Results of rockfish and rockfish habitat survey in Whatcom County

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Summary
A survey of rockfish abundance and habitat was conducted on June 21, 2007 along the south-western shore of Lummi Island. Previous surveys had indicated that this was an area that possessed some of the best potential rockfish habitat in Whatcom County. The survey covered 500 m^2 of bottom habitat. Several species of fish were observed including Puget Sound rockfish (*Sebastes emphaeus*) and one fish that was either a Copper rockfish (*Sebastes caurinus*) or a quillback rockfish (*Sebastes maliger*). Puget Sound rockfish were found at depths deeper than 19 m and their abundance was highest in areas with abundant boulders and bottom slopes steeper than 20 degrees. The single specimen of either copper of quillback rockfish was found at 50 m depth in an area with large boulders and a bottom slope of approximately 40 degrees. These findings indicate that the best rockfish habitat is found at the southern-most portion of Lummi Island, which possesses large boulder fields and rock walls with slopes greatly exceeding 20 degrees. Northwest of this area along the island, the bottom slope levels and boulder fields are replaced by sand and gravel bottom. No rockfish were observed in this low-relief, sand-and-gravel habitat.

Introduction
Over the last few decades, rockfish abundance and reproductive potential has declined greatly in Puget Sound and the Georgia Basin. Rockfish landings in Washington State are at 50-year lows (Palsson et al. 1998, Dinnel et al. 2001), which is consistent with a broader-scale trend of rockfish overexploitation in the northeast Pacific (Love et al. 2002). Rockfish populations are particularly susceptible to the fishing pressure because they have long generation times and swim bladders that do not adjust well to pressure changes. As a result, rockfish cannot be caught as by-catch and returned to the water safely. Because of these characteristics, standard fishing regulations such as bag limits and fishing season restrictions appear to be ineffective management strategies. Many have argued that marine protected areas are essential to preserve and effectively manage rockfish species in Washington State (Tuya et al. 2000, Eisenhart 2001).

Before effective management strategies for rockfish can be established in Whatcom County, baseline information on rockfish abundance and habitat distribution is necessary. Rockfish generally require rocky reef habitat, but different species of rockfish prefer different bottom types and depth ranges (Love et al. 2002). A recent survey by Pacunski and Palsson (1998) documented rockfish habitat topography and substrate types in Washington State throughout Puget Sound and Georgia Strait using a submersible camera. They documented that copper rockfish were found primarily in association with rock walls (≥45 degrees) and high-relief boulder fields whereas quillback rockfish preferred low-relief boulder fields and high complexity walls. In Whatcom County,

habitat types that match these characteristics were found primarily along the west side of Lummi Island.

The purpose of this study was to observe and quantify rockfish habitat along the south-western portion of Lummi Island and to identify and enumerate rockfish that were present in this region. The south-western portion of Lummi Island was selected for this survey (Fig. 1) because the broader-scale survey by Pacunski and Palsson (1998) indicated that this region possessed the type of habitat likely to harbor rockfish and because a pilot ROV survey conducted by Shull and students from WWU in February 2007 also indicated that the region of Lummi Island near Carter Point possessed the highest numbers of rockfish and the most complex rocky habitat.

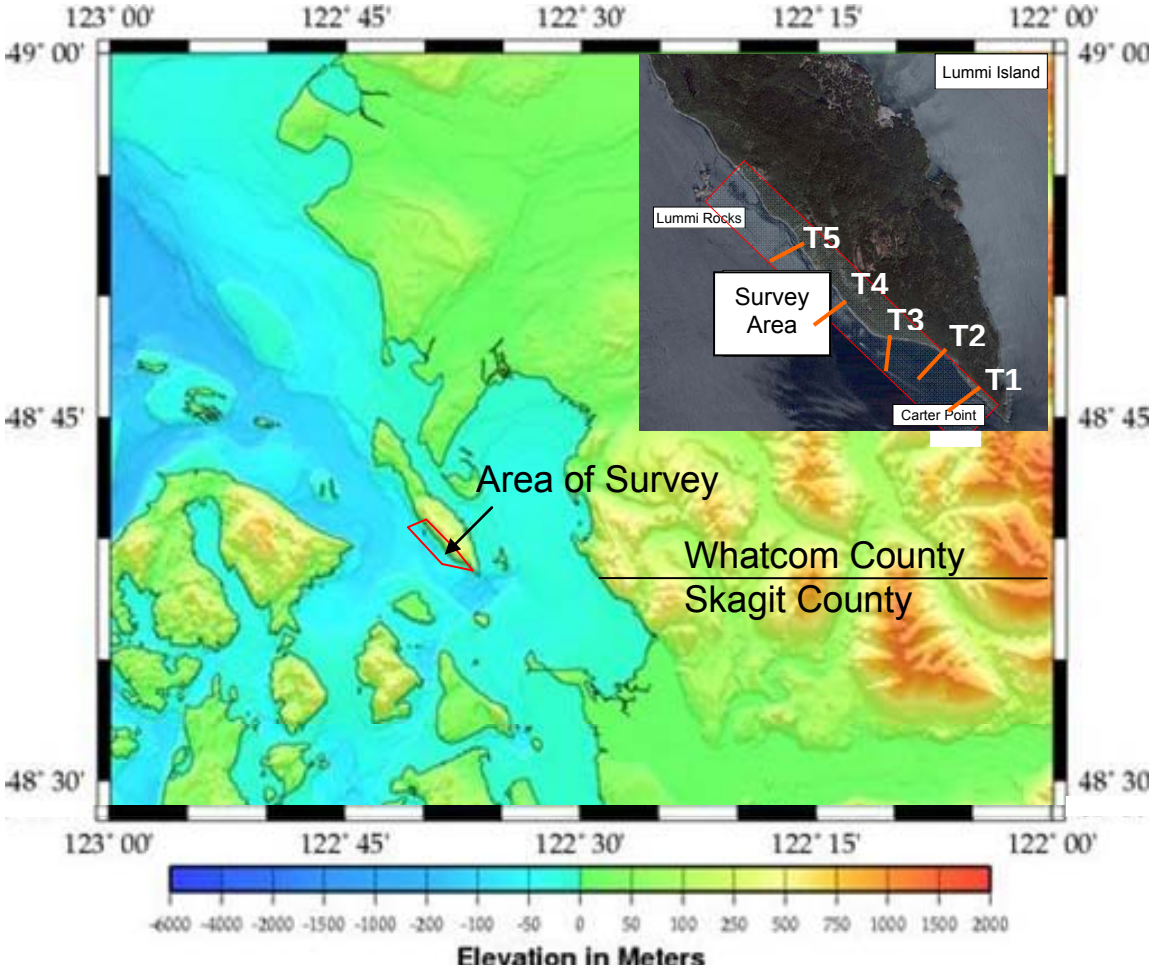

Figure 1. Chart showing region of Lummi Island where rockfish survey was conducted. Orange lines in inset image show approximate locations of transects T1 through T5.

Methods

The survey was conducted using a VideoRay Pro 3 ROV (remotely operated vehicle) with a front-mounted color video camera, parallel laser beams, an integrated DVD recording system, and a depth gauge. The ROV was deployed from Western's research vessel R/V Zoea. Because the seafloor slope in this area can be extremely steep, we ran

transects perpendicular to shore, starting offshore at depths between 25 and 50 m and ending in shallow water (approximately 5 m). The starting depth was limited by the length of the ROV's tether, which also limited the total transect length. Greater depths could be reached in areas with steeper bottom slopes. Before starting a transect, the bottom slope was determined by use of the R/V Zoea's depth finder and GPS (global positioning system). Bottom depth and ship's horizontal position were determined at several locations along the intended transect. Coordinates from the GPS were converted to horizontal onshore distances from the starting point. The bottom slope was calculated from the slope of the linear regression between water depth and onshore distance. Once the bottom slope was determined, we flew the ROV close to the bottom directly up slope from our starting point until we reached shallow water (~5m water depth).

Any rockfish, or other rocky-reef ground fish, captured on video were noted, and those observed within the video transect were counted. Given the bottom slope measurement, we were able to calculate the total length of our transects from the change in depth alone. The ROV's laser beam allowed us to quantify the field of view, enabling us to calculate the area surveyed and therefore the density of rockfish per square meter (Fig. 2). We surveyed rockfish and bottom habitat along eight transects between the southern tip of Lummi Island and Lummi Rocks. For this report, the first five transects were analyzed. These transects covered 500 m^2 of sea floor.

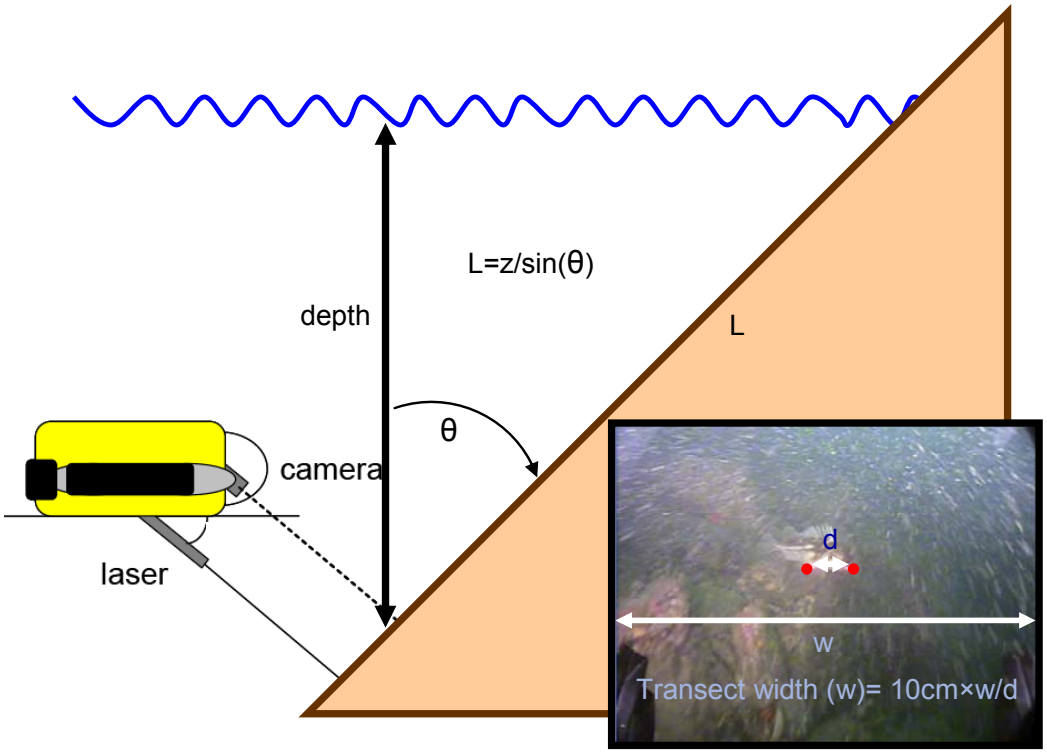

Figure 2. Diagram of ROV deployment. The ROV was flown upslope from a depth of 25 to 50 m to shallow water (~ 5m). Transect length was calculated from the change in depth and the slope of the bottom (θ). Transect width was determined from the on-screen distance of the parallel lasers (red dots in inset screen capture).

Results

The five transects analyzed for this report extended from Carter Point (T1) northwest to the Lummi Island shoreline just south Lummi Rocks (T5) (see Fig. 1 for transect locations). Bottom topography varied greatly among the five transect locations (Fig. 3). The steepest bottom slopes were found near Carter Point. Toward the northwest, approaching Lummi Rocks, the bottom slope leveled. Large boulders were also more abundant near Carter Point and this steep high-relief bottom was replaced by a flatter bottom with a sand-gravel substrate. The bottom observed in transect one and two possessed large boulders whereas bottom observed in transect three, four and five was mainly sand and gravel.

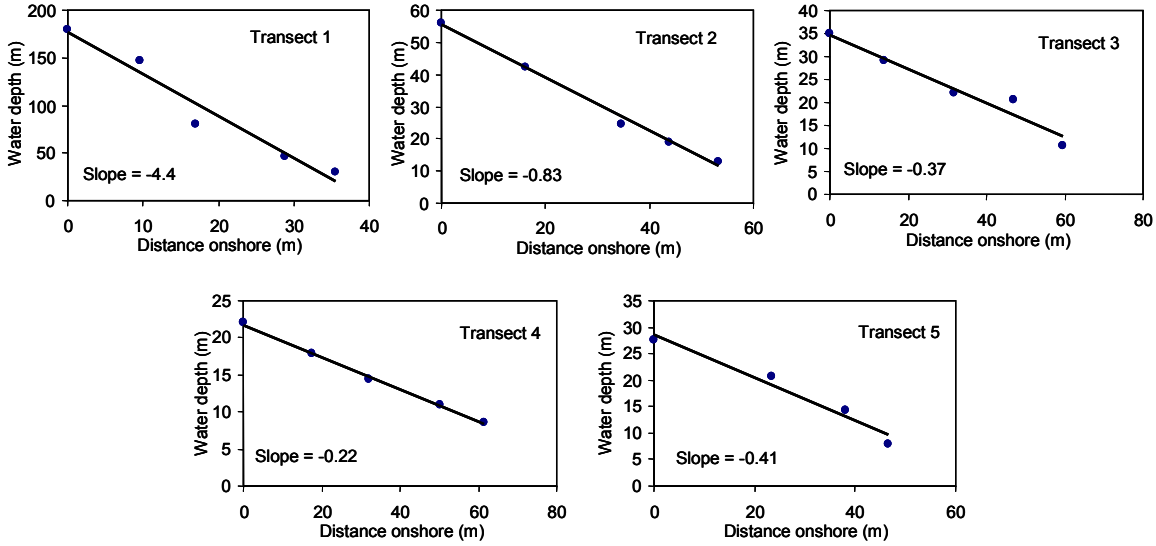

Figure 3. Bottom slopes at each transect location determined from the ship's depth sounder and GPS. Each point represents an individual reading and the lines show the best least-squares relationship.

Several species of fish were observed during the survey. These included two species of rockfish, Puget Sound rockfish (*Sebastes emphaeus*), either copper or quillback rockfish (*S. caurinus* or *S. maliger*). These last two rockfish species are similar in appearance. These two species can often be differentiated on video by the presence of a white line near the copper rockfish lateral line, which is absent from the quillback. Unfortunately, this characteristic was not visible in the video image. In addition to these species, we observed kelp greenling (*Hexagrammos decagrammus*), painted greenling (*Oxylebius pictus*), ling cod (*Ophiodon elongatus*), spiny dogfish (*Squalus acanthias*), and a few unidentified fish species.

Densities of Puget Sound rockfish were highest along transect one (0.65 fish m^{-2}). Lower densities were encountered along transect two (0.07 fish m^{-2}) and none were observed along transects three through five. Puget Sound rockfish were only observed in areas with large boulders. Our data also suggest a possible relationship between Puget Sound rockfish and bottom slope (Fig. 4). These fish were observed primarily in areas with the greatest slope. Puget Sound rockfish were generally found at the deepest depths along both transects. Figure 5 displays the depth distributions of Puget Sound rockfish along

the two transects. Note that the first transect began at a depth of 31 m and the second started at 50 m. At both locations, Puget Sound rockfish were observed at the greatest depths of the transects. No Puget Sound rockfish were observed at depths shallower than 19 m. The single copper or quillback rockfish was spotted on transect two at 50 m depth.

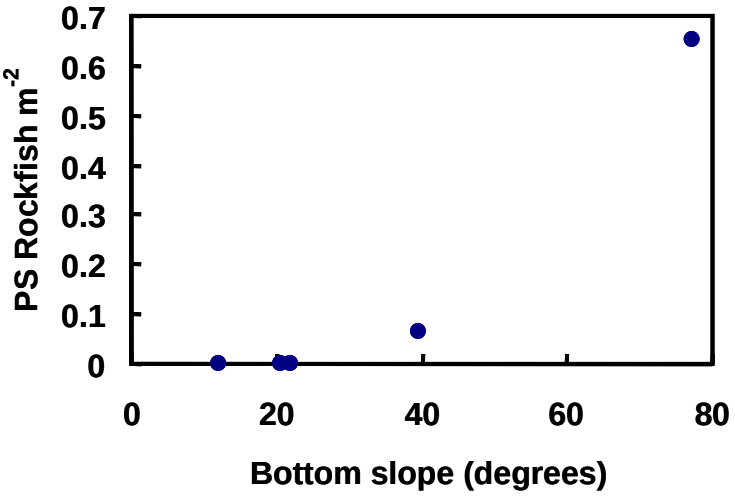

Figure 4. Relationship between density of Puget Sound rockfish and bottom slope. Each point represents the average density of fish for each transect.

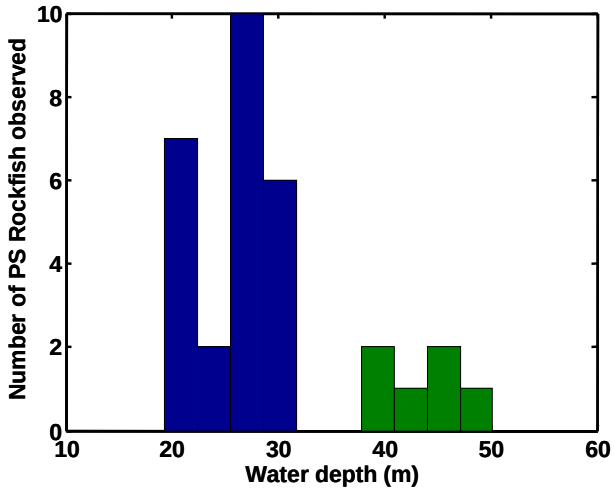

Figure 5. Depth distribution of Puget Sound rockfish observations from transects one and two. The blue bars represent data from transect one and the green bars represent data from transect two.

Discussion

The observation that rockfishes were most abundant near Carter Point, the region surveyed with the greatest bottom slope and abundant boulders, is consistent with previous studies of rockfish in the Strait of Georgia and Puget Sound which found that Copper and Quillback rockfish are most abundant and show highest site fidelity for high-relief rocky reef (Richards 1986, 1987, Matthews 1990a, b, Pacunski and Palsson 2003). Puget Sound rockfish also prefer high-relief rocky habitats (Johnson et al. 2003). These

previous studies along with the data collected from this survey and data from previous habitat surveys indicate that the southern end of Lummi Island is the best habitat for rockfish. Other areas with potentially good rockfish habitat in Whatcom County include areas southeast Pt. Roberts and Alden Bank (Pacunski and Palsson 1998). These areas should be included in future surveys.

Within the 500 m^2 surveyed, 30 Puget Sound rockfish were observed but only one other species of rockfish was seen. Although it was not possible to distinguish whether this individual was a copper or quillback rockfish, all other rockfish observed in this area on previous surveys that match the size and general appearance of this fish were copper rockfish. Thus, it is likely that this fish too was a copper rockfish. Unfortunately, it is not possible to determine an average density of copper rockfish from this one observation. But, it is important to note that either copper or quillback rockfish present in this area and that future surveys could better quantify their abundance.

One of the questions driving this research is whether there are regions within Whatcom County that deserve special protection as habitat for rockfish. Although more work is needed, these preliminary data suggest that the area around Carter Point on Lummi Island possesses valuable rockfish habitat that deserves protection.

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Task 5

ROCKFISH AND HABITAT BASELINE SURVEYS
WHATCOM COUNTY MARINE RESOURCES COMMITTEE

Background

Throughout the Puget Sound, populations of rockfish, a subset of groundfish, are depressed, both in terms of population and fish size (Palsson et al.1998, PSAT 2002). In fact, the spawning potential of rockfish populations in the Puget Sound has declined by an estimated 75% from the 1970s (PSAT 2002). Rockfish play an important role in the marine ecology of Whatcom County and are a key local recreational harvest species. Currently, there is limited data on rockfish populations and habitat in Whatcom County. To date, the groundfish species data for Whatcom County, which includes rockfish data, is based primarily on commercial landings rather than on habitat assessment (availability, quality and utilization) and population statistics derived through empirical observation. Two goals the Whatcom County MRC is targeting are the NWSC benchmark to "exhibit measurable increases in factors supporting recovery of bottomfish" and the Puget Sound Action Team long-term goal of balanced, stable, and self-sustaining populations of indigenous rockfish (PSAT 2003). In order to reach these goals, we need greater information on rockfish population and habitat quality in Whatcom County marine waters. By helping fill this data gap, recommendations for restoration and protection efforts can be based on scientifically-sound data.

In Phase 1 of the Whatcom County Rockfish Dive Survey Project, reconnaissance dives were conducted at three sites that were identified as potential rockfish habitat areas in Whatcom County. In addition, methodology was created for dive surveys conducted by volunteers and references for safety plans were compiled. While dive surveys conducted by volunteers would be an effective pathway for increasing community involvement and awareness of rockfish issues, volunteer data would be more qualitative in nature. In order to gather quantitative baseline data, the Whatcom County MRC will adapt methods used in Skagit County to characterize rockfish populations and habitats.

The Skagit County visual strip transect survey methods were used for baseline surveys of candidate sites for protection of rocky reef fishes in Skagit County Weispfenning et al. (2004). The Skagit County methods conducted by scuba divers were adapted from McCormick and Choat (1987) and Eisenhardt (2001). These methods were used to estimate rockfish density, fish size, and document habitat complexity within candidate marine reserve areas. Survey sites were chosen based on the existence of complex rocky reefs identified by the Washington Department of Fish and Wildlife as excellent habitat, previous diving excursions, and the presence of substantial bull kelp (*Nereocystis leutkeana)* beds. Depth soundings also aided in site selection by providing bathymetric profiles of the prospective rocky reef habitat.

The WCMRC will adapt the Skagit County methods with the following alternatives:

- The diving surveyors must remain in visual contact with each other at all times.
- Each diver will identify, enumerate, and estimate size of the rockfish observed on their side of the transect line within a 4m x 4m x 2m (LHW) meter cube (with the height of the survey unit centered around the diver). The two divers' results will be combined to create a complete transect (25m x 4m x 4m).
- The transect line will be 25 m reel type tape measure with a spike at the zero end to be used as an anchor. When the 25 m transect is complete the tape will be reeled in from the end of the transect.
- Length of rockfish will not be measured but rather the fish will be categorized as adult or juvenile based on relative lengths within the species.
- Specific descriptions regarding identification of the survey starting point and transect location in relation to the reef will follow the Eisenhardt (2001) methods.

Methods

Every attempt will be made to conduct all surveys during the high slack tide period in order to maintain consistency between sampling dates, avoid the effects of tidal currents on diving safety and fish behavior, and maximize the period of best subtidal visibility. GPS coordinates will be recorded at the start and end of the survey, as well as notes regarding current, weather conditions, and fishing activity.

Each survey (the experimental unit) will consist of eight, 25m x 4m x 4m (length, height, width) transects between two depth strata (14-20m and 9-14m). In general, the overall dive profile will be parallel to shore despite some variation in reef slope and will begin with the four deep transects in a stair step-like fashion:

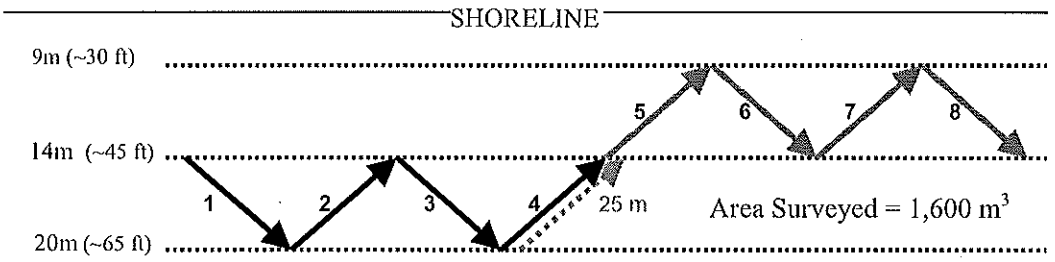

Figure 1. Diagram of the survey transect configuration (adapted from Eisenhardt 2001 and Weispfenning et al. 2004).

The divers will enter the water at the approximate starting point, descend to the starting depth (14m) and proceed via the most direct route to a starting location 2m off the bottom at this depth. The transect line will be 25 m reel type tape measure with a spike at the zero end to be used as an anchor. The divers will remain 1m above the substrate (or 1m off the vertical wall) while moving across reef slope. The two divers will swim side by side (centered on the tape measure) at a constant rate (using approximately 30 fin strokes per minute as a reference). While swimming, the divers will reel out the tape measure and change depth at a relatively constant slope to reach the desired depth by the end of the 25 m transect. Each diver will record fish observed in 4m x 4m x 2m (LHW) cubes along the transect (Figure 2). Along vertical walls, one diver will reel out the tape and observe fish adjacent to the wall and the second diver will swim and observe fish in a parallel pattern 2m from the first diver (Figure 3).

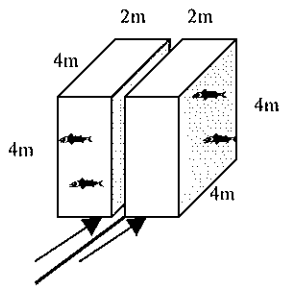

Figure 2. Two divers (denoted by arrows) centered on the strip transect line observing 4m x 4m x 2m cubes.

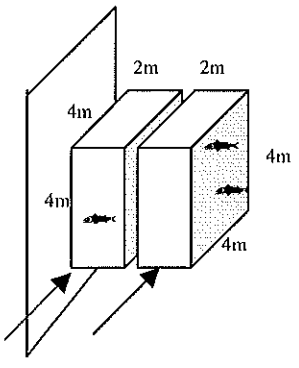

Figure 3. Two divers (denoted by arrows) observing 4m x 4m x 2m cubes along a vertical wall.

Variation in reef slope within the survey site may have some effect on whether the entire depth stratum (14-20m and 9-14m) can be covered by the 25 m transect and the angle of the individual transects. Along vertical walls, the entire depth stratum should be able to be observed and the individual transects may run nearly parallel to the shoreline. Along gradual slopes, the entire depth stratum may not be able to be observed in the 25m transect and the angles of the individual transects may be narrower. In complex rocky reef areas it is important to look within crevices, behind rocks, and amongst macro algae for cryptic fish. Potential sampling bias will be minimized by focusing only on the immediate 4 m x 4 m x 2 m cube and maintaining a constant course.

Species surveyed will include all large nearshore rockfish observed during surveys: ie: rockfish; black (*Sebastes melanops*), canary (*Sebastes pinniger*), copper (*Sebastes caurinus*), quillback (*Sebastes maliger*), Puget Sound (*Sebastes emphaeus*) and yellowtail (*Sebastes flavidus*), as well as lingcod (*Ophiodon elongatus*), kelp greenling (*Hexagrammos decagrammus*), and cabezon (*Scorpaenichthys marmoratus*). Identified fish will be characterized as adult or juvenile. The abundance of other fish species observed will also be recorded by each surveyor while swimming along the transect.

At the end of each transect one diver will reel in the transect line and the other will record notes on survey attributes including water clarity, habitat characteristic (0 = mud and sand, 1 = shell rubble and small rocks/cobble, 2 = boulders < 1 m, 3 = boulders 1 – 3 m, and 4 = boulders > 3 m), and other incidental observations of benthic fauna and vegetation. In addition, if schools of rockfish (e.g. Puget Sound rockfish) are observed adjacent to the transect, they will be noted.

This cycle will be repeated 8 times (4 in each of two depth strata) with approximately 30-40 minutes of bottom time for each survey.

Survey Locations

In Phase 1 of the Whatcom County Rockfish Dive Surveys, reconnaissance dives were conducted at Fern Point (Lummi Island), Lummi Rocks, and Carter Point (Lummi Island). The reconnaissance dives found that Lummi Rocks and Carter Point are viable locations for future rockfish dive surveys. As Fern Point did not have quality rockfish habitat or rockfish species present, a third site will be selected for a reconnaissance dive in Phase 2. Following is a description of the dive survey locations for Lummi Rocks and Carter Point.

Lummi Rocks- A rock pinnacle with vertical walls at the southwest corner of Lummi Rocks will be the focus of the dive survey. The starting coordinates for this dive survey will be approximately Latitude N 48° 40' 05.9", Longitude W 122° 40' 06.5". The starting point will be adjusted in relation to the reef depth and in order to avoid derelict gear.

Carter Point- This dive survey will cover both the west and east sides of the point. The starting coordinates for this dive survey are approximately Latitude N 48° 38' 22.5", Longitude W 122° 36' 29.6". The starting point will be adjusted in relation to the reef depth and in order to avoid derelict gear.

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Rockfish and rockfish habitat survey by ROV

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Scope of work

In order to quantify the distribution of rockfish habitat and rockfish abundance in Whatcom County, we will perform a survey on February 16th, 2007, using a VideoRay Pro III GTO ROV. The spatial extent of our investigation will be guided by the results of a 1999 camera survey by researchers from the Department of Fish and Wildlife who identified habitat types in Whatcom County (Wayne Palsson, pers. comm., Fig. 1).

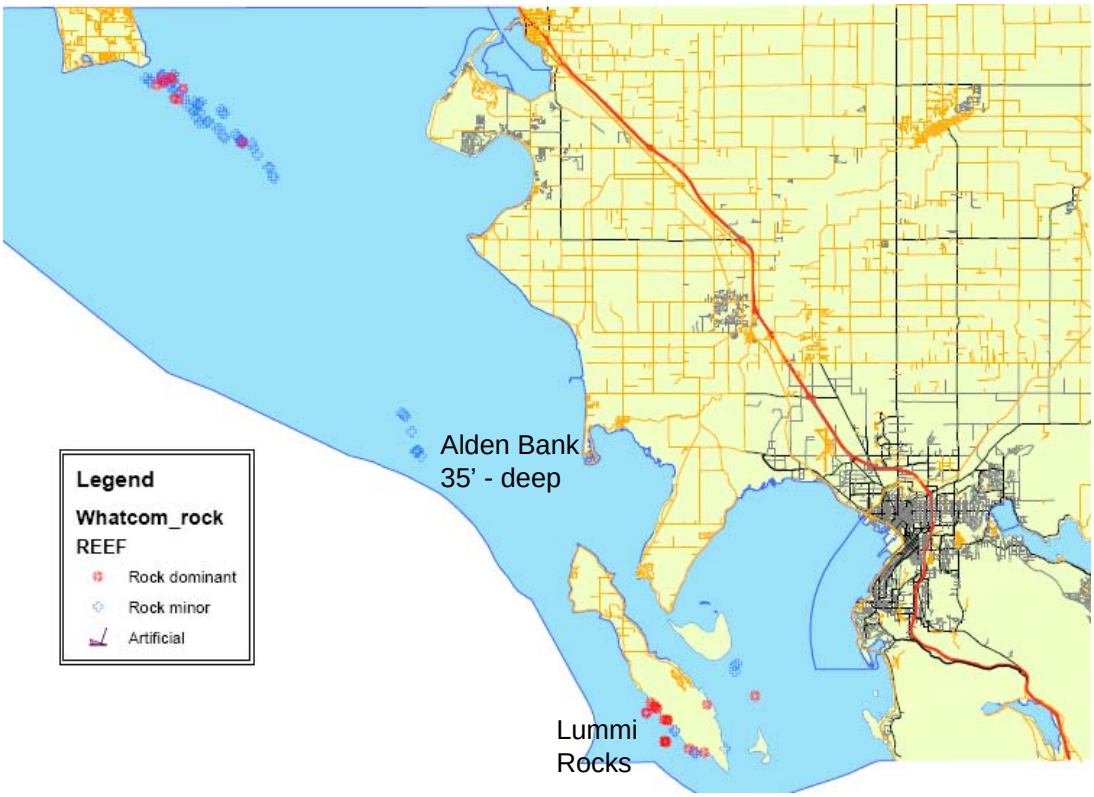


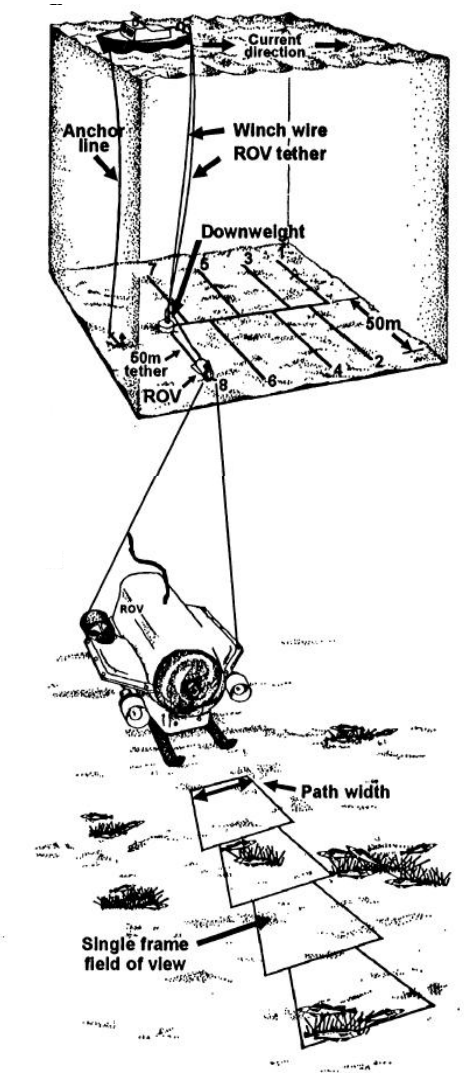
Figure 1. Rockfish habitat in Whatcom County identified by a WDFW survey in 1999.

Survey design and description and capabilities of the ROV

The VideoRay Pro III-GTO ROV is a small and easily deployed remotely operated vehicle (ROV). It has a depth capability of 500 feet. In front, the ROV possesses a high-resolution color CCD camera. It also possesses a black-and-white, low light rear-facing CCD camera. Two forward-facing lights provide illumination. Images from the camera

system are used for underwater navigation and the video is recorded directly onto DVD at high resolution. The ROV is also equipped with parallel red-light lasers 10 cm apart. These are used to determine the actual size of video frames. Two thrusters provide forward and backward mobility and one vertical thruster controls the ROV depth. The ROV is tethered to a control box on the surface and controlled using a joy stick.
We will deploy the ROV in a manner similar to that depicted in Figure 2.

Figure 2. ROV deployment and video collection plan (from Auster et al. 1997).



We plan to conduct our survey on February 16th, 2007. The survey will establish sampling locations in areas where rocky habitats have been observed in the past (Fig. 1). At each sampling location, we will lower the ROV to the bottom attached to a downweight and a 25 m tether. The downweight is necessary because current pulling on the ROV tether would make it difficult to maneuver the vehicle on the bottom. Also, by flying the entire 25-m tether we will also be able to calculate the area of bottom surveyed. Once on the bottom, we will fly the ROV away from the downweight to the end of the tether. This will constitute one transect. At each sampling station, we will fly several transects away from the downweight in four different directions, using the ROV's compass. Once the transects are completed we will redeploy the downweight at a new location and repeat.

After the video has been recorded, we will analyze it by considering video frames making up the transect to be a series of adjacent video quadrats (Fig. 1). Each quadrat is shaped like a trapezoid and will be analyzed as a separate sample.

The parallel lasers, 10 cm apart, lasers are set at a known angle from the horizontal so that the vertical distance scale can also be determined. To simplify the scale conversions, the camera tilt will be adjusted so that the laser dots are centered within the video field of view (Fig. 3). If $\boldsymbol{L}$ is the distance between the two lasers, and $\boldsymbol{l}$ is the distance between the two laser dots on the video screen, and $\boldsymbol{a}$ is the width of the video quadrat, then the actual width of the video, $\boldsymbol{A}$, is equal to $\boldsymbol{(L/l)a}$. If $\boldsymbol{\theta}$ is the angle between the laser and the

horizontal, and ***b*** is the height of the video frame, then the actual height of the frame, ***B***, equals ***(L/l)b/sin(θ)***.

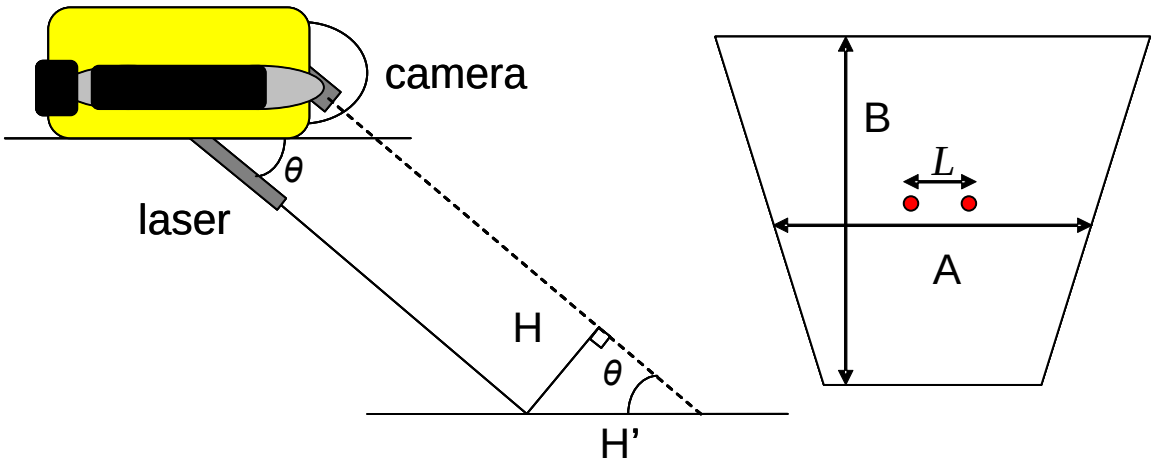


Figure 3. Relationships between quadrat height and width and the laser beam angle θ.

Analyzing the video data

After the survey, the videos will be analyzed to determine the habitat type and the number of rockfish per unit area of habitat. Rockfish will be identified to species, when possible and their distribution patterns will be analyzed with respect to habitat type and water depth.

Deliverables

WWU will deliver a report to the Whatcom County MRC detailing the distribution patterns of rockfish and rockfish habitat in Whatcom County. We will calculate the number of rockfish per unit area at each sampling station and examine the data for possible relationships between rockfish density and habitat characteristics. The report will also examine constraints on the possible establishment of marine protected areas in Whatcom County.

Budget

The first phase of this project (Feb 1st – March 23rd) will not require funding. Ship time and personnel will be provided through educational funds. Further work on rockfish habitat and distributions would require funding to pay for personnel, ship time, and expendable supplies.

Contact for contracts at WWU

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Reference

Auster, P,J., R. J. Malatesta and C. L. S. Donaldson. 1997. Distributional responses to small-scale habitat variability by early juvenile silver hake, *Merluccius bilinearis*. Environmental Biology of Fishes 50: 195–200.

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