A Biological Survey of Rocky Shores in Oregon: data entry and preliminary analysis

Report prepared for the Oregon Department of Fish and Wildlife

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Table of Contents

1. INTRODUCTION

In June of 1994 two teams from the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Institute of Marine Biology (OIMB) conducted a quantitative survey of intertidal habitats and biota at 12 sites on the Oregon coast (Fox, 1994). This study was undertaken with a view toward developing intertidal community descriptions that can be applied over a wide range of spatial scales and be used as a basis for management decisions (Fox, 1994). It also provides important baseline data, allowing us to gauge the effects on Oregon's rocky shores of potential large-scale perturbations such as oil spills, tectonic shifts in elevation, increased human use, and global climate change.

This report presents the results of a preliminary analysis of the data collected during the survey, focusing on: (1) variation in the abundance and distribution of abundant or ecologically important species, and (2) site-specific differences in species richness. It concludes with suggestions for further analyses and recommendations for improving and repeating the survey.

2. STUDY SITES AND METHODS

2.1 Study Sites

Locations of the study sites are shown in Figure 1, and some general characteristics for each site are given in Table 1. "The primary criteria for selecting the sites included: representing as many habitat types as possible, evenly spreading the sites along the entire coastline, and focusing on the largest rocky intertidal areas" (Fox,1994). In selecting the sites we also considered their accessibility. Qualitative descriptions of these sites can be found in Fox et al. (1994) and Fox (1994).

2.2 Survey Design and Sampling Procedures

Sampling procedures, developed in consultation with Lucinda Tear of the University of Washington, were described in detail by Fox (1994:2-4, Appendices A-C). Additional details, especially ones relevant to the analysis of the data, are presented below.

Briefly, each site was divided into four tide levels (strata) based on surveyed heights above Mean Lower Low Water (we did not sample minus tide levels). Within each tide level three sampling procedures were used, each aimed at a different component of the community:

1. A random-point sampling technique was used to estimate percent cover of sessile macrobiota and the association of that biota with substrate type. 80 points were semi-randomly chosen within 1 X 10 m plots (6 plots per stratum), and the sessile organisms and substratum type intercepted by each point recorded.

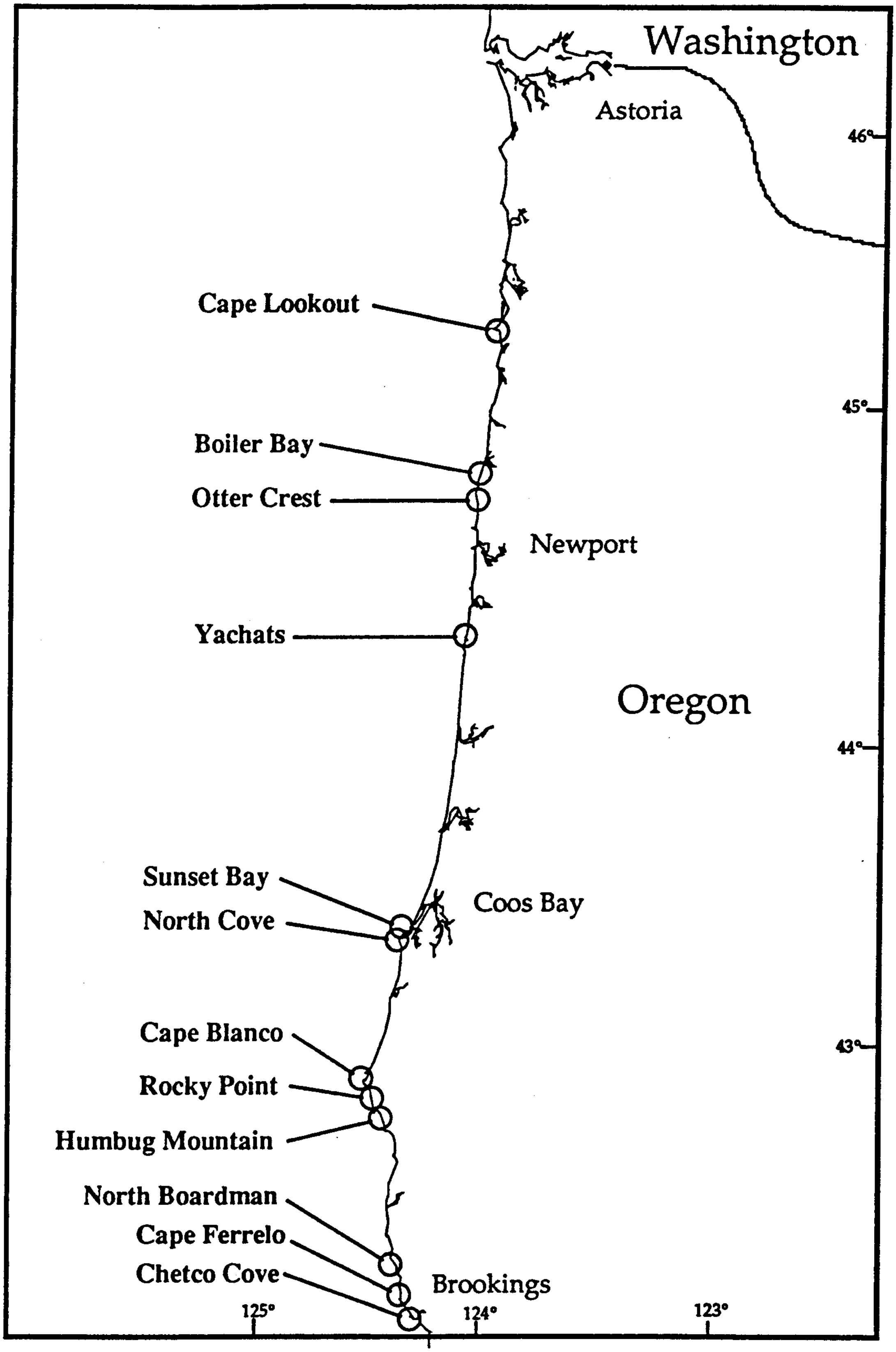


Figure 1. Location of rocky intertidal survey sites on the Oregon coast.

From Fox (1994)

Table 1. General characteristics of the study sites.

Site	Latitude	Orientation of shore[1]	Width of shore (m)*	Wave exposure[2]	Predominate substrate type	Substrate composition
Cape Lookout	45° 20'	S	108	protected	small boulders	basalt
Boiler Bay	44° 50'	SW**	≈22	protected	bedrock	basalt
Otter Crest	44° 45'	WSW	117 (0-2 m	protected	bedrock, sand	sandstone
Yachats	44° 19'	W	>54	exposed	bedrock	basalt
Sunset Bay	43° 20'	NW-N	>84	protected	small boulders, bedrock	sandstone
North Cove	43° 19'	NW	>78	protected	bedrock, boulders	sandstone
Cape Blanco	42° 50'	NNE	56	protected	small boulders, bedrock	sandstone, schist
Rocky Point	42° 43'	WSW	69 (0-1 m)	protected	small boulders, sand	sandstone
Humbug Mtn	42° 40'	SSW	51	protected	small boulders	sandstone, conglomerate
North Boardman	42° 13'	SSW	74	protected	small boulders	sandstone
Cape Ferrelo	42° 06'	S	50	protected	small boulders	sandstone, mixed[3]
Chetco Cove	42° 03'	SE	102	protected	mixed	sandstone

[1] compass direction of line perpendicular to the water's edge.

* width of shore between MLLW and +3 m tide level, measured along longest baseline. Values for Otter Crest and Rocky Point are widths measured between the tide levels given in parentheses.

[2] protected and exposed = protected outer coast and open coast, respectively, of Ricketts et al. (1985).

** Boiler Bay opens to the northwest and is exposed to waves at its mouth; our study site was located in a protected part of the bay.

[3] mixed = mixture of volcanic, metamorphic ,and sedimentary rocks.

We did not distinguish occupation of primary vs. canopy space (i.e., rock surfaces vs. the overlying space). Because canopies can be multi-layered, total percent cover for a given plot or tide level (including cover of bare rock and sand) can exceed 100%.

Placement of plots within a stratum was random. However, in order to expedite sampling, the placement of points within a plot was semi-systematic, utilizing a 0.5 X 0.5 m sampling grid (divided into 10 X 10 cm squares), and placing 4 points in every 0.5 X 1 m section of a plot (Fox, 1994). Positioning of the 4 points on the sampling grid was random and repeated each time the grid was moved along a plot.

We did not observe any patterns in the spacing of the organisms or the underlying substratum which matched our sample spacing, and consider (for statistical purposes) the points to be random and independent samples.

2. A quadrat sampling technique was used to estimate the abundance of the more common mobile and sessile macrofauna, excluding the under rock fauna. Using previously generated random numbers, three 0.25 m^2 quadrats were randomly positioned in each plot, and the macrofauna individually counted or visually estimated by order of magnitude. Owing to their placement within the plots, the quadrats are not, strictly speaking, entirely random and independent of one another within a given tide level. The underlying heterogeneity of the habitat makes it unlikely that our sample spacing introduced any bias, and, as for the point-sampling above, we consider the quadrats random and independent samples.

3. A modified quadrat sampling technique was used to estimate abundances of rarer macrofauna. We individually counted large, conspicuous macrofauna in 1 X 20 m "belt transects" which were 1 X 10 m linear extensions of the plots described above. At Sunset Bay, North Cove, and the southern 6 sites, belt transects were also used to record the presence of as many taxa as possible (to provide overall species lists that could be compared to those generated by the quadrat data). Thus, in terms of the proportion of animal taxa present, the belt transect sampling was inconsistent, especially between the 4 northernmost sites and the other 8 sites. With exception of some belt transects sampled by Dave Fox of ODFW at Boiler Bay, belt transects at the 4 northernmost sites were sampled exclusively by Jeff Harding of OSU, by Jeff Harding and Jeff Goddard (OIMB) at Sunset Bay and North Cove, and exclusively by Jeff Goddard at the southern 6 sites.

As noted by Fox (1994, Appendix C), we relied on tide predictions (generated by Harbormaster computer software) to calibrate our surveys of tide elevations in the field. During the survey weather was generally clear, with northwest winds and calm seas, indicating a high pressure system. The observed tides therefore may have been slightly lower than predicted

Abundances were recorded on data forms containing lists of species likely to be encountered (see Appendix B in Fox (1994)). Taxonomic identifications and nomenclature followed Abbott and Hollenberg (1976) and Gabrielson et al. (1990) for macroflora and Kozloff (1987) and Smith and Carlton (1975) for macrofauna, including Lindberg (1981) for limpets (with recent name changes), and Behrens (1991) for opisthobranchs.

Owing to time constraints and the diversity of organisms encountered, some organisms were identified to genus only, and several were grouped into larger categories (e.g., crustose coralline algae, boring bivalves, amphipods).

Participants in the survey (listed in Appendix D) were chosen on the basis of experience and interest in the intertidal biota of Oregon and spent the week prior to the field work learning the sampling procedures and reviewing taxonomic identifications. Each of the two teams had two members with considerable research and taxonomic experience with the biota. An important role of these latter members during the survey was to verify and standardize identifications made in the field. Each team was equipped with taxonomic keys and a dissecting microscope, and a few troublesome or unfamiliar taxa were identified during the course of the field work. A few specimens were collected and preserved for identification after completion of the field work. In the field each team also had access to a reference collection of the shells of common prosobranchs, especially limpets (collected and identified by Jeff Goddard).

Although we attempted to standardize field identifications, differences between teams were inevitable, stemming from the expertise and interests of their respective members. For example, taxonomic expertise was weighted toward the algae on the northern team and toward the invertebrates on the southern, and members on the northern team may have tended to split categories of organisms, while those on the southern team tended to lump categories. These kinds of differences may have influenced the results, with implications for any comparisons made between the northern and southern sites.

2.3 Data Entry and Analysis

Data were entered into Microsoft Excel (version 5.0) spreadsheets and descriptive statistics generated to compare means and standard errors of the samples, especially those for the two kinds of density estimates. Percent cover data were collected in the field in a way that allows for a point by point association of cover type (species, sand, or bare rock) with substrate type. However, owing to constraints of time, these data were entered into the spreadsheets as the total number of points per plot intercepting a particular cover and substrate type. Time also did not permit more than a cursory analysis of the percent cover estimates. Tables and figures were generated using Excel versions 5.0 and 7.0.

Abundances of organisms and percentage substrate type were calculated for each tide level at each site. Sample sizes per tide level vary because (1) we were not able to complete all planned samples; (2) we sampled some tide levels using a deliberately reduced sample size (this applied to higher tide levels with little or no biological cover); and (3) elevation survey data revealed that some quadrats and plots actually belonged to a tide level (stratum) different from the one to which they had been assigned in the field. Tidal elevations were determined in the field for each quadrat, and three additional elevations were determined for each plot (see Fox, 1994, Appendix C). In the data analysis I reassigned quadrats to a different stratum if their elevation was outside the range prescribed for their original stratum, and reassigned plots only when all 6 elevations (at 0,5, and 10 m and at the center of each quadrat) were outside the prescribed range.

Density estimates of invertebrates were generally derived from counts of individual organisms. However, abundances were sometimes recorded in the field as visual estimates of order of magnitude, especially for more abundant species (e.g. *Littorina* spp. and *Anthopleura elegantissima*). When calculating mean densities using the latter type of data, I used the order of magnitude itself as the value. Thus, if a species had been recorded as occurring in the hundreds in a particular sample, I used a value of 100 in the calculations. Density estimates incorporating these type of data are conservative and, if based entirely on them, obviously will severely underestimate actual densities. In the latter case, the estimates are of comparative value only, and can not be used as estimates of actual densities.

3. RESULTS

3.1 Substrate Type

Total percent substrate type at each tide level at each site is presented in Tables 2 and 3 and shown graphically in Figures 2-5. These values represent the total number of points intercepting a particular substrate type in a tide level, divided by the total number of points per tide level; they are virtually identical to mean values per plot per tide level.

Based on these data the sites can be divided into 5 categories: (1) sites dominated by boulders (Cape Lookout, Humbug Mt., and Cape Ferrelo); (2) sites dominated by boulders and sand (Rocky Point); (3) sites comprised of a mixture of bedrock and boulders (Sunset Bay, North Cove, North Boardman, and Chetco Cove); (4) sites comprised largely of bedrock (Boiler Bay and Yachats); and finally, (5) sites dominated by both bedrock and sand (Otter Crest).

Yachats and Boiler Bay, with their basalt bedrock benches, were the most uniform sites with regard to substrate type, and Chetco Cove the most mixed. At Otter Crest the 2-3 m tide level was entirely sandy beach and therefore not sampled for rocky intertidal organisms; likewise for both the 1-2 m and 2-3 m tide levels at Rocky Point.

The presence at a site of a significant amount of smaller-sized particles (i.e. sand, gravel, cobbles and small boulders) usually reflects reduced wave-energy, and, indeed, our only truly wave-exposed site was Yachats. At the other sites a combination of factors result in reduced wave exposure, including the presence of outer reefs and rocks, a gently sloping shore, or the location of the site in a cove or near the beginning of a point.

Table 2. Total percent substrate type and percent cover by impounded tidepools in 10 m^2 plots at 4 tide levels at the north coast sites.* Particle sizes: large boulder > 1.25 m, small boulder 30.5 cm - 1.25 m, cobble 64 - 305 mm, gravel 4 - 64 mm, sand < 4 mm. Gravel and sand can overlay other substrate types, resulting in totals greater than 100%. Data collected using a point-sampling technique and 80 random points per plot (see Methods).

Site	Tide level (m)	No. of plots	Total No. of points	Substrate type						Tide-pool
				bedrock	large boulder	small boulder	cobble	gravel	sand	
Cape Lookout	0-0.5	4	316	2.5	28.5	50.6	6.3	6.6	5.4	11.1
	0.5-1	6	476	0.0	16.2	59.7	15.1	6.1	3.8	9.0
	1-2	8	636	0.2	25.3	49.5	12.7	9.9	2.2	5.3
	2-3	6	479	1.7	18.8	68.5	4.8	6.1	0.2	0.0
Boiler Bay	0-0.5	4	319	99.1	0.0	0.0	0.0	0.6	34.5	4.1
	0.5-1	5	400	100.0	0.0	0.0	0.0	0.0	4.3	6.0
	1-2	4	320	100.0	0.0	0.0	0.0	0.0	7.2	2.5
	2-3	6	479	99.8	0.0	0.0	0.0	0.0	0.2	13.2
Otter Crest	0-0.5	5	399	96.2	0.0	0.0	0.0	0.0	20.8	18.5
	0.5-1	8	638	97.3	1.9	0.0	1.3	0.6	69.9	45.9
	1-2	5	400	96.5	0.3	0.0	2.0	0.3	48.8	21.5
	2-3	0	0						100.0	0.0
Yachats	0-0.5	6	479	92.1	0.0	1.3	0.2	0.4	7.5	24.4
	0.5-1	4	318	99.1	0.0	0.6	0.0	0.0	3.1	19.5
	1-2	6	475	99.8	0.0	0.0	0.0	1.1	0.0	12.0
	2-3	6	476	97.7	0.0	1.5	0.0	3.4	7.4	15.1
Sunset Bay	0-0.5	4	317	11.0	13.9	56.8	6.0	0.6	15.5	4.7
	0.5-1	4	315	21.0	21.9	38.4	4.1	3.8	12.7	14.3
	1-2	6	479	70.1	19.8	2.1	2.5	10.9	10.0	14.0
	2-3	6	480	7.9	31.3	53.3	5.0	3.5	0.0	0.0
North Cove	0-0.5	9	714	34.0	30.7	20.6	6.2	3.8	22.5	19.9
	0.5-1	4	318	47.8	22.0	13.8	7.9	2.5	7.5	12.9
	1-2	6	379	55.9	12.1	23.2	5.5	1.3	6.6	12.1
	2-3	6	478	7.1	25.7	54.8	11.5	0.6	0.0	0.2

* values are percentage of points intercepting a substrate type out of the total number of points per tide level per site.

Table 3. Total percent substrate type and percent cover by impounded tidepools in 10 m^2 plots at 4 tide levels at the south coast sites.* Particle sizes: large boulder > 1.25 m, small boulder 30.5 cm - 1.25 m, cobble 64 - 305 mm, gravel 4 - 64 mm, sand < 4 mm. Gravel and sand can overlay other substrate types, resulting in totals greater than 100%. Data collected using a point-sampling technique and 80 random points per plot (see Methods).

Site	Tide level (m)	No. of plots	Total No. of points	Substrate type: bedrock	large boulder	small boulder	cobble	gravel	sand	Tide-pool
Cape Blanco	0-0.5	6	478	30.8	19.7	33.5	6.5	1.7	7.9	9.0
	0.5-1	6	479	12.9	21.5	47.2	10.2	0.8	6.7	6.5
	1-2	6	480	49.0	11.3	22.9	8.8	4.0	4.6	7.7
	2-3	6	480	66.3	4.0	11.0	14.0	4.8	0.0	0.8
Rocky Point	0-0.5	5	400	9.5	9.0	22.0	19.8	9.0	28.5	34.5
	0.5-1	7	559	4.8	1.6	21.5	40.6	12.7	18.6	33.8
	1-2	0							100.0	0.0
	2-3	0							100.0	0.0
Humbug Mtn.	0-0.5	6	478	6.9	14.2	53.3	17.4	3.1	5.0	5.2
	0.5-1	6	476	3.8	16.0	41.2	27.7	7.6	3.8	4.8
	1-2	6	479	6.3	8.6	43.4	35.3	6.1	0.4	1.5
	2-3	3	240	0.0	0.8	77.1	17.1	5.0	0.0	0.0
North Boardman	0-0.5	6	479	8.1	22.1	54.5	12.1	2.3	4.8	10.4
	0.5-1	5	397	36.5	16.9	24.2	8.8	9.3	4.5	12.8
	1-2	7	557	14.2	39.5	23.2	10.2	12.9	0.0	2.5
	2-3	3	214	9.8	21.0	42.1	22.4	4.7	0.0	0.5
Cape Ferrelo	0-0.5	5	396	1.0	32.8	51.8	9.6	1.8	0.5	3.0
	0.5-1	6	479	0.8	26.1	50.1	16.3	6.1	0.6	7.1
	1-2	6	479	3.1	19.4	44.5	21.5	7.1	4.4	2.3
	2-3	6	480	0.0	31.5	22.7	27.3	16.3	2.3	0.0
Chetco Cove	0-0.5	6	475	48.8	10.1	21.1	12.8	5.3	1.9	16.2
	0.5-1	7	558	44.3	6.6	11.1	19.9	9.0	9.7	17.7
	1-2	5	399	10.8	0.3	25.6	26.6	20.6	15.8	8.3
	2-3	3	239	15.5	3.3	22.6	18.4	8.4	31.8	0.0

* values are percentage of points intercepting a substrate type out of the total number of points per tide level per site.

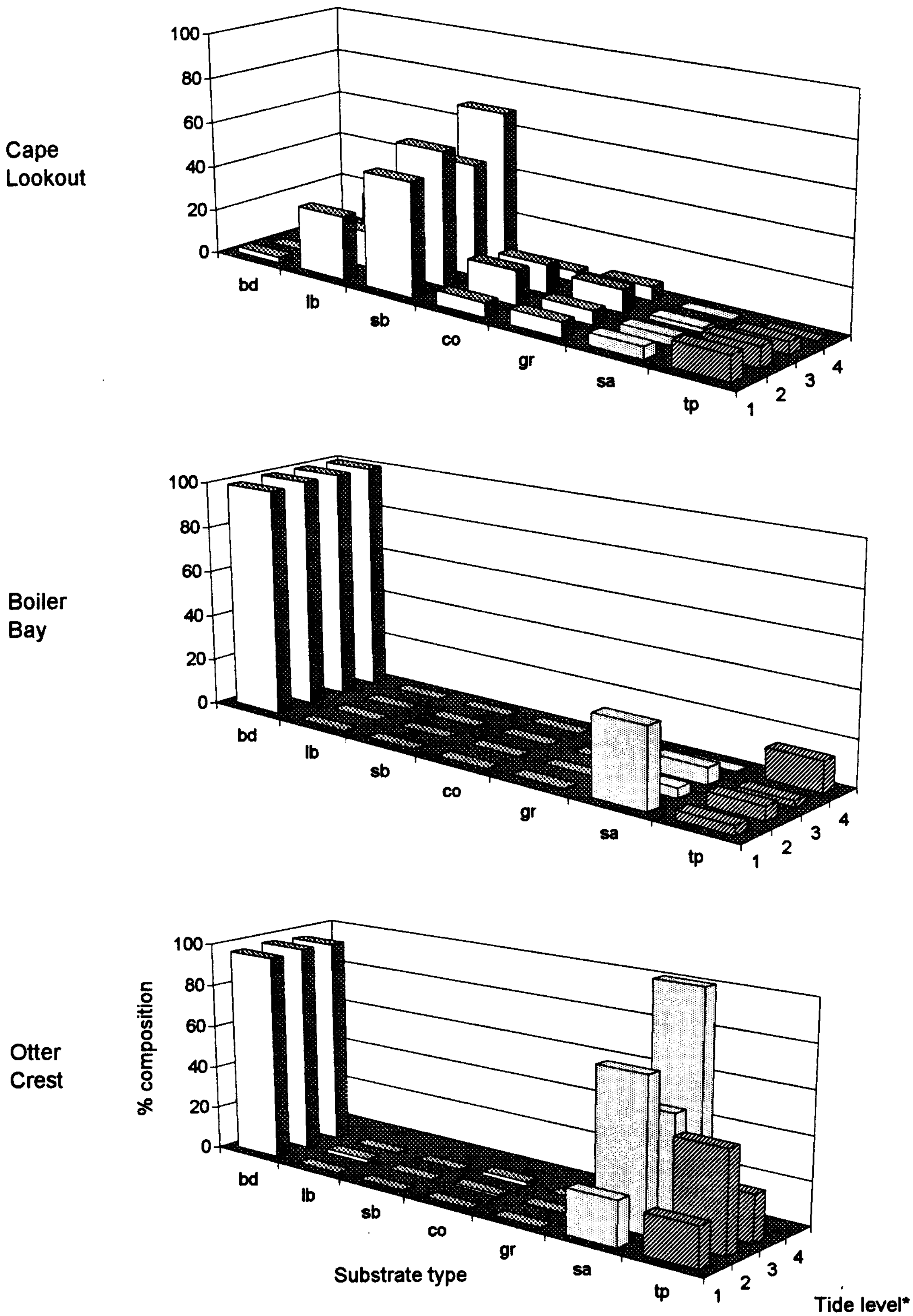
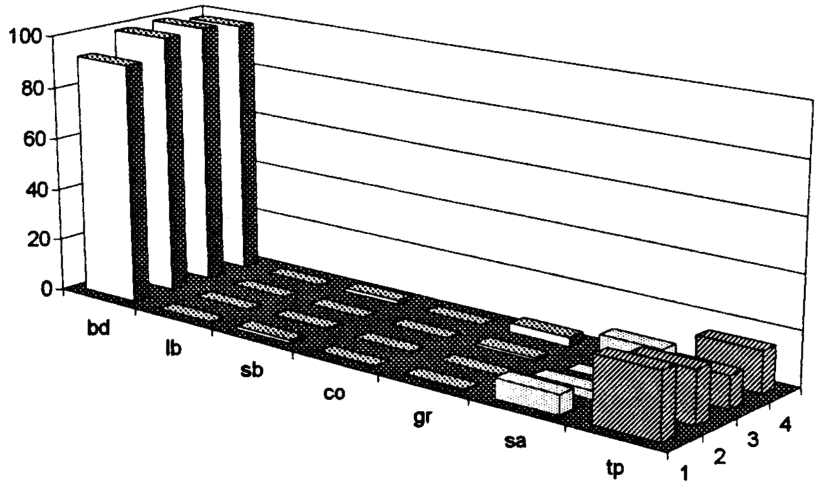
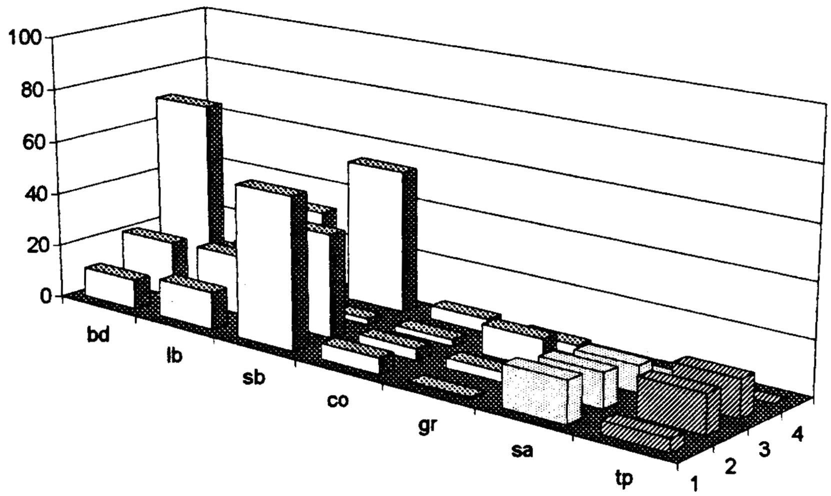


Figure 2. Percent substrate type and % cover by tidepools at 3 northern sites. Data from Table 2. Bd = bedrock, lb = large boulder, sb = small boulder, co = cobble, gr = gravel, s = sand, tp = tidepool. (see Table 2 for particle size classes). *Tide level: 1 = 0-0.5 m, 2 = 0.5 - 1 m, 3 = 1-2 m, 4 = 2-3 m.

Yachats



Sunset Bay



North Cove

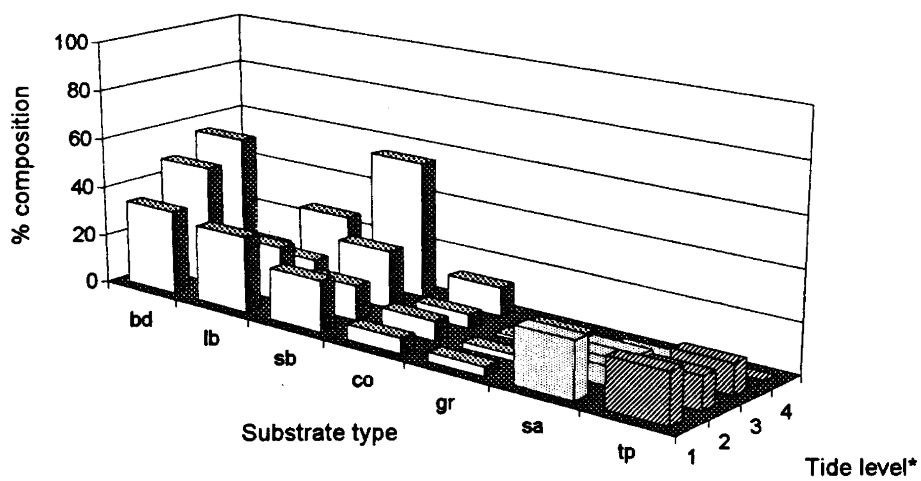


Figure 3. Percent substrate type and % cover by tidepools at 3 northern sites. Data from Table 2. Bd = bedrock, lb = large boulder, sb = small boulder, co = cobble, gr = gravel, s = sand, tp = tidepool. (see Table 2 for particle size classes). *Tide level: 1 = 0-0.5 m, 2 = 0.5 - 1 m, 3 = 1-2 m, 4 = 2-3 m.

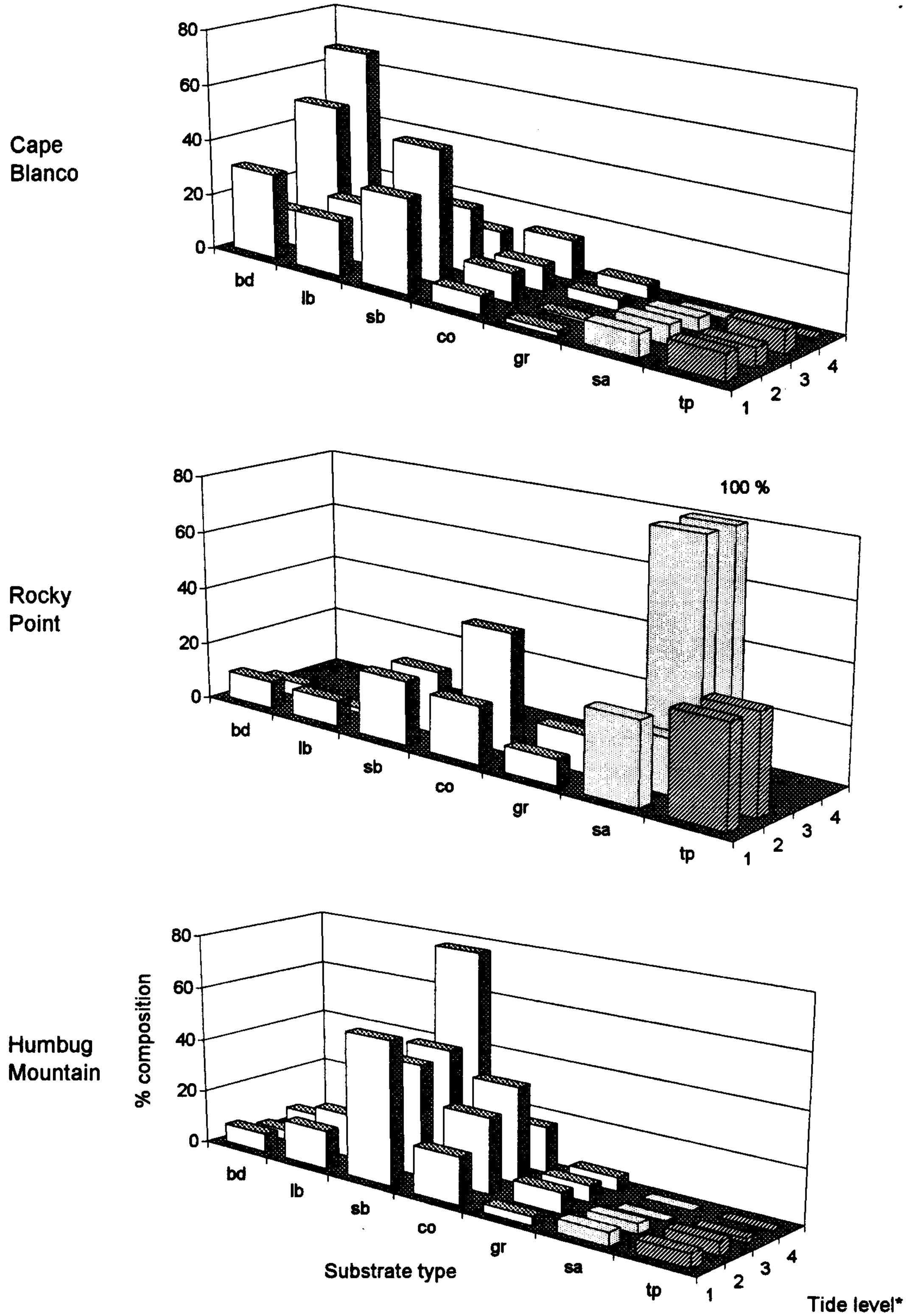


Figure 4. Percent substrate type and % cover by tidepools at 3 southern sites. Data from Table 3. Bd = bedrock, lb = large boulder, sb = small boulder, co = cobble, gr = gravel, s = sand, tp = tidepool. (see Table 3 for particle size classes). *Tide level: 1 = 0-0.5 m, 2 = 0.5 - 1 m, 3 = 1-2 m, 4 = 2-3 m.

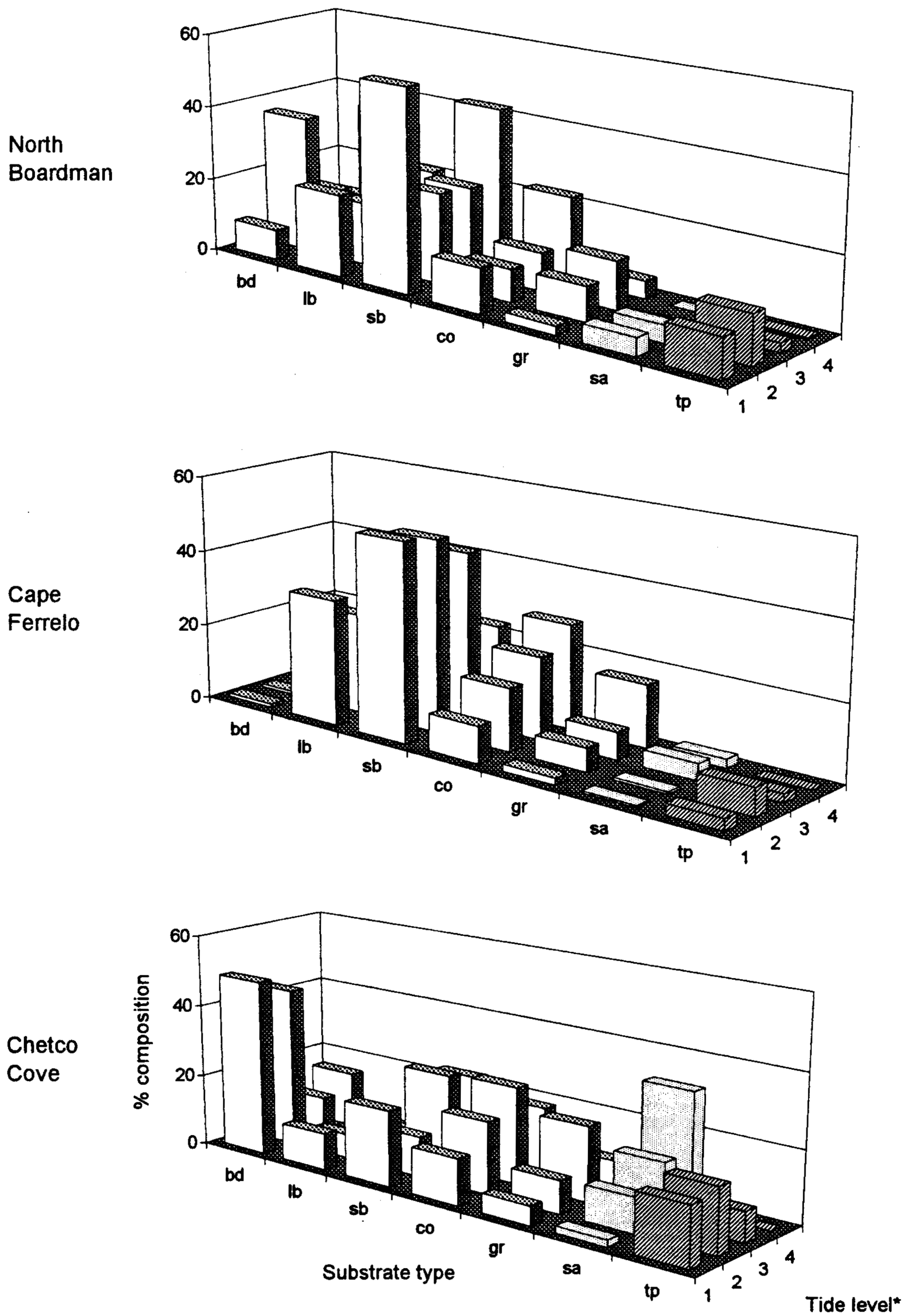


Figure 5. Percent substrate type and % cover by tidepools at 3 southern sites. Data from Table 3. Bd = bedrock, lb = large boulder, sb = small boulder, co = cobble, gr = gravel, s = sand, tp = tidepool. (see Table 3 for particle size classes). *Tide level: 1 = 0-0.5 m, 2 = 0.5 - 1 m, 3 = 1-2 m, 4 = 2-3 m.

3.2 Density of Selected Invertebrates

A. Quadrats.

Density data are presented for 10 conspicuous, easily identified, and ecologically important species in Table 4 and for six of these species in Figures 6-9. *Mytilus californianus* and small *Mytilus* (the latter are likely a mixture of *M. californianus* and *M. trossulus*) were abundant at Yachats and Boiler Bay and uncommon to absent at the other sites. They were also more abundant in the 2-3 m tide level at Yachats than at Boiler Bay (Figures 6 and 7). Two important predators of *Mytilus*, *Pisaster ochraceus* and *Nucella emarginata* were more abundant at Yachats than at any other site. Other species found in the 2-3 m tide level at Yachats were either less common or absent in this tide level at the other sites (Table 4).

In contrast to the pattern observed for *Mytilus*, black turban snails, *Tegula funebralis*, and shield limpets, *Tectura scutum*, were much more abundant at sites with boulders than at the bedrock -dominated sites (Figures 8 and 9).

Aggregating anemones, *Anthopleura elegantissima*, were most abundant at Yachats and Humbug Mountain (Figures 8 and 9) and were not found above 2 m except at 3 northern sites, especially Yachats.

Purple sea urchins, *Stronglyocentrotus purpuratus* were abundant at Boiler Bay and , to a lesser degree, at Sunset Bay, but, as evidenced by the large standard errors, were very patchy in distribution at these sites.

B. Belt transects.

Belt transects were used to estimate the densities of invertebrates which are larger and more widely dispersed than those targeted by the quadrat sampling. Densities (No. per 20 m^2) for 4 of these species are presented in Table 5.

Like *Anthopleura elegantissima*, *A. xanthogrammica* was most abundant at Yachats, including at the 2-3 m tide level. However, in contrast to *A. elegantissima*, *A. xanthogrammica* was not observed (in either belts transects or quadrats) at Humbug Mountain.

C. Comparison of densities estimated using belts transects and quadrats.

All macro invertebrates were counted in the quadrats, allowing a comparison of density estimates for species also counted in the belt transects. Comparisons for three species are shown in Figures 10 and 11. As might be expected given the differences between belt transects and quadrats in sampling area and sampling effort per unit area, densities estimated using the quadrats tended to be higher than estimates obtained from the belt transects. This was more apparent at the northern six sites than the southern ones. The belts, however, were more sensitive to the presence of a species when it was rare (Figures 10 and 11). This was apparent at both northern and southern sites, and can also be seen in Table 6, which compares the number of sites at which a species was found in either a belt transect or quadrat. Conspicuous, more common species (e.g. *Pisaster*, *Katharina*, and *Anthopleura xanthogrammmica*) were detected at equal

Table 4. Mean density (No./m^2), ± 1 standard error, of selected invertebrates at 4 tide levels at each study site. Data are from 0.25 m^2 quadrats randomly placed within each of 3-8 plots, each 10 m^2 in area and randomly placed in each tide level (see Methods). N = total number of quadrats per tide level. Blanks mean species were not seen in the quadrats. For comparative purposes, occurrence of a species in a 20 m^2 belt transect (see Methods) but not in a quadrat is indicated by an asterisk (*).

Site	Tide level (m)	N	*Pisaster ochraceus*	*Mytilus californianus*	small *Mytilus*[1]	*Nucella emarginata*	*Tegula funebralis*	*Tectura scutum*	*Anthopleura elegantissima*	*Anthopleura xanthogram.*	*Strongylo. purpuratus* (adults only)	*Lottia digitalis*	*Semibalanus cariosus*
Cape	0-0.5	8	1.0 ± 0.7	*	0.5 ± 0.5			3.5 ± 1.6	51.5 ± 17.5	1.5 ± 0.7			
Lookout	0.5-1	21	1.1 ± 0.4				3.8 ± 1.3	3.2 ± 1.0	91.6 ± 22.7	1.0 ± 0.7		0.2 ± 0.2	0.6 ± 0.4
	1-2	29	1.0 ± 0.4				20.1 ± 5.9	3.3 ± 1.3	69.0 ± 33.8	0.8 ± 0.6		2.1 ± 1.1	
	2-3	10										0.4 ± 0.4	
Boiler	0-0.5	16	0.8 ± 0.8					0.3 ± 0.3	0.3 ± 0.3	0.5 ± 0.3	32.8 ± 21.1		
Bay	0.5-1	15	1.9 ± 0.8	0.3 ± 0.3				0.3 ± 0.3	18.9 ± 16.5	0.8 ± 0.4	2.7 ± 1.1	0.3 ± 0.3	0.5 ± 0.5
	1-2	9		92.0 ± 83.7	49.3 ± 44.1		1.3 ± 0.9	0.9 ± 0.9	37.3 ± 27.3	6.7 ± 4.4		84.9 ± 34.5	16.0 ± 10.7
	2-3	17		1.6 ± 1.0	4.5 ± 2.3	0.5 ± 0.3	1.9 ± 1.6		5.2 ± 4.9			89.9 ± 28.5	
	0-0.5	12	*	*					1.0 ± 0.7	1.0 ± 0.7	0.7 ± 0.4		
Otter	0.5-1	34					0.9 ± 0.4		13.9 ± 3.3				
Crest	1-2	8							16.0 ± 14.9			*	
	2-3	0											
Yachats	0-0.5	19	6.1 ± 1.9	0.6 ± 0.5	6.5 ± 3.4	0.4 ± 0.4		*[2]	55.6 ± 18.2	5.9 ± 2.1		2.7 ± 2.1	3.6 ± 2.2
	0.5-1	11	9.1 ± 4.4		12.0 ± 5.4	4.4 ± 2.7			195.3 ± 77.4	12.4 ± 4.5	0.4 ± 0.4	8.4 ± 4.8	13.8 ± 5.4
	1-2	22	2.2 ± 1.1	52.5 ± 24.7	85.8 ± 32.5	15.1 ± 4.9	1.3 ± 1.0		104.0 ± 26.1	8.2 ± 4.3		71.6 ± 28.9	112.0 ± 34.3
	2-3	14		91.4 ± 44.9	34.6 ± 28.4	22.0 ± 15.4	0.3 ± 0.3		42.3 ± 14.2	1.4 ± 1.4		77.1 ± 49.2	50.0 ± 28.2
Sunset	0-0.5	12	1.0 ± 0.7	*	0.3 ± 0.3			7.0 ± 3.7		*	2.3 ± 1.7	1.0 ± 0.7	
Bay	0.5-1	9	1.3 ± 0.9		1.3 ± 0.7		11.6 ± 11.1	7.6 ± 5.0	0.9 ± 0.9	*	1.3 ± 1.3		
	1-2	21			5.0 ± 2.6	0.2 ± 0.2	9.5 ± 3.1	8.4 ± 3.4	9.0 ± 5.9	*	0.4 ± 0.3	19.4 ± 10.0	
	2-3	18					1.3 ± 1.1		4.7 ± 4.7			6.2 ± 3.4	
North		22	0.2 ± 0.2				24.2 ± 7.0	1.1 ± 0.8	0.2 ± 0.2	0.4 ± 0.3	*	0.2 ± 0.2	
Cove	0.5-1	15					135.5 ± 29.7	3.2 ± 2.1	17.1 ± 8.4			0.5 ± 0.4	
	1-2	23		*	2.3 ± 1.7	0.2 ± 0.2	46.8 ± 16.2	1.2 ± 0.8	32.3 ± 18.8			21.9 ± 7.0	
	2-3	12					1.0 ± 0.5						

Table 4. Continued.

Site	Tide level (m)	N	*Pisaster ochraceus*	*Mytilus californianus*	small *Mytilus*	*Nucella emarginata*	*Tegula funebralis*	*Tectura scutum*	*Anthopleura elegantissima*	*Anthopleura xanthogram.*	*Stronglyo. purpuratus* (adults only)	*Lottia digitalis*	*Semibalanus cariosus*
Cape	0-0.5	10			0.4 ± 0.4			2.4 ± 1.4	4.8 ± 1.9	1.2 ± 0.6	*		
Blanco	0.5-1	19	2.5 ± 1.1		0.2 ± 0.2		0.6 ± 0.3	7.6 ± 2.3	40.6 ± 12.4	4.4 ± 1.9			
	1-2	19	1.3 ± 0.7	*	0.2 ± 0.2	0.6 ± 0.3	118.5 ± 42.7	10.5 ± 4.8	62.5 ± 16.5	2.3 ± 1.5		1.1 ± 0.7	
	2-3	24		*		0.3 ± 0.2	18.5 ± 16.6	0.2 ± 0.2				2.0 ± 1.4	
Rocky	0-0.5	13					43.1 ± 33.9	2.8 ± 1.6	38.8 ± 12.9	0.6 ± 0.6			*
Point	0.5-1	23	0.7 ± 0.4		*		58.1 ± 24.4	2.3 ± 1.3	72.9 ± 15.2			0.7 ± 0.5	
	1-2	0											
	2-3	0											
Humbug	0-0.5	17					3.8 ± 1.9	7.5 ± 2.3	112.0 ± 32.7		*		
Moutain	0.5-1	16					21.5 ± 7.1	6.3 ± 1.9	129.0 ± 35.5				
	1-2	21	0.4 ± 0.4	0.8 ± 0.8		0.2 ± 0.2	76.0 ± 31.7	2.7 ± 1.6	5.7 ± 4.3			3.8 ± 2.3	
	2-3	9					1.8 ± 1.0						
North	0-0.5	14	1.4 ± 0.7				5.1 ± 2.9	7.4 ± 2.7	12.6 ± 10.2				
Board-	0.5-1	17	0.2 ± 0.2	*		0.2 ± 0.2	12.9 ± 5.4	7.5 ± 2.6	32.9 ± 13.1	0.5 ± 0.3		0.2 ± 0.2	
man	1-2	24	0.2 ± 0.2	*	0.3 ± 0.2	5.3 ± 2.4	16.5 ± 5.9	1.8 ± 1.1	6.0 ± 3.1			4.2 ± 1.8	*
	2-3	8				0.5 ± 0.5	0.5 ± 0.5					1.0 ± 1.0	
Cape	0-0.5	6						4.0 ± 3.3	7.3 ± 6.6				
Ferrelo	0.5-1	15	0.3 ± 0.3	0.3 ± 0.3			103.5 ± 58.9	21.1 ± 5.9	16.0 ± 7.5	0.5 ± 0.4		0.5 ± 0.4	2.7 ± 2.7
	1-2	30	0.4 ± 0.4	0.3 ± 0.3		0.3 ± 0.2	55.9 ± 9.8	18.1 ± 5.0	21.1 ± 8.5	0.3 ± 0.3	0.7 ± 0.5	0.8 ± 0.6	
	2-3	19					0.4 ± 0.4					0.2 ± 0.2	
Chetco	0-0.5	13	0.6 ± 0.6				3.7 ± 1.9	4.9 ± 1.9	0.9 ± 0.9		*	*	
Cove	0.5-1	28	0.6 ± 0.3		0.1 ± 0.1		58.4 ± 13.8	3.9 ± 1.4	15.4 ± 6.8	0.1 ± 0.1		*	
	1-2	16					54.8 ± 19.0	2.5 ± 1.5	0.8 ± 0.5			*	
	2-3	7											

[1] small *Mytilus* are a mixture of *M. californianus* and *M. trossulus*

[2] Recorded as *Lottia pelta* with "weak ribs."

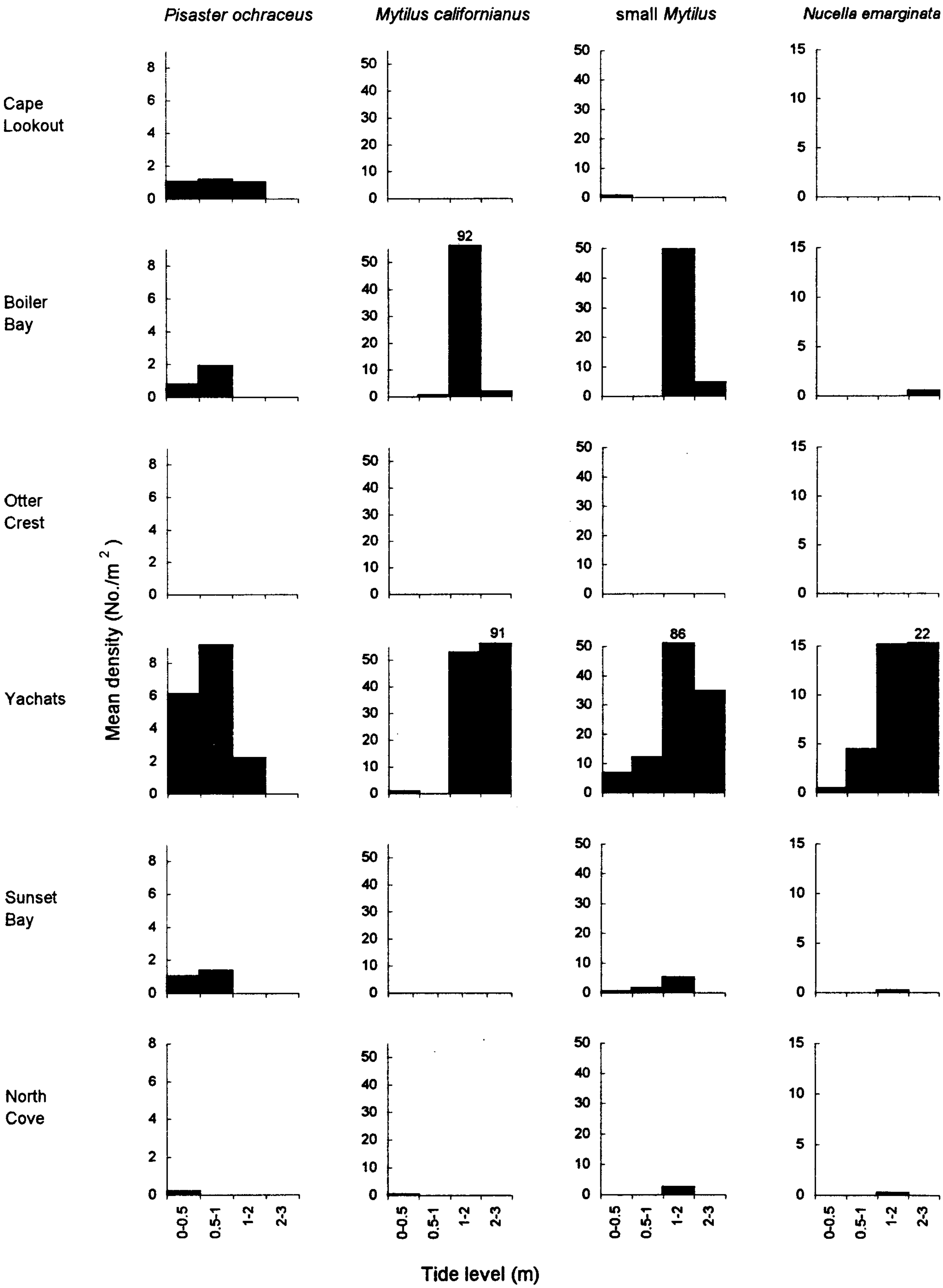


Figure 6. Mean density (No./m^2) of *Pisaster*, mussels, and *Nucella emarginata* at four tide levels at the northern sites. Data from Table 4. Numbers above bars are means falling outside the scale chosen for the y-axis. See Table 4 for sample sizes and standard errors.

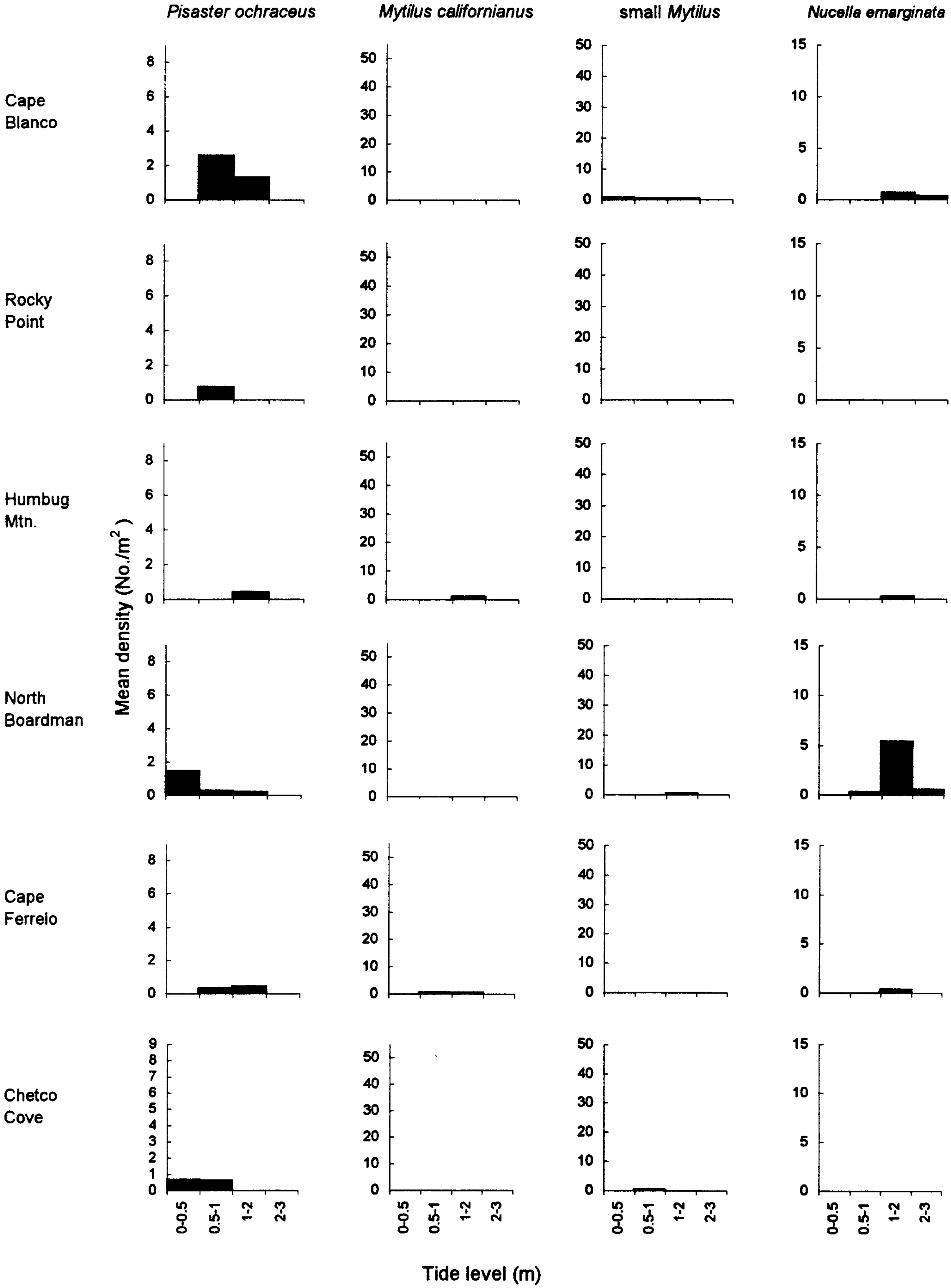


Figure 7. Mean density (No./m^2) of *Pisaster*, mussels, and *Nucella emarginata* at four tide levels at the southern sites. Data from Table 4. See Table 4 for sample sizes and standard errors.

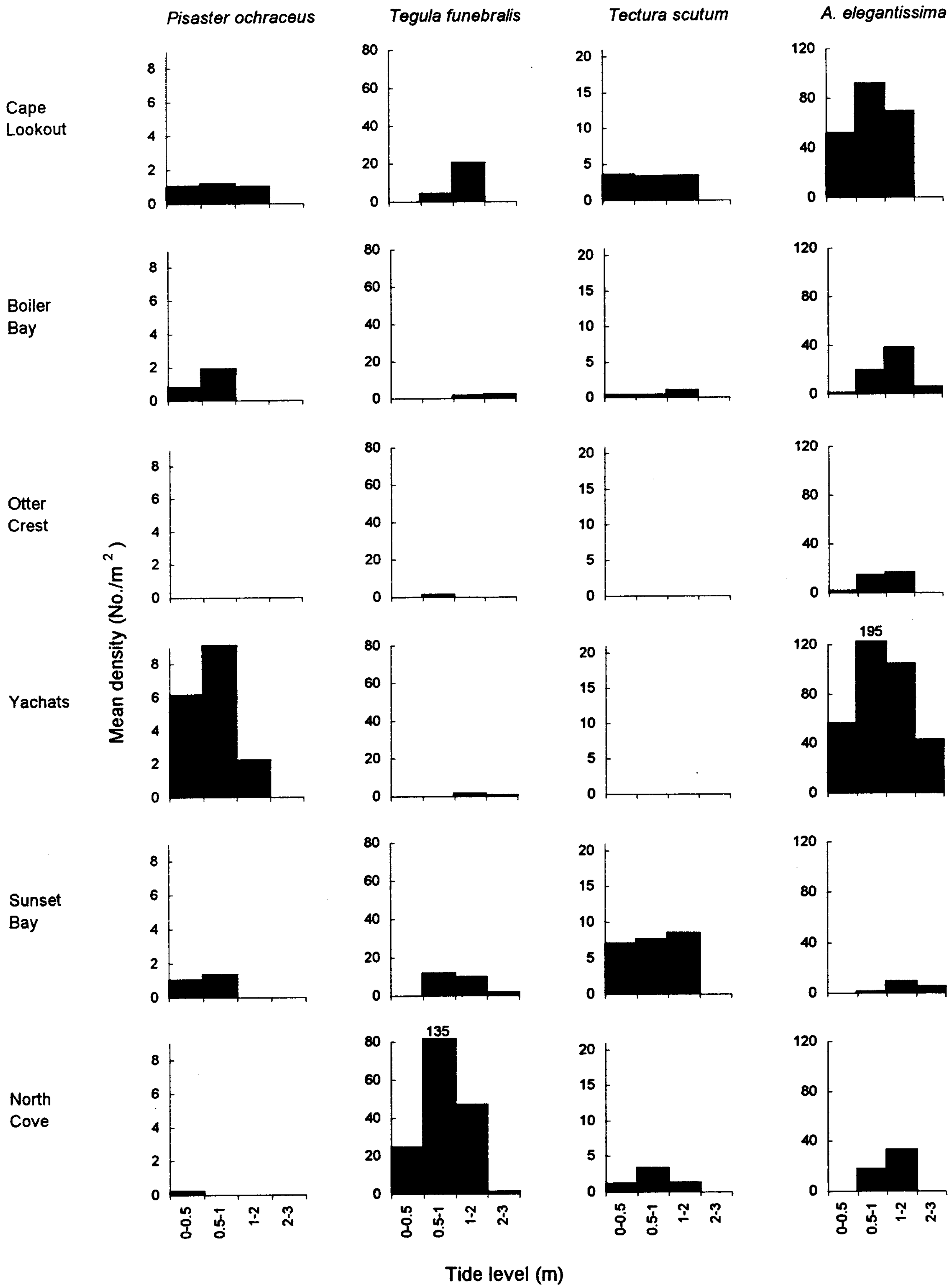


Figure 8. Mean density (No./m^2) of *Pisaster*, *Tegula funebralis, Tectura scutum*, and *Anthopleura elegantissima* at four tide levels at the northern sites. Data from Table 4. Numbers above bars are means falling outside the scale chosen for the y-axis. See Table 4 for sample sizes and standard errors.

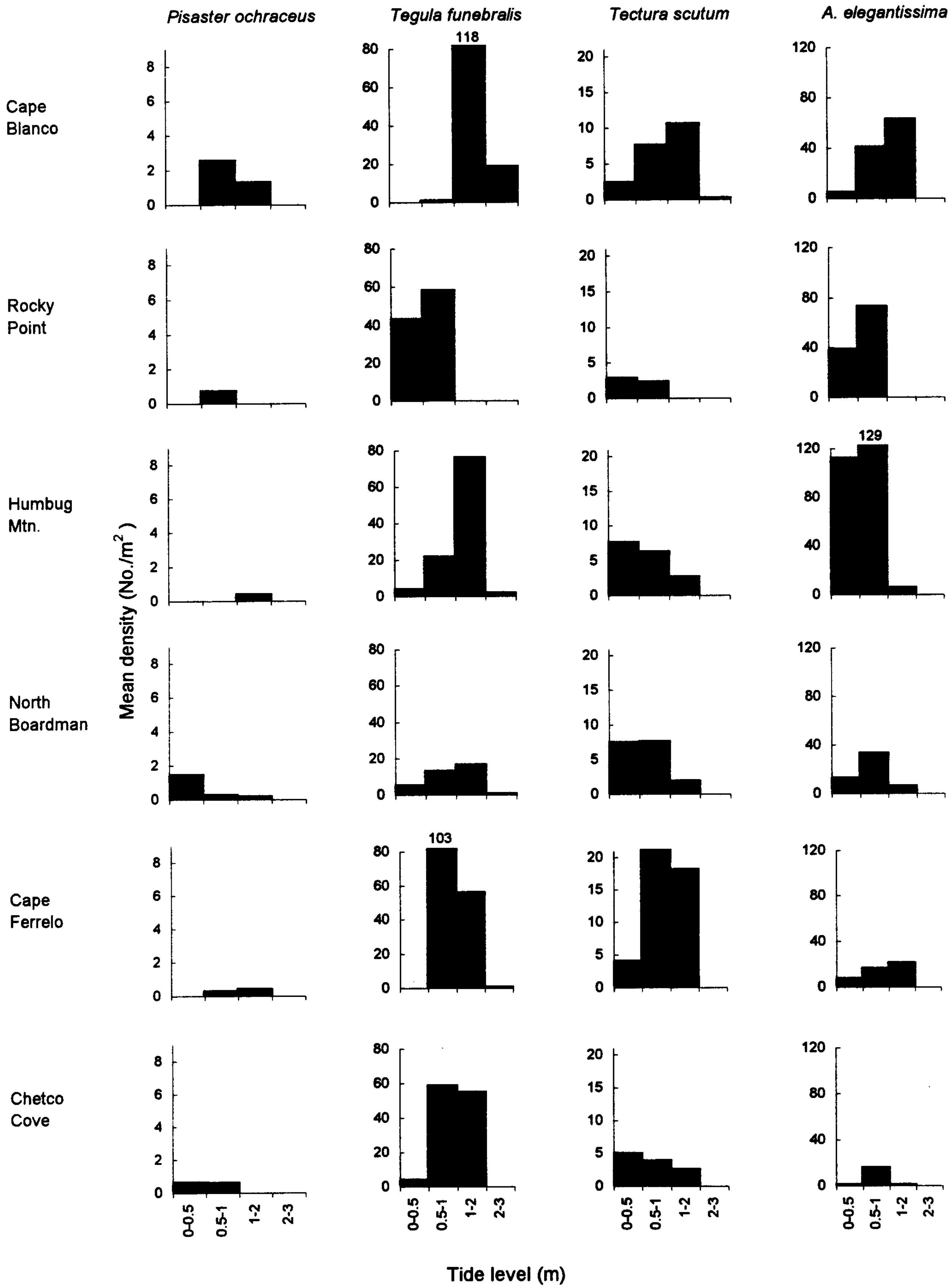


Figure 9. Mean density (No./m^2) of *Pisaster*, *Tegula funebralis, Tectura scutum*, and *Anthopleura elegantissima* at four tide levels at the southern sites. Data from Table 4. Numbers above bars are means falling outside the scale chosen for the y-axis. See Table 4 for sample sizes and standard errors.

Table 5. Mean density (No./20m^2), ± 1 standard error, of selected invertebrates at 4 tide levels at each study site. Data are from 20 m^2 belt transects randomly placed in each tide level (see Methods). N = number of belt transects per tide level. Blanks mean species were not found in the transects. For comparative purposes, occurrence of a species in 0.25 m^2 quadrats but not in a belt transect is indicated by an asterisk (*).

Site	Tide level (m)	N	*Pisaster ochraceus*	*Anthopleura xanthogrammica*	adult *Strongylocentrotus purpuratus*	*Cryptochiton stelleri*
Cape	0-0.5	6	12.02 ± 4.66	35.52 ± 16.28		0.33 ± 0.21
Lookout	0.5-1	6	12.17 ± 1.82	5.83 ± 2.21	0.17 ± 0.17	
	1-2	7	11.43 ± 3.14	0.29 ± 0.18		
	2-3	6				
Boiler	0-0.5	4	*	1.25 ± 0.48	497.25 ± 373.51	0.50 ± 0.50
Bay	0.5-1	5	1.00 ± 0.45	11.40 ± 3.01	33.40 ± 12.62	0.20 ± 0.20
	1-2	4	1.00 ± 0.58	27.25 ± 6.38	6.00 ± 3.49	*
	2-3	6		3.50 ± 2.08		
Otter	0-0.5	5	0.60 ± 0.40	4.00 ± 1.14	17.00 ± 12.34	
Crest	0.5-1	8		0.38 ± 0.38		
	1-2	5				
	2-3	0				
Yachats	0-0.5	5	19.60 ± 9.05	53.20 ± 11.00	1.20 ± 0.58	
	0.5-1	2	16.50 ± 2.50	49.50 ± 38.50	0.50 ± 0.50	
	1-2	6	7.67 ± 4.39	76.83 ± 19.86		
	2-3	6	6.50 ± 5.74	76.00 ± 44.15		
Sunset	0-0.5	3	2.00 ± 1.15	1.33 ± 0.67	72.67 ± 68.68	
Bay	0.5-1	4	1.75 ± 1.03	0.75 ± 0.48	6.75 ± 6.75	
	1-2	6	1.17 ± 0.98	0.33 ± 0.21	*	
	2-3	6				
North	0-0.5	7	2.00 ± 0.65	1.29 ± 0.57	7.86 ± 7.86	0.14 0.14
Cove	0.5-1	4	1.00 ± 0.71	0.75 ± 0.25		
	1-2	6		0.50 ± 0.34		
	2-3	6				
Cape	0-0.5	5	20.00 ± 6.66	54.00 ± 33.74	1.20 ± 0.80	
Blanco	0.5-1	6	26.17 ± 6.06	52.33 ± 12.27		0.33 ± 0.33
	1-2	6	11.83 ± 4.29	8.00 ± 4.93		
	2-3	6				
	0-0.5	5	2.80 ± 1.24	5.00 ± 2.19		
Rocky	0.5-1	7	4.43 ± 1.62	2.14 ± 0.91		
Point	1-2	0				
	2-3	0				
Humbug	0-0.5	6	2.67 ± 0.95		0.33 ± 0.33	
Mountain	0.5-1	6	3.00 ± 0.45			
	1-2	6	1.33 ± 0.76			
	2-3	3				
North	0-0.5	6	3.83 ± 1.35	11.50 ± 4.46		
Boardman	0.5-1	5	5.00 ± 1.00	1.00 ± 0.63		
	1-2	7	2.29 ± 1.48	0.29 ± 0.29		
	2-3	3				
Cape	0-0.5	5	1.00 ± 0.77	4.20 ± 1.77	5.80 ± 3.26	4.20 ± 1.77
Ferrelo	0.5-1	6	1.33 ± 0.61	4.33 ± 2.85	0.17 ± 0.17	
	1-2	6				
	2-3	6				
Chetco	0-0.5	6	4.67 ± 2.03	2.83 ± 1.90	0.33 ± 0.33	
Cove	0.5-1	7	5.00 ± 1.57	0.71 ± 0.29		
	1-2	5				
	2-3	3				

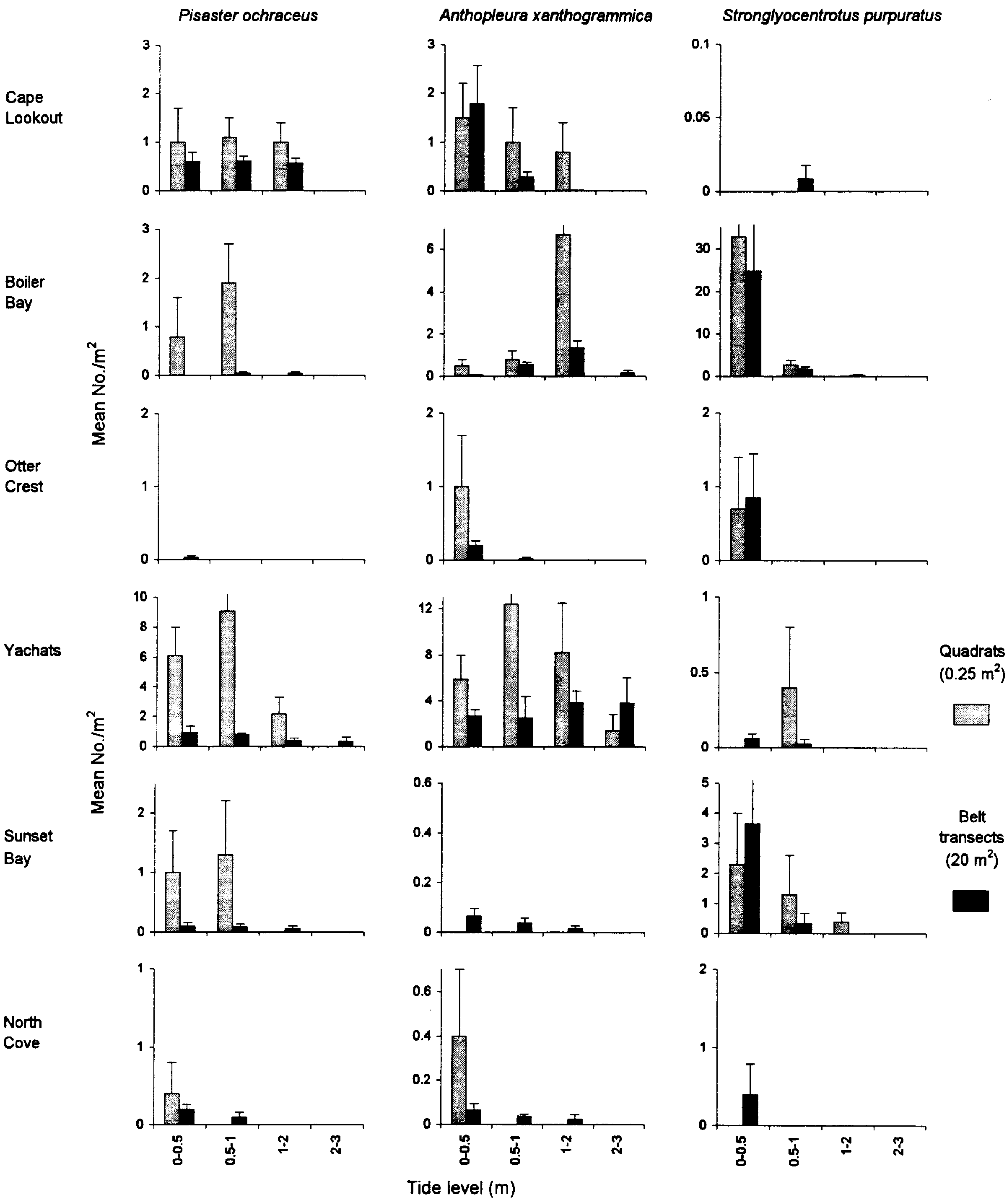


Figure 10. Comparison of densities (No./m^2) of 3 conspicuous invertebrates estimated from counts in 0.25 m^2 quadrats and 20 m^2 belt transects at 4 tide levels at the northern sites. Error bars represent one standard error. Note varying y-axis scales. Quadrat data from Table 4; belt transect data from Table 5 (with densities adjusted to No./m^2).

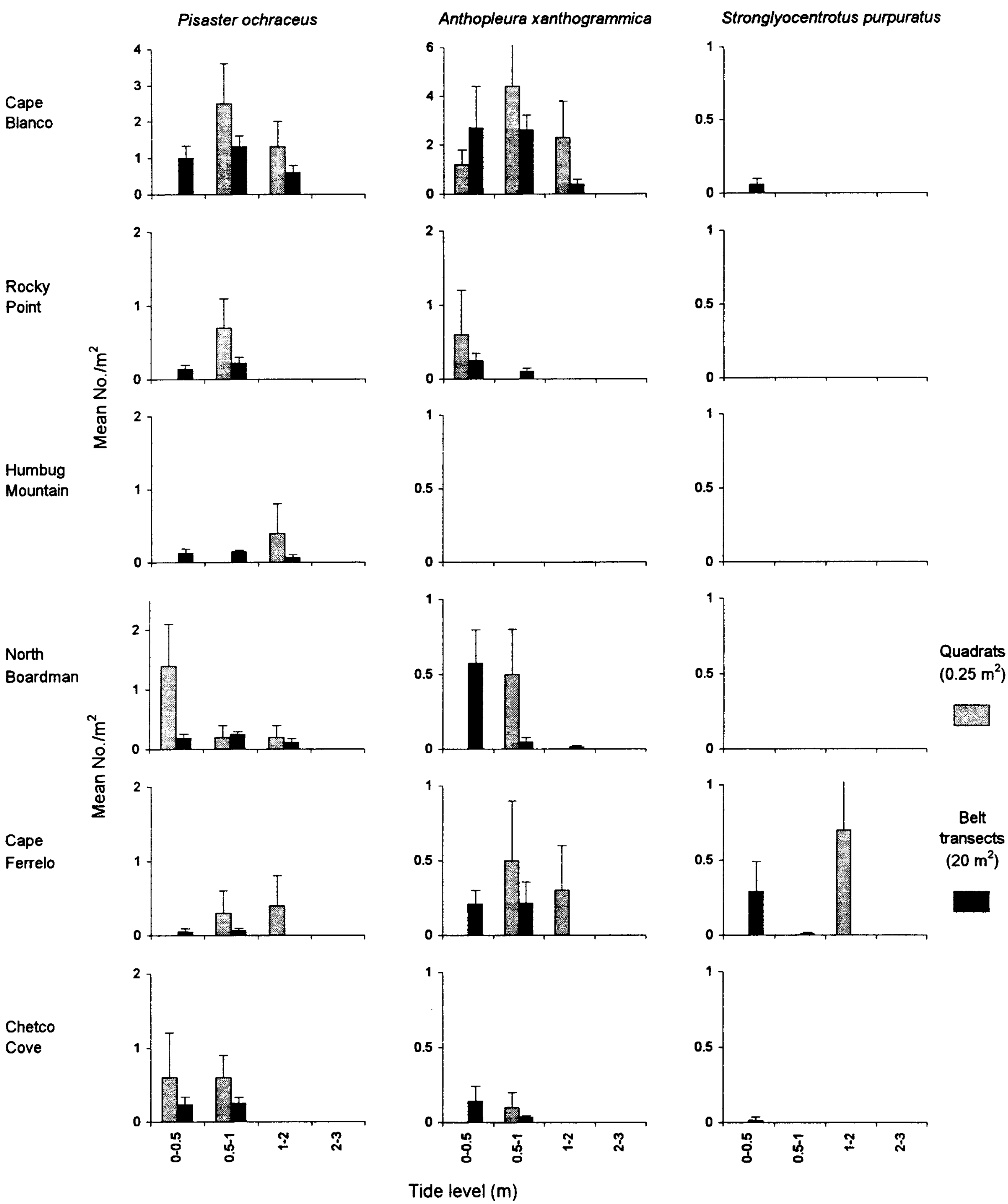


Figure 11. Comparison of densities (No./m^2) of 3 conspicuous invertebrates estimated from counts in 0.25 m^2 quadrats and 20 m^2 belt transects at 4 tide levels at the southern sites. Error bars represent one standard error. Note varying y-axis scales. Quadrat data from Table 4; belt transect data from Table 5 (with densities adjusted to No./m^2).

Table 6. Comparison of the number of sites at which 8 conspicuous invertebrates were found in 20 m^2 belt transects and 0.25 m^2 quadrats.

Species	Number of sites in quadrats	Number of sites in belts
Anthopleura xanthogrammica	10	11
Dermasterias imbricata	0	2
Pycnopodia helianthoides	1	6
Pisaster ochraceus	11	12
Solaster dawsoni	0	1
Stronglyocentrotus purpuratus (adults only)	5	10
Cryptochiton stelleri (juveniles and adults)	2	5
Katharina tunicata	5	5

numbers of sites using the two sampling methods, while conspicuous but rarer species (e.g. the asteroids *Dermasterias imbricata* and *Pycnopodia helianthoides*) were found at more sites in the belt transects.

3.3 Abundance and Distribution of Sessile Macrofauna and Flora

By percent cover, the four most abundant sessile invertebrates were *Anthopleura elegantissima*, *Mytilus californianus*, *Balanus glandula*, and *Chthamalus dalli*. Estimates of mean percent cover for these species, as well as for bare rock and sand are given in Table 7. Percent cover by these species was generally low, except at Yachats, where cover by mussels and barnacles averaged up to 20 percent. As we did not distinguish occupants of primary vs. secondary space (i.e. rock surfaces vs. the surfaces of other organisms), "cover" can mean growing on another organism, as well as on rock surfaces.

Bare rock surfaces can result from various physical and biological disturbances, including grazing, or from physiological stresses such as desiccation and heat. The amount of bare rock generally increased at each site with increasing tidal height (it should be noted, however, that cover by sand also needs to be considered when evaluating the amount of bare primary substratum (or its converse, occupied primary substratum)). At any given tide level, bare rock was least abundant at the bedrock dominated sites (Boiler Bay, Otter Crest, and Yachats) and most abundant at the south-facing, boulder-dominated sites (Cape Lookout, Humbug Mountain, Cape Ferrelo, and Chetco Cove) (Table 7).

The most abundant species encountered in the percent cover sampling are listed with their areas of occurrence in Table 8. This list is based on a cursory analysis of the data, one utilizing the number of plots in which a species covered 10% or more of the area of the plot. Based on this analysis, the red algae *Neorhodomela larix* and *Odonthalia floccosa* appeared to be more abundant at the more northerly sites, while *Mastocarpus* spp. tended to be more abundant at the southerly sites. Species of *Enteromorpha* were only found at the northerly sites.

3.4 Species Richness

A total of 168 taxa were observed in the quadrat samples, 157 in the belt transects, and 131 while sampling for percent cover (Appendices A-C). The number of taxa observed at each site using each of these sampling methods is presented in Table 9 and compared visually in Figure 12.

It is important to note that sampling in the belt transects varied between sites. We recorded the presence of as many species as possible in the belt transects at the southern 6 sites, as well as in those sampled in July and August at Sunset Bay, North Cove, and Boiler Bay (smaller species like *Spirorbis* spp. and Lacuna spp. may have been overlooked in these efforts). Sampling at the northernmost sites was limited to larger and more conspicuous species.

Bearing in mind these differences in sampling the belt transects, as well as potential biases between members of the north and south teams, a few points concerning these data are noteworthy. Overall,

Table 7. Mean percent cover (± 1 standard error) of bare rock, sand, and the 4 most abundant (by % cover) invertebrates at 4 tide levels at each site. Bare rock is rock surface lacking attached macro-organisms; sand is rock surface covered by sand; both can be covered by canopy species. Data were collected using 80 random points per 10 m^2 plot (see Methods). N = number of plots. Blanks mean species were not observed in the plots.

Site	Tide level (m)	N	Bare rock	Sand	*Anthopleura elegantissima*	*Mytilus californianus* [1]	*Balanus glandula*	*Chthamalus dalli*
Cape	0-0.5	4	12.6 ± 3.2	5.4 ± 3.0	3.5 ± 2.2	3.1 ± 3.1	2.5 ± 2.5	1.3 ± 0.5
Lookout	0.5-1	6	33.2 ± 6.3	3.8 ± 2.6	6.3 ± 1.4		0.4 ± 0.3	4.0 ± 1.9
	1-2	8	52.2 ± 5.9	2.2 ± 1.0	4.2 ± 0.9		1.6 ± 0.8	4.4 ± 1.7
	2-3	6	99.6 ± 0.3	0.2 ± 0.2				
Boiler	0-0.5	4	7.3 ± 3.5	34.4 ± 13.2				
Bay	0.5-1	5	5.8 ± 4.0	4.3 ± 1.2				
	1-2	4	13.8 ± 3.4	7.2 ± 4.2	0.9 ± 0.6	14.4 ± 14.4	7.5 ± 3.7	10.3 ± 5.0
	2-3	6	47.0 ± 4.2	0.2 ± 0.2	0.2 ± 0.2	0.4 ± 0.4	3.6 ± 1.3	3.0 ± 1.4
Otter	0-0.5	5	3.0 ± 2.0	20.8 ± 9.0				
Crest	0.5-1	8	8.8 ± 4.7	69.9 ± 4.1	1.4 ± 0.7			
	1-2	5	40.5 ± 15.0	48.8 ± 13.4	0.3 ± 0.3			0.3 ± 0.3
	2-3	0	0.0 ± 0.0	100.0 ± 0.0				
Yachats[2]	0-0.5	6	11.3 ± 5.3	7.5 ± 2.6	1.9 ± 1.0	0.2 ± 0.2	0.2 ± 0.2	
	0.5-1	4	12.8 ± 5.7	3.1 ± 2.4	6.6 ± 3.5		3.4 ± 1.7	5.9 ± 2.1
	1-2	6	7.3 ± 2.3	0.0 ± 0.0	14.0 ± 3.0	15.5 ± 6.2	18.1 ± 7.8	1.9 ± 0.8
	2-3	6	18.2 ± 4.2	7.4 ± 4.6	2.1 ± 0.6	20.4 ± 13.7	14.4 ± 5.5	4.2 ± 3.7
Sunset	0-0.5	4	5.3 ± 3.2	15.4 ± 6.0			1.3 ± 0.9	2.8 ± 1.8
Bay	0.5-1	4	42.2 ± 16.6	12.9 ± 6.2			0.9 ± 0.6	0.9 ± 0.9
	1-2	6	54.1 ± 8.3	10.0 ± 6.1	0.8 ± 0.6		3.8 ± 1.3	3.1 ± 1.3
	2-3	6	45.2 ± 6.9	0.0 ± 0.0				
North	0-0.5	9	17.5 ± 6.1	22.6 ± 7.6			0.7 ± 0.3	1.9 ± 1.1
Cove	0.5-1	4	35.3 ± 7.7	7.6 ± 2.6	0.6 ± 0.4		3.2 ± 1.1	2.8 ± 2.8
	1-2	6	48.7 ± 10.2	5.2 ± 3.0	0.6 ± 0.3		3.5 ± 2.3	2.9 ± 1.4
	2-3	6	72.8 ± 6.5	0.0 ± 0.0				0.4 ± 0.3
Cape	0-0.5	6	26.8 ± 2.8	7.9 ± 3.2			1.5 ± 0.9	1.5 ± 0.8
Blanco	0.5-1	6	37.5 ± 7.4	6.7 ± 5.0	3.1 ± 0.8		4.4 ± 3.9	3.1 ± 1.5
	1-2	6	42.1 ± 6.8	4.6 ± 2.4	0.2 ± 0.2		0.8 ± 0.6	0.6 ± 0.4
	2-3	6	89.2 ± 4.9	0.0 ± 0.0			0.2 ± 0.2	0.2 ± 0.2
Rocky	0-0.5	5	20.3 ± 3.0	28.5 ± 6.8	3.0 ± 0.8		3.5 ± 3.2	1.3 ± 1.3
Point	0.5-1	7	42.9 ± 8.3	18.6 ± 7.3	3.8 ± 1.1		0.7 ± 0.4	0.9 ± 0.4
	1-2	0	0.0 ± 0.0	100.0 ± 0.0				
	2-3	0	0.0 ± 0.0	100.0 ± 0.0				
Humbug	0-0.5	6	30.6 ± 3.5	5.1 ± 3.9	5.6 ± 1.9		1.0 ± 0.7	2.7 ± 1.2
Mountain	0.5-1	6	35.9 ± 5.1	3.8 ± 1.6	5.0 ± 1.8		3.8 ± 2.3	1.0 ± 0.6
	1-2	6	86.3 ± 5.4	0.4 ± 0.3			2.1 ± 2.1	
	2-3	3	100.0 ± 0.0	0.0 ± 0.0				
North	0-0.5	6	21.9 ± 3.6	4.8 ± 2.9			1.7 ± 1.0	0.2 ± 0.2
Boardman	0.5-1	5	33.7 ± 8.5	4.5 ± 3.6	0.8 ± 0.3		4.5 ± 3.9	1.8 ± 0.9
	1-2	7	61.7 ± 7.8	0.0 ± 0.0			6.5 ± 1.5	0.5 ± 0.3
	2-3	3	85.0 ± 8.3	0.0 ± 0.0				
Cape	0-0.5	5	16.3 ± 4.1	0.5 ± 0.3	0.3 ± 0.3	0.3 ± 0.3		2.3 ± 1.5
Ferrelo	0.5-1	6	23.9 ± 4.8	0.6 ± 0.3	1.9 ± 1.1		0.4 ± 0.4	0.8 ± 0.3
	1-2	6	46.5 ± 3.2	4.4 ± 4.1			0.2 ± 0.2	2.1 ± 1.4
	2-3	6	97.3 ± 2.2	2.3 ± 2.3				
Chetco	0-0.5	6	19.5 ± 4.8	1.9 ± 1.2				
Cove	0.5-1	7	29.5 ± 5.4	9.7 ± 4.9			1.4 ± 0.7	2.3 ± 1.1
	1-2	5	60.6 ± 9.6	15.9 ± 12.8	0.5 ± 0.5		3.5 ± 1.4	1.8 ± 1.8
	2-3	3	67.4 ± 9.4	31.7 ± 10.1				

[1] Includes large and small *Mytilus* and may, therefore, also include *M. trossulus*.

[2] Yachats also had significant cover of *Anthopleura xanthogrammica* and *Semibalanus cariosus*.

Table 8. Distribution of sessile biota occcupying at least 10 % of canopy and (or) primary space in 4 or more 10 m^2 plots at at least one site. Percent cover estimated using 80 random points per plot and 3-9 plots in each of 4 tide levels (see Methods). ■ ≥10 % cover in 10 or more plots, ▓ ≥10 % cover in 4-9 plots, ░ = presence recorded in at least one plot. Blanks mean species not recorded at that site.

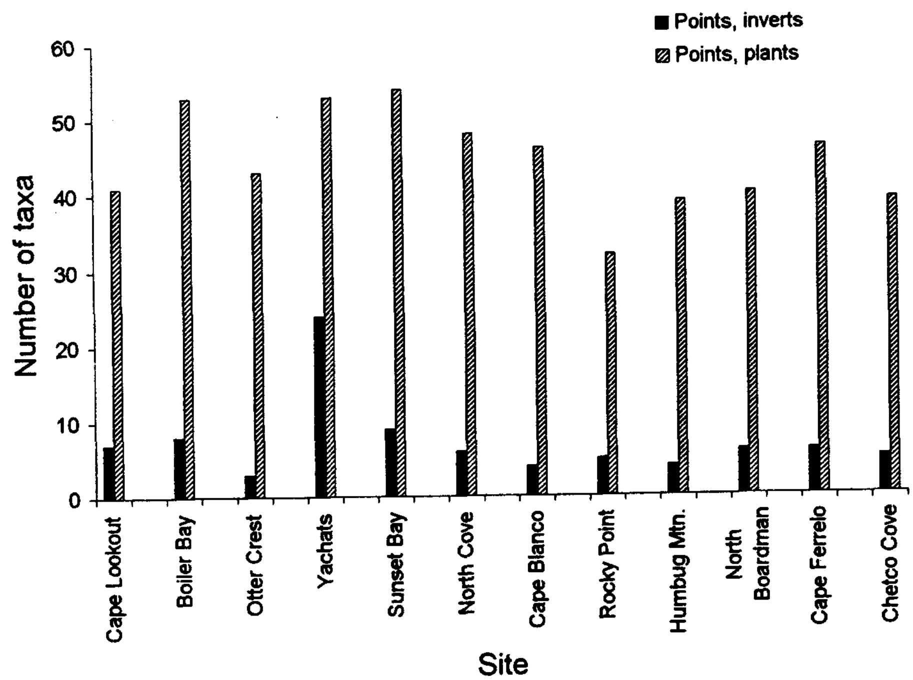
	Site											
Species	Cape Lookout	Boiler Bay	Otter Crest	Yachats	Sunset Bay	North Cove	Cape Blanco	Rocky Point	Humbug Mtn.	North Boardman	Cape Ferrelo	Chetco Cove
Invertebrates												
Anthopleura elegantissima	▒	▒	▒	■	▒	▒	▒	▒	▒	▒	▒	▒
Balanus glandula	▒	▒		■	▒	▒	▒	▒	▒	▒	▒	▒
Mytilus spp.	▒	▒	▒	■	▒	▒	▒	▒	▒	▒	▒	▒
Green algae												
Blidingia spp.					▒	■						
Cladaphora spp.		▒	▒	■	▒	▒	▒	▒		▒		▒
Enteromorpha linza	▒		■		▒	▒						
Enteromorpha sp.		▒	■	▒	■							
Ulva/Monostroma spp.	▒	▒	▒	■	■	▒	▒	▒	▒	■	▒	■
Brown algae												
Egregia menziesii	▒	▒	■	■	■		▒	▒		▒	▒	▒
Fucus gardneri	■			▒	■	▒	▒	■	▒	■	■	■
Hedophyllum sessile	▒	▒	▒	■	▒	▒	▒	▒			▒	
Laminaria sinclairii				■								
Red algae												
Bossiella sp.	▒	▒	■	▒	▒	▒	▒	■	▒	▒	▒	
crustose corallines	▒	■	▒	■	■	■	▒	▒	▒	▒	■	▒
Dilsea californica	▒	▒	▒	■	▒	▒	▒	▒	▒		▒	▒
Endocladia muricata	■	▒		▒	▒	■	■	▒	■	▒	■	■
Gelidium coulteri	▒	▒			▒	■	▒	▒	▒	▒	▒	■
Gigartina canaliculata				▒	▒	■	▒					▒
Hildenbrandia sp.		▒			▒	▒	▒	▒	▒	▒	▒	■
Hymenena/Cryptopleura	▒	■	▒	▒	▒	▒	▒		▒		▒	▒
Iridaea heterocarpa	▒	▒	▒	▒	▒	▒	▒	▒	▒	■	▒	▒
Iridaea splendens		▒		■	■	■	■	▒	▒	▒	■	▒
Mastocarpus jardinii	▒				▒	▒	■	■	■	■	■	▒
Mastocarpus papillatus					▒	■	■	■	■	■	▒	■
"Petrocelis"	▒	▒		▒	▒	■	■	■	■	■	■	■
Mastocarpus sp.[1]	■	▒		■	■	■	▒	▒	▒	▒	▒	▒
Neorhodomela larix	■	■	■	▒	■	■	■	■	▒	▒	▒	■
Odonthalia floccosa	▒	▒	■		■	▒	■	▒	▒	▒	▒	▒
Porphyra spp.	▒	▒		▒	▒		■	▒	▒	▒	▒	▒
Ptilota filicina	▒	▒	▒	■	▒	▒	▒	▒	▒	▒	▒	▒
Angiosperms												
Phyllospadix scouleri	▒	■	■	▒	▒	■	■	▒	▒	▒	▒	▒
Phyllospadix torreyi	▒	■	▒	▒		■	▒		▒		▒	▒

[1] At the northern 6 sites, and possibly the southern sites as well, *Mastocarpus* sp. was a mixture of *M. jardinii* and *M. papillatus*, with the latter species predominating, especially at higher tide levels.

Table 9. Number of taxa observed at each site using each sampling method. Quadrats and belt transects sampled invertebrates only, and random points sampled all sessile macro fauna and flora. Totals fom Appendices A-C.

Site	Quadrats ($0.25\ m^2$)	Belt transects* ($20\ m^2$)	Random points (for percent cover; 80 pts./$10\ m^2$)	
			inverte-brates	plants
Cape Lookout	67	35	7	41
Boiler Bay	66	45	8	53
Otter Crest	47	26	3	43
Yachats	83	28	24	53
Sunset Bay	69	72	9	54
North Cove	66	63	6	48
Cape Blanco	63	71	4	46
Rocky Point	26	30	5	32
Humbug Mtn.	38	45	4	39
North Boardman	55	84	6	40
Cape Ferrelo	55	70	6	46
Chetco Cove	33	45	5	39

* Belt transects focused on larger, more widely dispersed species but were often used to record as many taxa as possible, especially from Sunset Bay south.



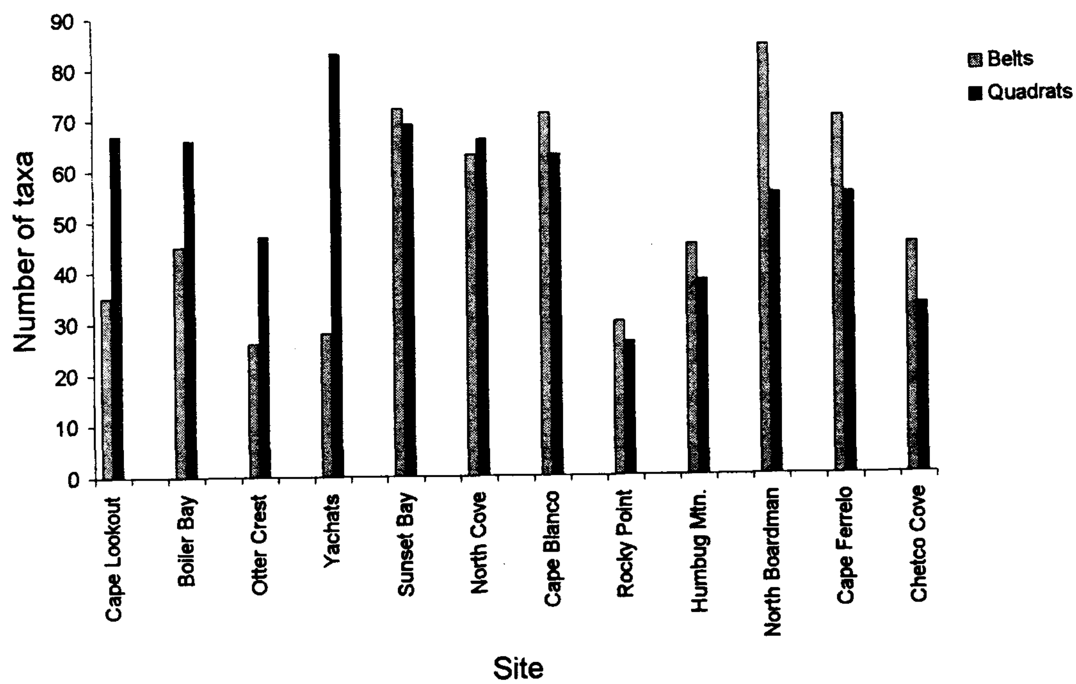


Figure 12. Number of taxa observed at each site using 3 different sampling methods ($0.25\ m^2$ quadrats, 1 X 20 m belt transects, and random points). Data from Table 9.

Yachats was the richest site, although similar numbers of plant taxa were observed at Boiler Bay and Sunset Bay, and at least as many animal taxa were recorded in the belt transects at North Boardman (Table 9). Sites with the lowest number of taxa were Rocky Point, Humbug Mountain, Chetco Cove, and Cape Lookout, in roughly that order. The northern 7 sites appeared to have greater species richness than the southern 5 sites, although similar numbers of taxa were recorded at North Boardman and Cape Ferrelo in at least one of the sampling methods.

4. DISCUSSION

4.1 Distribution and Abundance of Selected Organisms

Mussels (*Mytilus californianus* and the smaller *M. trossulus*) were clearly more abundant at the sites with a predominately bedrock substratum those dominated by boulders (Figures 2-7). The study site at Otter crest was an exception to this (Figure 6). However, mussels are abundant on much of the broad rock bench at Otter Crest (Fox et al., 1994; Osis, 1975; personal observations); our study site (located at the north end of the sandy beach just north of Devil's Punchbowl) was largely covered by sand (Figure 2) and happened to miss the mussel beds.

Of the bedrock sites, *Mytilus* and two of its predators, *Pisaster ochraceus* and *Nucella emarginata*, were significantly more abundant at Yachats, which is the most wave-exposed of our sites. Menge (1992) and Menge et al. (1994) reported similar results for exposed vs. protected sites on the central Oregon coast.

High abundances of both predators and prey suggest high levels of prey production and (or) recruitment. One or both of these processes could be enhanced for sessile organisms at Yachats by high primary production of local waters or by the direct effects of high wave energy itself, such as increased delivery of available nutrients or reductions in predator activity (Menge, 1992; Leigh et al., 1987).

Bedrock benches may provide mussels a more extensive spatial refuge from mobile predators than rock surfaces in boulder-dominated habitats. Depending on tidal height, movement over large, flat or gently sloping surfaces can expose intertidal predators to physiologically stressful conditions, including desiccation and temperature extremes. In boulder fields (especially those dominated by small boulders), *Pisaster* and other mobile organisms are never far from the relatively cool, shaded sides and undersides of a boulder, allowing them to forage over most of the area present. Mussels, therefore, may have few refuges from predators in this kind of habitat. Indeed, during our survey, the only places we found appreciable numbers of mussels in boulder fields were on the sides or tops of large boulders, where they appeared to be effectively out of reach of *Pisaster*. Highly fissured and pocketed rock shelves should provide comparable refuges.

For a given tidal regime, increased wave exposure increases the vertical extent of the intertidal zone (Lewis, 1964; Ricketts et al., 1985). This is reflected in the abundance of mussels, barnacles, and other organisms in the 2-3 m tide level at Yachats and their scarcity in the same tide level at our other sites (Tables 4, 6, and 7). By sampling only a predetermined set of tide levels, we effectively missed sampling the highest part of the intertidal zone at Yachats.

Increased wave exposure and its effects on the upper limits of distribution probably also explains the abundance of the low intertidal species *Laminaria sinclairii* at Yachats compared to the other sites (Table 8).

Wave exposure aside, the upper limits of distribution of intertidal species can also be shifted upwards on north vs. south-facing slopes owing to reduced solar radiation, heat stress, and desiccation (Lewis, 1964; Connell, 1972). This can be seen in a comparison of the vertical distribution and abundance of organisms at Humbug Mountain and Cape Blanco, two sites at similar latitude, but facing in opposite compass directions (Table 1). As seen in Figure 13, sessile organisms are more abundant at higher tide levels at the northward-facing site at Cape Blanco than at Humbug Mountain (this is also reflected in the amount of bare rock at both sites). Major high intertidal grazers are also more abundant at higher tide levels at Cape Blanco (Figure 13), all but ruling out differences in grazing pressure as an explanation for the differences in vertical distribution of the sessile organisms. The two sites appear to have similar overall protection from waves, but without additional data, this factor can not be ruled out as an explanation for the observed differences in vertical distribution.

In contrast to mussels, black turban snails, *Tegula funebralis*, and shield limpets, *Tectura scutum*, were considerably more abundant at sites dominated by boulders than those dominated by bedrock (Figures 8 and 9). There was, however, considerable variation in the density of *Tegula* among boulder-dominated sites. For example, Sunset Bay and North Cove, with similar proportions of substratum types (Figure 3), differ greatly in *Tegula* density (Figure 8, Table 4). At boulder-dominated sites *Tegula* density was not obviously correlated with any single factor, including substratum type and the density of one of its major predators, *Pisaster ochraceus*.

Over a range of spatial scales, the abundance of *Tegula* and other intertidal organisms varies with a wide variety of physical and biological factors (Ricketts, et al., 1985; Raffaelli & Hawkins, 1996; Schoch & Dethier, 1996). Statistical association between species abundance and habitat type therefore requires multivariate analyses. Principal components analysis (PCA) could be used to identify, group, and evaluate important variables, and multivariate analysis of variance (MANOVA) utilized to test for differences in abundance between sites and between tide levels. In an important recent paper, Schoch & Dethier (1996) describe a systematic approach for statistically associating abundances of rocky shore organisms with geomorphologically similar habitats. Their results, obtained from a study of 5 km of shoreline in the San Juan Islands, WA, should be applicable to rocky shores at a wide variety of spatial scales.

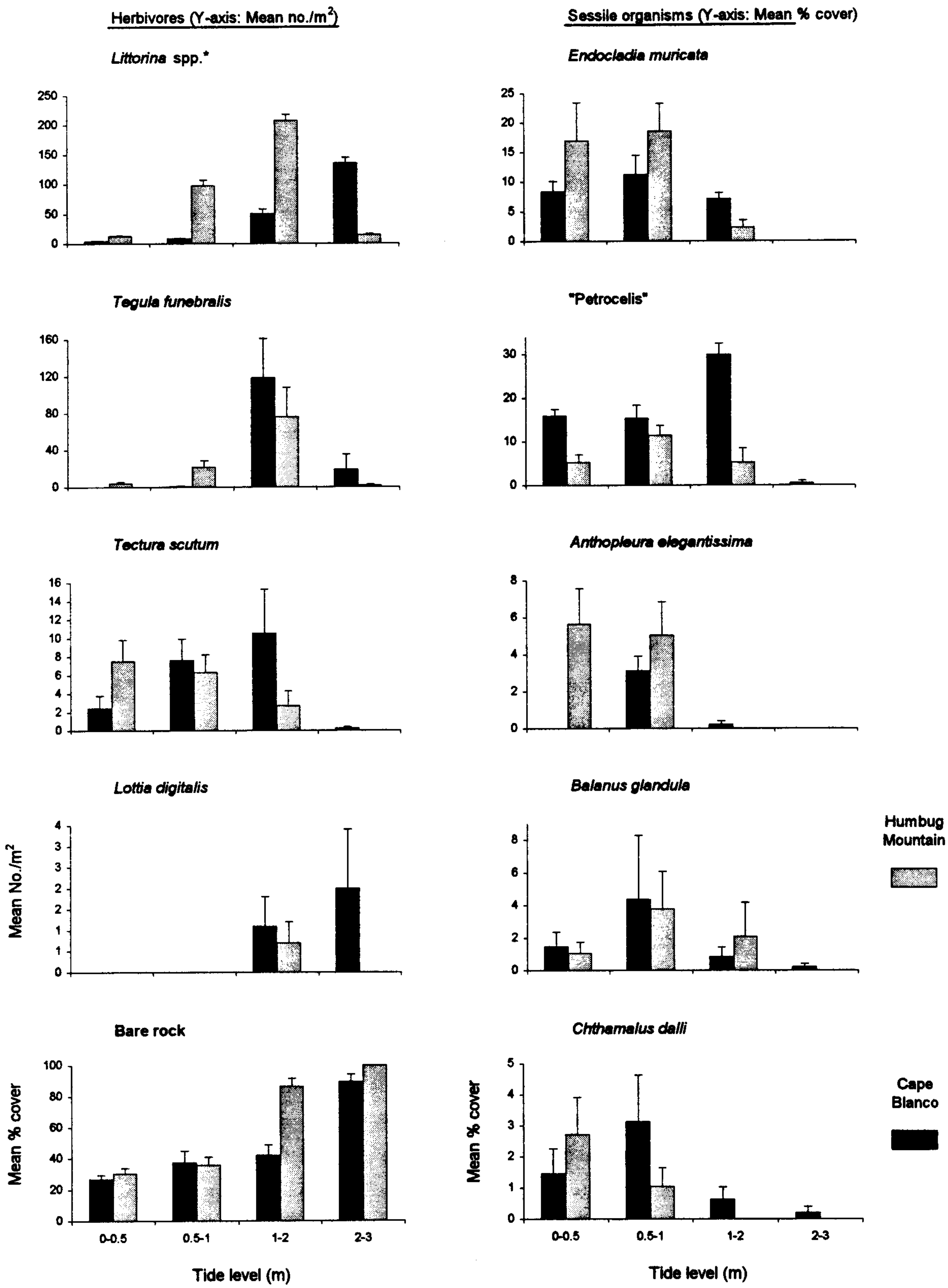


Figure 13. Comparison of abundance (Means ± 1 standard error) of some common grazers, sessile organisms, and bare rock at 4 tide levels at a north-facing site (Cape Blanco) and a south-facing site (Humbug Mountain). Bare rock is rock surface lacking attached macro-organisms; it can be covered by canopy species. "Petrocelis" is the crustose, tetrasporophytic phase of the red alga *Mastocarpus papillata*. Data from Tables 4 and 7. *Littorina* densities were calculated using order of magnitude estimates of abundance (see Methods) and greatly underestimate actual densities. Note varying Y-axis scales.

4.2 Species Richness, Community Composition, and Habitat Type

Northern sites tended to have more taxa than southern sites (Table 9; Figure 12). Some of this difference might be explained by team-specific differences in sampling bias and identification of taxa (see Methods), and it would have been useful to have each team sample the same site to evaluate the magnitude of these effects.

Two other factors might bear on the northern vs. southern differences in species richness: (1) Latitudinal gradients in physical factors such as tidal range, solar radiation, temperature, wave exposure, and rainfall can increase the vertical extent of the intertidal zone as one moves north, resulting in increasing numbers of taxa at a given tidal elevation, especially in the more species-rich low intertidal zones. By sampling set tide elevations, we may, in effect, be sampling somewhat different intertidal zones (defined by their biota) at different sites. This was obvious at Yachats, where the increased wave exposure of the site resulted in a more speciose biota at 2-3 m than at the other sites (and also resulted in our missing the high intertidal zone altogether). (2) The shoreline at more of the southern 6 sites was oriented toward the south than at the northern sites (Table 1). Increasing southern exposure tends to shift the vertical distribution of intertidal organisms downward, which would clearly result in decreasing species richness at a given tidal elevation. Organisms that were found above MLLW at some of the northern sites may occur only at minus tides levels (and therefore out of our sampling range) at the southern sites. This appears to have been the case for the red urchin, *Stronglyocentrotus franciscanus*, which occurs at minus tide levels at many of the southern sites (personal observations), but was observed in this study only at Boiler Bay (Appendices A and B).

Approximately one half of the common invertebrate species observed at Yachats in the random point sampling (Appendix C) were associated with the holdfasts and stipes of the low intertidal brown algae, *Laminaria sinclairii*. These include the bryozoan *Flustrellidra*, hydroids, sponges, sabellid polychaetes, and various ascidians. These types of organisms can be found in abundance at many of the other sites we examined, but only at minus tide levels (personal observations). Increased wave exposure at Yachats is probably the major factor allowing these organisms to live at slightly higher tide levels.

Aside from the association between bedrock dominated habitats (especially those not exposed to high levels of sand) and a high percent cover of mussels, barnacles, anemones, and other organisms, few patterns of association between groups or communities of species and particular habitat types are obvious in the data as presented herein. *Mastocarpus* spp, tolerant of relatively high temperatures and drying conditions, appears to have been more abundant at the south-facing boulder dominated sites, and *Enteromorpha* spp., which favors bedrock with freshwater seeps, more common at the northern bedrock sites. Other species may tend to be associated with these two genera.

More associations likely exist, but will require more sophisticated analyses to detect them. Cluster analysis and similarity indices could be used to group similar sites by species and species by substrate type or tidal elevation.

Even if sites do not vary much in species composition, they may in species abundances. Statistically associating biological communities with habitat types therefore requires analysis of variance (ANOVA), and given the influence of so many physical and biological factors on species abundances, would be even better accomplished by a multivariate analysis of variance (MANOVA). Schoch and Dethier (1996) applied these kinds of analyses to make community level comparisons using their data on rocky intertidal organisms from the San Juan Islands and should be consulted. They describe a detailed rocky shoreline classification system based on important geomorphologic parameters and showed that rocky intertidal community composition can be statistically inferred for broad spatial scales based on necessarily limited transect sampling. The Oregon rocky intertidal survey measured some of the important parameters described by Schoch & Dethier (1996), and would probably benefit by the addition of a few others. Recommendations follow.

5. RECOMMENDATIONS

5.1 General

- The intertidal survey should be repeated, preferably in the same season (intertidal distributions can vary with season). The more information on interannual variability, the better the baseline. If the survey can not be repeated at all sites, give preference to sites that have Marine Garden or Research Reserve status.

- The data obtained in this and future intertidal surveys should be made available to other researchers and institutions. The data set is reasonably robust, and the geographic coverage uncommon.

5.2 Specific

- If the survey is repeated, and different teams are used in the fieldwork, each team should sample the same site at least once. This will provide a measure of team-specific differences in sampling bias and taxonomic identification.

- Limit sampling in the belt transects to rarer, more widely dispersed species (as was originally intended), and use the whatever time is saved to either (1) increase the number of quadrats sampled, or (2) have the person responsible for sampling the belts spend more time verifying identifications by other team members.

- Standard errors for the density estimates based on quadrats samples are fairly high, suggesting that an increase in quadrat sample size is warranted. Standard errors for the percent cover data, on the other hand, are fairly low.

- Position and survey elevations of quadrats as before, but repeat the process, if necessary, until all three quadrats lie within the elevations prescribed for the plot.

- Utilize (if available; from NOAA?) measurements of observed tides to calibrate the elevation survey data, which are based on predicted tides. This will allow more accurate comparisons between and within years, especially if weather conditions vary greatly during the surveys.

- Two people are needed to enter the percent cover data if a point by point correspondence between cover type and substrate type is desired (one person to read off the data, another to actually enter it).

- On the percent cover data sheets, it may be useful to distinguish occupants of canopy cover vs. primary cover. Regardless, possible types of cover need to spelled out for the field sampling teams (e.g., organism (canopy or primary space), bare rock, sand, substrate type, tidepool); there were some inconsistencies in the data that were a pain to sort out.

- Consult Schoch and Dethier (1996) for important shoreline classification parameters. The power of our data set would be increased by incorporating better information on the following (some or all of which could be added without too much extra effort): wave exposure (I have used the crudest of classifications above), shoreline roughness (rugosity; influences the number of refuges available to organisms, as well as drainage; see Raffaelli & Hawkins, 1996), substrate composition (visit the southern sites with a geologist), latitudinal variation in climate variables.

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Appendix A. Distribution by site of all taxa recorded in 0.25 m^2 quadrats. Species codes are codes used in the ODFW database. CL = Cape Lookout, BB = Boiler Bay, OC = Otter Crest, YA = Yachats, SB = Sunset Bay, NC = North Cove, CB = Cape Blanco, RP = Rocky Point, HM = Humbug Mountain, NB = North Boardman, CF = Cape Ferrelo, CC = Chetco Cove. Some taxa were not included in the site totals owing to redundancy in representation (e.g., *Lacuna* eggs were not included if *Lacuna* spp. was recorded at that site), or if the taxon is not an intertidal organism (e.g., ants).

	Species codes		Site											
Species	group	species	CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Anthozoa	aa													
Anthopleura artemisia	aa	aa			X	X	X	X	X					
Anthopleura elegantissima	aa	ae	X	X	X	X	X	X	X	X	X	X	X	X
Anthopleura sp.	aa	an	X	X										
Aulactinia incubans	aa	ai										X		
Anthopleura xanthogrammica	aa	ax	X	X	X	X		X	X	X		X	X	X
Epiactis prolifera	aa	ep	X		X	X		X	X		X	X	X	
Halcampa decemtentaculata	aa	hd						X						
Urticina crassicornis	aa	ur							X					
Urticina coriacea	aa	us								X				
unidentified anemone	aa	u					X	X						
Asteroidea	as													
Leptasterias hexactis	as	lh		X			X	X	X				X	X
Pycnopodia helianthoides	as	ph	X											
Pisaster ochraceus	as	po	X	X		X	X	X	X	X	X	X	X	X
unidentified juvenile asteroid	as	ut											X	
unidentified asteroid	as	u				X								
Bivalvia	bi													
Adula californiensis	bi	ac			X		X	X						
boring bivalves	bi	bo			X	X	X	X						
unidentified, small clam	bi	cl						X						
Crassedoma giganteum	bi	hg				X								
Mytilus californianus	bi	mc		X		X					X		X	
small unident. Mytilus	bi	sm	X	X		X	X	X	X			X		X
unidentified bivalve	bi	u		X										
Bryozoa	bz													
unident. arborescent species	bz	bb			X	X	X		X					
unident. encrusting species	bz	en	X		X	X	X		X	X	X	X	X	
Flustrellidra corniculata	bz	fl				X								
Heteropora alaskensis	bz	ha							X					
Tricellaria occidentalis	bz	to					X							
unidentified bryozoan	bz	u	X		X	X								
Cirripedia	ci													
Balanus glandula	ci	bg	X	X	X	X	X	X	X	X	X	X	X	X
Chthamalus dalli	ci	cd	X	X	X	X	X	X	X	X	X	X	X	X
Pollicipes polymerus	ci	pp				X								
unident. small acorn barnacles	ci	sb	(X)		X	(X)	X							
Semibalanus cariosus	ci	sc	X	X		X							X	
unidentified barnacle	ci	u										X		

Appendix A. Continued.

Species	Species codes: group	Species codes: species	CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Decapoda	de													
Cancer antennarius	de	ca	X			X								
small *Cancer* sp.	de	cc	X	X		X	X							
Petrolisthes cinctipes	de	ci						X						
Cancer jordani	de	cj					X							
Cancer oregonensis	de	co					X		X					
Cancer productus	de	cp	X			X	X							
unidentified Majid	de	dc				X								
juvenile *Cancer productus*	de	du												
unidentified grapsid	de	gp		X		X	X	X				X	X	
Pugettia gracilis	de	gr	X	X		X	X	X						
Heptacarpus sp.	de	he	X					X						
Hemigrapsus nudus	de	hn	X		X	X	X	X			X	X	X	X
Hemigrapsus oregonenesis	de	ho	X									X		
Lophopanopeus bellus	de	lo	X	X										
settled megalopae	de	me	(X)		(X)		(X)	(X)						
Oedignathus inermis	de	oi				X								
Pachygrapsus crassipes	de	pc	X	X				X	X		X	X	X	X
Petrolisthes spp.	de	pe	X	X		X		X	X		X	X	X	X
small hermit crabs	de	pg	X	X	X	X	X	X	X	X	X	X	X	X
large hermit crabs	de	pl	X	X	X	X	X	X	X	X	X	X	X	X
Pugettia producta	de	pp	X	X	X	X	X	X	X	X	X	X	X	X
small crab	de	sd	X				X		X	X	X		X	X
small grapsid crab	de	sg	X	(X)	X	(X)	(X)	(X)	X					
Crangon sp	de	ss	X											
small *Pugettia* sp.	de	tp					(X)							
unidentified crab	de	u	X	X	X							X		
unknown shrimp	de	us	X		X									
Echinoidea	ec													
Stronglyocen. franciscanus	ec	sf		X										
Stronglyocen. purpuratus	ec	sp		X	X	X	X						X	
small *S. purpuratus*	ec	st							X			X	X	
unidentified juvenile urchin	ec	u					X							
Platyhelminthes	fw													
Notoplana sp	fw	no							X					
unidentified flatworm	fw	u											X	
Gastropoda	gm													
Amphissa reticulata	gm	ab					X							
Acmaea mitra	gm	ac	X	X			X	X	X		X		X	
Amphissa sp.	gm	ag	X	X	X	X	X	X						
Alia carinata	gm	al		X			X	X	X					
Archidoris monterensis	gm	am							X					
Alia tuberosa	gm	at									X			
Bittium attenuatum	gm	ba	X					X						
Bittium spp.	gm	bg		X		X	X	X	X			X	X	X

Appendix A. Continued.

Species	Species codes: group	species	Site: CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Calliostoma ligatum	gm	cl		X	X							X		
Crepidula adunca	gm	cr						X						
Diaulula sandiegensis	gm	ds				X								
Hermissenda crassicornis	gm	hc		X		X			X					
Lottia asmi	gm	la					X	X	X	X	X	X	X	X
Lacuna spp.	gm	lc	X	X	X	X	X	X	X	X	X			
Lottia digitalis	gm	ld	X	X		X	X	X	X	X	X	X	X	
Littorina spp.	gm	li	X	X	X	X	X	X	X	X	X	X	X	X
Lacuna eggs	gm	ll	(X)											
Margarites or *Lirularia*	gm	lm	X	X				X	X		X			
Lottia pelta	gm	lp	X	X		X	X	X	X	X	X	X	X	X
Lottia strigatella	gm	ls	X	X	X	X	X	X	X	X	X	X	X	X
unidentified limpet	gm	lu	X											
Marsenina rhombica	gm	mr				X								
Macclintockia scabra	gm	ms							X		X		X	
Nucella canaliculata	gm	nc				X						X		
Nucella emarginata	gm	ne		X		X	X	X	X		X	X	X	
Nucella lamellosa	gm	nl				X		X				X		
Nitidiscala sp.	gm	nt						X			X			X
Onchidella borealis	gm	ob							X			X		X
Opalia borealis	gm	op			X									
Ocenebra interfossa	gm	oi					X							
Ocenebra lurida	gm	ol			X		X							
Diodora aspera	gm	rk				X								
small conical snail	gm	sc	X	X	X	X	X	X				X		
Searlesia dira	gm	sd	X	X	X		X	X	X		X	X	X	X
unidentified small limpet	gm	sl	X	X	X	X	X	X	X	X	X	X	X	X
small round snail	gm	sr	X	X	X	X	X	X	X			X		
unidentified snail	gm	su		X		X								
Tegula brunnea	gm	tb											X	
Tectura fenestrata	gm	te	X	X	X	X	X	X			X	X		
Tegula funebralis	gm	tf	X	X	X	X	X	X	X	X	X	X	X	X
Tectura persona	gm	tp	X			X	X	X	X	X	X	X	X	X
Tectura scutum	gm	ts	X	X			X	X	X	X	X	X	X	X
Holothuroidea	ho													
Cucumaria miniata	ho	cm							X					
Eupentacta quinquesemita	ho	eu	X											
unidentified holothuroid	ho	u			X									
Hydrozoa	hy													
Abietinaria sp.	hy	ab				X								
Sertularia sp.	hy	se				X								
Tubularia sp.	hy	tu			X							X		
unknown hydroid	hy	u	X			X	X	X				X		
Nemertea	ne													
Amphiporus imparispinosus	ne	ai							X				X	

Appendix A. Continued.

Species	Species codes: group	Species codes: species	Site: CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Emplectonema gracile	ne	eg											X	
unidentified nemertean	ne	u		X		X								
Other arthropods	oa													
ant	oa	an	(X)						(X)					(X)
mite	oa	mi					X							
Ophiuroidea	op													
unidentifed ophiuroid	op	u	X	X	X			X						
Bony fishes	pi													
Gobiesox meandricus	pi	gm					X							
gunnels or pricklebacks	pi	gp		X										
gunnel	pi	gu		(X)			X							
sculpins	pi	sc		X	X	X		X						
small unidentified fish	pi	sf		X				X						
Polyplacophora	pl													
small *Cryptochiton stelleri*	pl	ci		(X)										
Cryptochiton stelleri	pl	cs		X									X	
Katharina tunicata	pl	kt		X		X			X			X	X	
Lepidozona cooperi	pl	lc		X		X		X				X		
Lepidochitona dentiens	pl	ld	X	X			X	X	X	X	X	X	X	X
Lepidozona mertensii	pl	lm		X										
Mopalia ciliata	pl	mc										X		X
Mopalia lignosa	pl	ml		X	X	X	X							
Mopalia muscosa	pl	mm	X			X	X			X			X	
unidentified small chiton	pl	sc	X	X	X	X	X	X	X		X	X	X	X
Tonicella lineata	pl	tl	X	X		X	X		X			X	X	
unidentified chiton	pl	u	X	X		X	X	X				X	X	
Porifera	po													
encrusting yellow sponge	po	ey	X		X									
Haliclona permollis	po	ha	X		X									
Halichondria panicea	po	hp				X							X	
Mycale macginitiei	po	mm							X					
Neoesperiopsis sp.	po	ne				X								
red-orange species	po	ro	X		X			X	X			X		
unidentified species	po	u				X								X
Polychaeta	pw													
Dodecaceria fewkesii	pw	df							X					
hard sand tube worm, Sabellariid, prob. *Idanthyrsus*	pw	hs					X							
Nereis-like polychaete	pw	ne	X	X		X	X		X			X		
Pista elongata	pw	pe			X	X		X						
unidentified sabellids	pw	pt	X			X	X							
Spirorbis spp.	pw	sp	X		X	X	X	X	X	X	X	X	X	X

Appendix A. Continued.

Species	Species codes		Site											
	group	species	CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Serpula vermicularis	pw	sv	X	X		X	X	X	X				X	
unidentified terebellid	pw	tb						X						
unidentified tube worm	pw	tu	X	X		X	X					X		
unidentified polychaete	pw	u		X					X		X		X	
Pycnogonida	py													
unidentified pycnogonid	py	u				X		X						
small crustaceans	sc													
Idotea sp.	sc	ig	X	X	X	X	X	X	X	X	X	X	X	X
unidentified amphipods	sc	sa	X	X	X	X	X	X	X	X	X	X	X	X
unidentified isopods	sc	si	X	X	X	X	X	X	X					
Sipuncula	si													
Phascolosoma agassizii	si	pa				X			X				X	
Phascolosoma or *Themiste*	si	u		X			X	X					X	
Ascidiacea	ta													
Aplidium californicum (?)	ta	ap				X								
unident. compound ascidian	ta	co				X			X				X	
Didemnum or *Trididemnum*	ta	dt				X								
Perophora annectens	ta	pa										X		
Styela montereyensis	ta	sm				X			X					
unidentified ascidian	ta	u				X								
total number of taxa		168	67	66	47	83	69	66	63	26	38	55	55	33

Appendix B. Distribution by site of all taxa recorded in 1 X 20 m belt transects. Species codes are codes used in the ODFW database. CL = Cape Lookout, BB = Boiler Bay, OC = Otter Crest, YA = Yachats, SB = Sunset Bay, NC = North Cove, CB = Cape Blanco, RP = Rocky Point, HM = Humbug Mountain, NB = North Boardman, CF = Cape Ferrelo, CC = Chetco Cove.

	Species codes		Site											
Species	group	species	CI	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Anthozoa	aa													
Anthopleura artemisia	aa	aa		X	X	X	X	X	X			X	X	
Anthopleura elegantissima	aa	ae	X	X	X	X	X	X	X	X	X	X	X	X
Aulactinia incubans	aa	ai									X	X	X	
Anthopl. xanthogrammica	aa	ax	X	X	X	X	X	X	X	X		X	X	X
Balanophyllia elegans	aa	be											X	
Epiactis prolifera	aa	ep	X	X	X		X	X	X		X	X	X	X
Halcam. decemtentaculata	aa	hd					X					X		
Urticina crassicornis	aa	ur	X	X			X		X			X	X	
Urticina coriacea	aa	us			X		X	X	X	X	X		X	
Asteroidea	as													
Dermasterias imbricata	as	di											X	X
Evasterias troschellii	as	et					X							
Henricia leviuscula	as	hl											X	
Henricia sp. (small, mottled)	as	hs			X			X	X		X		X	
Leptasterias hexactis	as	lh	X				X	X	X				X	X
Pycnopodia helianthoides	as	ph	X				X				X	X	X	X
Pisaster ochraceus	as	po	X	X	X	X	X	X	X	X	X	X	X	X
Solaster dawsoni	as	sd										X		
Bivalvia	bi													
boring bivalves	bi	bo			X		X	X						
Protothaca staminea	bi	ln			X									
Mytilus californianus	bi	mc	X	X	X		X	X	X			X		
small *Mytilus*	bi	sm								X				
Bryozoa	bz													
unident. arborescent species	bz	bb					X	X	X			X		
Costazia ventricosa	bz	cv							X					
Dendrobeania lichenoides	bz	dl					X		X			X		
Eurystomella bilabiata	bz	eb					X	X				X		
unident. encrusting species	bz	en		X			X	X	X			X		
Flustrellidra corniculata	bz	fl				X								
Heteropora alaskensis	bz	ha							X					
Tricellaria occidentalis	bz	to					X							
Cirripedia	ci													
Balanus glandula	ci	bg		X			X	X	X	X	X	X	X	X
Chthamalus dalli	ci	cd		X			X	X	X	X	X	X	X	X
Pollicipes polymerus	ci	pp		X								X		
Semibalanus cariosus	ci	sc		X						X		X		

Appendix B. Continued.

Species	Species codes group	Species codes species	CI	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
unknown barnacle	ci	u		(X)										
Decapoda	de													
Cancer antennarius	de	ca					X			X				X
small Cancer sp.	de	cc		X	X									
Cancer jordani	de	cj		X			X	X						
Cancer oregonensis	de	co		X		X	X	X						
Cancer productus	de	cp	X		X	X		X						
Cryptolithoides sitchensis	de	cr											X	
unidentified Majid	de	dc				X						X	X	
juvenile *Cancer productus*	de	du	X		X									
unidentified grapsid	de	gp	X											
Pugettia gracilis	de	gr	X						X					
Hemigrapsus nudus	de	hn	X			X	X	X	X	X	X	X	X	X
Hemigrapsus oregonenesis	de	ho	X											
Pagurus spp.	de	hu					X	X	X	X	X	X	X	X
Pachygrapsus crassipes	de	pc	X	X			X	X	X		X	X	X	X
Petrolisthes spp.	de	pe					X	X		X			X	X
Pugettia producta	de	pp	X	X	X	X	X	X	X	X	X	X	X	X
small crab	de	sd												
small grapsid	de	sg			X									
unidentified crab	de	u		X	X									
Echinoidea	ec													
Stronglyocen. franciscanus	ec	sf		X										
Stronglyocen. purpuratus	ec	sp	X	X	X	X	X	X	X		X		X	X
small *S. purpuratus*	ec	st							X			X	X	
Platyhelminthes	fw													
Notoplana sp	fw	no							X					
Gastropoda	gm													
Amphissa columbiana	gm	aa					X							
Amphissa reticulata	gm	ab							X					
Acmaea mitra	gm	ac	X				X	X	X		X	X	X	
Amphissa sp.	gm	ag		X			X							
Archidoris monterensis	gm	am	X	X		X						X		X
Anisodoris nobilis	gm	an	X											
Aeolidia papillosa	gm	ap					X							
Alia tuberosa	gm	at						X				X		
Alia sp.	gm	au												X
Bittium spp.	gm	bg						X	X					
Ceratostoma foliatum	gm	cf		X			X					X	X	
Lottia ochracea	gm	ch							X				X	
Laila cockerelli	gm	ck										X		

Appendix B. Continued.

Species	Species codes: group	Species codes: species	Site: CI	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Calliostoma ligatum	gm	cl	X	X	X		X					X	X	X
Crepidula adunca	gm	cr						X						
Dirona albolineata	gm	da	X			X		X				X		
Dendronotus sp.	gm	de				X								
Diaulula sandiegensis	gm	ds				X	X	X			X	X	X	X
Flabellina trilineata	gm	ft										X		
Hermissenda crassicornis	gm	hc	X			X		X	X		X	X	X	
Janolus fuscus	gm	jf				X	X	X				X		
Lottia asmi	gm	la							X	X	X	X	X	X
Lacuna spp.	gm	lc					X	X		X	X	X		
Lottia digitalis	gm	ld	X	X	X		X	X	X		X	X	X	X
Littorina spp.	gm	li	X	X			X	X	X	X	X	X	X	X
Margarites or *Lirularia*	gm	lm		X				X				X		X
Lottia pelta	gm	lp		X	X		X	X	X	X	X	X	X	X
Lottia strigatella	gm	ls		X	X		X	X	X	X	X	X	X	X
unidentified limpet	gm	lu		X										
Marsenina rhombica	gm	mr				X								
Macclintockia scabra	gm	ms									X	X	X	X
Nucella canaliculata	gm	nc		X										
Nucella emarginata	gm	ne		X					X		X	X	X	
Nucella lamellosa	gm	nl				X		X	X	X	X	X		
Nitidiscala sp.	gm	nt							X		X	X		X
Onchidella borealis	gm	ob					X	X	X		X	X		X
Opalia chacei	gm	oc						X						
Ocenebra interfossa	gm	oi					X							
Ocenebra lurida	gm	ol					X		X			X	X	
Diodora aspera	gm	rk	X			X		X	X			X	X	X
Rostanga pulchra	gm	rp	X	X								X	X	
Searlesia dira	gm	sd		X	X		X	X	X		X	X	X	
Tegula brunnea	gm	tb											X	
Triopha catalinae	gm	tc				X						X		
Tectura fenestrata	gm	te			X		X	X	X	X	X	X	X	
Tegula funebralis	gm	tf	X	X			X	X	X	X	X	X	X	X
Triopha maculata	gm	tm							X			X		
Tectura persona	gm	tp	X				X	X	X		X	X	X	X
Tectura scutum	gm	ts		X		X	X	X	X	X	X	X	X	X
Holothuroidea	ho													
Cucumaria miniata	ho	cm	X						X			X	X	
Eupentacta quinquesemita	ho	eu										X		
Hydrozoa	hy													
Plumularia sp.	hy	pl						X						
Tubularia sp.	hy	tu										X		

Appendix B. Continued.

Species	Species codes: group	Species codes: species	Site: CI	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Nemertea	ne													
Amphiporus imparispinosus	ne	ai					X	X	X			X	X	X
Emplectonema gracile	ne	eg								X				
Paranemertes peregrina	ne	pp					X							
Tubulanus polymorphus	ne	tp					X							
Octocorallia	oc													
Alcyonium rudyi	oc	ar						X				X	X	
Ophiuroidea	op													
unidentifed ophiuroids	op	u	X						X			X	X	
Polyplacophora	pl													
Cryptochiton stelleri	pl	cs	X	X				X	X				X	
Katharina tunicata	pl	kt		X		X		X	X				X	
Lepidozona cooperi	pl	lc	X				X	X	X		X	X	X	
Lepidochitona dentiens	pl	ld		X			X	X	X	X	X	X	X	X
Lepidozona mertensii	pl	lm	X									X		
Mopalia ciliata	pl	mc					X		X			X	X	
Mopalia hindsii	pl	mh					X						X	
Mopalia lignosa	pl	ml					X	X	X		X	X		X
Mopalia muscosa	pl	mm		X	X	X		X	X	X	X			
Mopalia or *Nuttalina*	pl	mn					X							
Nuttallina californica	pl	nc						X						
Placiphorella velata	pl	pv											X	
Tonicella lineata	pl	tl		X			X	X	X		X	X	X	
Porifera	po													
Aplysilla glacialis	po	ag											X	
encrusting yellow sponge	po	ey		X										
Haliclona permollis	po	ha									X	X		X
Halichondria panicea	po	hp					X			X				
Lissodendoryx firma	po	lf											X	
Mycale macginitiei	po	mm										X	X	
Reniera sp. A of Hartman (1975)	po	re									X	X	X	X
red-orange species	po	ro					X	X	X	X	X	X		X
Suberites ficus	po	sf							X					
unidentified species	po	u					X		X			X		
Polychaeta	pw													
Dodecaceria fewkesii	pw	df							X			X		
Pista elongata	pw	pe			X	X	X	X	X	X	X	X	X	
unidentified sabellids	pw	pt					X					X	X	
Spirorbis spp.	pw	sp			X		X	X	X	X	X		X	X

Appendix B. Continued.

Species	Species codes: group	Species codes: species	Site: CI	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Serpula vermicularis	pw	sv	X	X		X	X	X	X	X	X	X		X
Thelepus crispus	pw	tc					X							
small crustaceans	sc													
Idotea sp.	sc	ig		X					X				X	X
Ligia sp.	sc	li										X	X	X
unidentified amphipods	sc	sa												
amphipods w/ drift algae	sc	sd							X				X	X
Sipuncula	si													
Phascolosoma or Themiste	si	u				X	X	X	X			X	X	X
Ascidiacea	ta													
Archidistoma ritteri (?)	ta	ar									X			
unident. compound ascidian	ta	co							X			X		
Didemnum or *Tridídemnum*	ta	dt		X			X							
Perophora annectens	ta	pa					X					X		
Pyura haustor	ta	ph					X		X					
Styela montereyensis	ta	sm				X			X			X		
total number of taxa		156	35	45	26	28	72	63	71	30	45	84	70	45

Appendix C. Distribution by site of all taxa recorded in point-sampling of sessile biota. Species codes are codes used in the ODFW database. CL = Cape Lookout, BB = Boiler Bay, OC = Otter Crest, YA = Yachats, SB = Sunset Bay, NC = North Cove, CB = Cape Blanco, RP = Rocky Point, HM = Humbug Mountain, NB = North Boardman, Cape Ferrelo, CC = Chetco Cove.

Species	Species code		Site											
			CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Invertebrates	group	species												
Anthopleura artemisia	aa	aa				X								
Anthopleura elegantissima	aa	ae	X	X	X	X	X	X	X	X	X	X	X	X
Anthopl. xanthogrammica	aa	ax		X		X	X	X	X	X		X		
Urticina sp.	aa	ug				X								
boring bivalves	bi	bo				X								
Mytilus californianus	bi	mc	X	X		X								
small *Mytilus*	bi	sm				X							X	
unident. arbores. bryozoa	bz	bb				X								
unident. encrusting bryozoa	bz	en				X								
Flustrellidra corniculata	bz	fl				X								
Tricellaria occidentalis	bz	to					X							
unidentified bryozoan	bz	u					X							
Balanus glandula	ci	bg	X	X		X	X	X	X	X	X	X	X	X
Chthamalus dalli	ci	cd	X	X	X	X	X	X	X	X	X	X	X	X
empty barnacles	ci	db									(X)	(X)		
Pollicipes polymerus	ci	pp				X								
unident. small barnacles	ci	sb	(X)											
Semibalanus cariosus	ci	sc	X	X		X								
unidentified barnacles	ci	u	(X)	(X)			X	X				X	X	
Strongylocen. franciscanus	ec	sf		X										
Stronglyocen. purpuratus	ec	sp	X	X			X							
Barentsia benedeni	en	bb				X								
unidentified hydroids	hy	u			X	X								
encrusting yellow sponge	po	ey				X								
Haliclona permollis	po	ha												X
unidentified sponges	po	u				X								
Pista elongata	pw	pe				X								
unidentified Sabellid	pw	pt				X	X							
Spirorbis sp.	pw	sp	X			X		X		X	X	X	X	X
Aplidium sp.	ta	ap				X								
Didemnum or *Trididemnum*	ta	dt				X								
unidentified ascidian	ta	u				X								
Diatoms														
epiphytic diatoms	cr	da										X		
benthic diatoms	cr	di		X	X		X				X	X	X	
Green algae														
Acrosiphonia coalita	ch	ac	X		X		X				X	X	X	
Blidingia minima	ch	bl					X	X						
Cladophora spp.	ch	cc		X	X	X	X	X	X	X		X		X
Chaetomorpha sp.	ch	ch				X								

Appendix C. Continued

Species	Species code		Site											
			CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Enteromorpha intestinalis	ch	ei		X	X		X							
Enteromorpha linza	ch	el	X	X	X		X	X						
Enteromorpha sp.	ch	es			X	X	X							
Kormania leptoderma	ch	kl			X									
Ulva/Monostroma	ch	um	X	X		X	X	X	X	X	X	X	X	X
Ulva taeniata	ch	ut			X							X		
Brown algae														
Analipus japonicus	ph	aj		X		X	X	X	X					X
Alaria marginata	ph	am			X	X	X		X				X	
Costaria costata	ph	cc			X									
Colpomenia sp.	ph	co		X			X							
Cystoseira osmundacea	ph	cy							X				X	
Desmarestia ligulata	ph	de		X		X								
Egregia menziesii	ph	em	X	X	X	X	X		X	X		X	X	X
Fucus gardneri	ph	fg	X			X	X	X	X	X	X	X	X	X
Hedophyllum sessile	ph	hs	X	X	X	X	X	X	X	X			X	
Laminaria setchellii	ph	la				X				X			X	
Leathesia difformis	ph	le		X		X	X							X
Laminaria sinclairii	ph	ls				X								
Pelvetia fastigiata	ph	pf								X				X
Pelvetiopsis limitata	ph	pl		X		X		X	X		X	X	X	
Ralfsia fungiformis	ph	rf	X							X		X		X
Scytosiphon lomentaria	ph	sl	X	X		X	X					X		
Sargassum muticum	ph	sm	X						X					X
Soranthera ulvoidea	ph	so		X	X		X		X					
Laminaria sp.	ph	sp		X										
unidentified brown algae	ph	u		X										
Red algae														
Callithamnion pikeanum	rh	ca	X		X			X	X		X		X	
Ceramium sp.	rh	cm	X	X	X		X	X	X		X	X	X	X
Constantinia simplex	rh	cs				X								
Cumagloia andersonii	rh	cu					X	X						
Cryptosiphonia woodii	rh	cw	X	X	X	X	X	X	X	X	X	X		X
Dilsea californica	rh	dc	X	X	X	X	X	X	X	X	X		X	X
Erythrophyll. delesserioides	rh	ed											X	
Endocladia muricata	rh	em	X	X		X	X	X	X	X	X	X	X	X
unidentified "fine frilly red"	rh	ff											X	
Farlowia mollis	rh	fm			X	X	X							
Gigartina canaliculata	rh	gc				X	X	X	X					X
Gelidium coulteri	rh	ge	X	X			X	X	X	X	X	X	X	X
Gymnogongrus linearis	rh	gl				X								
Grateloupia setchelli	rh	gs							X					
Gigartina exasperata or *G. corymbifera*	rh	gx				X								

Appendix C. Continued

Species	Species code		Site											
			CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
Hymenena/Cryptopleura	rh	hc	X	X	X	X	X	X	X		X		X	X
Halosaccion glandiforme	rh	hg					X		X	X	X			
Halymenia/Schizymenia/ Dilsea	rh	hs	X	X				X	X		X		X	
Iridaea cornucopiae	rh	ic		X										
Iridaea heterocarpa	rh	ih	X	X	X	X	X	X	X	X	X	X	X	X
Iridaea sp.	rh	ir			X			X	X		X	X	X	
Iridaea splendens	rh	is		X		X	X	X	X	X	X	X		X
Laurencia spectabilis	rh	ls	X		X	X	X				X		X	X
Microcladia borealis	rh	mb	X	X	X	X	X	X	X	X	X		X	X
Microcladia coulteri	rh	mc							X			X		
Melobesia mediocris	rh	me		X										
Mastocarpus jardinii	rh	mj	X				X	X	X	X	X	X	X	X
Mastocarpus papillatus	rh	mp					X	X	X	X	X	X	X	X
Mastocarpus sp.	rh	ms	X	X		X	X	X	X	X	X	X	X	X
Neorhodomela larix	rh	nl	X	X	X	X	X	X	X	X	X	X	X	X
Neorhodomela oregona	rh	no	X	X	X	X	X							
Odonthalia floccosa	rh	of	X	X	X		X	X	X	X	X	X	X	X
Odonthalia sp.	rh	os	X	X	X		X	X	X	X	X	X	X	X
Odon. washingtoniensis	rh	ow									X	X	X	X
Prionitis lanceolata	rh	pa				X		X						
Pterosiphonia bipinnata	rh	pb	X		X									
Plocamium cartilagineum	rh	pc		X	X	X	X	X	X				X	
Porphyra spp.	rh	pf	X	X		X	X		X	X	X	X	X	X
Pterosiphonia gracilis	rh	pg		X			X							
Plocamium sp.	rh	pl						X						
Plocamium oregonum	rh	po		X		X								
Prionitis sp.	rh	pr				X	X							
Prionitis spp.	rh	pr	X	X				X	X	X	X	X	X	X
Polysiphonia sp.	rh	ps		X	X	X	X	X		X		X	X	X
Ptilota filicina	rh	pt	X	X	X	X	X	X		X	X	X	X	X
Pterosiphonia sp.	rh	pu			X	X		X						
Plocamium violaceum	rh	pv	X	X	X	X	X	X						X
Smithora naiadum	rh	sm			X	X								
unidentified red algae	rh	u		X		X								
Red algae: corallines and crusts														
articulate corallines	rh	ac							X		X	X	X	
Audouinella pupurea	rh	ap	X											
Bossiella sp.	rh	bo	X	X	X	X	X	X	X	X	X	X	X	
coralline crust	rh	cc	X	X	X	X	X	X	X	X	X	X	X	X
Corallina sp.	rh	cg		X	X	X	X	X	X			X	X	
Corallina officinalis	rh	co				X								
Calliarthron tuberculosum	rh	ct	X		X	X		X			X		X	
Corallina vancouveriensis	rh	cv	X	X	X	X	X	X					X	

Appendix C. Continued

Species	Species code		Site											
			CL	BB	OC	YA	SB	NC	CB	RP	HM	NB	CF	CC
epiphytic coralline crust	rh	ec		X								X		
fleshy crust	rh	fc	X	X	X	X	X	X	X	X	X	X	X	X
Hildenbrandia sp.	rh	hi		X			X	X	X	X	X	X	X	X
"Petrocelis"	rh	pe	X	X		X	X	X	X	X	X	X	X	X
unidentified algae	cg	al	X	X	X	X			X		X	X		X
drift algae	cg	da	(X)		(X)		(X)	(X)				(X)	(X)	(X)
Lichens														
Verrucaria maura	li	ve					X	X						
unidentified lichens	li	u						X						
Anthophytes														
Phyllospadix scouleri	sp	ps	X	X	X	X	X	X	X	X	X	X	X	X
Phyllospadix torreyi	sp	pt	X	X	X	X		X	X		X		X	X
Total invertebrate taxa	32		7	8	3	24	9	6	4	5	4	6	6	5
Total plant taxa	99		41	53	43	53	54	48	46	32	39	40	46	39
Total number of taxa	131		48	61	46	77	63	54	50	37	43	46	52	44

Appendix D. Participants in the ODFW/OIMB rocky intertidal survey, June, 1994.

North coast team:

Arlene Merems	ODFW
Jeff Harding	OSU
June Mohler	ODFW
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Carol McKillip	student, OIMB
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North coast team with help from:

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Jeff Goddard	OIMB
Mary Holbert	ODFW
Peggy Hughes	student, OIMB
Ken Long	ODFW
Jean McCrae	ODFW
John Schaefer	ODFW

South coast team:

David Fox	ODFW
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Michele Long	ODFW
Eric Allen	student, OIMB
Rachel Bain	student, OIMB
Rick Hochberg	student, OIMB
Carrie Hitchcocok	student, OIMB
Peggy Hughes	student, OIMB
Anne Morris	student, OIMB
Jennifer Roth	student, OIMB