

ECOLOGICAL RESOURCE INVENTORY OF THE CABRILLO NATIONAL MONUMENT INTERTIDAL ZONE

Project
1976 Report



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FOR

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PROJECT SUMMARY

This document describes the ecological resources of the Cabrillo National Monument intertidal zone and makes recommendations for their management. A summary of the accomplishments follows:

1. A map of the major intertidal communities was developed using field observations and aerial photographs of the study area.

2. Species lists for plants and animals are annotated with ecological information specific to the study area. The 1976 study documents the presence of 109 plant species and 160 invertebrate animal species (birds and fishes were not inventoried). Some of the species were found only as dead individuals.

3. A brochure to be given to intertidal visitors was drafted and awaits Monument approval for publication. It describes the major intertidal habitats and stresses the value of the ecological resources, the impact which the public can have on individual species, and the potential for community-wide effects resulting from impacts on individual species.

4. Detailed descriptions of the ecological resources are provided for six habitats which were inventoried in spring and fall 1976: Algal Mats, Phyllospadix Pools, Pelvetia Rocks, Mytilus Rocks, Barnacle Rocks and Cliff Faces.

5. The communities found in these habitats are compared among areas of low and frequent public use to develop hypotheses concerning the impact of the public on intertidal biota. Plants which appear to be decreased in abundance by public use include the limestone-encrusted Corallina spp., the brown rockweed, Pelvetia fastigiata, and the understory plants of the Phyllospadix pools. Animals which were less abundant in frequently used areas were the sand castle worm, Phragmatopoma californica, the limpets, Acmaea digitalis and Acmaea scabra, and the small barnacle, Chthamalus fissus (on Mytilus rocks).

The small red alga, Centroceras clavulatum, and the sea anemone, Anthopleura elegantissima, were both more abundant in used areas and appear to be favored by public use. Higher abundances of the barnacles, Tetraclita squamosa and Chthamalus fissus (on Barnacle rocks), in used areas are less likely due to public use, and their distributions require further study.

Consideration of the trophic structure, total cover of plants, and numbers of plant and animal species suggested no major differences in community structure with degree of public use. We conclude that the current public impact is localized near access routes and on sensitive species. Previous public impact, including harvesting lobsters and abalone, has probably had major effects on ecological community structure throughout the study area.

6. Management recommendations are to limit the number of visitors to the intertidal zone, to provide more control of visitor activities, to expend more effort in educating the public through brochures and in situ explanations of the ecological resources, and to control erosion of the access foot path and the natural arch. A monitoring program is suggested to assess long-term changes in intertidal biota.

PROJECT OBJECTIVES AND RESEARCH APPROACH

The purpose of the Ecological Resource Inventory was to describe the biological resources present in the Cabrillo National Monument Intertidal Zone and to make recommendations for their management. Financial support was through a grant from the National Park Service to the principal investigator.

The research approach required a sampling design which would allow us to determine what marine species were present as well as to assess the existing impacts of the public on those species. We chose a design which would allow us to assess the abundance of plants and animals in a variety of ecological habitats which were subjected to different degrees of public utilization. We restricted our sampling to the western portion of the Monument's intertidal zone, directly below and to the north of the Naval Undersea Center (Figure 1). We selected three general sampling areas in January of 1976 which differed in the degree of public use. At that time, the intertidal access was near NUC, and we selected two areas which were near that access, designated "North Use" and "South Use" areas on Figure 1. A distant location, rarely visited by the public, was chosen and designated "Low Use." Late in spring 1976, after our first inventory sample, the Low Use area became the major access route for intertidal visitors, following the erosion and closure of the original access. Hence the designations "Low Use" and "Use" areas are descriptive of our spring inventory sample, but no longer apply to the actual public use. For consistency, however, we have maintained the designations as they exist on Figure 1.

Habitat Site Selection

Within each sampling area, we chose seven different ecological habitats for sampling of species abundance. Plants are most conspicuous on the first

CABRILLO NATIONAL MONUMENT Map of Intertidal Communities

Legend (Communities are named for the dominant species or species group.)

1 = Algal mat

2 = Phyllospadix Pools (Surf Grass)

3 = Pelvetia Rocks (Rock Weed)

4 = Mytilus Rocks (Mussels)

5 = Barnacle Rocks

6 = Cliff Face

7 = Rocky Rubble, Small Rocks

8 = Egregia (Feather Boa)

9 = Sargassum

10 = Sandy Beach

11 = Tetriclita Rocks (Thatched Barnacle)

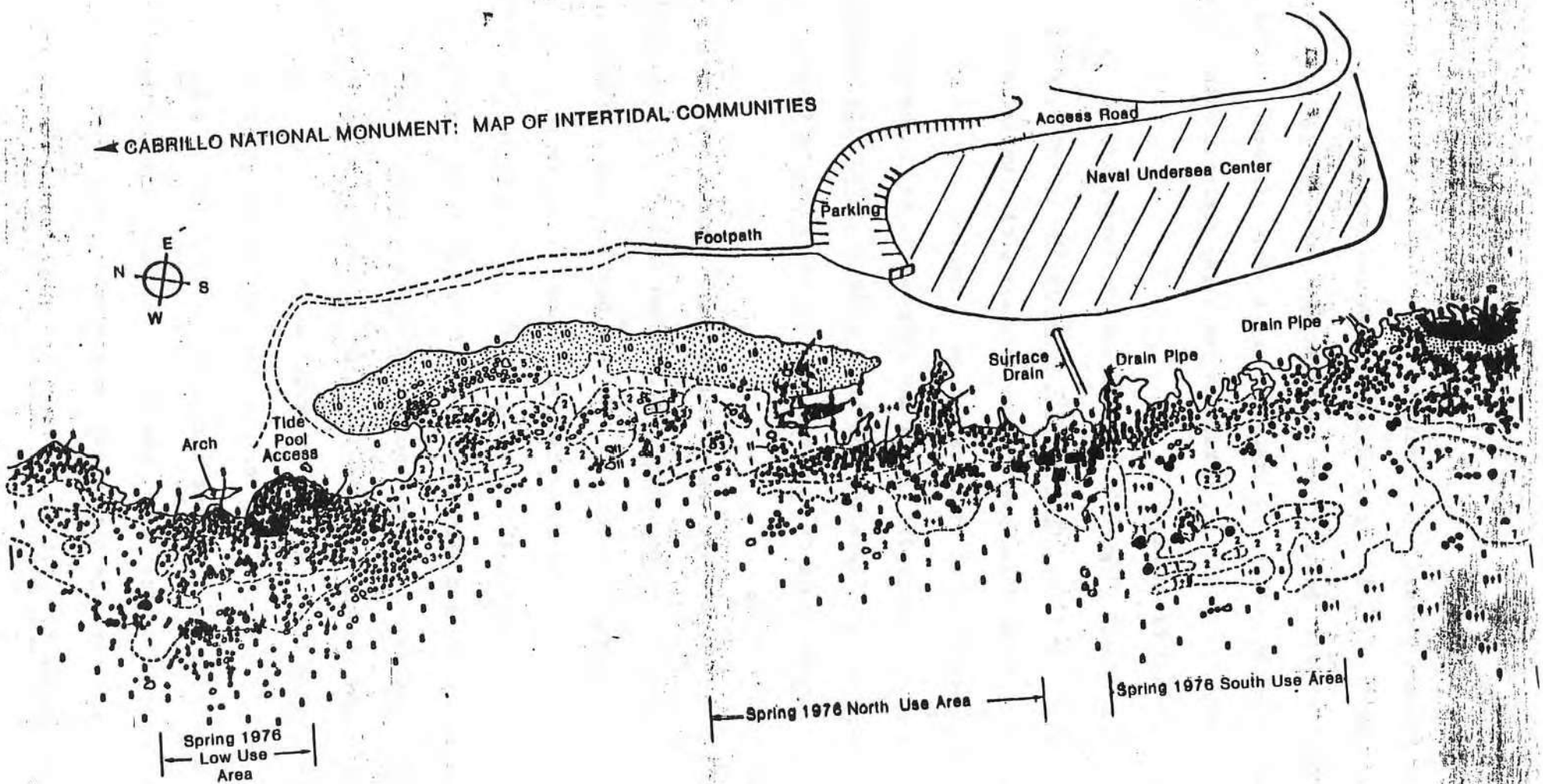
12 = Bare Rocks

13 = Small Cobblestones

Where two community types occur together, they are mapped as 1 + 8 , 8 + 1, etc., with the dominant listed first.

Large rocks are mapped as ● if dominated by Mytilus;
○ if not dominated by Mytilus.

Dashed lines encircle large areas of similar biota.


CABRILLO NATIONAL MONUMENT: MAP OF INTERTIDAL COMMUNITIES
Access Road
Naval Undersea Center
Parking
Footpath
E
N
S
W
Drain Pipe
Surface Drain
Drain Pipe
Arch
Tide Pool Access
Spring 1976 Low Use Area
Spring 1976 North Use Area
Spring 1976 South Use Area

three habitats; animals dominate the remaining four.

1. Algal Mats (Figure 2): This habitat is very extensive and covers the large flat rock "benches" in the intertidal zone. The cover of algae is very dense but short, so that it forms a turf. Several species of algae are intermixed. Calcified, coralline red algae dominate with other small species of red and brown algae.

2. Phyllospadix Pools (Figure 2): These are the larger tide pools which retain water at low tide. Phyllospadix scouleri (surf grass), which is a flowering plant, forms dense green cover in these pools; underneath its "canopy" are several species of algae and many animals.

3. Pelvetia Rocks (Figure 3): Small and large boulders in the middle intertidal zone are often dominated by the large brown alga Pelvetia fastigiata. The boulder tops are often bare of seaweeds, so that the Pelvetia forms a band around the sides of the rocks.

4. Mytilus Rocks (Figure 4): Large boulders are dominated by the California mussel, Mytilus californianus, which often coexists with the gooseneck barnacle, Pollicipes polymerus. The giant Mytilus boulders are a prominant feature of the intertidal zone and several can be seen in Figure 1.

5. Barnacle Rocks (Figure 5): Boulders which are highest in the intertidal zone are usually covered with barnacles of three different species (Balanas glandula, Chthamalus fissus, and Tetraclita squamosa). They are useful stepping stones for the intertidal visitor because the sharp edged barnacle shells provide traction in an otherwise slippery habitat.

6. Cliff Face (Figure 6): The vertical face of the sandstone cliffs separates the intertidal zone from the terrestrial environment. It is the highest extent of the intertidal zone, and many areas receive only wave splash or inundation at extreme high tides. Algae have sparse cover, and animals are often hidden in crevices.



Figure 2. Algal mats covering the rock benches are interspersed with large boulders and tidepools. A Phyllospadix dominated pool is shown at the right.

Figure 3. Pelvetia Rocks are dominated by Pelvetia fastigiata on the sides and barnacles on top. The Pelvetia plants reach lengths of .5 meters.





Figure 4. Mytilus Rocks are large (2-3 meters in height) conspicuous components of the Cabrillo Monument intertidal zone. Here they are surrounded by Algal Mat and Phyllospadix Pool habitats.

Figure 5. Barnacle Rocks are abundant near the upper limit of the intertidal zone. The common name, buckshot barnacle, is descriptive of the dense and widely distributed dominant, Chthamalus fissus.





Figure 6. Cliff Face habitats are structurally heterogeneous because of the differential erosion of rock layers. The smallest indentations, however, are caused by the action of their limpet occupants.

7. Rocky Rubble, Small Rocks: Lower in the intertidal zone are found patches of rocks which are suitable habitat for animals that live underneath a protective shelter. We have sampled the undersides of these rocks to inventory fauna such as brittle stars, chitons, sponges, and others. Rock tops are colonized by a variety of plants and animals not unlike the algal mat habitat.

Additional habitats have been identified and are mapped in Figure 1. However, these have not yet been sampled, either because they were not replicated in the different Use conditions or because of insufficient time. Inventory of their ecological resources will follow in 1977.

Sampling Methods

After identifying replicate areas of each habitat type in the three Use areas we chose sampling methods for plants and animals which would provide a rapid but quantitative estimate of the abundance of each species in each habitat. Representative habitats were selected and mapped for easy relocation.

Plants were sampled by measuring percent cover for each species. A meter-square frame was strung with elastic thread to create a grid of 100 intersections or points. The presence of each species under a point was then recorded for four such meter-square areas, for a total of 400 points per habitat in each use area. The elastic remained flat for the algal mats, Phyllospadix pools, and cliff face, and stretched easily over the curved surfaces of the boulder habitats. Plant species abundance data are thus percent cover (the proportion of points occupied) for each habitat sampled.

Animals were inventoried by counting individuals in two sizes of circular quadrats, .1 m^2 for the larger, less dense species, and .01 m^2 for the smallest or most abundant species. Three to five quadrats were placed under randomly selected points, using a gridded square meter frame.

Our results on abundance of animals consist of density per square meter

except for certain under-rock fauna for which it was impossible to separate individuals (e.g. sponges). Here percent cover data weretaken using the same procedure as for plants.

Each of the seven habitats was sampled in the Low, North, and South Use areas in winter-spring 1976 and again in fall 1976. The winter-spring sample was to obtain basic inventory data on species abundance throughout the intertidal zone and to compare abundances under low and frequent public use. The fall sample was done to locate additional species which might be seasonal in their distribution, and to determine if species abundances change with season. In addition, we wanted to determine if species abundances would increase following the summer period when public use is limited since tides are high during daylight hours.

RESULTS

A. Map of Intertidal Communities

An oblique aerial photo of the intertidal study area was taken at low tide in early spring of 1976. Although the angle from which the photograph was taken is not best for mapping purposes, it is very useful for viewing each of the habitats which were inventoried. Since there is undoubtedly distortion in exact location of objects in the photo, the map is an approximation, and not a precise duplication of the intertidal zone.

The map was drawn by Steve Hosmer, who has been a member of the sampling team throughout 1976 and who has obtained considerable field experience on the project. He prepared sketches of segments of the study area in the field, using the aerial photo as a guide, and took notes on the dominant species on each large boulder, each tide pool, etc. Information from the sketches was transferred onto an overlay on the aerial photo. Graphics were improved and printed by the SDSU Audio-Visual Services.

The legend for the map explains the symbols used to designate different areas. Each number symbol refers to the dominant species or habitat type present. The first seven communities are those areas which are most similar to the seven habitats chosen for quantitative sampling. Brief descriptions of these habitats are given in the previous section; detailed data are provided in a later section. Numbers 8 through 13 have not been sampled yet.

B. Species Lists for Plants and Animals

The following are annotated species lists for the plants and animals identified throughout the 1976 study period. Included are species found in the areas sampled quantitatively as well as species seen elsewhere in the study area. Species are grouped by major taxonomic categories, following the sources indicated. Complete names are given, with the genus and species underlined, followed by the name(s) of the taxonomist(s) who described the organism (and later revised it).

Taxonomy for the algae follows Abbott and Hollenberg's newly published Marine Algae of California (1976; Stanford University Press) which came out in time to correct nomenclature used in the spring inventory. Sources used in identifying the fauna include Light's Manual: Intertidal Invertebrates of the Central California Coast, edited by Smith and Carlton (3rd edition, 1975: University of California Press) and Allen's Common Intertidal Invertebrates of Southern California (Revised Edition, 1976: Peek Publications), Abbott's Marine Shells of Southern California (1974: Van Nostrand Reinhold), McLean's Marine Shells of Southern California (1969: Los Angeles County Museum of Nat. History, Sci. Ser. 24, Zool. #11), Ricketts and Calvin's Between Pacific Tides (1968: Stanford Univ. Press), and Johnson and Snook's Seashore animals of the Pacific Coast (1955: Dover Publications).

SPECIES LIST OF THE INTERTIDAL ALGAE OF CABRILLO NATIONAL MONUMENT

Note: The morphological descriptions provided for algal species in this list were paraphrased from I. A. Abbott and G. J. Hollenberg in Marine Algae of California (1976: Stanford University Press). Ecological information is based on observations in the Cabrillo National Monument intertidal zone.

CHLOROPHYTA

Order Ulotrichales

1. Enteromorpha compressa (Linnaeus) Greville
Plants tubular, upper portions compressed, tapering to base; thallus usually branched. This species occurs in the moist areas of cliff faces and rarely on the sides of large rocks in the mid-intertidal.
Distribution: High to mid-intertidal.

2. Enteromorpha flexuosa (Roth) J. Agardh (E. tubulosa)
Plants usually unbranched, cylindrical or sometimes slightly compressed. This species occurred in moist areas of cliff faces together with E. compressa.
Distribution: High intertidal.

3. Enteromorpha spp. Link 1820
Plants hollow and tubular; the walls one cell thick; thallus cylindrical or expanded and blade-like in upper portions. This genus of algae most frequently occurs in moist areas on cliff faces and on the east and north sides of large rocks in the upper intertidal.

4. Ulva angusta Setchell and Gardner
Blades light to medium green, more or less, strap-like; thallus spirally twisted with highly ruffled margins. This species was found to occur exclusively in the lower intertidal on rocks in Phyllospadix pools.
Distribution: Low intertidal to sub-tidal.

5. Ulva californica Wille (U. rigida)
Blades mostly 1.5 to 2 cm tall; wedge-shaped to ovate, commonly much crisped; usually in dense turf-like stands on recently disturbed areas or overturned rocks. Sparsely occurs on the moist faces of large rocks and occasionally on algal mats and on rocks in Phyllospadix pools.
Distribution: High to mid-tidal.

Order Cladophorales

6. Chaetomorpha linum (Muller) Kutzing (C. aerea)
Plants grass-green to yellowish-green; filaments straight, basally attached by delicate rhizoids. Occasionally occurs in shaded areas on large rocks and in Phyllospadix pools.
Distribution: Mid to low intertidal.

7. Cladophora spp. Kutzing
Plants erect, upper branches usually with conspicuous unilateral branching; lower portions sometimes matted, diminutive. Rarely occurs in shaded, moist areas of large rocks and in Phyllospadix pools.
Distribution: Mid to low intertidal.

Order Siphonales

8. Codium fragile (Suringar) Hariot
Plants dark green, 10-30 cm tall; branches thickened, blunt tipped and cylindrical throughout. Commonly occurring on the sides of large rocks and on the tops of smaller rocks.
Distribution: Mid to low intertidal.

PHAEOPHYTA

Order Ectocarpales

9. Ectocarpus parvus (Saunders) Hollenberg (E. confervoides)
Plants epiphytic upon Laminariales, forming patches on the host; filaments simple and mostly 4-12 mm tall, occurs on older, somewhat deteriorating, parts of the thallus of Egregia menziesii.
Distribution: Mid to sub-tidal.

10. Ralfsia spp. Berkeley (R. pacifica)
Plants crustose, expanded and commonly a dark brown. Commonly occurs on cliffs, large and small rocks and on various sessile invertebrates. These species occur in areas of high desiccation but obtain a thicker and more robust appearance when they occur in moist shaded areas, such as under Pelvetia.
Distribution: Upper to lower intertidal.

Order Chordariales

11. Cylindrocarpus rugosus Okamura (Petrospongium sp.)
Plants cushion-shaped, spongy, convoluted to wrinkled, up to 5 cm broad. This species commonly occurs on drier areas of cliff faces and large rocks.
Distribution: Upper intertidal.

Order Dictyosiphonales

12. Colpomenia sinuosa (Roth) Derbes and Solier
Plants globular, becoming expanded and commonly deeply convoluted, 2-5 cm broad, relatively thick walled. These plants are epiphytic on a wide variety of algae, becoming common in late spring and summer.
Distribution: mid to low intertidal.

13. Endarachne binghamiae J. Agardh
Blades usually in clusters 10-18 cm tall, linear to cuneate or broadly spatulate. Plants sparsely occurring on the sides of large rocks.
Distribution: High to mid intertidal.

14. Scytosiphon dotyi Wynne
Small tufted plant, greenish to dark brown, cylindrical to flattened and mostly not constricted. Plants occurring on the vertical and steeply sloping faces of cliffs and tidal benches in moist depressions or crevices in the upper intertidal.

Order Dictyotales

15. Dictyopteris undulata Holmes
Plants 8-12 cm tall with short terminal branches, irregularly dichotomous with prominent midrib. Plants occasionally occurring in Phyllospadix pools, appearing somewhat iridescent in life.
Distribution: Low intertidal to subtidal.

16. Dictyota flabellata (Collins) Setchell and Gardner
Plants 10-20 cm tall, branches dichotomous with rounded apices. Thallus appearing light brown, easily mistaken for Pachydictyon coriaceum. This species occurs rarely in Phyllospadix pools.
Distribution: Low intertidal.

17. Pachydictyon coriaceum (Holmes) Okamura
Plants 20-30 cm tall, arising from a thickened mass of dark brown hairs; these closely appressed and extending some distance up the main axis. Thallus similar to that of Dictyota flabellata usually occurring in Phyllospadix pools in the lower intertidal.

18. Taonia lennebackerae J. Agardh
Plants 10-30 cm tall, olive to dark brown; thallus with deeply incised flabulate divisions; sporangia borne in vaguely concentric lines. Plants rare, found partially imbedded in sand.
Distribution: Lower intertidal.

Order Sphacelariales

19. Sphacelaria californica (Sauvageau) Setchell and Gardner (Brown filamentous)
Plants brown, stiffly tufted, up to 3 cm, upper branches cylindrical, frequent but irregularly arranged. Apical cells conspicuous; propagula club shaped. This plant occasionally occurs in Phyllospadix pools where its distribution is patchy on exposed rock.
Distribution: Lower intertidal.

Order Laminariales

20. Egregia menziesii (Turner) Areschoug (E. laevigata)
Plants 5-15 m long with flattened, strap-like branches covered distichously with linear blades and subspherical pneumatocysts. This plant is frequently the host for a large number of epiphytes as it ages and begins to deteriorate. It dominates lower intertidal pools and boulders; frequent as drift.

21. Eisenia arborea Areschoug
Plants with conspicuous stipes that are bifurcated and topped with numerous blades. Blade margins toothed and forming dense groves. This plant is very rarely found in deep intertidal pools and commonly as drift.
Distribution: lower intertidal and subtidal.

22. Laminaria farlowii Setchell
Plants dark chocolate brown with single stipe and blade. Blade leathery thick and longitudinally corrugated. This plant is rarely found in the low intertidal on rocks or on sandy beaches as drift.
Distribution: Low to sub tidal.

23. Macrocystis integrifolia Bory
Plants to 6 m long; stipe dichotomously branched, terminal portion narrowly sickle-shaped. Blades lanceolate. Single plants rarely found at the tops of subtidal ledges in areas of strong surf.
Distribution: Low intertidal to subtidal.

24. Macrocystis pyrifera (Linnaeus) C. Agardh
Plants to 45 m long; holdfast conical to one meter tall. Blades lanceolate. This species is frequently found on beaches as drift where it may make up the bulk of the drift material.
Distribution: Subtidal.

25. Pelagophycus porra (Leman) Setchell
Large plants with antlers; blades corrugated with spiny margins. Stipes to 27 m long terminated by spherical pneumatocyst. Thalli occasionally found as drift only, rarely whole.
Distribution: Subtidal.

26. Pterygophora californica Ruprecht
Plants 2-3 m tall; stipes long with upper portion flattened, terminated by single blade to 80 cm long; sporophyll present along stipe resemble terminal blade. Stipes and blades are shed in winter; occasionally found on beach as drift only.

Order Fucales

27. Cystoseira osmundacea (Turner) C. Agardh
Plants up to 8 m tall; branches below flattened, upper portions develop series of 5-12 subspherical pneumatocysts. These plants are occasionally found in groups on rocks or tidal ledges along subtidal areas. Distribution patchy; plants indistinguishable from Halidrys dioica when pneumatocysts are not present.

28. Halidrys dioica Gardner
Plants to 2 m tall with apparent zig-zag branching; upper stipe bearing tapering 5-12 chambered, flattened pneumatocysts. Plants frequently found off tops of subtidal ledges and in lower intertidal pools.

29. Pelvetia fastigiata (J. Agardh) DeToni
Plants to 90 cm long, dark olive-green; branches dichotomous, subcylindrical to compressed. Apices swollen and containing conceptacles. This is the dominant algal species on upper midtidal rocks; it forms a moist canopy over rocks sheltering various algae and invertebrates.

30. Sargassum agardhianum J. Agardh
Plants attached by irregular holdfast; branching off main axis from basal area few to many and cylindrical; main stipe shorter than lateral branchlets. Berry-like pneumatocyst occurring in branchlets. Rare in mid-intertidal pools sometimes emerging from a sandy bottom.

31. Sargassum muticum (Yendo) Fensholt
Plants locally to 1 m; main axis intricately branched; leaves lanceolate with pneumatocysts borne in their axils. This species is commonly the dominant alga in mid-intertidal pools replacing Phyllospadix which becomes dominant in lower intertidal. Thallus is attached by holdfast to rocky bottom, frequently emerging through sandy layer.

RHODOPHYTA

Order Bangiales

32. Smithora naiadum (Anderson) Hollenberg
Purplish red to deep purple epiphytes 2-10 mm high; host specific for Phyllospadix. Blades are broadly wedge shaped and membranous. This species exhibits patchy distribution on Phyllospadix scouleri in lower intertidal pools; when occurring common throughout host.

33. Erythrotrichia sp. Areschoug (Unbranched red)
Plants erect, filamentous throughout; apices cylindrical or flattened; upper portions usually unbranched; diminutive. Sparsely occurs on exposed rocky bottoms of Phyllospadix pools in lower intertidal.

Order Nemalionales

34. Acrochaetium pacificum Kylin
Plants epiphytic with occasional endophytic attachments; filaments 1-3 mm long, branching irregular, alternate or unilateral. Axes are simple or branched in more than one plane. Sparsely occurs on the older deteriorating thallus of Egregia menziesii in the lower and subtidal zone.

35. Acrochaetium thuretii (Bornet) Collins and Hervey
Plants epiphytic, superficially attached, 4-5 mm long, erect filaments branched alternately or unilaterally, usually ending in hair-like extensions. Occasionally occurs with Acrochaetium pacificum on Egregia menziesii in the lower and subtidal.

36. Cumagloia andersonii (Farlow) Setchell and Gardner
Plants annual, olive brown to deep purplish-red, gelatinous but tough; young axes cylindrical, older axes flattened. Rarely found attached to exposed rocky bottom of Phyllospadix pools in lower intertidal, reportedly common in upper intertidal.

Order Gelidiales

37. Gelidium nudifrons Gardner
Plants to 35 cm tall, clumped, sparsely or irregularly branched; axes compressed to flattened with all parts of equal dimensions. Appearance much like heavily grazed and abused Pterocladia capillacea; occasionally found as drift.
Distribution: Subtidal.

38. Gelidium pusillum (Stackhouse) LeJolis (Serrated, pinnate red)
Abundant or tufted plants 1-3 cm tall, with prostrate axes and compressed erect branches that may become secondarily attached to the substrate. Commonly occurring epizoic on Tetraclita squamosa and other barnacles. Occasionally occurring on Mytilus californianus as well as on moist sides of rocks in the mid to lower high intertidal.

39. Gelidium robustum (Gardner) Hollenberg and Abbott
Plants to 40 cm tall, the branches mostly compressed and basal axes cylindrical; branching distichous and often strickingly geniculate. Frequently found growing on the tops and sides of rocks in the lower intertidal Egregia zone.

40. Pterocladia caloglossoides (Howe) Dawson
Erect branches, 1-2 cm high, arising from creeping rhyzome-like systems, and flattened except at the bases. Rarely found on algal mats in the mid intertidal to lower intertidal.

41. Pterocladia capillacea (Gmelin) Bornet and Thuret (Pterocladia pyramidale)
Plants to 30 cm high; distichous with pinnate appearance; sparse to abundant branching; axes compressed with upper portions flattened. Commonly very dense in tide pools attached to the base of rocks or occurring on their moist surfaces.
Distribution: Mid to subtidal.

Order Cryptonemiales

42. Bossiella orbigniana ssp. dichotoma (Manza) Johansen (Bossea gardneri)
Plants mostly dichotomously branched, the margins of the branches incised; intergenicula arrow-shaped midrib not projecting from lower and upper ends of intergenicula. Occasionally found occurring on rocky surfaces and on rocks in Phyllospadix pools in the lower intertidal.

43. Bossiella orbigniana ssp. orbigniana (Decaisne) Silva
Plants mostly dichotomously branched; thallus much like ssp. dichotoma except midrib is evident above and below intergenicula ends; adjacent intergenicula complete, delicate and conspicuously arrow-shaped. Frequently found as drift throughout intertidal, occurs subtidally.

44. Callophyllis firma (Kylin) R. Norris
Blades broad and circular, simple, dissected, lobed or peltate, deep rose, crisp and brittle; large medullar cells visible to unaided eye. May occur as epiphyte on Crytopleura corallinara which is epiphytic on Corallina sp.; easily over looked when occurring on former species.
Distribution: Mid to subtidal.

45. Corallina frondescens Postels and Ruprecht
Fronds to 5 cm tall; axial intergenicula to 1 mm long, flattened, winged; terminal intergenicula sometimes broadly expanded, irregularly incised; conceptacles axial, sometimes bulging from surfaces. Commonly occurs in moist areas under Pelvetia fastigiata where it is commonly associated with Callithamnion rupicolum. Occasionally found on moist rock surfaces in various habitats throughout mid intertidal.

46. Corallina officinalis var. chilensis (Decaisne) Kutzing
Fronds pinkish, up to 15 cm tall, mostly pinnate; branches becoming progressively smaller, lying in one plane; intergenicula robust. Commonly occurring on rocks in tide pools or rarely on the moist sides of rocks in the low intertidal.

47. Corallina pinnatifolia (Manza) Dawson (Corallina gracilus f. foliosa, densa)
Fronds to 7 cm tall, forming dense clumps, axes densely branched; axial intergenicula broader than long; non-axial intergenicula sometimes flattened and irregularly lobed; conceptacles axial. Frequently the dominant species on algal mats and on rock surfaces in tide pools.
Distribution: Mid to low intertidal.

48. Corallina polysticha Dawson
Fronds to 4 cm tall, branched, stiff and erect; 2-10 branches arising in a more or less whorled fashion from the branching intergenicula. Occasionally found among stands of C. pinnatifolia in algal mats as well as on moist rock surfaces in the lower mid tidal.

49. Corallina vancouveriensis Yendo
Fronds purplish to 14 cm long, usually densely branched and congested in limp tufts; intergenicula of branches narrower but longer than those of main axes. Occurring in a number of varieties; easily confused with C. pinnatifolia. May be common in same habitats. Reportedly highly capable of withstanding desiccation.

50. Endocladia muricata (Postels and Ruprecht) J. Agardh
Plants dark red to brown, densely bushy, 4 cm tall; branches cylindrical and covered with spines. Occasionally found growing in tufts on exposed surfaces of large rocks in the high to mid intertidal. Seasonal occurrence can be indeterminate.

51. Fosliella paschalis (Lemoine) Setchell and Gardner
Thin crustose, epiphytic plants, forming pink patches on various algae; discoid outgrowths with stipe-like attachments may be present. Found rarely occurring on Rhodymenia pacifica in the lower mid intertidal.

52. Gloiosiphonia verticillaris Farlow
Deep rose plants, usually growing in dense tufts; cylindrical stalks with small whorled branchlets. Rare, occurring in low intertidal Phyllospadix pools.

53. Haliptylon gracile (Lamouroux) Johansen
Fronds multipinnate; branch intergenicula are smaller than axial intergenicula and are cylindrical; thallus appearance delicate. Rare, occurring in low intertidal Phyllospadix pools.

54. Hildenbrandia sp. Nardo 1834
A crustose, uncalcified, indefinitely expanded alga that appears to be a purplish-red stain upon rocks. These species are difficult to distinguish and may actually be different life cycle forms of other algae. They occur on bare rock surfaces in high intertidal to subtidal habitats.

55. Jania crassa Lamouroux
An articulated calcified alga 4-6 cm tall; fronds dichotomously branched throughout. Found in tide pools and algal mats where it is often associated with Corallina species.
Distribution: Mid to upper low intertidal.

56. Jania tenella (Kutzing) Grunow
Plants usually epiphytic; fronds form soft, dense, tufts 1-2 cm tall; branch angles less than 45 degrees. Occasionally found in warm tide pools where it may occur with J. crassa.

57. Leptocladia binghamiae J. Agardh
Plants compressed, deep red, dichotomously to irregularly branched; margins of branches with short pointed teeth. Final branches are tooth-like or slightly broadened. Common in drift after winter storms; occurs subtidally.

58. Lithothamnion sp. Philippe 1837 (Lithothamnion giganteum)
A nonarticulated and sometimes nodular crustose alga, epilithic, epiphytic or epizoic in habit. Frequently found on moist rock surfaces on cliff faces in crevices and on mid tidal rocks.

59. Lithothrix aspergillum Gray
Plants 3-5 cm high; articulated calcified fronds with irregular, sometimes abundant branching, conceptacles are lateral. Most common in warm tide pools and on algal mats.
Distribution: Mid to upper low intertidal.

60. Melobesia mediocris (Foslie) Setchell and Mason
Plants appear as purplish-pink to white, thin, irregular, crustose patches upon Phyllospadix scouleri. Species specific to host but occurrence is patchy; when occurring common throughout host.
Distribution: Low intertidal.

61. Mesophyllum conchatum (Setchell and Foslie) Adey
Plants dark lavender, forming circular crusts up to 3 cm diameter, attached to articulated corallines by short central stalk; upper surface often with concentric rings. Commonly epiphytic on Corallina sp. in algal mats; may densely occur over host thallus.
Distribution: Mid to low intertidal.

62. Prionitis lanceolata (Harvey) Harvey
Red to red-brown stipes, 3-35 cm tall, with irregular dichotomous branching; small lateral blades commonly present. Rarely occurring on algal mats but frequently found as drift.
Distribution: Low to subtidal.

Order Gigartinales

63. Gigartina canaliculata Harvey
Annually arising from perennial bases; lower portions of thallus greenish, upper portions purplish and compressed; growing in dense clumps. Infrequent from mid to low intertidal on rock surfaces.

64. Gigartina leptorhynchos J. Agardh
Plants dark brown to blackish, slender, woolly or soft, irregularly branched, cylindrical to compressed; spines numerous and of irregular length. Occasionally occurring on moist sides of Pelvetia rocks in the mid tidal where thallus is seldom over 3 cm long.

65. Gigartina tepida Hollenberg
Plants purplish to black, loosely tufted; main branchlets spinose; lateral branches arising mainly from basal portions. Common as epiphyte over Corallina sp. and other algae or Phragmatopoma colonies on the moist sides of mid tidal rocks. Infrequent on rocks in Phyllospadix pools in low intertidal.

66. Gracilaria andersonii (Grunow) Kylin
Thallus dark red to 10 cm tall with numerous and irregular branching; apices straw-colored. Found epiphytic on Corallina sp. in low intertidal Phyllospadix pools.

67. Gracilaria veleroae Dawson
Plants erect, dark red, membranous, less than 6 cm tall; blades with wedge-shaped bases; irregular and dichotomously flabellate branches with round apices. Rare; found epiphytic on Corallina sp. in low intertidal Phyllospadix pools.

68. Hypnea valentiae (Turner) Montagne (Hypnea coulteri)
Plants erect to decumbent and bushy; branches numerous with acute apices; commonly with small stellate groups of branches which may be attached to large jagged stand grains. Common to occasional in tide pools and algal mats on various algae.
Distribution: Mid to low intertidal.

69. Opuntiella californica (Farlow) Kylin
Plants broad, deep dark red; a single blade arising from a round stipe; secondary blades fan-shaped to broadly obovate, commonly larger than primary blade. All blades of a rubbery texture. Frequently found in drift and rarely occurring intertidally. When found secondary branches usually missing and thallus badly torn.

70. Ozophora latifolia Abbott
Plants erect, brick red with or without round stipes; main axes blade-like, dichotomously flabellate or with stipitate proliferous margins. Rare intertidally on moist surfaces of lower rocks; occasional as drift.
Distribution: Low to subtidal.

71. Petroglossum pacificum Hollenberg
Plants with erect branches, to 5 cm tall, purplish-red, with few to many flabellate divisions; usually slightly crisped. Rare; found projecting from thin sand layer below Phyllospadix cover in low intertidal pools.

72. Petroglossum parvum Hollenberg
Plants 10-18 mm tall, purple to reddish; erect branches simple, ligulate to spatulate, producing several new branches from eroded apex. Rare; found in same habit and habitat as P. pacificum.

73. Plocamium cartilagineum (Linnaeus) Dixon (P. coccineum v. pacificum)
Plants pink to purplish-red, and 5-20 cm high; erect plumose branches are compressed and of several orders with the tips curved outwardly. Occasionally found in Phyllospadix pools sheltered below surf grass cover and as drift. Easily noticeable due to its brilliant color and delicate appearance.

74. Rhodoglossum affine (Harvey) Kylin (flat, unbranched, fleshy brown)
Plants are greenish-olive or reddish-purple to black, in bushy tufts 1.5-5 cm high; blades linear to broadly lanceolate with margins entire and the apices tapering. Frequently found on moist surfaces of large rocks in the mid intertidal.

Order Rhodymeniales

75. Coeloseira compressa Hollenberg
Plants to 3 cm tall, dark red to pink, tubular and septate throughout; commonly with downward curving apices developing additional stipes. Frequently found in lush algal mats and where mat-like algal assemblages occur on moist rock surfaces in the mid to lower intertidal.

76. Coeloseira parva Hollenberg
Plants 2-3.5 cm tall, dark red with tubular septate branches borne on erect solid stipes. Superficially similar to C. compressa but often projecting out of algal mat surface and branches not compressed. Found in similar habit and habitat as C. compressa.

77. Gastroclonium coulteri (Harvey) Kylin
Plants 10-26 cm tall, with reddish bases and greenish tops; solid cylindrical axes bearing many short, hollow, septate branchlets. Branchlets often heavily grazed making identification difficult. Occurs on moist rock surfaces in mid intertidal.

78. Rhodymenia californica Kylin
Bright pink to deep red bushy clumps, 3-5 cm tall; one to many spreading, dichotomously divided blades upon short stipes that arise from a stoloniferous system. Rare; occurring on the moist surfaces of large rocks and at their bases in mid tidal pools. Frequent in drift; reportedly preferring shaded habitat.

79. Rhodymenia pacifica Kylin
Thallus deep rose, flattened and attached by discoid holdfast; branching dichotomous in flabellate blades at irregular intervals; blades often blunt and terminally broadened. Rare; occurring on shaded moist rock surfaces in mid to lower intertidal; occasional as drift.

Order Ceramiales.

80. Acrosorium uncinatum (Turner) Kylin
Plants deep rose red; blades irregularly toothed, occasionally ending in hooks that function as tendrils. Thallus extremely flattened and delicate. Epiphytic on a variety of algae; most common on moist surfaces of Pelvetia dominated rocks and on lush mat-like algal assemblages in mid to low intertidal.

81. Anisocladella pacifica Kylin
Blades usually 1.5-3 cm tall, deep rose pink, forming masses, frequently buried in fine sand; blades with oppositely branched midveins. Rare; easily overlooked under Phyllospadix cover in low intertidal pools.

82. Callithamnion biseriatum Kylin
Plants epiphytic, deep rose, uncorticated with endophytic rhizoids; conspicuous percurrent axes alternately branched in one plane with unilateral appearance. Found on older deteriorating portions of Egregia menziesii in low to subtidal.

83. Callithamnion rupicolum Anderson
Plants form soft, felted, deep rose to chocolate brown tufts, 1-2 cm tall; branching alternate. Frequently found over sandy substrate and associated with Corallina frondescens beneath Pelvetia cover and in Phyllospadix pools; occurs mid to low intertidal.

84. Centroceras clavulatum (C. Agardh) Montagne
Plants dark red, tufted, 1-3 cm tall; each segment in younger branches with several spines; ultimate branches incurved in pairs. This species is frequently found occurring as an epiphyte on a variety of algae on algal mats in the low to mid intertidal.

85. Ceramium eatonianum (Farlow) DeToni
Plants purplish-brown, 1-4 cm tall, in loose tufts, branching dichotomous; lower portions appear banded. Frequently found on moist surfaces of Pelvetia rocks and on mat forming algae in the mid to low intertidal.

86. Ceramium sp. Roth
Plants usually erect, cylindrical and freely branched; branches corticated continuously or in transverse bands at nodes; apices usually forcipate. These species may occur fairly frequently throughout the intertidal but are difficult to identify due to their small size and microscopic distinguishing characteristics.

87. Chondria californica (Collins) Kylin
Plants usually purplish and conspicuously iridescent in life, 4-5 cm tall; thallus densely and openly branched. Always found epiphytic on various algae; easily identified due to its iridescence and delicate appearance. Most commonly found in low intertidal pools.

88. Chondria nidifica Harvey
Plants dark red, 15-20 cm tall; cylindrical axes remotely and multifariously branched, these terminally attenuated. These plants were found to occur only beneath Phyllospadix in the low intertidal. They commonly may host up to four species of epiphytes.

89. Chondria sp. C. Agardh
Plants erect, polysiphonous; branches cylindrical; branching radial or irregular and sometimes whorled. These species are generally common in tide pools but are difficult to identify due to their simple form.

90. Cryptopleura corallinara (Nott) Gardner
Plants brownish-red, adhering closely to coralline host; margins smooth to scalloped; branches free and partly erect. Frequent wherever Corallina sp. occur in abundance, usually mid to subtidal.

91. Cryptopleura crispa Kylin
Plants rose red, creeping, with erect portions, 3-8 cm tall; margins undulate to densely scalloped and crisp; epiphytic upon Pterocladia, Gelidium or Corallina. This species attains its most robust appearance below Phyllospadix in the lower intertidal.

92. Erythrocystis saccata (J. Agardh) Silva
Plants ellipsoidal, to 1 cm long; epiphytic mostly upon Laurencia pacifica and occasionally on other Laurencia spp. This plant is most commonly found on its host in the low intertidal zone.

93. Griffithsia pacifica Kylin
Tufted plants up to 3 cm high; orange-pink in color; lower parts dichotomous with bases entangled. Rare; only occurred on algal mats in the low intertidal during spring.

94. Herposiphonia verticillata (Harvey) Kylin (H. parva)
Prostrate plants commonly epiphytic upon corallines; deep red in color with branching in one plane, 3-4 cm high. This plant closely adheres to its host and can be seen conspicuously entwined around it. Occasional where Corallina occurs abundantly.

95. Heterosiphonia erecta Gardner
Plants small, dark rose and partly prostrate; erect portions stout with branching every two segments; axes uncorticated with monosiphonous laterals and divergent acute apices. Dominant epiphyte on Egregia; occurs low to subtidally.

96. Janczewskia lappacea Setchell
Plants growing on Chondria nidifica; pink, burr-like, 3-5 mm in diameter. Occasionally found on its host under Phyllospadix in the low intertidal.

97. Jantinella verrucaeformis (Setchell and McFadd) Kylin
Minute, whitish plants growing on Chondria californica and C. nidifica; free polysiphonous branches spirally inserted; commonly causing slight bend at attachment point. May be found to be common on hosts under microscopic examination; occurs wherever hosts are common.

98. Laurencia pacifica Kylin
Deep reddish-purple; numerous radially branched erect axes, 6-16 cm tall, arising from numerous stolons; ultimate branchlets inversely conical. Common in dense groups on the bottoms and sides of mid tidal rocks and below Phyllospadix and Egregia cover in low intertidal. Frequently found as epiphyte on deteriorating Egregia sp.

99. Laurencia sinicola Setchell and Gardner (L. scrippsensis)
A small pinnately branched epiphyte, 10-16 mm high, growing in dense tufts; branches flattened and usually contorted. Common on lush algal mats and on large flat rocks in Phyllospadix pools; occasionally occurring on algae on moist rock faces in the mid intertidal.

100. Laurencia spectabilis v. diegoensis (Dawson) Dawson
Deep reddish-brown plants, 8-20 cm high with characteristic apical pits; the largest of our flattened Laurencia's. Frequently found with a blue-green iridescent pigment on the top side of the thallus as in L. sinicola. Commonly occurring low in the intertidal on rock.

101. Laurencia splendens Hollenberg
Plants 3-20 cm tall, reddish-brown; erect axes strongly compressed, bearing dense simple branchlets; often epiphytic upon corallines. Found exclusively occurring on sandy bottoms of Phyllospadix pools in the low intertidal.

102. Laurencia subopposita (J. Agardh) Setchell
Deep rose epiphytic plants, 10-20 cm high; plants characterized by terminal hooks coiling around the host plants. Abundant on low intertidal stands of Phyllospadix and various algae.

103. Levringiella gardneri (Setchell) Kylin
Minute, tufted, pinkish-white plants, 'parasitic' on Pterosiphonia sp.; branches radial and spirally arranged. Locally found occurring on Chondria nidifica in the low intertidal.

104. Platysiphonia parva Silva and Cleary
Delicate deep rose epiphytes occurring on Codium fragile and up to 1 cm tall; branching somewhat sparse and unilateral; the branches flattened and polysiphonous, containing four pericentral cells per segment. Easily overlooked on host; may be common upon close examination; distribution, mid tidal.

105. Pogonophorella californica (J. Agardh) Silva
Small dense plants with erect dark red axes projecting through fine sand; repeatedly branched and radially organized; each segment bearing branched filaments. Rare; found exclusively under Phyllospadix in low intertidal pools.

106. Polysiphonia savatieri Harvey
Plants 3-10 mm tall; erect branches spreading somewhat dichotomously, tuft-like; often epiphytic upon Codium fragile. This species was exclusively found growing on its host in the mid intertidal.

107. Polysiphonia scopulorum v. villum (J. Agardh) Hollenberg
Brownish-red plants arising from unicellular rhizoids; erect branches simple or sparingly branched; lateral branches independent of infrequent trichoblasts. These plants are microscopic in character and occasionally occur as an epiphyte on older deteriorating portions of Egregia sp. in the low and subtidal.

108. Pterosiphonia baileyi (Harvey) Falkenberg
Plants 8-25 cm tall, nearly black, main axes percurrent, cylindrical, much branched above and completely corticated. Occasionally found almost completely buried in sand deposits under Phyllospadix in the low intertidal. When found secondary branches missing from lower two-thirds of plants.

109. Pterosiphonia dendroidea (Montagne) Falkenberg
Plants brownish-red to deep red, with numerous erect percurrent branches of 2 or 3 orders; branches of all orders arising at intervals of 2 segments. Infrequent; occasionally occurring on moist faces of mid tidal rocks and on rock surfaces of Phyllospadix pools; easily overlooked due to its small size.

SPECIES LIST OF INTERTIDAL ANIMALS OF CABRILLO NATIONAL MONUMENT

PORIFERA

Class Demospongiae:

1. Plocamia karykina de Laubenfels, 1927 (Family Plocamiidae) Common on the undersides of mid- and low-tide rocks; red.

2. Cliona celata californiana de Laubenfels, 1932 (Family Clionidae) Several abalone shells found at low tide with Cliona bored in dorsal shell surface; yellow boring sponge.

3. Xestospongia vanilla (de Laubenfels, 1930) (Family Haliclonidae) Found on the undersides of a few low-tide rocks; white sponge.

CNIDARIA

Class Anthozoa:

4. Anthopleura elegantissima (Brandt, 1835) (Family Anthopleuridae) Very abundant on high- and mid-tide barnacle, Pelvetia and Mytilus rocks; common as solitary individuals on algal mat and in tidepools; usually in large aggregations, oral disk with stripes.

5. Astrangia lajollaensis Durham, 1947 (Family Astrangidae) Common on the undersides of some mid-tide rocks; red-orange coral.

6. Unidentified small red anemone on undersides of rock.

PLATYHELMINTHES

Two species have been observed on the undersides of high- and mid-tide rocks, both unidentified.

NEMERTEA

Several unidentified species have been found under mid-tide rocks and in Mytilus beds.

ANNELIDA

Class Polychaeta:

7. Halosydna brevisetosa Kinberg, 1855 (Family Polynoidae) Found on the undersides of some mid-tide rocks; scale worm.

8. Spirorbis spirillum (Linnaeus, 1758) (Family Serpulidae) Found on hard surfaces and on the undersides of high- to low-tide rocks; dextral spiral tube.

9. Spirorbis eximius Bush, 1904 (Family Serpulidae) Found on hard surfaces and on the undersides of high- to low-tide rocks; sinistral, corrugated spiral tube.

10. Spirorbis sp. (Family Serpulidae) Found on hard surfaces and on the undersides of high- to low-tide rocks; sinistral, smooth spiral tube. These last two species very abundant.

11. Eupomatis gracilis Bush, 1904 (Family Serpulidae) Common on the undersides of mid- to low-tide rocks; non-spiral calcareous tube.

12. Salmacina tribranchiata (Moore, 1923) (Family Serpulidae) Very abundant on the undersides of some mid- and low-tide rocks; small tube worms.

13. Phragmatopoma californica (Fewkes, 1889) (Family Sabellaridae) Large colonies found at base of some high-tide barnacle rocks; colonies common on Pelvetia rocks; sand castle worm.

14. Unidentified tube worm. Found on the undersides of mid- to low-tide rocks; tubes composed of shell and debris.

15. Lumbrineris sp. (Family Lumbrineridae) One large individual found in sand below low-tide rock; earthworm-like.

16. Unidentified Nereid Worm (Family Nereidae) Worms found in Mytilus beds and in sand underneath rocks; may be more than one species.

ARTHROPODA

Class Crustacea:

Subclass Cirripedia:

17. Pollicipes polymerus (Sowerby, 1833) (Family Scalpellidae) Common along with Mytilus and at base of cliff faces; Goose-neck Barnacle.

18. Balanus glandula Darwin, 1854 (Family Balanidae) Common on high-tide barnacle rocks and some S. Use Mytilus rocks.

19. Tetraclita squamosa Darwin, 1854 (Family Balanidae) Abundant on the bases and verticla faces of Mytilus and Pelvetia rocks.

20. Chthamalus fissus Darwin, 1854 (Family Balanidae) Very abundant on barnacle rocks and on Mytilus shells in Mytilus beds; common throughout the mid- and high-tide on most rocks.

Subclass Malacostraca:

Order Isopoda:

21. Cirolana harfordi (Lockington, 1877) (Family Cirolanidae) Common on the undersides of mid- and low-tide rocks.

22. Ligia occidentalis Dana, 1853 (Family Ligidae) Fairly common on extreme high tide cliff faces.

23. Idotea urotoma Stimpson, 1864 (Family Idoteidae) Common on the undersides of mid-tide rocks.

24. Pentidotea resecata (Stimpson, 1857) (Family Idoteidae) A few specimens found on Phyllospadix leaves.

Order Amphipoda:

There are probably several species of amphipods, all species unidentified. Mainly found on algal mats.

Order Decapoda:

25. Lysmata californica (Stimpson, 1860) (Family Hippolytidae) Moderately common under rocks and in tidal pools.

26. Spirontocaris picta (Stimpson, 1871) (Family Hippolytidae) Moderately common under rocks and in tidal pools.

27. Pagurus samuelis (Stimpson, 1857) (Family Paguridae) Found inhabiting shells in high and middle tide tidepools; also very common along rocks on flat benches.

28. Pagurus hirsutiusculus (Dana, 1851) (Family Paguridae) Same habitat as P. samuelis.

29. Petrolisthes cinctipes (Randall, 1839) (Family Porcellanidae) Fairly common on the undersides of mid- and low-tide rocks.

30. Pugettia producta (Randall, 1839) (Family Majiidae) Occasionally found at mid to low tide in Pelvetia and Egregia.

31. Taliepus nuttalli (Randall, 1839) (Family Majiidae) A few individuals found at low tide in pools covered by algae.

32. Loxorhynchus crispatus Stimpson, 1857 (Family Majiidae) Moderately common on the undersides of mid-tide rocks.

33. Cancer antennarius Stimpson, 1856 (Family Cancridae) A few individuals found at low tide in algae-covered pools.

34. Pachygrapsus crassipes Randall, 1839 (Family Grapsidae) Common in crevices at high tide; fairly common on Mytilus rocks.

ECHINODERMATA

Class Asteroidea:

35. Pisaster giganteus (Stimpson, 1857) (Family Astriidae) A few individuals found under some mid-tide rocks and in tide pools in S. Use area.

36. Pisaster ochraceus (Brandt, 1835) (Family Astriidae) Only a couple of individuals found at the base of large Mytilus rocks.

37. Patiria miniata (Brandt, 1835) (Family Astrinidae) Several small individuals found on rock benches among rubble from mid to low tide in S. Use area.

38. Astrometis sertulifera Xantus, 1860 (Family Astriidae) Ted Turk reports seeing this species.

Class Ophiuroidea:

39. Ophioderma panamense Lutkin, 1872 (Family Ophiocomidae) Common on the undersides of mid and low-tide rocks.

40. Ophiopteris papillosa (Lyman, 1875) (Family Ophiocomidae) Moderately common on the undersides of mid and low-tide rocks.

41. Ophioplocus esmarki (Lyman, 1874) (Family Ophioleptidae) A few individuals found on the undersides of mid and low-tide rocks.

42. Ophiothrix rudis Lyman, 1874 (Family Ophioleptidae) Ted Turk reports seeing this species.

43. Ophiothrix spiculata LeConte, 1851 (Family Ophioleptidae) Ted Turk reports seeing this species.

44. Ophionereis annulata LeConte, 1851 (Family Ophiactidae) Ted Turk reports seeing this species.

45. Amphipholis pugetana (Lyman, 1860) (Family Amphiuridae) Ted Turk reports seeing this species.

Class Echinoidae:

46. Lytechinus pictus (Verrill, 1867) (Family Toxopneustidae) A single individual found in depression on the undersides of a low-tide rock.

47. Strongylocentrotus purpuratus (Stimpson, 1857) (Family Strongylocentrotidae) A few individuals found under low-tide rocks.

48. Strongylocentrotus franciscanus Agassiz, 1879 (Family Strongylocentrotidae) Ted Turk reports seeing this species.

ECTOPROCTA:

While there are probably many species of bryozoans found in the intertidal zone at Cabrillo, only two seem to be conspicuous:

49. Red Bryozoan Common, forming flat, red encrustations on the undersides of rocks from mid to low tide.

50. Brown Bryozoan Common, forming flat, brown encrustations on the undersides of rocks from mid to low tide.

CHORDATA:

Subphylum Urochordata:

51. Euherdmania claviformis (Ritter, 1903) (Family Synoicidae) Moderately common in colonies on the undersides of some mid and low-tide rocks; club-shaped colonies.

MOLLUSCA

Class Pelecypoda:

52. Barbatia bailyi (Bartsch, 1931) (Family Arcidae) Common, attached by byssal threads to the undersides of mid-tide rocks.

53. Mytilus californianus Conrad, 1837 (Family Mytilidae) Very common in large colonies, attached to large mid-tide rocks; smaller colonies found at base of cliff face.

54. Septifer bifurcatus (Conrad, 1837) (Family Mytilidae) Small colonies fairly common, attached in crevices of high-tide rocks and on Pelvetia rocks.

55. Modiolus capax (Conrad, 1837) (Family Mytilidae) Empty shells found at low tide among rocks in rubble area.

56. Adula falcata (Gould, 1851) (Family Mytilidae) Only moderately common, found bored in soft shale at mid and low-tide.

57. Lithophaga plumula (Hanley, 1843) (Family Mytilidae) A couple of specimens found bored in empty shells of Haliotis and Hinnites.

58. Ostrea lurida Carpenter, 1864 (Family Ostreidae) Empty shells found among debris and rubble.

59. Leptopecten monotimeris (Conrad, 1837) (Family Pectinidae) One specimen found attached to a blade of Macrocystis washed up.

60. Hinnites multirugosus (Gale, 1928) (Family Pectinidae) Empty shells found at low tide among rocks.

61. Chama pellucida Broderip, 1835 (Family Chamidae) Not very common, attached to the undersides of some low-tide rocks.

62. Pseudochama exogyra (Conrad, 1837) (Family Chamidae) Fairly common, attached to the undersides and bases of low-tide rocks; occasionally attached to rock on algal mat benches.

63. Glans subquadrata (Carpenter, 1864) (Family Carditidae) Common, attached to the undersides of mid and low-tide rocks.

64. Lasaea subviridis Dall, 1899 (Family Erycinidae) A few empty shells found in gravel among rocks.

65. Codakia californica (Conrad, 1837) (Family Lucinidae) A couple of empty shells found among rocks in rubble area.

66. Diplodonta orbellus (Gould, 1851) (Family Ungulinidae) Moderately common, nestled among rubble and rocks at low tide; a couple of individuals found among algae in samll pools in algal mat area.

67. Trachycardium quadragenarium (Conrad, 1837) (Family Cardiidae) One empty valve found in rocky rubble at low tide.

68. Chione undatella (Sowerby, 1835) (Family Veneridae) A few empty shells found among rocks.

69. Protothaca staminea (Conrad, 1837) (Family Veneridae) Empty shells common among rocks and debris.

70. Cumingia californica Conrad, 1837 (Family Semelidae) Fairly common, found in rock crevices at low tide.

71. Semele decisa (Conrad, 1837) (Family Semelidae) Empty shells found among low-tide rocks.

72. Semele rupicola Dall, 1915 (Family Semelidae) Empty shells found among rocks.

73. Sanguinolaria nuttallii (Conrad, 1837) (Family Psammobiidae) One empty shell found washed up onto Grunion Beach.

74. Platyodon cancellatus (Conrad, 1837) (Family Myidae) Empty shells very common in rubble area at mid and low tide; a few living specimens found burrowed in soft shale.

75. Hiatella arctica (Linnaeus, 1767) (Family Hiatellidae) Empty shells common in gravel.

76. Penitella penita (Conrad, 1837) (Family Pholadidae) Common, bored in soft shale from mid to low tide.

77. Netastoma rostrata (Valenciennes, 1846) (Family Pholadidae) Common, bored in soft shale from mid to low tide.

Class Gastropoda:

78. Haliotis corrugata Wood, 1828 (Family Haliotidae) Empty shells moderately common among rocks at low tide.

79. Haliotis rufescens Swainson, 1822 (Family Haliotidae) One empty shell seen among rocks at low tide.

80. Haliotis cracherodii Leach, 1814 (Family Haliotidae) Several specimens found attached to bases and undersides of mid-tide rocks.

81. Diodora aspera (Rathke, 1833) (Family Fissurellidae) One empty shell found among rocks at low tide.

82. Megathura crenulata (Sowerby, 1825) (Family Fissurellidae) Occasionally found on mid-tide rock benches.

83. Fissurella volcano Reeve, 1849 (Family Fissurellidae) Common on the undersides of mid and low-tide rocks and on rocks covered by Pelvetia.

84. Acmaea rosacea Carpenter, 1864 (Family Acmaeidae) One living specimen found on the underside of a low-tide rock; empty shells fairly common in gravel.

85. Collisella pelta (Rathke, 1833) (Family Acmaeidae) Common on rocks covered by Pelvetia. (Referred to as Acmaea pelta in text.)

86. Collisella digitalis (Rathke, 1833) (Family Acmaeidae) Very common on vertical cliff faces at high tide and splash zone; common on barnacle rocks. (Referred to as Acmaea digitalis in text.)
87. Collisella scabra (Gould, 1846) (Family Acmaeidae) Common on rocks in most areas, especially cliff faces, barnacle rocks, Pelvetia and Mytilus rocks. (Referred to as Acmaea scabra in text.)
88. Collisella conus (Test, 1945) (Family Acmaeidae) Common on rocks in upper mid-tide zone (grouped with C. scabra due to difficulty in identification). (Referred to as Acmaea conus in text.)
89. Collisella limatula (Carpenter, 1864) (Family Acmaeidae) Fairly common on rocks covered by Pelvetia and some Mytilus rocks. (Referred to as Acmaea limatula in text.)
90. Collisella strigatella (Carpenter, 1864) (Family Acmaeidae) Common on most mid-and high-tide ricks. (Referred to as Acmaea strigatella in text.)
91. Collisella asmi (Middendorff, 1847) (Family Acmaeidae) A few individuals found attached on shells of living Tegula funebralis in upper mid tide zone. (Referred to as Acmaea asmi in text.)
92. Notoacmea fenestrata (Reeve, 1855) (Family Acmaeidae) One individual found attached to blade of Egregia at low tide. (Referred to as Acmaea fenestrata in text.)
93. Notoacmea insessa (Hinds, 1843) (Family Acmaeidae) Fairly common, attached to blades of Egregia in surge channels. (Referred to as Acmaea insessa in text.)
94. Notoacmea paleacea (Gould, 1853) (Family Acmaeidae) Common on leaves of Phyllospadix. (Referred to as Acmaea paleacea in text.)

95. Lottia gigantea Sowerby, 1834 (Family Acmaeidae) Common on cliff faces and Mytilus rocks.

96. Norrisia norrisi (Sowerby, 1838) (Family Trochidae) Only moderately common among rubble and rocks at low tide.

97. Tegula aureotincta (Forbes, 1852) (Family Trochidae) Several individuals found among rock rubble from mid to low tide.

98. Tegula eiseni Jordan, 1936 (Family Trochidae) Common on midtide benches and on the undersides of mid-tide rocks.

99. Tegula funebralis (A. Adams, 1855) (Family Trochidae) Very common in the lower high tide zone, on and under rocks.

100. Homalopoma luridum (Dall, 1885) (Family Turbinidae) Common on the undersides of midtide rocks.

101. Astraea undosa (Wood, 1828) (Family Turbinidae) Moderately common among rocks at low tide.

102. Tricolia pulloides (Carpenter, 1865) (Family Phasianellidae) Fairly common on leaves of Phyllospadix.

103. Tricolia rubrilineata (Strong, 1928) (Family Phasianellidae) Several empty shells found in gravel.

104. Lacuna unifasciata Carpenter, 1857 (Family Lacunidae) Common on leaves of Phyllospadix; moderately common on coraline algae on algal mats.

105. Littorina planaxis Philippi, 1847 (Family Littorinidae) Very common, found on cliff faces from high tide to above the splash zone.

106. Littorina scutulata (Gould, 1849 (Family Littorinidae) Very common in crevices from high to mid tide; common in empty barnacle shells.

107. Teinostoma supravallatum (Carpenter, 1864) (Family Vitrinellidae) A few empty shells found in gravel.

108. Vitrinella oldroydi Bartsch, 1907 (Family Vitrinellidae) A few empty shells found in gravel.

109. Caecum californicum Dall, 1885 (Family Caecidae) Empty shells found in gravel.

110. Caecum crebricinctum (Carpenter, 1864) (Family Caecidae) One empty shell found in gravel.

111. Fartulum orcutti (Dall, 1885) (Family Caecidae) Very common on the undersides of some mid-tide rocks.

112. Serpulorbis squamigerus (Carpenter, 1857) (Family Vermetidae) Common on the undersides of mid- to low-tide rocks and on rocks covered by Pelvetia.

113. Cerithiopsis cosmia Bartsch, 1907 (Family Cerithiopsidae) A few empty shells found in gravel.

114. Seila montereyensis Bartsch, 1907 (Family Cerithiopsidae) A few empty shells found in gravel.

115. Triphora pedroana Bartsch, 1907 (Family Triphoridae) A few empty shells found in gravel.

116. Epitonium tinctum (Carpenter, 1864) (Family Epitoniidae) Several individuals found at bases of Anthopleura.

117. Opalia funiculata Carpenter, 1857 (Family Epitoniidae) A couple of individuals found in rocky rubble at low tide.

118. Hipponix antiquatus (Linnaeus, 1767) (Family Hipponicidae) Empty shells found among rocks.

119. Crepidula aculeata (Gmelin, 1791) (Family Calyptraeidae) Empty shells common in gravel.

120. Crepidula acunca Sowerby, 1825 (Family Calyptraeidae) A single empty shell found in gravel.

121. Crepidula norrisiarum Williamson, 1905 (Family Calyptraeidae) Empty shells found in gravel.

122. Crepidula onyx Sowerby, 1824 (Family Calyptraeidae) Empty shells found among rocks.

123. Crepidula perforans (Valenciennes, 1846) (Family Calyptraeidae) Common, attached to the inside apertures of large shells of empty Tegula, Astraea and Kelletia.

124. Crepipatella lingulata (Gould, 1846) (Family Calyptraeidae) Moderately common, attached to undersides of mid-tide rocks.

125. Trivia californiana (Gray, 1827) (Family Eratoidae) One empty shell found in gravel.

126. Cypraea spadicea Swainson, 1823 (Family Cypraeidae) Empty shells found among mid-tide rocks.

127. Erato vitellina Hinds, 1844 (Family Eratoidae) One individual found on the underside of a mid-tide rock.

128. Ceratostoma nuttalli (Conrad, 1837) (Family Muricidae) Fairly common in Mytilus beds and in rocky rubble at low tide.

129. Ocenebra circumtexta Stearns, 1871 (Family Muricidae) Fairly common on the undersides of mid-tide rocks.

130. Ocenebra poulsoni (Carpenter, 1864) (Family Muricidae) A single individual found at the base of a Mytilus rock.

131. Acanthina lugubris (Sowerby, 1821) (Family Thaididae) Common on lower cliff faces and on Mytilus rocks.

132. Acanthina spirata (Blainville, 1832) (Family Thaididae) Only moderately common, among Mytilus.

133. Kelletia kelletii (Forbes, 1852) (Family Buccinidae) Empty shells common among rocks at low tide; several living specimens found among rocks in low tide rubble.

134. Macron lividus (A. Adams, 1855) (Family Buccinidae) Common, found under Pelvetia, on the undersides of rocks and on mid tide algal benches.

135. Nassarina penicillata (Carpenter, 1864) (Family Columbellidae) (=Anachis penicillata) Found on the undersides of some mid-tide rocks.

136. Mitrella carinata (Hinds, 1844) (Family Columbellidae) Common on Phyllospadix leaves and on the undersides of mid-tide rocks.

137. Mitra idae Melvill, 1893 (Family Mitridae) Several empty shells found among rocky rubble at low tide.

138. Hyalina taeniolata (Moerch, 1860) (Family Marginellidae) Moderately common on the undersides of mid- and low-tide rocks.

139. Olivella biplicata (Sowerby, 1825) (Family Olividae) Empty shells found among rocks.

140. Conus californicus Hinds, 1844 (Family Conidae) Fairly common in sand in Phyllospadix pools and on algal benches in sand.

141. Pseudomelatoma penicillata (Carpenter, 1864) (Family Turridae) Fairly common on algal mat areas; common on the undersides of low-tide rocks.

142. Haminoea virescens (Sowerby, 1833) (Family Atyidae) A couple of individuals found in a mid-tide pool on algae.

143. Hopkinsia rosacea MacFarland, 1905 (Family Goniodorididae) Common on the undersides of mid-tide rocks and in tidepools.

144. Coryphella iodinea (Cooper, 1862) (Family Coryphellidae) (=Flabellina iodinea) Moderately common on the undersides of mid-tide rocks.

145. Hermissenda crassicornis (Eschscholtz, 1831) (Family Favorinidae) Common on the undersides of mid-tide rocks.

146. Doriopsilla albopunctata (Cooper, 1863) (Family Dendrodorididae) One individual found on the undersides of a low-tide rock.

147. Navanax inermis (Cooper, 1862) (Family Aglajidae) A few specimens found in pools on mid-tide benches.

148. Aplysia californica (Cooper, 1863) (Family Aplysiidae) Common, mainly on mid-tide benches and in pools dominated by Sargassum.

149. Odostomia nota Dall and Bartsch, 1909 (Family Pyramidellidae) Found on the undersides of midtide rocks; fairly common.

150. Turbonilla tenuicula (Gould, 1853) (Family Pyramidellidae) Fairly common on the undersides of mid-tide rocks.

151. Turbonilla kelseyi Dall and Bartsch, 1909 (Family Pyramidellidae) Empty shells found in gravel.

152. Turbonilla jewetti Dall and Bartsch, 1909 (Family Pyramidellidae) Several empty shells found in gravel.

153. Pedipes unisulcatus Cooper, 1866 (Family Ellobiidae) Several individuals found on the undersides of mid-tide rocks.

154. Trimusculus reticulatus (Sowerby, 1835) (Family Trimusculidae) Moderately common on the undersides of mid-tide rocks.

Class Polyplacophora:

155. Cyanoplax hartwegii (Carpenter, 1855) (Family Lepidochitonidae) Common under Pelvetia on rocks; fairly common in crevices at high tide.

156. Nuttallina fluxa (Carpenter, 1864) (Family Lepidochitonidae) Very common, in depressions in rock at base of cliff face.

157. Mopalia muscosa (Gould, 1846) (Family Mopaliidae) Several individuals found on the undersides of mid-tide rocks.

158. Lepidozona californiensis Berry, 1931 (Family Ischnochitonidae) Common, on the undersides of mid-tide rocks.

159. Stenoplax conspicua (Pilsbry, 1892) (Family Ischnochitonidae) Very common, on the undersides of mid-tide rocks having a layer of sand under the rocks.

Class Cephalopoda:

160. Octopus bimaculatus Verrill, 1883 (Family Octopodidae) Fairly common in crevices and holes at bases of large rocks.

C. Draft Brochure

An Introduction to the Marine Life of the Cabrillo National Monument Intertidal Zone

Cabrillo National Monument contains one of the few remaining "natural" rocky intertidal areas in southern California. "Intertidal" designates the region of the seashore lying between the high tide and low tide levels. This region is often called "tidepools," which refers to the many depressions and low areas throughout the intertidal zone that retain water at low tide. The diverse marine life of the intertidal zone area is a valuable resource in many ways. Many commercially important species, including lobster, abalone and fish spend at least part of their life cycle here. Also, ease of accessibility, in addition to the rich life, makes it one of the most observed of marine habitats, by the recreational visitor and the scientist alike. Much has been learned about how nature works through study of the intertidal zone.

The purpose of this brochure is to acquaint you, the visitor, with some of the intertidal plants and animals and to seek your cooperation in preserving the marine life of this area for the enjoyment and education of future generations. Feel free to observe and handle the organisms you find, but please do not abuse or molest them in any way. Since many of the species here interact with others, the abuse of one organism can affect others. If you turn over a rock, be sure to turn it back to its original position. If a rock is left overturned, the organisms on both the top and bottom will die. Do not remove permanently attached organisms, such as seaweed, mussels or barnacles. Also, the collection of any animal or plant, living or dead, or of sand, rocks, etc. is prohibited.

Although some of the species found here occur in deeper water, many are restricted to the intertidal region. This may be because life here requires adaptation to a special condition: exposure to the air twice a day during low tides. In the intertidal zone there is a large variation in the duration

of this exposure. Areas near the land are exposed for long periods, while the most seaward parts are almost always submerged. So, there is also variation in the drying stress caused by the exposure to air. Many intertidal organisms are adapted to particular amounts of exposure and therefore occur at certain levels. This, along with competition and predation, leads to a zonation of intertidal biota. You may notice this change of species with intertidal level as you explore the area. This brochure divides the intertidal zone into three major zones: high, middle, and low.

High Intertidal Zone

Since the organisms in this zone are out of the water for long periods, they must be well protected against the drying effect of the air. Indeed, parts of this habitat are moistened only by the occasional splashes of breaking waves. Among the hardy species here are the periwinkles snails, limpets (snails with cap-shaped shells), and several kinds of barnacles, including the goose-neck barnacle. These animals can be seen on the cliff faces and the large boulders as you enter the intertidal area.

Periwinkles and limpets are herbivores. Using a tongue-like structure covered with many small teeth, they graze on the small seaweeds in their habitat. Barnacles and California mussels, on the other hand, have feeding structures designed to filter small organisms, plankton, from the water around them. This is called filter feeding. At low tide, mussels and barnacles close up tight to avoid drying out.

Boulders slightly closer to the water's edge are often covered with mussels, barnacles, and rockweed. The photograph below (37) shows a boulder on which zonation between two species is quite distinct. Mussels occupy the top of the rock, while the lower part is covered with rockweed.

A mussel clump constitutes a separate biological community in itself. Many types of plants and animals, some very small, find shelter in the dense

mass of mussel shells. Many of these organisms, although mobile, spend their entire adult lives in a single mussel clump. In addition, some species are specially adapted to live among mussels and are not found in any other marine habitat.

Mussels can have a considerable effect on other intertidal organisms through another kind of interaction, competition for space. Biologists have found that on some rocky shores the California mussel is capable of occupying almost all the rock surface, thus excluding many other species from the area. If the mussels are removed, the other species have room to attach and grow. In some areas, these other species can exist only because predators such as starfish kill and eat some of the mussels. Obviously, the mussel is one of the most important intertidal species in influencing the organisms around it. Any disturbance that changes the abundance of mussels could have repercussions among many other species.

Another predator on mussels, snails and barnacles in our area is the brown drill. This snail drills through the shell of its prey and, using its extended proboscis, eats the soft tissue inside. This species occurs mostly in Mexico; Pt. Loma is its northernmost occurrence.

The most active resident of the high zone is the lined shore crab, which is often found hiding under rocks. When disturbed, these nimble creatures scurry rapidly over the rocks to new hiding places. Another animal that gathers under rocks at low tide is the black turban snail. At high tide these snails move out over the rocks to graze on microscopic algae.

Also found in this zone is the sand castle worm, which builds colonies of tube-shaped dwellings on the undersides of large boulders. As the name indicates, these colonies are made of sand. They are very fragile, and to prevent damage they should not be touched. These worms, filter feeders like mussels and barnacles, extend feeding structures out of the tube to strain

food from the water.

The green sea anemone is a common and well-known denizen of the upper intertidal. These animals, related to corals and jellyfish, use their tentacles to catch seaweed and living and dead animals that drift by. When exposed by the receding tide, sea anemones close up by tucking in their tentacles, and hold on to pieces of gravel and other debris. This may serve to camouflage the anemones from predators such as birds.

The anemone's green color is due to microscopic algae that live in its tissues. By this association the algae receive a place to live from the anemone, while the anemone derives nutrition from substances produced by the photosynthesizing algae. This kind of relationship, in which both parties benefit, is called "symbiotic."

Visible seaweed species fall into one of three major groups: red, green or brown. These groups are more common in some areas than in others. For example, green seaweeds are most common in this upper zone, while reds and browns are prevalent lower down. One of the most distinctive seaweeds of the high zone is the green dead man's fingers. The origin of this rather gruesone name is obvious from the shape of the plant. Also, notice the unusual spongy texture.

Since seaweeds serve as food for many grazing species, a change in seaweed abundance could also affect populations of these grazers.

Middle Intertidal Zone

As you move closer to the water's edge, you may notice fairly large, flat areas with few boulders. These benches are composed of the same soft sandstone as the cliffs. There are few animals here at low tide; most of the area is covered by a lawn of small, stiff red seaweeds called coralline algae. Their hard texture is due to the presence of calcium in the branches, which gives them a vague resemblance to coral. More fleshy red and brown seaweeds

also occur in this habitat, but they are less abundant than the corallines. Perhaps their hardness gives them some protection from grazers that the other seaweeds lack.

Tidepools can be found almost anywhere along a rocky shore at low tide, and they are common at the middle intertidal level at Pt. Loma. Because they contain water at low tide, they usually have a more luxuriant growth of seaweeds than do the surrounding higher areas. One of the most abundant plants in these pools is the brown sargasso weed, a native of Japan. Another is surfgrass, which consists of many long, thin green blades. Surfgrass, unlike most marine plants, is a flowering plant and is more closely related to land plants than to algae. The flowers are very small and difficult to see.

At low tide, tidepools serve as refuges for many mobile animals, including fish, shrimp, and the slug-like sea hare. This large snail appears to have no shell, but its shell is internal and small. The sea hare is a blotched dark red to gray-green in color and can weigh over 20 lbs., although most are much smaller. Sea hares can be seen elsewhere in the intertidal, either stranded high and dry by the receding tide, or searching for seaweed to eat in places where water remains. When disturbed, sea hares exude a deep purple ink.

Low Intertidal Zone

In the lowest parts of the intertidal you will notice that the growth of seaweeds becomes denser and that large, fleshy species are more common than in the higher zones. This region is almost always submerged and is therefore more suitable for algal growth. There are many species of seaweed here. One of the most conspicuous is the feather boa kelp, so named because some of its branches resemble the snake-like arrangements of feathers that women used to wear around their shoulders. Another kind of kelp, giant kelp, forms the large kelp beds offshore.

Most of the animals in the low zone are found under rocks. This may be because the seaweeds, due to favorable conditions in this zone, occupy all the space on the tops of rocks. The animals have nowhere else to attach except under rocks, where there is little light for the plants. Here there is a rich new assemblage of species, almost completely different from those on the rocks higher up. In the under-rock habitat you will find brittle stars, sea urchins, sponges, worms, chitons, new kinds of snails and crabs, and the intriguing octopus. Most of these species require protection from exposure, so be sure to return all overturned rocks to their original position.

Chitons are oval-shaped mollusks that are covered by a series of hard plates. (Mollusks are clams, mussels, snails, limpets, abalones, chitons, octopus and squid.) Chitons cling tenaciously to the undersides of rocks and, like limpets, are grazers. Since there are few algae under rocks, chitons must move up to the sides and tops of rocks to find seaweed to eat. They never do this in daylight, only at night. This is probably another example of predator-avoidance behavior. Chitons have a primitive appearance and, indeed, they have been on the earth for about 600 million years.

Another grazer found in the low zone is the large, limpet-like abalone. Although they are not very abundant, abalones can be seen on the undersides of large rocks, especially ones standing in pools of water. There are several species of abalone; reds and greens are most prevalent in the intertidal region. The meat of abalone is very popular, but, of course, the taking of abalone is prohibited in Cabrillo National Monument.

Brittle stars consist of a central disc and five long, flexible arms, and they are quite common under rocks. The "brittle" part of the name comes from the ease with which the arms can break or become detached. Be careful to pick up brittle stars by the central disc, since one that is held by one arm will quickly shed it.

Another echinoderm that may shed the arm by which it is held is the soft starfish. (Echinoderms are starfish, brittle stars, sea urchins, and sand dollars.) The soft starfish is usually gray-green, with attractive orange and blue spines. It is a predator that feeds on snails, chitons, barnacles and even sea urchins and brittle stars.

Several kinds of large crab can be found hiding among the rocks in the low zone. One of these is the kelp crab, which can be quite large and has long, thin legs. It is reddish purple in color and, although it is clumsy, its claws are very strong and it should be treated with caution.

Now that you have learned a little about the fascinating and varied life of the intertidal zone, we hope that you realize the value of this resource and will always act to preserve it when visiting Cabrillo National Monument or other seashores.

This brochure was prepared as part of a biological survey of the Cabrillo National Monument intertidal zone, sponsored by the U. S. National Park Service.

* * *

The brochure will be published as a two-page pamphlet with illustrations of the following: general intertidal scene, goose-neck barnacles, sand castle worm and brown drills, green sea anemones, dead man's fingers, sea hare, feather-boa kelp and surfgrass, brittle star, chiton, and black abalone.

Publication awaits Monument approval and necessary revisions.

D. Ecological Resources of the Habitats Inventoried

Descriptions of the habitats which were sampled in spring and fall 1976 are provided below. For each habitat, a capsule summary of dominant species is given followed by the total number of species found in the fall sample. The community structure is discussed, and suggestions concerning the relationships of species to their physical environment and the importance of biological interactions (competition and predation) are made. Photographs of each habitat are provided in Figures 1-6. Details of species composition are given in Tables 1-6.

1. Algal mats

Dominants of the algal mat community

Plants: Corallina spp., Centroceras clavulatum

Omnivores: Anthopleura elegantissima

Species of plants: 34

Species of animals: 4

Large areas have solid flat rock benches extending from the mid through the low intertidal zones. These benches are covered by short, thick algal mats with a turf- or lawn-like appearance. Coralline (limestone encrusted) algae, including Corallina pinnatifolia, C. vancouveriensis, Lithothrix aspergillum and Jania crassa, dominate these mats. On their thalli can be found up to 17 species of epiphytes, of which the most common are Ulva californica, Acrosorium uncinatum, Laurencia sinicola, and Centroceras clavulatum.

The effects of drifting sand seem to be very important to the structure of the algal mat communities. Where little sand is present, the algal mats are robust in appearance and high in species diversity. Areas subject to high amounts of sand abrasion are almost exclusively inhabitated by the alga Centroceras clavulatum.

Few species of animals occur on the algal mats. The sea anemone Anthopleura elegantissima frequently inhabits depressions throughout the algal mat regardless of the degree of sand abrasion, and minute amphipods and juvenile crabs, such as Pachygrapsus crassipes and Pagurus samuelis, are present except in the heavily abraded mats. Grazer species are rare in this habitat. Although algal food is plentiful, it may be that the coralline nature of the dominant species makes them unpalatable to most animals. The only limpets in this region which are adapted to feed on coralline algae are subtidal species which do not occur in the study area. Pachygrapsis is known to feed on corallines, but these crabs, especially large individuals, are rare here. Their scarcity may be due to predation by birds. Since there are few hiding places in the short dense turf, any conspicuous grazer could be easy prey to the abundant bird life.

2. Phyllospadix pools

Dominants of the Phyllospadix pool community

Plants: Phyllospadix scouleri, Sargassum muticum

Grazers: Acmaea paleacea, Lacuna fasciata

Species of plants: 58

Species of animals: 7

The Phyllospadix dominated pools of the low intertidal support a diverse group of algal species but few species of fauna. The roots of Phyllospadix scouleri trap large quantities of drifting sand on the seaward side of the pools. The shifting nature of this substrate seems to prevent settlement and establishment by other organisms. However, as one moves away from the Phyllospadix roots, the action of the surf removes sand from the bottom making the rock substrate available for colonization. The shade provided by the Phyllospadix overstory and shallower layer of sand create a combination of

environmental conditions which are suitable for species such as Anisocladella pacifica, Bossiella orbigniana, and Plocamium pacificum.

The Phyllospadix overstory also supports a unique group of life forms. The algae Melobesia mediocris and Smithora naiadum are specific epiphytes on the surf grass, while the gastropods Acmaea paleacea, Lacuna unifasciata, and Mitrella carinata, are the main fauna found grazing on its tough surface. The shading effects of the Phyllospadix cover and the control of sand depostis by its roots and canopy make it evident that the environment of these pools is directly related to the density and conditions of this flowering plant.

3. Pelvetia rocks

Dominants of the Pelvetia rock community

Plants: Pelvetia fastigata

Filter feeders: Chthamalus fissus, Phragmatopoma californica, Tetraclita squamosa

Grazers: Acmaea scabra, Acmaea strigatella

Predators: Acanthina lugubris

Omnivores: Anthopleura elegantissima

Species of plants: 39

Species of animals: 24

The Pelvetia dominated rocks of the mid intertidal support one of the most diverse assemblages of algal and invertebrate species in the intertidal zone. The high diversity is attributed to the variety of microhabitats available. Pelvetia fastigiata forms a canopy over the tops of these rocks that creates a moist, shaded area in which limpets of the genus Acmaea graze upon crustose algae such as Ralfsia. One species of limpet, Acmaea pelta, occurred exclusively under this moist Pelvetia canopy.

The north and east sides of these rocks are often covered by overhanging

Pelvetia and are subject to low desiccation and wave exposure, whereas the south and west sides generally exhibit conditions of high desiccation and wave exposure. These different environmental conditions support different groups of fauna and flora. Colonies of the sand castle worm, Phragmatopoma californica, often densely cover the rock surface. The sand covered tubes and the rock surfaces support a tufted mat of algae, including Corallina species, Gigartina tepida, and various epiphytes.

The south and west sides of the rocks are usually less densely covered by algae unless adjacent rocks form protection against wave exposure or supply shade from the sun. In these areas the barnacles become the dominants. Chthamalus fissus occurs along the drier rock surfaces, while Tetraclita squamosa dominates the moist perimeter, supporting tufts of the epizoic alga Gelidium pusillum.

Since each of the microhabitats on the Pelvetia rocks supports a different group of organisms, we expect that physical environmental factors are important in determining community composition.

4. Mytilus rocks

Dominants of the Mytilus rock community

Plants: Ralfsia sp., Gelidium pusillum, Lithothamnion sp.

Filter feeders: Mytilus californianus, Cthamalus fissus, Balanus glandula, Pollicipes polymerus, Tetraclita squamosa

Grazers: Acmaea scabra, Acmaea strigatella, Lottia gigantea

Predators: Acanthina lugubris

Omnivores: Anthopleura elegantissima, Pachygrapsus crassipes

Species of plants: 20

Species of animals: 20

Large boulders in the lower mid intertidal zone are frequently dominated by the mussel, Mytilus californianus. This filter-feeding mollusc attaches itself to the rock surface and to other mussels by natural "plastic" fibers called byssal threads. Dense beds from one to four individuals thick are formed by this method of attachment. The complex structure of the Mytilus bed harbors a large number of other animal species which are not evident on first examination of the Mytilus rocks. Mytilus provides an important secondary substrate as well as shelter for a diversity of organisms. The surface of the mussel shells is frequently covered by patches of the barnacles, Chthamalus fissus, Balanus glandula, Tetraclita squamosa, and Pollicipes polymerus. Gelidium pusillum is the only alga that becomes abundant on Mytilus and its associated barnacles. The gastropods of the genus Acmaea seem to graze on Ralfsia, which is found on the mussel shells. The predatory snail, Acanthina lugubris, feeds on the mussels by drilling into their shells.

Mytilus has been shown to be the competitive dominant where it occurs in the upper intertidal zone. This means that where the habitat is suitable, Mytilus will eventually grow and replace other animals or algae which colonize the rocks. The only successful competitor of Mytilus appears to be the owl limpet, Lottia gigantea. This limpet is known to maintain a home range free of competing species by dislodging intruders. In our study area, this limpet is occasionally found occupying a bare hole in the Mytilus beds. Starfish, which are capable of controlling mussel densities, are rare in the study area.

The moist sides of the Mytilus rocks support the same assemblage of species that is found on Pelvetia rocks. Mytilus rocks are frequently surrounded by shallow tide pools and the submerged fringe of these rocks are covered by algae normally found in tide pools or lower in the intertidal zone. These include Pterocladia capillacea, Laurencia pacifica and Halidrys dioica.

5. Barnacle rocks

Dominants of the Barnacle rock community

Plants: Ralfsia sp.

Filter feeders: Chthamalus fissus, Balanus glandula

Grazers: Acmaea strigatella, A. scabra, A. digitalis

Predators: Acanthina lugubris

Omnivores: Anthopleura elegantissima

Species of plants: 14

Species of animals: 14

The barnacle rocks at the upper intertidal are composed of erosion-resistent granite which erodes evenly across the surfaces. Indentations are rare, and the relatively smooth surface makes the boulders an even less hospitable environment than the crevice-covered cliffs.

The dominant species occurring here are those which are common on dry, sun exposed cliff faces. Chthamalus fissus is dominant and can be found in densities as high as 43,000 per square meter. The stressful nature of this habitat is suggested by the abundance of Littorina scutulata and the limpets that also are common on the liff face, Acmaea digitalis, A. scabra, and A. strigatella. The anemone, Anthopleura elegantissima, and the barnacles, Pollicipes polymerus and Tetraclita squamosa, inhabit the few moist depressions and cracks on the rocks. The only algal species evident on the upper surfaces of the barnacle rocks are Ralfsia sp. and the epizoic Gelidium pusillum. However, the moister bases of these rocks support algal species which are common to the Pelvetia Rocks.

6. Cliff face

Dominants of the Cliff face community

Plants: Ralfsia sp., Lithothamnion sp., Enteromorpha sp.

Filter feeders: Chthamalus fissus, Pollicipes polymerus

Grazers: Acmaea digitalis, Littorina scutulata,
Acmaea scabra, Acmaea stigatella

Omnivores: Pachygrapsus crassipes

Species of plants: 9

Species of animals: 17

The landward perimeter of the intertidal zone is bounded by near vertical cliffs. The faces of these cliffs are covered by horizontal crevices and depressions formed by differential erosion of the rock by wave and wind action.

Desiccation, high daytime temperatures, and often violent wave force limit the species diversity here. Littorina scutulata and L. planaxis are snails which are well adapted to withstand these types of environmental stress, as are several species of Acmaea.

Although the cliffs appear to be devoid of plant food in most places, a microscopic examination of the rock surface would reveal the presence of many diatom and bluegreen algal species. These provide food for the grazers Littorina and Acmaea. Experiments elsewhere have demonstrated that these herbivores control the algal cover by their constant grazing pressure.

Only the crevices and overhanging ledges are moist and well shaded. These are favorable microhabitats for algae of the genera Enteromorpha, Ralfsia, and Lithothamnion. The shore crab, Pachygrapsus crassipes, takes refuge here from desiccation and possibly from predation by shore birds. Acmaea scabra, A. digitalis, and A. strigatella attain their greatest size in the crevices. On the dry sun exposed faces of the cliffs, the Acmaea species are smaller and the buckshot barnacle Chthamalus fissus is frequently found Ralfsia and Cylindrocarpus rugosus are the only algae occurring on the drier cliff faces.

E. Comparisons of communities under low and frequent public use

Public use may have direct or indirect effects on the ecological resources of the intertidal zone. A direct effect is the immediate removal of plants or animals as a result of human activities, whether it be through trampling, dislodging, or collecting. If direct effects exist, those changes may in turn alter the abundance or growth of other species, especially if there is a strong dependence of one species upon another. Such an effect is indirect, and would usually lag considerably behind the direct effects. For instance, a predator (or group of predators) which feeds largely upon a preferred prey item may not be damaged by direct public use; however, it may decline in growth or abundance if its perferred prey is decreased by use. Likewise, a grazer (or group of grazers) may be indirectly affected by decreased availability of algal food.

To develop hypotheses about the direct and indirect effects of public use upon the intertidal zone, we have compared the Low Use, North Use and South Use areas in several ways. We have examined the abundance of individual species and statistically tested the data to determine if average cover or density differs significantly between areas and to determine if species have increased their abundance following the summer "release" from trampling. We have grouped species together to see if functionally similar species differ significantly in their total abundance between the use areas. Last, we have examined characteristics of community structure (total cover of algae, total numbers of species) to determine if these general community characteristics differ between the use areas.

The raw data for the various habitats in three Use areas are provided in Appendix I ; summaries of those data are provided in Tables 1-6.

1) Differences in plant species abundance, comparing Low, North and South Use areas.

Several patterns in the abundance of plants were noted in both the spring and fall samples. During spring we found the following to be more abundant in the Low Use area: cover of understory plants in Phyllospadix pools, total Corallina spp. on the algal mat, and cover of Pelvetia fastigiata on randomly sampled rocks. The higher cover values for the Low Use area compared to the North and South Use areas suggest a possible impact where public use is greatest. Certainly the brittle coralline algae would be expected to be damaged by trampling. Most of these are slow growing forms which would not recover quickly from breakage; this would explain their lower cover in used areas. Understory cover would also be expected to be lower where trampling has a significant effect on the rocky substrate.

Two patterns noted for the spring sample did not fit this explanation, and these were the higher total cover for plants on the Mytilus rocks of the South Use area compared to the Low Use area and the higher cover of a red turf alga, Centroceras clavulatum (previously identified as Ceramium eatonianum). The latter species had 55.5 and 37.3% cover in the North and South use algal mat areas, respectively, compared to only 11.8% in the Low Use area. However, this is probably an example of a species responding to disturbance, since the same species behaved as an opportunistic colonizer in a disturbance study by Emerson (1975). Since it readily colonized artificially scraped rocks at False Point (San Diego), it would also be expected to colonize areas which are denuded by trampling. And that is its apparent behavior here.

During the fall we found some similar and some different patterns. As in spring, the turf alga, Centroceras clavulatum, was less abundant in the Low Use area algal mat, and total cover of plants on the Mytilus rocks was higher in the South Use area. More abundant in the Low Use area were total cover of Corallina spp. on the algal mat, and cover of Phyllospadix in

Phyllospadix pools. However, whereas in spring the total plant cover of the Phyllospadix pools was higher in the Low Use area, in fall the pattern had reversed so that the Low Use area had lower total plant cover. (Total cover in the Phyllospadix pools excluded the Phyllospadix canopy and measured cover of plants on the rock and sand substrate, as in other habitats.)

To determine what was responsible for the shift in total cover of understory in Phyllospadix pools from being higher in the Low Use area (72.2%) than in the North Use area (26.8) and South Use area (68.5) for the spring sample but lower in the Low Use area (52.8) than in the North Use (67.2) and South Use (83.0) areas in fall, we examined the spring to fall changes for each area. Total cover of plants showed significant changes for two of the areas. In the Low Use area, total cover declined from 73.2% to 53.0%. At the same time, total cover of the North Use area increased from 27.0% to 67.2%. The dominant, Phyllospadix scouleri, also changed significantly in these two areas but both changes were increases: from 53.8% cover in spring to 95.8% in fall in the Low Use area, and from 21.5% to 51.8% in the North Use area. Thus, total cover declined in the Low Use area despite an increase in canopy cover by Phyllospadix. Thus it is difficult to determine the cause of the shift. It seems to be the combined decreases of several species in the Low Use area, which lowered total cover a small but significant amount while at the same time, the dominant and other species (such as Corallina spp.) increased their cover dramatically in the South and particularly the North Use areas.

Overall seasonal changes in abundance were investigated by comparing spring and fall data for several species. All but one of the significant values showed an increase in cover from spring to fall. Corallina spp. declined in cover in the SouthUse algal mat, but the change was small (59.2% in spring to 48.5% in fall). The significant increases were: Phyllospadix scouleri in the Low and North Use Phyllospadix pools (as discussed above), Ralfsia sp. on the North Use Mytilus rocks (1.0% in spring to 23.0% in fall),

Pelvetia fastigiata on the North Use Mytilus rocks (57.8% in spring to 86.0% in fall), Corallina spp. in the North Use Phyllospadix pools (3.5% in spring to 48.8% in fall). Total plant cover on the South Use cliff face habitat increased from 21.0% in spring to 67.3% in fall.

These increases in plant cover indicate that the spring to fall period is a good growing season, since, during the daytime, tides are not extreme and exposure by low tides is brief and infrequent. Desiccation from warm weather during the fall low tides sometimes is detrimental, especially when hot dry Santa Ana conditions coincide with low tides. Damage of this type was not severe in 1976. Unexpected, however, were the declines of total cover for Low Use Phyllospadix pools and Corallina spp. in the South Use algal mat. The latter is particularly interesting, because the same species group showed a significant increase in the North Use Phyllospadix pools. We conclude that algal species are variable in their behavior, and much more needs to be known about their seasonal abundance changes in different habitats. The ecology of intertidal algae is poorly known, especially for southern California where very little field research has been done.

In our attempt to examine whether plant species in the Use areas had shown a response to release from trampling over the summer, we note that four of the significant increases in cover are in the North Use area and one is in the South Use area. Only one significant increase occurred in the Low Use area, and that was Phyllospadix in its pools. Even for this species, however, its increase in the North Use area (1.8x) was greater than its increase (2.4x) in the Low Use area. So there seems to be some indication of a pattern for greater growth during the summer in areas previously used by the public. However, the great variability in the data, and lack of species to respond similarly in all habitats, limits our interpretation of these results.

2) Differences in animal species abundance, comparing Low, North and South Use areas

The three Use areas were compared in spring and fall, testing for differences in density for individual species. In the spring sample we had several samples from randomly selected rocks that were added to the permanently located rocks of the three rock habitats. We used the combined data for statistical analysis in these three habitats in order to have as large a data base as possible to show significant differences.

Several species were more abundant in the Low Use area than in the Used areas. In spring the sand castle worm, Phragmatopoma californica, numbered 343/m^2 in the Low Use Pelvetia Rock habitat (random rocks included) compared to 40 and 56 in the North and South Use areas. Densities for the three areas, excluding random rocks, were 560, 132, and 87 in the spring and 132, 51, and 88 in the fall, respectively. This species builds a fragile tube colony out of sand. Because touching or trampling this structure damages it, we would expect an impact of public use, and the higher abundance for the Low Use habitat confirms our field observations of lower density where public use is frequent. The declines from spring to fall, however, were not evident in the field, and we suspect that the lower densities in fall were the result of slightly different placement of quadrats so that areas where the species was most abundant (i.e. crevices at the boulder-substrate interface) were missed. Quadrat placement can make a difference in obtaining density estimates for species which are very clumped, as in Phragmatopoma californica. Rather than declining, it appeared in the field that this species was recovering from trampling in the North and South Use areas. Because of these suspected discrepancies between the field observations and data for clumped species, the 1977 study will alter sampling methods slightly, obtaining more data for P. californica and other sensitive species, and using a rectangular shaped quadrat which will provide less variable data then the circular quadrats.

Two limpet species were also most abundant in the Low Use area. Acmaea digitalis was significantly denser in the Barnacle rock habitat of the Low Use area (79/m^2 with random rocks included) compared to the North (17/m^2) and South (9/m^2) Use areas. By fall, however, this difference had disappeared with the decline of A. digitalis in all areas. Since quadrat placement is less critical for this species, we have more confidence in the data. A. digitalis forms a mucus seal upon exposure to desiccation, and disturbance of this seal could lead to mortality. Attempts to pry the species off the rocks, even if unsuccessful, could damage this species of Acmaea; hence an impact of public use would be expected.

Acmaea scabra was similar in density for the three Use areas for the Cliff face, Barnacle rock and Mytilus rock habitats in spring. However, densities were higher in the Low Use area for each of these three habitats in fall. Comparison for spring and fall densities for the Low Use area do not show significant increases, so that small increases in the Low Use area plus small decreases in the North and South Use areas seem to have caused the significantly higher values for the Low Use area in fall. Unlike A. digitalis, A. scabra does not form a mucus seal against the substrate upon drying. Trampling or dislodging would probably have to be complete in order to cause a significant impact on this species.

Chthamalus fissus, the smallest and most numerous barnacle of the intertidal zone, was significantly more abundant in the Low Use Mytilus rocks in both spring and fall. However, on the Barnacle rocks, it was lower in density in the Low Use area. These differences could be due to public use if this species is sensitive to trampling as we suspect. There appears to be a difference in the accessibility of the Barnacle rocks in the three Use areas so that this habitat may not be well replicated. For instance, the rocks of the Low Use area are now directly in the paths of persons spreading out to the north of the

access. They could have been lightly trampled even during spring when occasional visitors were in the Low Use area. They are heavily used now that the access is near the Low Use area. The Barnacle rocks of the South and North Use areas which we chose to sample at the beginning of the study are somewhat less trampled when the tides are low, since ample area of algal mat and rock bench are available. Monitoring of barnacles in 1977 will play closer attention to rock selection and will expand our study of the three barnacle species. Because of differences in the shell hardness, we would expect differences in sensitivity to trampling.

Obviously, there are problems in attributing our results to public use. We have seen responses from a single species which are different in the various habitats where it is found. We have seen different responses of the same species for spring and fall. It is possible to find reasons to explain seemingly contradictory results. For instance, a species which is affected by trampling but not by dislodging would be expected to behave differently for different habitats. On Mytilus rocks, which are too large to step on, one would expect less impact on such species than on Pelvetia and Barnacle rocks. However, when we know so little about the direct effects of the public users on different species, our interpretations are subject to error. The data presented in this report are correlations between abundance and general public use. What are needed are carefully controlled experiments on the communities as a whole as well as detailed studies on species which we suspect to be sensitive to public use. These studies are planned for 1977.

Other significant differences in the animal densities show greater abundance in the North and South Use areas than in the Low Use area. A pattern such as this would be expected of opportunistic species which colonize areas denuded by public use. Species which produce large numbers of offspring year round which might behave as opportunists include Chthamalus, Anthopleura,

and Littorina scutulata.

The sea anemone, Anthopleura elegantissima, was highest in density in the South Use Pelvetia, Barnacle, and Mytilus rock habitats in both spring and fall. These results lend support to the hypothesis that it responds to disturbance by invading denuded areas; however, only a controlled experiment can confirm or negate that hypothesis.

Tetraclita squamosa, the largest barnacle, was significantly more abundant in the South Use Pelvetia rocks (including randomly selected rocks) in spring. Although the data are not statistically significant for the Barnacle rock and Mytilus rock habitats, the numbers are largest in the South Use, as observed in the field, in both spring and fall. Densities seem to have changed very little between spring and fall except that the high Pelvetia rock value of $1020/m^2$ was reduced to $227/m^2$. This decline is probably a sampling artifact, since Tetraclita is most abundant on the sides and base of rocks, and could be undersampled if quadrats fell on the upper parts of rocks.

Although differences were not statistically significant, it appears that Littorina scutulata is more abundant in the two Used Cliff face habitats, although its occurrence on Barnacle rocks is highly variable.

These patterns, which are similar to our expectations, suggest that several species do increase their density with disturbance, and studies of these individual species will be carried out in greater detail in 1977.

3) Differences in animal species abundance, comparing feeding types in Low, North and South Use areas.

There are several ways in which the public might affect consumer species as a group. The following expectations prompted the analysis of total filter feeders, total grazers and total predators for the Low, North, and South Use areas.

For filter feeders, we expected individuals on tops of rocks could be

damaged by trampling and should be less numerous in used areas. Filter feeders found under rocks were probably turned under by people who failed to roll back the rocks, and should also be less abundant in used areas.

Grazers living on the rock or algal surfaces likewise would be subject to trampling or collecting and could be depleted that way. In addition, if food were limited by the trampling and removal of algae, an indirect effect would also exist. Such grazers should also be decreased by use.

Predators would likewise be subject to direct removal or indirect depletion because of limiting numbers of prey and would be decreased by public use.

Under rock fauna which are adapted to finding food in a sheltered location, however, might show increases in density with human activities. The under rock habitat is subject to sand accumulation by physical processes, and increased sand causes reduced circulation and less import of food in the form of algal debris. The manual rolling of rocks might lead to increased circulation and sand removal and higher density of those species adapted to feed on debris under rocks (chitons, brittlestars, sea urchins). Rock rolling activities, if done carefully and if rocks are replaced right side up, may actually increase growth or densities of some intertidal species.

The comparison of functionally similar feeding groups show interesting results and suggests that the differences noted in algal cover have not had indirect effects upon the community consumers. Tables 5-6 summarize the densities of several filter feeders, herbivore grazers, and predators found in the three use areas.

Barnacles are most abundant and dominate the densities of filter feeders. A few additional species contribute high densities, but the totals rank in the same order as the barnacles taken separately. Hence we see the same patterns as explored above on the species level. The density of filter

feeders of all seven habitats and the randomly sampled rocks was averaged for the Low, North and South Use areas and found to be 8,078; 9,509; and 10,024, respectively. These are very similar numbers, considering the heterogeneity of the data that were averaged! Clearly there is no major difference in abundance of filter feeders for the three areas.

Herbivore grazers were likewise compared, and Acmaea sp. and Littorina sp. provide the bulk of the data. These species are feeding on the algal mats and on microscopic algae such as diatoms and thin layers of bluegreen algae, which were not sampled in the study. The sums for this feeding group show remarkably similar densities across the three use areas, so that again the averages for all habitats are very similar numbers: 267, 344, and 284, respectively. No major differences exist in density of grazers for the three areas.

Predators, which would be the last trophic level to feel the effects of an impact on algae, are not noticeably different in density when summed by habitat type for the three use areas. The presence of Acanthina lugubris in higher numbers in the South Use area dominates the data for four of the habitats compared. Averages across all habitats for the Low, North and South Use areas are 1.7, 7.7, and 7.9 predators per square meter. These numbers are averages of data which are too variable to show any statistically significant differences, and hence we cannot hypothesize that an impact of public use is being felt by the intertidal predators.

The lack of major differences in the densities of different feeding groups for Low, North and South Use areas suggests that no significant effects of public use are occurring at this time. It is possible that slow, long term changes, are occurring which are unmeasurable given the variability of the data. It is also possible that such effects have already proceeded to the point of total removal of species from the entire area study. Several species

are conspicuous by their absence in the data and are probably rare because of human exploitation. Lobsters and abalone are no doubt much less abundant and of smaller size than they would be without past or present human influence.

In summary, the impact of public use on the fauna of the intertidal zone was probably much greater in past years when lobster and abalone, and perhaps other interesting shell-bearing species (e.g. Astraea undosa, the wavy top shell) were heavily collected. Recovery of these species assuming they were formerly abundant, cannot be expected to be quick, since they are slow growing and still subject to removal by poaching.

The removal or depletion of large animals, such as lobster and abalone, might have an effect on the smaller, faster growing, or less sought animals of the intertidal zone. Their absence may be beneficial to growth and reproduction of the remaining species. Indeed, it could well be that the lack of numerous large consumers means that there is less competition for food among the remaining species so that a reduction in the plants or base of the food chain is not sufficient to affect higher trophic levels. Plant food is certainly abundant in the Cabrillo intertidal zone. The only location where heavy grazing seems to occur is in the Cliff Face habitat where algal cover is sparse and experimental studies elsewhere have shown luxuriant regrowth of algae with removal of limpets and periwinkles. Lower in the intertidal area, however, the algal mat is dense and no areas appear to be denuded because of grazing, and we assume that food is not limiting to herbivores. The changes in cover of algae therefore do not seem to be responsible for the changes noted for individual animal species. Since there are no visible changes in feeding groups, no indirect effect of algal reduction is seen here either.

4) Differences in community structure, comparing Low, North and South Use areas.

Differences in plant community structure were sought in examining total cover discussed above and in total species found for each habitat. Neither of these indices of community structure shows a consistent pattern of being lower in the Used areas. When total cover in spring is averaged for the six habitats, the values are 71.2% in the Low Use, 62.4% in the North Use, and 73.4% in the South Use areas. Similar values for fall are 72.9% in the Low Use, 80.7% in the North Use and 82.5% in the South Use areas.

Average number of plant species for the six habitats in spring were 10.5, 8.3, and 7.5 for Low, North and South Use areas, compared to 15.3, 19.2 and 15.5, respectively, in fall. The larger numbers found in fall are due in part to better taxonomic identification.

The average total cover and numbers of species of plants are similar for the three Use areas and no strong effect of public use is apparent.

Animal community structure was compared by examining total density and numbers of species for the three Use areas. Because the density data are highly variable they have not been tested for significance. However, there is only one habitat in spring, the Mytilus Rocks, for which the density sum is larger for the Low Use condition, and there the difference is slight. None of the habitats has its highest density in the Low Use area in fall.

Numbers of animal species are low in all habitats under all use conditions. The most diverse habitats in spring and fall were the Pelvetia Rocks and Mytilus Rocks. Averaging across all habitats gave 8.5, 8.2 and 8.8 species for the Low, North and South Use areas, respectively, in spring and 12.3, 10.0 and 11.3 species, respectively, in fall. No indication of an impact on total species numbers is apparent.

Combining the numbers of plant and animal species likewise did not show great differences for the Use conditions, since neither type of data showed

differences individually. The totals averaged for all six habitats were: for spring, 19.0 in Low Use, 16.5 in North Use, and 16.3 in South Use; for fall, comparable numbers are 27.7, 29.2, and 26.8.

F. MANAGEMENT RECOMMENDATIONS

Based on the results of our comparisons between low and frequently used areas of the intertidal zone and on our general observations and knowledge of intertidal areas, we present the following recommendations for the protection and perpetuation of the ecological resources of the Cabrillo National Monument intertidal zone. We assume that public use is responsible for many differences in species abundance that occur where use is frequent.

1. The number of visitors to the intertidal zone should be more limited. When the daily visitors number in the hundreds, we expect much greater damage to the biota. Heavy use probably leads to a greater impact on the biota than the same number of individuals visiting the same area on different days. The reasons we believe this to be so are: a) People tend to be found in clumps; when one individual finds something of interest, a group gathers around and trampling is locally heavy. Fewer people would mean smaller group formation and more dispersed trampling. It is the localized heavy trampling that seems to lead to the reductions in algal cover. b) Bad habits of one group of visitors are readily acquired by others. Rock rolling is an example. When one group begins to turn over rocks and find interesting animals, others follow in step. Few people bother to turn the rocks back again.

2. Funds should be provided to support more rangers to police the intertidal zone during lower low tides. It would be desirable to have 1-2 rangers in the intertidal area during all periods of public use. Problems with poaching and collecting could then be controlled more effectively.

3. A greater effort should be expended to educate the public which uses the intertidal zone. The main problem here seems to be in reaching the casual visitor, rather than the organized group with visit reservations. The availability of a brochure such as the one we have drafted should aid this education process. Three important concepts must be presented: 1) the resources are

valuable; 2) public use can abuse these resources; 3) an impact on one species may alter others. Hiring additional rangers to educate, as well as police, would help greatly.

4. Erosion on the foot path should be controlled by using some type of retaining fabric or asphault. Climbing on the natural arches should be expressly prohibited.

The Monument cliffs are extremely erodable, and landslides occur if soil-holding plants are worn away. This process led to the landslide and entrance closure near NUC. It will occur again at the new access unless funds are provided from erosion control.

The natural arch near the new access is an interesting landscape feature and should be protected from unnecessary erosion (human abuse). Climbing and jumping are accelerating its disappearance.

5. Additional research of two general types is recommended to determine the cause-effect relationships between public use and intertidal biota. The first type of research, an experimental approach to examine replicate areas with and without public use, is planned for 1977. This work seeks to establish whether or not public use, rather than other coincidental environmental conditions, determines the observed differences in intertidal biota.

The second type of research recommended is a monitoring program to assess long-term changes in the major intertidal communities. This approach is recommended because the great natural variability of intertidal populations from year to year can mask effects which are due to continual public pressure. The differences in the abundance of a species under low and frequent public use which we found in 1976 could be due to natural variation in intertidal populations. However, if these differences continue to exist year after year, regardless of differences in seasonal or annual recruitment, there is much

stronger evidence that the cause is public use.

Also, determination of the long-term changes in intertidal biota resulting from public use, requires study over several years. A unique opportunity to assess these effects exists because of the change in access route from near NUC to the "Low Use" area. We inventoried the Low Use area in Spring 1976 when it was rarely used by visitors. Annual or biennial re-surveys of that area, will permit the discovery of slow but gradual changes in communities and populations which coincide with continuing public use. At the same time, annual or biennial surveys of the areas which were formerly heavily used will make it possible to document any differences in biota which correlate with a release from public utilization. The Fall 1976 resample showed only a few changes which may result from altered use patterns; more information, gathered over several years time, is necessary to document the long-term patterns of ecological change. The monitoring program should be carried out under direct supervision of the Monument, with permanent funding to insure continuity in data collection and interpretation.

PERSONNEL

This project has been carried out under the direction of Dr. Joy Zedler, Biology Department, San Diego State University.

Many San Diego State University students have assisted with the field work and data analysis. Their contributions are listed below and acknowledged with gratitude:

Ted R. Turk, Ph.D. candidate in Ecology: assisted in organizing the project, supervising the field work, and writing up results. Mr. Turk was responsible for preparing the brochure.

Stephen Hosmer, M.S. student in Ecology: in charge of collecting all the faunal data; prepared the habitat map; assisted in summarizing data; prepared the annotated animal species list.

James Lopez, M.S. student in Ecology: in charge of collecting all the fall 1976 algal data; prepared the annotated algal species list; developed descriptions of the six major habitat types; analyzed algal data.

Susan Emerson, M.S. and Grossmont High School Teacher: supervised the algal data collection in spring 1976 and assisted Mr. Lopez with algal identification.

Kathy Parker, undergraduate biology major: did most of the statistical analysis, beginning in summer 1976; began assessing people-use in fall 1976.

Kathy Guehlstorff, undergraduate botany major: assisted Mr. Lopez with algal field work, identification, and preparation of the species list.

Bruce McIntyre, Bob Shaver, Stuart U'Ren, Jurij Jomziak, and Todd Johnson, all M.S. students in biology, assisted in various ways in the field and laboratory.

Kristine Creed and Sandy Krett typed the report.

Two consultants have assisted with identification and analysis of the results.

Dr. T. A. Ebert, Professor of Biology, SDSU: provided suggestions for data analysis and interpretation, and reviewed the project report.

Mr. Robert Setzer, Curator of the USC Herbarium and Ph.D. candidate at USC: identified algae in the field and verified identifications of Mr. Lopez and Ms. Guehlstorff.



Figure 2. Algal mats covering the rock benches are interspersed with large boulders and tidepools. A Phyllospadix dominated pool is shown at the right.

Figure 3. Pelvetia Rocks are dominated by Pelvetia fastigiata on the sides and barnacles on top. The Pelvetia plants reach lengths of .5 meters.





Figure 4. Mytilus Rocks are large (2-3 meters in height) conspicuous components of the Cabrillo Monument intertidal zone. Here they are surrounded by Algal Mat and Phyllospadix Pool habitats.

Figure 5. Barnacle Rocks are abundant near the upper limit of the intertidal zone. The common name, buckshot barnacle, is descriptive of the dense and widely distributed dominant, Chthamalus fissus.

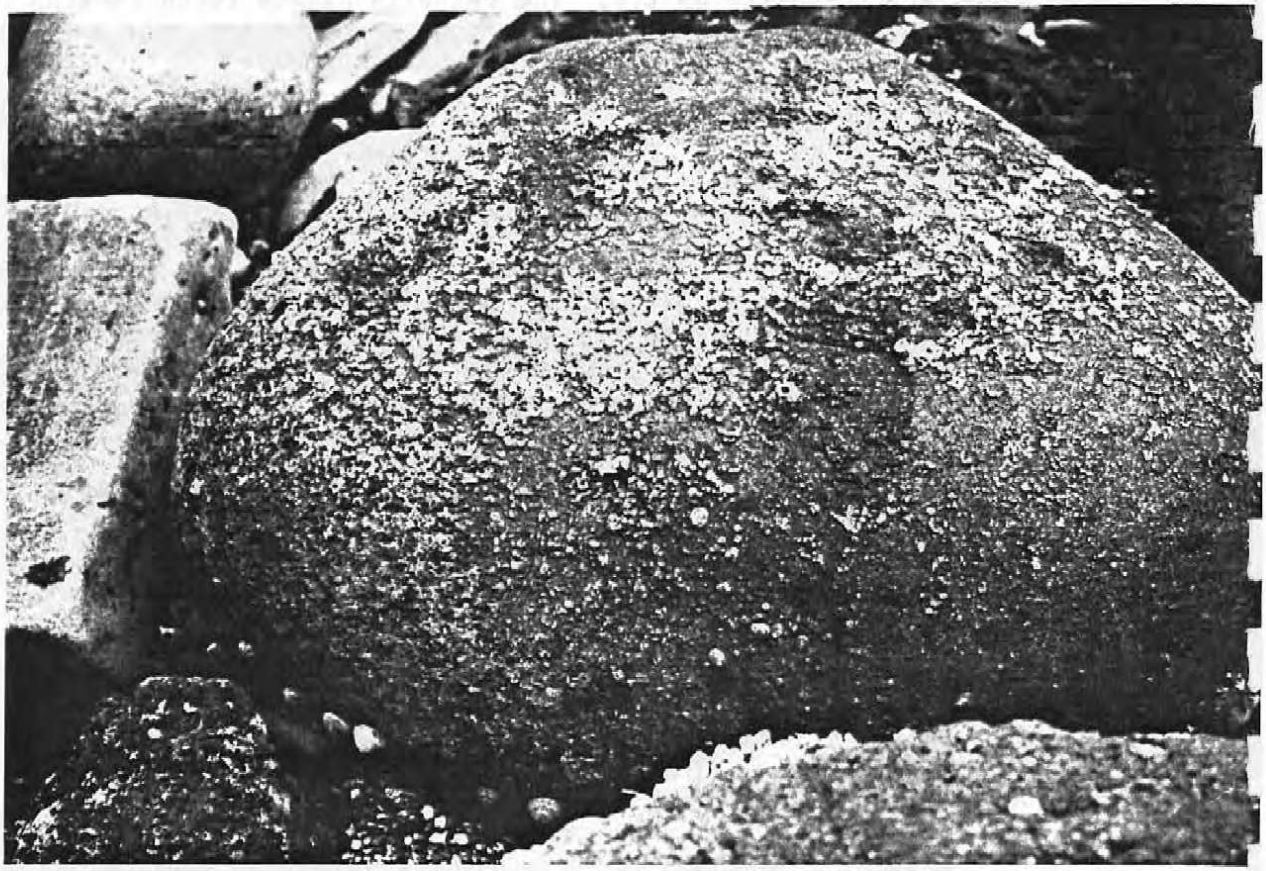




Figure 6. Cliff Face habitats are structurally heterogeneous because of the differential erosion of rock layers. The smallest indentations, however, are caused by the action of their limpet occupants.

TABLE 1. Spring 1976 inventory of the plants of the Cabrillo National Monument intertidal zone. Data are percent cover of algae (seaweeds) and Phyllospadix (surf grass) for six habitats under three public use conditions. See text for explanation of "Random" Rocks. *Indicates that the underlined values are significantly different at the 95% probability level.

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks			"Random" Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
CHLOROPHYTA (Green algae)																					
Chaetomorpha aerea							.2													.1	
Codium fragile					.2															2.1	.1
Colpomenia sinuosa			.2						.5											.3	
Enteromorpha tubulosa					.2			.8													
Enteromorpha sp.										.8	.2	.8		.2							
Ulva rigida				.2	.2	.2	1.2	.8	1.8							.3		.2	.2	1.9	
PHAEOPHYTA (Brown algae)																					
Cystoseira osmundacea	.8	1.0	.2																	.3	
Cystoseira sp.					.8	.2													.1	.1	
Ectocarpus confervoides								.8													
Egregia laevigata	.8	4.3																			
Eisenia arborea	.3																				
Laminaria sp.	.2																				
Pelvetia fastigiata				60.5	57.8	46.3										1.3			*47.5	15.1	4.0
Petrospongium sp.											.8	.5					.2			.1	
Ralfsia pacifica				10.0																	
Ralfsia sp.				3.0	17.5	11.0				19.7	8.0	21.0	4.5	8.5	2.5	3.3	1.0	.5	10.1	12.1	3.3
Sargassum agardhianum			16.0																		
Brown filamentous					.2					16.0	1.5	9.0									
Flat brown																			.3	.5	.1
Unbranched brown					1.8	1.3															
Unknown fleshy brown					1.0																
RHODOPHYTA (Red algae)																					
Acrosorium uncinatum	.5																		.1	.3	
Bossea gardneri																				.1	
Bossea sp.	11.3		.2				.5														
Centroceras clavulatum				1.2			2.8													.1	
Ceramium eatonianum							*11.8	55.5	37.3												
Ceramium sp.																					
Chondria californica							1.0	.8	3.0												
Chondria sp.					.2														.2	.8	
Corallina chilensis	3.8	3.5	29.0	4.0	20.0	20.0	* 3.2								1.8		.5	2.3	13.0	4.9	4.2
C. gracilus foliosa								20.8	59.3							.8					
C. g. densa				20.8			75.0														
Endocladia muricata				.2												.3				.4	
Endocladia sp.					3.0	2.5							.8	.5	.8		.8		.8		.7
Gastroclonium coulteri				.5																.2	
Gelidium crinale			.5	2.3	9.0	4.0		1.8											2.0		.4
G. nudifrons							1.0												.7	.4	
G. robustum		.5																	.2		
Gigartina canaliculata				.5	2.0															.3	.4

TABLE 1. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks			"Random" Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
Gloiosiphonia verticillaris		.2																			
Gloiosiphonia sp.			.2																		
Griffithsia pacifica							1.8														
Herposiphonia parva							1.5														
Herposiphonia sp.																			.4	.4	
Hildenbrandia sp.																			.5		
Hypnea coulteri?	.8			.2	.2	1.0		14.0	6.3						.5	.1	.2	.2	6.0	3.5	3.6
Jania	1.8		.8				10.8												.1		
Laurencia diegoensis																				.1	
L. scrippsensis					.2	2.0	.2								.5					.4	.2
L. subopposita																			.1		
Laurencia sp.																		.2	2.2	.1	
Lithothamnion giganteum							.2														
Lithothamnion sp.			.2	4.3	3.8	3.5				.2	1.5	1.5			.5					1.0	.2
Lithothrix aspergillum				.5																.1	
Melobesia sp.	.5																				
Nienburgia andersoniana	1.5						5.5												.3		
Plocamium coccineum var. pacificum		2.0																			
P. pacificum	15.3		3.8			.8	.8														
Polysiphonia sp.				.5				.2													
Prionitis lanceolata							.2														
Pterocladia caloglossoides																.8					
P. pyramidale					1.2																
Pterocladia sp.																			2.3	.5	
Rhodoglossum affine	.8			.2																.1	
Rhodymenia californica					5.0															.1	.2
Rhodymenia sp.			1.5	5.3		2.3													3.0		
Smithora naiadum	9.8																				
Smithora sp.		.2	12.8																		
long red serrated																				.2	
pinnate red																			.1		
serrated red																				2.3	
unbranched red																		1.0			
unknown alga	3.5																				
TRACHEOPHYTA (Higher Plants)																					
Phyllospadix scouleri	53.8	23.8	31.0																		
Phyllospadix sp.																	.2				
TOTAL COVER	*72.2	26.8	68.5	86.3	78.8	82.5	87.0	91.8	83.8	28.5	23.2	21.0	75.8	75.0	77.8	*80.0	79.0	96.8	81.6	77.1	99.5
Number of species	16	8	13	17	19	13	17	9	6	4	5	1	2	3	6	7	6	6	22	31	12

TABLE 2. Spring 1976 inventory of the animals of the Cabrillo National Monument intertidal zone. Data are numbers of animals per m^2.
a) Comparison of six habitats under three public use conditions.

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
PORIFERA																		
Red sponge																		
Yellow sponge																		
CNIDARIA (Coelentrates)																		
Anthopleura elegantissima					13	373	3	145	25						290		60	270
A. xanthogrammica							.8											
Astrangia lajollaensis																		
ANNELIDA (Segmented worms)																		
Eupomatis gracilis																		
Unidentified tube building worm																		
Phragmatopoma californica				560	120	87												
Serpulorbis squamosa																		
Spirabis sp.																		
Halosydas johnsoni																		
MOLLUSCA																		
Gastropoda (Snails, sea slugs)																		
Acanthina lugubris				7	7	20						13			10	3	30	
Acmaea digitalis				7	7					453	534	300	150	40	30	25	80	20
A. insessa		5																
A. limatula					7													
A. paleacea	2.5	35	75															
A. pelta				13	7	20												
A. scabra				13	73	173		20		73	133	100	30	10	70	193	210	210
A. strigatella				60	20	47				13		27	50	50	100	128	290	180
Total Acmaea	2.5	40	75	93	113	240		20		540	667	427	230	100	200	345	580	410
Anachis penicillata																		
Ceratostoma nuttallii																		
Conus californicus	.8								5									
Crepipatella lingulata																		
Epitoneum tinctum																		
Erato vitellina																		
Eartulum occidentales																		
Hermissenda																		
Homalopoma luridum																		
Hopkinsia rosacea																		
Hyalina taeniolata																		
Lacuna unifasciata	2.5	35	35				.8											
Littorina scutulata						33				173	240	187	500	490	300		10	10
L. planaxis										13	20							
Lottia gigantea											13	13				3	10	
Macron lividus	.8																	
Mitrelia carinata	10	55	25															

TABLE 2a. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
Ocenebra circumtexta																		
Ocenebra poulsoni																		
Odostomia nota																		
Pseudomelastoma penicillata																		
Tegula funebralis																		
T. eiseni					7													
Tricolia pulloides	.8																	
Serpulorbis squamigerus																		
Trimusculus reticulatus																		
Turbonilla sp.	.8																	
Fissurella volcano					20	7												
Pelecypoda (Bivalves)																		
Glans subquadrata																		
Mytilus californianus				13	27	127								140		394	610	230
Netastroma rostrata																		
Penitella penita																		
Pseudochama exogyra									5									
Septifer bifurcatus				7		33												
Polyplacophora (Chitons)																		
Cyanoplax hartwegii				13	47	27				20	7	20						
Lepidozona cooperi																		
Mopalia muscosa												13				43		
Nuttallina fluxa						13												
ARTHROPODA																		
Cirrepidia (Barnacles)																		
Balanus glandula				13	73	87							2940	2110		384		200
Chthamalus fissus				5180	2107	6120				587	1780	867	25670	36750	34840	11967	9780	10430
Policipes polymerus				7		53				127						163	180	
Tetraclita squamosa				13	67	1020									10	127	240	510
Isopoda																		
Idothea sp.																		
Cirolana harfordi																		
Amphipoda																		
Pycnogonida																		
Malacostraca (Crabs, shrimp)																		
Unidentified shrimp																		
Loxorhynchus																		
Pachygrapsus crassipes						7	1.7		10		7	7				.8	20	10
Pagurus samuelis		30	10				.8											
Petrolisthes cinctipes																		
Pugettia producta																		
Unidentified crab																		
ECHINODERMATA																		
Ophioderma panamense																		
Ophiopterus papaillosa																		
Ophioplocus esmarki																		
Pisaster giganteus																		
Pi ter ochraceus																		

TABLE 2a. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
ECTOPROCTA (Bryozoa)																		
Red Bryozoan																		
Bryzoan #2																		
CHORDATA																		
Urochordata																		
Tunicate #1 (white)																		
Tunicate #2 (leathery)																		
Vertebrata																		
Gobiesox sp.																		
TOTAL DENSITY	18	160	145	5906	2602	8247	7.1	165	45	1459	2734	1547	29340	39590	35650	13430	11490	12070
Number of Species	7	5	4	13	15	17	5	2	4	8	8	10	6	7	8	12	12	10

TABLE 2. Spring 1976 inventory of the animals of the Cabrillo National Monument intertidal zone. Data are numbers of animals per m². b) The first data column includes all "Random" Rocks (see text), the next three columns separate the randomly selected rocks by habitat and show averages which include the monitored rocks for each habitat; the last two columns show data for Under Rocks, with density and percent cover (for species not easily sorted into individuals). *Indicates that the underlined values are significantly different at the 95% probability level.

Habitat:	"Random" Rocks			Random Rocks Included									Under Rocks					
				Pelvetia Rocks			Barnacle Rocks			Mytilus Rocks			Density			Percent Cover		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
PORIFERA																		
Red Sponge																1.6	9.7	1.1
Yellow Sponge																		1.1
CNIDARIA (Coelenterates)																		
Anthopleura elegantissima	48	186	432	*7.5	60	492	*60	140	384		164	213	.9	2.9				
A. xanthogrammica														159	25		2	
Astrangia lajollaensis																		
ANNELIDA (Segmented worms)																		
Eupomatis gracilis													114	44	56	2.4	.7	2.2
Unidentified tube building worm													1.7		6.1			
Phragmatopoma californica	106	8	2	*343	40	56							74	7.3	1.1	4.7		
Serpulorbis squamosa	2																	
Spirabis sp.													P	A	C	17.2	11.1	20
Halosydas johnsoni													1.3					
MOLLUSCA																		
Gastropoda (Sanils, sea slubs)																		
Acanthina lugubris		4	14															
Acmaea digitalis	32	2	4	15	3.3		*79	17	9	25	32	20						
A. insessa																		
A. limatula																		
A. paleacea																		
A. pelta	12	8	4															
A. scabra	30	224	116	*275	157	188	26	193	98	192	160	147						
A. strigatella	68	118	36	78	57	32	49	97	56	127	200	133		.9				
Total Acamea	142	352	160	140	230	240	149	310	160	345	396	300						
Anachis penicillata													.8	2.0	1.5			
Ceratostoma nuttalli		2												.6				
Conus californicus																		
Crepipatella lingulata															1.6			
Epitoneum tinctum	2																	
Erato vitellina														.7				
Fartulum occidentales														32.8				
Hermissenda														1.4	4.2			
Homalopoma luridum													7.3	2.8	.9			
Hopkinsia rosacea															1.7			
Hyalina taeniolata															2.3			
Lacuna unifaciata													1.1	5.2				
Littorina scutulata	82	22	158				223	200	238									
L. Planaxis																		
Lottia gigantea		2																
Macron lividus		4																
Mitrella carinata		4																

TABLE 2b. (Continued)

Habitat:	"Random" Rocks			Pelvetia Rocks			Random Rocks Included Barnacle Rocks			Mytilus Rocks			Under Rocks Density			Under Rocks Percent Cover		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
Ocenebra circumtexta														2.1	.9			
Ocenebra poulsoni																		
Odostomia nota													2.3					
Pseudomelastoma penicillata													6.2	.5				
Tegula funebralis			12															
T. eiseni		2											6.9	1.4	2.7	.8	.7	
Tricolia pulloides																		
Serpulorbis squamigerus													5.6	6.6	4.6	1.6	1.4	6.7
Trimusculus reticulatus														.9				
Turbonilla sp.														.7				
Fissurella volcano													2.5	1.4	1.5			
Pelecypoda (Bivalves)																		
Glans subquadrata													3.9	1.2	3.2			
Mytilus californianus	98	192	26	80	40	80	54	70	4.4	394	568	220						
Netastroma rostrata														P				
Penitella penita														P				
Pseudochama exogyra	2												.5					
Septifer bifurcatus		8	2										4.3	2	4			
Polyplacophora (Chitons)																		
Cyanoplax hartwegii	8	8	4															
Lepidozona cooperi													1.7	.6	.8			
Mopalia muscosa		4	2										.9					
Nuttallina fluxa																		
ARTHROPODA																		
Cirrepidia (Barnacles)																		
Balanus glandula	1202	264	696										838	12		3.1	.7	
Chthamalus fissus	14624	20668	24096	7455	6760	7176	21669	27887	32036	11967	21816	8553	135	300	91	5	1.4	2.2
Policipes polymerus	104	296	476															
Tetraclita squamosa	30	350	170	*30	170	884	5.7	397	40	127	140	340						
Isopoda																		
Idothea sp.													4.4	4.8	17.8	.8		
Cirolana harfordi													8	9	8			
Amphipoda																		
Pycnogonida															2.3			
Malacostraca (Crabs, shrimp)																		
Unidentified shrimp															4.4			
Loxorhynchus													.5	1.9	5			
Pachygrapsus crassipes														2.3				
Pagurus samuelis																		
Petrolisthes cinctipes													1.4	2.2	7.7		.7	
Pugettia producta														.9				
Unidentified crab													5.5	11	1.1			
ECHINODERMATA																		
Ophioderma panamense													1.9		10.6			
Ophiopterus papaillosa																		
Ophioplocus esmarki															2.5			
Pisaster giganteus															.7			
Pisaster ochraceus																		

TABLE 2b. (Continued)

Habitat:	"Random" Rocks			Pelvetia Rocks			Random Rocks Included Barnacle Rocks			Mytilus Rocks			Under Rocks Density		Under Rocks Percent Cover		
Use Condition:	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use	Low Use	North Use	South Use
ECTOPROCTA (Bryozoa)																		
Red Bryozoan																7.3	14.8	28.9
Bryozoan #2																		1.1
CHORDATA																		
Urochordata																		
Tunicate #1 (White)																1.6	18	12.2
Tunicate #2 (leathery)																	2.1	
Vertebrata																		
Gobiesox sp.														.7	.7			
TOTAL DENSITY	16450	22376	26250															
Number of Species	16	21	17															

P = present
C = common
A = abundant

TABLE 3. Fall 1976 inventory of the plants of the Cabrillo National Monument intertidal zone. Data are percent cover of algae and Phyllospadix for six habitats under three public use conditions. *Indicates that the underlined values are significantly different at the 95% probability level.

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
CHLOROPHYTA (Green algae)																		
Chaetomorpha linum	.8	2.0	.5	.3	.3		2.0			.3	.3			.3				
Cladophora sp.	.5	1.0				.6	.2											
Codium fragile				.3	.3												.3	
Enteromorpha compressa											2.3						.6	
E. flexuosa										.3	.3			2.3				
Enteromorpha sp.												3.6						
Ulva angusta		2.2																
U. californica	.2	6.2	7.2	3.3	.3	1.6	8.5	.8	6.5					2.3	7.0		2.3	
PHAEOPHYTA (Brown algae)																		
Colpomenia sinuosa		1.2							.5						1.3			
Cylindrocarpus rugosus											.3						.6	
Cystoseira osmundacea																		
Dictyopteris undulata	.2	.2																
Dictyota binghamiae				.3														
Ectocarpus parvus																		
Egregia laevigata																		
Eisenia arborea																		
Endarachne binghamiae				.6													1.3	
Halidrys dioica	.2	.5																
Laminaria sp.																		
Pachydictyon coriaceum	4.0	4.2	1.2			.3												
Pelvetia fastigiata				53.3	86.0	67.6				.3								
Ralfsia sp.		.2	.2	13.6	26.6	23.3			.2	48.0	30.3	33.6	1.0	1.3	8.6	10.6	23.0	.3
Sargassum muticum	.8	9.5	28.5	.3	.3	.3			.2									
Sphacelaria sp.	.2											2.0						
large-celled brown							.2											
RHODOPHYTA (Red algae)																		
Acrosorium uncinatum	5.5	8.8	17.0	6.6	10.3	3.6	23.5		.2								.6	
Anisocladella pacifica		.2																
Bossiella orbigniana	1.8	3.8					.2											
Bossiella sp.																		
Callithamnion rupicolum	1.5	1.8		2.0	8.0	7.6											.6	
Centroceras clavulatum	.5	23.2	6.2	2.3	1.6	4.3	28.8	91.2	29.5						5.3		2.0	.3
Ceramium eatonianum		2.2		1.0	.3	2.0	1.8										.6	
Ceramium sp.						2.3												
Chondria californica	.2	4.8	10.8				1.2											
Chondria nidifica	3.2	1.0																
Chondria sp.		1.5			.6													
Coeloseira parva		1.8	2.0			.3	.5											
Corallina frondescens	5.8		9.8	12.6	16.3	33.6	6.2		1.8								2.3	

TABLE 3. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
Corallina officin. v. chilensis		6.8	.8	.3	4.6	.6												
C. pinnatifolia		42.0	35.5	6.6	3.3	.3	74.5	26.0	46.8						5.3		.6	
Haliptylon gracile	.2																	
Cryptopleura corallinara		.8			1.3	.6	1.0											
C. crispa	.2	.2		2.3	11.6	1.6	.2											
Cumagloia andersonii		.2					.8											
Endocladia muricata																		
Erythrocystis saccata			.2															
Erythrotrichia sp.																		
Gastroclonium coulteri																		
Gelidium nudifrons																		
G. pusillum		1.2		2.3	2.3	6.3									.6	.6	.6	52.0
G. robustum																		
Gigartina canaliculata		.5			.3			1.8										
G. leptorhynchos		.5			1.0	.6												
G. tepida	.2	2.5	.2	2.3	8.0	14.3	2.0		2.0								1.0	.3
Gloiosiphonia verticillaris																		
Gloiosiphonia sp.																		
Griffithsia pacifica																		
Herposiphonia parva		5.2	.8			1.6												
Herposiphonia sp.																		
Hildenbrandia sp.															2.3			
Hypnea valentiae		7.0	26.8				2.5		1.8									
Janczewskia lappacea		.2																
Jania crassa		.2	2.5				33.0											
Laurencia diegoensis			.2						.5									
L. pacifica		1.0	1.8	4.2	.3	4.0	6.0									.6	4.6	
L. sinicola		6.0	.5	.6		1.3	15.5	.5	.2						.6			
L. splendens		.8																
L. subopposita		.2	.5			.6												
Laurencia sp.																		
Lithothamnion sp.	1.2		1.5	10.0	5.6	16.6				10.0	8.0	12.3			4.3	.3	4.6	1.6
Lithothrix aspergillum			2.8	.3	2.3		1.8		6.0								.3	
Melobesia mediocris	50.0		52.0															
Nienburgia andersoniana	3.2	.2		.3	1.3	.3	.5											
Petroglossum pacificum		.5																
P. parvum			.8															
Plocamium cartilagineum	9.2	1.8	4.0	.6	1.3		2.8											
Polysiphonia savatieri																	.3	
Polysiphonia sp.																		
Prionitis lanceolata																		
Pterocladia caloglossoides							.5											
P. capillacea		5.0	.8	1.6	17.0	.6	7.0	.5										
Pterosiphonia baileyi		2.8	.2				1.0											
P. dendroidea		.5			1.3													

TABLE 3. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
Rhodoglossum affine	1.0	.5		.6	1.0	1.3									.6		.6	
Rhodymenia californica	1.0						.2											
Rhodymenia sp.		.2			.6													
Smithora naiadum																		
Unknown #1							.2											
Champia-like (unknown)			.5	.6		.3	9.5	13.5							3.6			
Forked epi on L. pacifica																	.6	
Gelidium-like (unknown)		.8																
Unidentified algae																		
TRACHEOPHYTA (Higher Plants)																		
Phyllospadix scouleri	95.8	51.8	47.5															
Phyllospadix sp.																		
TOTAL COVER	52.8	67.2	83.0	89.0	85.3	93.6	98.8	97.8	84.8	65.0	53.6	67.0	55.6	91.3	69.6	76.3	89.0	96.6
NUMBER OF SPECIES	26	48	30	27	30	29	29	6	14	5	6	4	1	5	11	4	20	5

TABLE 4. Fall 1976 inventory of the animals of the Cabrillo National Monument intertidal zone. Data are numbers of animals per m^2 for six habitats under three public use conditions. *Indicates that the underlined values are significantly different at the 95% probability level.

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
SPECIES FOUND IN SPRING 1976																		
PORIFERA																		
Yellow sponge																		
CNIDARIA (Coelentrates)																		
Anthopleura elegantissima				2	11	362	3	82	8				7	13	320	80	100	460
A. xanthogrammica																		
Astrangia lajollaensis																		
ANNELIDA (Segmented worms)																		
Unidentified tube building worm																		
Eupomatis gracilia																		
Halosydna johnsoni																		
Phragmatopoma californica				132	51	88							0	0	100	20	93	13
Spirorbis squamosa																		
Spirorbis sp.																		
MOLLUSCA																		
Gastropoda (Snails, sea slugs)																		
Acanthina lugubris				0	0	9				2	0	7		0	20	7	47	0
Acmaea digitalis										181	288	100	33	20	0	27	13	7
A. insessa																		
A. limatula																7	0	67
A. paleacea	+	+	·															
A. pelta				3	4	2												
A. scabra				36	10	49				97	60	27	80	127	0	607	233	607
A. strigatella				39	58	96				62	42	12	47	47	7	740	460	453
Total Acmaea				78	72	147				340	390	139	160	194	7	1381	706	1134
Anachis penicillata																		
Ceratostoma nuttalli																		
Conus californicus																		
Crepipatella lingulata																		
Epitonium tinctum																		
Erato vitellina																		
Fartulum occidentales																		
Fissurella volcano				6	4	2												
Hermissenda																		
Homalopoma luridum																		
Hopkinsia rosacea																		
Hyalina taeniolata																		
Lacuna unifaciata	·	+	·															
Littorina planaxis										3	1	7						
L. scutulata										43	116	87	93	1540	0	7	0	7

TABLE 4. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
										12	3	1				13	13	0
Lottia gigantea																0	7	0
Macron lividus	1	0	0	1	6	13												
Mitrella carinata	-	-	.	9	0	2										7	0	0
Ocenebra circumtexta				1	0	0												
O. poulsoni																		
Odostomia nota																		
Pseudomelatoma penicillata				0	11	0												
Serpulorbis squamigerus																		
Tegula funebralis																		
T. eiseni																		
Tricolia pulloides	-	-	-															
Trimusculus reticulata																		
Turbonilla sp.																		
Pelecypoda (Bivalves)																		
Glans subquadrata				2	18	64				3	0	3	93	33	0	1307	687	913
Mytilus californianus																		
Netastroma rostrata																		
Penitella penita				0	2	0												
Pseudochama exogyra				7	3	18				0	1	0	7	153	0	60	40	7
Septifer bifurcatus																		
Polyplacophora (Chitons)																		
Cyanoplax hartwegii				10	4	16				7	1	14						
Lepidozona californiensis																		
Mopalia muscosa																20	0	0
Nuttallina fluxa				0	4	3				7	0	6						
ARTHROPODA																		
Cirripedia (Barnacles)										6	0	0	20	13	0	660	0	113
Balanus glandula				11	6	0				394	469	150	11700	43000	24867	4580	2933	17567
Chthamalus fissus				1617	533	2067										500	93	13
Pollicipes polymerus				0	0	1				34	0	1	53					
Tetraclita squamosa				9	26	227								0	13	200	73	540
Isopoda																		
Cirolana harfordi																		
Idothea sp.																		
Amphipoda	-	-	-	-	-	-	.	.	+									
Pycnogonida																		
Malacostraca (Crabs, shrimp)																		
Unidentified shrimp																		
Loxorhynchus crispatus				2	2	1	0	3	0	2	3	13				27	7	7
Pachygrapsus crassipes				0	0	1	2	4	2									
Pagurus samuelis																		
Petrolisthes cinctipes																		
Pugettia producta																		
Unidentified crab																		

TABLE 4. (Continued)

Habitat:	Phyllospadix			Pelvetia Rocks			Algal Mat			Cliff Face			Barnacle Rocks			Mytilus Rocks		
Use Condition:	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use	Low use	North use	South use
SPECIES FOUND ONLY IN FALL 1975																		
ANNELIDA (Segmented worms)																		
Polychaete-tube building							1											
Red polychaete									1									
MOLLUSCA																		
Gastropoda																		
Acanthina spirata																		7
Haliotis cracherodii																1		
Haminoea virascens									1									
Tegula aureohneta									1									
Tricolia pulloides																		
Mitrella carinata																		
Pelecypoda																		
Cumingia							3											
Diplodonta							1											
ARTHROPODA																		
Isopoda																		
Green isopod (Penticlotea resecata)		3																
Isopod (unidentified)							1											
Ligia occidentalis												1						
Malacostraca (Crabs, shrimp)																		
Cancer antennarius									1									
Lysmata californica (Red shrimp)							4											
Pagurus samuelis should be listed as Pagurus sp.																		
Spirontocaris picta (Green shrimp)									2									
TOTAL NUMBER OF SPECIES	3	2	3	17	18	19	8	4	8	15	11	15	11	10	7	20	15	16
DENSITY	3+	2+	3+	1965	825	3177	16	90	17+	1193	1374	567	23993	45140	25334	10251	5505	21915

TABLE 5. Comparison of filter feeders, grazers, and predators in the Low, North and South Use areas. Data are numbers per square meter in Spring 1976.

Filter feeders included: Red sponge, yellow sponge, Phragmatopoma californica, Serpulorbis squamosa, Glans subquadrata, Mytilus californi Neostoma rostrata, Penitella penita, Pseudochama exogyra, Septifer bifurcatus, Balanus glandula, Chthamalus fissus, Policipes polymerus, and Tetraclita squamosa.

Grazers included: Acmaea digitalis, A. insessa, A. limatula, A. paleacea, A. pelta, A. scabra, A. strigatella, Crepipatella lingulata, Homalopoma luridum, Lacuna unifaciata, Littorina scutulata, L. planaxis, Lottia gigantia, Tegula funebralis, T. eiseni, and Fissurella volcano.

Predators included: Acanthina lugubris, Ceratostoma nutalli, Conus californicus, Epitonium tinctum, Erato vitellina, Macron lividus, Ocenebra circumtexta, O. poulsoni, and Pseudomelastoma pencillata.

Habitat and Use Condition		Filter Feeders	Grazers	Predators
Phyllospadix Pools	Low Use	0	5.0	1.6
	North Use	0	75.0	0
	South Use	0	110.0	0
Pelvetia Rocks	Low Use	5,793	86	7
	North Use	2,394	141	7
	South Use	7,527	280	20
Algal Mat	Low Use	0	.8	0
	North Use	0	20.0	0
	South Use	5	0	5
Cliff Face	Low Use	714	725	0
	North Use	1,780	940	0
	South Use	867	627	13
Barnacle Rocks	Low Use	28,610	730	0
	North Use	39,000	590	0
	South Use	34,850	500	10
Mytilus Rocks	Low Use	13,035	349	3
	North Use	10,780	600	30
	South Use	11,370	420	0
"Random" Rocks	Low Use	16,166	224	2
	North Use	21,786	378	10
	South Use	25,468	330	14

TABLE 5. (Continued)

Habitat and Use Condition		Filter Feeders	Grazers	Predators
Under Rocks	Low Use	307.1	17.8	0
	North Use	329.1	11.7	14.8
	South Use	103.9	6.7	1.4
Average for all seven habitats	Low Use	8,078	267	1.7
	North Use	9,509	344	7.7
	South Use	10,024	284	7.9
Average for Pelvetia Rocks, Cliff Face, Barnacle Rocks and Mytilus Rocks	Low Use	12,038	472	2.5
	North Use	13,489	568	9.2
	South Use	13,654	457	10.8

TABLE 6. Comparison of filter feeders, grazers, and predators in the Low, North and South Use areas. Data are numbers per square meter in Fall 1976. Species included in each feeding group are as in Table 4.

Habitat and Use Condition		Filter Feeders	Grazers	Predators
Pelvetia Rocks	Low Use	1,778	84	2
	North Use	639	76	6
	South Use	2,465	149	22
Cliff Face	Low Use	437	398	2
	North Use	470	510	0
	South Use	154	234	7
Barnacle Rocks	Low Use	11,873	253	0
	North Use	43,159	1,734	0
	South Use	24,980	7	20
Mytilus Rocks	Low Use	7,327	1,401	20
	North Use	3,919	714	14
	South Use	19,166	1,141	54
Average for the four habitats considered	Low Use	5,354	534	4.8
	North Use	12,047	434	15.0
	South Use	11,691	383	12.3