Coastal Zone Management Section 309 Grant

2003 Nearshore Rocky Reef Habitat and Fish Survey, and Multi-Year Summary

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Acknowledgements

This report represents a continuation of a multi-year effort to better understand nearshore rocky reefs and their significance to Oregon fisheries. Our colleague Dave Fox initiated this series, and it is through building on his vision and commitment that we have been able to continue these studies.

We also thank Bob Bailey of the Department of Land Conservation and Development for his continued philosophical and material support.

This work could not have been accomplished without the technical wizardry and hard work of Bill Miller who makes complex mechanical and electronic systems operate in synch both on the bench and at-sea. Jennifer Conrad reviewed hours of video tape, recording data, and assisting with field work. Jedidiah Moore provided assistance in our at-sea work, and Hal Gray of OSU Ship Operations assisted with shoreside logistics.

We especially thank Perry York of the OSU R/V *Elakha* for providing a safe, stable platform for our surveys, and for sharing his knowledge of the nearshore ocean.

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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 the development of the live-fish fishery combined with reductions in offshore fishery opportunities as more conservative harvest management measures have been adopted. Non-fishery pressures including 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. The recent U.S. Commission on Ocean Policy report expressed support for the development of marine aquaculture operations. Recently, nearshore hypoxic events have been observed off the central Oregon coast (2002 and 2004) resulting in localized mortality of some marine species. While these appear to have been generated by natural processes including large-scale ocean transport of hypoxic waters from the sub-Arctic to the south and thence onto the Oregon continental shelf through upwelling (Freeland, et al. 2003, Huyer 2003, Grantham, et al. 2004), the frequency, distribution and intensity of these events is not understood. Further, the relationship of these events to human-induced environmental change is also unknown. 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.

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 suite 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 further offshore such as canary rockfish (*S. pinniger*) and yelloweye rockfish (*S. ruberrimus*).

Our efforts in 2003, as in prior years, focus on the continued development of methods to estimate fish abundance on nearshore rocky reefs by better understanding the association of fishes with rocky habitat on both course and fine scales. Most of these species have not been quantitatively assessed, yet are subject to substantial fishing pressure. Growing 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. To date, eight reefs have been surveyed and mapped with sidescan and/or multi-beam bathymetry at resolutions believed to be indicative of fish habitat. 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 fish-habitat relationships become better understood, and estimation methods refined, we believe that we will be able to expand this understanding to estimate abundances at the habitat and reef scale, track changes resulting from management actions, and ultimately develop fish abundance estimates for nearshore rocky reefs in Oregon.

In 2003, we conducted a fourth ROV survey at Cape Perpetua Reef. This report summarizes that work, and also incorporates information from the 2002 survey.

1. Methods

ROV Survey

ROV surveys at Cape Perpetua Reef were conducted on June 11 and August 7 and 8, 2003. Sixteen transects ranging in length from 58 to 921 meters and totaling 5.2 kilometers were conducted; 3 transects conducted in June were repeated in August. The Cape Perpetua Reef complex is comprised of several rocky outcroppings of diverse sizes in an otherwise sandy bottom just to the south of Yachats, and approximately 5 km offshore. Depth is approximately 50 meters. A sidescan sonar survey was conducted on Cape Perpetua Reef in 2000 (Fox, et al. 2000).

The ROV video survey, including field operations, data retrieval, and processing, followed the procedures described in Fox, et al. (2000) and Amend, et al. (2001). The ROV survey consisted of continuous video coverage along a transect; length of the transect being determined principally by the size of the rocky patch. Fish and habitat data observation and recording methods also followed those described in Amend, et al. (2001). Data feeds from the ROV to the video recording equipment included time, depth and geographic position. Information recorded during video review included fish taxa and count and bottom habitat type. Most larger species were identified to species. Young-of-the-year rockfish were grouped into a single category, 'juvenile rockfish.' All data were synchronized by time.

Data Analysis

For the analyses presented here, video fish counts were converted to fish density (number of fish/100 m^2). Habitat area (m^2) was calculated in the same manner as described in Fox et al. (2000).

2. Results

Fish densities by transect, sampled area and rock patch area for the years 2000 through 2003 are presented in Table 3.1.

Table 3.1 Fish density (no. fish / 100 m^2) by transect on Perpetua Reef for 2000 – 2003. Transects are ordered left to right by increasing patch size. No size data is available for patches 5a and 5b.

	TRANSECT	1.2f	1.4l	1.4x	1.4y	1.4e	3b	1.4t	1.4g	1.4v	1.2i	1.3e	1.1d	1.1c	3a	1.1i	1.2h	1.3a	2d	1.1k	3c	1.2a	1.4a	1.2d	4a	1.4d	2a	1.3b	5a	5b
Year	Patch Size (m2)	25	25	70	70	80	144	360	375	500	550	720	750	1200	1225	1400	1400	2200	3290	3325	3600	4000	6000	7875	10920	12000	12500	30000		
2000	Total Fish	59.91	86.75	15.43	3.67	13.46	130.54	54.50	9.45	30.42	81.62	71.34	44.48	10.29	16.05			10.41		23.54			42.62	21.95			18.60	5.31		
2001							3.21	37.56	21.08	37.51			28.84	51.22	14.79			5.41		7.04	24.07	39.25	25.87		29.25	10.69	12.61	32.53		
2002													5.37	0		6.19	0.94	1.73	12.29	10.73		6.48	2.19	2.70		4.47	4.00	4.01		
2003													6.12	9.87					10.29	9.09		3.2	2.32	4.5		9.07	5.73	9.75	8.86	6.4
2000	Black rockfish	0	0	0	0	0	70.29	1.36	0	0	18.98	1.18	0	0	7.78			0		0.30			5.23	0.10			8.09	0.64		
2001	*Sebastes melanops*						0	0	1.51	12.31			0.44	0.00	1.61			0.86		0.43	0	14.12	2.19		9.29	0.39	2.17	7.30		
2002													0	0		0	0	0	3.60	0.35		0	0	0		0.39	0.64	0.32		
2003													0	0.99					4.12	0		0	0.12	0		2.47	0.22	5.11	1.06	0
2000	Blue rockfish	0	0	0	0	0	0	0	0	0	7.59	0.24	0	0	0			0		0			0.11	0.10			0.00	0.00		
2001	*S. mystinus*						0	0	0	0			0	2.85	0			0		0	0	1.38	2.00		0.58	0.13	0.00	0.88		
2002													0.00	0.00		0	0	0	0.90	0		0	0	0		0.00	0.00	0.48		
2003													0	0					0	0		0	0	0		0.41	0	0	0	0
2000	Brown rockfish	0	0	0	0	0	2.01	0	0	0	1.89	0.24	0.65	0	0.17			0		0.60			0	0.21			0.14	0.00		
2001	*S. auriculatus*						0	0	0	0			0	1.22	0			0		0	0	0	0		0.00	0.00	0.00	0.10		
2002													0	0		0	0	0	0	0.35		1.04	0	0		0.08	0.00	0.08		
2003													0	0					0	0		0	0	0		0	0	0	0	0
2000	Canary rockfish	0	55.21	0	0	0	2.01	34.06	1.05	16.38	5.69	8.95	8.38	7.49	0.33			6.46		9.53			4.88	9.57			3.50	0.81		
2001	*S. pinniger*						0	8.35	0	11.14			9.76	7.32	0.32			1.14		2.77	0	0.34	1.46		1.16	1.11	0.69	0.88		
2002													1.15	0		0	0	0.35	0.60	1.73		0	0	0.13		1.31	0.96	0.40		
2003													0	1.97					0	0		0	0.49	0.56		0.21	0	0	0.21	0
2000	China rockfish	0	0	0	0	0	0	0	1.05	0	0	0	1.29	0	0			0		0			0	0			0.14	0		
2001	*S. nebulosus*						0	0	0	0			0	0	0			0		0	0	0	0		0	0.07	0.00	0.00		
2002													0	0		0	0	0	0	0		0	0	0		0	0	0		
2003													0	0					0	0		0	0	0		0	0	0	0	0
2000	Copper rockfish	0	0	0	0	0	0	10.90	0	1.56	0	0.94	0.65	0.47	0.66			0.36		0.60			0.84	1.25			0.27	0.18		
2001	*S. caurinus*						0	2.50	0	2.34			0	1.63	0			0.29		0	0	2.07	0.36		0.35	0.26	0.10	0.49		
2002													0	0		0	0	0	0	0.35		0.26	0.20	0		0	0.16	0		
2003													0	0					0	0		0	0.12	0		0	0	0	0	0
2000	Quillback rockfish	0	0	0	0	0	0	4.09	0	1.56	1.89	4.48	5.16	0.94	0.66			0.36		2.98			2.50	3.23			1.49	1.44		
2001	*S. maliger*						0.00	0.00	4.52	0.00			1.33	5.29	0.64			0.57		1.07	0	1.72	1.09		0.70	1.50	0.89	1.85		
2002													0.38	0		0	0	0	1.80	0.35		2.59	0.40	0.51		0.23	0	0.56		
2003													1.36	0.99					1.03	1.36		0	0.37	0		0.41	0	0.24	0.07	0
2000	Tiger rockfish	0	0	0	0	0	0	0	0	0	0	0.24	0	0	0			0		0			0	0			0.00	0.00		
2001	*S. nigrocinctus*						0	0	0	0			0	0	0			0		0	0	0	0		0	0.07	0	0.29		
2002													0	0		0	0	0	0	0		0.26	0	0		0	0	0		
2003													0	0					0	0		0	0	0		0	0	0	0	0
2000	Yelloweye rockfish	0	0	0	0	0	0	0	0	1.56	3.80	1.41	1.94	0	0			0		0			0.35	0.84			0.27	0.18		
2001	*S. ruberrimus*						0	0	0	0			0	0.81	0.32			0		0	0	0.34	0		0.23	0.52	0	0.68		
2002													0	0		0	0	0.69	0	0		0.26	0	0.13		0.15	0.32	0.24		
2003													0	0					0	0		0	0	0		0	0	0.12	0.07	0
2000	Yellowtail rockfish	0	0	0	0	0	8.03	0	1.05	0	0	6.35	14.82	0	0			0.36		1.49			0.35	0.21			0.14	0.36		
2001	*S. flavidus*						0	19.20	0	1.17			0.44	4.88	4.50			0.29		0	0	0	1.28		4.88	0.26	0	1.75		
2002													1.15	0		0	0	0	0.30	4.85		0	0.20	0.90		0.85	0.16	0.16		
2003													0	1.97					1.03	0		0	0.24	0		1.03	0	0.71	0.07	0
2000	Juvenile Rockfish	0	31.55	0	0	3.36	36.16	0	0	0	26.57	45.69	6.44	0	3.47			0.36		5.37			25.96	2.81			1.49	0.09		
2001	*Sebastes sp.*						0	0	0	0			10.21	23.17	0			0.86		1.49	12.74	12.05	12.21		3.25	2.22	4.43	14.70		
2002													0	0		1.90	0	0	1.20	2.42		0	0.40	0		0	0.16	0.08		
2003													0	0					0	0		0	0	0		0.31	0	0.24	0.50	0
2000	Kelp greenling	49.92	0	11.02	3.67	6.73	10.04	2.73	6.30	9.36	3.80	1.41	4.51	0.94	1.81			1.07		0.90			1.90	1.25			1.88	0.64		
2001	*Hexagrammos decagrammus*						0	4.17	3.01	2.93			3.99	0.81	3.54			0.29		0.43	0	1.38	1.28		2.55	0.98	1.68	1.07		
2002													0	0		0.95	0	0.35	0	0		0	0.40	0.39		0.15	0.16	0.24		
2003													0	0					0	0		0	0	0		0	0	0	0.21	1.24
2000	Lingcod	9.98	0	2.20	0	3.36	2.01	1.36	0	0	5.69	0.24	0.65	0.47	0.50			1.44		1.79			0.48	1.88			0.81	0.36		
2001	*Ophiodon elongatus*						0	1.67	10.54	5.28			2.22	2.03	1.61			0.86		0.43	0	2.07	1.64		2.67	1.11	0.39	1.17		
2002													0.38	0		0	0	0	0.90	0		1.82	0.20	0.26		0.69	0.48	0.64		
2003													0.00	0					1.03	0		0	0	0		0.52	0.22	0	0.14	0
2000	Flatfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0		0			0	0			0	0		
2001	Pleuronectiformes						0	0	0	0.59			0	0	0			0		0	0	0	0		0	0	0.30	0		
2002													0	0		0	0.94	0	0	0.35		1.04	0.40	0.13		0	0	0		
2003													2.72	0.99					0	6.36		2.67	0.61	0.84		0.72	3.09	0.83	2.69	1.45
2000	Ratfish	0	0	0	0	0	0	0	0	0	5.69	0	0	0	0.33			0		0			0	0.31			0.14	0.54		
2001	*Hydrolagus colliei*						0	0	0	0			0	0	0			0		0	0	2.75	1.09		0	0.65	0.00	0.78		
2002													0	0		0	0	0	2.40	0		0	0	0.13		0.39	0.16	0.40		
2003													0	0					3.09	0		0	0	0.84		0.31	0.88	0.71	0.21	0.21
2000	Spotted Wolf-eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33			0		0			0	0			0.27	0.09		
2001	*Anarhichthys ocellatus*						0	0	0	0			0	0.41	0			0		0	0	0.34	0		0.12	0.26	0	0		
2002													0	0		0	0	0	0	0		0	0	0		0	0	0		
2003													0	0					0	0		0	0	0		0	0	0	0	0

Figure 3.1a presents the fish community composition observed in Cape Perpetua surveys in August 2003. Because we conducted surveys in both June and August, comparative percent abundance information for the two months is presented only for transects sampled during both months in Figure 3.1b. From this, we see some hints at seasonal variability in fish abundance on Cape Perpetua reef: surfperch were observed in June, but not in August, while flatfish were much more abundant in August than in June.

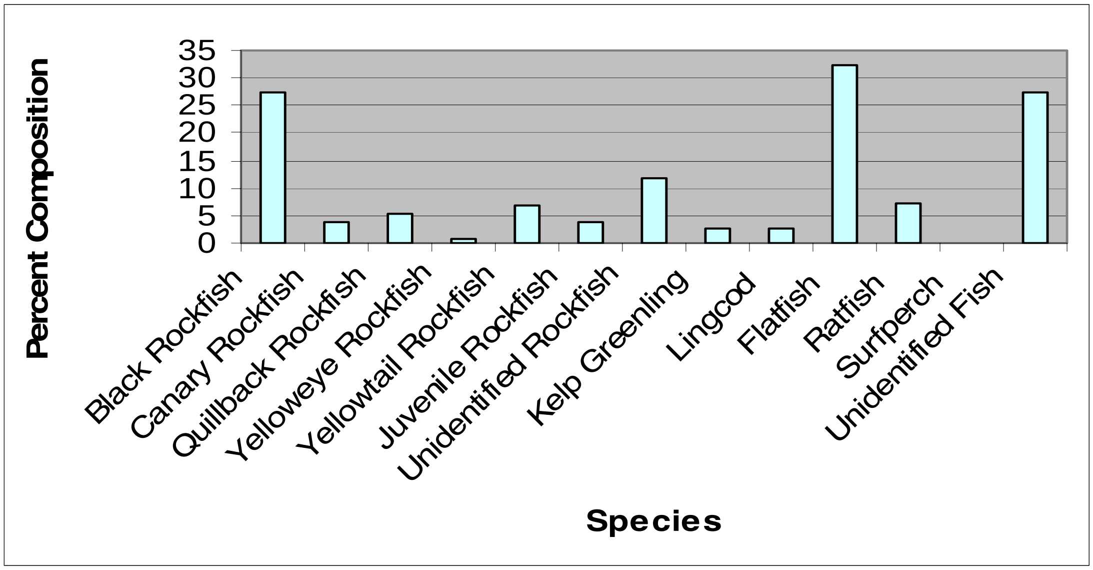

Figure 3.1a. Cape Perpetua Fish Community Composition in August 2003

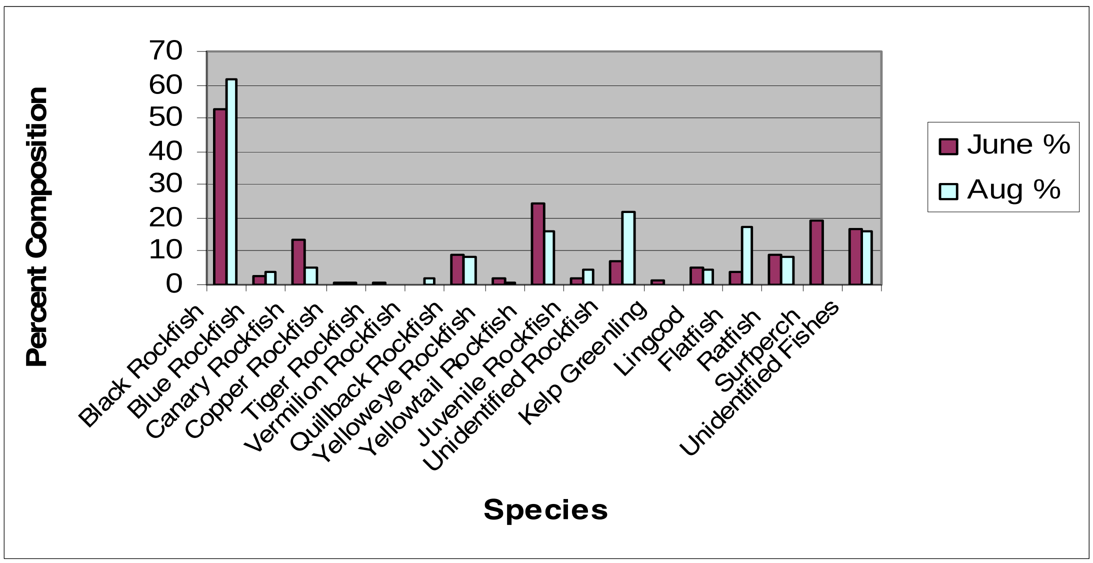

Figure 3.1b. Seasonal Variability in Fish Community Composition on 3 Common Transects in June and August 2003

Fish community composition shows substantial interannual variability. Figure 3.2 depicts the percent species composition for the most abundant species or species groups for each of the four years of this study.

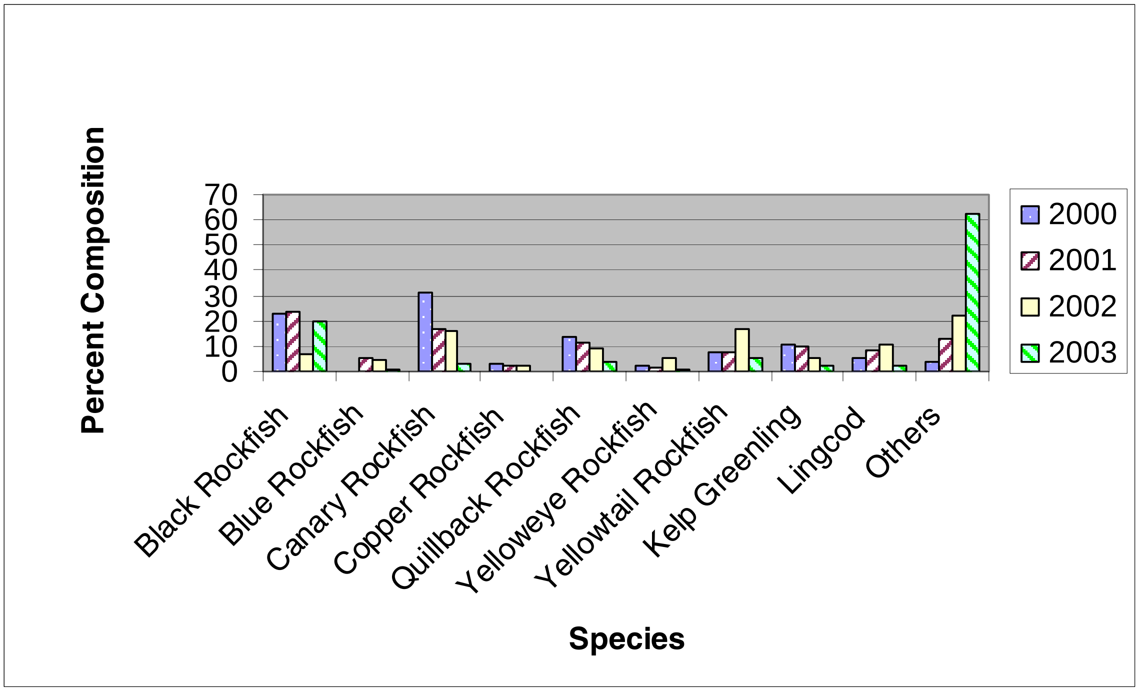

Figure 3.2. Cape Perpetua Fish Community Composition from seven common transects in 2000 – 2003.

We observed substantially lower densities of fish in 2002 and 2003 relative to the previous two years. A significant hypoxic event impacted the central Oregon coast in 2002, and we made ROV observations of many dead fish, and an absence of live fish, on Cape Perpetua in July 2002. Consequently, information presented for October 2002 in Table 3.1 likely represents some level of recovery from the hypoxic event of that summer. densities observed in 2003 remained low for most species, though for some density increased slightly.

Amend, et al. (2001) used paired t-tests to compare densities on twelve common transects between 2000 and 2001. We use two-way analysis of variance to compare densities on seven transects surveyed in each of 2000, 2001 and 2003. (Table 3.2) We excluded 2002 as the severe hypoxic event of that year represents a confounding variable. We find statistically significant differences for total fish, most rockfish species, kelp greenling, lingcod and the flatfish category. Only black rockfish, yelloweye rockfish, yellowtail rockfish and ratfish were not significantly different across the three years of this analysis. Differences in density across transects, with two exceptions, are not statistically significant.

Table 3.2 – Results of ANOVA of fish densities in seven common transects sampled in 2000 – 2003 (2002 excluded).

Species or Group	Back-transformed mean densities (#/100 m^2)						
	Aug 2000	June 2001	Aug 2003	p (years)		p (transects)	
Total Fish	3.03	3.10	2.02	0.0438	*	0.8886	
Total Adult Fish	2.80	2.64	2.02	0.0809		0.7068	
Total Rockfish	2.62	2.30	1.28	0.0134	*	0.6178	
Black Rockfish	0.79	0.82	0.47	0.6438		0.1723	
Canary Rockfish	1.85	1.32	0.25	0.0002	**	0.0374	*
Copper Rockfish	0.40	0.29	0.02	0.0468	*	0.4868	
Quillback Rockfish	1.14	0.95	0.49	0.0473	*	0.3595	
Yelloweye Rockfish	0.29	0.17	0.02	0.3430		0.7612	
Yellowtail Rockfish	0.74	0.64	0.31	0.6389		0.6461	
Juvenile Rockfish	1.37	2.21	0.04	0.0066	**	0.6636	
Kelp Greenling	0.95	0.83	0.00	0.0001	**	0.0362	*
Lingcod	0.56	0.78	0.03	0.0050	**	0.9789	
Flatfish	0.00	0.04	1.08	0.0003	**	0.3971	
Ratfish	0.08	0.20	0.20	0.6268		0.1737	

* significant at p<.05

** significant at p<.01

Fox, et al. (2000) investigated changes in fish density with respect to habitat patch size and found significant changes only for three species or species aggregates: quillback rockfish, kelp greenling and non-schooling rockfish. This result suggested an edge effect with a threshold for very small patches. Surveys in 2002 and 2003 did not sample the smallest patches addressed in 2000 and 2001. This, along with lower overall densities in the latter two years, precluded us from repeating this analysis with 2002 and 2003 data.

Island biogeography theory (Macarther and Wilson 1967) suggests that species (diversity?) should increase as a logarithmic function of island (or patch) area in the form of

$$S = cA^{-z}$$

where S is the number of species, A is the area of the island or patch, c is a constant, and z is the exponent of the logarithmic curve.

We plotted number of species species as a function of patch area for each of the four years of this study, and observed patterns of increase in species number with patch area for each year. (Figures 3.3a – e). This pattern held consistently for each year, though was weakest for 2003. One patch that is surveyed by transect 1.3b is more than double the area of the next largest patch, consequently data points for this patch will disproportionately impact any species-area calculations. We re-plotted the species-area relationships excluding this patch, and see the same robust relationship that was again weakest in 2003.

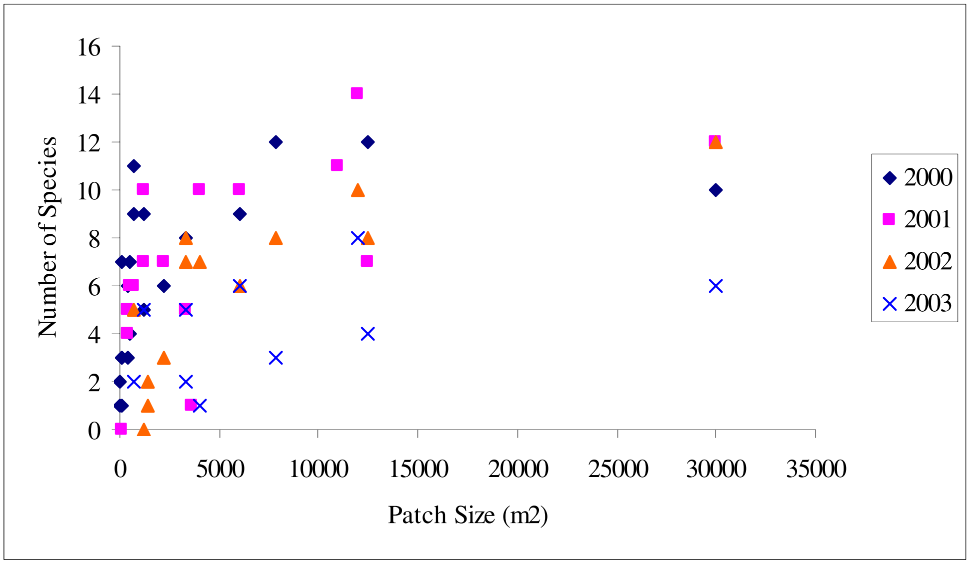

Figure 3.3a. Number of fish species observed by patch area for Cape Perpetua Reef over four years.

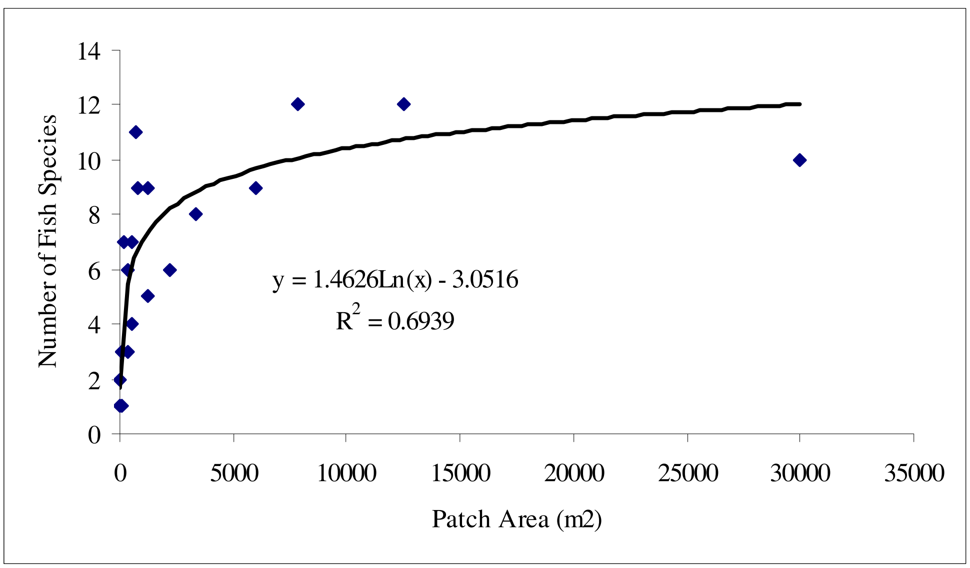

Figure 3.3b. Number of fish species observed by patch area for Cape Perpetua Reef in 2000 surveys.

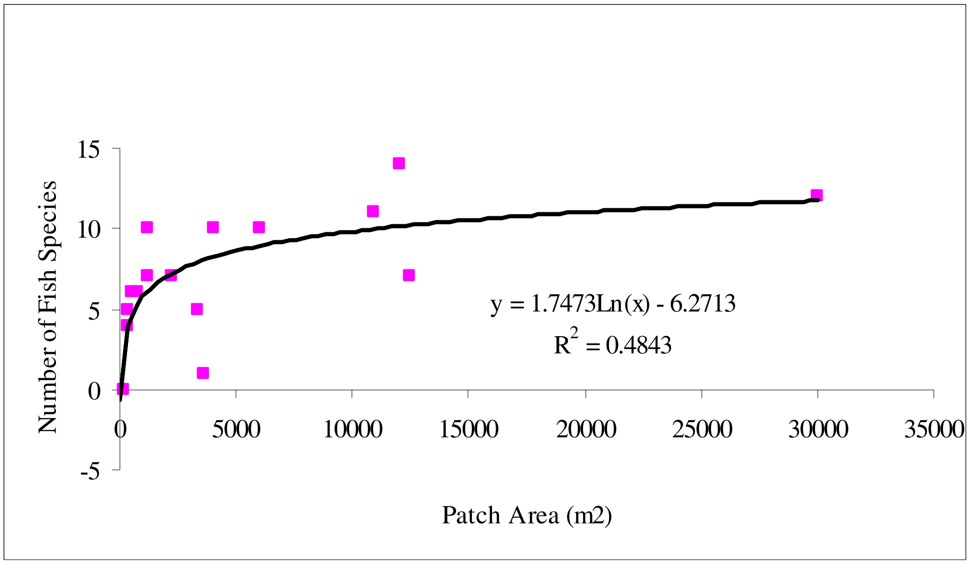

Figure 3.3c. Number of fish species observed by patch area for Cape Perpetua Reef in 2001 surveys.

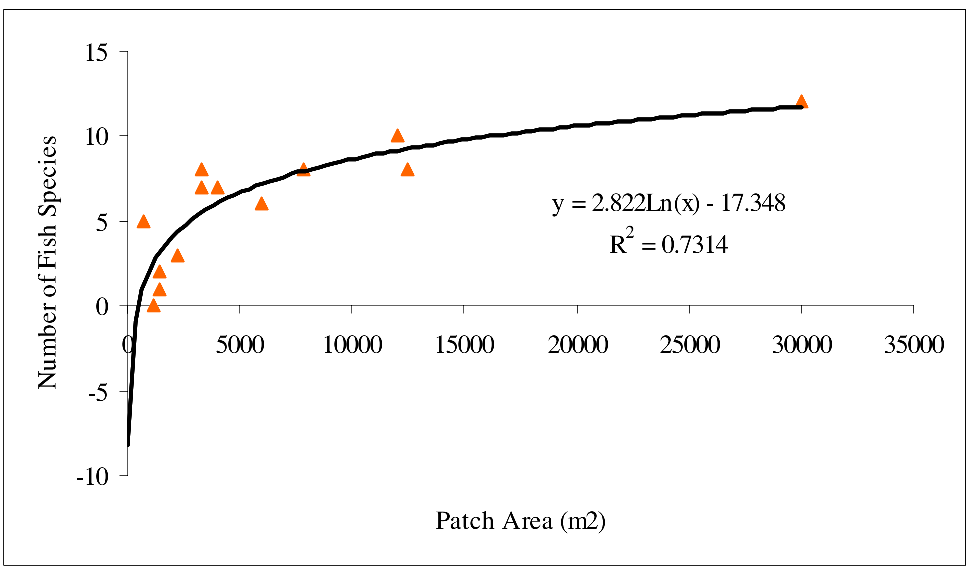

Figure 3.3d. Number of fish species observed by patch area for Cape Perpetua Reef in 2002 surveys.

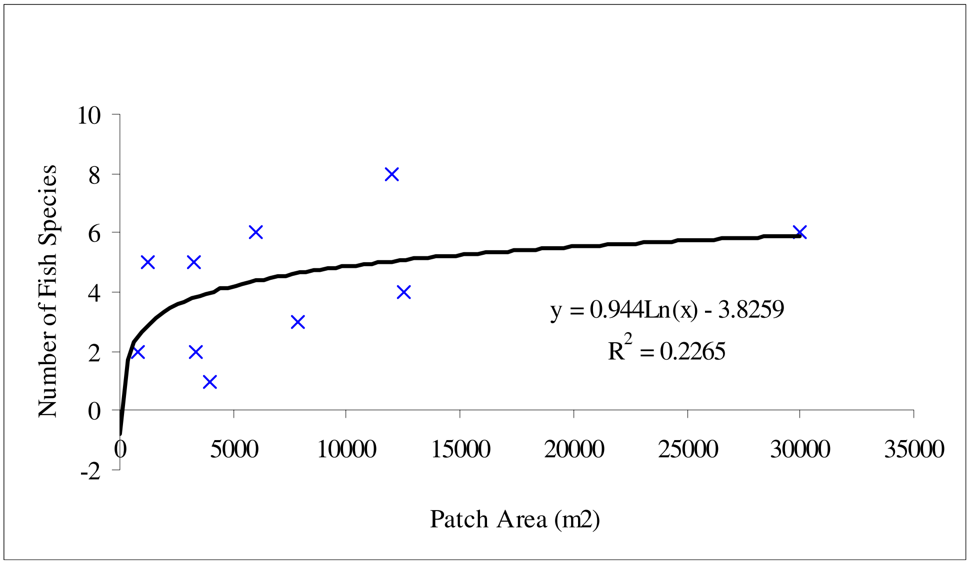

Figure 3.3e. Number of fish species observed by patch area for Cape Perpetua Reef in 2003 surveys.

4. Discussion and Management Implications

The Oregon Department of Fish and Wildlife Marine Resources Program has completed four years of ROV surveys on the Cape Perpetua Reef complex. Previous work (Fox et al 2000, Amend et al. 2001) demonstrated a degree of habitat preference among the species found on the reef. Comparison of common transects surveyed in 2000 and 2001 indicated very few differences in species density.

In 2002, a significant hypoxia (low-oxygen) event impacted the central Oregon coast, including the Cape Perpetua reef complex. Fishermen first noted this event in July through observations of dead crab and fish in crab pots. A subsequent ROV investigation in July 2002 of the reef complex showed numerous dead fishes and an absence of live fishes. The later surveys of the Perpetua Reef complex in August and October of 2002 documented much lower abundance of fishes, with substantial decrease in density and community composition relative to the previous two years (Fox et al 2004). However, the fact that there were fishes at all on the reef later in 2002 suggested that recovery of the reef community was taking place, and a degree of resilience in the community.

In light of the disturbance to the reef community from the 2002 hypoxia event, we expected that 2003 surveys would show further recovery, with fish densities approximating those of 2000 and 2001. Surprisingly, this proved not to be the case. While some species such as ratfish, black rockfish, yellowtail rockfish and quillback rockfish were found at densities greater than in 2002, other species such as canary rockfish, copper rockfish, kelp greenling and lingcod were at levels even lower than 2002. Ratfish, black rockfish and yellowtail rockfish are somewhat more pelagic in their habits than other members of the Cape Perpetua reef community. This may enable them to recolonize areas after forced movement more rapidly than less mobile species. We would expect to see this trend continue in our results from 2004 surveys.

There are also hints of seasonal change in the Cape Perpetua reef community, as evidenced by the notable abundance of surfperch in June 2003, and their absence in August 2003, and the converse presence of flatfish in August 2003 but not earlier in the year. However, the 2000 Cape Perpetua survey was also conducted in August, and no flatfish were noted during that survey.

It is becoming clear that the Cape Perpetua reef community is dynamic, with some changes imposed by apparently transient environmental shifts, and some apparently being influenced by the behavior and movement of constituent species. We anticipate that our 2004 surveys will further enable us to better understand these factors.

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