**Coastal Zone Management Section 309 Grant**

# 2006 Orford Reef Pilot ROV Survey

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**Acknowledgements**

This report addresses a new study effort focused on Orford Reef off of Cape Blanco with three goals: 1) to develop methods to survey fish populations on rocky reefs using non-invasive methodology, 2) to improve capabilities of remotely operated vehicle (ROV) as a survey tool, and 3) to better understand nearshore rocky reefs and their significance to Oregon fisheries. Our colleague, Dave Fox, initiated this effort, and it is through building on his vision and commitment that we have been able to continue these studies.

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## 1. Introduction

Oregon's nearshore environment and the living marine resources that depend upon it have been subject to increasing pressures for several years. Emphasis and effort on nearshore fisheries has increased with reductions in offshore fishery opportunities and the development of the live-fish fishery. Non-fishery pressures including coastal land development, dredge material disposal and oil spills and leaks can compromise the health and viability of the nearshore ecosystem. The potential for future offshore energy exploration and extraction remains open. Recently, nearshore hypoxic events have been observed off the central Oregon coast (2002 -- 2006) resulting in localized mortality of some marine species. These events are under active investigation by oceanographers and ecologists from Oregon State University, with collaboration from the Oregon Department of Fish and Wildlife (Barth, pers. comm., Chan, pers. comm., Freeland, et al. 2003, Huyer 2003, Grantham, et al. 2004). The relationship of these events to human-induced environmental change is not known.

Oregon must continue to work to sustain its nearshore resources and the functioning of nearshore ecological systems by balancing the demands for harvest and habitat uses with prudent conservation measures, all within the context of substantial natural variation. To address this need, the Oregon Fish and Wildlife Commission has adopted a Nearshore Marine Resources Management Strategy. The intent of this Strategy is to put the Department's fish and wildlife management and conservation efforts into an ecological context, and to develop a strategic, prioritized approach to a very large and complex set of issues while working within existing policies and authorities.

Rocky reef habitats represent a focal point for these concerns as fishing pressures can be intense, and habitat is both limited and subject to degradation. A community of commercially and recreationally valuable species are found primarily, or only, on nearshore rocky reefs or other rocky substrate. These include species such as greenlings and lingcod (Family Hexagrammidae), quillback rockfish (*Sebastes maliger*), China rockfish (*S. nebulosus*), black rockfish (*S. melanops*), and blue rockfish (*S. mystinus*). In addition, nearshore rocky reefs are utilized by juveniles of other species more frequently fished farther offshore such as canary rockfish (*S. pinniger*) and yelloweye rockfish (*S. ruberrimus*). Many of these species have not been quantitatively assessed, yet are subject to substantial fishing pressure. Understanding of fish-habitat associations will contribute to broader goals of monitoring and protecting important habitat areas, improving nearshore fish stock assessments, and improving research design. We are particularly interested in the question of whether nearshore fish abundance and distribution can be predicted by seafloor characteristics.

The ODFW Marine Habitat Project has worked since the mid-1990s to gather information on rocky reef habitats, and fish, invertebrate and plant species occupying them. Much of this work has been conducted in collaboration with scientists and other resource agencies to develop methods for classifying and mapping nearshore rocky reef habitats off Oregon and quantifying fish densities . To date, eight reefs have been surveyed and mapped with sidescan sonar and/or multi-beam bathymetry at resolutions believed to be indicative of fish habitat. In aggregate, the mapped area of these eight reefs is approximately 175 $km^2$, which is roughly 5% of the area of the Oregon Territorial Sea. ODFW has also been developing non-extractive fish survey techniques using a remotely operated vehicle (ROV) to characterize fish-habitat relationships and estimate fish densities as an index of abundance. Much of this developmental work took place at Perpetua and Siletz Reefs from 2000 through 2004 (Fox et al. 1999, Fox et al. 2000, Amend et al. 2001, Merems 2002, Weeks and Merems 2004, and Weeks et al. 2005). As fish-habitat relationships become better understood, and methods are refined, we believe that we will be able to expand this understanding to track changes in densities resulting from management actions, fisheries and/or natural variation.

In 2006, the Marine Habitat Project conducted a pilot ROV survey on Orford Reef. This reef lies to the southwest of Cape Blanco, and is the principal fishing location for commercial fishing vessels from Port Orford harvesting nearshore species. The reef was surveyed with sidescan sonar in 1995 by the Geologic Survey of Canada covering 24 $km^2$. A multibeam sonar survey yielding detailed bathymetric information, at a resolution of one meter, was performed under ODFW contract by SeaVisual Consulting that covered 42 $km^2$ (Fox et al. 1999).

Previously, fishes in shallow waters of Orford Reef had been surveyed using SCUBA gear (Fox et al. 1996, Miller et al. 1997). These surveys were components of studies of the kelp resource of Orford and neighboring reefs conducted from 1996 through 1999 (Fox et al. 1999).

The 2006 pilot ROV survey had three principal objectives. First, could the ROV, along with its ancillary equipment, be successfully and safely operated using a small commercial fishing vessel as an operational platform. Second, to determine how much survey coverage could be made per day over several days of sea-time. Third, to collect preliminary information on densities of Orford Reef fishes, and if possible, to compare these results to previous SCUBA survey results.

In additional to the principle objectives, we took this opportunity to examine and discuss differences between fine scale and coarse scale methods for interpreting habitat types on a rocky reef.

## 2. Materials and Methods

### 2.1 Survey Design

For our work at Orford Reef, seventeen circular plots were randomly selected and stratified by depth from previous surveys by Fox, et al. (1999), (Fig. 2.1). We eliminated five of the plots due to hazards to navigation for the support vessel and ROV. The remaining twelve plots were stratified by depth, five at 0-30 m., four at 30-60 m., and three at greater than 60 m.. We selected one plot from each depth strata and created a 500 m. by 1000 m. box (sampling unit) within each circular plot. The orientation of the boxes within the circular plots were determined, on the day of the survey, based on weather and sea conditions. There were eleven possible parallel transects per box. Each ran the width of the box, measuring 500 m in length, and was spaced 100 m apart. We randomly selected four transects for each box.

### 2.2 Remotely Operated Vehicle Procedures

2.2.1 Equipment Configuration

We used a remotely operated vehicle (ROV), Phantom HD2+2 manufactured by Deep Ocean Engineering (D.O.E), for the Orford Reef Pilot Survey. We have made several modifications to the ROV's configuration as originally described in Fox, et al. (2000) and Amend, et al. (2001) (Fig. 2.2). We added two bottom horizontal thrusters. Under normal operation we have 150 lbs. of forward thrust. With the hand controller set to boost we have a maximum of 200 lbs in an emergency. The original halogen lights were replaced with two

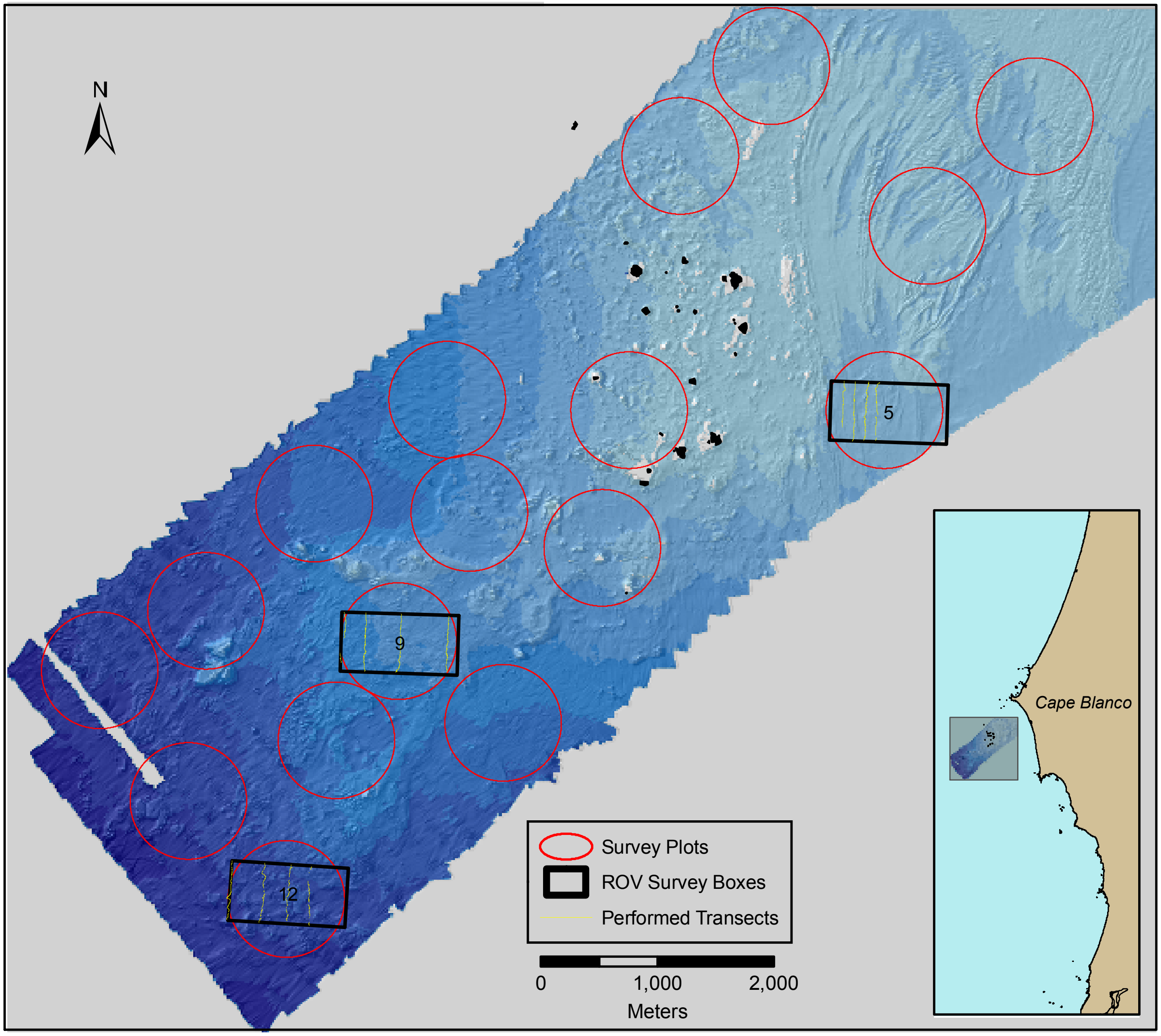


Figure 2.1. ROV Video SurveyTransects overlaid on multibeam bathymetry at Orford Reef.

Fig. 2.2. Phantom ROV – old configuration

Newtlite's from Nuytco Research Limited. The Newtlite delivers abundant true white light at 5600 degrees Kelvin for maximum color resolution. However, the increased payload demand brought on by the weight of these 200 watt HMI lights along with the added crash frames made it necessary to remove the lateral thruster. A digital altimeter (Tritech PA500) was mounted on top of the parallel lasers to be used for determining the distance from the front of the main camera to the substrate (ranging altimeter). Knowing this distance allows us to determine the altitude of the ROV and estimate the transect width. To enable us to know what angle the main camera is from horizontal we installed a tilt sensor (Crossbow CXTLA02) inside the main camera housing. Knowing the angle of the main camera allows us to know the trim of the ROV in space. In order to maintain a consistent speed, altitude, and heading of the ROV, we made several upgrades through D.O.E. To improve the ROV's flying, D.O.E. added a horizontal trim knob installed on the hand controller. This allowed us to dial in a speed for the given conditions and focus on maintaining altitude off the bottom. Second, the compass board was replaced with one that had a rate gyro (D.O.E. PSE 424 r2). This enabled the auto heading to keep the ROV on track without jerking back and forth, and aids in maintaining a consistent/smooth heading of the ROV. We refer to these upgrades as the "cruise control". Third, D.O.E. installed a pair of measurement devices to aid us in navigation and data processing.

The components used on the ROV for the Orford Reef Pilot Survey (Fig. 2.3) are: a Sony EVI-330 video camera (main camera, cam #1), two D.O.E. 15mW lasers (mounted on top of the camera housing and are aligned parallel at approximately 10 cm apart to provide a reference scale), a depth pressure sensor, a compass (D.O.E. PSE 424 r2), an On-Screen

Display video overlay (D.O.E. OSD-379), Imagenex model 881A digital multi-frequency imaging sonar, and an Offshore Research Equipment 4330B Multibeacon (for acoustic navigation). On the same twisted pair as the main camera we have a forward-looking camera set at a fixed 20° below horizontal (DEEPSEA Power & Light Multi *SeaCam* 1050, cam #2). A downward-looking video camera is set at a fixed downward angle of 40° below horizontal (DEEPSEA Power & Light Multi *SeaCam* 1060, cam #3). Two video monitors on the survey vessel provide a live feed from cameras. The main monitor displays cam #1 and #2, the second monitor displays cam #3. Universal Time Code, ROV depth, ROV heading, main camera tilt, and altimeter are overlaid on to the video from cam #1/#2 and displayed on the main monitor. Two digital decks record the video images onto MiniDV cassettes, a Sony DSR-45 (for cam #1/#2) and a Panasonic DV-2000 MiniDV (for cam #3).

Fig. 2.3. Phantom ROV configured for Orford Reef Pilot Survey

2.2.2 ROV Deployment / Retrieval

We chartered the F/V CRYSTAL SEA for our pilot survey. This single screw commercial fishing boat is thirty-three feet long and eleven and one-half feet wide. For 110 volt power we used the vessel's on board generator and for 240 volt we used our own portable generator. To deploy/ retrieve the ROV and clump weight the boat was equipped with a heavy duty davit arm that had a hydraulically powered winch (Fig. 2.4). Deployment follows the same protocol developed in our 2000/2001 field seasons, Amend, et al. (2001):

1) The support vessel is positioned upwind of the desired transect start location. This may vary depending on surface and subsurface currents.
2) The ROV is attached to the winch cable and lowered into the water.
3) The ROV is run out astern of the vessel until about 50 m of umbilical is paid out (the umbilical has gangion clips at 50 m and every 4 m thereafter to secure the umbilical to the vessel's winch cable). During this procedure, a small subsurface float is attached to the umbilical at the 25 m mark.
4) A 335 lb. "clump weight" is attached to the winch cable and lowered off the davit to about 2 m under the water surface.
5) A survey crew member clips the first umbilical gangion clip to the winch cable.
6) The clump weight is lowered about 4 m and the second umbilical gangion clip is clipped to the winch cable. The lowering and clipping process is repeated until the clump weight is approximately 6 m above the seafloor.

Retrieval follows these steps in reverse order.

Fig. 2.4. Davit arm F/V CRYSTAL SEA

### 2.2.3 ROV Navigation

Navigation of the ROV is achieved through a combination of acoustic and GPS data acquisition. The Trackpoint II (ORE) acoustic positioning system consists of a pole-mounted hydrophone, a beacon, a processing unit, and an external compass. The hydrophone pole is bracketed to the vessel via a custom-built swivel joint. The hydrophone, mounted on the end of this pole, extends vertically below the keel of the vessel. The beacon is attached to the ROV, mounted upright. There is also a beacon on the clump weight to track its location while the ROV is in the water. The processing unit is located in the vessel cabin and controls and filters the transmitted and received acoustic signals (2 seconds/pulse). The slant range, bearing, and depth signals are used to calculate the ROV's position relative to the hydrophone. Smoothing, ROV velocity threshold, and time gating filters are applied to the signals to remove errant echo returns. For nearshore work, we have been using the following filter settings with a high degree of success: Filter Level: LOW, Smoothing: ON, Threshold: MED-LO. The calculated relative ROV position and the magnetic heading (supplied by an external fluxgate compass) are finally sent as serial data to the navigation computer.

Hypack MAX Survey (©Coastal Oceanographics, Inc.) software is used for navigation, data acquisition, and processing of ROV position data. A Furuno GP37 differential GPS is mounted on the F/V CRYSTAL SEA, providing 1-2m accuracy of the vessel's position. The data string is sent to the navigation computer (Dell Latitude laptop, 1700MHz Pentium (R) M, 1.0 GB RAM, Quatech multi-port serial PCMCIA card), where it is displayed and logged. The vessel position data are then used by Hypack to interpret the ROV data sent by Trackpoint. A calculated geographic position of the ROV is then displayed and logged simultaneously.

The ROV pilot uses both the live video feed and the laptop's navigation screen to complete a dive. Attention is paid to ROV heading to keep consistent with the planned transect line. A second computer monitor displaying Hypack is situated in the vessel wheelhouse for use by the captain. Instructions on live-boat vessel navigation are given to keep the vessel and the ROV within the tether radius of the umbilical cable running out from the clump weight. Communication with the captain is essential to completing a safe and effective dive.

### 2.2.4 ROV Navigation Data Processing

The acoustic navigation data collected by HYPACK MAX Survey needs to be "cleaned up" before it is used for any kind of spatial analyses. This step is standard for acoustic data from Trackpoint II (Susan Merle, pers. comm.). Positional errors beyond a reasonable amount, not captured by the Trackpoint unit's filtering, need to be removed from the dataset.

HYPACK includes a Single Beam Editor program that, while primarily designed for bathymetric surveys, applies well to our ROV data. Criteria for position (x,y) and depth

(z) outliers can be selected to pick out errant points. At this time, we are using a 2m radius for x,y, and +/-1m for depth. The editing program uses these criteria as it scans the raw navigation file (transect). The scan stops when one location differs from the previously scanned location by one of the criteria (either location, depth, or both). The user can then (1) average the outlier using the adjacent points (good for isolated outliers), or (2) remove the outlier (typical if outliers are persistent for several seconds).

For geographic position to be "tied in" to video review observations (i.e. where and when was this organism seen), we use a relational database to match ROV navigation data to video interpretation data. Trackpoint navigation data are typically one position every two seconds. However, video data are recorded with accuracy to one second. The navigation data, after removing outliers, is run through Generic Mapping Tools sample1d program (GMT©, Paul Wessel and Walter H. F. Smith) which interpolates the points using an akima spline, generating a 1-second interval output navigation file. The two final 1-second files can then be related by time and joined in a database for data query and analysis.

### 2.2.5 Video Review

Video footage recorded during surveys is the most important unit of ROV data. We use MiniDV format to record the video. This format captures the resolution of the Sony camera mounted on the ROV, 460(H) x 350(V) lines. Review of the video is performed in our Newport office using the recording deck, a Sony DSR-45 digital videocassette recorder and Adobe Video Collection software to control the deck through a P.I. Engineering X-Keys Pad. Frame-by-frame advance with editing software allows for detailed identification of organisms, measurements, and habitat interpretation. We use a JVC TM-H1700 video monitor as the primary display for video review. The On-Screen Display unit overlays ROV depth, ROV heading, main camera tilt, and ranging altimeter on the recorded video. The time record obtained during review of the video is the Universal Time Code (UTC) that was overlaid onto the video signal and audio track by a Horita GPS3 and Sony DSR-45. The GPS3 and HYPACK get the UTC from the Furuno GPS and are later matched to the time HYPACK tags its data strings.

## 2.3 Initial Video Assessment

Typically, post-processing of ROV navigation data and video data begin at the same time. Thus, a video quality check is made while navigation data are also being checked. An initial run-through of ROV dive video seeks to identify sections that contain footage not considered usable for quantitative counts of organisms, ranging altimeter readings, and habitat identification. This assessment also identifies "Start" and "Stop" times of the sampling unit (in our case, a transect).

The judgment of footage usability is framed by the study design. For example, our transect-based study design requires "distance traveled" to be calculated from ROV navigation data.  If the ROV is pulled by the support vessel during live-boat operations, the distance traveled during the pull may be significant enough to distort the cumulative distance covered.  This time segment is then removed from the ROV navigation data prior to smoothing and interpolation as described in Section 2.1.4.

Another important data processing component  is bottom time coverage.  If there is need to rest the ROV on the bottom for a tape change or a video close-up, consideration must be given to the duration of this footage.  Our post-processing involves sampling the video at periodic intervals and one to several of these sampling intervals may fall within this stationary footage time frame.  During a close-up, an organism or bottom type may dominate the video, disproportionately representing itself in relative time. The “removal” of this footage consists of noting start and stop times, and then later *not collecting* visually interpreted review data during these times.

The beginning and end of the video sampling unit need to be identified prior to quantitative video review.  Similar to usable video, these endpoints are determined by reviewing the video, transect field notes, inspection of the track, line and planned transect line.  The transect notes contain the time when the ROV initially came within 25 m. of the planned line, start time.  Similarly, the end time, is recorded in the transect notes.

**2.4 Finfish Enumeration**

The digital video record of each transect is reviewed by two people simultaneously to more effectively spot all fish that come into the field of view.  Only fish that can be identified as present in the lower 80% of the video screen are counted.  This accounts for an unrealistic extension of the top of the camera’s field of view beyond the practical limits of visibility.  The UTC time, fish taxa, and fish count are recorded into a data base using the X-Keys Pad and Time code Wedge.

Nineteen species of adult fish were identified to species level.  All other fish were placed into one of seven generalized fish groups (Table 2.1).  Rockfish that can not be identified to species are recorded as a generalized rockfish species.  Juvenile rockfish (principally young-of-the-year) are recorded without a reference to their species.    Flatfish are also counted, but not identified to species, and are recorded as generalized flatfish.  The generalized sculpin group includes members of the family Cottidae other than cabezon.  It is probable that some very small fishes or very cryptic species are unobserved and unrecorded.

Each fish or taxonomic unit has a UTC time record attributed to it in the database.  UTC time is obtained from the tapes time code track.  Fish count / UTC time data also contain an "instantaneous" interpretation of benthic habitat type that describes the habitat in the immediate vicinity of the fish.

Table 2.1. Species and generalized groups used for finfish enumeration of the Orford Reef Pilot Survey.

| Ninteen Species |
|---|
| Black Rockfish (Sebastes melanops) |
| Blue Rockfish (S. mystinus) |
| Canary Rockfish (S. pinniger) |
| Rosethorn Rockfish (S. helvomaculatus) |
| Yelloweye Rockfish (S. ruberrimus) |
| Yellowtail Rockfish (S. flavidus) |
| Copper Rockfish (S. caurinus) |
| China Rockfish (S. nebulosus) |
| Vermilion Rockfish (S. miniatus) |
| Quillback Rockfish (S. maliger) |
| Tiger Rockfish (S. nigrocinctus) |
| Brown Rockfish (S. auriculatus) |
| Kelp Greenling (Hexagrammos decagrammus) |
| Lingcod (Ophiodon elongatus) |
| Painted Greenling (Oxylebius pictus) |
| Cabezon (Scorpaenichthys marmoratus) |
| Wolfeel (Anarrhichthys ocellatus) |
| Spotted Ratfish (Hydrolagus colliei) |
| Halibut (Hippoglossus stenolepis) |
| **Seven Generalized Fish Groups** |
| "Eelpout" (several possible families) |
| Flatfish (Pleuronectiformes) |
| Juvenile Rockfish |
| Rockfish Species (Genus Sebastes) |
| Sculpin (Cottidae) |
| Surf Perch (Embiotocidae) |
| Unidentified Fish |

## 2.5 Transect Area Estimation

An important piece of information needed to quantify benthic attributes and fish densities is the transect area. This step requires estimating seafloor surface area sampled in the video. We used the relationship between lasers and transect width to calculate the ranging altimeter reading to transect width. The laser to transect width relationship was based on work of Wakefield and Genin (1987), as adapted by Amend, et al. (2001). The ranging altimeter allows us to have a second by second estimate of the transect width. The transect width for every second is then multiplied by the distanced traveled every second. The area for each second is then summed over the duration of the transect to give total transect area.

## 2.6 Habitat Classification and Segmentation

We use a substrate classification system described in Fox, et al. (1998), with a few modifications to speed the review process (Table 2.2). Habitats are segmented along the transect by viewing the tape looking for only one of the substrate categories at a time. This substrate must be continuous for a period of at least ten seconds and be a major component of the substrate.

The method of extracting habitat type from video differed from previous years in that the video was scanned multiple times, recording one habitat type per visual scan. No estimate of percent cover was recorded, nor were habitat types qualified as primary or secondary. During data processing, the multiple scans were synchronized by time, resulting in some transect segments having more than one habitat type. The dominant habitat type could not be discerned for reasons mentioned above, so all habitat types were weighted equally when appearing together in a transect segment.

Our intention was to examine Orford Reef habitats at varying spatial scales to explore how this might affect our analysis and predictability of fish-habitat associations. Ideally, bottom relief would be a more meaningful habitat condition than substrate type alone to compare at different spatial scales, however the video data were processed without habitat relief qualifiers on which to base such a comparison. Another limiting factor is that the ROV altimeter could not be used to calculate bottom relief as it was not angled directly vertically below the ROV. The ROV altimeter data cannot provide the depth data necessary to conduct this analysis because it is not directed straight down. Instead, we provide a simple qualitative comparison of spatial scale on substrate-habitat type. ROV video observations provide a fine scale approach and sidescan sonar data from a previous survey of Orford Reef (1995) provide a broad scale approach. Between these data sets, enough differences occur that only a qualitative comparison is warranted.

Table 2.2. Description of substrate categories used in the Orford Reef Pilot Project, with single letter code and interpretive guide.

| Substrate | Code | Interpretation |
|---|---|---|
| Bedrock | F | >3m |
| Sm. Boulder | B | 0.25-1m |
| Lg. Boulder | L | 1m- 3m |
| Cobble | C | 64-250 mm |
| Gravel | G | 2-64 mm |
| Sand | S | 0.06-2mm |

## 3. Results

### 3.1 ROV Operation and Survey Coverage

We successfully surveyed four randomly selected transects (500 m each) in each of three boxes on May 20 and September 25 and 26, 2006 (Figure 2.4). Some equipment and electronic failures consumed partial days at sea on other dates that resulted in no data collected. Our expectation was to conduct surveys on all available days-at-sea (six) during the summer months, however, strong and persistent winds through the summer of 2006 prevented at-sea operations between May and late September resulting in only four and a half survey days. On each of the effective survey days, we found that vessel travel between Port Orford and Orford Reef and four survey transects fully consumed a contracted nine hour vessel-day.

### 3.2 Observations of Fish and Habitats

For purposes of this pilot study, the survey box was the sampling unit, and we have one measure for each box representing deep, intermediate and shallow depth strata. We present average density of each fish species or taxonomic grouping (Table 3.1) based on each individual box surveyed.

We observed ten rockfish species and at least nine other fish species during our survey. Some fishes could be identified only to higher taxonomic group (e.g. flatfish, sculpin, and eelpout/gunnel) as we could not resolve key features important to identification at the species level. Blue rockfish (*Sebastes mystinus*) and kelp greenling (*Hexagrammos decagrammus*) were the two most abundant species observed. Both were found only in the shallow and intermediate depth boxes. The greatest numbers of fish species, individual fishes, and fish density were observed in the intermediate depth box with a depth range of 43-59 meters. In addition to blue rockfish and kelp greenling, rosethorn rockfish (*S. helvomaculatus*) were particularly abundant there. The lowest number of species, individual fish and fish density were observed in the deepest box (depth range = 72-99 meters). Table 3.1 presents a summary of fishes observed based on number of individuals, density (#/100 $m^2$) and percent of total fish for each of the three boxes surveyed. Figure 3.1 shows the densities of the most abundant species in each of the three boxes. Figures 3.2 a – c depict the relative community composition for each box.

The proportions of benthic habitat types for each survey box based on video observations are summarized in Figure 3.3. Benthic habitat in each surveyed box was composed principally of boulder and bedrock. Cobble, gravel and sand were proportionately much less prevalent. The relative proportion of bedrock decreased with depth, while the relative proportion of rock pieces of smaller sizes increased with depth. For example, survey Box 5 was dominated by bedrock, (54%) or bedrock mixed with boulder, cobble or gravel. In aggregate, bedrock was found in 76% of the surveyed area. Survey Box 9 was dominated by small boulders (39%). Large and small boulders mixed (19%) and large boulder were also prevalant (13%).  Bedrock was a minor habitat type (13%) and cobble and gravel contributed less than 5%.  Survey Box 12 was dominated by gravel (25%), small boulder (22%) and gravel-sand mixed (17%). Bedrock and large boulder were minor components here (12% and 7%, respectively).

Spatial overlay analysis of habitat features using GIS confirmed the discrepancies in the habitat interpretation methods used on the sidescan sonar data and the video observation data (Fig. 3.4). Survey Box 5 is the only one video survey that overlaps that portion of the reef previously surveyed with sidescan sonar. Not surprising, the video observation method detected greater variety of habitat types and at a greater frequency of occurrence than the sidescan method. In Survey Box 5, eleven substrate types, including substrate combinations, were detected from video observations. As noted previously, bedrock was the dominant substrate type there. Other substrate types, in order of decreasing percentage,  were bedrock-small boulder mix, small boulder, cobble, bedrock-cobble mix, and bedrock-gravel mix). In contrast, only five substrate types were detected from sidescan sonar  in Box 5. The dominant substrate was large boulder, and to a lesser extent, small boulder, bedrock, and largeboulder- small boulder mixed.

Expanding the view out from Box 5 to a larger expanse of reef, shows the full array of habitat types described with sidescan sonar. Patterns and formations in the substrate become apparent (Figures 3.5 and 3.6). Multibeam sonar imagery acquired in 1999 (Fox, 1999) is overlaid on the sidescan image, adding complexity and relief to an otherwise two-dimensional view. This presents a more realistic and three dimensional view of Orford reef, and better models the habitat that exists there.

Principal macro-invertebrate groups observed include sea anemones (esp. *Metridium giganteum*), cup corals (*Balanophyllia elegans* and/or *Paracyathus stearnsii)*, basket stars (Ophiuroidea), and sea cucumbers (Holothuroidea). We did not attempt to identify all macroinvertebrates observed, nor did we quantify their abundance. We also observed numerous small individuals (10 – 20 cm) of bull kelp (*Nereocystis luetkeana*) in the most shallow box surveyed.  There were numerous other epilithic organisms observed, but small size or limited visibility prevented identification.

Table 3.1 Density and Fish Species Observed During the 2006 Orford Reef Pilot ROV Survey.
Depths reported are based on ROV depth gauge and are not true bottom depths.

| | Box 5 (shallow) Mean Depth: 26.0 m Range: 20.9 - 30.1 m | | | Box 9 (intermediate) Mean Depth: 51.1 m Range: 43.2 - 58.5 m | | | Box 12 (deep) Mean Depth: 86.3 m Range: 72.1 - 98.7 m | | |
|---|---|---|---|---|---|---|---|---|---|
| | number | density (#/100 $m^2$) | % (of individuals observed in box) | number | density (#/100 $m^2$) | % (of individuals observed in box) | number | density (#/100 $m^2$) | % (of individuals observed in box) |
| All Fishes | 122 | 2.56 | 100% | 302 | 4.48 | 100% | 53 | 1.05 | 100% |
| Black Rockfish (*Sebastes melanops*) | 9 | 0.19 | 7.4% | 0 | 0.00 | 0.0% | 0 | 0.00 | 0.00% |
| Blue Rockfish (*S. mystinus*) | 46 | 0.96 | 37.7% | 55 | 0.82 | 18.2% | 0 | 0.00 | 0.00% |
| Canary Rockfish (*S. pinniger*) | 13 | 0.27 | 10.7% | 0 | 0.00 | 0.0% | 4 | 0.08 | 7.55% |
| Rosethorn Rockfish (*S. helvomaculatus*) | 0 | 0.00 | 0.0% | 40 | 0.59 | 13.2% | 4 | 0.08 | 7.55% |
| Yelloweye Rockfish (*S. ruberrimus*) | 0 | 0.00 | 0.0% | 7 | 0.10 | 2.3% | 0 | 0.00 | 0.00% |
| Yellowtail Rockfish (*S. flavidus*) | 0 | 0.00 | 0.0% | 7 | 0.10 | 2.3% | 8 | 0.16 | 15.09% |
| Copper Rockfish (*S. caurinus*) | 2 | 0.04 | 1.6% | 2 | 0.03 | 0.7% | 0 | 0.00 | 0.00% |
| China Rockfish (*S. nebulosus*) | 1 | 0.02 | 0.8% | 9 | 0.13 | 3.0% | 0 | 0.00 | 0.00% |
| Vermilion Rockfish (*S. miniatus*) | 0 | 0.00 | 0.0% | 6 | 0.09 | 2.0% | 0 | 0.00 | 0.00% |
| Quillback Rockfish (S. *maliger*) | 2 | 0.04 | 1.6% | 3 | 0.04 | 1.0% | 0 | 0.00 | 0.00% |
| Unidentified Rockfish | 0 | 0.00 | 0.0% | 6 | 0.09 | 2.0% | 11 | 0.22 | 20.75% |
| Juvenile Rockfish | 12 | 0.25 | 9.8% | 73 | 1.08 | 24.2% | 3 | 0.06 | 5.66% |
| Kelp Greenling (*Hexagrammos decagrammus)* | 28 | 0.59 | 23.0% | 54 | 0.80 | 17.9% | 1 | 0.02 | 1.89% |
| Lingcod (*Ophiodon elongatus)* | 2 | 0.04 | 1.6% | 9 | 0.13 | 3.0% | 1 | 0.02 | 1.89% |
| Painted Greenling (*Oxylebius pictus*) | 0 | 0.00 | 0.0% | 0 | 0.00 | 0.0% | 1 | 0.02 | 1.89% |
| Cabezon (*Scorpaenichthys marmoratus)* | 1 | 0.02 | 0.8% | 0 | 0.00 | 0.0% | 0 | 0.00 | 0.00% |
| Sculpin (Cottidae) | 3 | 0.06 | 2.5% | 5 | 0.07 | 1.7% | 1 | 0.02 | 1.89% |
| Wolfeel (*Anarrhichthys ocellatus*) | 0 | 0.00 | 0.0% | 1 | 0.01 | 0.3% | 0 | 0.00 | 0.00% |
| Spotted Ratfish (*Hydrolagus colliei*) | 0 | 0.00 | 0.0% | 0 | 0.00 | 0.0% | 14 | 0.28 | 26.42% |
| "Eelpout" (several possible families) | 0 | 0.00 | 0.0% | 6 | 0.09 | 2.0% | 0 | 0.00 | 0.00% |
| Flatfish (Pleuronectiformes) | 0 | 0.00 | 0.0% | 0 | 0.00 | 0.0% | 1 | 0.02 | 1.89% |
| Unidentified Fish | 3 | 0.06 | 2.5% | 19 | 0.28 | 6.3% | 4 | 0.08 | 7.55% |

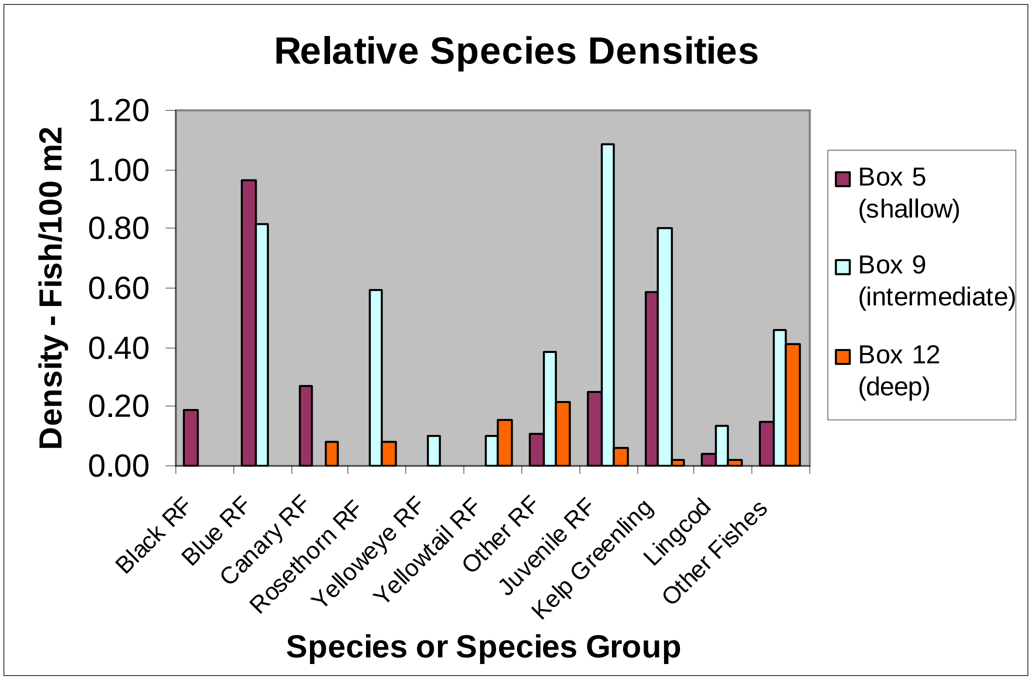


Figure 3.1 Densities of the most abundant fish species or groups in three survey boxes on Orford Reef.

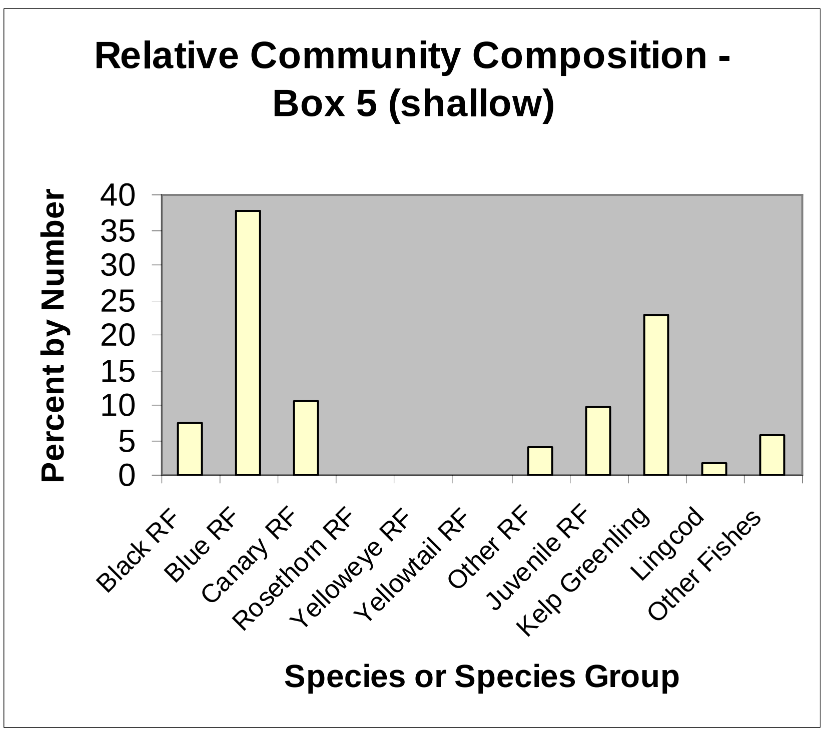


Figure 3.2a Relative community composition of the principal fish species and groups in the most shallow box surveyed on Orford Reef.

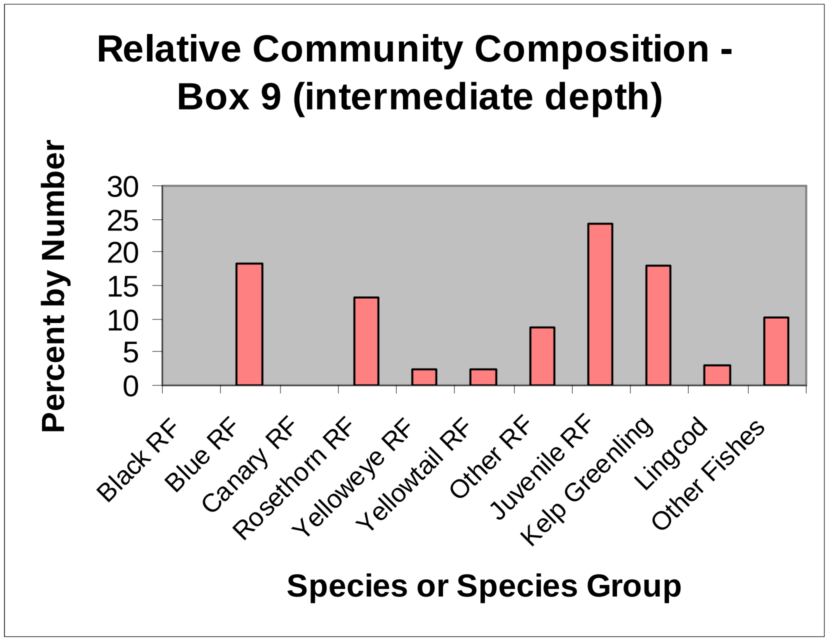


Figure 3.2b Relative community composition of the principal fish species and groups in the intermediate depth box surveyed on Orford Reef.

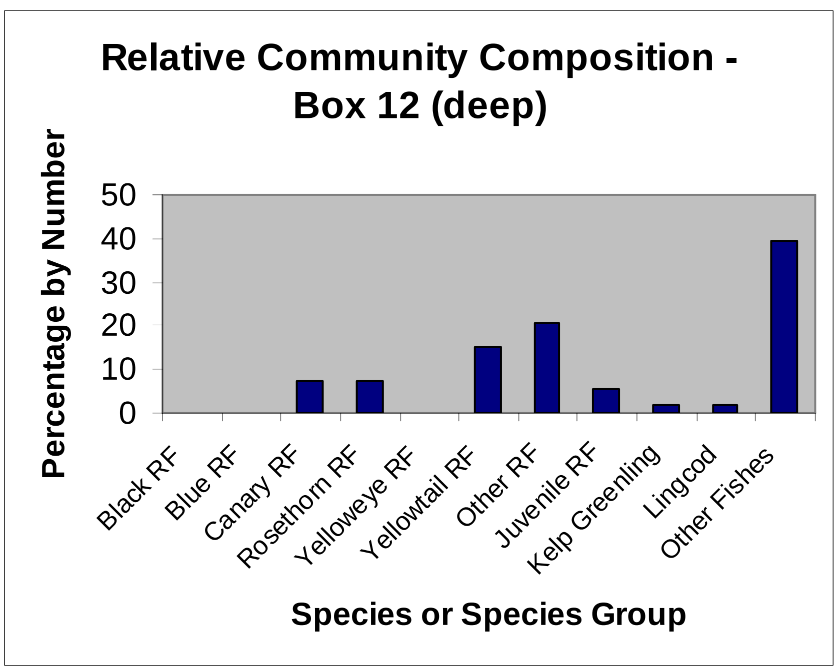


Figure 3.2c Relative community composition of the principal fish species and groups in the deepest depth box surveyed on Orford Reef.

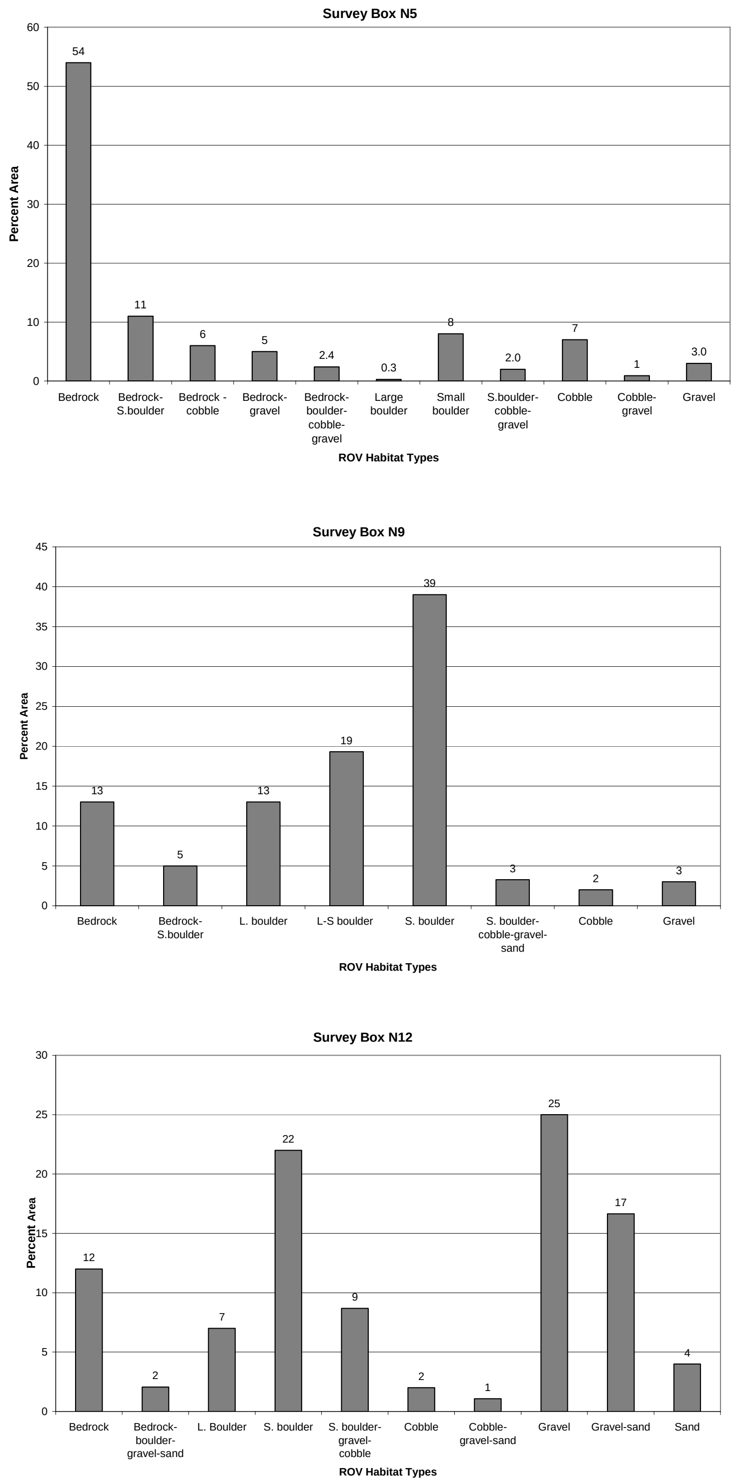


Figure 3.3. Dominant habitat types observed in each survey box expressed as percent habitat area.

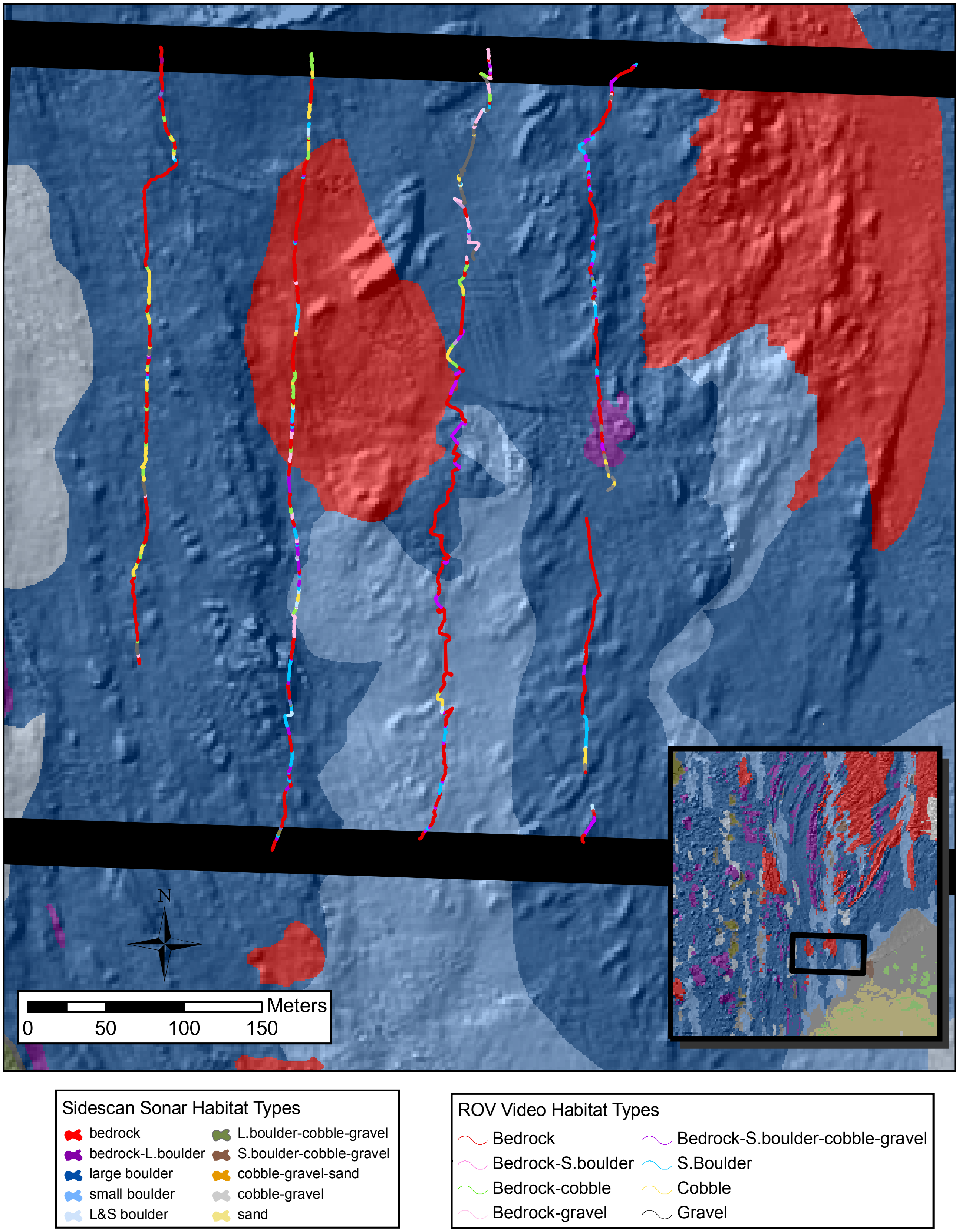


Figure 3.4. Survey Box 5 with ROV video transect habitats overlaid on habitats as interpreted from sidescan sonar.

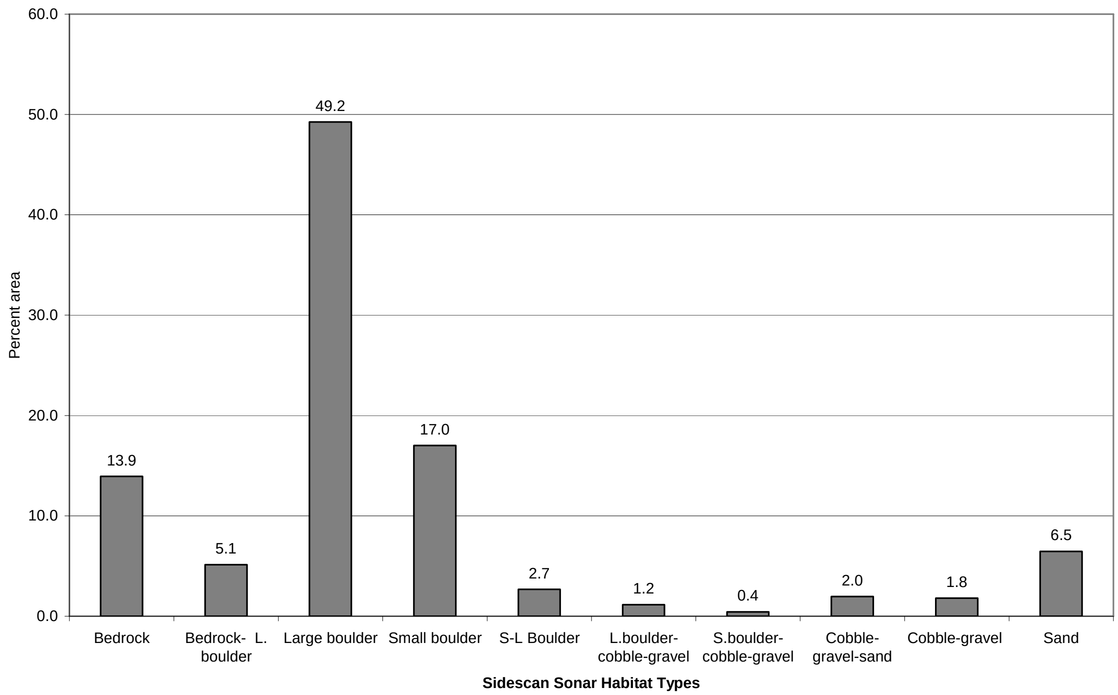


Figure 3.5. Habitat types of Orford Reef interpreted from 1995 sidescan sonar survey imagery (2m resolution).

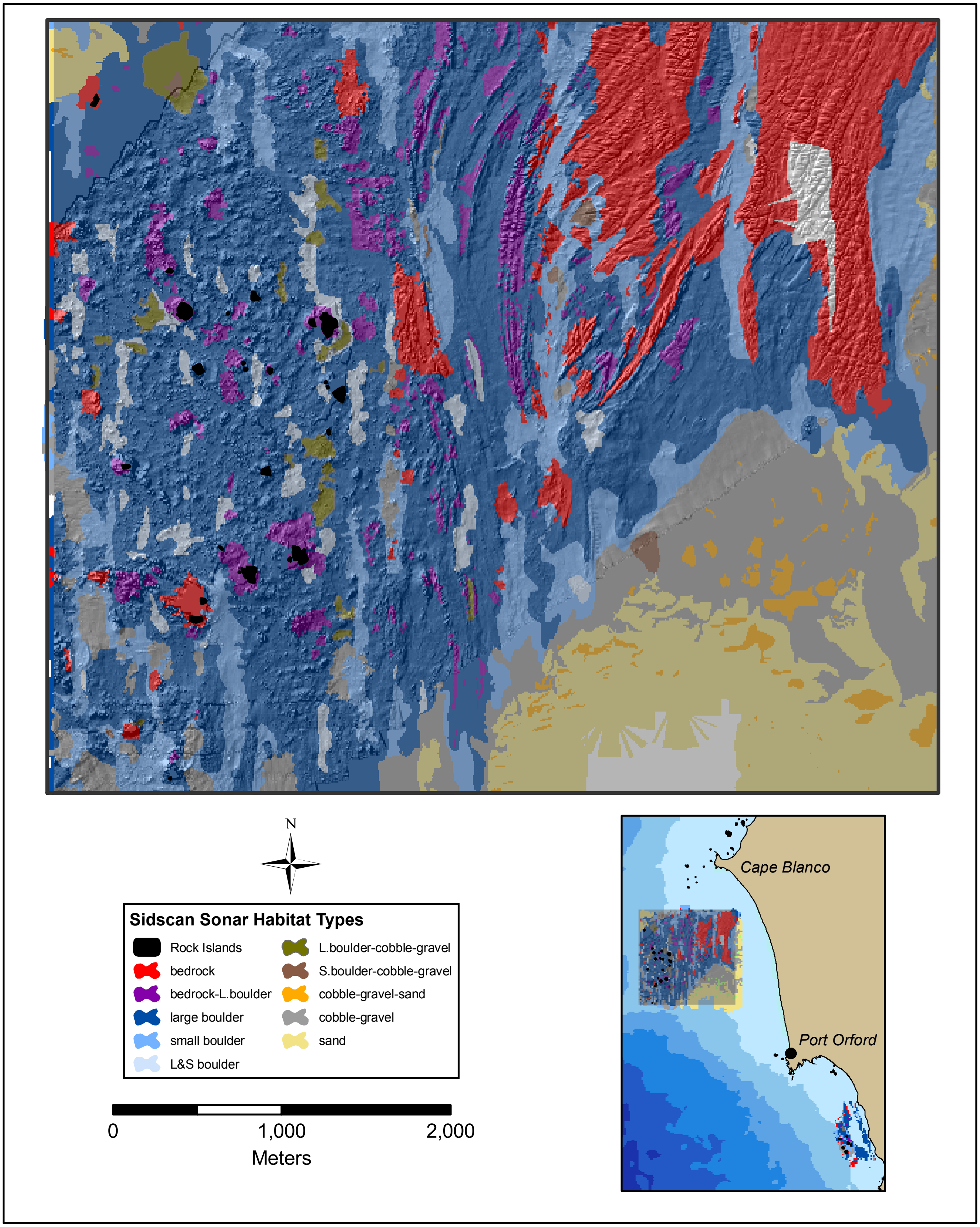


Figure 3.6. Orford Reef: Overlaid images of sidescan sonar and multibeam bathymetry. Habitat interpretation by Geologic Survey of Canada, 1995.

## 4. Discussion and Management Implications

The 2006 Orford Pilot ROV survey had three fundamental objectives. First, could we safely and effectively launch, retrieve and operate the ROV from a small commercial fishing vessel? Second, what was a realistic level of survey coverage that could be accomplished in a full working day? And third, to collect preliminary information on fishes of Orford Reef. We successfully accomplished each of these objectives.

The ROV and associated equipment were a tight fit on the F/V Crystal Sea, both on deck (ROV and cable reel) and in the cabin (electronics). While space was at an absolute premium, the arrangement was functional. Modifications to the vessel by the owner, specifically installation of an aluminum davit with a winch (Fig 2.3), made launch and retrieval of the ROV and the associated clump weight possible. Installation of a plywood table to expand the horizontal surface of the port cabin shelf significantly eased the space constraints imposed by the four electronics boxes. Launch and retrieval of the ROV was accomplished smoothly, and survey operations were readily coordinated between the cabin and the deck.

We were consistent in surveying four 500 meter transects within a survey box on each of our successful survey days. In combination with vessel time and from the reef, we believe that this is a reliable estimate of the level of survey coverage that can be performed in a full workday. A reliable effort of potential survey coverage will be an important element to incorporate into the future survey planning on Orford Reef.

Because Oregon's nearshore ocean, and in particular, high relief rocky reefs, are areas not surveyed by traditional NOAA Fisheries trawl surveys for developing quantitative estimates of fish abundance, there is interest in developing alternative methodology that can provide comparable quantitative information for high relief rocky habitats. One underlying motivation for this pilot survey was to investigate whether this was a realistic expectation.

Interpretation and management applications of visual survey results must take into account possible changes in fish behavior in response to the lights or sound of the survey platform. (Trenkel et al 2004a, 2004b, Stoner et al. in prep.) There is anecdotal evidence that fishes can be distracted by the presence of an ROV (Miller, Weeks personal observation). Some species, such as cabezon, are cryptic and tend not to move when approached by the ROV. Consequently, without attraction or repulsion, there is a potential for underestimating species such as this based only on unaltered behavior patterns. These considerations strongly suggest that results of visual surveys are best used as an index of relative abundance unless adequate calibration studies are performed.

Using visual surveys as a relative index of abundance can allow comparisons of fish density over time, or between different locations of comparable habitat qualities. The intensity of observations needed to detect differences between differing times or locations will be a function of variability in survey operations, environmental factors, as well as any actual differences in density. Survey operations should be standardized or varied as little as possible. Environmental conditions (e.g. water clarity and visibility) obviously cannot be controlled.

In general, discerning differences in density with a certain level of statistical confidence is a function of the absolute differences in density between sampling units (a box), the variability in density within a sampling unit (i.e. from survey transect to survey transect within a box), and the number of survey transects conducted in each sampling unit. Thus, the nature of the management question (e.g. needing to know whether the difference is 10%, 25% or 50% from some baseline) will strongly influence the survey design, and hence the data needs and expense, to answer the question. (Fox et al. 2000) As an example, the observed difference in kelp greenling density between Box 5 and Box 9 is not statistically significant (alpha=0.05). A preliminary power analysis suggests that we would have had to conduct 8 survey transects, rather than the actual 4, for this difference to be statistically significant.

Another important value of ROV surveys is to ground-truth sonar surveys. In the one survey box (5) that overlapped with the 1995 sidescan sonar survey, we noted important differences in relative proportions of habitat types. One factor contributing to the discrepancy in habitat types between the sidescan data and video observation data is that minimal ground-truthing of the sidescan data was conducted to validate the interpretation at the time of this sonar survey. (Fox et al. 1998). Also, some ground-truthing surveys did not use dGPS, so edges of habitat polygons are subject to greater error, in some cases up to 200 m.

Another factor is differences in how habitat types are classified, primarily with respect to bedrock, large boulder and small boulder. The sidescan method differentiates between small and large boulder at a diameter of 2 m. The video method uses a 1m diameter and classifies large boulders between 1 and 3 m. In addition, the sidescan interpretation had difficulty interpreting some sonar signatures. Ground-truthing found that the sidecan interpretation consistently overestimated boulder size, classifying boulders as large (>2m) when they were between 1 and 2 m diameter. A qualitative discrepancy between the two approaches was in classifying very large rock structures as either fractured bedrock or large boulder. Structure that might be called boulder in the video process would be classified as bedrock in the sidescan process. This is readily apparent upon visual inspection (Fig. 3.4)

Other differences in habitat interpretation are explained by the issue of scale. The field of view of the ROV video survey is less than three meters. For this reason, rock structure larger than the field of view, or greater than 3 meters, is classified as bedrock since boulders larger than 3 meters cannot be viewed or measured. The sidescan interpretation, having a much broader view of the reef, detected boulders at sizes greater than 2m and could differentiate extremely large boulders from bedrock. Given sidescan's broader 'field of view' of the reef, the complexities of characteristics between bedrock and boulder are perhaps more readily discernable. Video observations, however, occur at a much finer scale, thus allowing the detection of more frequent and subtle changes in substrate type that is not possible with sidescan.

In this survey, the ROV video review methods differed from previous surveys at other reefs by not including habitat relief codes or differentiating between primary and secondary habitat types where habitat types overlapped (Fox et al., 1998). Orford Reef is characterized by rock ridges, fractured rock, and rock pinnacles – all features that provide tremendous vertical relief. By not including a vertical relief component in the data, habitat characteristics as described in this study are less meaningful, with regard to fish utilization. Vertical relief is an important habitat component for fish. In addition, it is quite useful in ground-truthing sonar data. Future surveys of Orford Reef should use a habitat classification system similar to the initial system designed by Fox et al (1998).

Rocky reef surveys must address the issue of spatial scale and resolution from several perspectives, which may or may not coincide. First is the scale at which habitat is meaningful to fish, how individuals use habitat features for foraging, shelter and other activities, and how these features are distributed. Second is the spatial scale at which inferences of fish-habitat associations are possible. This incorporates consideration of fish behavior, along with the data collection capacity of the tools available. Third, we must consider the spatial scale that provides usable information for fisheries management. Lastly, it must also be noted that the dynamic and seasonal environments that characterize Oregon's nearshore rocky reefs also change dramatically with time on several scales (daily, tidal sequence, seasonal as well as interannual changes) and temporal changes further compound our understanding of spatial scales of habitat use.

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