
- There are no deltas associated with the Dewatto drainages, whereas most other streams that empty into the canal have well-formed deltas;

- Hummocky bathymetry adjacent to the mounds is consistent with hummocky terrain associated with subaerial landslides.
- A steep headwall at the mouths of the drainages and the mound deposit areas is consistent with landslide morphology.
- Seismic profiles of the deposits reported by Chien-Hom (2007) are consistent with landslide deposits.

Strong currents within Hood Canal may have eroded fine sediments off of the upper portion of the mound, exposing coarse gravel deposits or alternatively no fines were deposited there. The rounded clasts originated in a fluvial environment (glacial outwash). These coarse cobbles appear to be semi-consolidated, and locally sustain steep slope gradients on the east flank of the south mound (perhaps >32 degrees).

ACKNOWLEDGEMENTS

We thank David K. Norman (Division Manager, DGER) for supporting our joint investigation and Wayne Palsson of the WDFW for providing staff and vessel time.

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Appendix A. The Crew

Figure A1. ROV operation room – WDFW biologist Bob Pacunski (operating the ROV) and DNR geologist Josh Logan (noting the video observations)

Figure A2. Todd Palzer (left) and DNR geologist Chris Johnson (right) handling ROV cable operations in the deck area.

Figure A3. DNR geophysicist Recep (Ray) Cakir (left) and WDFW biologist Lisa Hillier (right) are checking the protocol for the ROV operation.

Figure A4. Captain Jim Beam (WDFW) handling the navigation system.

Appendix B. The ROV and Its Operation

ROV operations were conducted using the methods described in Pacunski and others (2008). The support vessel used in this study was the 12 m [40 ft] *R/V Molluscan*, owned and operated by WDFW. The ROV was tracked with a Linkquest TrackLink 1500 ultra-short baseline (USBL) acoustic tracking system, which provided real-time geo-positioning of the vehicle throughout each deployment. A pair of green lasers aligned in parallel (10 cm [4 in.] separation) were mounted on top of the video camera to provide a scalar reference for the collected video imagery. However, a failure of the mounting bracket resulted in a loss of alignment and a concomitant convergence of the laser beams. Based on the lead ROV pilot's experience, it was estimated that the beam spread at nominal camera tilt angle (40–50°) and ROV height-off-bottom (~0.25–0.5 m; 0.8–1.6 ft) ranged between 2 and 8 cm (0.8–3.2 in.). To facilitate spatial analysis of substrate features and fish distribution, the position of the ROV (lat/long) was imprinted on the videotapes with a PISCES text overlay system.

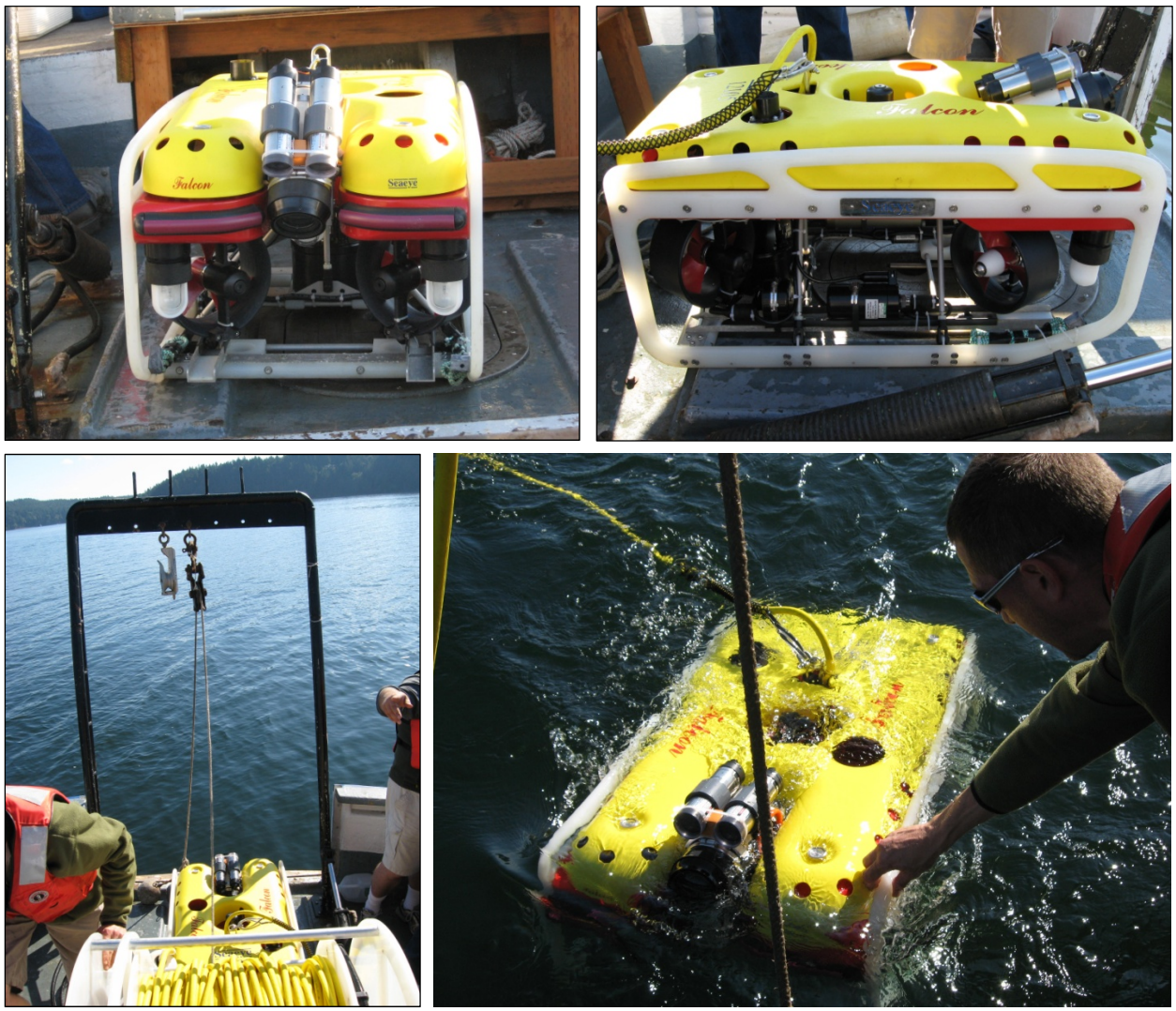

Figure B1. Remotely operated vehicle (ROV)—front and side views of paired lasers mounted on top of camera (top photos), lowering and early testing of the elements of the ROV (bottom photos).

Figure B2. Navigation and ROV operation room (top left), TrackLink acoustic transducer used to locate ROV position (top right), video monitor and ROV electronic operating unit (bottom left), and research boat navigation monitors and control room (bottom right).

Appendix C. Supplemental Information

- ESRI shapefiles – showing the tracklines of the ROV and video observation points. These are included in the zip file for this report.
- Three DVDs – ROV video records of the two mounds and the scarp between the Dewatto mound and Dewatto Bay. These DVDs may be obtained by contacting Ray Cakir (recep.cakir@dnr.wa.gov; 360-902-1460) or the Washington Division of Geology and Earth Resources (geology@dnr.wa.gov; 360-902-1450).