L.b.

A ZONATION AND BIOMASS STUDY OF INTERTIDAL FLORA AND FAUNA IN AN AREA OF BOILER BAY

By Mirna Marin
Jose Nunez
Craig Bardell
Patricia Kenney

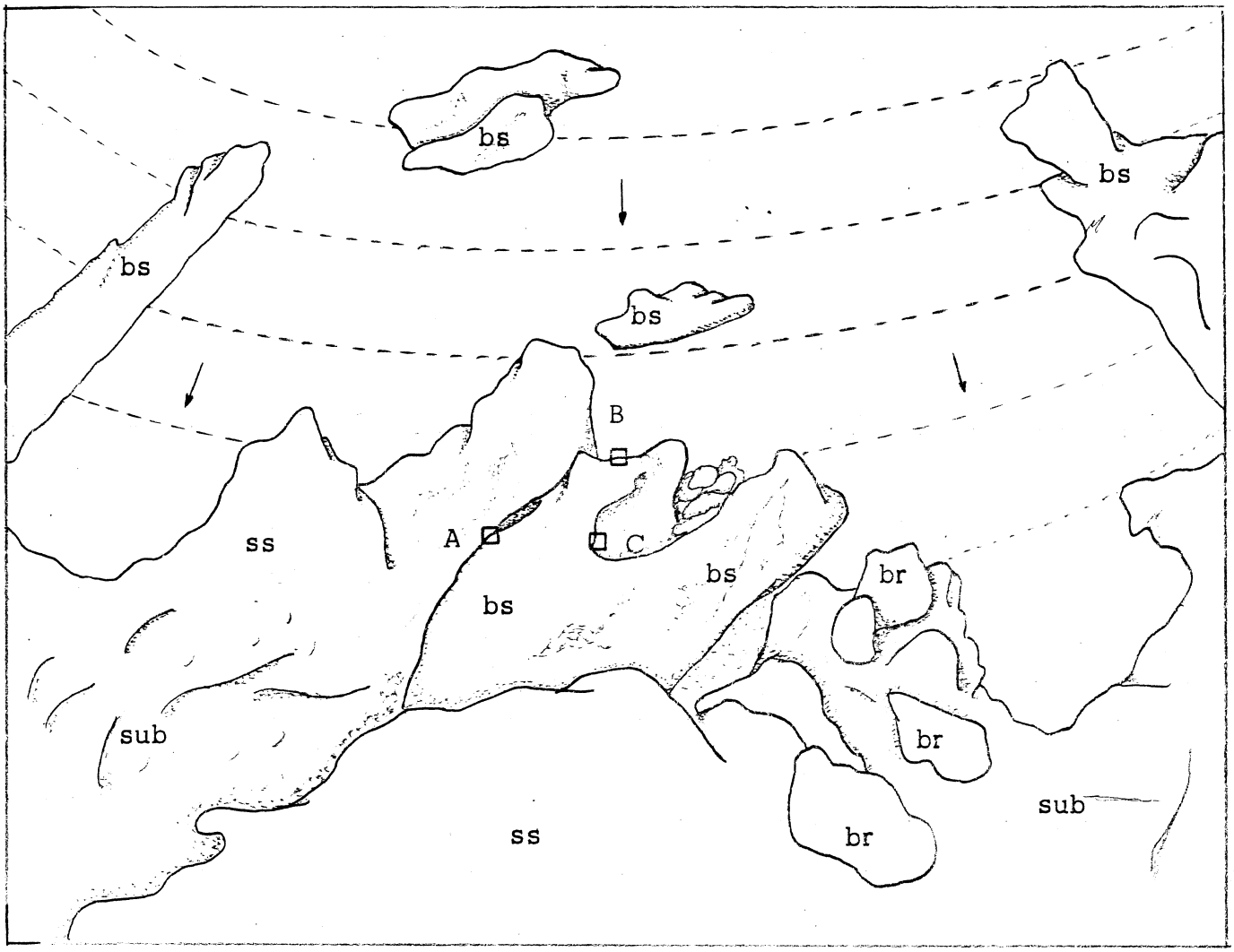
A Zonation and Biomass Study of Intertidal Flora and Fauna in An Area of Boiler Bay

This study was made on a rocky projection in a semi-protected area of Boiler Bay located about 9 miles north of Depoe Bay on Highway 101. The topography of this area is determined among other factors by the geological nature of the substrate, consisting of sandstone, breccia and basalt (Fig. 1). The study was conducted for the purpose of observation of zonation and familiarization of flora and fauna in the area. Some environmental factors were also considered in reference to species distribution and mussel biomass. Conclusions were derived on the basis of data collected in the area with the scope of this study narrowed considerably by exclusion of several environmental factors not easily determined.

Methods and materials:

For the zonation studies, three zones were chosen (Figure 1) -- one with a southerly exposure (A), one with a northerly exposure (C) and one facing the wave action in a westerly direction (B). The lower and upper limits of each zone were taken using a stadia rod and a hand level and the width of each belt was measured with a tape measure. The percentage cover was estimated for each species in each zone using a square frame 30 centimeters by 30 centimeters divided with string into 100 smaller squares of equal size. Three observations were made in the middle of each belt and three at the lower and upper limits in the transition area between belts for Zone A. For Zone C two samples were taken in the

Figure 1 : Geological and physical features of the study area and proximity



A, B, C: Mussel sample sites
ss : sandstone
bs : basalt
br : breccia
sub : sea urchin bed
⟶ : wave direction

middle of each belt only. No percent cover was observed for Zone B only the heights of the belts. Samples of species not readily identifiable were taken back to the lab for positive identification. The information gathered by these methods was used to make Figures 4 and 5.

For the biomass study a sample 15 centimeters by 15 centimeters from the mussel bed of each zone was taken back to the lab where quantitative studies were made with the live animals. Wet weights were measured with a balance scale for the total sample taken from each zone and again for a random sample of 10 from each zone along with the lengths and widths of the ten measured with a caliper. This information was used in constructing Figure 6.

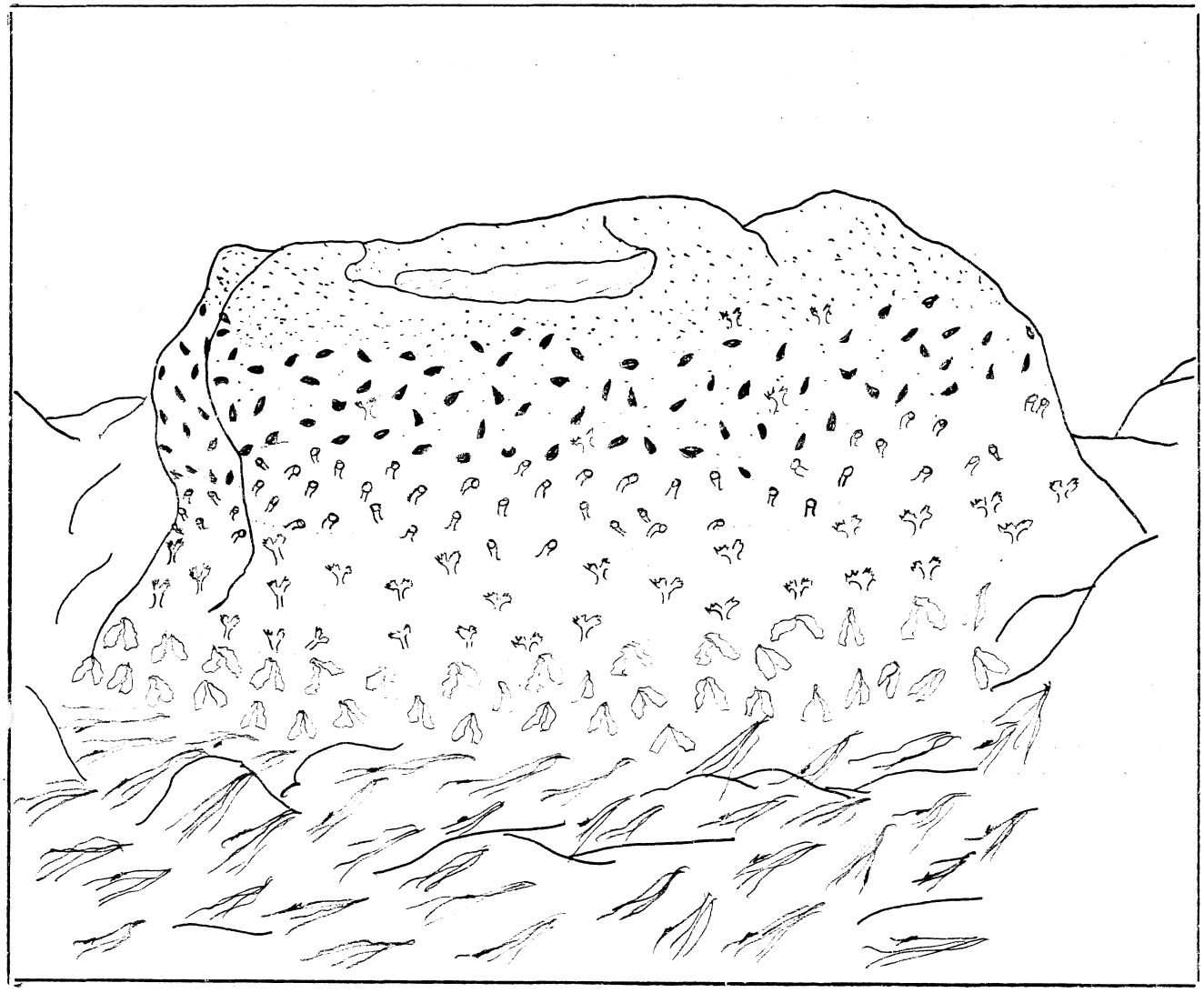
Pictures were drawn on site of Zones A and C (Figures 2 and 3) and one of the general proximity showing geological and physical features (Figure 1). No polar orientation could be accurately established due to unavailability of a compass.

Results:

Using the data shown in Figures and the dominant* species for each belt in Zones A and C were found to be as listed below:

Zone A: Belt	Dominant species	Other Dominants
-2.1 ft	Phyllospodix scouleri	
-2.1 to 2.3	Hedophyllum sessile	Odonthalia floccosa Porphyra perforata
2.3 to 3.5	Endocladia muricata	Bossiella sp.
3.5 to 5.5	Mytilus californianus	Balanus glandula Balanus cariosis (found on Mytilus)

Figure 2 : Stylized representation of source of the patterns of zonation in rocky shore of Boiler Bay. Zone A.



Barnacles Balanus cariosus
Balanus glandula
Chthamalus dalli

Gigartina papillata

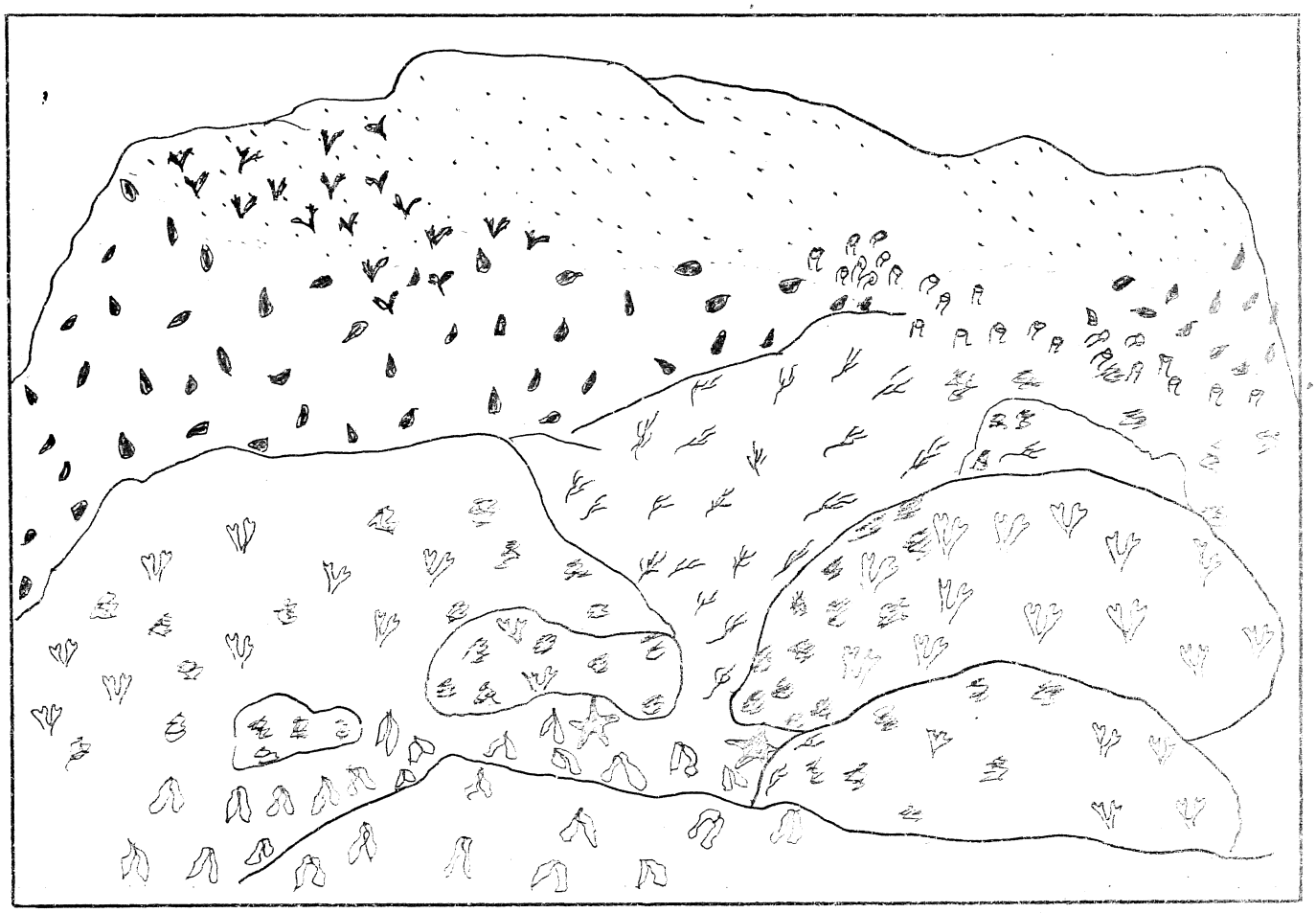
Mytilus californianus

Hedophyllum sessile

Pollicipes polymerus

Phyllospadix scouleri

Figure 3 : Stylized representation of source of the patterns of zonation in rocky shore of Boiler Bay. Zone C



Barnacles — Balanus cariosus, Balanus glandula, Chthamalus dalli

Mytilus californianus

Pollicipes polymerus

Odonthalia floccosa

Endocladia muricata

Fucus distichus

Pelvetiopsis limitata

Hedophyllum sessile

Pisaster ochraceus

5.5 to 8.0	Balanus glandula Balanus cariosis	Gigartina papillata

Zone C:

0 to 1.7	Iridaea linearis	
1.7 to 3.5	Fucus distichus	Ulva
3.5 to 4.7	Odonthalia floccosa	
4.7 to 6.0	Mytilus californianus	Balanus glandula Balanus cariosis
6.0 to 8.0	Balanus glandula Balanus cariosis	Endocladia muricata

*Considered dominant if found in at least two of the percent cover samples taken in the belt.

The weight and size of the mussel samples was found to be greatest in Zone B and smallest in Zone A with Zone C being intermediate; the total biomass corresponded respectively (Figure 6). The width of the mussel bed in Zone B was the largest at 209 cm; Zone A the intermediate at 127 cm; and Zone C the smallest at 57 cm.

Conclusion and Discussion:

Data from our zonation comparison of Zone A and C suggests that the two areas differ in species composition. It is believed that these differences are due in large part to a number of environmental factors -- sun exposure, wave exposure, slope, substrate, competition, predation, grazing, etc. In this study only sun exposure, wave exposure and slope could be considered due to time limitation with emphasis on wave exposure.

In Boiler Bay the communities correspond to an exposed coast and the study area was consider as semiprotected. The terminology of protected and exposed used in this study is only relative to the immediate area.

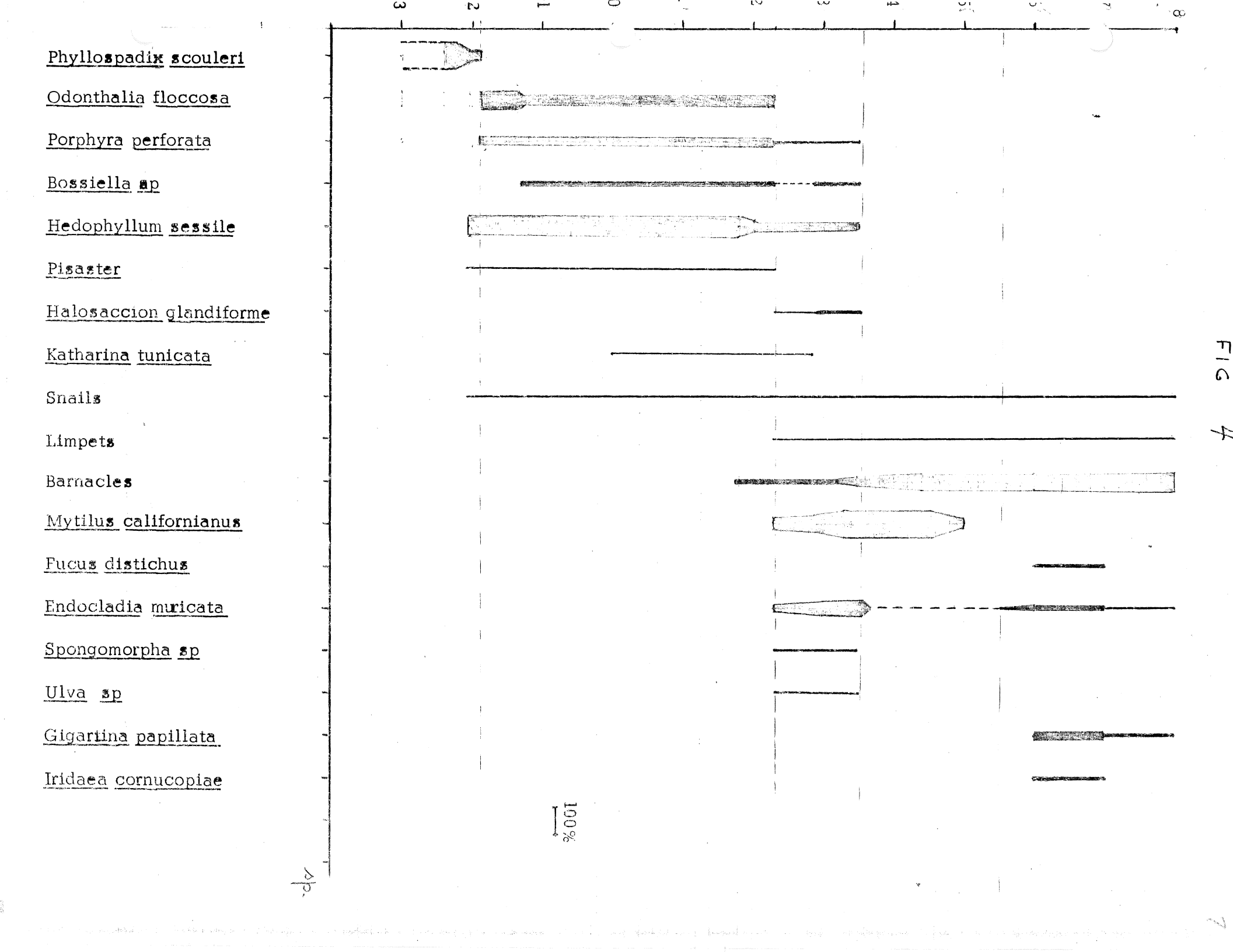
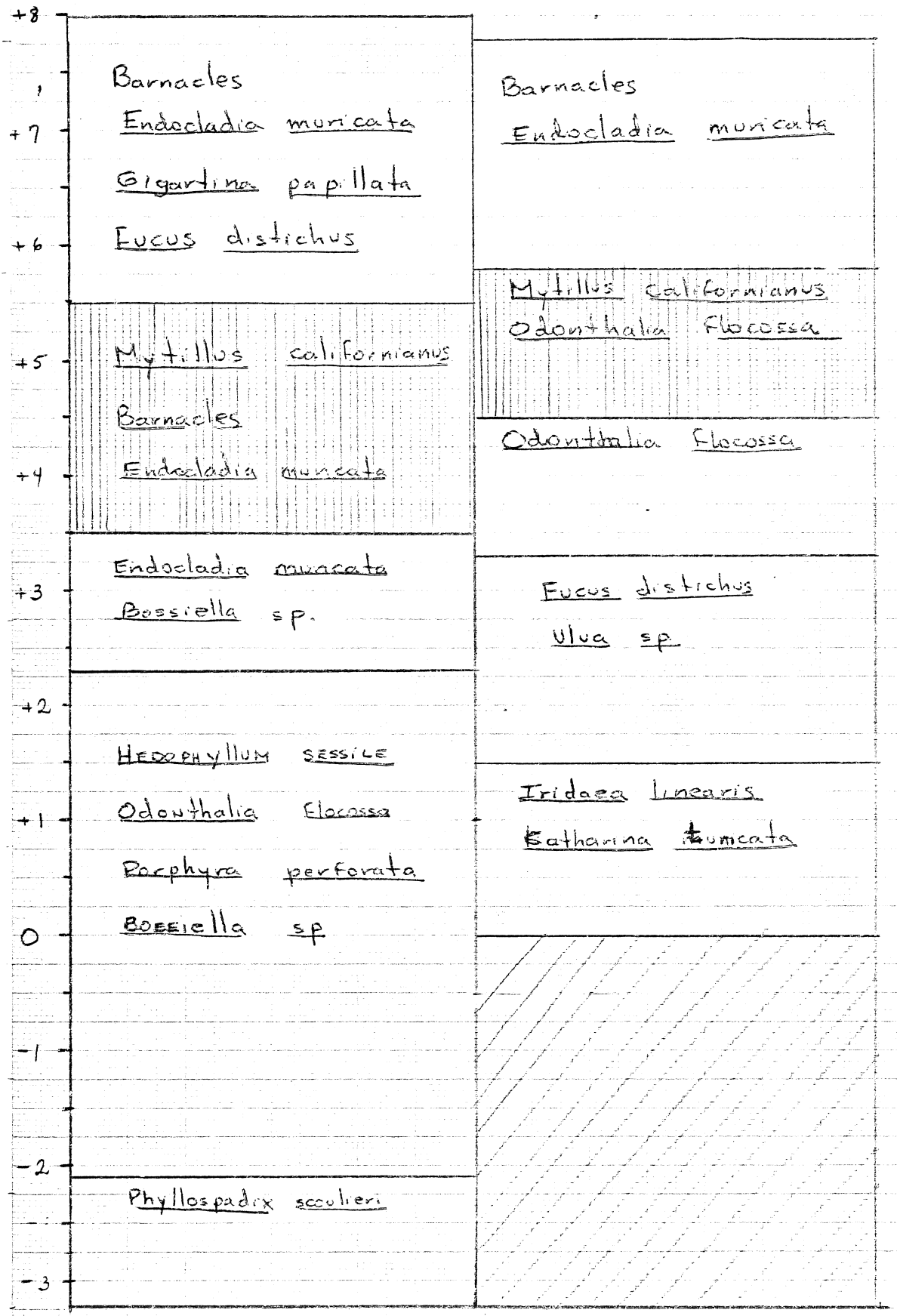

Phyllospadix scouleri
Odonthalia floccosa
Porphyra perforata
Bossiella sp
Hedophyllum sessile
Pisaster
Halosaccion glandiforme
Katharina tunicata
Snails
Limpets
Barnacles
Mytilus californianus
Fucus distichus
Endocladia muricata
Spongomorpha sp
Ulva sp
Gigartina papillata
Iridaea cornucopiae
100%
-dbr

FIG 4

Fig 5

TIDE LEVEL

COMPARISON OF THE BELT'S COMPOSITION



The zones chosen within the study area show definite differences in species distribution and composition (Figure 4 and 5). The major differences appear to be due to the wave action. The species can be arranged in categories of exposure tolerance.

Zones A-3 and C-3 correspond to what is classically called lower mid-littoral zone. This zone is characterized by Mytil us californianus and Pollicipes polymerus. The wider mussel bed in Zone A suggests that this zone is more exposed than Zone C, as does the presence of Gigartina and Porphyra which is typical of exposed area. On the othe r hand, the presence of Fucus distichus as well as the axial frills on the snail shells collected in Zone C are indicative of a protected condition.

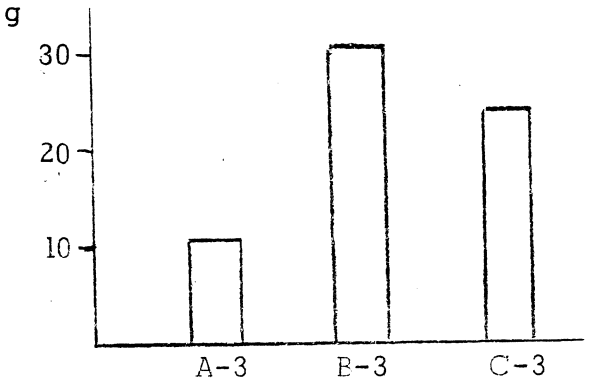
The differences in abundance and diversity of species of algae between Zone A and C (Figure 5 and Appendix V and VI) could be explainable in terms of the sun exposure in addition to wave exposure since the intensity and quality of light are indispensable factors for algal growth and also the abundance of chitons found in Zone C would suggest a more shaded environment.

Since wave splash is one of the main factors considered as determinative in the presence and distribution of filter feeders such as mussels and barnacles, it was considered important to make an estimation of the biomass of the more conspicuous group in our zonation, namely Mytilus californianus, results which appear in Figure 6 . To complete the whole idea it was considered important to determine the changes in size of individuals according to different degree of wave exposure (Figure , 2 and 3).

Figure 6
Comparative mussel size and biomass of zones A-3, B-3 and C-3

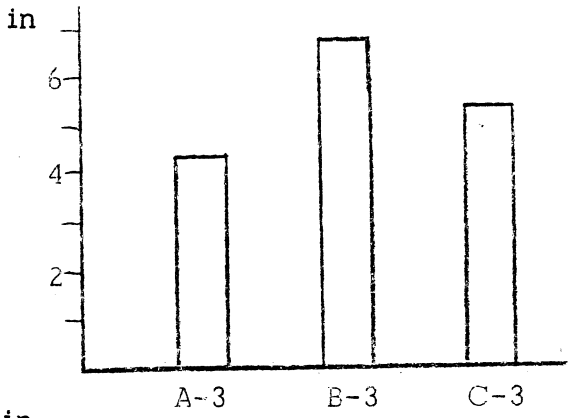
Weight

Zone	Mean
A-3	11.50 g
B-3	31.84 g
C-3	20.41 g



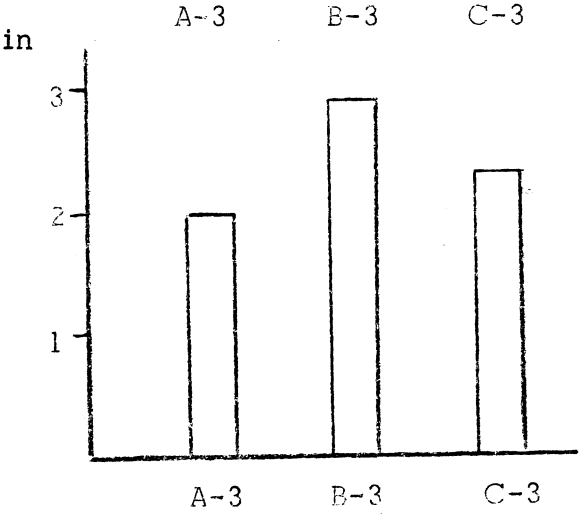
Length

Zone	Mean
A-3	4.42 in
B-3	6.85 in
C-3	5.43 in



Width

Zone	Mean
A-3	2.06 in
B-3	2.91 in
C-3	2.48 in



Biomass:

Zone	Biomass (kg/sq m)
A-3	52.52
B-3	51.81
C-3	49.60

The biomass of Mytilus californianus showed to be higher in Zone A and lower in Zone C. This result was due to the waves exposure and slope because while in Zone A the slope is less steeper than in Zone C the waves exposure is higher in Zone A. Since Mytilus requires wave wash (splash and submergence) for feeding, it is understandable that the succesful settling in places where the wave action is stronger and where the slope permits a slow drainage as in Zone A. The analysis of average weight, length and width of the random samples (Figure 6) shows consistently higher values in Zone B where the wave splash is directly bringing the Mytilus the necessary food.

Appendix I - List of animal species in study area and proximity

Phylum Cnidaria

Class Anthozoa

Order Actiniaria: *Anthopleura xanthogrammica* (Brandt)

Tealia crassicornis (Muller)

Phylum Arthropoda

Class Crustacea

Subclass Cirripedia

Order Thoraeica: *Balanus (Balanus) glandula* (Darwin)

Balanus (Semibalanus) cariosis (Pallas)

Chthamalus dalli (Pilsbry)

Pollicipes polymerus (Sowerby)

Order Isopoda: *Idotea (Pentidotea) wosnesenskii* (Brandt)

Order Decapoda: *Pugettia producta* (Randall)

Pagurus hirsutiusculus (Dana)

Petrolisthes sp.

Phylum Mollusca

Class Polyplacophora

Family Acanthochitonidae

Cryptochiton stelleri (Middendorff)

Family Ischnochitonidae

Tonicella lineata (Wood)

Family Mopaliidae

Katherina tunicata (Wood)

Appendix I (cont)

Class Gastropoda

Order Archaeogastropoda

Family Acmaeidae

Collisella digitalis (Rathke)

Collisella pelta (Rathke)

Family Thaididae

Nucella canaliculata (Duclos)

Nucella emarginata (Deshayes)

Nucella lamellosa (Gmeliu)

Family Littorinidae

Littorina scutulata (Gould)

Subclass Opisthobranchia

Order Nudibranchia

Archidoris montereyensis (Cooper)

Diaulula sandiegensis (Cooper)

Class Bivalvia

Order Mytiloidea

Mytilus californianus (Conrad)

Phylum Echinodermata

Class Asteroidea

Order Fercipulata

Pisaster ochraceus (Brandt)

Pycnopodia helianthoides (Brandt)

Appendix I (cont)

Class Holothuroidea

Order Dendrochirotida

Cucumaria piperata (Stimpson)

Eupentacta quinquesemita (Selenka)

Class Echinoidea

Order Regularia

Strengylocentrotus purpuratus (Stimpson)

Strengylocentrotus franciscanus (Agassiz)

Appendix II - Descriptive characteristics of animal species

Anthopleura xanthogrammica

Tentacles and disc uniformally colored (green); disc without conspicuous radial lines.

Tealia crassicornis

Column red and without tubercles; morethan 24 tentacles, without acentia.

Balanus cariosis

Tergum with beak; rostrum overlapping adjacent plates.

Balanus glandula

Scutum with pit on either side at adducter ridge; tergum without beak.

Chthamalus dalli

Rostrum overlapped by adjacent plates; scutum with lone, strong adducter ridge, with lateral depressor muscle crests.

Pollicipes polymerus

Stalked form; capitular plates more than 5 in number, basally surrounded by whorl of imbricated plates.

Idotea wosnesenskii

Eyes reniform; maxillipedal palp with 5 articles; maxilliped with 1 coupling hook.

Pugettia producta

Carapace longer than broad; rostrum bifid; prominent posterolateral projections; surface of carapace smooth.

Pagurus hirsutiusculus

Body dark orange-brown; rostrum triangular, acute; antennae not red; right cheliped larger than left.

Petrolisthes sp.

Body and chelae flattened; carpus of chelipeds longer than broad.

Appendix II (cont)

Cryptochiton stelleri

Valves completely covered by a thick, brick-red or brown-red girdle.

Katherina tunicata

Valves exposed, only small portion of valve exposed.

Tonicella lineata

Most of valve area exposed; pattern of red and white wavy lines.

Collisella digitalis

Anterior slope generally concave, posterior convex; shell sculptured; no internal deck; ribs strongest on posterior slope.

Collisella pelta

Similar to C. digitalis except anterior slope not concave; apex subcentral; smoother; and ribs equally developed on all sides.

Nucella canaliculata

Shell with smooth, often closely set, spiral ridges; interspaces with minute axial scales; somewhat elongate, narrow unbilical chink.

Nucella emarginata

Shell with irregularly nodulose, often well separated, spiral cords; columella excavated; anterior canal short; umbilicus closed.

Nucella lamellosa

Sculpture various; nearly smooth, or with prominent axial lamellae, or with spiral cords and weaker, irregular, axial swellings; anterior canal moderately long; unbilicus small, sometimes closed.

Littorina scutulata

Shell conical; columella thin; aperture without white band (external color bands may show through shell); color pattern more or less dotted .

Archidoris montereyensis

Rhinophores not in form of a longitudinally rolled plate; oral tentacles

Appendix II (cont)

usually present; blackish pigment in blotches on both dorsum and tubercles; 7 branchial plumes, yellowish; ground color light yellow; 25 mm.

Diaulula sandiegensis

Rhinophores not in form of a longitudinally rolled plate; oral tentacles usually present ; dorsum has velvet appearance; dorsum with a few brown to black markings; generally asconspicuous rings; ground color whitish yellow to very pale brown.

Mytilus californianus

Shell brown or black, cylindrical or tapering anteriorly; anterior end open, lacking internal septum; anterior adductor scar situated more anteriorly.

Pisaster ochraceus

Normally 5 arms; arm spines generally small, low, rounded, beadlike; spines on lateral and dorsal surfaces of arms forming extensive irregular, reticulated pattern, or separate convex, curved groups at arm tips; color purple, red, brown or ochre yellow.

Pycnopodia helianthoides

Fifteen to twenty-four or more limp flexible arms, with soft fleshy covering; color in life pink to purple.

Cumaria piperata

Tube feet not confined to venter; body color white or cream with small brown spots, which may be widespread or restricted to tentacular crown.

Eupentacta quinquesemita

Tube feet not confined to venter; body color white, without spots; tube feet rigid and nonretractile, giving animal a bristly appearence; long branched yellow tentacles.

Strongylocentrotus purpuratus

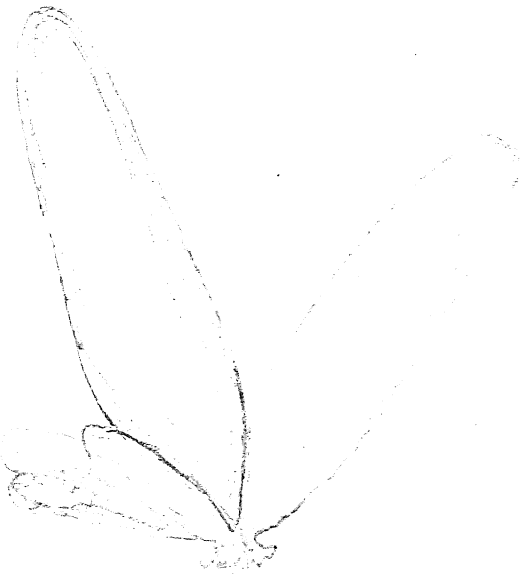
Purple sea urchin; spines uniformly rich purple, body is dark reddish purple.

Appendix II (cont)

Strongylocentrotus franciscanus

Red sea urchin; spines long and range from pale, nearly white, to a dark nearly black, reddish or maroon.

Gigartina papillata



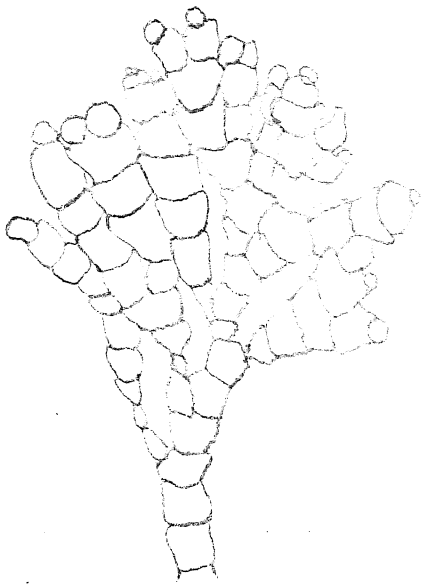
Halosaccion glandiforme

Endocladia muricata

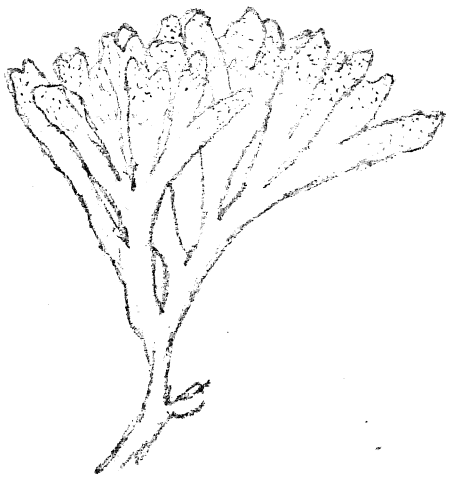
Mytilus californianus

Katherina tunicata

Porphyra perforata

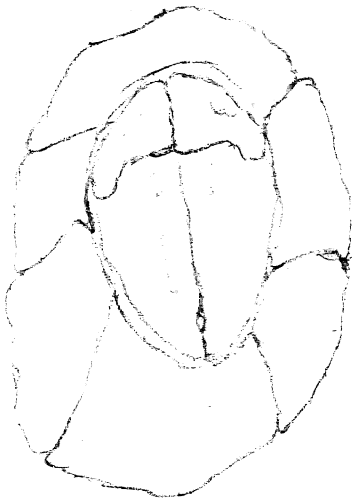


Bossiella

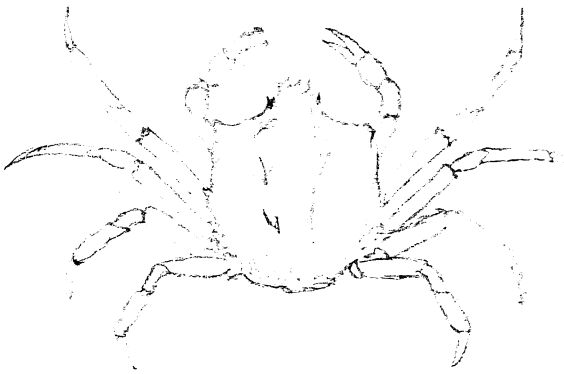


Fucus distichus

Pollicipes polymerus



Chthamalus dalli



Pugettia producta

Littorina scutulata

Nucella lamellosa

Nucella emarginata

Appendix III - Plant species found in study area and proximity

Phylum Chlorophyta

Cladophora hemisphaerica (Gardner)

Prasiola meridionatis (Setchell and Gardner)

Ulva sp.

Phylum Phaeophyta

Fucus distichus L. (Linnaeus)

Hedophyllum sessile

Pelvetiopsis limitata (Gardner)

Phylum Rhodophyta

Botryoglossum farlowianum (J. Agardh)

Iridaea cornucopiae (Postels and Ruprecht)

Halosaccion glandiforme (Gmelin)

Odonthalia floccosa (Esper)

Endocladia muricata (Postels and Ruprecht)

Bossiella sp. (Silva)

Gigartina papillata (C. Agardh)

Porphyra perforata (J. Agardh)

Halymenia sp.

Appendix IV:- Measurements of random sample taken from each zone mussel bed

Zone A-3:	No.	Length	Width	Weight
	1	4.79 in	2.14 in	
	2	4.81	2.08	
	3	4.30	2.12	
	4	7.09	2.70	
	5	4.20	2.01	
	6	4.46	2.19	
	7	4.40	2.12	
	8	3.39	1.71	
	9	3.77	1.92	
	10	2.88	1.59	
Total		44.18 in	20.57 in	115.0 g
Mean		4.42 in	2.06 in	11.5 g

Zone B-3:	No.	Length	Width	Weight
	1	7.35	3.04	
	2	7.51	3.09	
	3	6.92	2.91	
	4	5.47	2.45	
	5	7.32	2.74	
	6	5.85	2.97	
	7	8.62	3.51	
	8	7.98	3.37	
	9	5.81	2.49	
	10	5.65	2.48	
Total		68.48 in	29.05 in	318.4 g
Mean		6.85 in	2.91 in	31.84 g

Zone C-3:	No.	Length	Width	Weight
	1	6.70	3.02	
	2	6.28	2.84	
	3	6.53	2.91	
	4	5.42	2.60	
	5	5.96	2.49	
	6	5.65	2.13	
	7	5.46	2.48	
	8	4.89	2.49	
	9	4.10	1.91	
	10	3.79	1.94	
Total		54.28 in	24.81 in	204.1 g
Mean		5.43 in	2.48 in	20.41 g

APENDIX V PERCENT COVERAGE FOR ZONE A

ZONE	SAMPLE 1		SAMPLE 2		SAMPLE 3	
1 (Lower)	Phyllospadix scouleri	28%	Phyllospadix scouleri	22%	Phyllospadix scouleri	20%
	Odonthalia floccosa	28%	Odonthalia floccosa	75%	Odonthalia floccosa	52%
	Botryoglossum farlowianum	9%	Porphyra perforata	5%	Porphyra perforata	15%
	kelp crab (Pugettia)	1	Bossiella sp	5%	Snails	4
	Mussel (Mytilus californianus)	1	snail	1		
	Snail	1				
1 (Middle)	Hedophyllum sessile	90%	Hedophyllum sessile	78%	Odonthalia floccosa	30%
	Odonthalia floccosa	70%	Porphyra perforata	15%	Porphyra perforata	5%
	Bossiella sp	15%	Odonthalia floccosa	20%	Bossiella sp	18%
	Pisaster sp	1	Bossiella sp	8%		
	Chiton	1				
Transition zone (1-2)	Hedophyllum sessile	39%	Endocladia muricata	30%	Endocladia muricata	15%
	Odonthalia floccosa	21%	Fucus distichus	14%	Hedophyllum sessile	30%
	Bossiella sp	35%	porphyra perforata	3%	Iridaea sp	9%
	Halosaccion glandiforme	1%	Halosaccion glandiforme	.5%	Halosaccion glandiforme	1%
	Porphyra perforata	1%	Chthamalus dalli	15%	Balanus sp	20%
	Snail	1	Limpets (very tiny)	5%	Limpets (very tiny)	5%
	Chiton (Little)	1			nemertinea	1
	Limpet	1				
2	Endocladia muricata	70%	Endocladia muricata	60%	Endocladia muricata	30%
	Halosaccion glandiforme	3%	Halosaccion glandiforme	.5%	Halosaccion glandiforme	1%
	Bossiella sp	6%	Ulva sp	.5%	Ulva sp	1%
	Spongomorpha sp	2%	Spongomorpha sp	.5%	Iridaea	2%
	Ulva sp	1%	Many tiny barnacles.		Bossiella sp	11%
	Chiton (Tiny)	1	Limpets	1	Limpets	2
	Limpets	10			Amphipods	2
Transition zone (2-3)	Pollicipes polymerus	5%	Mytilus californianus	53%	Mytilus californianus	50%
	Balanus (glandula & canosis)	6%	Balanus (glandula & canosis)	50%	Balanus (glandula & canosis)	25%
	Mytilus californianus	31%	Endocladia muricata	6%	Endocladia muricata	40%
	Endocladia muricata	5%	Snails	12		
	Snails	10	Many tiny limpets			
3	Mytilus californianus	100%	Mytilus californianus	100%	Mytilus californianus	100%
	Balanus (glandula & canosis)	40%	Balanus (glandula & canosis)	70%	Balanus (glandula & canosis)	40%
	Pollicipes polymerus	1%	Pollicipes Polymerus	5%	Many tiny snails	
	Many tiny snails				many tiny limpets.	
	Many tiny limpets					

ONE	SAMPLE 1	SAMPLE 2	SAMPLE 3
Transition zone (3--4)	Mytillus californianus 45% Balanus (conosis & glandula) 75% Endocladia muricata 2% Limpet 1	Mytillus californianus 38% Balanus (conosis & glandula) 45% Endocladia muricata 2% Gigartina papillata 4%	Mytillus californianus 20% Balanus (conosis & glandula) 45% Endocladia muricata 5% Gigartina papillata 10% snail 1
4.	Fucus distichus 12% Gigartina papillata 16% Endocladia muricata 12% Balanus sp + chthamalus dalli 60% my little snails few little mussels	Gigartina papillata 45% Iridaea cornucopiae 6% Ulva sp 1% Mytillus californianus (small) 3% Balanus conosus & glandula 40% Tiny snails	Iridaea cornucopiae 15% Endocladia muricata 10% Balanus conosus & glandula 40%
5.	Balanus conosus & glandula 95% Gigartina papillata 4% Endocladia muricata 1% Many little snails some limpets.	Balanus conosus & glandula 30% Gigartina papillata 5% Endocladia muricata 2% many little snails.	Balanus sp. 95% Gigartina papillata 5% Pelvetiopsis limitata 3% Endocladia muricata 1%

APENDIX VI PERCENT COVERAGE FOR ZONE "C"

ZONE	SAMPLE 1		SAMPLE 2	
1.	Iridaea lineavis	70%	Iridaea lineavis	65%
	Katharina tunicata	1	Mytillus californianus	2
	hermicrab	1	Katharina tunicata	1
2.	Eucus distichus	50%	Eucus distichus	14%
	Ulva sp	8%	Rhodomela larix	20%
	many small limpets		Hedophillum sessile	9%
	" " barnacles.		Ulva sp	6%
			Halosaccion glandforme	2%
#3	ODONTalia Flocossa	46%	Odontalia Flocossa	100%
	Bossiella sp	35%	Mytillus californianus	1
	Hedophillum sessile	1%	chthamalus dally	2
	Mytillus californianus	10		
	many small mussels			
#4	Mytillus californianus	90%	Mytillus californianus	100%
	Pollicipes polymerus	24%	Endocladia muricata	6%
	Odontholia Flocossa	5%	Barnacles (B. cariosis & B. glandula)	50%
	Small barnacles at the top of mytillus shells		Snails	2
#5	Barnacles (B. cariosis, B. glandula & chthamalus)	60%	Barnacles (B. cariosis, B. glandula, & chthamalus)	35%
	Endocladia muricata	2%	Endocladia muricata	3%
	Limpets	4	Limpets	9
	Snails	1	Snails	8
	many small snails		Mytillus californianus	12%

Bibliography

Abbott, I. A. and Hollenberg, G. J. Marine Algae of California. Stanford, Ca.: Stanford Univ. Press. 1976.

Barbour, M. G.; Craig, R. B.; et.al. Coastal Ecology: Bodega Head. Berkeley, Los Angeles, London.: Univ. of California Press. 1973.

Carpenter, R. J. An Ecological Glossary. New York: Hafner Publishing Co. 1938.

Kozloff, E. N. Seashore Life of Puget Sound, the Strait of Georgia, and the San Juan Archipelago. Seattle and London: Univ. of Washington Press. 1973.

Lewis, J. R. The Ecology of Rocky Shores. London, England: The English Universities Press LTD, 1964.

Light, S. F. Light's Manual: Intertidal Invertibrates of the Central California Coast. Smith, R.I., and J. T. Carlton, ed. Berkeley, Los Angeles, London.: Univ. of California Press. 1975.

Southward, A. J. Life on the Seashore. Cambridge, Mass.: Harvard University Press. 1965.

Tait, R.V. Elements of Marine Ecology: An Introductory Course. 2nd ed. revised by R. S. DeSanto. New York: Springer-Verlag. 1972.