Nearshore habitat associations of young-of-year copper (*Sebastes caurinus)* and quillback (*S. maliger)* rockfish in the San Juan Channel, Washington.

Jessica Hayden-Spear

A thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Science
University of Washington
2006

Program Authorized to Offer Degree:
School of Aquatic and Fishery
Sciences

University of Washington
Graduate School

This is to certify that I have examined this copy of a master's thesis by

Jessica Hayden-Spear

and have found that it is complete and satisfactory in all respects, and that any and all revisions required by the final examining committee have been made.

Committee Members:

____
Donald R. Gunderson

____
Raymond M. Buckley

____
Terrie Klinger

____
Wayne Palsson

Date: ______________________

University of Washington

Abstract

Nearshore habitat associations of young-of-year copper (*Sebastes caurinus)* and quillback (*S. maliger)* rockfish in the San Juan Channel, Washington.

Jessica Hayden-Spear
Chair of the Supervisory Committee:
Professor Donald R. Gunderson
School of Aquatic and Fishery Sciences

I established SCUBA survey methods for young-of-year (YOY) copper (*Sebastes caurinus*) and quillback (*S. maliger*) rockfishes and used these to conduct density and habitat assessments in the San Juan Channel in 2004 and 2005. Results from both years indicated that YOY copper and quillback rockfishes occur primarily in areas with a high percent coverage (60 - 100%) of understory kelp at shallow depths (1.5 - 4.5 m). YOY copper and quillback rockfishes were patchily distributed in these areas, and predator densities did not seem to be a factor in determining which areas were utilized. These findings suggest that preserving shallow-water understory kelp habitats is a critical part of the conservation and management of copper and quillback rockfishes in the San Juan Archipelago.

Table of Contents

Page

List of Figures

List of Tables

Table Number **Page**

Acknowledgements

Thanks to my advisor Donald Gunderson, as well as my committee members Raymond Buckley, Wayne Palsson, and Terrie Klinger. Your input and involvement are greatly appreciated. Also, thanks to all those who provided invaluable advice, especially Bob Pacunski, Jeff Christiansen, Miles Logsdon, and Nick Lowry. In addition, thanks to Pema Kitaeff, Brent Leithauser, Tim Dwyer, Kim Barrett-Smith, Roddy Foley, Brandon Jensen, Jason Hall, and all other field techs and volunteers, as well as the faculty, staff and students at Friday Harbor Labs. This project would not have been possible without funding from the following sources: Washington SeaGrant, UW-SAFS, GSFEI Graduate Student Travel Award, Floyd E. Ellis Memorial Scholarship, Richard T. Whiteleather Fisheries Scholarship, and the Claire L. and Evelyn S. Egdvedt Fellowship. And finally, thanks to my friends and family for all their support. Thanks to my parents for listening and advising. Dad, thank you for being such an excellent editor. Tom, thank you for your unconditional support and for your endless patience.

Introduction

Copper (*Sebastes caurinus*) and quillback (*S.* maliger) rockfish populations in the San Juan Archipelago have declined sharply in recent years (PSAT 2002). These declines may be attributed to fishing pressures, because these species are frequently targeted by recreational fishermen in Puget Sound (Stout et al. 2001) and dominate the recreational catch in the San Juan Archipelago. Rockfish are also incidentally taken in the recreational salmon fishery.

In response to these declines, bag limits in the San Juan Archipelago were reduced from ten rockfish per person per day to five in 1994. In 2000, bag limits were further reduced to the current bag limit of one rockfish per person per day. Over approximately the same period, twelve marine protected areas (MPAs), or marine reserves, were created in the San Juan Archipelago. Four of these are regulatory reserves from which the removal of rockfish is prohibited; eight others are voluntary reserves from which the removal of rockfish is discouraged. Copper rockfish and lingcod (*Ophiodon elongatus*) were found to be larger and more abundant inside some of the regulatory reserves in the San Juan Channel, compared to nearby sites outside reserves (Eisenhardt 2001). Despite these protective measures, copper and quillback rockfish populations in the area continue to decline (PSAT 2002).

A remotely operated vehicle (ROV) survey of subtidal habitats at 3 to 150 meters depth within the San Juan Channel conducted in 2004 showed that copper and quillback rockfishes dominated the adult rockfish fauna, with other species of rockfish being relatively uncommon (Robert Pacunski, Washington Department of Fish and Wildlife, 2006, pers. comm.). While it is known that adult copper and quillback rockfishes prefer high relief, rocky reef habitat (Pacunski and Palsson 2002), much less is known about the habitat associations of young-of-year (YOY or 0+ age) in the San Juan Archipelago (Buckley 1997). Knowledge of YOY copper and quillback rockfish habitat associations will help determine which habitats need protection in order to manage and conserve rockfish populations in the San Juan Archipelago.

Carr (1991) found that YOY copper rockfish recruit to canopy kelp off the central coast of California. Matthews (1990) observed YOY copper, quillback, and brown rockfish in eelgrass and understory kelp in Puget Sound, but never observed any YOY rockfishes in canopy kelp. In the Strait of Georgia, Haldorson and Richards (1986) found that copper rockfish recruit to kelp beds in August, and then move to eelgrass and *Agarum* beds in September and October. Buckley (1997) reported YOY quillback rockfish on shallow (<20 meters depth) rocks in artificial reefs in Puget Sound, and hypothesized that they might initially settle in deep water on unknown habitats, and may use benthic drifting algae as protective habitat to move into areas with kelp canopy and understory kelp. Thus, previous work indicated where to start looking for YOY copper and quillback rockfishes. However, we still need more detailed information about habitat associations of YOY copper and quillback rockfishes in the San Juan Archipelago if we hope to improve local conservation efforts of these species. The goal of this study is to conduct quantitative surveys to examine YOY copper and quillback habitat associations over time in natural habitats in the San Juan Channel.

Methods

In 2003 and 2004 I surveyed several areas using a towed video camera, and used habitat information from these video surveys to choose six sites within the San Juan Channel for further study: Tift Rocks, Shady Cove, Pt George, North Bay, Shark Reef, and Cattle Pt (Figure 1). I chose these sites because each included a variety of habitat types including understory kelp, eelgrass, and Ulvoids, and because these sites are distributed along the Channel. Each site was defined as a 100 - 300 meter length of shoreline. Site length varied in order to include the greatest variety of habitat types possible at each site. During July 2004 I performed weekly snorkel surveys to monitor rockfishes within the kelp canopy, based on previous findings that YOY copper rockfish move from the pelagic zone to kelp canopy in early summer, before finally settling into nearshore habitats shortly thereafter (Buckley 1997). I began seeing YOY rockfish in the kelp canopy in late July 2004 and initiated the SCUBA surveys immediately. Surveys were conducted July 28 - September 15, 2004 and July 18 - September 20, 2005.

For SCUBA surveys, each site was subdivided into sampling points approximately ten meters apart along a line parallel to the shoreline. From a randomly selected sampling point, I moved perpendicular to the shoreline until I reached one of four randomly selected seafloor depths (3, 6, 9 or 12 meters). This location and depth was the starting point for each dive. From this starting point I then swam consecutive 5-meter transects along the depth contour. I swam in a direction so as to maintain constant depth and reasonably constant sampling speed relative to the current. Each dive consisted of 7 - 25 consecutive 5-meter transects. Over the course of the study I dove each site 9 - 13 times from multiple randomly selected sampling points and depths. I did not go deeper than 12 meters because YOY copper and quillback rockfish are found in relatively shallow waters in the summer (Buckley 1997). In order to eliminate tidal height as a potentially confounding variable I dove each site at high and low tide before moving on to the next site. I conducted 39 dives in 2004 and 22 in 2005.

The transect line was defined by a 5-meter, collapsible PVC pole placed along the depth contour. Diver #1 then swam the length of the pole, pressing down any vegetation in an attempt to flush out YOY. This diver searched for fish two meters or less from the bottom and one meter to either side of the pole, and counted individuals of all species of rockfish (copper, quillback, and Puget Sound rockfish (*Sebastes emphaeus*)), lingcod (*Ophiodon elongatus*) and greenling (*Hexagrammidae* spp.) using the approximate size categories given in Table 1. Diver #2 followed several meters behind Diver #1 and conducted point-contact habitat surveys (Murray et al. 2006) by noting all vegetation types present (Table 2) at each

1-meter increment, from 0-5 meters along the pole (6 observations). During each dive I swam as many 5-meter transects as possible, depending on limitations such as water temperature, current speed, and air consumption. I averaged 19 transects per dive in 2004 and 14 transects per dive in 2005.

It was not possible to visually differentiate YOY rockfish species (particularly copper and quillback) in the field or in the laboratory at the time surveys were conducted. In an effort to confirm species composition I collected 26 YOY rockfish from sites near our study area. Twenty of these YOY were raised in tanks until they were large enough to visually identify. Six were subjected to genetic analysis. Of the 20 YOY maintained in the lab, 12 proved to be quillback rockfish. The remaining eight were either quillback or copper rockfish. Mitochondrial and satellite DNA analyses are still in progress, but of the six fish processed, four were quillback, one was a copper, and one was identified as either a copper, quillback, or a hybrid of the two (Piper Schwenke, NOAA, 2006, pers. comm.).

I converted the point-contact observations into percentages by summing the number of contact points for each vegetation type (including "no algae") and dividing this by the total number of observations. More than one vegetation type could be present at each contact point. For example, if understory kelp was present at 5/6 contact points along a particular transect, the transect was considered 83.33% understory kelp.

However, if branched red algae were present at 3/6 contact points, this transect was also 50% branched red algae. The total vegetative cover for this transect would be 133.33%.

Several brief behavioral studies were conducted to observe the reaction of YOY rockfish to the pole used in sampling. We categorized reactions as attraction to, avoidance of, or neutral reaction to the pole. For behavioral studies, I chose an area where YOY rockfish had previously been sighted. Once a YOY rockfish was located, I placed a 1-meter PVC pole on the seafloor immediately adjacent to it and observed any reaction to the pole. I conducted 13 trials on 14 individuals. Typically (73% of observations) the YOY rockfish moved less than 0.5 meters, and then remained stationary, even when a diver was present. Twenty-seven percent of the time the YOY rockfish showed no reaction at all. The behavioral studies support our assumptions that YOY rockfish are not significantly affected by the PVC pole used to indicate each transect, nor by the diver holding the pole. Because our transect width was 1 meter, results are not affected by fish avoidance and suggest that there is little potential for double-counting or undercounting because fish moved away from the counting area.

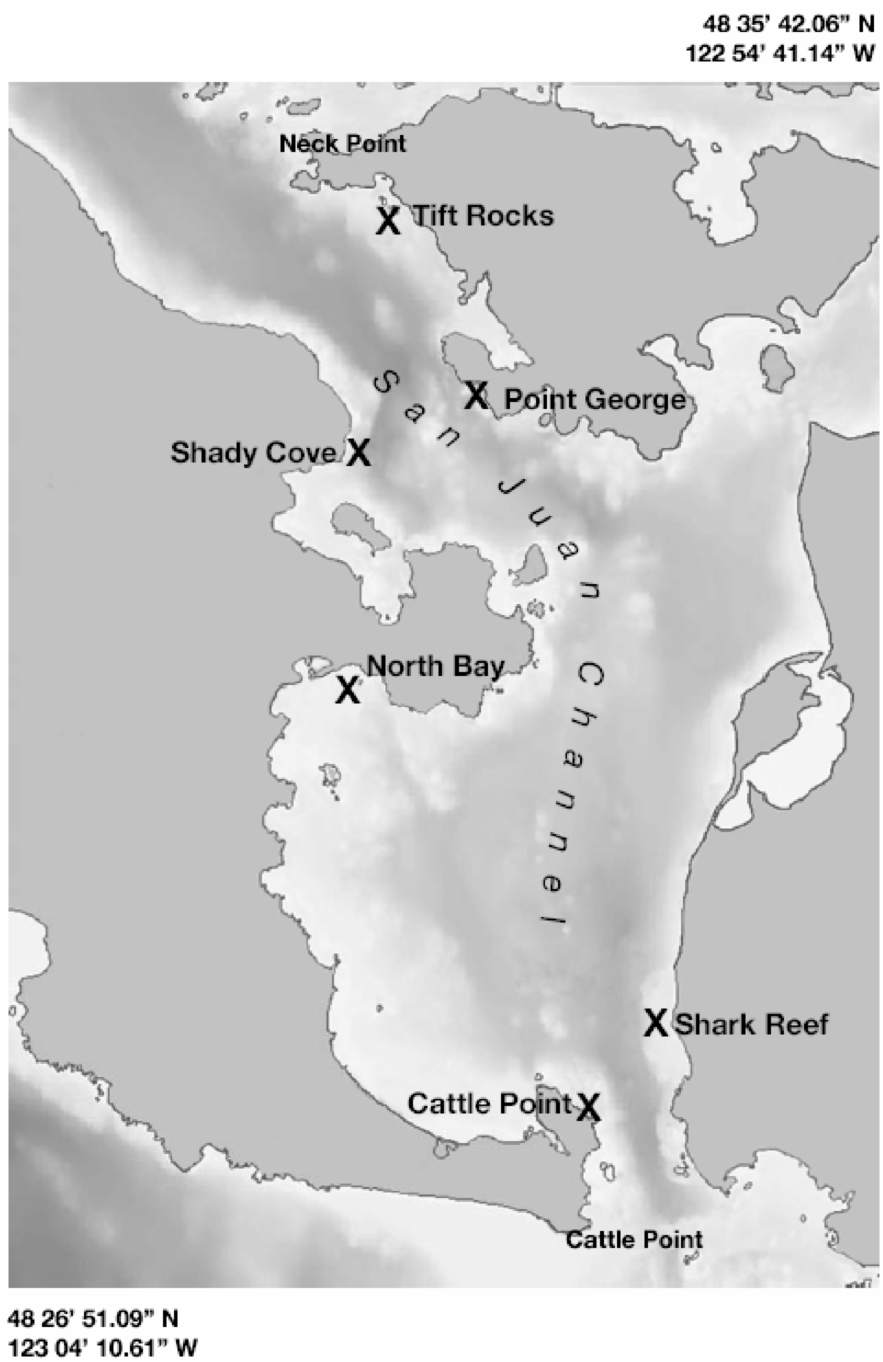

Figure 1. Study sites (indicated by an "X") within the San Juan Channel.

Table 1. Species and abundance of all fish counted in 2004 and 2005.

Species	Number of Fish		Approximate Size (cm)
	2004	2005	
YOY *Sebastes caurinus/S. maliger*	59	202	3-7
juvenile *S. maliger*	0	3	8-20
adult *S. maliger*	5	3	21-40
juvenile *S. caurinus*	13	35	8-30
adult *S. caurinus*	32	26	31-45
juvenile *Hexagrammidae* spp.	7	0	10-20
adult *Hexagrammidae* spp.	31	25	21-50
adult *Sebastes emphaeus*	4	15	8-18
adult *Ophiodon elongatus*	21	9	50-100

Table 2. Vegetation types quantified by Diver #2.

Vegetation Types Noted:	Example
Sea lettuce	*Ulva spp.*
Eelgrass	*Zostera marina*
Canopy kelp	*Nereocystis luetkeana*
Understory kelp	*Laminaria* spp.
Stipitate Kelp	*Pterygophora* spp.
Desmarestia (filamentous)	*Desmarestia viridis*
Sargassum	*Sargassum muticum*
Fucus	*Fucus gardneri*
Green filamentous algae	*Acrosiphonia* spp
Branched red algae	*Callophyllis* spp
Foliose red algae	*Chondracanthus* spp

Results

During 2004, I surveyed a total of 7160 m^2, and found 59 YOY copper and quillback rockfish. In 2005, I surveyed a total of 4440 m^2 and found 202 YOY copper and quillback rockfish. In both 2004 and 2005, all YOY rockfish (261 of 261) were found in transects containing some amount of understory kelp (Figure 2).

I analyzed the percentage of YOY rockfish observed in each habitat type, compared with the total percent of each habitat type that was available. Note that the total percentage of YOY rockfish sums to more than 100 because it is possible for a YOY to be associated with more than one habitat type in a given transect. In 2004 100% of the YOY rockfish were found in understory kelp, yet this habitat type made up only 52% of the total area surveyed (Figure 3). In 2005, 100% of the YOY rockfish were again found in understory kelp, yet this habitat type made up only 43% of the total habitat surveyed (Figure 3). In 2005, YOY rockfish were found in a greater variety of habitat types than in 2004, in that disproportionately high densities of YOY rockfish were also found in transects containing *Ulva*, *Nereocystis*, and branched red algae, as well as understory kelp.

I found that YOY copper and quillback rockfishes not only prefer areas with understory kelp, but they prefer areas with a high percent coverage of understory kelp. In both 2004 and 2005, a disproportionately high fraction of YOY rockfish were observed in transects with a large amount of understory kelp (Figure 4), and these differences were highly significant statistically (Chi square test, $p<.001$). In 2004, 88% of YOY rockfish were present in transects composed of 80-100% understory kelp even though this represented only 35% of all available habitats (Figure 4). Although a greater percentage of YOY were observed in transects containing 60-80% understory kelp in 2005, the overall pattern remains the same: all of the YOY were found in areas with a high percent cover of understory kelp (60% cover or more) (Figure 4).

In 2004, YOY rockfish were observed at tide-corrected depths of 0.6 - 9.8 m with the majority (83%) between 1.5 - 4.5 m (Figure 5). In 2005, YOY rockfish were observed at tide-corrected depths of 0.7 - 6.8 meters, with the majority (93%) between 1.5 - 4.5 meters (Figure 5). Differences in YOY density by depth were highly significant statistically for both 2004 and 2005 (Chi square test, $p<.001$).

I found that YOY copper and quillback rockfishes require a combination of both relatively shallow depths and high percent cover of understory kelp. In 2004, 81% of YOY rockfishes were found at shallow depths (<4.5 meters) and high percent coverage (>60%) kelp, whereas only 5% of YOY rockfishes were found in shallow depths and low understory kelp cover, and only 12% were found at deeper depths with high understory kelp cover (Table 3) . In 2005, I observed a similar pattern: no YOY rockfish were found in shallow depths and low understory kelp cover, 5% were found at deeper depths with high understory kelp cover, with 95% of YOY found at shallow depths and in areas with a high cover of understory kelp (Table 3).

Although YOY rockfish prefer areas with a high percent cover of understory kelp at depths of 1.5 - 4.5 meters, habitats that fit this description do not always contain YOY copper and quillback rockfish. In 2004, YOY rockfish were found in only 10% of transects composed of at least 60% understory kelp at 1.5 - 4.5 meters, and in 2005 YOY rockfish were found in only 17% of transects fitting this description.

Of the six sites I surveyed in 2004, I measured the highest densities of YOY rockfish at Shady Cove and Point George (Figure 6). Both of these sites are within regulatory reserves, where both size and density of adult rockfish and lingcod are higher than in comparable unprotected sites (Eisenhardt 2001; Figure 7). In 2005, YOY densities at Shady Cove and Point George were higher than in 2004, and there were also high densities of YOY rockfish in North Bay and at Shark Reef (Figure 6). North Bay and Shark Reef are not within or adjacent to MPAs.

Although I saw numerous other fishes while conducting surveys (Table 1, Figure 8), only two fish were seen in transects containing YOY rockfish: one adult greenling in the same transect as three YOY rockfish, and one adult lingcod in the same transect as one YOY rockfish. Adult greenling, lingcod, and rockfish are all potential predators of YOY rockfish (Miller and Geibel 1973, Simenstad et al. 1979, Hobson 2001).

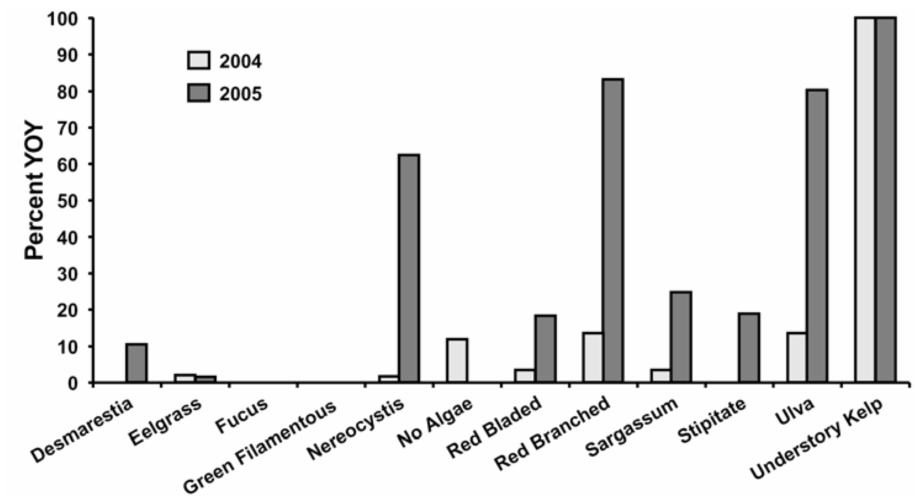

Figure 2. Percentage of young-of-year rockfish (YOY) found in each vegetation type, by year. Note that a given transect could have more than one vegetation type. Therefore, percentages total to more than 100%.

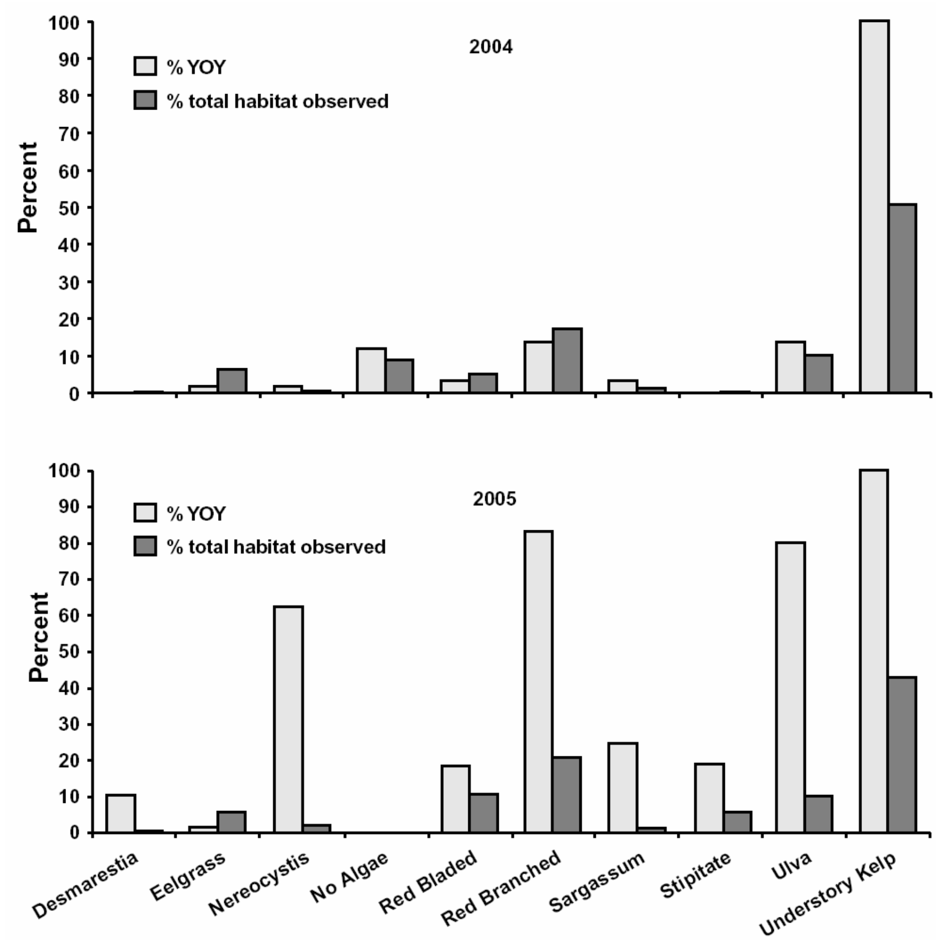

Figure 3. Percentage of young-of-year rockfish (YOY) observed in each vegetation type (solid bars), compared to percentage of each habitat type available (open bars), by year.

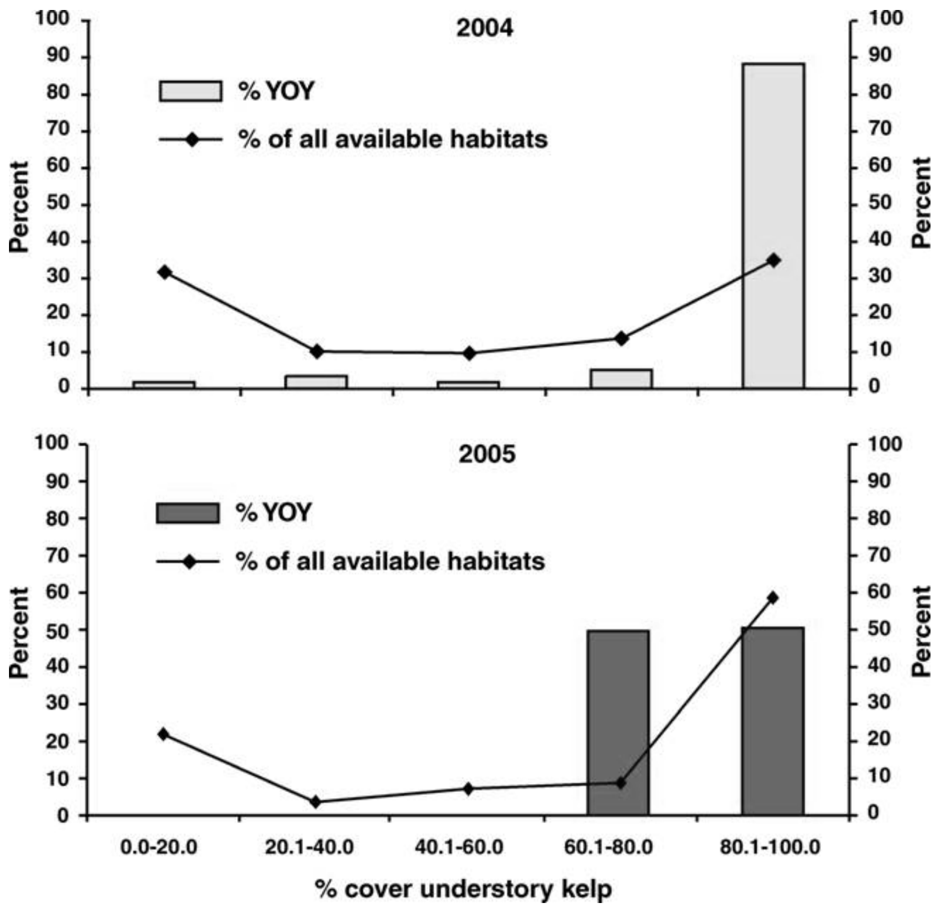

Figure 4. Percentage of young-of-year rockfish (YOY) observed (bars), and percentage of all available habitats (line) for five levels of understory kelp coverage, by year.

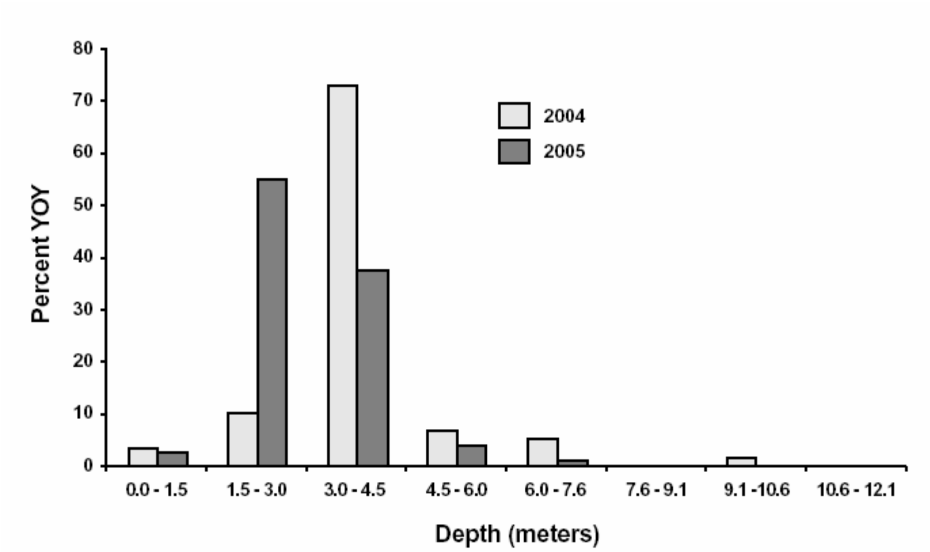

Figure 5. Percent of YOY observed, by tide-corrected depth and year.

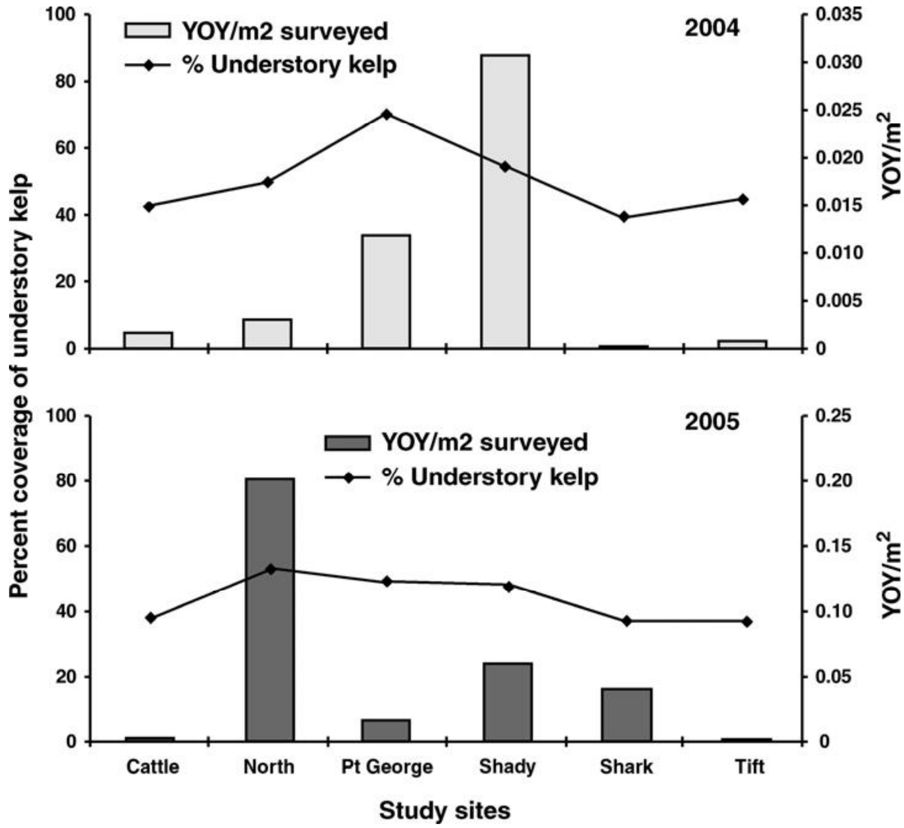

Figure 6. Percent coverage of understory kelp and density of young-of-year rockfish (YOY/m^2) at each study site, by year.

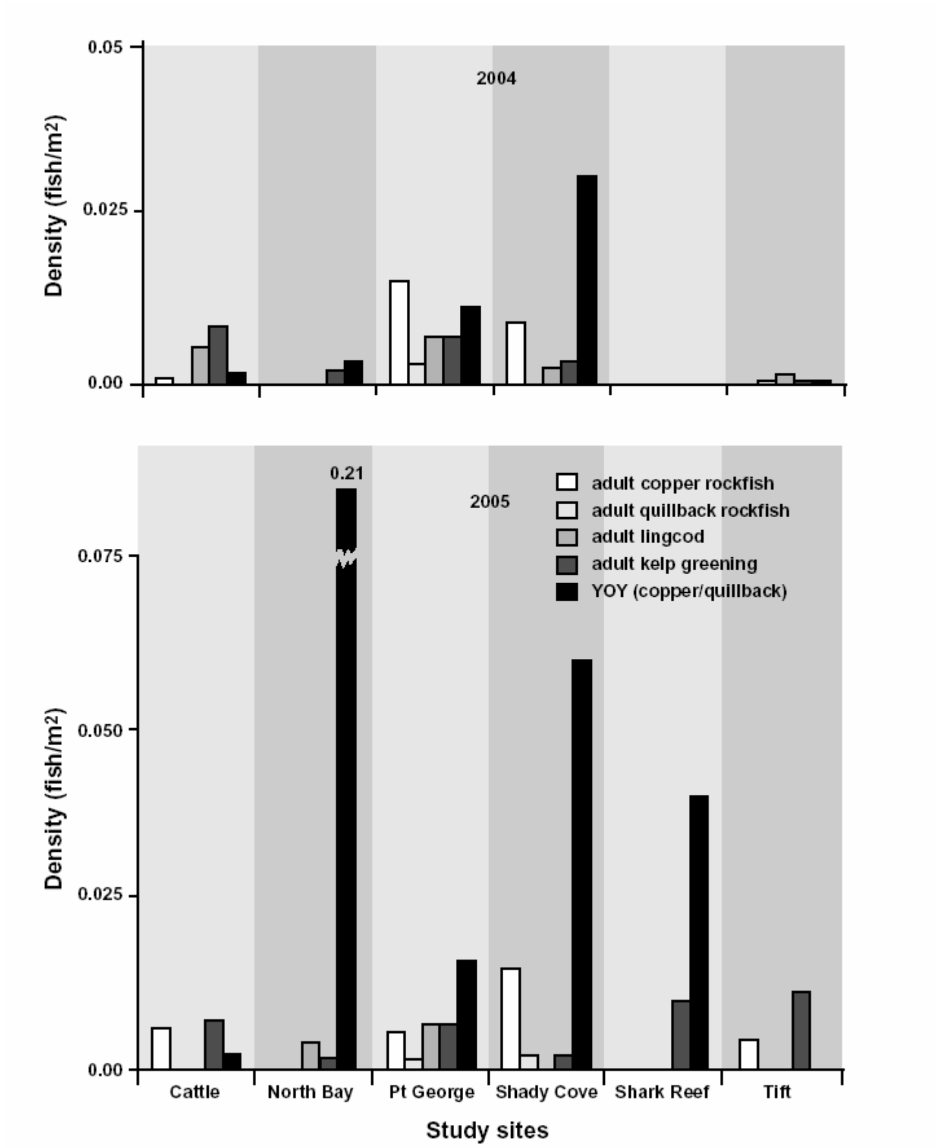

Figure 7. Density of young-of-year rockfish (YOY) potential predators and YOY at each study site, by year.

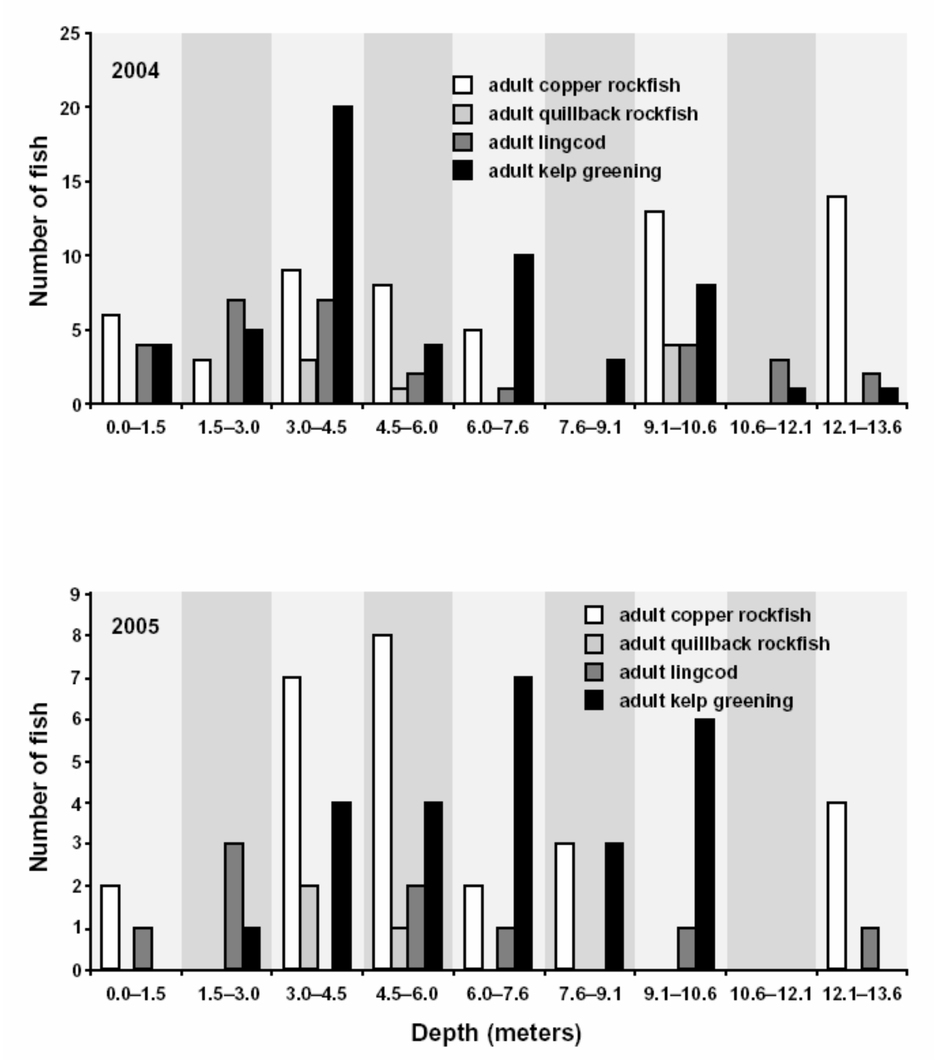

Figure 8. Depth distribution of young-of-year rockfish (YOY) potential predators, by year.

Table 3. Percentage of young-of-year rockfish (YOY) found at shallow vs deep depths and high vs low kelp coverage by year.

2004		
	low (<50%) kelp coverage	high (>50%) kelp coverage
shallow (<4.5 meters)	5	81
deep (>4.5 meters)	2	12

2005		
	low (<50%) kelp coverage	high (>50%) kelp coverage
shallow (<4.5 meters)	0	95
deep (>4.5 meters)	0	5

Discussion

Understory kelp beds are important habitats for YOY rockfishes. All YOY copper and quillback rockfishes in this study were sighted in transects that contained understory kelp, while understory kelp represented only 52% of the total available habitat surveyed in 2004, and only 43% of the total available habitat surveyed in 2005. The density of understory kelp was also important: 88% of YOYs were found in transects composed of 80-100% understory kelp in 2004, and 100% of YOYs were found in transects composed of 60 -100% understory kelp in 2005 (Figure 4).

Depth distributions of YOY rockfishes were clearly defined in this study, with highest occurrence in relatively shallow depths (1.5 - 4.5 m) (Figure 5). I conducted 643 transects outside of this depth range, and 313 of these transects (49%) were composed of 60-100% understory kelp, indicating that the depth range occupied by YOY rockfish represents only a minor fraction of understory kelp habitat available.

YOY rockfishes require a combination of both relatively shallow depths and a high percent cover of understory kelp. In both 2004 and 2005, areas with high percent coverage (>50%) of understory kelp at depths greater than 4.5 meters, and areas with a low percent cover of understory kelp at depths shallower than 4.5 meters contained very few YOY rockfish (Table 3).

YOY copper and quillback rockfishes are patchily distributed in that a high percent cover of understory kelp at depths of 1.5 - 4.5 meters does not necessarily indicate the presence of YOY. Although most of the YOY I observed were found in areas with a high percent cover of understory kelp at depths of 1.5 - 4.5 meters, YOY are not present in all areas fitting this description. In other words, a high percent cover of understory kelp at depths less than 4.5 meters are necessary but not sufficient habitat requirements for YOY copper and quillback rockfish.

One possible explanation for this patchy distribution is predator avoidance. Adult rockfish, lingcod, and kelp greenling are all potential predators of YOY rockfish (Miller and Geibel 1973, Simenstad et al. 1979, Hobson 2001), and although these species were observed in areas with a high percent cover of understory kelp at depths of 1.5 - 4.5 meters (Figure 8), I rarely sighted any fish in the same transect as YOY rockfish. This could indicate that YOY rockfish are avoiding predators on a small spatial scale. However, statistical tests indicate that there is no relationship between YOY rockfish and predator presence or absence in the same transect. This is true when all predators are grouped together and when each predator species is tested individually (Chi square $p>.10$ for all tests). Even in optimal habitat both YOY rockfish and their predators occur in low densities, and I might not have seen them in the same transect due to the low probability of two rare events occurring in a single 5-meter transect: the probability of a YOY rockfish and predator occurring in the same transect was 0.004 in 2004 and 0.006 in 2005.

Predator avoidance also does not explain the difference in YOY rockfish densities at a larger scale, i.e. between study sites. In 2004 I found relatively high densities of YOY rockfishes at the two study sites within MPAs. This was unexpected because YOY rockfish predators such as lingcod are larger and more abundant within MPAs (Eisenhardt 2001; Figure 7). In 2005, although higher densities of YOY were found at some sites outside of MPAs, YOY densities at sites within MPAs remained high. Our results indicate that differences in YOY densities between sites can not be attributed to predator abundance. Again, this is true when all predators are grouped together and when each predator species is tested individually (Figure 7, Spearman Rank Correlation test $p>.10$ for all tests).

Understory kelp coverage was relatively uniform across sites (Figure 6) and did not explain the difference in YOY densities between sites either.

Another possible explanation for patchy distribution is small-scale oceanographic factors. For example, Matthews (1990) and Haldorson and Richards (1987) both observed YOY rockfish in low-current areas, and Matthews hypothesized that recruits might be swept off high current reefs.

Unfortunately, measuring current speed was beyond the scope of this study so I am unable to explore this hypothesis. Future studies could examine the influence of factors such as small-scale eddies and convergence of currents on habitat utilization by YOY rockfishes.

YOY were found in a greater variety of habitat types in 2005 than in 2004. Higher densities of YOY in 2005 may have resulted in spillover from the optimum habitat (areas with a high percent coverage of understory kelp) into less ideal habitat types such as *Ulva, Nereocystis,* and red-branched algae. Although understory kelp is not a limiting habitat type overall, it could be locally-limiting in specific areas where YOY are found. Another explanation is that YOY prefer areas with a high percent cover of understory kelp, and in 2005 these transects also had a high percent cover of *Ulva, Nereocystis*, or red branched algae, either by random chance or because of interannual differences in algal abundance.

YOY rockfish were not found in association with other common algae such as *Desmerestia*, *Fucus*, or filamentous green algae in the San Juan Channel, and they were rarely found in eelgrass beds. These results differ from Haldorson and Richards (1986), who found that YOY copper rockfish made extensive use of eelgrass beds in the Strait of Georgia. Matthews (1990) also found YOY copper and quillback rockfish in eelgrass beds in central Puget Sound. One possible explanation for the difference between our results and other studies is that eelgrass was not as common as alternative vegetation types at our study sites (Figure 3).

Although YOY were occasionally found in *Nereocystis* beds (Figure 2), this was not a critical habitat for YOY copper or quillback rockfish in the San Juan Archipelago. Matthews (1990) did not observe any YOY copper or quillback rockfish associated with *Nereocystis* either. However, Carr (1991) found YOY copper rockfish primarily in the kelp canopy off the coast of central California. This is a good example of regional variations in rockfish recruitment and illustrates the need for local YOY rockfish habitat surveys.

It is clear that YOY copper and quillback rockfishes in the San Juan Channel prefer areas with a high percent coverage of understory kelp, at depths of 1.5 - 4.5 meters. However, they are patchily distributed both within and between sites, across optimal habitat, and this patchy distribution could not be readily explained by predator abundance or kelp coverage. Future studies could explore the effect of small-scale oceanographic features on the distribution of YOY rockfish.

Despite the patchy distribution of YOY rockfishes across optimal habitat, shallow areas with high percent coverage of understory kelp are necessary habitats for YOY copper and quillback rockfishes within the San

Juan Channel. Preservation of these habitats should be an important component of the conservation and management of these species.

References

Buckley R.M. 1997. Substrate associated recruitment of juvenile Sebastes in artificial reef and natural habitats in Puget Sound and the San Juan Archipelago, Washington. Dissertation. University of Washington, Seattle, WA. 320 p.

Carr M.H. 1991 Habitat selection and recruitment of an assemblage of temperate zone reef fishes. J. Exp. Mar. Biol. Ecol. 146: 113-137.

Eisenhardt E. 2001. A marine preserve network in San Juan Channel: is it working for nearshore rocky reef fish? In: Puget Sound Research '01. Puget Sound Water Quality Action Team, Olympia, WA.

Haldorson L. and L.J. Richards. 1986. Post-larval copper rockfish in the Strait of Georgia: Habitat use, feeding, and growth in the first year. In Proc. Int. Rockfish Symposium. Alaska Sea Grant College Program, Anchorage, Alaska. 87-2: 129-141.

Hobson,E.S., J.R. Chess, and D.F. Howard. 2001. Interannual variation in predation on first-year *Sebastes* spp. by three northern California predators. Fishery Bulletin 99: 292-302.

Matthews, K.R. 1990. An experimental study of the habitat preferences and movement patterns of copper, quillback, and brown rockfishes (*Sebastes* spp.) Environmental Biology of Fishes 29: 161-178.

Miller, D.J. and J.J. Geibel. 1973. Summary of blue rockfish and lingcod life histories: a reef ecology study; and giant kelp, Macrocystis pyrifera, experiments in Monterey Bay, California. Calif. Dept. Fish Game Fish. Bull. 158: 131.

Murray S.N., R. Ambrose and M. Dethier. 2006. Monitoring Rocky Shores: chapter 5. University of California Press, Berkeley, California.

Pacunski, R.E. and Palsson, W.A. 2002. Macro-and micro-habitat relationships of adult and subadult rockfish, lingcod, and kelp greenling in Puget Sound. In: Proceedings of the 2001 Puget Sound Research Conference. T. Droscher (Ed.). Puget Sound Water Quality Action Team. Olympia, Washington.

PSAT 2002. The Puget Sound Update 2002. Puget Sound Action Team. Olympia, WA.

Simenstad, C., B. Miller, C. Nyblade, K. Thornburgh, and L. Bledsoe. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca: a synthesis of available knowledge. NOAA-EPA-600/7-79-259.

Stout H.A., McCain B.B., Vetter R.D., Builder T.L., Lenarz W.H., Johnson L.L, and Methot R.D. 2001. Status review of copper rockfish (*Sebastes caurinus)*, quillback rockfish (*S. maliger*), and brown rockfish (*S. auriculatus*), in Puget Sound, Washington. NOAA Technical Memorandum NMFS-NWFSC-46.