

# INTERTIDAL BRYOZOA (CHEILOSTOMATA) OF THE KODIAK VICINITY, ALASKA

By

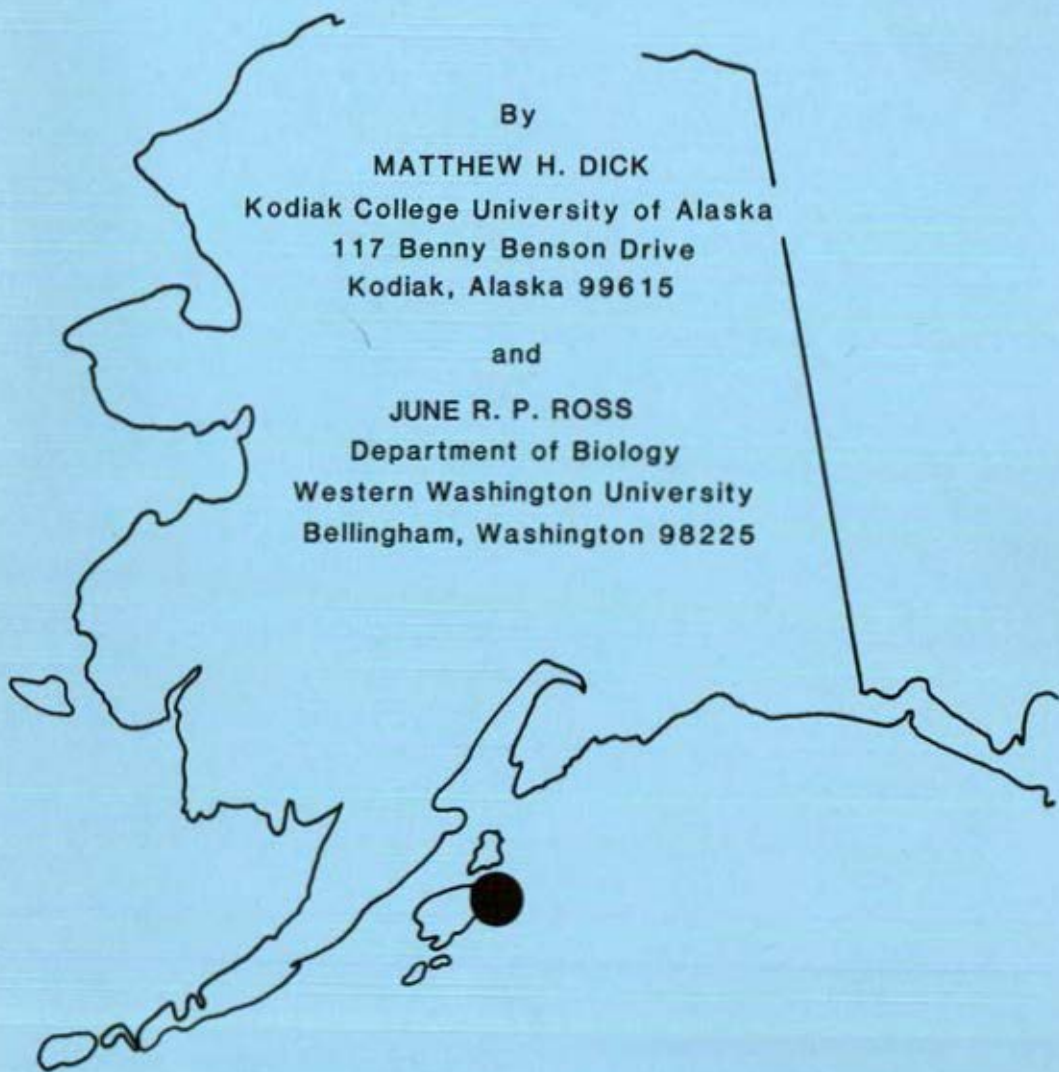
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## ABSTRACT

The distribution and abundance of cheilostome bryozoans in the cryptic, intertidal rock-pile habitat were investigated along an 11 km stretch of protected outer coast at Narrow Strait in the western Gulf of Alaska. One hundred and ten rocks with a combined area of 4.25 m<sup>2</sup> were examined. Fifty-seven species were found, 14 of which are described as new. Twenty-three species proved to be prominent, judged by three subjective criteria. Species composition and relative abundance were strongly influenced by intertidal height at two localities. Faunal differences between sites of similar height and structure were attributed to differences in physical factors, especially wave exposure and degree of variation in salinity, though the relationships were not quantified. A cluster analysis showed that sites of similar height, structure, and environmental characteristics converged with respect to species composition and diversity. The assemblage of bryozoans low in the intertidal zone was defined by the presence of three dominant taxa, *Celleporella* spp., *Microporella* spp., and *Porella alba*. At higher levels, an association defined by *Celleporella hyalina*, *Hippoporina vulgaris*, *Cryptosula okadai*, and *Electra crustulenta* occurred. Nearshore waters in the Kodiak area are polyhaline, and this study added to the list of cheilostomes known to exist in reduced salinity. Forty-four percent of the species at Narrow Strait were of arctic-boreal affinity; 49% had strictly boreal distributions; and 7% had boreal-tropical affinity. Fifty-four percent of the total species, and 92% of the arctic-boreal species, had amphi-Pacific distributions. About half of the total species contained embryos during the study period, early October to early December. Although there appears to be no latitudinal gradient in intertidal bryozoan species diversity, too few intensive studies have been done to permit an unequivocal conclusion. If there is a gradient, then it is probably bimodal, with highest diversities at mid latitudes in both hemispheres. Intertidal bryozoan communities are primarily physically regulated, and diversity is determined by the combined effects of stress gradients.

## INTRODUCTION

The status of knowledge of bryozoans in Alaska was summarized by Dick and Ross (1986). To that summary should be added the work of Kluge (1975), who identified many subtidal species from the Bering and Chukchi Seas. He did not indicate specific localities, so it is impossible to determine which species occurred in the North American region. Nonetheless, this work is a major reference on Alaskan bryozoans. Cuffey and Turner (1987) reported 37 modern bryozoan species in sediment samples from the Kodiak shelf.

The shortcoming of most regional studies on bryozoans is that they include scattered records from geographically wide areas. MacGinitie (1955) wrote, "Only through continued intensive work in a small area can anywhere near an accurate picture of the fauna of a region be obtained." Even when specific localities have been studied, few studies have delineated species assemblages by habitat and depth. In addition, collecting has commonly not been done systematically, making it difficult to determine relative species abundance and the degree to which a species list reflects the actual species diversity in an area. Intensive study in a localized area is necessary for the accumulation of information pertinent to zoogeographical questions, for otherwise numerous uncommon species will not be found. MacGinitie's (1955) study of the benthic fauna at Point Barrow has provided the most comprehensive collection of bryozoans at a single locality along the western coast of North America; even then, the relative abundances of species and the zoogeographic relationships of the bryozoan community were obscured by presentation of the results in a regional taxonomic study (Osburn 1950, 1952, 1953). A similar lack of intensive local studies exists in the western North Pacific and hampers examination of zoogeographic relationships between the bryozoans of Alaska and those of eastern Asia.

Most studies on the structure or dynamics of bryozoan communities have been conducted subtidally, and have dealt with the fauna on natural substrate (Eggleston 1972b, Moore 1973, Jackson and Winston 1982, Grant and Hayward 1986, Hakansson and Winston 1986) settlement panels (Jackson and Winston 1981, Pisano and Balduzzi 1986), or both (Harmelin 1986, Winston and Jackson 1984). The distribution and abundance of bryozoan species, and the diversity and composition of assemblages of species, are related to availability of suitable substrate (Eggleston 1972b, Ryland 1976); to bathymetric range (Ryland 1967; Schopf 1968, 1969; Gordon 1987); to physical factors such as temperature (Abbott 1973, 1975), ice scouring (O'Clair 1981), salinity (Winston 1977, Occhipinti Ambrogi 1986), and current (Annoscia and Fierro 1973, Ryland 1976); and to biotic factors such as larval behavior (Ryland 1974a, 1977), reproductive strategy (Gordon 1970, Eggleston 1972a, Abbott 1975, Ross 1979, Winston and Jackson 1984), competition (Gordon 1972, Stebbing 1973, Jackson 1979, Rubin 1985), predation (Chadwick and Thorpe 1981), and existence on a living substrate (Ryland and Stebbing 1971, Jackson and Winston 1982, Palumbi and Jackson 1982). On a small scale, priority effects related to substrate area and species' relative competitive abilities have an influence on species composition and abundance (Jackson 1977, Jackson 1984, Winston and Jackson 1984). On a large scale, zoogeographical considerations are important (Maturio 1968). Only a few studies (Ryland 1975, Rao and Ganapati 1985) have dealt quantitatively with intertidal bryozoan communities, though other studies in various parts of the world indicate the species composition and richness of intertidal assemblages (Powell and Crowell 1967, Ryland 1974b, Gordon 1980, Winston 1982, Cook 1985).

Our study undertook to examine the species composition, relative abundance, and local distribution of cheilostome bryozoans in the rock-pile habitat along a stretch of shore in the faunally rich, protected outer coast of southcentral Alaska. Preliminary observations indicated that the area was exceptionally rich in bryozoans, and that the rock-pile habitat was richer than algal substrates or rock faces. Furthermore, small rocks were much more amenable to quantitative sampling than solid faces. A secondary goal of the study was to define at least some of the factors which influenced the local distribution and abundance of cheilostomes and their species richness from site to site. A consistent sampling scheme and qualitative knowledge of some environmental factors permitted us to address the secondary goal to a limited extent.

This report builds upon a thesis study (Dick 1984), from which a preliminary paper has been published (Dick and Ross 1986). Additional work on the taxonomy of the species has expanded the list of cheilostomes known intertidally from the Kodiak vicinity. Changes in some of the identifications presented by Dick and Ross (1986) are found in the synonymies of the species described herein. While the study focused primarily on cheilostomes inhabiting rock-pile habitats along Narrow Strait, incidental collections of intertidal cheilostomes elsewhere in the Kodiak archipelago have not turned up additional species. Hence, a broader title has been used for this report.

## ACKNOWLEDGMENTS

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## STUDY AREA

### *General Characteristics*

Narrow Strait (57°54'N, 152°27'W) is a semi-protected stretch of water 10 km long between Kodiak Island and the smaller Spruce Island in the western Gulf of Alaska (Fig. 1). The study area (Fig. 2) included all of Narrow Strait and parts of the eastern and western shores of Spruce Island. Narrow Strait lies in the Kodiak archipelago, which stretches 260 km in a southwest to northeast direction. The shore of the archipelago is highly convoluted and mostly rocky. Narrow Strait has a shore of cliffs falling to the water; beaches of solid rock (reef-flat), boulder, shingle, cobble, or gravel; and a few beaches of fine gravel or sand. Icon Bay and Neva Cove are outlets of extensive, sheltered, estuarine lagoons, and a small estuarine lagoon lies inside Sunny Cove. Eelgrass (*Zostera marina*) is abundant in all of these lagoons. Small freshwater stream outlets are scattered along the study area.

Shore rocks consist of highly metamorphosed, Upper Cretaceous slate, argillite, and graywacke (Capps 1937). The slate is quite fissile; this characteristic is evinced by the ease with which bryozoan specimens can be removed from it compared to the compact, more resistant argillite and graywacke.

Mean sea surface temperature along the Kodiak archipelago ranges from 3 °C in February to 12 °C in August. Surface temperatures in nearshore waters can reach 14 °C in August. During some winters, there is intermittent freezing of surface water at the heads of estuarine bays, but the coast is otherwise ice-free. The Gulf of Alaska is warmer than the Bering sea at the same latitude due to the ameliorating influence of the Alaska Current, which circulates counterclockwise around the gulf.

Surface salinity over the shelf east of Kodiak Island measured in March, 1977, was 32 ppt; salinities in Shelikof Strait west of Kodiak Island during the same month had about the same value from the surface to the bottom (Science Applications, Inc. 1979). Nearshore waters are more brackish because of stream outflow. Salinities measured by M. Dick near the city of Kodiak from July, 1986, to August, 1987, were 21-29 ppt at the surface and 27-30 ppt at 10 m. Salinities at Kalsin Bay near Kodiak from May to August, 1987, were 17-24 ppt at the surface and 22-24 ppt at 5 m, and varied more in the inner portion of the bay than in the outer portion (unpublished data, Alaska Department of Fish and Game). Although no measurements were taken during our study, salinities in the study area probably fall within the range of values given above.

Surface flow along the shelf break is dominated by the Alaska Current, with mean velocities of 0.7-1.0 km/hr and a net drift of 0.7 km/hr to the southwest (Science Applications, Inc. 1979). Inshore currents are tidally dominated. Tidal currents flood toward the northwest and ebb toward the southeast through Narrow Strait, with velocities reaching 2.8 km/hr in Ouzinkie Narrows at the west end (Tidal Current Tables 1988, NOAA, U.S. Dept. of Commerce). The mixed, predominantly semi-diurnal, tides have a maximum diurnal range of 4.1 m.

The shores of Narrow Strait are protected outer coast. Although the eastern end of the strait faces the Gulf of Alaska, it is protected from the full force of easterly storms by a series of subtidal reefs extending offshore from the northeastern tip of Kodiak Island. Fringing beds of bull kelp (*Nereocystis luetkeana*) also reduce wave impact on the shore. In fall and winter, winds are predominantly northeasterly. In spring and summer, predominantly southwesterly winds are favorable for nutrient-rich upwelling over the shelf east of Kodiak Island, with consequent enrichment of the nearshore zone (Science Applications, Inc. 1979).



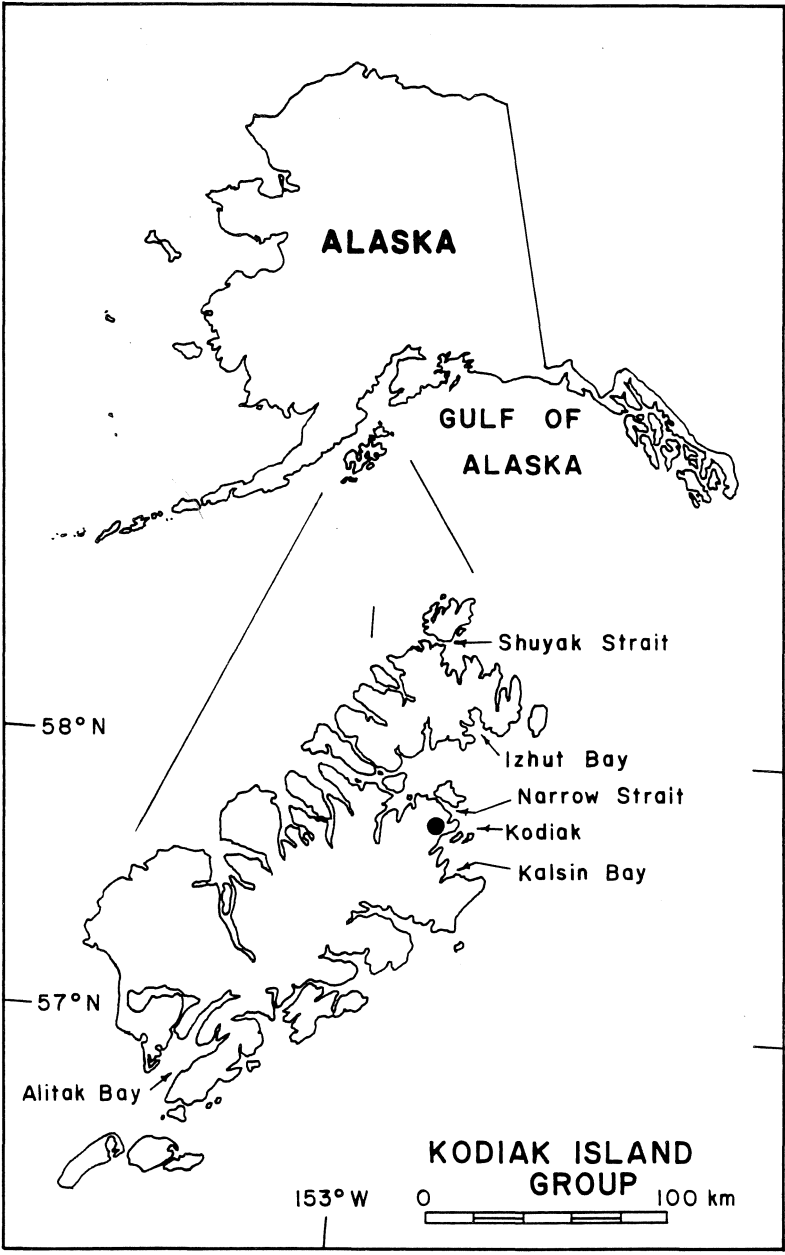


Figure 1. Location of Narrow Strait in Alaska and in the Kodiak Island group.

### Sampling Sites

All work was carried out in the intertidal cryptic rock-pile habitat. The term 'rock-pile' means an aggregation of removable and portable rocks and includes a variety of habitat subdivisions: small rocks lying under or near boulders on reef-flat, or in protected channels in the flat; rocky beach with smaller rocks under large boulders or slabs; and true rock-pile with several layers of rocks fairly uniform in size. The term 'cryptic' indicates the habitat on the undersides of rocks or on all surfaces of rocks which are themselves under slabs or boulders. 'Intertidal' is the area between the splash zone and extreme low water spring tide.

The 14 sampling sites, or stations, in the study area occurred along a variety of environmental gradients, such as intertidal height, degree of wave exposure, beach type, current velocity, and degree of freshwater influence. Figure 2 shows the distribution of stations along some of these gradients. The exact location of each station, a physical description, and a list of associated organisms present were given by Dick (1984: appendix). There was only one station per locality except at Icon Bay and Sunny Cove. Near Icon Bay, Stations 6-8 comprised a limited vertical transect from the upper midlittoral (*Endocladia/Fucus*) zone to the upper infralittoral fringe (*Alaria/Laminaria*) zone. At Sunny Cove, Stations 1 and 2 were situated in the lower midlittoral zone and Station 12 in the lower infralittoral fringe; all were within 50 m of one another.

The most exposed stations were those outside the strait to the east and west; the most sheltered were those behind islands and in coves. Exposure is influenced by factors difficult to assess, such as extent of offshore rocks, reefs and kelp beds. A list of stations from most to least exposed, based on qualitative observations of the area over six years, is as follows: 11, 6-8, 9, 5, 4, 3, 14, 13, 1-2-12, 10.

Differences noted in the type of rocky habitat were as follows. Stations 9 and 11 were reef-flat with scattered boulders and shingle. Most rocks were either too large or not heavily enough encrusted to be suitable for removal as samples (see METHODS). Small and well-encrusted rocks were present in sheltered spots behind boulders, underneath large slab rocks, or in pools and channels in the solid rock. Stations 3, 5 and 10 were of semi-reef-flat type, consisting of moderate numbers of slabs and cobbles on a solid rock base.

Stations 1, 2, 4, 6-8, and 12-14 were layered, either with generally portable rocks under larger boulders or with uniformly small rocks. The layers varied from two to several rocks deep. Stations 1, 2, 3, and 12 were within 0.2 km of stream outlets. Stations 10 and 6-8 were within 0.5 km of the outlets of estuarine lagoons. All eight stations were thus subjected to low and frequently varying salinities. Current velocities were greatest at Station 10, where the strait narrows. A gradient in velocity from one end of the strait to the other probably exists, though no measurements were made.

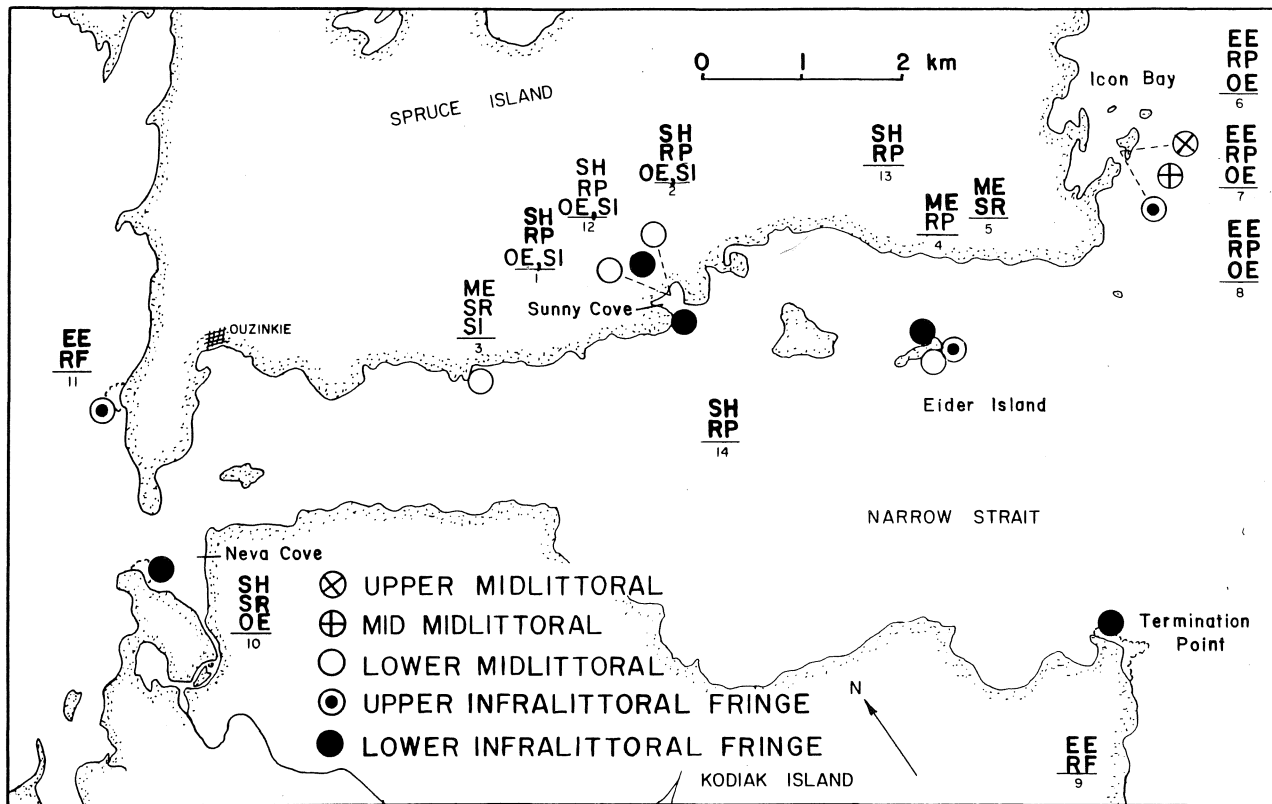


Figure 2. Height, exposure, subhabitat type, and degree of estuarine influence at the sampling stations. EE = extreme exposure; ME = moderate exposure; SH = sheltered; RF = reef-flat; SR = semi-reef-flat; RP = rock-pile; OE = outside estuarine lagoon; SI = stream influence.

## METHODS

### *Fieldwork*

Bryozoans were sampled over a two-month period from 5 October to 2 December, 1982. In preliminary study of the area from 1979 to 1981, several localities rich in bryozoans had been noted. These became Stations 3, 8, 10, and 14. Because greatest bryozoan diversity and cover occur in the lower intertidal, most sampling was carried out on extreme low, or minus, tides. Unfortunately, minus tides fall at night in autumn, and this necessitated travel in the dark by small boat. Choice of sampling localities generally depended upon where a boat could be taken during a minus tide series, given prevailing wind and sea conditions, and where it could be shored and anchored. The base of operations was located at Sunny Cove, and there was thus a concentration of sampling sites nearby.

The sampling unit consisted of a portable, heavily bryozoan-encrusted rock. A sample size of eight rocks was chosen after tabulating the species from ten rocks collected at each of Stations 1, 2, and 3. Graphs of cumulative percent of total species with each successive sample showed that 92-100% of the species present on ten rocks were found by the eighth rock at the three stations. Eight rocks were collected at all stations except Station 9, where only six were taken. Except at midlittoral stations 6 and 7, sampling began at the water's edge at slack low tide. In this way, the absolute as well as the zonal height at which the samples were taken could be gauged. Rocks were overturned and the most heavily encrusted, portable ones were set aside. When the tide began to flood, all the heavily encrusted rocks were reexamined, and the eight most heavily encrusted were wrapped in cloth for transportation. Samples were taken from at least 10 m along the shore at each station, though on some beach types such as reef-flat, considerably more distance had to be covered to find heavily encrusted rocks. Rock samples had to be small enough so that eight rocks could be carried in a backpack over shore to the boat, and small enough to be viewed under a stereoscopic microscope.

At each station, a general description of shore topography was recorded. The common species of macroalgae and macroinvertebrates in the sampling area and in the cryptic habitat were noted or collected, so as to help gauge the degree of exposure. The zonal position of the sampling sites was determined by comparing the lists of organisms present with those given by Zimmerman and Merrell (1976), who classified the rocky intertidal of the Kodiak archipelago into three midlittoral and two infralittoral fringe subzones, according to associations of organisms.

### *Laboratory Work*

Sample rocks were dried indoors. Examination of most of the samples was done on Spruce Island. The large number and considerable weight of rocks allowed us to transport only about 40 of them to Bellingham for study. From the rest, a representative collection of bryozoans was made; rock fragments bearing selected colonies were chipped off and mounted on glass slides.

For each rock, the following information was recorded: estimated area (cm<sup>2</sup>); bryozoan species present; estimated percent cover per species; number of colonies, or density, per species; and presence of embryos in colonies. In estimating the area of a rock, only faces where bryozoans occurred were included. For determining percent cover, a graded series of small to large circles of known areas was drawn on a strip of

paper. Each colony of a particular species was compared with this strip, and the area was either read directly or estimated through interpolation. Areas of irregular colonies were determined by estimating which circle they would occupy if condensed to circular shape. Dimensional measurements were made on large, irregular colonies, and the areas were calculated geometrically. Each colony was dotted with a marking pen to prevent repetition. This method was extremely tedious, but worked under field conditions.

Percent cover was obtained by summing the areas of all colonies of a species and dividing by the total area of the rock. Because it was not possible to estimate small areas of cover accurately, any species which occupied less than 1% was automatically assigned 0.5% cover. Mean percent cover was calculated for each species at each station by averaging the percent cover values from the eight samples.

The total density, or number of colonies, per species at each station was calculated by summing the values from the eight samples. Because sample areas and total area sampled varied, it was necessary to standardize the colony counts. Total areas ranged from 1,666 cm<sup>2</sup> at Station 8 to 4,376 cm<sup>2</sup> at Station 3, with an average of 3,266 cm<sup>2</sup>. Colony counts were standardized to an area of 3,000 cm<sup>2</sup>, or 0.3 m<sup>2</sup>.

### *Prominent Species*

Because of the complexity of animal communities, it is often desirable to choose species that are most important to the communities and subject them to detailed analysis (Lie 1968). The criteria used for the selection of important species vary and are always subjective (Feder et al. 1973). Feder et al. gave a brief review of the terms utilized for important species, which include 'characterizing species', 'numerically dominant species', 'prevalent species', 'ecologically significant species', and 'biologically important species'. Here the term *prominent species* will be used.

A species was determined to be prominent if it satisfied any of the following criteria:

- 1) The species had a mean cover of 1% or more at a station;
- 2) The species comprised 10% or more of the density at a station;
- 3) The species occurred on at least seven of the eight samples at a station.

Although the above criteria are not as rigorous as those utilized in other studies of benthic organisms (Lie 1968, Ellis 1969, Feder et al. 1973) and hence a greater proportion of the total species was selected, the three degrees of prominence allowed the species' importance to be examined at three levels. A species satisfying all three criteria was more prominent than a species satisfying only one or two.

### *Cluster Analysis*

A dissimilarity index was calculated for all possible pairs of stations by two methods, one using values of density/0.3 m<sup>2</sup> as species attributes and the other using values of mean percent cover as species attributes. The index was the Canberra Metric (Lance and Williams 1967):

Canberra Metric =  $(1/n) \sum_{j=1}^p (x_{1j}-x_{2j}) / (x_{1j}+x_{2j})$  where n = number of species in both stations; x<sub>1j</sub>, x<sub>2j</sub> = attribute values of the jth species from the two stations being compared. When an attribute value is zero because a species is lacking at one of the stations, the term

$$(x_{1j}-x_{2j}) / (x_{1j}+x_{2j})$$

becomes unity, no matter how large or small the corresponding attribute value. Clifford and Stephenson (1975) recommended replacing zero values with small positive values. In this study zero was replaced by 0.01% for mean cover and 0.1 for density.

Dissimilarity matrices were entered into the computer program HIERCLUSTER (Western Washington University Computer Center). The program produced dendrograms using two different clustering strategies, group average and incremental sum of squares. The former is weakly clustering and the latter highly clustering. Clifford and Stephenson (1975) recommended using the group average method to check for misclassifications resulting from more intensely clustering programs, and this has been done here.

# RESULTS

## Sampling

In all, 110 rock samples with a cumulative area of 4.25 m<sup>2</sup> were examined. The largest total area sampled, 4,376 cm<sup>2</sup> at Station 3, was 2.6 times as great as the smallest, 1,666 cm<sup>2</sup> at Station 8 (Table 1). This presented a problem in obtaining comparable estimates of species richness from station to station, because the number of species present in a sample increases with increasing sample size (Sanders 1968). Table 2 shows that from 81-100% of the total species found in eight samples at any station was recorded in the first five samples tabulated. At Stations 3 and 8, with the greatest difference between total areas sampled, the first five samples recruited 94% and 100%, respectively, of the species found in eight samples. This levelling off of species recruitment indicates that comparable values of species richness were obtained. Species recorded in the last three samples tabulated were invariably rarer species, making up small proportions of the total density and cover per station.

The percentage of the total species in the first five of eight samples depended upon which five samples were tabulated first. Table 2 also shows the percentage of total species in the combination of five samples which had the lowest species count at each station. The sets of five samples with the lowest species count recruited 53-100% of the

Table 1. Area and number of species per rock sample and per station. n = 8 for all stations except Station 9, where n = 6.

	Station						
	1*	2	3	4	5	6	7
Rock Area (cm <sup>2</sup> )							
Mean	-	346	547	524	439	326	326
(S.D.)	-	(137)	(364)	(201)	(206)	(131)	(240)
Range	-	216-537	114-1,280	176-874	221-896	154-534	64-834
Total area (cm <sup>2</sup> )	-	2,764	4,376	4,196	3,517	2,605	2,611
Species per rock							
Mean	4.1	5.5	7.6	10.0	14.5	3.9	5.9
(S.D.)	(1.5)	(1.4)	(2.5)	(1.4)	(2.3)	(1.6)	(1.9)
Range	2-6	4-8	5-11	8-12	10-18	2-6	3-9
Species per station**	9/9	11/12	18/19	18/19	22/25	7/7	16/17

	Station						
	8	9	10	11	12	13	14
Rock area (cm <sup>2</sup> )							
Mean	208	412	455	369	498	449	509
(S.D.)	(31)	(269)	(137)	(197)	(143)	(103)	(242)
Range	156-259	170-895	333-742	180-658	297-655	312-644	163-800
Total area (cm <sup>2</sup> )	1,666	2,469	3,641	2,953	3,987	3,596	4,072
Species per rock							
Mean	9.8	10.3	12.4	7.9	10.1	16.6	14.9
(S.D.)	(2.0)	(2.7)	(3.1)	(1.9)	(2.4)	(1.5)	(2.4)
Range	7-13	9-14	7-16	6-11	6-14	14-19	11-19
Species per station**	16/20	17/17	31/33	16/18	18/20	28/31	28/31

\*Rock areas were not measured for samples from Station 1.

\*\*The first number shows the same degree of taxonomic resolution as Means and Ranges listed for "Species per rock." The second number includes additional species identified later. Because not all rock samples were saved, the means and ranges of species per rock could not be re-calculated.

total species. The two stations (3 and 7) which showed the greatest differences between species actually tabulated after five samples and species recruited from the five samples giving the minimum recruitment were stations with a wide range in rock sample size. At three of the stations, the first five samples tabulated corresponded to the five samples which recruited the fewest species to the station.

### Prominent Species

A total of 57 species was found in the study (see List of Species Described). Twenty-three species met one or more of the criteria for prominence (see METHODS). Table 3 shows the prominent species by station, and indicates the number of criteria met. Species are listed in order of decreasing overall prominence; those with a high frequency of prominence and which satisfied all three criteria at some stations are ranked above those which were prominent at fewer stations and satisfied only one or two of the criteria. The prominent species comprised from 68-99% (average 86%) of the cheilostome density and from 62-97% (average 83%) of the cover among the stations.

The dominant species along Narrow Strait were *Celleporella hyalina*/*C. reflexa*, *Porella alba*, and *Microporella germana*/*M. neocribroides*. The two species of *Celleporella* and the two common species of *Microporella* were not identified separately initially. Because only a portion of the rock samples were saved, we could not always determine later which particular species of these two genera predominated at a station. *C. hyalina* alone was present at two stations, *C. reflexa* at one. At eleven stations, both species occurred but their relative abundance was not determined. The dominant species of *Microporella* were *M. germana* and *M. neocribroides*, although at Station 8, *M. alaskana* and *M. californica* were fairly common and may have

Table 2. Effectiveness of five versus eight samples per station.

Station	% of total species in first five samples tabulated	% of total colonies added by recruit species in last 3 samples tabulated	% of total cover added by recruit species in last 3 samples tabulated
1	89 (78)*	0.8 (2.6)	0.3 (0.7)*
2	90 (82)	0.5 (3.5)	0.2 (0.4)
3	94 (67)	0.9 (3.8)	1.0 (7.2)
4	89 (78)	0.4 (0.8)	0.8 (1.6)
5	86 (86)	0.3 (0.3)	1.2 (1.2)
6	100 (86)	0.0 (0.2)	0.0 (0.5)
7	87 (53)	1.5 (3.3)	0.4 (12.3)
8	100 (88)	0.0 (1.1)	0.0 (0.7)
9	---	---	---
10	81 (81)	1.6 (1.6)	3.0 (3.0)
11	94 (81)	1.5 (4.2)	1.0 (3.0)
12	89 (83)	0.3 (2.6)	1.1 (5.3)
13	93 (86)	0.1 (0.6)	0.6 (1.5)
14	82 (82)	1.9 (1.9)	2.9 (2.9)

\*In parentheses are corresponding values for the percentage of total species in the five samples which recruit the fewest species at a given station, and the percentages of total colonies and cover added by recruit species in the remaining three samples.



Table 3. Prominent species by station, showing criteria of prominence satisfied by each taxon: a, all; b, cover; d, density; f, frequency (see METHODS for description of criteria).

Species	Station													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<i>Celleporella</i> spp.		a	a	a	a		a	a	cf		df	a	a	a
<i>C. hyalina</i>	cd	*	*	*	*	a	*	*	*		*	*	*	*
<i>C. reflexa</i>		*	*	*	*		*	*	*	a	*	*	*	*
<i>Porella alba</i>	+		a	a	a		cd	a	cf	+	a	f	a	cf
<i>Microporella</i> spp.			cf	cf			a	cf		cd		cf		
<i>M. germana</i>		+	+	*	*		*	*	*	a	*	a	*	cf
<i>M. neocribroides</i>			*	*	*		a	*	*		*	*	*	
<i>Hippothoa mawatarii</i>		a	+	+	f	c	a	cf	c	+	+	+	+	+
<i>Cauloramphus spinifer</i>	+	+	cd	a	f		+	+	cf		+	+	cf	+
<i>Myrzoella plana</i>	+	+	c	+	cf		+	c	+	cf	+	a	f	+
<i>Hippoporina vulgaris</i>	a	cd	+	c	+	c	+				c		+	+
<i>Cryptosula okadai</i>	a	cd	+	+						+			+	+
<i>Callopora decidua</i>					+					f			a	f
<i>Tegella armifera</i>			+	+	cf			+		+		+	cf	cf
<i>Cribrilina annulata</i>	+	+	+	f	f		+	+	+	+	+	+	df	df
<i>Tegella arctica</i>			+	+	cf		+	+	+	+	+	+	cf	+
<i>Electra crustulenta</i>	cd					cf								
<i>Lagenicella neosocialis</i>			+	+	f	+	+	+	+	c	+	c	+	+
<i>Celleporina aspera</i>				+	+		c	cf	c	+	+	+	+	+
<i>Tegella aquilirostris</i>				+	+		+	+	+	+	+	+	cf	c
<i>Cauloramphus variegatus</i>				f	f			+	cf				+	
<i>Parasmittina trispinosa</i>					+					c	+	+	+	f
<i>Cylindroporella tubulosa</i>			+		+					+	+	+	f	+
<i>Cauloramphus magnus</i>			+	+	+	c	+						+	
<i>Tegella horrida</i>							+	c						
<b>Percent of Total Cheilostome</b>														
<b>cover:</b>	97	95	62	93	85	97	84	94	90	72	67	67	90	70
<b>density:</b>	89	86	77	96	94	99	93	89	93	71	71	82	96	68

\*Genus was prominent; both species occurred, and one or both were prominent.

+Species occurred, but did not achieve prominence.

satisfied at least one of the criteria for prominence. *M. germana* alone was present at five stations and prominent at three; *M. neocribroides* occurred alone and was prominent at one station. At six stations, both species occurred and together were prominent, but relative abundance was not determined.

The cheilostome bryozoan association along Narrow Strait, then, may be called a *Celleporella* spp./*Porella alba*/*Microporella* spp. association. At nine of the 14 stations, all three taxa achieved prominence. At Stations 3 and 10, *Microporella germana* and *Porella alba*, respectively, occurred but were not prominent. At Stations 1, 2, and 6, only *Celleporella* was prominent, and one or two of the other defining taxa were absent. At these stations, a different assemblage occurred, defined by *Hippoporina vulgaris* and *Cryptosula okadai* at Stations 1 and 2 and by *Electra crustulenta* at Stations 1 and 6. Stations 1, 2, and 6 had the lowest species richness among all stations (Table 1), and occupied extreme positions along environmental gradients. Station 6 was high and exposed; Stations 1 and 2 were moderately high, quite sheltered, and under considerable estuarine influence from two streams. Thus, at higher, environmentally stressed stations, a *C. hyalina*/*Hippoporina vulgaris*/*Cryptosula okadai*/*Electra crustulenta* association replaced that occurring at lower stations.

*Hippothoa mawatarii*, *Cauloramphus spinifer*, and *Myrzozoella plana* showed moderately high frequencies of prominence and occurrence. *Cribrilina annulata* and *Lagenicella neosocialis* showed high frequencies of occurrence, but were less frequently prominent. Species of *Tegella* were prominent at four stations. Only at Station 8 was a single species prominent; at Stations 5, 13, and 14, all located in the same part of Narrow Strait, two or three species of *Tegella* were co-prominent. While these stations belonged to the *Celleporella* spp./*Porella alba*/*Microporella* spp. association, the occurrence of two or three co-prominent species of *Tegella* defined a special subtype. *Cauloramphus spinifer* and *C. variegatus* were co-prominent at Station 9, and defined another subtype.

Using criteria of prominence obscured absolute abundance, which is best related by mean percent cover, in determining dominant species. However, the three criteria allowed inclusion of species like *Cribrilina annulata* and *Cylindroporella tubulosa*. These either had a high density, or showed a high frequency of occurrence, at some stations. Though they formed predominantly small colonies and never achieved significant cover, they were successful and should be included among the characterizing species in the rock-pile habitat.

### ***Variation with Intertidal Height***

Tables 4 and 5 show change in species composition and cover with intertidal height. At Icon Bay (Table 4), only three of 25 species were distributed throughout the intertidal. One species occurred only in the upper midlittoral zone, and four reached maximum cover there. Seven species were restricted to the infralittoral fringe, and six reached maximum cover there. Two species showed maximum cover in the mid-midlittoral, and one species was restricted to that zone.

At Sunny Cove (Table 5), seven of 25 species occupied both the lower midlittoral zone and the infralittoral fringe. Five species were restricted to the midlittoral zone, and two had higher cover there. Thirteen species were restricted to the infralittoral fringe, and four had higher cover there. Total cover was much greater in the upper zone due to the high cover attained by three of the species.

Some species showed a consistent zonal distribution at the two localities. *Hippothoa mawatarii* was more successful in the midlittoral, although it was prominent in the infralittoral fringe at Station 8. *Hippoporina vulgaris* was restricted to the midlittoral at both sites. *Myriozoella plana* occupied both the midlittoral and infralittoral fringe zones, but was prominent only in the infralittoral fringe.

Table 4. Change in cheilostome species composition and cover with tidal height near Icon Bay, 18 Oct., 1982.

Species	Mean Cover (%)		
	STA. 6	STA. 7	STA. 8
	Upper Midlitt. 2.8 m	Mid- Midlitt. 1.9 m	Infralitt. Fringe -0.3 m
<i>Electra crustulenta</i>	2.3		
<i>Cauloramphus magnus</i>	4.1	0.1	
<i>Hippoporina vulgaris</i>	1.5	0.9	
<i>Tricellaria ternata</i>	0.5	0.1	
<i>Scrupocellaria elongata</i>		0.1	
<i>Hippothoa mawatarii</i>	3.3	6.9	2.3
<i>Celleporella</i> spp.		2.0	2.7
<i>C. hyalina</i>	8.4	+	+
<i>C. reflexa</i>		+	+
<i>Lagenicella neosocialis</i>	0.1	0.1	0.3
<i>Cauloramphus spinifer</i>		0.1	0.9
<i>Celleporina aspera</i>		2.7	5.7
<i>Cribrilina annulata</i>		0.1	0.4
<i>Myriozoella plana</i>		0.6	5.3
<i>Porella alba</i>		2.2	2.8
<i>Tegella arctica</i>		0.3	0.3
<i>Tegella horrida</i>		5.0	0.1
<i>Microporella</i> spp.		24.3	36.5
<i>M. germana</i>		+	+
<i>M. neocribroides</i>		+	+
<i>M. alaskana</i>			+
<i>M. californica</i>			+
<i>Callopora nuda</i>			0.6
<i>Cauloramphus variegatus</i>			0.4
<i>Tegella aquilirostris</i>			1.6
<i>Tegella armifera</i>			0.1
<i>Terminoflustra membranac.</i>			0.3
TOTAL SPECIES	7	17	20
TOTAL MEAN COVER (%)	20.2	45.5	60.3

+Species present but relative abundance undetermined.

The two localities differed in the number of species which overlapped between the midlittoral and infralittoral fringe. At Sunny Cove, a sheltered site, only seven species were common to both zones. At Icon Bay, an exposed site, 13 species overlapped. *Porella alba* and *Microporella* spp. were confined to, or reached greatest abundance in, the infralittoral fringe at Sunny Cove. At Icon Bay they were also prominent constituents of the midlittoral. This greater zonal spread of species at the exposed site was perhaps due to increased submersion at higher levels resulting from wave action.

Table 5. Change in cheilostome species composition and cover with tidal height at Sunny Cove, 5 Oct.-30 Nov., 1982.

Species	Mean Cover (%)	
	STN. 2	STN. 12
	Lower Midlitt. 0.6 m	Infralitt. Fringe -0.7 m
<i>Cryptosula okadai</i>	16.8	
<i>Hippoporina vulgaris</i>	12.7	
<i>Dendrobeatia lichenoides</i>	0.4	
<i>Desmacystis sandalia</i>	0.1	
<i>Harmeria scutulata</i>	0.9	
<i>Cauloramphus spinifer</i>	0.5	0.1
<i>Cribrilina annulata</i>	0.1	0.3
<i>Hippothoa mawatarii</i>	15.9	0.4
<i>Celleporella</i> spp.	3.1	3.4
<i>C. hyalina</i>	+	+
<i>C. reflexa</i>	+	+
<i>Microporella germana</i>	0.1	3.6
<i>Myrionozella plana</i>	0.7	3.4
<i>Callopora nuda</i>		0.1
<i>Callopora decida</i>		0.2
<i>Cylindroporella tubulosa</i>		0.3
<i>Lagenicella neosocialis</i>		1.3
<i>Parasmittina trispinosa</i>		0.6
<i>Porella immersa</i>		0.3
<i>Porella alba</i>		0.7
<i>Posterula sarsi</i>		2.3
<i>Smittina bella</i>		0.1
<i>Tegella aquilirostris</i>		0.1
<i>Tegella arctica</i>		0.8
<i>Tegella armifera</i>		0.6
<i>Cauloramphus spectabilis</i>		0.1
TOTAL SPECIES	12	20
TOTAL MEAN COVER (%)	51.3	18.7

+Species present but relative abundance undetermined.

Icon Bay and Sunny Cove were of similar habitat type, layered rock-pile, and samples were taken in both the infralittoral fringe and the midlittoral zones at both sites. The two sites each had an overall richness of 25 species. Yet, of 36 species occurring at either site, only 14 (39%) were common to both. Other factors than habitat subtype or height are implicated in determining the different species compositions. The main difference between the two sites is degree of exposure. *Celleporina aspera* and *Microporella neocribroides*, both common in exposed areas in the Kodiak region, were prominent at Icon Bay but did not occur at Sunny Cove. Although both sites are located near the outlets of estuaries, the stations at Sunny Cove lie between the mouths of two streams and probably undergo more drastic variations in salinity.

### *Species Richness, Density, and Cover*

Total cheilostome density and mean cover by station are shown in Figure 3. Table 6 ranks the stations by increasing species richness and gives total mean cover, total colony density standardized to 0.3 m<sup>2</sup>, and mean colony size, obtained by dividing total bryozoan cover at a station by total density. Regression analyses were done to determine the relationships between these parameters. All combinations of the four were tested at the 0.05 significance level. There were only two significant regressions. Total colony density increased with increasing species richness ( $F_{\text{calc}} = 6.83 >$  critical value  $F = 4.84$  at 1, 11 d.f.), and total mean cover increased with increasing colony size ( $F_{\text{calc}} = 89.7 >$  critical value  $F = 4.84$  at 1, 11 d.f.). Species able to exist in stressed environments are likely adapted to those environments and tend to attain high abundance. The best adapted species become highly dominant. Examples of these dominant species were *Cryptosula okadai*, *Hippoporina vulgaris* and *Hippothoa mawatarii* at Station 2 and species of *Microporella* at Stations 7 and 8. Mean colony size and total mean cover of bryozoans (Table 6) were greatest at these three stations.

Table 6. Species richness, cover, colony size, and density of cheilostome bryozoans at Narrow Strait.

Station	Species Richness	Total Mean Cover(%)	Mean Colony Size(cm <sup>2</sup> )	Total Colony Density/0.3m <sup>2</sup>
6	7	20.2	1.0	598
1	9	29.9	-	-
2	12	51.3	7.1	218
7	17	45.5	3.5	389
9	17	22.9	0.6	986
11	18	9.6	0.7	411
3	19	9.7	1.0	306
4	19	24.7	0.8	929
12	20	18.7	0.8	723
8	20	60.3	1.9	956
5	25	21.0	0.5	1,287
14	31	19.7	0.8	811
13	31	33.5	0.5	2,103
10	33	16.7	0.6	905

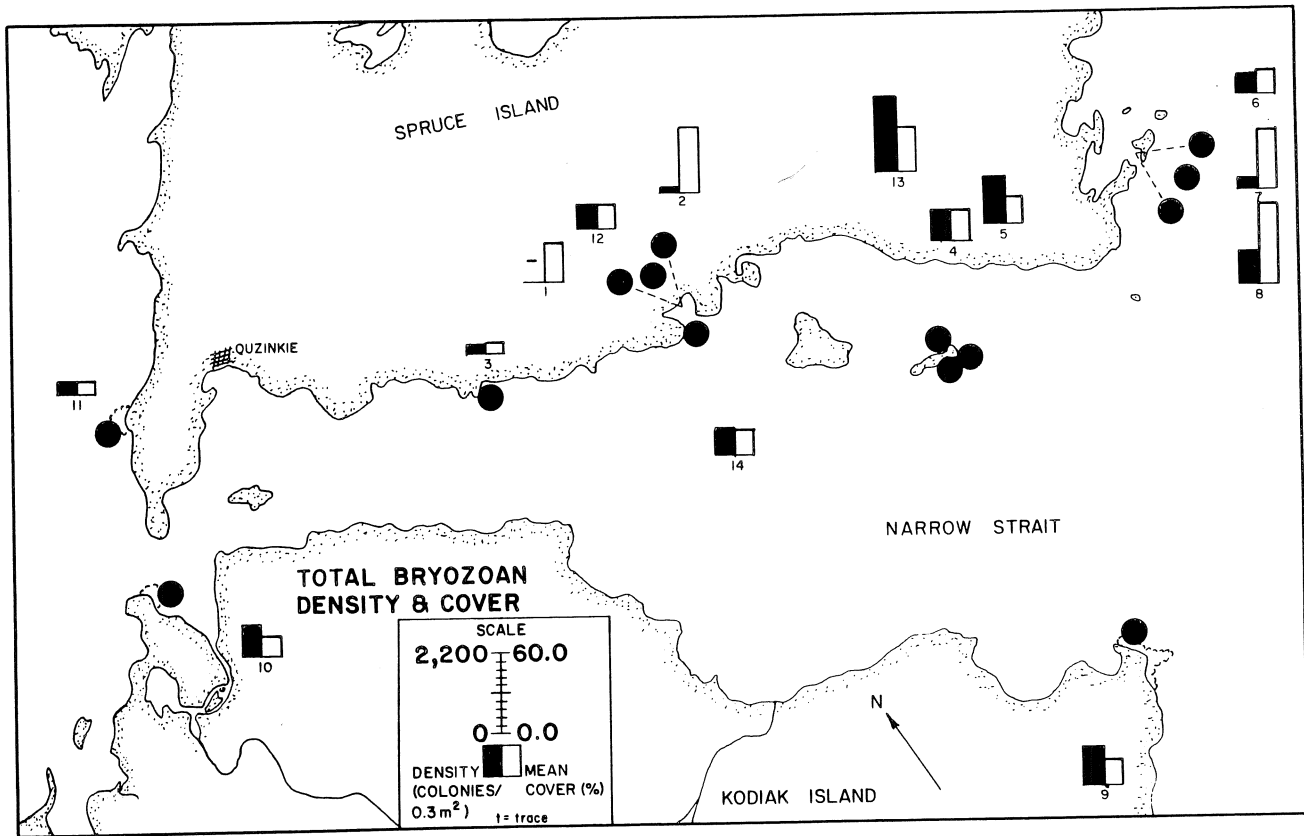


Figure 3. Total cheilostome density/0.3 m<sup>2</sup> and mean percent cover by station.

That factors other than intertidal height influenced species richness is shown by comparing the richness of stations of equivalent height. None of the other factors was measured, and these comparisons are only speculative. In the lower midlittoral, Stations 1 and 2 in sheltered Sunny Cove were less diverse than Stations 3 and 4 which faced onto Narrow Strait. The height gradient at the latter two was possibly shifted upward by splash effects of exposure. A clear stream and a stream running through a tideflat estuary drain into Sunny Cove; sedimentation and variable salinity may have been factors in the lower diversity there.

In the upper infralittoral fringe, Station 5 was not as exposed as either of the other stations of identical height, 8 and 11, and it had higher diversity. Whereas a little exposure increased diversity at Stations 3 and 4 relative to Stations 1 and 2, more extreme exposure in this case reduced diversity. The stresses resulting in the lower diversity at Station 8 may have been different from those at Station 11, as the two were of different subhabitat types: layered rock-pile at the former, reef-flat at the latter.

In the lower infralittoral fringe, Station 12 at Sunny Cove was considerably less diverse than Stations 10, 13, and 14 of similar subhabitat type. Station 12 was sheltered and probably more affected by salinity variation and sedimentation than the other stations. Station 9, also in the lower infralittoral fringe, was approximately equivalent in diversity to Station 12. It was on exposed reef-flat, and the reduced diversity could have been due to paucity of suitable substrate or to the distance of rocks from sources of colonizing larvae. The lower diversities at Stations 9 and 12 probably resulted from different combinations of stresses.

### *Cluster Analyses*

In order to examine what factors in addition to intertidal height might influence the local distribution of bryozoans, four cluster analyses were performed to determine patterns in the similarities of stations. The cluster analyses utilized two dissimilarity matrices, one based on density and the other on mean cover, and two clustering strategies, group average and incremental sum of squares (see METHODS). The results of the two clustering strategies were nearly identical, and only the results from the group average strategy will be presented.

Dendrograms are shown in Figures 4 and 5. They can be interpreted with reference to Figure 2. Both dendrograms showed clustering attributable to intertidal height. Four of the lowest stations (10, 12, 13, 14) clustered together. The highest station (6) was dissimilar to all other stations.

When stations of equal height cluster apart or, stated conversely, stations of different height cluster together, factors other than height are indicated in determining the similarity of the species assemblages. For example, Stations 1, 2, 3, and 4 were of equivalent height. In Figure 4, Station 2 was quite dissimilar from Stations 3 and 4, which were more similar to one another. Station 1 was not included in the analysis because sample areas were not measured and densities could not be standardized. In Figure 5, Stations 1 and 2 clustered together. Stations 1 and 2 were close to one another, quite sheltered, and probably encountered variation in salinity due to stream outlets nearby. Stations 3 and 4 faced the strait and were moderately exposed. Station 3 was also near a stream outlet, but its greater exposure perhaps allowed greater mixing.

Clustering attributable to exposure or subhabitat type is more clearly evident in Figure 4. Stations 3, 4 and 5, all moderately exposed stations facing southerly onto the

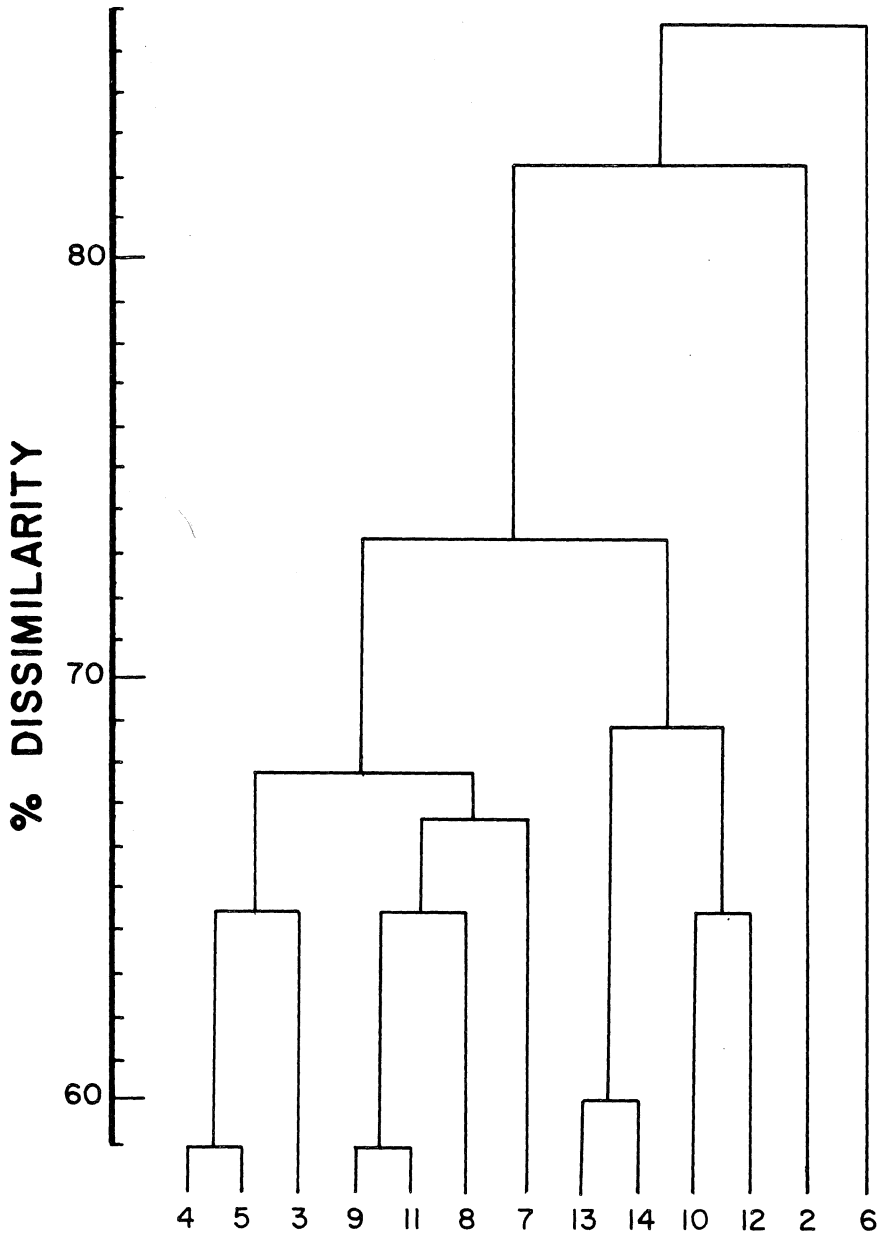


Figure 4. Dendrogram showing similarity of stations based on attributes of cheilostome density/0.3 m<sup>2</sup>.



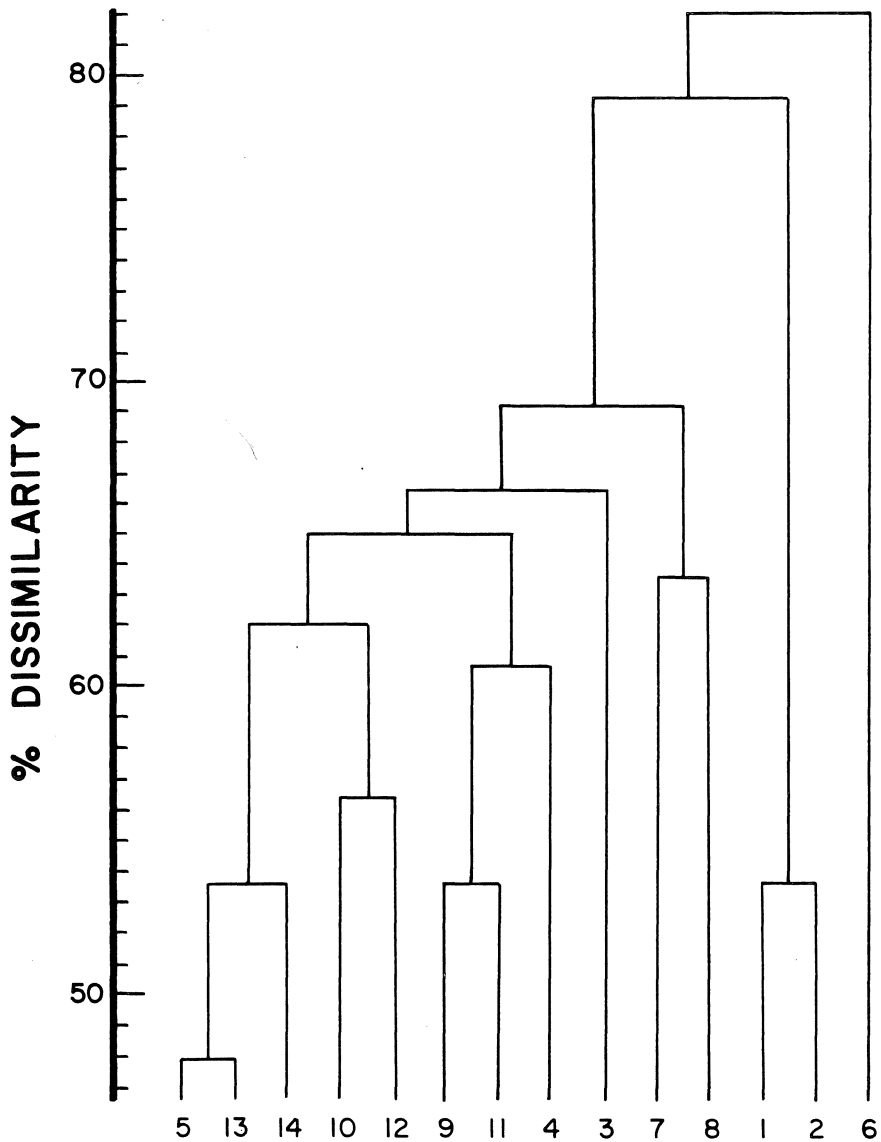


Figure 5. Dendrogram showing similarity of stations based on attributes of cheilostome mean percent cover.

strait, clustered together. Adjacent stations 4 and 5 were more similar to one another than to Station 3. The clustering of Stations 9 and 11 was the strongest indicator that subhabitat type influences the species association at a locality. These were the only stations located on true reef-flat, even though they were at opposite ends of the strait and of slightly different height. Station 8, an exposed site with a layered rock-pile structure, was more similar to exposed stations 9 and 11 than to Station 4 of comparable height and structure. Station 7 clustered with the other exposed stations, but it was the least similar due to its height. Stations 10, 12, 13 and 14 were all sheltered, infralittoral fringe sites. Station 12 was more similar to Station 10 than to nearby stations 13 and 14, even though species richness was significantly higher at the latter three stations (Table 4). Stations 10 and 12 were the most sheltered in the study area and were both located in areas of considerable estuarine influence.

Although environmental gradients were not measured, the cluster analyses indicated that the following factors might be involved in determining the species association at a particular intertidal height: subhabitat type; reef-flat versus layered rock-pile; degree of exposure to wave action; and degree of variation in salinity.

### *Zoogeography*

The west coast of North America comprises a number of zoogeographical regions which are defined by both faunal characteristics and hydrographic parameters (Ekman 1953, Briggs 1974, Bond 1979). The Arctic Region extends from arctic Alaska southward to Nunivak Island in the Bering Sea, at 60° N latitude. This boundary approximates the southern limit of pack ice in winter. Arctic waters are 0° C or less in winter and reach 5° C or somewhat more in summer. The Boreal, or Cold Temperate, Region extends from Nunivak Island to Point Conception, California, at 34-35° N. The Boreal Region is considered to be divided into a northern portion called the Subarctic or North Boreal Region, and a southern portion called the South Boreal Region. The boundary between the two lies at 42° N, just north of Cape Mendocino, California. The North Boreal Region is characterized by winter surface temperatures colder than 10° C and summer surface temperatures of 10-14° C. The South Boreal Region occupies a narrow portion of the California coast from near Cape Mendocino to Point Conception. Winter surface temperatures are 10-13° C. South of the Boreal Region, from Point Conception to the tip of Baja California, lies a Warm Temperate, or Subtropical, Region. The southern boundary lies at about 23° N, and winter surface temperatures are 13-20° C.

These regions are delineated by winter isotherms and can, therefore, be traced around the northern hemisphere. Although species of organisms may vary from one continental margin to another, the same groups of organisms tend to occur. For example, fishes of the Boreal Region worldwide include many species of sculpins, liparids, flounders, cods, and others (Bond 1979). Because many of the species within such common groups inhabiting a circumglobal hydrographic region vary from one ocean to another, from the eastern to the western part of the same ocean, or along a north-south gradient, it is useful to divide these regions into provinces. Provinces are delineated by the degree of endemism one area shows from other areas. The degree of endemism necessary to delineate a province is arbitrary. Briggs (1974) considered endemism of 10 percent or more to be sufficient to establish a province.

Provinces have not been designated in the Arctic Region because most species occurring there tend to be circumpolar in distribution. This has been well established for bryozoans (Osburn 1955) and for other groups reviewed by Briggs (1974). The Boreal Region in the eastern Pacific has historically been divided into a northern Aleutian Province and a southern Oregon Province. The boundary between the two has been variably placed by authors studying fishes, algae or invertebrates. Briggs (1974) felt there was good evidence for a boundary along the Alaskan Panhandle, perhaps as far north as Sitka, but lent more credence to Valentine's (1966) work on molluscs, which indicated a boundary near the Dixon Entrance.

Fourteen of the 57 species we found at Narrow Strait are described as new. Of these, only *Microporella alaskana* and *Lagenicella neosocialis* have known ranges extending outside Alaska. The rest will be considered boreal species so that our results are comparable with those of Androsova (1958); however, only species of known range are given in the following lists.

### *Arctic-Boreal Species*

In this group are species which range from arctic waters southward to temperate waters. The status of two species is uncertain. Although *Parasmittina trispinosa* has been reported from tropical waters, it belongs to a taxonomically difficult group and is likely restricted to boreal waters. *F. malusii* has often been considered "cosmopolitan," but will probably be resolved into a number of morphologically similar species in any region where it is studied in detail. For the purpose of this analysis, we consider "*F. malusii*" to be an amphi-Pacific boreal species extending southward at least to British Columbia; see the species' treatment under Systematics for further remarks on distribution. The arctic-boreal species are listed by the area of their easternmost or southernmost extent along the eastern Pacific coast (It is necessary to specify 'easternmost extent' because the tip of the Alaska Peninsula lies about as far south as Dixon Entrance in southeastern Alaska). Asterisks indicate an amphi-Pacific boreal distribution.

#### Narrow Strait

- Smittina majuscula*
- \* *Porella alba*
- \* *Schizomavella porifera*
- \* *Smittina bella*
- Harmeria scutulata*

#### Southeast Alaska

- \* *Callopora craticula*
- \* *Tegella arctica*
- \* *Posterula sarsi*
- \* *Myrziopora plana*

#### Queen Charlotte Is. and British Columbia

- \* *Microporina articulata*
- \* *Terminoflustra membranaceotruncata*
- \* *Cribrilina annulata*
- \* *Cylindroporella tubulosa*
- \* *Fenestulina malusii*

Puget Sound

- \* *Scrupocellaria elongata*
- \* *Rhaphostomella costata*
- \* *Stomachetosella cruenta*
- \* *Stomachetosella sinuosa*

California north of Pt. Conception

- \* *Electra crustulenta*
- \* *Tegella armifera*

Pt. Conception to tip of Baja California

- \* *Tricellaria ternata*
- \* *Porella acutirostris*
- \* *Porella concinna*
- \* *Celleporella hyalina*

South of Baja California

- \* *Parasmittina trispinosa*

**Boreal Species**

The boreal species are listed by their their easternmost or southernmost extent in the eastern Pacific. The range of *Cauloramphus spinifer* is a problem because Osburn (1950) applied the name to another species, and the southern limit of its range is unknown. Asterisks indicate an amphi-Pacific distribution.

Narrow Strait and Gulf of Alaska

- \* *Hincksina longiavicularia*
- \* *Cauloramphus pseudospinifer*
- \* *Cauloramphus spinifer*
- \* *Cryptosula okadai*
- \* *Porella immersa*

British Columbia

- \* *Desmacystis sandalia*
- Dendrobeania exilis*
- Codonellina argentea*

Washington

- \* *Tegella aquilirostris*
- Microporella alaskana*

California north of Pt. Conception

- Cauloramphus variegatus*
- Dendrobeania lichenoides*
- Hippoporina apertura*

Pt. Conception to tip of Baja California

- Lagenicella neosocialis*
- Celleporina robertsoniae*
- Fenestrulina porosa*

Four of the boreal species (*Hincksina longiavicularia*, *Cauloramphus pseudospinifer*, *Cryptosula okadai* and *Porella immersa*), all originally described from the western Pacific, have been found for the first time in the eastern Pacific. Similarly, *Desmacystis sandalia*, originally described from the eastern Pacific, was only recently found in the western Pacific (Gontar 1982). With future work, more boreal species will no doubt be found to have amphi-Pacific distributions. The ranges of many of the boreal species apparently endemic to the eastern Pacific (*Cauloramphus variegatus*, *Dendrobeania exilis*, *Codonellina argentea*, *Microporella alaskana*, *Hippoporina apertura*, *Fenestulina porosa*, *Lagenicella neosocialis*, and *Celleporina robertsoniae*) have been extended considerably northward.

### ***Boreal-Tropical Species***

This group includes species which extend from the Northern Boreal Region to tropical waters. Asterisks indicate an amphi-Pacific distribution.

- \* *Tegella horrida*
- Porella columbiana*
- Microporella californica*
- Rhynchozoon rostratum*

The following table shows the proportions of species in each zoogeographic region.

	Number	Percent
Arctic-boreal species	25	44
Amphi-Pacific boreal	23	40
Eastern Pacific only	2	4
Boreal species	28	49
Amphi-Pacific	7	12
Eastern Pacific endemics	9	16
New species, Alaska only	12	21
Boreal-tropical	4	7
Amphi-Pacific	1	2
Eastern Pacific endemics	3	5

Rather than omit new species from the analysis, as previously (Dick & Ross 1986), we have included them as boreal species. This allows comparison with Androsova's (1958: 180) results from the northern Sea of Japan. She found a higher proportion (54%) of arctic-boreal species and a lower proportion (43%) of boreal species, despite the fact that her study area is approximately eight degrees of latitude farther south than Narrow Strait. One factor in the difference may be that we considered only intertidal species, whereas Androsova's material was subtidal. Arctic species limited by maximum summer temperatures would extend farther south subtidally than intertidally. If this is so, then the subtidal fauna in the Kodiak area should show a higher proportion of arctic-boreal species than the intertidal fauna. Androsova found nearly the same proportion (13%) of boreal species with amphi-Pacific distributions.

All but two of the 25 arctic-boreal species recorded at Narrow Strait are of amphi-Pacific boreal occurrence. About half of the boreal species with the southern extent of the range ending north of California are also amphi-Pacific, but none of the

boreal species extending as far south as California is. The latter are endemic eastern Pacific species for which Narrow Strait is close to the northern or western limit of the range. The eastern extent of the known range of eight of the 30 amphi-Pacific arctic-boreal and boreal species lies at Narrow Strait or the Gulf of Alaska.

The proportions of amphi-Pacific species in each zoogeographic region are given in the following table; the new species are included as boreal species.

	Total Number	Amphi-Pacific Number	Percent
Arctic-boreal species	25	23	92
Boreal species	28	7	25
Boreal-tropical species	4	1	25
All species	57	31	54

### ***Reproduction***

The occurrence of embryos noted during the study period (early October-early December, 1982) and also at other times of the year is given in Table 7. A similar table was presented by Dick and Ross (1986), but identifications made since then, as well as changes in some of the previous identifications, warrant another table. Since systematic sampling was not done over the course of a year, little can be said about seasonal extent or peaks of reproduction. Of 57 species found in the study, 28 (49%) contained embryos during the study period, when water temperature ranged from 6-8°C. Sixteen (70%) of the 23 species which were prominent at one or more stations contained embryos during this period. Curiously, only 11 (39%) of the 28 species breeding in fall are arctic-boreal species. Some of the rest are boreal species with wide ranges, and it would be interesting to compare the temperatures at which they reproduce farther south with those at Narrow Strait.

Table 7. Occurrence of embryos (+) in cheilostome bryozoans at Narrow Strait.

Species	Oct. 5-18	Nov. 1- Dec. 2	Other
<i>Callopora decidua</i>		+	
<i>Cauloramphus magnus</i>	+		
<i>Cauloramphus spectabilis</i>	+		
<i>Cauloramphus variegatus</i>			March
<i>Celleporella hyalina</i>	+	+	
<i>Celleporina aspera</i>	+	+	February
<i>Codonellina argentea</i>		+	
<i>Cryptosula okadai</i>	+	+	
<i>Cylindroporella tubulosa</i>	+	+	
<i>Hippoporina apertura</i>	+		
<i>Hippoporina vulgaris</i>	+	+	
<i>Dendrobeatia exilis</i>		+	
<i>Dendrobeatia lichenoides</i>	+	+	
<i>Fenestrulina malusii</i>		+	
<i>Lagenicella neosocialis</i>	+	+	February
<i>Microporella alaskana</i>			July
<i>Microporella californica</i>	+		August
<i>Microporella germana</i>	+	+	July
<i>Myrionozella plana</i>		+	February
<i>Parasmittina trispinosa</i>		+	
<i>Porella acutirostris</i>		+	
<i>Porella alba</i>	+	+	
<i>Porella columbiana</i>			June-July
<i>Porella immersa</i>		+	
<i>Rhizophostomella costata</i>		+	
<i>Scrupocellaria elongata</i>	+	+	February
<i>Smittina majuscula</i>		+	
<i>Stomachetosella sienna</i>			February
<i>Tegella aquilirostris</i>	+	+	
<i>Tegella arctica</i>		+	
<i>Tegella armifera</i>	+	+	
<i>Tegella horrida</i>	+		
<i>Tricellaria ternata</i>			February

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### Systematics

Fifty-seven species of cheilostomes were identified in the study, 14 of which are described as new: *Callopora decidua*, *Callopora nuda*, *Cauloramphus magnus*, *Cauloramphus spectabilis*, *Hippoporina vulgaris*, *Stomachetosella sienna*, *Hippoporidra truculenta*, *Microporella alaskana*, *Microporella germana*, *Microporella neocribroides*, *Hippothoa mawatarii*, *Celleporella reflexa*, *Lagenicella neosocialis*, and *Celleporina aspera*. *Cryptosula okadai* replaced a preoccupied name. A new family, the Desmacystidae, was erected in the Anasca. All but three species were found in rock-pile habitat during systematic sampling conducted in 1982. *Schizomavella porifera* and *Stomachetosella sinuosa* occurred only in small collections made at Station 10 in 1982 and 1984, respectively. *Microporina articulata* was not found in rock-pile habitats, but only on solid reef substrates.

This section follows the classification of Ryland and Hayward (1977) and Hayward and Ryland (1979), with modifications by Gordon (1984). The synonymies are limited; they cite the original description, the reference in Osburn (1950, 1952, 1953), subsequent references from the eastern North Pacific, and references to major regional works such as Kluge (1975), Ryland and Hayward (1977), Hayward and Ryland (1979), Mawatari (1974a) and Mawatari and Mawatari (1979, 1980, 1981). A few of the taxonomically difficult species required more extensive synonymies.

To avoid confusion in describing the number of dietellae or septula in the lateral walls of zooids, we refer to the total number of connections on one side between a zooid and its neighbors. A zooid said to have two lateral septula, for example, actually has one septulum in the distal portion of the lateral wall and an opening to the septulum of an adjacent zooid in the proximal portion.

### Suborder ANASCA Levinsen, 1909

#### Family DESMACYSTIDAE n. fam.

**DIAGNOSIS:** Zooids are closely appressed and connected by multiporous septula. The gymnocyst is extensive and can have pores. Adventitious avicularia occur. Spines are lacking. The ovicell is small; hyperstomial; suspended from the distal curvature of the aperture; and not closed by the operculum.

**DISCUSSION:** The removal of *Desmacystis* from the Membraniporidae, where it was placed by previous authors (Robertson 1900, Osburn 1950, Gontar 1982), is necessitated by the occurrence of ovicells and avicularia, which are not present in that family (Ryland and Hayward 1977). *Desmacystis* might be placed in the Calloporidae; the ovicell is intermediate in form between *Cauloramphus*, with no defined ovicell, and *Callopora*, with a well-developed hyperstomial ovicell. However, the ovicell is more frail and of a form different from that in any calloporid genus. The lack of a cryptocyst and spines, and the extensive gymnocyst with pores, seem to warrant establishment of a new family.

#### Genus *DESMACYSTIS* Osburn, 1950

##### *Desmacystis sandalia* (Robertson)

##### Plate 1A

*Membranipora sandalia* Robertson, 1900: 324, pl. 20, figs. 9, 9a, 9b, pl. 21, fig. 10; 1908: 264, pl. 15, figs. 11-14.

*Desmacystis sandalia*, Osburn, 1950: 32, pl. 3, fig. 1; Gontar, 1981: 102; 1982: 543, pl. 1, fig. 1; Dick and Ross, 1986: 89.

**DESCRIPTION:** The species forms irregular, orange-brown, loosely encrusting colonies on rock and algal holdfasts. Zooids are 0.50-0.70 mm long by 0.25-0.30 mm wide and fairly high, the zooidal chamber measuring 0.25-0.50 mm from the frontal to the basal wall. All walls are thin. The transverse wall interconnects through numerous pores in the basal half; these are sometimes organized into two distinct septular areas. There are four small circular multiporous septula in each lateral wall. The opesia is nearly circular, 0.30 mm in diameter, surrounded by a thin, raised lip somewhat obscured by the costae of adjacent zooids. The gymnocyst occupies half or more of the frontal length. In early stages of development, it is smooth, but soon becomes

reinforced by high costal buttresses which run from the raised proximal and lateral edges of the zooid to the center of the gymnocyst and onto the sides of the avicularian chamber proximal to the opesia. Often the lateral costae merge with a heavy median costa before reaching the chamber. Occasional minute secondary pores occur near the margins of the gymnocyst; they are not evident when the gymnocyst forms, but appear later with the development of costae. A thin ectocyst overlies the costae and the deep intercostal depressions. A large suboral avicularium with a raised chamber overhangs the opesia; the mandible is semicircular or subspatulate and points frontolaterally. The ovicell, previously undescribed, is a small, transversely elongate hood suspended in the distal curvature of the aperture; it has an uncalcified central area which is sometimes open at the proximal margin.

**OCCURRENCE:** Uncommon; there were several colonies in the lower midlittoral (Stations 2 and 3) and one in the lower infralittoral fringe (Station 14).

**DISTRIBUTION:** This is a boreal Pacific species, originally described from Yakutat, Alaska (Robertson 1900), and subsequently found in the Queen Charlotte Islands (Osburn 1950) and Kurile Islands (Gontar 1981, 1982).

#### Family ELECTRIDAE Stach, 1937

##### *Electra crustulenta* (Pallas)

##### Plate 1B

*Eschara crustulenta* Pallas, 1766: 39.

*Electra crustulenta* var. *arctica*, Osburn, 1950: 36, pl. 3, fig. 4.

*Electra crustulenta* forma *typica*, Kluge, 1975: 321.

*Electra crustulenta*, Mawatari, 1974a: 44, fig. 8; Ryland and Hayward, 1977: 68, fig. 23; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is encrusting, radiating in a coherent fan-shaped pattern from the point of origin. Zooids are white; vitreous; thin-walled; translucent; arranged in linear series; and separated by deep grooves. Their size varies with astogenetic development; the largest are 0.75 mm long by 0.30 mm wide. The frontal wall is transversely convex. The oval opesia, raised on a thin lip which slopes inward, occupies three-fourths or more of the frontal surface. The lateral and proximal margins of the opesia are faintly crenulate. The smooth gymnocyst rises distally to a small boss terminating in a short, calcified spinous process just proximal to the opesia. The frontal membrane is thin and transparent, with a calcified operculum. Zooids interconnect by three to five circular multiporous septula in each lateral wall and around six minute pores at the base of the distal wall. The basal wall is slightly calcified around the periphery, uncalcified in the center. Avicularia, lateral spines, and ovicells are absent. All autozooids in colonies collected during the study period were dead. Living material was present only in zones of reduced zooids (pl. 1B) at the colony periphery. These zones extend three to seven zooids inward from the margin and up to five columns laterally. They are separated from other such zones by autozooids. The reduced zooids are 0.20-0.25 mm long by 0.25-0.37 mm wide and yellowish brown, the color imparted by cellular material inside the cystid. The opesia of reduced zooids is circular or oval, and variable in size, often so reduced as to form a large central pore; it is covered by a frontal membrane lacking an operculum. Reduced zooids lack the proximal spine, though some transitional forms between autozooids and reduced

zooids have it. The function of the reduced zooids is unknown, although they may be an overwintering adaptation. They have not been previously reported in this species. DISCUSSION: Osburn (1950) considered all *Electra crustulenta* with a calcified operculum and only a median spine proximal to the aperture to be variety *arctica*. However, variety *arctica* defined by Mawatari (1974a) and Kluge (1975) has smaller zooids (less than 0.50 mm long) than occur in our material; the proximal boss is larger and occupies a greater proportion of the gymnocyst; the proximal spine is longer, one-third to one-half the length of the opesia, and uncalcified. Kluge (1975) noted, for variety *arctica*, "This species is subject to great variation with regard to zooidal size and shape, and the degree of development of the proximal, vertical spine." Variation in this species may be environmentally induced, and we have not used the varietal designation.

OCCURRENCE: This species was common at midlittoral Stations 1 and 6, both of which lie at extremes of various environmental gradients, but was not found elsewhere. Station 6 is high, exposed, and possibly subject to estuarine influence from the lagoon system inside Icon Bay. Station 1 lies between the outlets of two streams flowing into Sunny Cove, and certainly undergoes variations in salinity.

DISTRIBUTION: This is a circumpolar, arctic-boreal species previously known in the eastern Pacific from Point Barrow, Alaska, south to Dillon Beach, California (Osburn 1950). Another form of *E. crustulenta* having mural spines, a weakly calcified or uncalcified operculum, and no proximal spine was recorded by Osburn (1950) from Oregon to California and by Soule (1959) from the Gulf of California.

Family FLUSTRIDAE Gray, 1848

Genus *HINCKSINA* Norman, 1903

*Hincksina longiavicularia* Gontar  
Plate 1E

*Hincksina longiavicularia* Gontar, 1982: 547, pl. 1, figs. 3a, b.

*Hincksina* sp., Dick and Ross, 1986: 89.

DESCRIPTION: Colonies are bright-orange, unilaminar, encrusting. Zooids are 0.40-0.65 mm long by 0.20-0.25 mm wide. The frontal membrane occupies the entire frontal surface; a cryptocyst is lacking, but occasionally a slight proximal gymnocyst is present. Five to seven (usually six or seven) pairs of straight or slightly curved spines, 0.15-0.20 mm long, arch over the opesia. Large spatulate vicarious avicularia, 0.30-0.50 mm long by 0.15-0.20 mm wide, are scattered sparsely throughout the colony, usually occurring at the divergence of a row of zooids. The avicularia lie somewhat above the general colony surface and slightly overhang the opesiae of following zooids. Ovicells are endozoocial, smooth and shallow, the proximal margin either evenly concave or forming a blunt, triangular point. Kenozooidal rhizoids mentioned in Gontar's (1982) description were not observed. Most zooids are attached firmly to the substrate by the basal wall. When portions of the colony are raised because of uneven substrate, the zooids either lack attachment or are attached by hollow columnar extensions of the basal wall.

OCCURRENCE: This was an uncommon infralittoral fringe species occurring at Stations 5, 10, 13, and 14.

DISTRIBUTION: *H. longiavicularia* is a boreal species endemic to the Pacific. It was originally described from the Kurile Islands (Gontar 1982). We have an additional specimen from Squirrel Bay at the southwestern edge of Prince William Sound, Alaska.

Genus *TERMINOFLUSTRA* Silen, 1941

*Terminoflustra membranaceotruncata* (Smitt)

Plate 1D

*Flustra membranaceo-truncata* Smitt 1868a: 358, pl. 20, figs. 1-5; Kluge, 1975: 376, fig. 194.

*Terminoflustra membranaceo-truncata*, Osburn, 1950: 40, pl. 3, fig. 10; Mawatari and Mawatari 1979: 40, fig. 9; Dick and Ross, 1986: 89.

DESCRIPTION: Colonies are 1-2 cm across; grayish-tan in color; unilaminar; recumbent; roughly circular in outline; and divided into irregular lobes. The colony is loosely attached by thin dorsal peduncles and closely follows the contour of the substrate; lobes at the periphery are often entirely free. Zooids are 0.50-0.70 mm long by 0.25 mm wide, and rectangular or elongate-hexagonal. The frontal membrane occupies the entire frontal surface. All walls are weakly calcified. There is usually a short, spinous process at each distolateral corner. Rectangular vicarious avicularia, 0.25 mm long by 0.20 mm wide, occur at the bifurcations of rows of zooids. The opesia of the avicularium is circular or oval, divided by the pivot into a distally directed, semicircular mandible and a proximal membranous area. Ovicells are lacking in our material.

OCCURRENCE: Nine colonies were found on two rocks at Station 8.

DISTRIBUTION: This is a circumpolar, arctic-boreal species known in the eastern Pacific from the Pribilof Islands, Alaska, to British Columbia; it has been found at 60 m depth in Alitak Bay, southern Kodiak Island (Osburn 1950).

Family CALLOPORIDAE Norman, 1903

Genus *CALLOPORA* Gray, 1848

*Callopora craticula* (Alder)

Plate 1C

*Membranipora craticula* Alder, 1856: 144, pl. 8, fig. 3. *Callopora craticula*, Osburn, 1950: 67, pl. 6, fig. 7; Androsova, 1958: 96, fig. 7; Kluge, 1975: 344, fig. 171; Ryland and Hayward, 1977: 92, fig. 37; Mawatari and Mawatari, 1980: 40, fig. 8; *Callopora horrida*, Dick and Ross, 1986: 89 (part).

DESCRIPTION: The colony is encrusting, tan colored. Zooids are 0.35-0.45 mm long by 0.18-0.25 mm wide; ovoid; tapering proximally; and separated by grooves. The opesia is either oval and widest proximally, or evenly elliptical, 0.19-0.25 mm long by 0.10-0.15 mm wide. The mural rim is raised and faintly granulose. The lateral gymnocyst is smooth, sloping and narrow; the proximal gymnocyst is also smooth, one-fourth to one-third the length of the zooid, and tapering. The cryptocyst is negligible. There are around four dietellae in each lateral wall and three or four single

pores in the distal wall. Around the mural rim are 12-15 thin, acuminate spines. The distal three pairs are longer, and vertical or angled distally. The proximal six to nine spines are thinner and arch regularly over the opesia, converging near the midline. They become progressively shorter toward the proximal end of the zooid, but there is sometimes no clear demarcation between the ending of the distal spines and the beginning of the proximal. In some cases, the distal spines at the colony margin are greatly elongated, up to 0.40 mm long, and there are four pairs rather than three. A small frontal avicularium with a raised chamber occupies the proximal gymnocyst close to the opesia, often abutting the ovicell of the preceding zooid. The sides of the chamber are nearly vertical; the triangular mandible lies at an angle to the colony surface and can point in any direction. Sometimes the frontal avicularia are paired, one on each side of the gymnocyst, or lacking altogether. Vicarious avicularia occur near the colony margin. These are somewhat smaller than autozooids and have a raised, acute, long-triangular mandible. The ovicell is hyperstomial, globose, 0.15-0.18 mm in length and width, with a transverse ridge across the top delineating a lunate or quadrate, sometimes granulose, proximal area.

**OCCURRENCE:** Previously we did not separate this species from *C. decidua* n. sp., and its local distribution was not adequately determined. We have specimens from Stations 10 and 14, both in the lower infralittoral fringe.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species previously known in the eastern Pacific from Penuk Island in the Bering Sea and Cleveland Passage in southeastern Alaska (Osburn 1950).

*Callopora decidua* n. sp.  
Plates 2C, 10A

*Callopora horrida*, Dick and Ross, 1986: 89 (part).

**DIAGNOSIS:** This species is characterized by having a large number of spines (14-21); small single or paired lateral avicularia; and a large proximal avicularium with a greatly elongated, decurved mandible extending forward alongside the opesia. The large avicularia occur only on zooids preceded by ovicells.

**HOLOTYPE:** USNM 415787. Five fragments from same colony, three on rock with other species, two detached; type fragments indicated by arrows.

**TYPE LOCALITY:** Station 10 (57° 55.6'N 152° 31.6'W), Neva Cove, west end of Narrow Strait, Kodiak Island, Alaska; intertidal; type collected 2 Nov. 1982.

**ETYMOLOGY:** The species name is from the Latin *deciduus* (deciduous), referring to the loss and regeneration of spines as zooids regenerate.

**DESCRIPTION:** The colony is encrusting, tan-colored. Zooids are 0.38-0.50 mm long by 0.25-0.33 mm wide, ovoid, tapering proximally, separated by a deep groove. The opesia is elliptical or oval, widest centrally or proximally, 0.25-0.35 mm long by 0.16-0.20 mm wide. The mural rim is smooth, raised, surrounded by a narrow, sloping lateral gymnocyst and a tapering proximal gymnocyst which varies from scarcely wider than the lateral gymnocyst to one-third the length of the zooid. The cryptocyst is negligible. There are four dietellae in each lateral wall and several single pores in the distal wall. Around the mural rim are 14-21 spines. The distal three pairs are long, stout, tapering or truncate, angled distally. Around the proximal two-thirds of the opesia are 9-14 shorter, thinner, somewhat curved, acuminate spines angled inward and converging along the midline, forming a tight, concave basket over the opesia.

Some zooids show evidence of regeneration. Around the mural rim of such zooids are holes left by previous spines. The inner edge of the mural rim has extended slightly into the opesia, and this new growth is vitreous in contrast to the chalky appearance of the old wall. At the junction between the new and old mural rims is a new set of spines around the opesia. Both proximal and lateral avicularia occur. Small, single or paired avicularia arise from the lateral gymnocyst at the juncture between the proximal and distal spines. These are 0.05-0.07 mm long and have a semicircular mandible directed laterally, flush with or slightly above the level of the mural rim. Not all zooids have lateral avicularia. Zooids not preceded by an ovicellate zooid generally lack a proximal avicularium; if present, it is small, scarcely larger than a lateral avicularium, raised on a bulbous chamber, with a rounded mandible angled upward and directed laterally or proximally. Nearly all zooids following an ovicell have a large proximal avicularium, the chamber of which covers the distal side, and up to half the top, of the ovicell. The chamber is as wide as the zooid, but compressed against the ovicell. A long, narrow, decurved, transversely concave rostrum extends to one side or the other around the opesia, commonly overhanging the bases of the proximal spines. The mandible is tapering and acuminate, up to 0.25 mm long, directed distolaterally. The development of the rostrum and mandible vary; sometimes their length is only one or two times their width. The formation of the large proximal avicularium is somehow induced by the presence of the ovicell, but there is no connection between the two. The avicularium is connected by minute pores to the gymnocyst of the autozooid beneath it. The ovicell is hyperstomial, globose, 0.17-0.20 mm in length and width, with a transverse ridge close to the proximal border. The ridge often bears a conical protuberance in the midline.

**DISCUSSION:** Because of the well-developed avicularium extending around the opesia, this species was originally identified as *C. horrida* (Dick and Ross 1986). The latter is more robust, has fewer and shorter spines, lacks lateral avicularia, and has no protuberance on the ovicell. Mawatari and Mawatari (1980) reviewed the characters of all known species of *Callopora*. No previously described species has the combination of characters summarized in the diagnosis above.

**OCCURRENCE:** *C. decidua* occurred at Stations 5, 10, and 13, all in the infralittoral fringe, but was prominent only at Station 13.

**DISTRIBUTION:** Narrow Strait is the only known locality.

*Callopora nuda* n. sp.

Plates 2B, 10B

*Alderina* sp., Dick and Ross, 1986: 89.

**DIAGNOSIS:** This species is distinguished by large zooids; the raised, coarsely granulose mural rim; the smooth cryptocyst and opesial outline; the well-developed, spherical ovicell with a conspicuous transverse rib; and infrequent large, irregularly shaped frontal avicularia with short-spatulate mandibles.

**HOLOTYPE:** USNM 415788. On rock with other species; type indicated by arrow.

**TYPE LOCALITY:** Station 8, (57° 53.5'N, 152° 21'W), east shore of Spruce Island near Kodiak, Alaska; intertidal; type collected 10 Aug. 1984.

**ETYMOLOGY:** The species name is from the Latin *nudus* (naked), referring to the paucity of spines.

**DESCRIPTION:** Colonies are tan colored, encrusting, up to 3-5 cm across. Zooids are variable in size within a colony, 0.68-0.95 mm long by 0.43-0.58 mm wide. The

shape of the opesia varies from elongate-oval to subcircular; the widest portion occurs at any part. A raised, coarsely granulose mural rim forms a distinct lip, quite pronounced distally and less so proximally, where it is a low ridge appressed to the high distal lip of the preceding zooid. Zooids are close together, sometimes separated by a deep, narrow groove which can reach halfway to the basal surface at the corners of the zooid. The basal wall is entirely calcified. Zooids interconnect by three or four large pore chambers in each lateral wall and one in the distal wall, each perforated by numerous pores. The gymnocyst is negligible. The cryptocyst is granulose at the rim, but forms a smooth shelf around the opesia, where it is widest proximally and gradually narrows laterally. Spines are usually lacking, but some zooids bear a pair of short, thick vertical spines lateral to the orifice, with occasionally a third more proximally on one side. In ovicellate zooids, the paired spines arise at the junctions of the proximolateral corners of the ovicell with the mural rim; they are sometimes slightly curved and angled toward the ovicell. Large frontal avicularia occur uncommonly and may be lacking in small colony fragments. They are 0.25-0.33 mm long by 0.20-0.23 mm wide; the chamber is ovoid, rounded-quadrate or trapezoidal, often raised, connecting with the gymnocyst of the parent zooid by several pores. The mandible is short-spatulate and points in any direction. Rarely, larger vicarious avicularia occur; the proximal wall rises to form a rostrum and the rounded mandible points proximally; these are intermediate in size between the frontal avicularia and autozooids. Ovicells are hyperstomial, globose, 0.38-0.48 mm long by 0.25-0.35 mm wide, closed by a special flap. A curved or distally angled transverse rib on the ovicell delineates a smooth or faintly granulose lunate area near the proximal margin, which bears a raised lip.

DISCUSSION: Our material is similar to Kluge's (1975) description of *Callopora lata* (Kluge), except that spines are uncommon in our specimens. Kluge (1975) made no mention of avicularia. Though uncommon, several can be found in moderately sized colony fragments from Narrow Strait. We have examined a specimen of *C. lata* from the White Sea. Avicularia are lacking; zooids are smaller, 0.58-0.78 mm long; all zooids bear from three to five spines; and the cryptocyst is poorly developed. We describe our material as new on the basis of these differences. *C. nuda* may eventually prove to be a form of *C. lata*.

OCCURRENCE: This species occurred sparsely at four widely scattered stations (8, 9, 11, 12) from the lower midlittoral to the infralittoral fringe.

DISTRIBUTION: *C. nuda* is known only from the Narrow Strait vicinity, Alaska.

#### Genus *CAULORAMPHUS* Norman, 1903

*Cauloramphus magnus* n. sp.

Plates 2F, 10C, 13B

*Cauloramphus cymbaeformis*, Dick and Ross, 1986: 89.

DIAGNOSIS: This species is distinguished by the large size of the zooids. The mural rim is narrow, and the opesia occupies a larger proportion of the frontal surface than in other species. The straight, sharp proximal spines are exceptionally thin and appear sparse, usually separated by more than twice their width. The opesial outline has a crenulate appearance due to coarse granulation on the mural rim.

HOLOTYPE: USNM 415789. Three fragments from same colony, two on rock and one detached; small colony of *C. spinifer* also on one of the rocks.



TYPE LOCALITY: Station 3 (57° 54.5'N, 152° 27.7'W), Spruce Island, central Narrow Strait, near Kodiak, Alaska; intertidal, on rock; type collected 6 Oct. 1982.  
ETYMOLOGY: The species name is from the Latin *magnus* (great), referring to the large size of zooids.

DESCRIPTION: Colonies are encrusting, light tan in color, closely adhering to the rock with a well-calcified base. They are commonly covered with adhering sediment which is difficult to wash off. Zooids are large, 0.60-0.80 mm long by 0.25-0.37 mm wide, separated by a shallow but distinct groove. The opesia is elliptical or oval, widest at any part, 0.50-0.60 mm long by 0.25-0.37 mm wide. The mural rim is narrow, often sharp on top, covered with coarse conical granules which give the outline of the opesia a crenulate appearance. The gymnocyst is generally reduced, consisting of a proximal widening of the granulose mural rim, but sometimes tapering back considerably between preceding zooids, in which case the portion proximal to the mural rim is smooth. There are six conspicuous dietellae in each lateral wall and three in the distal wall. Around the outside edge of the mural rim are 11-14 spines. Four to six straight distal spines, arranged in a semicircle around the orifice, are longer and thicker than the rest. The proximal two of these are perpendicular and the others angle slightly forward. The proximal spines are straight or curved, exceptionally thin, and taper to a sharp point. They angle over the opesia, sometimes meeting in the midline. Due to their thinness, they are separated by spaces of two or more times their width. In some zooids, the most proximal spine is longer, heavier and blunter than the rest; vertically oriented; and approaching or even exceeding the size of the distal spines. The tendency to have a pronounced proximal spine is also characteristic of *C. spinifer* at Narrow Strait and may indicate that the two species are closely related. Avicularia (Pl. 2F) are rare. Single or paired, they originate from the outer edge of the mural rim between the proximal and distal spines. They are slightly longer than the distal spines, with a short, thin pedicel gradually expanding to a heavy, curved chamber. The brood chamber consists of a shallow concavity distal to the orifice. It is difficult to distinguish brooding from non-brooding zooids unless an embryo is evident. Sometimes the former have a raised, crescentic lip distal to the orifice. Embryos are orange; in later stages they occupy one-third to one-half of the zooidal chamber and can readily be seen beneath the frontal membrane.

OCCURRENCE: *C. magnus* occurred uncommonly at five stations from the lower midlittoral to the infralittoral fringe. It was a prominent only at Station 6, an exposed upper midlittoral site. This is by far the dominant species of *Cauloramphus* on the outer Nyman Peninsula in Womens Bay and at the head of Monashka Bay near Kodiak, both areas of low circulation, high sedimentation, and freshwater seepage into the intertidal.

DISTRIBUTION: The Kodiak vicinity is the only known locality.

*Cauloramphus pseudospinifer* Androsova  
Plates 2A,H, 13C

*Cauloramphus pseudospinifera* Androsova, 1958: 108, fig. 18.

?*Membranipora spinifera*, O'Donoghue and O'Donoghue, 1923: 26.

?*Cauloramphus spinifer*, O'Donoghue and O'Donoghue, 1926: 39.

DESCRIPTION: Colonies are encrusting, tan colored. Zooids are 0.50-0.75 mm long by 0.35-0.45 mm wide, closely set with a well-defined groove between them. The opesia is oval, usually widest proximally, 0.50 mm long by 0.25 mm wide. The mural rim is

rounded and uniformly granulose on the top and inner side. The gymnocyst is either reduced and smooth, tapering back between preceding zooids, or absent. Sometimes the zooids are separated, so that a slight, smooth lateral gymnocyst may be seen. There are six to eight dietellae in each lateral wall and two or three in the distal wall. Around the outer edge of the mural rim are 14-18 spines. The five or six distalmost spines are straight, blunt, and thick; slightly longer than the proximal spines; and oriented in a semicircle around the orifice. The thinner, more acuminate proximal spines are straight or slightly curved, and angle over the opesia, nearly meeting in the midline. Avicularia (pl. 2H) arise from the lateral wall outside the row of spines. They are slightly longer than the distal spines and have a thin pedicel that gradually expands to a chamber not much thicker than the distal spines. The length of the pedicel is equal to or somewhat less than that of the expanded portion. Avicularia angle strongly outward over the mural rim of adjacent zooids, the mandible facing away from the colony surface. Two avicularia may arise from the same side of a zooid: one outside the proximal spines at or proximal to the middle of the zooid, the other outside the distal spines at the distolateral corner. There are thus four possible positions for avicularia per zooid, two on each side. Although zooids generally have two avicularia distributed in any combination of the four positions, some zooids have three. Ovicells were not observed.

**DISCUSSION:** Our material differs from Androsova's (1958) description in having 14-18 spines versus 18-23 spines per zooid. Androsova's figure does not represent the species well, particularly the irregular distribution of avicularia described above. A specimen from the Sea of Japan sent by Dr. V. I. Gontar shows avicularia in all four positions, though on opposite sides and no more than two per zooid. The avicularia on the Asian specimen are stouter, with a shorter peduncle relative to the expanded portion. A diagnostic character of this species is the dense palisade of spines arching regularly over the proximal two-thirds of the opesia, leaving the distal third open and surrounded by blunt, upright spines. The O'Donoghues (1923, 1926) found up to six avicularia per zooid, distributed over the four positions, in material from British Columbia which they identified as *C. spinifer*. They did not describe any characters other than the avicularia, and it is not possible to tell whether their species is *C. pseudospinifer*.

**OCCURRENCE:** This species was rare in the study area; one colony was found at Station 13. It was fairly common in exposed rock-pile habitats at Spruce Cape near the town of Kodiak.

**DISTRIBUTION:** This appears to be an endemic boreal Pacific species previously known only from the Sea of Japan (Androsova 1958).

*Cauloramphus spectabilis* n. sp.  
Plates 2G, 10D

*Caulorhamphus* sp., Dick and Ross, 1986: 89.

**DIAGNOSIS:** This species is distinguished by the large number of spines, up to 24, and their pronounced development; they cover the zooids so densely that they obscure the zooidal walls. There are four pairs of heavy distal spines. The mural rim is smooth, not granulose as in some species of *Cauloramphus*. Avicularia are long-stalked.

**HOLOTYPE:** USNM 415790. One colony on rock, partly overgrown by *C. spinifer*.

**TYPE LOCALITY:** Station 5 (57° 53.1'N, 152° 23.7'W), west shore of Sunny Cove, Spruce Island, near Kodiak, Alaska; intertidal; type collected 17 Oct. 1982.

ETYMOLOGY: The species name is from the Latin *spectabilis* (remarkable).

DESCRIPTION: The species forms tan-colored encrusting colonies on rock. The colony has a furry appearance due to the copious long spines. Zooids are 0.50-0.65 mm long by 0.30-0.45 mm wide. They are separated by moderately deep furrows and occasional intrajunctural pores. There is a short proximal gymnocyst and a lateral gymnocyst whose extent depends upon the width of the interzooidal furrow. The mural rim is smooth, but studded along the distal two-thirds with hollow, cylindrical projections upon which the spines attach. The opesia has an even, ovoid outline, 0.35-0.48 mm long by 0.23-0.28 mm wide. There are six to eight dietellae in each lateral wall and two in the distal wall. Around the distal one-third of the opesia are eight or nine stout, straight, hollow spines oriented perpendicular to the colony surface or angled distally. The distal spines are usually 0.4-0.5 mm long, but occasionally up to 0.7 mm long. Around the proximal two-thirds of the opesia are six to eight pairs of hollow, nearly straight spines angled inward to form a tentlike basket over the frontal membrane. The proximal spines are about half the length and diameter of the distal spines. Total spines number 19-24. Zooids bear a single avicularium attached to the lateral gymnocyst near the center, close to the bases of the proximal spines. Avicularia (pl. 2G) are uncommon and most zooids lack one. They are long-stalked and clavate, intermediate in length between the proximal and distal spines. They enlarge gradually from a thin pedicel into a chamber whose maximum width is greater than that of the distal spines; the inflated portion is roughly as long as a proximal spine. The rostral side is turned away from the zooid of attachment; thus, the mandible opens toward the zooid. The brood chamber consists of nothing more than the distal, concave end of the zooidal chamber. The embryo more than fills this concavity and extends back under the operculum; it is bright orange.

DISCUSSION: *C. opertus* Canu and Bassler, 1928, *C. disjunctus* Canu and Bassler, 1929, and *C. pseudospinifer* Androsova, 1958, can have up to 24 spines, but none of these species has four pairs of heavy distal spines, long-stalked avicularia and a smooth mural rim.

OCCURRENCE: This was an uncommon lower midlittoral and infralittoral fringe species. It occurred at Stations 5, 9, 10, 13 and 14 along Narrow Strait.

DISTRIBUTION: Narrow Strait is the only known locality.

*Cauloramphus spinifer* (Johnston)  
Plates 2D,E, 13D

*Membranipora spinifera* Johnston, 1832: 266, pl. 9, fig. 6.

?*Membranipora spinifera*, Robertson, 1900: 324.

Not *Membranipora spinifera*, Robertson, 1908: 265; O'Donoghue and O'Donoghue, 1923: 26, 1926: 39.

?*Cauloramphus spiniferum*, O'Donoghue, 1925: 98; Soule, 1959: 13.

Not *Cauloramphus spiniferum*, Osburn, 1950: 55.

*Cauloramphus spiniferum*, Mawatari 1956: 118, fig. 4a; Androsova, 1958: fig. 15; Kluge, 1975: 353, fig. 179; Ryland and Hayward, 1977: 98, fig. 41; Mawatari and Mawatari, 1981: 43, fig. 10.

*Caulorhamphus spiniferum*, Dick and Ross, 1986: 89.

DESCRIPTION: Colonies are encrusting, light yellowish brown. Zooids are 0.50-0.67 mm long by 0.30-0.40 mm wide, closely set, with a well defined-groove between them. Opesiae are 0.38-0.45 mm long by 0.23-0.28 mm wide. The mural rim is slightly

raised, with a slight, sloping cryptocyst; both are granulose. The outline of the opesia, especially on the proximal half, appears crenulate due to the granulation. Distal to the orifice, the transverse wall is raised above the level of the lateral walls in a smooth, sharp edged, crescentic lip. The gymnocyst is usually slight or lacking, although in some zooids it tapers back between preceding zooids. When present, it is smooth and vitreous, sharply delineated from the granulose mural rim. There are six or seven diatellae in each lateral wall and one or two in the distal wall. Around the mural rim are eight to 13 straight spines. The distal three are vertically oriented; blunter, thicker and occasionally longer than the rest; and placed in a triangle, one at the midline and one to each side of the orifice. Rarely there are four distal spines. Five to 10 more or less acuminate proximal spines angle over the opesia, sometimes meeting in the midline but generally not. Frequently the most proximal spine is perpendicular and longer, thicker, and blunter than even the distal spines. Pedicellate avicularia (pl. 2E) arise from the lateral edge of the mural rim between the proximal and distal spines, in line with the proximal edge of the orifice. They are about as long as the proximal spines and angle slightly over the opesia, with the curved rostral side turned inward. In the Narrow Strait material, collected from October to December, avicularia were copious, either singly or paired, although some zooids lacked them. In colonies collected in February from Spruce Cape near Kodiak, avicularia were rare; only single avicularia could be found on a few zooids per colony. Neither ovicells nor embryos were observed. The crescentic lip distal to the orifice is present on all zooids and apparently not indicative of an brood chamber.

**DISCUSSION:** The diagnostic characters of this species are: 1) the rapidly expanded avicularia about the same length as the spines and arising from the outer edge of the lateral mural rim between the proximal and distal spines; and 2) the overall shortness and uniformity of the spines. Although the distal spines are commonly somewhat longer, heavier, and blunter than the proximal ones, they are not greatly or invariably so. There is variation in the number of spines recorded from different areas: eight to 13 in the Kodiak vicinity, 10-14 in the Kurile Islands (Mawatari 1956), 11-16 in Britain (Ryland and Hayward 1977), 12-16 in northern Japan (Mawatari and Mawatari 1981) and the northern USSR (Kluge 1975), and 13-18 in the northern Sea of Japan (Androsova 1958). Five clearly distinct species of *Cauloramphus* occur at Narrow Strait, and this has allowed us to compare them without the confusion of geographical variation. Previous authors on the west coast of North America appear to have included a number of species in *C. spinifer*, and this has cast doubt on previous records there, especially those which give no description or figure.

**OCCURRENCE:** This was one of the prominent species, widespread and generally abundant throughout the intertidal, but lacking at the highest station (6) and one of the lowest (10).

**DISTRIBUTION:** This is a circumboreal species, perhaps extending into the Arctic. Because of the uncertainty associated with previous records, its range in the eastern Pacific needs to be reexamined.

*Cauloramphus variegatus* (Hincks)  
Plates 2I, 13E,F

*Membranipora variegata* Hincks, 1881: 131, pl. 5, fig. 2; 1882: 465.  
*Cauloramphus variegatum*, Osburn, 1950: 58.  
*Cauloramphus spiniferum*, Osburn, 1950: 55, pl. 5, fig. 9.  
*Cauloramphus brunnea*, Dick and Ross, 1986: 89.

**DESCRIPTION:** Colonies are encrusting, light yellowish- or grayish-brown. Zooids are 0.50-0.65 mm long by 0.30-0.40 mm wide, closely appressed, with only a slightly depressed line between them. Opesiae are 0.30-0.43 mm long by 0.15-0.26 mm wide. The mural rim is wide, rounded, entirely covered with coarse, uniform granules. The distance between opesiae is sometimes greater than the opesial width. The gymnocyst varies from a mere widening of the proximal mural rim to a short, tapered area between two preceding zooids; it is indistinguishable from the mural rim in texture. There are eight dietellae in each lateral wall and two in the distal wall; the openings are narrow, vertical slits separated by thicker columns. The opesia varies in shape from oval to elliptical to rounded-triangular. Around the distal half of the zooid are three pairs of coarse, blunt, cylindrical spines which are perpendicular or angled slightly distally. Around the proximal half are two to six thin, curved, acuminate spines angled over the opesia, the ends often converging at the midline. The bases of all spines are yellowish-brown to black in a band which sometimes occupies nearly half of the length of the spine, usually less. In hypochlorite-cleaned material, spine scars are evident as circular pits at the zooidal margin; there are no raised spine bases as in some other species of *Cauloramphus*. A pedicellate avicularium (pl. 2I) arises from the mural rim on one or both sides of the zooid, just lateral to the proximalmost of the large oral spines. The short, thin pedicel expands gradually to a chamber which is twice or more as long as it is wide. The avicularia are about as long, and slightly thicker than, the distal spines. Ovicells are lacking. Ciliated embryos still inside the vitelline membrane were observed in the distal portions of zooids of colonies collected in March, 1985.

Two forms of this species occur at Narrow Strait. The commoner form has brown spine bases and very thin, curved, acuminate proximal spines as described above. The other form has yellowish spine bases and generally fewer, straighter, coarser, blunter, more erect proximal spines. The two forms are identical in the features of the frontal wall and dietellae. The close common boundary formed when colonies of the two forms meet is characteristic of an intraspecific boundary.

**DISCUSSION:** Osburn (1950) considered *C. variegatus* a probable synonym of *C. spinifer*, which he noted "is a very common species all along the coast and frequently has the bases of the spines dark colored as in Hincks' original description of *variegata*." Osburn's (1950) illustration of *C. spinifer* is clearly the species which we consider to be *C. variegatus*. No authors other than Osburn (1950) have mentioned dark spine bases as a character of *C. spinifer*. Our material differs from Hincks' (1881) description of *C. variegatus* in having all three pairs of distal spines stout and subclavate rather than only the most proximal pair, which Hincks showed crossed over the opesia. In our material, the most proximal pair tends to angle somewhat over the opesia, whereas the two more distal pairs do not. The distinguishing character of this species is the exceptionally wide, granulose, closely set mural rim. In Hincks' (1881) material, the mural rim was covered with finer granules. We have a specimen from Port Etches, Alaska, in which the mural rim is finely granulose and in which there is a more distinct groove between zooids. The dark spine base is characteristic,

although not invariably. Some Narrow Strait colonies lack it altogether, as did all specimens from the Queen Charlotte Islands examined by Hincks (1882).

**OCCURRENCE:** This species occurred in the low midlittoral and infralittoral fringe at five stations in the eastern portion of the study area, but was abundant only at Station 9, an exposed reef-flat. It is common intertidally in other areas in the Kodiak vicinity.

**DISTRIBUTION:** The known range is from the Kodiak vicinity, Alaska, to Santa Cruz, California, the type locality (Hincks 1881).

Genus *TEGELLA* Levinsen, 1909

*Tegella aquilirostris* (O'Donoghue and O'Donoghue)

Plate 3A

*Membranipora aquilirostris* O'Donoghue and O'Donoghue, 1923: 28, pl. 2, fig. 16.

*Tegella aquilirostris*, O'Donoghue and O'Donoghue, 1926: 37, pl. 3, fig. 29; Osburn, 1950: 83; McCain and Ross, 1974: 13, fig. 26; Mawatari and Mawatari, 1980: 92, fig. 32; Dick and Ross, 1986: 89 (part).

*Tegella robertsonae*, Osburn, 1950: 81, pl. 9, fig. 5.

**DESCRIPTION:** Colonies are encrusting, subcircular, up to 3-4 cm across, sometimes white to tan but usually reddish-brown. Colonies growing on the overhanging surfaces of large boulders commonly are loosely attached, the margins rising from the substrate as recumbent, rounded lobes; those in the rock-pile habitat are more tightly attached. Zooids are 0.50-0.75 mm long by 0.30-0.45 mm wide, separated by a narrow groove only when young, closely set when older, with adjoining lateral walls forming a sharp ridge. Zooids connect through four circular or oval multiporous septula in each lateral wall and a crescent-shaped or bilobed zone of pores in the distal wall. The opesia is 0.30-0.50 mm long by 0.20-0.33 mm wide and varies from rounded-rectangular to oval or elliptical. The sloping cryptocyst is granulose, with a crenulate margin. Marginal zooids bear one or two pairs of straight, thick, blunt, hollow, erect spines around the distal third of the mural rim; in rapidly growing colonies these may be lacking. With age, only one spine is generally left lateral to the orifice; if a pair remains, then one is larger than the other. More proximally, a thinner, strongly curved spine angles over the middle of the opesia; occasionally there are two, either on the same side or opposite one another. The curved spines are about the same length as the distal spines. The most common arrangement is one erect distal spine and one curved central spine on opposite sides. Whole portions of some colonies have only one spine of either type or lack spines altogether. A large proximal avicularium, square or transversely rectangular in outline, occupies the entire gymnocyst. The high rostral side tilts the mandible at 45° to the frontal plane. The mandible is triangular, more-or-less elongate, with straight sides and an acute, decurved tip. It points laterally, distolaterally, or occasionally proximally, sometimes extending around the proximolateral edge of the aperture. The rostrum is commonly hooked upward at the tip, opposite in direction to the hook of the mandible. Ovicells are hyperstomial, salient, 0.21-0.25 mm long by 0.23-0.33 mm wide, with a strong crescentic or decurved transverse ridge on top which may be thickened into a blunt median knob. The proximal margin is thickened and slightly raised. There is a lunate tabula between the margin and the transverse ridge.

**OCCURRENCE:** This was a prominent species which occurred throughout the study area but reached greatest densities in the infralittoral fringe at Eider Island and Sunny Cove.

**DISTRIBUTION:** *T. aquilirostris* is a boreal Pacific species, previously known in the eastern Pacific from Juneau and Yakutat, Alaska (Robertson 1900, 1908); British Columbia (O'Donoghue and O'Donoghue 1923, 1926); and Puget Sound (McCain and Ross 1974). The southern extent of the range is open to question because some previous records of *T. robertsonae*, which has been synonymized with *T. aquilirostris*, may actually have been *T. horrida*. The species has also been found in Japan (Mawatari and Mawatari 1980).

*Tegella arctica* (d'Orbigny)

Plate 3B

*Reptoflustra arctica* d'Orbigny, 1851: 352.

*Tegella arctica*, Osburn, 1950: pl. 9, fig. 6; Kluge, 1975: 334, fig. 163; Mawatari and Mawatari, 1980: 94, fig. 33; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is encrusting, subcircular, up to several centimeters across, yellowish-brown. Zooids are 0.53-0.70 mm long by 0.25-0.35 mm wide, closely appressed or with a narrow, well-defined groove between them. The mural rim is raised, with a sloping, finely granulose cryptocyst. The opesia is oval or elliptical, 0.30-0.37 mm long by 0.15-0.25 mm wide, the outline finely crenulate. Four circular or oval multiporous septula connect each lateral wall; occasionally these lead to pore chambers. The distal wall bears a crescentic zone of pores across the basal half. Around the mural rim are five to eight spines. The distal pair, situated just proximal to the lateral avicularia and in line with the orifice, are straighter, slightly thicker, and more erect than the rest. The curved, acuminate proximal spines angle over the opesia, two or three on each side. Covering the proximal gymnocyst is a large square or rectangular avicularium with a raised rostrum. The triangular mandible lies at 45° to the frontal plane, points distolaterally or proximally, and does not extend laterally around the aperture. Two small paired avicularia lie on the mural rim lateral to the orifice; the triangular mandibles are angled up to 45° from the frontal plane and are directed distally. Ovicells are hyperstomial, 0.20-0.25 mm long by 0.23-0.30 mm wide, with a thick transverse rib across the top. The proximal margin is raised and there is a lunate tabula between the margin and ridge. The proximal avicularia generally abut and cover only the distal surface of the preceding ovicell.

**OCCURRENCE:** This was a prominent species widely distributed in the lower midlittoral and infralittoral fringe. As with *Tegella armifera*, it attained greatest density and cover on Eider Island.

**DISTRIBUTION:** *T. arctica* is a circumpolar, arctic-boreal species known previously in western North America from Point Barrow in the Arctic southward to Frederick Sound, southeastern Alaska (Osburn 1950).

*Tegella armifera* (Hincks)

Plate 3C

*Membranipora armifera* Hincks, 1880b: 82, pl. 11, fig. 5.

*Tegella armifera*, Osburn, 1950: 79, pl. 9, figs. 1, 7; Hulsemann and Soule, 1962: 229;

Mawatari and Mawatari, 1980: 96, fig. 34; Kluge, 1975: 328, fig. 159; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony forms roughly circular encrustations, whitish to tan in color. Zooids are ovoid, 0.50-0.70 mm long by 0.25-0.35 mm wide, closely appressed. The opesia is oval, 0.33-0.45 mm long by 0.20-0.28 mm wide, widest in the center, finely crenulate. The mural rim forms a sharp ridge with adjacent mural rims. The narrow, sloping cryptocyst is coarsely granulose and lacks a horizontal lamina. There are four multiporous septula in each lateral wall; these sometimes lead to pore chambers. The distal wall is perforated by a transverse band of pores. Spines are uncommon in our material. Some zooids have a single short, vertical hollow spine arising from the mural rim on one side, at or slightly distal to the middle of the opesia. Marginal zooids occasionally have a pair of thin, hollow distal spines; these are lost with age. The entire gymnocyst is covered by a large avicularium which is more or less square in outline; one side is raised and forms a triangular rostrum. The chamber abuts and commonly overlies the distal end of the ovicell of the preceding zooid. The proximal avicularium varies considerably in size and sometimes is not much larger than the lateral avicularia. It lies entirely proximal to the aperture or extends a short way around the proximal corner. The triangular mandible is downcurved at the tip, lies at about 45° to the frontal plane, and can point in any direction, although most often laterally or distolaterally. A pair of lateral avicularia lie atop the mural rim, in line with the orifice. Their triangular mandibles angle at 45° to the colony surface and point proximally. The lateral avicularia vary somewhat in size and height. The ovicell is hyperstomial, 0.15-0.20 mm long by 0.20-0.25 mm wide, with a transverse ridge across the top.

**DISCUSSION:** The interzooidal connections in our specimens of *T. armifera* are variable; both multiporous septula and pore chambers occur in the same colony. In some cases, a septulum in the distal half of the lateral wall of a zooid connects with a simple orifice in the proximal half of the lateral wall of the adjoining zooid. In other cases, a diagonal wall forms in the adjoining zooid, enclosing a small chamber which is triangular in cross section and open distally. These pore chambers, quite evident at the growing edge of the colony, predominate in our material. A subtidal specimen from Canoe Bay, Alaska, identified as *T. armifera* by Osburn (Allan Hancock Foundation Collection No. 1154), also has pore chambers. Specimens from the northern Bering Sea and Kasatochi Island in the Aleutians have predominantly septula, though occasionally a poorly developed pore chamber occurs. Kluge (1975) noted that pore chambers occur in several species of *Tegella* and predominate in some. Our observations indicate that interzooidal connections vary between populations of *T. armifera*. The only character Levinsen (1909) used in separating *Tegella* from *Callopora* was the presence of septula in the former versus pore chambers in the latter. This is apparently not a reliable character, and the classification of some species belonging to these genera may have to be revised.

**OCCURRENCE:** This was a prominent species widely distributed in the lower midlittoral and infralittoral fringe. It reached was most abundant at Eider Island and Sunny Cove.



DISTRIBUTION: *T. armifera* is a circumpolar, arctic-boreal species previously known along the west coast of North America from the Beaufort Sea (Hulsemann and Soule 1962) and from Point Barrow, Alaska, southward to San Pedro, California (Osburn 1950).

*Tegella horrida* (Hincks)

Plate 3D-G

*Membranipora horrida* Hincks, 1880b: 82, pl. 10, fig. 6; Robertson, 1908: 260, pl. 14, figs. 3, 4.

*Callopora horrida*, Osburn, 1950: 69, pl. 6, fig. 9; Androsova, 1958: 98, fig. 9; Mawatari and Mawatari, 1980: 42, fig. 9.

*Tegella robertsonae*, Osburn, 1950: 81, pl. 9, fig. 5.

*Tegella aquilirostris*, Dick and Ross, 1986: 89 (part).

DESCRIPTION: Colonies are encrusting, irregular to subcircular, up to 3 cm across, tan-colored. Zooids are 0.53-0.75 mm long by 0.33-0.50 mm wide, separated by deep grooves when young, the lateral gymnocyst with two or three small pores on each side. With age, the space between zooids becomes filled with calcification. Adjacent apertures are then separated by a wide, irregularly rounded, finely granulose mural rim, and the pores in the gymnocyst lead to larger lacunae on the surface. Zooidal boundaries are indistinct. The width of frontal surface between opesiae is commonly half, and sometimes as great as, the width of the opesia. The opesia, 0.30-0.40 mm long by 0.15-0.25 mm wide, varies in shape from oval to elliptical to rounded-quadrate. The gymnocyst comprises two-fifths to one-half the length of the zooid. Each lateral wall interconnects through three or four septula, although pore chambers also occur, as in *T. armifera*. The distal wall has a transverse band or crescentic zone of pores, sometimes organized into one or two circular septula, in the basal half. There is a sloping granulose cryptocyst with a crenulate margin. Two pairs of straight, blunt, hollow, erect distal spines are present on zooids at the growing edge. With age, only the most proximal pair remains, lateral to the posterior margin of the orifice. Occasionally one or both of these has been lost, or one replaced by a stout, acuminate, slightly curved spine angled over the opesia. Around the proximal two-thirds of the opesia are two to five thinner, shorter, acuminate, slightly curved spines angled medially. Covering the proximal gymnocyst is a large avicularium with an elongate, tapering rostrum often curving a considerable way laterally around the opesia. The rostrum is only slightly raised, if at all, from the colony surface and is commonly somewhat decurved. The mandible takes the shape of the rostrum, the tip more or less rounded and ending in a slight, decurved hook. Some zooids have one, or occasionally two, smaller proximal avicularia in place of the single large one; in these, the raised rostrum is unhooked. The mandible is nearly equilateral, with convex sides. It is oriented at 45 degrees to the colony surface and points in any direction, though most often proximally. The elongate avicularium is more common, but some colonies have predominantly the smaller avicularia. Even then, close examination reveals a few zooids with the elongate type. Large, vicarious avicularia are occasionally present, just as illustrated by Robertson (1908: pl. 14, fig. 4). These are derived from zooids in which the opesia has been partially closed by a horizontal lamina and either the proximal or distal wall raised to form a rostrum; the semicircular mandible thus points proximally or distally. Some of the heterozooids nonetheless retain one or two small

proximal avicularia. Ovicells are subimmersed, 0.25-0.28 mm long by 0.23-0.30 mm wide. In later stages, they are covered by granulose calcification from surrounding zooids. There is a slight, curved or distally angled transverse rib delineating a narrow, lunate or triangular tabula.

**DISCUSSION:** Our material is similar to specimens of *Callopora horrida* from Friday Harbor, Washington, identified by Osburn (Allan Hancock Foundation Collection No. 1144). In these specimens, as in ours, the interzooidal grooves are filled with granulose calcification perforated by lacunae; the opesiae are well separated by wide mural rims; large avicularia curving around the apertures predominate, but the smaller form occurs; and the ovicells are subimmersed and granulose, with a transverse rib. Pore chambers are present. Spines are similar in number and distribution. Vicarious avicularia are lacking. We examined a specimen of *Tegella robertsonae* from British Columbia, also identified by Osburn (AHF No. 1157). Frontal avicularia are similar to those of Osburn's *C. horrida*, and several of the vicarious avicularia reported for *C. horrida* by Robertson (1908) are present. The mural rim is wide and granulose, with intermural lacunae. The only major difference is the presence of multiporous septula rather than pore chambers. This, as has been shown, can be variable in the genus *Tegella*. McCain and Ross (1974) synonymized *T. robertsonae* with *T. aquilirostris*; however, Osburn's British Columbia specimen, as well as Osburn's (1950) description and illustration, indicate that material he identified as *T. robertsonae* is probably *C. horrida*. It appears that he distinguished between the two mainly on the basis of interzooidal connections. Another diagnostic character between *Callopora* and *Tegella* is the ovicell, closed by the operculum in the former but not in the latter (Ryland and Hayward 1977). Our specimens, and also Osburn's specimens of *T. robertsonae* and *C. horrida*, have the ovicell closed by a special flap distal to the orifice, which makes them *Tegella*. This is not to say that Robertson's (1900) species *Membranipora unicornis*, later renamed *M. occultata* by Robertson (1908) and given a new name, *T. robertsonae*, by O'Donoghue and O'Donoghue (1926), is not a synonym of *T. aquilirostris*, but only that Osburn's (1950) *T. robertsonae* seems to be a synonym of *C. horrida* (Hincks). *T. aquilirostris* has fewer spines and a raised, hooked avicularium not extending appreciably around the aperture.

**OCCURRENCE:** *T. horrida* occurred only at Stations 7 and 8, exposed midlittoral and infralittoral fringe stations, respectively. Additional specimens were found at Fossil Beach on Narrow Cape, Kodiak Island.

**DISTRIBUTION:** This is a boreal species apparently endemic to the North Pacific. It is previously known from British Columbia to California (Osburn 1950), Japan (Mawatari and Mawatari 1980), and the Sea of Japan (Androsova 1958).

Family MICROPORIDAE Gray, 1848

Genus *MICROPORINA* Levinsen, 1909

*Microporina articulata* (Fabricius)

Plate 10E

*Cellularia articulata* Fabricius: 1821: 27.

*Microporina borealis*, Osburn: 1950, pl. 11, fig. 2.

*Microporina articulata*, Kluge, 1975: 386, fig. 201.

**DESCRIPTION:** The colony is erect, whitish in color, up to 6 cm or more tall, consisting of dichotomous cylindrical branches separated into internodal segments by flexible nodes. There are 14 to 16 longitudinal series of zooids around the internodes, which are up to 13 mm long by 1.9 mm in diameter. Zooids are delineated by a fine brown line where adjacent frontal membranes meet; they are 0.63-0.75 mm long by 0.28-0.42 mm wide, and longest in the middle of the node. The raised, rounded, granulose mural rims of adjacent zooids are so closely appressed as to appear almost indistinguishable, except for a faint groove between them which is evident in hypochlorite-cleaned specimens. The frontal membrane is transparent and covers the zooid from margin to margin. A cryptocyst occupies the entire frontal surface proximal to the orifice; it is granulose, and perforated with numerous small pores which are cribriform at the inner opening. Proximal to the orifice is an imperforate area which rises to form the narrow, somewhat serrate, straight proximal lip of the orifice. Slightly proximal and lateral to this imperforate area are circular or elliptical opesiules which in our material are occluded by a thin calcified plate sometimes bearing cribriform pores. The orifice is broader than long, rounded distally. Circular or oval vicarious avicularia lie just distal to the aperture of many zooids. The avicularia tend to be more prevalent in the proximal and distal portions of internodes, and are often scarce or absent in the middle. They also have a rounded, granulose mural rim. The opesia of the avicularium is divided by a thick pivot; the triangular mandible points proximally. The colony is anchored by stout hollow rhizoids about 0.25 mm in diameter. These arise from the proximal half of the frontal membrane of some zooids occupying the proximal ends of internodes near the base of the colony. The rhizoids form branched, anastomosing holdfasts where they attach to the substrate. Sometimes the holdfast is calcified. Long, hairlike, auxiliary anchoring fibers also arise from the frontal membranes of some basal zooids in the colony. Ovicells and spines are lacking.

**OCCURRENCE:** This species was not found in the rock-pile habitat, but in crevices on solid reefs. It occurred in the infralittoral fringe in several parts of the study area, but was common only at Station 10. We have intertidal specimens from Marmot Island and Shuyak Strait, both in the northern portion of the Kodiak archipelago.

**DISTRIBUTION:** *M. articulata* is an arctic-boreal species. In North America it ranges from the Bering Sea to British Columbia (Osburn 1950), and eastward in the Arctic to Greenland (Kluge 1975).

Family SCRUPOCELLARIIDAE Levinsen, 1909

Genus SCRUPOCELLARIA van Beneden, 1845

*Scrupocellaria elongata* (Smitt) var. *congesta* (Norman)  
Plate 4B

*Cellularia scabra* forma *elongata* Smitt, 1868a: 284, pl. 17, figs. 35-36.

*Scrupocellaria scabra* J. van Beneden var. *septentrionalis* subvar. *congesta* Norman, 1903: 580.

*Scrupocellaria elongata* var. *congesta*, Ryland, 1963: 12, fig. 2.

*Tricellaria erecta*, Osburn, 1950: 126, pl. 14, figs. 7, 8; Mawatari, 1956: 120, fig. 4e; McCain and Ross, 1974: 13.

*Scrupocellaria arctica*, Kluge, 1975: 461, fig. 243; Dick and Ross 1986: 89.

**DESCRIPTION:** The colony is tan-colored, erect, up to 2 cm high in the rock-pile habitat, dichotomously branched, anchored by radicle fibers. Zooids are 0.50-1.00 mm long by 0.25-0.35 mm wide, arranged biserially. The lowest internodes contain three zooids, the ultimate internodes up to 14 zooids. The oval opesia occupies one-half to two-thirds of the visible frontal surface. A scutum is attached to the smooth, sharp edge of the opesia on the inner side, in line with the proximal margin of the orifice. It varies from a spinelike process to a flattened triangular structure, sometimes with two or three lobes. There is a single short spine at the outer distolateral corner of the opesia. The central zooid at a branch bifurcation has a median distal spine as well. Zooids bear a lateral avicularium, which is less than half the length of the opesia, attached to the outer distolateral surface; the mandible lies in line with the orifice. A smaller frontal avicularium is located at the inner edge of the gymnocyst and abuts the proximal edge of the opesia, the raised mandible pointing proximally. Either type may be absent from a particular zooid. Ovicells are hyperstomial, globose, slightly wider than long, and closed by a special membrane. There is a crescentic fenestra in the ectooecium bordering the opening of the ovicell. Embryos are red-orange. Vibracula are absent. Stout radicle fibers up to 0.12 mm in diameter arise from the outer, proximolateral surface of primarily lower zooids, but occasionally from zooids in the longer internodes.

**DISCUSSION:** This species has been placed in either *Tricellaria* or *Scrupocellaria* by previous authors. Kluge (1975) gave a good argument for placing it in *Scrupocellaria*, even though it lacks vibracula. It has a type of bifurcation characteristic of *Scrupocellaria* (Type 8) rather than of *Tricellaria* (Types 9-12, see Harmer 1923). Ryland (1963) discussed why the trivial name *arctica* (Busk 1855a) cannot be used in place of *elongata* Smitt. Although Kluge (1975) did not include North American references in his synonymy, he recognized *Tricellaria erecta* (Robertson) as a synonym of his *S. arctica* in the outline of distribution.

**OCCURRENCE:** There were one or two colonies at each of Stations 3, 7, 10, and 14, ranging from the midlittoral to the infralittoral fringe.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species (Kluge 1975). On the west coast of North America it ranges from Point Barrow, Alaska, southward to Puget Sound, Washington (Osburn 1950).

Genus *TRICELLARIA* Fleming, 1828

*Tricellaria ternata* (Ellis and Solander)

Plate 4A

*Cellaria ternata* Ellis and Solander 1786: 30.

*Tricellaria ternata*, Osburn, 1950: 123, pl. 14, figs. 1, 2; McCain and Ross, 1974: 13;

Kluge, 1975: 451, fig. 235; Ryland and Hayward, 1977: 144, fig. 69; Dick and Ross, 1986: 89.

**DESCRIPTION:** Colonies in the rock-pile habitat are about 1 cm high, tightly arborescent, tan-white in color. Zooids vary from 0.50-1.0 mm long, depending upon their position in an internode and in the colony. Most internodes have three zooids, but distal ones can have six to eight. The elliptical opesia occupies about a third of the zooidal length. Zooids typically have three distal spines, the lateral two separated from the one on the axial side. Axial zooids at bifurcations usually have four spines, the medial two closer to one another than to the lateral two; sometimes there is a central median spine and two distolateral ones as in Plate 4A. The spines in the basal part of the colony are short, but on peripheral zooids they reach 0.75 mm in length. A scutum is attached near the middle of the opesia on either side and varies from a curved spinous process to a triangularly spatulate, sometimes bilobed structure. Most non-axial zooids have a large, raised lateral avicularium with a hooked rostrum; occasionally this is lacking. A small frontal avicularium with a raised, proximally directed mandible is sometimes present, usually only on the axial zooid at the bifurcation of a branch. The bifurcation is Type 9 (see Harmer 1923), with the proximal portions of zooids F and G not in contact. Some zooids, especially those low in the colony, have a proximally directed radicle fiber originating from a slight disc on the frontolateral or lateral wall of the zooid, just proximal to the large avicularium. Zooids can also have a distally directed tendril fiber originating from a flattened chamber on the lateral wall, immediately distal to the large avicularium. A given zooid can bear both types of attachment kenozooids. The globose ovicell is smooth and imperforate. Embryos are orange.

**OCCURRENCE:** This species was uncommon in the rock-pile habitat. Five colonies were found at Stations 6 and 7 in the upper midlittoral. It was more common on overhanging rock faces and also occurred among algal holdfasts.

**DISTRIBUTION:** *T. ternata* is a circumpolar, arctic-boreal species previously known in the eastern Pacific from the Bering Sea (Kluge 1975), and from southeastern Alaska to southern California (Osburn 1950).

Family BUGULIDAE Gray, 1848

Genus *DENDROBEANIA* Levinsen, 1909

*Dendrobeatia exilis* (Hincks)

Plate 5G

*Membranipora exilis* Hincks, 1882: 249, 466, pl. 20, fig. 1.

*Dendrobeatia* sp., Dick and Ross, 1986: 89. not *Callopora exilis*, O'Donoghue and O'Donoghue, 1926: 33, pl. 3, fig. 25; Osburn, 1950: 68, pl. 6, fig. 8.

**DESCRIPTION:** The colony is tan to orange-brown, encrusting rocks and algal stipes. Colony shape is determined by the type of substrate. Colonies on rock are roughly circular with irregular lobes, some of which may not be attached; those on algae adhere closely. Radicle fibers are lacking. The opesia is 0.50-0.90 mm long by 0.30-0.40 mm wide and occupies the entire exposed frontal surface, surrounded by a thin, smooth mural rim. Lateral walls are more or less loosely appressed to one another, with deep grooves between some of them. Zooids interconnect through multiporous septula, one in the distal wall and four in each lateral wall. All walls except the basal are relatively heavily calcified for a species of this genus. The basal wall of some zooids is punctate with white spots which can easily be seen from the dorsal side. Around the distal one-half to one-third of the opesia are four to seven coarse, straight or irregularly curved, spines which are 0.25-0.40 mm long and number two to four on each side. The second pair from the distal end are usually longer and thicker than the rest. Single, or occasionally paired, lateral avicularia are scattered irregularly throughout the colony. They are 0.20-0.25 mm long and about the same height. The mandible is spatulate or rounded-triangular and points proximally. The avicularium arises from the lateral wall of the parent zooid and is attached by a broad base. This base represents a modified pedicel, present in other species of the genus, which has expanded to attach the whole dorsal wall of the rostrum and has become completely calcified. The wall of the rostrum can be distinguished from the base of attachment by a thin striation which is homologous to the flexible joint in other species. Avicularia occur much more commonly on non-ovicellate than on ovicellate zooids and are rare in some colonies, abundant in others. Ovicells are 0.30 mm long by 0.37 mm wide, globular, raised, vitreous, with irregularly radiating striations. Embryos are orange.

**DISCUSSION:** Hincks' (1882: 466) description is quite accurate when applied to our specimens: zooids "of considerable size and delicate half-membranous material . . . the front wall wholly membranous." O'Donoghue and O'Donoghue (1926) and Osburn (1950) appear to have erroneously applied the name *M. exilis* to one, or perhaps two, species of *Callopora*. Hincks' illustration is clearly that of a *Dendrobeatia* rather than a *Callopora*.

**OCCURRENCE:** Only one colony was found intertidally, at Station 14 in the lower infralittoral fringe. This is predominantly a subtidal species.

**DISTRIBUTION:** We have subtidal specimens from drift algae at Spruce Cape, Kodiak; from Shuyak Strait 60 km north of Narrow Strait; and from Makushkin Bay on Unalaska Island. The only other records are from the Queen Charlotte Islands (Hincks 1882). This is a boreal species known only from the eastern Pacific.

*Dendrobeatia lichenoides* (Robertson)

Plate 4D

*Flustra lichenoides* Robertson, 1900: 322, figs. 7, 8.

*Dendrobeatia lichenoides*, Osburn, 1950: 167, pl. 25, fig. 6; McCain and Ross, 1974: 13; Dick and Ross, 1986: 89.

**DESCRIPTION:** The species forms flexible, unilaminar, loosely attached, licheniform, tan-colored fronds. Zooids are arranged in linear series, each slightly overlapping the next in the column. They are loosely connected, so that in dried material there are deep grooves between them. The opesia, 0.65-1.25 mm long by 0.25-0.35 mm wide, occupies the entire exposed frontal surface of the zooid. All walls are thin. There are up to three pairs of spines around the distal third of the zooid, but there is much variation both within and between colonies. There may be two spines on one side and three on the other, or they may be lacking altogether. They may be long and coarse, or consist of tiny projections. Spines tend to be longer, coarser, and more numerous on ovicellate zooids. Ovicells are 0.25 mm long by 0.30 mm wide, globose, raised, vitreous, with faint radiating lines. Avicularia are lacking. Some zooids have a radicle fiber arising from the dorsal, distolateral corner. This forms a branched holdfast where it connects with the substrate.

**OCCURRENCE:** There were a few colonies at each of Stations 2, 3, and 14.

**DISTRIBUTION:** *D. lichenoides* is a boreal species known only from the eastern Pacific. It has been found from Orca, Prince William Sound, Alaska (Robertson 1900), southward to San Francisco Bay (Robertson 1905). We have an additional specimen from a depth of 2-10 m at Port Valdez, Alaska. Narrow Strait represents the westward limit of the known range.

**Suborder ASCOPHORA Levinsen 1909**

Family CRIBRILINIDAE Hincks 1879

Genus *CRIBRILINA* Gray, 1848

*Cribrilina annulata* (Fabricius)

Plate 4C

*Cellepora annulata* Fabricius, 1780: 436.

*Cribrilina annulata*, Osburn, 1950: 177, pl. 28, fig. 7; Kluge, 1975: 471, fig. 247; Hayward and Ryland, 1979: 60, fig. 15; Dick and Ross, 1986: 89.

**DESCRIPTION:** Colonies are small, rarely exceeding 2 cm in diameter, encrusting, pink. Zooids are 0.40-0.55 mm long by 0.25-0.40 mm wide, separated by deep grooves. The inflated frontal shield consists of five to seven pairs of flattened costae fused together, with six to 10 intercostal pores in a transverse series between costae. The distalmost pair of costae are wider and heavier than the others and form a thickened lip with a prominent, pointed umbo proximal to the orifice; sometimes they are incompletely fused. A short, straight, tapering median spine and a pair of longer lateral spines, which are often curved medially, lie around the distal portion of the orifice; sometimes there are four spines. In the central portion of the colony are numerous, randomly oriented, dwarf ovicellate zooids which arise frontally from the autozooids. Their frontal shield consists of three to five fused costae with a few

intercostal pores between them. The two sub-apertural costae are prominent and form a projection, as with autozooids. The ovicell of dwarf zooids is derived from the two distolateral spines, which are broadened and thickened to form the lip of the ovicell, and an extension of the distal rim of the orifice to form the distal wall of the ovicell. Dwarf ovicells bear one to four small pores. Ovicells are present on some of the autozooids; these are similar in form to the dwarf ovicells, but larger, with up to six pores arranged transversely. Avicularia are lacking.

**OCCURRENCE:** This was a prominent species, present throughout the study area except at upper midlittoral Station 6. It was most abundant at infralittoral fringe stations 13 and 14.

**DISTRIBUTION:** *C. annulata* is a circumpolar, arctic-boreal species known along western North America from Point Barrow, Alaska, to British Columbia (Osburn 1950).

Family UMBONULIDAE Canu, 1904

Genus *POSTERULA* Jullien, 1903

*Posterula sarsi* (Smitt)

Plate 4C

*Escharoides sarsi* Smitt, 1868b: 24, 158, pl. 26, figs. 147-154.

*Escharopsis sarsi*, Kluge, 1975: 666, fig. 384.

*Posterula sarsi*, Osburn, 1952: 310, pl. 35, fig. 6; Powell, 1968: 2298, pl. 6c, d; Dick and Ross, 1986: 89.

**DESCRIPTION:** Colonies are unilaminar, encrusting, flesh-colored, irregularly circular, up to 2 cm across. Zooids are hexagonal or ovoid, 0.43-0.60 mm long by 0.30-0.40 mm wide, separated by a groove, sometimes with a raised margin. The frontal wall is convex, imperforate, smooth or minutely granulose, irregularly sculptured with low nodules, sometimes quite nodular and rugose with age. Around the margin is a row of areolar pores separated by costae. The approximately circular primary orifice is 0.15 mm across, obscured by a deep peristome formed from a sharp, raised lip distally and the thick frontal wall proximally. Most zooids have a small, very narrow, straight or slightly uncinuate lyrula on the proximal border of the orifice. In young zooids it arises in the midline; with the development of the peristome, it shifts to one side. The secondary orifice is asymmetrically pyriform or irregular in shape. Just inside the peristome, to one side or the other of the midline, lies a small laterally directed avicularium with a subspatulate mandible. The avicularium jutting into the peristome helps impart the asymmetrical aspect to the secondary orifice; also, the peristomial rim opposite the avicularium sometimes forms a flange. The ovicell is hyperstomial, globose, 0.25 mm across, with a triangular or diamond-shaped sinus on top, not closed by the operculum. In later stages of calcification, the ovicell becomes subimmersed, with only the top showing. Colonies of this species usually rise from an encrusting base into erect, bilaminar frills, but we found only unilaminar encrusting colonies intertidally. Zooid measurements are smaller than those of subtidal material from other localities (Osburn 1952, Androsova 1958, Kluge 1975).

**OCCURRENCE:** This was a generally uncommon infralittoral fringe species present in low densities at Stations 5, 10, 13, and 14. There were 52 colonies at Station 12, a sheltered site probably with considerable estuarine influence.



DISTRIBUTION: *P. sarsi* is a circumpolar, primarily arctic species previously known in western North America from Point Barrow to Juneau, Alaska (Osburn 1952).

Family CRYPTOSULIDAE Vigneaux, 1949

Genus *CRYPTOSULA* Canu and Bassler, 1925

*Cryptosula okadai* n. nom.

Plate 5F

*Lepralia reticulata* Okada, 1929: 24, pl. 5, figs. 4, 5.

*Lepralia pallasiana*, O'Donoghue, 1925: 19 (in part?).

*Cryptosula pallasiana*, Dick and Ross, 1986: 89.

DESCRIPTION: The colony is circular, up to 5 cm across; yellowish, tan, brownish, or pinkish; unilaminar; and encrusting, with the margins sometimes rising from the substrate in recumbent lobes. Living colonies exude a foul, pungent odor which pervades the shore during summertime low tides. Zooids are subrectangular, widest in the middle, rounded distally, 0.60-1.18 mm long by 0.25-0.53 mm wide, separated by grooves and sometimes a raised calcareous line. The frontal wall is cryptocystidean, convex, finely granulose, perforated with large, uniform pores over the entire surface. With age, the pores become infundibular and the surface retiform, with rounded ridges between the pores. The frontal wall rises distally to a suboral umbo which varies from a low, conical projection to a tall, frequently costate process. The umbo leans slightly distally and is often hollowed on the distal surface, the hollow obscured by ectocyst. The orifice is semicircular, 0.18-0.23 mm wide by 0.15-0.23 mm long. The poster is slightly broader than the anter, and the two are separated by low, rounded, proximally directed cardelles. There is no raised peristome. An area of smooth frontal wall devoid of pores borders the orifice proximally and laterally. The orifice of one zooid is higher than the frontal surface of the succeeding zooid. The operculum has a marginal sclerite on each side; often these extend and meet distally, forming a continuous border. Each lateral wall interconnects through two large, elliptical multiporous septula. The distal wall has an extensive basal multiporous septular area which is rectangular, bilobed, or divided into two septula side by side. In some colonies, there are scattered marginal zones of kenozooids which lack an orifice. Kenozooids have the entire frontal surface calcified and covered with pores. They are similar to autozooids in all other respects, including the umbo. Sometimes the outline of the orifice is evident as a suture line in the calcification. The zones of marginal kenozooids extend up to 16 columns wide by four rows deep and are interspersed with zones of marginal autozooids; occasionally kenozooids and autozooids are mixed in the same area. The formation of marginal kenozooids appears to occur seasonally. Rapidly growing colonies in summer lack them, but they are present in colonies collected in fall and winter. Spines, avicularia and ovicells are lacking. Reddish-orange embryos are brooded internally in the distal part of the zooid. The form of the ancestrula was not reported by Okada (1929) or Androsova (1958). It is tatiform, without spines, and buds a triplet of smaller zooids distally. Average measurements of five ancestrulae were 0.51 mm long by 0.40 mm wide.

DISCUSSION: The name *Lepralia reticulata* Okada, 1929, is a junior primary homonym of *Lepralia reticulata* MacGillivray, 1842. Okada's species has all the characters of the genus *Cryptosula* (see Hayward and Ryland 1979), and, as there are

no available synonyms, we have renamed it as *Cryptosula okadai*. *C. okadai* is similar to *C. pallasiana* (Moll), but there are significant differences. The orifice of *C. pallasiana* is proportionately larger relative to the size of the zooid and has a markedly concave proximal border. The proximal border of *C. okadai* is straight or slightly concave. Marginal pores extend around the orifice in *C. pallasiana* (see Osburn 1912: fig. 54 and 1952: pl. 57, figs. 4-5; Mawatari 1974b: fig. 127; Hayward and Ryland 1979: fig. 30; Winston 1982: fig. 67) but not in *C. okadai*. The ancestrula of *C. pallasiana* resembles later zooids (Hayward and Ryland 1979), whereas that of *C. okadai* is tafiform. Suboral avicularia and a flaring peristome occur in *C. pallasiana* but have not been noted in *C. okadai*. *C. pallasiana* generally lacks the marginal kenozooids which are common in *C. okadai*, although in a large colony of the former from Port Angeles, Washington, we found a single marginal kenozooid.

**OCCURRENCE:** This was a prominent species, one of the most abundant intertidal bryozoans in the Kodiak region. Our study did not reflect its actual abundance, because it attains the greatest density and cover on exposed rock surfaces in the upper midlittoral zone, where it overgrows barnacles and other sessile organisms. This success is perhaps due to allelopathic properties of the substance responsible for the foul odor of the species.

**DISTRIBUTION:** This is a boreal Pacific species. Androsova (1958) recorded it at depths of 15-40 m in the Sea of Japan, and Okada (1929) found it at Mutsu Bay, Japan. We have reexamined Alaskan specimens, which we previously identified as *C. pallasiana*, ranging from the Gulf of Alaska to the Bering Sea. All have proven to be *C. okadai*. We have intertidal specimens from Port Etches, Zaikof Bay, Squirrel Bay, and Anchor Cove, all in the northern Gulf of Alaska; from Midarm Island and Sharatin Bay in the Kodiak archipelago; and from Dutch Harbor in the eastern Aleutian Islands. A specimen was collected in the drift at Nanvak Bay on the Bering Sea coast. The southward extent of the range in the eastern Pacific remains to be determined. We did not find *C. okadai* in an intertidal collection from the Blashke Islands in southeastern Alaska. *C. pallasiana* has not been recorded in Alaska and apparently has a more southern distribution. O'Donoghue's (1925) description and figure of *C. pallasiana* from Homer, Alaska, actually represent *C. okadai*. The records by McCain and Ross (1974) of *C. pallasiana* from Washington are correct, and Osburn's (1952) numerous records of the species from southern California and Mexico are likely also correct.

### Genus *HARMERIA* Norman, 1903

This monotypic genus has been included in the Hippothoidae by previous authors (Osburn 1952, Kluge 1975), but Kluge noted that this classification was temporary. *Harmeria* lacks pore chambers and ovicells and cannot be a hippothoid. Kluge implied that the frontal wall is gymnocystidean, but we believe that it is cryptocystidean. Formation of vertical walls at the growing edge is followed by frontal calcification which originates at the proximal end of the zooid and continues distally. The small peripheral zooids in our dried material have a cuticle separated from the calcified frontal wall by what can only be a hypostegal coelom. This is not evident in the large zooids, where the cuticle is either tightly adhering or has been worn away. An orifice shape similar to that in the genus *Cryptosula*; the lack of ovicells and spines; and the presence of multiporous septula all favor placement of *Harmeria* in the Cryptosulidae.

*Harmeria scutulata* (Busk)

Plate 9D

*Lepralia scutulata* Busk, 1855a: 255, pl. 2, figs. 1-2.

*Harmeria scutulata*, Osburn, 1952: 282; Kluge, 1975: 627, fig. 360; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is unilaminar, encrusting, white or flesh-colored, up to 1.5 cm across. Zooids are arranged in radiating rows from the ancestrula and occur in two sizes. Larger zooids 0.60-0.73 mm long by 0.25 mm wide occupy the central portion of the colony in a zone six or seven zooids deep. This zone abruptly ends, giving rise to a peripheral band five to 12 zooids deep in which the zooids are 0.18-0.25 mm long by 0.13-0.18 mm wide. The large zooids are hexagonal or ovate. The frontal wall is thin, smooth, vitreous, and strongly transversely convex, with a deep groove between zooids. It is uniformly perforated with small pores in a central scutiform area which is delineated from a thicker, imperforate marginal border by a sharp line. The frontal wall rises toward the orifice, where it forms a pronounced, triangular, somewhat lunate lip with a thickened margin. The orifice, raised but lacking a peristome, has a semicircular anter separated from an equally broad poster by a slight constriction of the orificial margin. The proximal margin is straight or slightly concave. The small peripheral zooids have the same basic form as the central zooids, but are longitudinally compressed and markedly hexagonal. They are more heavily calcified; the frontal pores are smaller; and the frontal surface is almost flat. Around the proximal half of the orifice is a heavy, lunate, almost umbonate lip terminating in a blunt median projection curved over the orifice. Spines, avicularia, and ovicells are lacking. In colonies collected early in October, the large central zooids were dead, with only the white cystids remaining. The small peripheral zooids were alive and flesh-colored. In some colonies, the large zooids had broken apart, leaving only a ring of peripheral zooids.

**OCCURRENCE:** This species was fairly common at upper midlittoral Stations 1 and 2 and lower midlittoral Station 3, all in central Narrow Strait. It may be more widely distributed in the midlittoral than was indicated by the few stations placed in that zone.

**DISTRIBUTION:** This is a circumpolar, primarily arctic species (Kluge 1975), to our knowledge not previously collected below 60° north latitude. There are two other records from western North America: Bering Strait (Kluge 1975) and Punuk Island, Bering Sea (Osburn 1952).

Family HIPPOPODINIDAE Levinsen, 1909

Genus *CODONELLINA* Bassler, 1934

*Codonellina argentea* (Hincks)

Plate 10F

*Porella argentea* Hincks, 1884b: 212, pl. 9, fig. 1.

*Hippodiplosia* sp., Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is encrusting, unilaminar, yellowish. Zooids are irregularly hexagonal, long-obovate, or barrel-shaped; 0.50-0.75 mm long by 0.30-0.43 mm wide; separated by a raised line and sometimes a moderate groove; and

covered with a shiny ectocyst, beneath which is granular, bright-yellow pigmentation. The frontal wall varies from slightly to markedly convex. It is finely granulose and evenly perforated with small, uniform pores from margin to margin. With increased calcification, the frontal pores become infundibular and the surface moderately rugose or tuberculate. A low, more-or-less lunate umbo develops proximal to the orifice in some zooids; if an avicularium is present, the umbo overlies the chamber. The umbo is nodular, rugose, or costate. Lateral walls interconnect through four small, circular or elliptical, basally positioned septula with a few pores, and there are two similar septula in the distal wall. The primary orifice is 0.15-0.18 mm long by 0.18 mm wide. The anter is nearly semicircular, and is separated from a deep, broad, tapering poster by prominent, rounded cardelles. The proximal border of the poster is straight or slightly convex. The primary orifice lies slightly below, and nearly parallel to, the frontal surface. The slight peristome consists of a thin, sharp lip above the orifice, best developed distally, less so laterally, and scarcely so proximally. Immediately proximal to the orifice is a small median suboral avicularium on a raised chamber. The mandible is semicircular, raised, and directed proximally. Commonly the avicularium fails to develop, leaving a smooth imperforate area proximal to the orifice. The ovicell, 0.18-0.25 mm long by 0.25-0.33 mm wide, is raised and globose at first. With age, it becomes subimmersed, and only the top is visible. The surface is granulose and rugose, with a single median pore near the proximal margin. The raised calcareous margins of adjacent zooids form a band of calcification around the base of the ovicell; this secondary calcification extends across the proximolateral corners of the ovicell and across the proximal margin. The raised peristomial lip also extends across the proximal border of the ovicell. Spines are lacking.

**DISCUSSION:** We have placed this species in the genus *Codonellina* on the basis of the regularly perforated frontal wall; the deep, broad poster behind prominent cardelles; the suboral avicularium; a prominent ovicell closed by the operculum; and multiporous septula. The marginated ovicell with a single median pore is not characteristic of most species of *Codonellina*, which tend to have ovicells regularly perforated with many pores. However, variation in ovicell perforation occurs in other genera, such as *Smittina*, in which some species have a single pore and others many pores. Gordon (1984) transferred *Codonellina* from the Smittinidae to the Hippopodiniidae, primarily on the basis of the broad poster. In *C. argentea*, the suboral avicularium communicates through a small median pore rather than areolar pores on each side, a characteristic of the Hippopodiniidae rather than the Smittinidae (Gordon 1984).

**OCCURRENCE:** This species was rare in the intertidal. Three colonies were found at Stations 13 and 14 in the lower infralittoral fringe. Another specimen was collected at a depth of 20 m off Termination Point, Narrow Strait.

**DISTRIBUTION:** The only previous record was from the Queen Charlotte Islands (Hincks 1884b). This is a boreal species apparently endemic to the eastern Pacific.

Genus *HIPPOPORINA* Neviani, 1895

*Hippoporina apertura* (Osburn)

Plate 4E

*Dakaria apertura* Osburn, 1952: 326, pl. 39, figs. 7-9.

*Dakaria* sp. A, Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is unilaminar, encrusting, rust-colored. Zooids are variable in size and shape; 0.60-1.04 mm (average 0.80 mm) long by 0.28-0.68 mm (average 0.48 mm) wide; hexagonal, long-rectangular or irregular; sometimes nearly as wide as long; and separated by a raised calcareous line. The frontal wall is thick, convex, coarsely granulose, covered with a reddish-brown ectocyst, perforated by numerous infundibular pores from margin to margin, reticulate with age. The frontal pores usually extend halfway or more around the sides of the orifice. Zooids interconnect through six or seven small circular septula with a few pores each; transverse walls have three or four minute circular septula at the base. The primary orifice is circular, 0.20-0.25 mm across. The operculum is thick, transparent, the same color as the ectocyst, with a bordering sclerite. The anter is separated from the poster by strong cardelles; the curve of the poster is of slightly less radius than the anter. Around the anter is a low, sharp lip. Bordering the poster is a narrow imperforate area which is distinct from the rest of the frontal wall and sometimes bordered by a lunate ridge. This ridge and the lip around the distal portion of the orifice form the only indication of a peristome. The ovicell is raised, 0.28-0.40 mm (average 0.35 mm) long by 0.32-0.52 mm (average 0.42 mm) wide, closed by the operculum. Thick secondary calcification from adjacent zooids extends in a ribbed band around the sides of the ovicell, leaving a circular area on top perforated with many irregular pores. Spines and avicularia are lacking.

**DISCUSSION:** This species was placed in the genus *Dakaria* by Osburn (1952). *Dakaria* Jullien, 1903, is a junior synonym of *Watersipora* Neviani, 1895 (Cook 1985). All of Osburn's (1952) species of "*Dakaria*" have ovicells and thus belong to some other genus than *Watersipora*, which lacks them. Osburn distinguished between "*Dakaria*" and a related genus, *Hippodiplosia* Canu, 1916, by the absence of avicularia in the former versus presence of avicularia (though not invariably) in the latter. Other distinctions between the two were unclear: both have a tremocyst; an orifice with cardelles and a more-or-less broadly arcuate proximal margin; and a perforate ovicell closed by the operculum. "*Dakaria*" *apertura* has multiporous septula, as do species of *Hippodiplosia*. *Hippodiplosia* is a junior synonym of *Hippoporina* Neviani, 1895 (Cheetham and Sandberg 1964). "*Dakaria*" *apertura*, at least, seems to belong in *Hippoporina*; this may not be true of all Osburn's species of "*Dakaria*."

**OCCURRENCE:** Three colonies were found at Station 10 in the lower infralittoral fringe.

**DISTRIBUTION:** This is apparently a boreal species endemic to the eastern Pacific. The only other record is from Tomales Bay, California, the type locality (Osburn 1952).

*Hippoporina vulgaris* n. sp.  
Plate 11A

*Dakaria dawsoni*, Dick and Ross, 1986: 89.

**DIAGNOSIS:** This species is distinguished by the variability in size and shape of zooids with astogenetic change; the lack of avicularia; a tremocyst, which may be thickened by a deep reticulate layer of secondary calcification; and a smooth ovicell with one to several large circular or irregular perforations on top. The ovicell is generally subimmersed by the raised tremocyst of adjacent zooids.

**HOLOTYPE:** USNM 415791. Two fragments from the same colony, on rock.

**TYPE LOCALITY:** Station 1 (57° 54.3'N, 152° 25.8'W), Sunny Cove, south shore of Spruce Island near Kodiak, Alaska; intertidal; type collected 1 October 1982.

**ETYMOLOGY:** The species name is from the Latin *vulgaris* (commonplace), referring to the species' general abundance in the intertidal.

**DESCRIPTION:** Colonies are yellowish or tan, forming circular, unilaminar encrustations up to 5 cm across. They are more or less tightly adhering, depending upon substrate; sometimes the edges of the colony are raised in unilaminar frills. Zooids are separated by broad grooves and vary considerably in size and shape with astogenetic change. In autumn, there may be four zones of zooids. In the central portion of the colony, zooids are short and wide, 0.44-0.60 mm long by 0.28-0.48 mm wide, more or less hexagonal, sometimes wider than long. Around the central zone is a broad zone of rapid expansion where zooids are long-rectangular, 0.48-1.12 mm long by 0.20-0.36 mm wide. Next to outermost is a zone of ovicellate zooids which measure 0.64-0.76 mm long by 0.28-0.36 mm wide from the distal edge of one ovicell to the next; these zooids are laterally compressed to make room for the ovicells, which are wider than the zooids proper. The outermost zone is composed of short, wide hexagonal zooids 0.52-0.64 mm long by 0.36-0.64 mm wide. The frontal wall is a thin, ventricose tremocyst covered with infundibular pores except in a triangular area proximal to the orifice. In later stages, especially in the two outermost zones, the tremocyst becomes reinforced by a high, more-or-less delicate, reticulate buildup of calcification. The openings in the secondary layer are large, some of them corresponding to two or three primary pores which can be seen below. The secondary layer often forms an umbo proximal to the orifice. In some colonies, this is low and broad; in others, it is quite high and pointed. Each lateral wall interconnects through two circular multiporous septula, and the distal wall bears two large elliptical or irregular multiporous septula. The primary orifice is approximately circular, sometimes slightly greater in length or width, 0.18-0.23 mm in maximum dimension. The cardelles are small, rounded, sometimes scarcely evident. The poster is a broad curve from cardelle to cardelle, and of somewhat lesser radius than the anter. In fertile zooids and in zooids with a raised, reticulate frontal wall, a peristome and secondary orifice are present. The ovicell is hyperstomial, 0.35-0.38 mm wide by 0.23-0.25 mm long, closed by the operculum. It is smooth, usually with a single large, circular or irregular, membrane-covered perforation on top. Occasionally, there are two or three smaller perforations. During ovicell formation, calcification proceeds medially from the distal and lateral margins, eventually closing off the ovicell along the proximal margin but leaving a central area imperforate. Some zooids are collected at the stage where an open channel or suture line remains between the central perforation and proximal margin of the ovicell. Avicularia and spines are lacking.

As described above, at least four astogenetic stages can be recognized in colonies of *H. vulgaris* collected in autumn: a central zone of short hexagonal zooids with a thin frontal wall; a zone of rapid growth having elongate zooids with a thin wall; a fertile zone of shorter zooids with subimmersed ovicells and a high, reticulate frontal wall; and a marginal zone of short, non-fertile zooids with a high, reticulate frontal wall. The first zone apparently corresponds to growth either from an ancestrula or from overwintering zooids in early spring; the second to rapid expansion of the colony in summer; the third to reproduction in autumn; and the outermost to an overwintering morphology which can bud new zooids in spring. In colonies collected in October and November, many zooids in the first and second zones were dead and falling apart. Zooids in the outer zones with the reinforced frontal walls remained intact.

**OCCURRENCE:** This species reached greatest density and cover at sheltered midlittoral Stations 1 and 2, where it was associated with *Cryptosula okadai* and *Harmeria scutulata*. It was widely distributed but not abundant in the infralittoral fringe.

**DISTRIBUTION:** *H. vulgaris* is so common that it is surprising previous authors have not reported it. It is widely distributed intertidally in the northeastern portion of the Kodiak archipelago: specimens have been collected from Sharatin Bay, Midarm Island in Izhut Bay, and Marmot Island. We have one specimen from Rush Point, Glacier Bay National Monument. The known range, therefore, is the Gulf of Alaska.

#### Family SMITTINIDAE Levinsen, 1909

#### Genus *SMITTINA* Norman, 1903

#### *Smittina bella* (Busk)

#### Plate 11B

*Lepralia bella* Busk, 1860: 144.

*Smittina bella*, Osburn, 1952: 403, pl. 47, figs. 4, 5; Mawatari, 1956: 130, figs. 12a-e, 13; Powell, 1968: 2304.

?*Prenantia bella*, Hayward and Ryland, 1979: 106, fig. 38.

*Smittina rigida*, Androsova, 1958: 152, fig. 80; Kluge, 1975: 520, fig. 280.

*Smittina* sp., Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is unilaminar, encrusting, light tan in color. Zooids are irregularly hexagonal or long-ovate, often with sinuouse margins; interlocked, so that the peristome of each zooid is formed from portions of the lateral and proximal walls of surrounding zooids; 0.50-0.75 mm long by 0.25-0.45 mm wide; and separated by grooves and suture lines. Young zooids in newly formed colonies have a minutely granulose, moderately convex, more or less rugose frontal wall rising to a broad, blunt conical suboral umbo. There are four to six pores along each lateral margin and two to seven additional frontal pores. The frontal wall greatly thickens with age and becomes more coarsely granulose; many of the frontal pores become occluded by calcification. In some older zooids, the entire frontal wall forms an evenly inflated tuberosity; the marginal pores are small, and only an occasional frontal pore is evident. In others, there is a more sharply defined umbo; the frontal openings of the marginal pores are enlarged and the heavy, rounded costae between them merge with the base of the umbo. A single enlarged frontal opening sometimes leads to two primary pores: one marginal and one more central. Zooids interconnect through minute basal septula

perforated by two to four pores and leading to tubular channels; there are four such connections in each lateral wall and two in the distal wall. The primary orifice is subcircular, usually slightly broader than long, 0.15 mm across. The lyrula varies from a slight convexity to a low, broad projection; occasionally it is longer and narrower. Most zooids lack cardelles, but a few zooids have a poorly developed projection on one side or the other. A deep peristome obscures the primary orifice. The secondary orifice is circular, transversely elliptical, rounded-quadrate, or pyriform. A small circular or spatulate suboral avicularium with a subspatulate mandible lies vertically in the peristome, immediately proximal to, and about as wide as, the lyrula. The ovicell is subimmersed, 0.25 mm wide by 0.20-0.23 mm long, covered by granulose calcification from adjacent zooids. Some ovicells have a Y-shaped suture line and median frontal pore, but these are generally obscured with advanced calcification. A slight, straight, smooth shelf formed by the proximal margin of the ovicell runs horizontally across the distal wall of the peristome below secondary orifice. The ovicell appears to be closed by the zooidal operculum, though this was difficult to determine in our dried specimens.

DISCUSSION: The distinction between *Smittina bella* (Busk) and *S. rigida* Lorenz is not clear, and indeed they may be synonymous. For lack of a clear understanding of the differences between the two, we have simply used the older name. Previous authors have apparently had similar problems. Osburn (1952) identified only *S. bella*, and Kluge (1975) only *S. rigida*, from the Arctic. Mawatari (1956) found only *S. bella* in the Kurile Islands, Androsova (1958) only *S. rigida* in the Sea of Japan. Powell (1968) identified both in the Arctic, but noted that they resemble one another, having in common a pyriform secondary orifice, a heavily calcified frontal wall, and a median pore on the ovicell. He distinguished between them by an oval avicularium and smaller lyrula in *S. bella* versus a spatulate avicularium and larger lyrula in *S. rigida*. These, however, seem to be variable characters. Hayward and Ryland (1979) transferred *S. bella* to the genus *Prenantia*, which has pore chambers rather than septula and has the ovicell closed by the zooidal operculum. We have examined a Greenland specimen of *P. bella* from the British Museum (Catalog No. 1911-10.1.11-1-04); although some pore chambers are clearly evident, other interzooidal connections appear to be tiny septula leading to tubes through the thick walls, as figured by Mawatari (1956). The avicularia are more spatulate, rather than symmetrically oval as shown by Mawatari (1956). Our material has tubular interzooidal connections with tiny septula, and the avicularium varies from spatulate to oval even in the same colony. The shape of the lyrula has been variably described: short, narrow, and truncate in *S. bella* (Osburn 1952); small and quadrate in *P. bella* (Hayward and Ryland 1979); usually low, but sometimes straight and narrow, or forming a blunt, tapering denticle which is often barely observable in *S. rigida* (Kluge 1975); low and variable in *S. rigida* (Androsova 1958). The lyrula in our material varies from quadrate, sometimes tapering, to low and broad. Cardelles are indicated for *S. rigida* (Kluge 1975), *P. bella* (Hayward and Ryland 1979) and *S. bella* (Osburn 1952). Mawatari (1956) does not mention them for *S. bella*, and Androsova (1958) clearly shows a primary orifice without cardelles for *S. rigida*. In the specimen of *P. bella* from the British Museum, as in our material, most zooids lack cardelles, but a few have a poorly developed projection on one or both sides. The relatively few frontal pores and greatly inflated frontal wall seen in our material are not characteristic of either species, but are perhaps related to growth in an intertidal rather than a subtidal habitat.



OCCURRENCE: This was an uncommon lower midlittoral and infralittoral fringe species occurring in low densities at Stations 4, 10, 11, 12, and 13.

DISTRIBUTION: *S. bella* is a circumpolar, arctic-boreal species. The only previous Alaskan records are from Point Barrow and Icy Cape (Osburn 1952).

*Smittina majuscula* (Smitt)

Plate 8D

*Escharella porifera* var. *majuscula* Smitt, 1868b: 9, 74, pl. 24, figs. 36-38.

*Smittina arctica*, Osburn, 1952: 402, pl. 47, figs. 13-14 (in part).

*Smittina majuscula*, Powell, 1968: 2304; Kluge, 1975: 515, fig. 276.

*Smittina landsborovi*, Dick and Ross, 1986: 89.

DESCRIPTION: Colonies are white, unilaminar, encrusting on rock. Zooids are covered with a glistening, transparent ectocyst when alive; 0.60-0.75 mm long by 0.25-0.50 mm wide; generally hexagonal but varying to long-rectangular or long-obovate; and separated by deep grooves with a raised calcareous line. The frontal wall is transversely convex; completely covered with small, uniform, infundibular pores; and minutely granulose between the pores. Areolar pores are lacking. The primary orifice is circular, 0.15-0.18 mm in diameter, interrupted by bracket-shaped cardelles and a well-developed lyrula. The lyrula is either tapering and truncate, or more or less quadrate, with a widened end bearing transverse projections. At the base of the lyrula is a small, median, slightly raised avicularium with a rounded-triangular mandible which is longer than broad and points proximally. The chamber is transverse, slightly swollen, sometimes lunate, not quite extending from margin to margin. Thin lateral and distal flanges around the orifice form a low, continuous, raised peristomial collar. The lateral flanges are confluent with the rostrum of the avicularium. The distal flange is not as well developed in ovicellate zooids, but forms an upturned border on the ovicell. The ovicell is prominent, globose, granulose, 0.20-0.30 mm wide by 0.18-0.20 mm long, imperforate except for a single median pore near the proximal border. Calcification from adjacent zooids, delineated by a sharp line, extends as a thin layer around the base of the ovicell and onto the proximolateral corners.

DISCUSSION: Osburn (1952) included *Smittina majuscula* (Smitt) as a synonym of *S. arctica* (Norman). He did not include *S. minuscula* (Smitt) in the synonymy, but one of his illustrations of *S. arctica* (1952: pl. 47, fig. 14) is obviously Kluge's (1975) *S. minuscula*. Our material shows characters of both *S. majuscula* and *S. minuscula* as treated by Kluge (1975). Zooid lengths are intermediate between those given by Kluge (1975) for the two species, and intermediate between the ranges of lengths in a specimen of each sent by Dr. V. I. Gontar. Our material shows well developed cardelles; a broad avicularian chamber; a small avicularium not obscuring the lyrula and with a rounded-triangular mandible which is longer than broad; and a peristome less well developed in ovicellate than in non-ovicellate zooids. These are all characters of *S. majuscula*. The lyrula is generally wide and truncate, often with transverse terminal projections, and the ovicell has a proximal median pore; these are characters of *S. minuscula*. Powell (1968) considered *S. arctica*, Osburn, 1952, to be a synonym of *S. majuscula*, but did not include *S. minuscula* in the synonymy. Powell must have examined Osburn's (1952) illustrations of *S. arctica*, and he apparently concurred that the two forms illustrated fall within the range of variation of a single species, *S. majuscula*. *S. majuscula* and *S. minuscula* were originally described as varieties

*majuscula* and *minuscula* of *Escharella porifera* Smitt, 1868. Given that our material has characters of both, they may actually be the same species. We use the name *S. majuscula* here, realizing that there are problems with it which must eventually be resolved.

**OCCURRENCE:** This species was rare in the intertidal. Three colonies were found at Station 10 in the lower infralittoral fringe. We have an additional intertidal specimen from Shuyak Strait at the north end of the Kodiak archipelago.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species. Osburn (1952) found it at Point Barrow, Alaska, and Kluge (1975) reported it from the Bering Sea. Narrow Strait is the southern limit of the known range in the eastern Pacific.

Genus *PARASMITTINA* Osburn, 1952

*Parasmittina trispinosa* (Johnston)

Plate 5D, E

*Discopora trispinosa* Johnston, 1838: 222.

*Parasmittina trispinosa*, Osburn, 1952: 412, pl. 49, figs. 7-8; Soule 1961: 35; Soule and Soule, 1964: 26; McCain and Ross, 1974: 14; Hayward and Ryland, 1979: 114, fig. 42; Dick and Ross, 1986: 89.

?*Parasmittina trispinosa*, Soule and Duff, 1957: 121.

**DESCRIPTION:** The colony is encrusting, usually unilaminar but occasionally building up a frontally-budded layer of irregularly oriented zooids; subcircular, forming patches to several centimeters across; and yellowish, with a lemon-yellow membranous growing edge at least two zooids deep. Zooids are ovoid, subrectangular, or hexagonal; 0.40-0.70 mm long by 0.25-0.40 mm wide; arranged in alternate series; and delineated by a shallow groove and sometimes a raised line. The frontal wall is convex; vitreous; imperforate except for conspicuous marginal pores; and rugose with small, rounded nodules. There is a conical or nodular suboral process which varies in size and is sometimes lacking; occasionally one or two additional projections are present around the peristome or elsewhere on the frontal surface. The primary orifice is subcircular, somewhat broader than long, 0.12 mm across, with a low, broad lyrula and small cardelles directed proximomedially. Thick frontal calcification in older zooids creates a tubular peristome, which is surrounded by a raised lip. The peristomial lip is either continuous, often confluent with the suboral process, or present as two lateral lappets separated by a sinus. Two, or rarely three, distal oral spines occur, but these are commonly lacking. Large avicularia with acutely triangular mandibles originate at the lateral margin and point medially or distomedially, the rostrum slightly raised and usually reaching the peristome. Rarely, the large avicularia are paired; many zooids lack them altogether. Smaller avicularia with a semicircular mandible occasionally replace a large avicularium near the orifice or occur more proximally along the margin. The smaller avicularia are generally uncommon, but were abundant in one colony. The ovicell is globose, 0.30-0.35 mm wide by 0.23-0.28 mm long, with a smooth, somewhat flattened area on top bearing two to six pores of varying size. It is recumbent on the following zooid, calcification from which covers the sides of the ovicell, sometimes forming one or two small nodules.

**DISCUSSION:** Our material, with often prominent suboral nodulation and a large, broad ovicell, appears very similar to *Parasmittina collifera* (Robertson). Osburn's

(1952) illustration of *P. collifera* represents our material very well, but his illustration lacks the extreme nodulation and median frontal avicularia originally figured by Robertson (1900). The primary orifice of our material is smaller than indicated for *P. collifera* by Osburn (1952). Our material is more similar to *P. trispinosa* Johnston, especially in the placement and types of avicularia. The presence of nodules is troublesome; however, there is variation in their degree of development. Some zooids lack them altogether and show a continuous peristomial lip or lateral lappets separated by a sinus. A subtidal specimen from Narrow Strait shows much less development of nodules and frontal rugosity than the intertidal material, and nodulation may be an environmentally induced character. *P. trispinosa* was once regarded as cosmopolitan; recently, various authors have expressed doubts that all of the records represent a single species (Osburn 1952, Soule and Soule 1973, Hayward and Ryland 1979). Soule and Soule (1973) stated, "... it is doubtful that any of the eastern Pacific material actually belongs to *P. trispinosa* (Johnston) ... Various authors have contributed to the confusion by placing almost any parasmittinid with three (sometimes two or four) spines and with an acute avicularium in *P. trispinosa* ... A thorough collecting, such as was done in the Hawaiian material, is necessary in order to clarify this situation." Ryland and Hayward (1979), however, included Osburn's (1952) *P. trispinosa* in their brief synonymy of *P. trispinosa* (Johnston), which they consider a cool temperate species probably not reaching arctic waters.

**OCCURRENCE:** This was a prominent species found at six stations in the infralittoral fringe. It was most abundant at Station 10.

**DISTRIBUTION:** Osburn (1952) reported *P. trispinosa* from Point Barrow, Alaska, southward to the Galapagos Islands. In view of the preceding comments, the range and even the identity of this species in the eastern Pacific need to be reexamined.

### Genus *PORELLA* Gray, 1848

#### *Porella acutirostris* Smitt

#### Plate 8A

*Porella acutirostris* Smitt, 1868b: 21, 132, pl. 26, figs. 106-108; Osburn, 1952: 394, pl. 46, fig. 4; Mawatari, 1956: 129, figs. 10h-k; Kluge, 1975: 550, fig. 300; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is encrusting, tan-colored, more or less circular, up to 3 cm across. Zooids are 0.42-0.68 mm long by 0.23-0.35 mm wide; ovoid, long-rectangular, irregularly hexagonal, or tapering proximally; covered with a thin, yellowish ectocyst when alive; and sometimes separated by a slight raised line but generally only by a groove. The frontal wall is convex, imperforate, coarsely granulose, with approximately six areolar pores along each margin. The primary orifice is semicircular, with a straight or slightly convex proximal margin and low, broad, inconspicuous cardelles. A sharp, raised lip extends from the suboral avicularium around the distal curvature of the orifice, forming a circular or transversely elliptical peristome. A median suboral avicularium with a rounded-triangular mandible lies at the peristomial rim. The chamber, inflated and broader than long, occupies one-third to one-half the frontal wall and extends from margin to margin, usually occluding the areolar pores lateral to it. Often it is umbonate. Ovicells are globose, raised, 0.20-0.23 mm across, imperforate, granulose like the frontal wall.

**OCCURRENCE:** This was an uncommon, infralittoral fringe species found at Stations 10, 12, and 13.

**DISTRIBUTION:** *P. acutirostris* is a circumpolar, arctic-boreal species previously known in the eastern Pacific from Point Barrow, Alaska, to southern California (Osburn 1952).

*Porella alba* Nordgaard  
Plate 8B,C

*Porella alba* Nordgaard, 1906: 25, pl. 3, figs 43-46; Hayward and Ryland, 1979: 122, fig. 46; Hayward, 1979: 77, figs. 2d-f; Dick and Ross, 1986: 89.

*Porella minuta*, Osburn, 1953: 780, pl. 81, fig. 9.

**DESCRIPTION:** The colony is white, encrusting, circular or multilobed, up to 4 cm across. Zooids are 0.38-0.50 mm long by 0.23-0.28 mm wide; vitreous at first but opaque white with age; and separated by deep grooves. The frontal wall is convex; smooth or faintly granulose; and imperforate except for eight to 12 small areolar pores on each side. With increasing calcification, the areolar pores enlarge, sometimes becoming elongate with costae between them. The primary orifice is semicircular and has a straight or slightly convex proximal margin; lyrula and cardelles are lacking. Thin lateral oral flanges and the raised proximal lip of the ovicell form the peristome. Just inside the peristome lies the small suboral avicularium with a proximally directed semicircular mandible. The avicularium is angled to the colony surface and can be seen from above. The chamber is globose or broader than long, raised, and often umbonate. It extends across the zooid between opposite areolae and occupies up to half the frontal surface. The ovicell is raised, imperforate, smooth or faintly granulose, about 0.20 mm across, usually completely immersed with age.

**OCCURRENCE:** This was a prominent species widely distributed and abundant in the study area. It occurred from the mid-midlittoral to the infralittoral fringe but reached its greatest density and cover at lower midlittoral and infralittoral fringe Stations 4, 5, and 13 on Eider Island.

**DISTRIBUTION:** *P. alba* is a circumpolar, primarily arctic species (Hayward and Ryland 1979). Osburn (1953) found it at Point Barrow but identified it as *P. minuta* (Norman). His specimens lacked a lyrula, whereas the closely similar *P. minuta*, a boreal species, has a lyrula (Hayward 1979). Our material represents the southernmost and easternmost extent of the known range in the eastern Pacific. Narrow Strait lies at about the same latitude as the northeast coast of Scotland, where *P. alba* reaches the southern limit of its range in Britain (Hayward 1979).

*Porella columbiana* O'Donoghue and O'Donoghue  
Plate 5B,C

*Porella columbiana* O'Donoghue and O'Donoghue, 1923: 41, pl. 3, fig. 28; Osburn, 1952: 398, pl. 46, figs. 7-8; McCain and Ross, 1974: 14.

**DESCRIPTION:** The colony is unilaminar, encrusting, glistening, yellowish white. Our specimens are up to 1 cm across, on rock and shell. Zooids are 0.33-0.43 mm long by 0.18-0.30 mm wide, irregularly hexagonal or ovate, separated by conspicuous grooves when young but less distinct with age. The frontal wall is minutely granulose;

shiny and vitreous; hyaline and tinged with yellow in marginal zooids; opaque white with age. It is moderately convex, imperforate, with four to seven areolar pores along each lateral margin. The primary orifice is transversely elliptical, 0.10-0.13 mm wide by 0.06-0.08 mm long; the proximal border varies from straight to convex and has a slight, broad lyrula which is sometimes higher on one side than the other. Minute rounded cardelles, sometimes scarcely evident, are present about a fourth of the way from the proximal margin to the distal. The peristome is moderately deep, beginning as thin lateral lappets which eventually meet distally to form a continuous peristomial lip. The lip either joins the suboral avicularium or encloses it proximally. The suboral avicularium is oval, with a thin pivot in the lower third and a semicircular mandible pointing proximally. It lies at the edge of the peristome, above the proximal margin of the primary orifice, and is tilted at about 45° to the colony surface. The chamber of the avicularium is lunate. In young zooids it is considerably inflated above the frontal surface; with age, it becomes completely immersed and the frontal wall is then uniformly convex. The chamber bears a small frontal pore on each side. Additional frontal avicularia are lacking. Marginal zooids have four long, transient distal spines. The ovicell is 0.21 mm long by 0.16 mm wide; hyperstomial; globose; minutely granulose; imperforate; sometimes with fine, radiating lines; and not closed by the operculum. With age it becomes immersed, the top flush with the colony surface but not covered by calcification from surrounding zooids. Orange embryos were present in colonies collected in June and July.

**DISCUSSION:** Our material compares favorably with the O'Donoghues' (1923) and Osburn's (1952) descriptions. We have examined specimens of *P. columbiana* from British Columbia, identified by Osburn (Allan Hancock Foundation Collection No. 976). The zooids are larger than ours, and the areolar pores tend to be larger, often with prominent costae between them at the margin. The pores in our specimens vary. In older zooids they are usually small or occluded, but some zooids have large pores separated by costae. In all other respects, the British Columbia material is similar.

**OCCURRENCE:** This species was not found during systematic sampling in the rock-pile habitat. Two colonies were collected during preliminary sampling at Station 3 in June and July, 1981.

**DISTRIBUTION:** *P. columbiana* is previously known from British Columbia to southern California, and from the Galapagos Islands (Osburn 1952). It is apparently a boreal-tropical species endemic to the eastern Pacific.

*Porella concinna* (Busk)

Plate 8E

*Lepralia concinna* Busk, 1854: 67, pl. 99, figs. 1-6.

*Smittina concinna*, Kluge, 1975: 522, figs. 282, 283.

*Porella concinna*, Osburn, 1952: 396, pl. 46, figs. 5, 6; Mawatari, 1956: 130, figs. 101-o, 11c; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is unilaminar, tightly encrusting, whitish in color. Zooids are 0.33-0.55 mm long by 0.23-0.35 mm wide; rectangular, ovoid or irregularly hexagonal; vitreous and shiny; translucent and delineated by suture lines when young; opaque white and separated by deep grooves with age. The frontal wall is imperforate, with four or five areolar pores along each margin. In young zooids it is nearly flat and covered with coarse granulation. With age, it is quite convex and even more granulose,

the margin sinuous and the marginal pores almost occluded. The primary orifice is semicircular with a low, broad lyrula which is lacking in some zooids, leaving a straight proximal border. The peristome is deep, the secondary orifice roughly oval and flush with the colony surface. A median suboral avicularium with a semicircular mandible lies in the peristome, just below the secondary orifice, vertically oriented or tilted slightly proximally. The chamber is broader than long and occupies about half the frontal surface. Rarely, there are one or two additional avicularia above the distal curvature of the orifice or along the lateral margin of the zooid; the mandibles are of the same shape and size as the suboral avicularium. Ovicells and spines are lacking in our material.

**OCCURRENCE:** There were six colonies at Station 10 in the lower infralittoral fringe.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species previously recorded at numerous localities from Point Barrow, Alaska, to San Pedro, California, including Alitak Bay in the Kodiak archipelago (Osburn, 1952).

*Porella immersa* Mawatari  
Plate 8F,G

*Porella immersa* Mawatari, 1956: 127, figs. 10e-g, 11b.

*Porella kurilensis* Mawatari, 1956: 130, figs. 10 p-r, 11d, e; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is encrusting; subcircular or irregular; up to 4 cm across; and light brownish-red in color, although old colonies may be white. Zooids are hexagonal, quadrate or barrel-shaped; 0.37-0.50 mm long by 0.25-0.40 mm wide; and distinct, separated by a shallow groove and sometimes a raised calcareous line. Young zooids are vitreous, covered with a reddish ectocyst, the areolar pores bright red. The frontal wall is slightly convex, imperforate, minutely granulose, with five to seven areolar pores along each margin. With age it can become as thick as the height of the zooidal chamber. Each lateral wall interconnects through two large, elliptical, multiporous septula; the distal wall bears two smaller septula. The primary orifice is 0.13-0.15 mm wide by 0.11-0.13 mm long, semicircular distally, with a broadly arcuate, concave proximal margin having small cardelles at the corners. A peristome forms with increasing calcification. The secondary orifice is pyriform, and flush with the frontal surface. A small, circular median suboral avicularium with a semicircular mandible and complete pivot lies at the edge of the peristome or, in older zooids, is oriented nearly vertically on the proximal wall of the peristome. The chamber, visible through the frontal wall of young zooids, is broader than long and extends from margin to margin; it commonly bears a low, conical projection, or sometimes a larger umbo. Ovicells are globose, imperforate, granulose, immersed partly at first and completely with age, 0.25 mm long by 0.20-0.25 mm wide, not closed by the operculum. Spines are lacking in our material.

**DISCUSSION:** Our specimens have similarities to *Porella immersa* and *P. kurilensis*, both originally described by Mawatari (1956). Zooids with both shapes of primary orifice occur in the same colony. Ovicells are generally immersed and not evident on the surface; however, young zooids have raised ovicells like those illustrated by Mawatari (1956) for *P. kurilensis*. Mawatari's (1956) descriptions are inadequate for separating the two species, and they may be synonymous, representing colonies from different environments or of different ages. The identification of our specimens as *P.*

*immersa* is based upon the totally immersed ovicells and the brownish-red color. *P. immersa* is dark brown or purple; Mawatari (1956) did not indicate the color of *P. kurilensis*. He did not report cardelles in either species, but they are often difficult to discern in our specimens. At our request for type specimens, Dr. Shunsuke Mawatari searched extensively at the National Museum in Tokyo, but could not locate the types or any other specimens of either species. He believed they had been lost, and suggested we designate a neotype for one of the species. We have not done so, with the hope that the types will eventually be found or, if not, that neotypes will be designated from specimens from the Kurile Islands.

**OCCURRENCE:** This was a fairly common species in the infralittoral fringe. It occurred at Stations 9, 10, 11, 12, 13, and 14.

**DISTRIBUTION:** *P. immersa* is previously known only from the Kurile Islands (Mawatari 1956).

Genus *RHAMPHOSTOMELLA* Lorenz, 1886

*Rhamphostomella costata* Lorenz

Plate 5A

*Rhamphostomella costata* Lorenz, 1886: 94, pl. 7, fig. 11; Osburn, 1952: 426, pl. 50, fig. 7; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is white, encrusting, unilaminar. Zooids are about 0.75 mm long by 0.37-0.50 mm wide; zooid length is difficult to measure because the zooids overlap. The frontal wall is vitreous; imperforate; convex; surrounded by large areolar pores; and surmounted by a tall, thick, blunt or sharp, strongly costate umbo which covers most of the frontal surface. The primary orifice is subcircular, variable in shape, longer than broad or vice-versa, 0.20-0.25 mm across, with a semicircular distal margin and a straighter proximal margin. The lyrula is quadrate, or short and broad; cardelles are lacking. With increasing frontal calcification, a deep peristome forms. The base of the umbo adjoins and sometimes overhangs the peristome, making the secondary orifice somewhat angular and asymmetrical. On the distolateral side of the umbo, above the peristome, is a moderately large, vertically oriented avicularium with a semi-elliptical mandible. Frontal avicularia are lacking in our specimen. The ovicell is 0.25 mm long by 0.35 mm wide, smooth, globose, with large pores covering the top; it opens above the peristome and overgrows the distal zooid. It is partly immersed around the sides by calcification from surrounding zooids. Embryos are reddish-orange. The above description is based on a single small colony.

**OCCURRENCE:** One colony was found at Station 10 in the lower infralittoral fringe.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species previously known along western North America from Point Barrow, Alaska, to Puget Sound, Washington (Osburn 1952).

Family SCHIZOPORELLIDAE Jullien, 1903

Genus *SCHIZOMAVELLA* Canu and Bassler, 1917

*Schizomavella porifera* (Smitt)

Plate 6A

- Escharella porifera* forma *typica* Smitt, 1868b: 9, 70, pl. 24, figs. 30-32.  
*Schizomavella porifera*, Osburn, 1952: 332, pl. 38, fig. 10; Powell, 1968: 2299.  
*Codonellina operculata* Mawatari, 1956: 125, figs. 8h-k, 9c.  
*Schizoporella porifera*, Kluge, 1975: 588, fig. 329.

**DESCRIPTION:** The colony is unilaminar, encrusting. Zooids are 0.50-0.67 mm long by 0.23-0.35 mm wide; rectangular to hexagonal; and separated by grooves. The frontal wall is moderately convex and perforated with small, uniform infundibular pores from margin to margin. The orifice is semicircular, with a broad, rounded proximal sinus behind prominent cardelles. A shallow peristome is formed by a raised distal lip and lateral lappets, the latter confluent with the chamber of the suboral avicularium. This chamber is lunate, extends from margin to margin, and bears a subpatulate mandible pointing proximally. The ovicell 0.18-0.23 mm long by 0.20-0.28 mm wide, hyperstomial, prominent at first but submersed with age, perforate, with a band of secondary calcification around the margin and covering the proximolateral corners.

**OCCURRENCE:** One colony on shell was collected at Station 10 in July, 1982. This species was not found during systematic sampling from Sept.-Dec., 1982.

**DISTRIBUTION:** *S. porifera* is a circumpolar, primarily arctic species (Kluge 1975) previously recorded in western North America at Point Barrow (Osburn 1952). It extends into cold temperate waters on both sides of the Pacific; Mawatari (1956) found it in the Kurile Islands.

Family STOMACHETOSELLIDAE Canu and Bassler, 1917

Genus *STOMACHETOSELLA* Canu and Bassler, 1917

*Stomachetosella cruenta* (Busk)

Plate 9A

- Lepralia violacea* var. *cruenta* Busk, 1854: 69, pl. 110, fig. 1.  
*Stomachetosella cruenta*, Osburn, 1952: 306, pl. 34, fig. 1; Kluge 1975: 613, fig. 351;  
Hayward and Ryland, 1979: 210, fig. 89; Dick and Ross, 1986: 89.

**DESCRIPTION:** The colony is unilaminar, encrusting, circular, dark purplish brown, becoming almost black when dried. Zooids are 0.40-0.63 mm long by 0.33-0.48 mm wide; oval or hexagonal; separated by a groove and sometimes additionally by a raised line; and covered with a thin ectocyst which imparts the color. The frontal wall is convex, coarsely granulose, with large areolar pores along the margin and 10-13 smaller pores scattered over the surface. The frontal wall rapidly thickens with age; the pores become infundibular, the surface rugose. Blunt, conical nodules occur anywhere on the frontal surface, but there is usually a pair of them at the proximal border of the secondary orifice and one or two near the proximal end of the zooid. Each orifice, therefore, has three or four nodules associated with it: two at the proximal margin and one or two on the following zooid. The primary orifice is semicircular, broader than



long, 0.18 mm across, with a broadly U-shaped or rounded sinus which is wider than half the width of the orifice and bordered by small cardelles. The primary orifice lies inside a moderately deep peristome but is nonetheless visible. The secondary orifice is larger than the primary one and is pyriform, with a deep, rounded groove leading from the proximal margin to the sinus of the primary orifice. Ovicells, spines, and avicularia are lacking.

**OCCURRENCE:** This species was rare in the intertidal. One colony was found at Station 14 in the infralittoral fringe.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species previously recorded along western North America from Point Barrow, Alaska, to Puget Sound, Washington (Osburn 1952).

*Stomachetosella sienna* n. sp.

Plate 11C

**DIAGNOSIS:** The colony is reddish-brown, with a relatively smooth, regular surface. Zooids are moderately large and separated by a raised line. They have a thick, slightly convex frontal wall perforated from margin to margin with small stellate pores. The peristome is deep. The orifice is semicircular, markedly transverse, with a wide, rounded median proximal sinus bordered by coarse, low cardelles. The ovicell is completely immersed, perforated by a large central pore. This species appears similar to *Stomachetosella sinuosa*, but differs in color, the much larger zooid size, the shape of the orifice, and the immersed ovicell.

**HOLOTYPE:** USNM 415792. One circular colony in center of shell fragment.

**TYPE LOCALITY:** About 27 km due east of Cape Barnabas, Kodiak Island, Alaska; depth 90-110 m; on *Neptunea lyrata* shell; type collected 29 February 1988 by Kimberly Phillips.

**ETYMOLOGY:** The species name is from the Italian *Sienna*, referring to the reddish-brown color.

**DESCRIPTION:** The colony is encrusting, unilaminar, reddish-brown. Zooids are ovoid, long-rectangular, or barrel-shaped; 0.55-0.90 mm long by 0.35-0.65 mm wide; covered with a tightly adhering ectocyst, sometimes with concentrations of pigmentation in the pores; and separated by a raised line. The frontal wall is flat or slightly convex; minutely granulose; and punctured with small infundibular stellate pores, with slightly larger marginal pores. The lateral wall interconnects through four or five small, basal, circular or elliptical septula with a few pores each, the distal wall through two similar septula. The septula lead to tubular channels through the opposing wall. The primary orifice is semicircular; markedly transverse; 0.18-0.20 mm wide by 0.10-0.13 mm long, with a straight proximal border. A wide, rounded median sinus occupies about half the proximal border and is bordered by low, broad cardelles. The sinus varies from a deep U-shaped notch to a shallow concavity. Young zooids have a moderate peristome; with age, the frontal wall becomes quite thick and a deep peristome develops. The secondary orifice is level with the colony surface and similar in shape to the primary one, though it tends to be more arcuate proximally and has a narrower sinus. A groove the same shape as the sinus runs up the proximal side of the peristome. Sometimes the secondary orifice is surrounded by a rounded, slightly raised rim which is either smooth or bears several slight tubercles. A few marginal zooids in one of our specimens have reduced orifices of a different shape than those of autozooids; these may be kenozooids. Spines and avicularia are lacking. The ovicell

averages 0.30 mm long by 0.33 mm wide, is completely immersed by the granulose calcification of the succeeding zooid, and is closed by the zooidal operculum. It has a single large central pore. Embryos are orange-red.

**OCCURRENCE:** One small colony was found at Station 10 in the infralittoral fringe.

**DISTRIBUTION:** We have two additional specimens, both subtidal. One came from Makushkin Bay on Unalaska Island; the other, which has been designated as the holotype because it has ovicells, is from the Kodiak shelf. The known range is from the Gulf of Alaska to the eastern Aleutians.

*Stomachetosella sinuosa* (Busk)

Plate 9B

*Lepralia sinuosa* Busk, 1860: 125, pl. 24, figs. 2, 3.

*Stomachetosella sinuosa*, Osburn, 1952: 306, pl. 34, fig. 3; Hayward and Ryland, 1979: 208, fig. 88; Kluge, 1975: 611, fig. 349.

**DESCRIPTION:** The colony is encrusting; unilaminar; small and circular; and light reddish in color. Zooids are hexagonal or ovate, 0.38–0.50 mm long by 0.25–0.38 mm wide, separated by grooves. The frontal wall is moderately convex, granulose, covered uniformly from margin to margin with small pores. The pores become infundibular with age. Sometimes there is a low, nodular swelling proximal to the orifice. The primary orifice is semicircular, 0.10 mm across, with a more or less straight proximal margin bearing a narrow, U-shaped median sinus. The peristome is deep. The secondary orifice is flush with the surface and sharply defined, approximately the same shape as the primary orifice, though off-center. The ovicell is hyperstomial, globose, 0.27 mm wide by 0.20 mm long, granulose, with a central pore. It is raised at first, but becomes subimmersed with age.

**OCCURRENCE:** This species was not found during systematic sampling in the rock-pile habitat. A single small colony was found on shell at Station 10, August, 1984.

**DISTRIBUTION:** This is a circumpolar, arctic-boreal species previously known along western North America from Point Barrow, Alaska, to Puget Sound, Washington (Osburn 1952).

Family HIPPOPORIDRIDAE Vigneaux, 1949

Genus *HIPPOPORIDRA* Canu and Bassler, 1927

*Hippoporidra truculenta* n. sp.

Plate 11D, E

Hippoporinid sp., Dick and Ross, 1986: 89.

**DIAGNOSIS:** Colony unilaminar, encrusting. Frontal wall vitreous, with large marginal pores; conical tubercles often present. Primary orifice horseshoe-shaped, with prominent cardelles; generally two oral spines. Suboral avicularium median, circular, with a semicircular mandible; large, elliptical vicarious avicularia occur. Ovicells immersed, with a semicircular tabula, sometimes with a single pore. Zooids with a reduced orifice occur.

**HOLOTYPE:** USNM 415793.

TYPE LOCALITY: Sample 1, Makushkin Bay, Unalaska Island, Alaska (53° 44.0'N, 166° 45.8'W); subtidal; substrate unknown. Type collected 13 August 1975, collector unknown.

ETYMOLOGY: The species name is from the Latin *truculentus* (fierce, cruel), referring to the armour-like appearance of the frontal wall with conical tubercles.

DESCRIPTION: The colony is unilaminar, white, encrusting on rock and shell. Zooids are approximately hexagonal, sometimes as broad as long, 0.43-0.68 mm long by 0.35-0.55 mm wide, separated by a broad groove and a suture line, indistinct with age. The frontal wall is smooth, thick, vitreous, translucent-white, moderately inflated. It rises to a conical suboral tubercle; sometimes, there are one to three additional tubercles over the frontal surface or at one or both sides of the orifice. The frontal wall is mostly imperforate, with four to six conspicuous marginal pores on each side. Rarely, zooids bear one or two additional pores inward from the margin. With age the pores become enlarged, infundibular, and often elliptical or slitlike at the surface, where they are separated by rounded costae. Lateral walls interconnect through two basal elliptical septula having a few pores, transverse walls through two irregular septula; all septula lead to tubular channels. The primary orifice is horseshoe-shaped, 0.14-0.18 mm long by 0.13-0.15 mm wide, with a straight proximal margin. The anter comprises somewhat more than a semicircle. The poster is as wide as, or slightly narrower than, the anter and comprises about one-fourth the length of the orifice; it is separated from the anter by prominent cardelles. The operculum is yellow, chitinous, of the same shape as the orifice. With thickening of the frontal wall, a deep peristome develops; the secondary orifice is flush with the colony surface and is circular, semicircular, or quadrate in shape. In the midline, immediately proximal to the poster and vertically suspended in the peristome, is a circular avicularium (pl. 11E), the opening traversed by a thin pivot. The mandible is semicircular, 0.10 mm wide, and directed frontally. The chamber is elongate and occupies most of the frontal surface inside the pores; it sometimes diverges proximally or laterally into several tapering rami which connect with marginal pores. The type specimen has a few large, randomly oriented vicarious avicularia scattered among the autozooids; these did not occur on specimens from Narrow Strait. The vicarious avicularium is elliptical, 0.20-0.25 mm long by 0.15-0.20 mm wide, with a semicircular or short-spatulate mandible. It develops over the orifice of an autozoid; the frontal wall is like that of an autozoid and bears marginal pores. Marginal zooids bear two, or rarely three, long distal oral spines which are lost with age. The ovicell is hyperstomial, not closed by the operculum. It is completely immersed by frontal calcification from adjacent zooids in later stages and sometimes bears a conical tubercle. There is a semicircular tabula above the proximal margin, sometimes with a single pore at the top of the tabula. What appear to be kenozooids occur sparsely among the autozooids, especially at the colony margin. These are approximately the same size as autozooids. The orifice is of the same shape as that of autozooids, but smaller, 0.12 mm long by 0.10 mm wide, and with or without the suboral avicularium.

DISCUSSION: This species is tentatively assigned to the genus *Hippoporidra* because of the large marginal pores, the occurrence of both adventitious and vicarious avicularia, the imperforate ovicell with a tabula, and the apparent occurrence of kenozooids. Other species of *Hippoporidra*, however, form nodular or erect colonies, usually on shells occupied by hermit crabs (Cook 1964, Hayward and Ryland 1979). This description of *H. truculenta* is based on limited material, four colonies from two localities.

OCCURRENCE: This species was rare in the intertidal. Three colonies were found at Station 10 in the lower infralittoral fringe.

DISTRIBUTION: The only known locality besides Narrow Strait is Makushkin Bay, Unalaska Island.

Family MICROPORELLIDAE Hincks, 1880a

Genus *MICROPORELLA* Hincks, 1877

*Microporella alaskana* n. sp.

Plate 11F

*Microporella* sp. A, McCain and Ross, 1974: 14, fig. 2e.

*Microporella ciliata*, Dick and Ross, 1986: 89 (in part).

DIAGNOSIS: This species has two prominent avicularia beside the ascopore. The mandible is distinctive, with a short-triangular base and a setose tip; the avicularia point distally or distolaterally. The frontal wall is coarse; thick; with large pores; often reticulate or costate with age; and usually umbonate. The ascopore is small, close to the orifice, circular, with a lunate opening.

HOLOTYPE: USNM 415794. Type is largest, hypochlorite-cleaned specimen on shell attached to a slide with five other fragments, which are part of the type series.

TYPE LOCALITY: Station 8 (57° 53.5'N, 152° 21'W), east shore of Spruce Island near Kodiak, Alaska; intertidal, on shell; type collected 2 July 1981.

ETYMOLOGY: The species name is derived from the place name *Alaska*.

DESCRIPTION: The colony is whitish, more or less circular, forming unilaminar encrustations on rock and shell. Zooids are 0.43-0.55 mm (average 0.49 mm) long by 0.23-0.45 mm (average 0.31 mm) wide; rectangular, ovoid or hexagonal in shape; and separated by grooves. The frontal wall is inflated, finely granulose, perforated with coarse pores, covered with a glistening, transparent ectocyst. The pores tend to be arranged in rows converging from the periphery toward the center of the frontal wall. The frontal wall thickens with age. The pores become infundibular; costae develop between rows of pores, and each intercostal depression leads to one to three primary pores. In some cases, the frontal wall appears reticulate between these large secondary openings which, at the periphery, are slitlike. Proximal to the ascopore there is usually an umbo varying from a low tubercle to a tall, sharply conical costate process. In some cases, the entire frontal wall becomes quite thick and inflated, essentially a large umbo, with two or three nodular processes arising from it. The orifice is semicircular, 0.06-0.10 mm (average 0.08 mm) long by 0.10-0.13 mm (average 0.10 mm) wide, the straight proximal margin faintly crenulate, with minute cardelles at each corner. Around the distal rim are three to six long spines, usually present only on marginal zooids. Modal spine number is four (53% frequency). The ascopore is small; circular or transversely elliptical; with a delicate distal shelf which leaves a lunate opening; and with a faintly denticulate proximal margin. The ascopore is separated from the orifice by approximately the diameter of the ascopore. Avicularia are moderate in size, usually paired, one at each side of the ascopore and close to the orifice so that the inner wall of the avicularian chamber forms part of the peristome. The frequency of zooids with paired avicularia in the Narrow Strait population is 80%; 20% have a single avicularium on either side. The avicularia point forward or angle slightly distolaterally. The mandible has a short-triangular base, from which extends a

tapering setose tip. Ovicells are globose; 0.18-0.28 mm (average 0.24 mm) wide; either distinct or subimmersed; and with radial ridges around the sides, sometimes extending onto the top. In more calcified colonies, the heavy frontal costae of the succeeding zooid cover the ovicell, leading to a nodular or umbonate top. Young ovicells have small marginal pores, and a few additional pores are scattered over the surface.

DISCUSSION: Other species with predominantly two avicularia include *M. tractabilis*, *M. marsupiated*, *M. cribrata*, *M. californica*, *M. setiformis*, and *M. coronata* (Osburn 1952). Key differences between *M. alaskana* and these species occur in one or more of the following characters: zooid and orifice size; shape of the orifice; size, placement and shape of opening of the ascopore; size and direction of the avicularia; shape of the mandible; presence and shape of an umbo; and size of frontal pores. A comparison of the differences between *M. alaskana* and *M. germana* n. sp. is given under Discussion for the latter.

OCCURRENCE: This species was found at Stations 5, 8, and 13, all in the infralittoral fringe. Its distribution along Narrow Strait was not adequately documented due to initial confusion with other species of *Microporella*.

DISTRIBUTION: This is a boreal Pacific species, at present known only from the eastern Pacific. McCain and Ross (1974) collected it along the Strait of Juan de Fuca, Washington. Marcus (1939: pl. 10, fig. 17) figured similar material from the Vancouver region, British Columbia, as *M. ciliata*. Narrow Strait is the northernmost extent of the known range.

### *Microporella californica* (Busk)

Plate 9C

*Lepralia californica* Busk, 1856: 310, Pl. 11, figs. 6, 7.

*Microporella californica*, Osburn, 1952: 381, pl. 44, fig. 2; Soule and Duff, 1957: 116;

Soule, 1961: 24; McCain and Ross, 1974: 14.

*Microporella ciliata*, Dick and Ross, 1986: 89 (part).

DESCRIPTION: The colony is whitish and forms unilaminar, roughly circular encrustations on rock. Zooids are ovoid or hexagonal, separated by deep grooves, 0.55-0.82 mm (average 0.66 mm) long by 0.33-0.58 mm (average 0.42 mm) wide. The frontal wall is inflated and faintly granulose; has pores over the entire surface; and is covered with a glistening transparent ectocyst when young. The pores are coarse and somewhat infundibular in early stages, but become smaller as the tremocyst thickens with age. Proximal to the ascopore is an umbonate process which varies from a small tubercle to a high, blunt umbo occupying half the frontal surface. The orifice is 0.10-0.12 mm (average 0.12 mm) long by 0.12-0.18 mm (average 0.15 mm) wide. The distal curvature is more than a semicircle; the sides curve inward to meet the straight proximal margin, which is smooth and lacks cardelles. Distal to the orifice are three to five (usually four) heavy, straight spines which are commonly brown at the base. The ascopore is moderate in size and slightly transversely elliptical; has a lunate opening and often a denticulate proximal margin; and is separated from the orifice by approximately the width of the ascopore. Avicularia are single (70% frequency) or paired (30% frequency) and lie lateral to the ascopore, directed distolaterally, with a long-triangular mandible ending in a setose tip. Ovicells are 0.28-0.42 mm (average 0.35 mm) wide; globose; distinct; uniformly perforated with small pores; and with radiating ridges extending up the sides and onto the top, which sometimes bears a low umbo.

OCURRENCE: We found *M. californica* only at Station 8, an exposed locality where it was common.

DISTRIBUTION: If previous records in the literature are correct, this species extends from boreal to tropical regions in the eastern Pacific. It is previously known from Vancouver Island southward to Mexico and the Galapagos Islands (Osburn 1952). There are records from British Columbia (Hincks 1883, O'Donoghue and O'Donoghue 1923, 1926), but Osburn (1952) questioned these because of possible confusion with *M. cribrosa*. We have additional specimens from Latouche in the northern Gulf of Alaska and the Blashke Islands in southeastern Alaska. Narrow Strait is the northernmost extent of the known range.

*Microporella germana* n. sp.

Plate 12A,B

?*Microporella ciliata*, Kluge, 1975: 629, fig. 361.

*Microporella ciliata*, Dick and Ross, 1986: 89 (in part).

DIAGNOSIS: The frontal wall is convex, but generally not greatly inflated, thickened, or umbonate. There is commonly a small median process proximal to the ascopore. The orifice is semicircular. The small ascopore lies close to the orifice. It is transversely elliptical and has a projecting shelf, often with rays of calcification connecting the shelf and proximal margin. Zooids have one or, more commonly, two avicularia separated from the peristome by at least some granulate frontal wall. The avicularia are commonly turned at different angles to the midline of the zooid. The mandible is long-triangular, tapering evenly to a setose tip.

HOLOTYPE: USNM 415795. Four fragments from same colony, on rock.

TYPE LOCALITY: Station 13 (57° 53.3'N, 152° 23.8'W), north shore of Eider Island, Narrow Strait, near Kodiak, Alaska; intertidal; type collected 1 Dec. 1982.

ETYMOLOGY: The species name is derived from the Latin *germanus* (sibling), referring to the similarity to another species, *M. alaskana*.

DESCRIPTION: The colony is whitish, forming unilaminar, roughly circular encrustations on rock and shell. Zooids are oval or hexagonal; sometimes wide in relation to length; 0.45-0.60 mm (average 0.54 mm) long by 0.25-0.50 mm (average 0.36 mm) wide; separated by grooves; and covered with a glistening ectocyst which gives the frontal surface a smooth, even appearance. The frontal wall is convex, granulate, covered with small pores, bordered by larger areolar pores. Commonly, there is a small median process immediately proximal to the ascopore, sometimes overhanging it. The primary orifice is semicircular, 0.06-0.10 mm (average 0.08 mm) long by 0.10-0.13 mm (average 0.12 mm) wide. The proximal margin is straight, faintly crenulate, with minute cardelles at the corners. Around the distal curvature of the orifice are three to five spines, the modal number four (frequency 80%). The ascopore is small, transversely elliptical, separated from the orifice by no more than the width of the ascopore. A projecting distal shelf leaves a lunate opening. Commonly, there are delicate rays of calcification connecting the distal shelf with the proximal border. If the rays are lacking, the proximal border is finely denticulate. Zooids have one (68% frequency) or two (32% frequency) avicularia situated lateral to the ascopore, directed distolaterally, with a long-triangular mandible tapering to a setose tip. Avicularia are generally not immediately adjacent to the orifice, but are separated from it by some of the granulate frontal wall; if two are present, they are commonly directed at somewhat

different angles relative to the longitudinal axis of the zooid. Ovicells are raised, prominent, 0.23-0.33 mm (average 0.28 mm) wide, with ribs around the sides and sometimes extending onto the top. The surface is granulose, and imperforate except for small marginal pores.

**DISCUSSION:** This species is similar to *M. alaskana*, and indeed the two may eventually prove to be the same, for they overlap in nearly all characters. We have separated them for the following reasons. *M. alaskana* is slightly smaller in all measurements except orifice length. Range of spine number is similar, but the frequencies differ. Both forms have one or two avicularia, but the frequencies are reversed: *M. alaskana* has predominantly two avicularia, *M. germana*, one. *M. alaskana* tends to have larger pores and a more or less costate frontal wall; if an umbo is present, it is often large and costate. *M. germana* has small pores and lacks pronounced costae; the umbo is rarely large. The orifice is wider in proportion to length in *M. germana*. Avicularia tend to be close to the orifice in *M. alaskana*, somewhat removed in *M. germana*. Mandibles of *M. alaskana* are more robust; the base is short-triangular, and there is a sharp demarcation between base and setose tip. Mandibles of *M. germana* tend to be long-triangular, evenly tapering, with little demarcation between base and tip. The ascopore of *M. germana* tends to be partly occluded by delicate rays of calcification; that of *M. alaskana* is rarely so. Ovicells of *M. germana* have only marginal pores; those of *M. alaskana* have marginal pores and a few additional pores over the surface. The distributions of the two forms differed. *M. germana* was found at eight stations the length of Narrow Strait; *M. alaskana* was restricted to three stations at Eider Island and Icon Bay, where *M. germana* also occurred, commonly on the same rock. We have two specimens of one form overgrowing the other. No specimens showed a clear intra-colony gradation from one form to the other.

*M. germana* may include some of the records of *M. ciliata* of previous Pacific studies. Except for having smaller zooids, *M. germana* is very similar to Kluge's (1975, fig. 361) *M. ciliata*. Kluge shows the ascopore close to the orifice and partly occluded by rays; the frontal surface is even, with a small median process; avicularia number one, rarely two. Osburn (1952) mentioned one, occasionally two, avicularia for *M. ciliata* on the Pacific Coast. Soule and Duff (1957), Androsova (1958), and Soule (1961) noted one or two avicularia in Pacific "*M. ciliata*." European *M. ciliata* has invariably one avicularium which is commonly situated in the lateral corner of the zooid and directed laterally; the ascopore is separated from the orifice by at least twice its width, with some of the frontal wall granulation in between (Hayward and Ryland 1979; P. Cook, pers. comm.). Osburn's (1952: pl. 44, fig. 1) *M. ciliata* shows a separate ascopore as well as a laterally placed single avicularium, indicating that this species probably does occur along the West Coast of North America. We have a subtidal specimen from the west side of Kodiak Island which likewise appears to be *M. ciliata*.

**OCCURRENCE:** *M. germana* was a prominent species occurring at all but three stations (1, 6, and 7) and ranging from the midlittoral to the infralittoral fringe.

**DISTRIBUTION:** We have additional intertidal specimens from Katalla and Dutch Harbor, Alaska, and specimens from 4-10 m depth, Uganik and Chiniak Bays, Kodiak Island. These records establish a known range from the northern Gulf of Alaska to the eastern Aleutian Islands.

*Microporella neocribroides* n. sp.

Plate 12C

*Microporella ciliata*, Dick and Ross, 1986: 89 (part).

**DIAGNOSIS:** The frontal wall is markedly inflated. The primary orifice is broader than long. The ascopore is small, cribriform, and situated close to the orifice. There is only one avicularium per zooid, situated anywhere along the lateral margin. The mandible is triangular and points laterally or proximally. Many zooids lack avicularia. There are commonly two spines, one at each side of the orifice.

**HOLOTYPE:** USNM 415796. One fragment on rock.

**TYPE LOCALITY:** Station 9 (57° 51.4'N, 152° 23.5'W), reef-flat along east shore of Termination Point near Kodiak, Alaska; intertidal; type collected 1 Nov. 1982.

**ETYMOLOGY:** The species name is a combination of the Greek *neos* (new) and *-oideos* (type of) and the Latin *cribrum* (sieve), referring to a new species having a cribriform ascopore.

**DESCRIPTION:** The species forms circular, unilaminar, whitish encrustations on rock. Zooids are oval, long-rectangular, or hexagonal; sometimes quite wide in relation to length; 0.48-0.65 mm (average 0.55 mm) long by 0.25-0.45 mm (average 0.35 mm) wide; separated by deep grooves; and covered with a glistening, transparent ectocyst. The frontal wall is markedly inflated, covered with numerous small pores, finely granulose. It is regular when young, but can become thickened and somewhat rugose with age; the pores become infundibular. An umbo is sometimes present, varying from a slight conical process proximal to the ascopore to a high, blunt conical projection occupying the distal half of the frontal wall. The orifice is semicircular, 0.06-0.10 mm (average 0.08 mm) long by 0.10-0.15 mm (average 0.12 mm) wide, the proximal border straight and smooth, occasionally with slight cardelles at the corners. Spines are generally lacking. Marginal zooids sometimes bear a stout spine on each side of the orifice; rarely, an additional one or two are present distal to the orifice. Proximal to the orifice is a small, transversely elliptical ascopore covered with a perforated plate. Sometimes a small distal shelf projects into the ascopore as in other species; the remaining area is nonetheless perforated with minute, circular pores. The distance between the ascopore and orifice is less than or equal to the width of the ascopore. The ascopore and perforated plate are usually horizontally oriented in the same plane as the operculum. A single avicularium with a triangular mandible is variably situated. Sometimes it lies distal to or alongside the orifice and points distolaterally. It is more usually located along the lateral margin slightly proximal to the ascopore, at the lateral corner, or in the proximal third of the zooid, with the mandible pointing laterally or proximally. Some colonies lack avicularia almost entirely. Ovicells are globose, granulose, 0.25-0.40 mm (average 0.31 mm) wide. They are ribbed on the sides and imperforate except for marginal pores between the ribs. The top sometimes bears a conical umbo.

**DISCUSSION:** This species is distinguished from most other species of *Microporella* by a cribriform cover over the ascopore. *M. cribrifera* Osburn also has a perforated cover, but that species has five to seven distal spines, a large ascopore, and two avicularia, one to each side of the ascopore and pointing distolaterally.

**OCCURRENCE:** This was a prominent species, occurring at Stations 4, 5, 7, 8, 9, 11, and 13, ranging from the upper midlittoral to the infralittoral fringe. It was the dominant *Microporella* at Station 7 and also at Spruce Cape near Kodiak, both exposed localities.



DISTRIBUTION: We have a single additional specimen collected intertidally at Katalla, 500 km northeast of Kodiak. The known range is the western Gulf of Alaska.

Genus *FENESTRULINA* Jullien, 1888

*Fenestulina malusii* (Audouin)

Plate 9F

*Cellepora malusii* Audouin, 1826: 239, pl. 8, fig. 8.

*Microporella malusii*, Hincks, 1880a: 211, pl. 28, figs. 9-11, pl. 29, fig. 12; Androsova, 1958: 150, fig. 78; Kluge, 1975: 633, fig. 364.

?*Microporella malusii* var. *glabra*, O'Donoghue and O'Donoghue, 1923: 174; 1926: 63.

*Fenestulina malusii*, Hayward and Ryland, 1979: 224, fig. 96; Dick and Ross, 1986: 89 (part); Cheetham and Sandberg, 1964: 1036, fig. 42.

DESCRIPTION: The colony is small, whitish, glistening, unilaminar, encrusting on rock. Zooids are separated by deep grooves which sometimes reach the basal surface. They are hexagonal or ovoid; 0.48-0.55 mm long (average 0.52 mm) by 0.38-0.55 mm wide (average 0.42 mm); vitreous and hyaline at first, but opaque white with age. The base of the zooid is uncalcified, except for a narrow band around the margin. The frontal wall is thin, markedly convex, somewhat inflated. It is highest, sometimes forming a conical peak, proximal to the ascopore. It is perforated by large, stellate pores forming a single row completely around the zooid, with an inner row beginning lateral to the ascopore and extending toward the orifice. One or two rows of pores lie between the ascopore and orifice. Some zooids have the frontal wall margined by a band of secondary calcification reaching, and sometimes partly covering, the marginal pores. This band is variable in width; its edge forms a smoothly curved "line" which delineates a scutiform frontal area. The ascopore is separated from the orifice by a distance about equal to the length of the orifice. It is broader than long and has a semicircular shelf projecting from the distal margin, leaving a lunate opening. The proximal margin of the ascopore is finely denticulate, and even finer denticles are sometimes present on the margin of the shelf. The orifice is semicircular, 0.14-0.15 mm wide by 0.09-0.10 mm long, surrounded by a low rim. The proximal margin is straight; minute, shelflike denticles are sometimes present at the corners. There are two to four distal spines, but three is by far the commonest number. The ovicell is prominent, globose, smooth, vitreous, translucent, with faint lines radiating from the proximal margin. It is imperforate except for a row of basal pores all around the base and is surrounded by a raised basal collar of ectooecium. The ovicell of one zooid usually abuts the ascopore of the succeeding distal zooid. On ovicellate zooids, the proximal two spines are situated more posteriorly than on infertile zooids and are retained near the proximolateral corners of the ovicell. Embryos are yellow-orange. The ancestrula is tatiform and gives rise to a triad of distal zooids. We found only one ancestrula; the opesia was ovoid, 0.28 mm long by 0.20 mm wide, and bore eleven spines around the margin. Zooids interconnect through elongate multiporous septula which lead to pore chambers in adjacent zooids; there is one connection for each face of the hexagon comprising the shape of the zooid.

DISCUSSION: It is questionable whether this species is actually *F. malusii*, which was originally described from the Red Sea. It is similar to British material (Hincks 1880a, Hayward and Ryland 1979) in zooid size, pore distribution, ascopore form, the

degree to which the ovicell overlaps the succeeding distal zooid, spine number, embryo color, and the form and budding pattern of the ancestrula. However, in our specimens, ovicellate zooids retain the two most proximal spines, which is not the case with British or Eastern Mediterranean material (see Gordon 1984: pl. 41F). Our specimens differ from some previous records of *F. malusii* in the Eastern Pacific. For example, specimens from southern California (Robertson 1908) have more spines and a larger ascopore, and the ancestrula has a circular opesia. Zooids described by Osburn (1952), O'Donoghue and O'Donoghue (1923, var. *typica*), and Soule (1961) all have four or five spines and numerous pores over the frontal surface. Kluge (1975), Androsova (1958) and Cheetham and Sandberg (1964) described material similar to ours from the Sea of Chukotsk, Sea of Japan and Louisiana, respectively. All indicated a single row of pores around the margin, up to four or five spines, and retention of the proximal pair of spines on ovicellate zooids. *F. malusii* has historically been considered "cosmopolitan," occurring in all the world's seas, at a wide range of latitudes and depths, and on a variety of substrates. As with other such species, it will likely be resolved upon closer scrutiny into a number of distinct species and species complexes. OCCURRENCE: This species was uncommon. Thirty-six colonies occurred at Station 10 and several at Station 14, both in the infralittoral fringe.

DISTRIBUTION: Little can be said regarding distribution because of the uncertainty over the identity of this species. We will consider the Pacific distribution to be amphiboreal, based on the similarity of our material to records from the Sea of Japan and some of those from British Columbia. Although Kluge (1975) found what may be the same species in the Chukotsk Sea, he did not find it farther north and west. Neither Osburn (1952) nor Powell (1968) found it in the Arctic.

*Fenestrulina porosa* Canu and Bassler  
Plate 9E

*Fenestrulina porosa* Canu and Bassler, 1923: 117, pl. 37, fig. 4.

*Microporella malusii* var. *umbonata* O'Donoghue and O'Donoghue 1926: 63, pl. 5, fig. 45.

*Fenestrulina malusi* var. *umbonata*, Osburn, 1952: 388; McCain and Ross, 1974: 14.

*Fenestrulina malusii*, Dick and Ross, 1986: 89 (part).

DESCRIPTION: The colony is white, unilaminar, encrusting on rock and shell. Zooids are hexagonal or sometimes ovoid, separated by a deep groove, 0.55-0.70 mm long (average 0.66 mm) by 0.38-0.63 mm wide (average 0.47 mm). The frontal wall is opaque white, glossy, convex, moderately thick, entirely perforated with pores except in the highest, central portion. A conical or tuberculate umbo is variably present just proximal to the ascopore. Umbos occur throughout some colonies and are absent from others; there is variation even within colonies. Inward from the lateral and proximal margins are three or four rows of pores. A row of pores extends around the orifice, and there are two or three rows between the ascopore and the orifice. The pores are large and simple in developing zooids, but become smaller in diameter, slightly infundibular, and stellate as frontal calcification thickens. The ascopore, located at the center of the zooid and separated from the orifice by a distance approximately equal to the length of the orifice, is semicircular, broader than long, with a thin hyaline shelf projecting from the distal margin and leaving a narrowly lunate opening. The proximal margin of the ascopore, and sometimes the margin of the shelf, are finely

denticulate. The orifice is 0.15-0.18 mm wide by 0.10-0.13 mm long and somewhat more than semicircular, so that the lateral margin curves slightly medially to meet the straight proximal margin. There is a blunt, scarcely evident denticle in the corner of the orifice at each side. The orifice is commonly surrounded by a low rim. Zooids usually have a pair of distal spines; rarely, a single median spine is present, or there are three spines. In our material, all spines have been lost, even from marginal zooids, and their occurrence is indicated only by small tuberculate bases of attachment. On ovicellate zooids, the spine bases are lateral to the orifice and abut, but are not covered by the ovicell. The ovicell is prominent, globose, 0.35-0.40 mm wide by 0.38-0.40 mm long, glossy, sometimes roughened with low, inconspicuous tubercles on top. There are pores all around the base, which is marginated by a raised collar of ectoecium "surrounded by a salient ring," (Canu and Bassler 1923). The ovicell of one zooid usually does not reach the ascopore of the succeeding zooid. Zooids interconnect through elongate multiporous septula which lead to pore chambers in adjacent zooids; there is one connection for each face of the hexagon comprising the shape of the zooid.

DISCUSSION: *F. porosa* is distinguished from *F. malusii* Audouin, 1826, by having numerous pores which leave only a small, central area of the frontal wall imperforate; two or three rows of pores between the ascopore and orifice; two distal spines which are shifted to the lateral margin of the orifice on fertile zooids and not covered by the ovicell; and variable presence of a frontal umbo. *F. malusii* var. *umbonata* (O'Donoghue and O'Donoghue, 1926) appears to be a synonym. Although Canu and Bassler (1923) did not mention an umbo in the original description of *F. porosa*, this character is variable and might easily have been absent in their limited Pleistocene material. At Narrow Strait, zooids of *F. porosa* are larger than those of *F. malusii*; except for zooid width, the measurements scarcely overlap.

OCCURRENCE: This species was rare in the intertidal region. Several colonies occurred at Station 14. We have two subtidal specimens from Shuyak Strait at the north end of the Kodiak archipelago.

DISTRIBUTION: This is a boreal, Eastern Pacific species ranging from the Kodiak archipelago southward to the Queen Charlotte Islands (Hincks 1884a), British Columbia (Osburn 1952), the San Juan Islands (O'Donoghue and O'Donoghue 1926), and Santa Catalina Island (Osburn 1952). It was originally described from Pleistocene sediments near Santa Monica, California (Canu and Bassler 1923). Soule's (1961) record of *F. malusii* from the Gulf of California may belong to this species, but the zooids have from four to six spines.

Family TESSARODOMIDAE Jullien, 1903

Genus *CYLINDROPORELLA* Hincks, 1877

*Cylindroporella tubulosa* (Norman)

Plate 9G

*Lepralia tubulosa* Norman, 1868: 308.

*Cylindroporella tubulosa*, Osburn, 1952: 303, pl. 35, fig. 2; Kluge, 1975: 636, fig. 366; Dick and Ross, 1986: 89.

DESCRIPTION: This species forms small, irregularly lobed, light-orange encrusting colonies on rock and shell. Zooids are 0.42-0.58 mm long by 0.20-0.28 mm wide, separated by grooves. The frontal wall is smooth, vitreous, convex, covered with pores

from margin to margin. The primary orifice is nearly circular, but is visible only in marginal zooids. It is obscured by a tall, cylindrical, raised peristome. The base of the peristome is smooth and bulbous. On the proximal side it bears a large, median, circular or transversely elliptical spiramen with a tubiform lip. The peristome is tilted distally. Its opening is evenly truncate or forms several rounded or pointed lobes; sometimes it is flared. The ovicell is globose, smooth, and either imperforate or with a single median pore just distal to the insertion of the peristome. Sometimes there is a faint lunate ridge around the pore. The ovicell is subimmersed, with only the top showing, and opens into the bulbous base of the peristome. Embryo color varies from cream-colored to orange, probably as a function of maturity.

**OCCURRENCE:** This was a prominent species widely distributed in the infralittoral fringe.

**DISTRIBUTION:** *C. tubulosa* is a circumpolar, arctic-boreal species previously known along the western North American coast from Point Barrow, Alaska, to British Columbia (Osburn 1952).

Family HIPPOTHOIDAE Levinsen, 1909

Genus *HIPPOTHOA* Lamouroux, 1821

*Hippothoa mawatarii* n. sp.

Plate 7A-D, 12D

*Hippothoa* sp., Dick and Ross, 1986: 89.

**DIAGNOSIS:** Colony form is uniserial, dendritic, or occasionally aggregated. Branching is Y-shaped rather than cruciform. Autozooids and smaller ovicellate female zooids occur; zoeciules are lacking. The cauda is short and wide, or lacking. The orifice of autozooids has cardelles and a rounded-V-shaped sinus. Lateral pore chambers are of the rounded type, and there are two pores in the distal wall. The orifice of female zooids is compressed, D-shaped, with a straight proximal border lacking cardelles. The ovicell is imperforate. The ancestrula is kenozooidal and buds one distal and two distolateral zooids. A gizzard is lacking.

**HOLOTYPE:** USNM 415797. On rock.

**TYPE LOCALITY:** Station 8 (57° 53.5'N, 152° 21'W), east shore of Spruce Island, near Kodiak, Alaska; intertidal; type collected 18 Oct. 1984.

**ETYMOLOGY:** The species is named for Dr. Shizuo Mawatari, Japanese bryozoologist.

**DESCRIPTION:** The colony is uniserial and branched, forming delicate, white, irregular, lacelike encrustations on rock. The size of older colonies is difficult to determine because they are diffuse and commonly intertwined with other colonies of the same species. Such aggregations can cover areas 5-10 cm across. Occasionally, colonies are circular and aggregated. In this case, branches grow parallel to one another, with adjacent series closely appressed. Some female zooids lie in the groove between adjacent autozooids, giving the colony a multilaminar appearance. Zooids are hyaline or opaque white. Autozooids and ovicellate female zooids occur; zoeciules are lacking. Autozooids are 0.40-0.88 mm long by 0.18-0.33 mm wide. The wide cauda is generally less than half the length of the expanded portion, and commonly much shorter or lacking. The frontal wall is smooth, hemicylindrical, imperforate, with faint transverse growth lines variably present. The highest portion

lies proximal to the orifice. The orifice (pl. 7B) is 0.08 mm in length and width, semicircular distally, with a rounded-V-shaped proximal sinus bordered by cardelles. Just proximal to the orifice is a minute pore, difficult to see with a stereomicroscope but visible in electron micrographs (pl. 12D). A gizzard is lacking. Autozooids have four or five lateral pore chambers (Pl. 7D) of the rounded type (see Gordon and Hastings 1979). The proximal one or two are nearly symmetrical in optical section; the most distal is enlarged and elongate, with the outer opening offset distally from the inner pore. The intervening pore chambers are intermediate in form. The transverse wall has a communication pore on each side. The basal wall is uncalcified except in a narrow band around the margin. Autozooids never bud more than three daughter zooids: one distally and one from each of the large distolateral pore chambers in a Y-pattern. Occasionally, one of the more proximal pore chambers gives rise to a tubular extension which connects with a lateral pore of a nearby zooid by autosyndromy. Sometimes, especially in crowded colonies, one or both distolaterally budded daughter zooids lie appressed to the axially budded zooid. When this occurs, the walls become fused, with several pore chambers connecting the zooids. This happens more frequently with female zooids, but occurs with autozooids as well. Female zooids are 0.35-0.45 mm long (including ovicell) by 0.18-0.25 mm wide, generally triangular, the cauda short or lacking. The orifice is longitudinally compressed, D-shaped, with a straight proximal margin lacking cardelles (pl. 7C). The ovicell is globose and imperforate, and forms the widest portion of the female zooid. The ancestrula is schizoporellid, short and proportionately wide compared to autozooids. It buds one daughter zooid distally and two distolaterally (pl. 7A); the latter grow in a proximal direction so that the colony expands radially.

**DISCUSSION:** This species shows generic characters of both *Hippothoa* Lamouroux, 1821, and *Celleporella* Gray, 1848, as defined by Gordon and Hastings (1979). The lack of zoeciules, a wide female orifice without cardelles, and a schizoporellid ancestrula are characteristic of *Celleporella*; uniserial growth and rounded, rather than tubular, pore chambers are characteristic of *Hippothoa*. Species of both genera lack a gizzard. Moyano (1986) extended the definition of *Hippothoa* to include schizoporellid and tatiform ancestrulae in addition to the kenozooidal type. He also divided *Celleporella* into four subgenera, one of which (*Neothoa*) includes uniserial species with reduced female zooids lacking cardelles. Because of the rounded pore chambers and uniserial growth form, we have placed our species into *Hippothoa*. This necessitates expanding the definition of the genus to include species which have compressed female orifices lacking cardelles, and which lack zoeciules. The form of the pore chambers appears to be the only consistent character separating *Celleporella* and *Hippothoa*.

**OCCURRENCE:** This was a prominent species, occurring at all stations except Station 1. Densities were highest at exposed stations. The greatest cover occurred at sheltered Station 2, a midlittoral site.

**DISTRIBUTION:** The only known localities are the Kodiak vicinity and Dutch Harbor, Alaska.

Genus *CELLEPORELLA* Gray, 1848

*Celleporella hyalina* (Linnaeus)

Plate 7F

*Cellepora hyalina* Linnaeus, 1767: 1286.

*Hippothoa hyalina*, Osburn, 1952: 277, pl. 30, figs. 1-5; Soule and Duff, 1957: 106 (in part); McCain and Ross, 1974: 13; Ryland and Gordon, 1977: 38, figs. 11, 12C; Morris, 1980: 13, text figs. 10-14, 45-46, pl. 2, figs. 1-2, 4-6, pl. 4, fig. 1, pl. 6, figs. 1-2.

*Celleporella hyalina*, Hayward and Ryland, 1979: 252, fig. 109; Dick and Ross, 1986: 89 (part).

**DESCRIPTION:** The colony is white to tan in color, encrusting, subcircular or irregular on rock, 1-2 cm across, coherent, unilaminar at first but multilaminar with age. Autozooids, ovicellate female zooids, and male zooids occur. The initial layer consists entirely of autozooids. These are 0.43-0.63 mm long by 0.18-0.25 mm wide, elongate-elliptical, rounded distally, tapering proximally, widest in the middle, separated by deep grooves. The frontal wall is hemicylindrical, smooth and hyaline, transversely striated, rising distally to a lunate suboral projection. The primary orifice is subcircular, 0.11 mm long by 0.09 mm wide, with a deep, broadly U-shaped proximal sinus separated from the anter by angular cardelles. A sharp, raised peristomial lip extends from the base of the suboral projection distally around the orifice. Slitlike lacunae occur in the groove between young zooids but are soon obscured with age. Minute incipient adventitious zooids are common between autozooids. Female and male zooids, as well as autozooids, are budded frontally from the primary layer of autozooids to form a superposed layer one to several zooids thick. Male zooids are about half the length of autozooids and have a similarly shaped orifice one-fourth or less the area of that of autozooids. Female zooids are short, triangular, with a bow-shaped, longitudinally compressed orifice having a straight or broadly concave proximal margin. Each female zooid bears a smooth, globose, raised, perforated ovicell. The ancestrula is schizoporellid with unilateral budding and spiral astogeny.

**OCCURRENCE:** This was the most abundant species in the study. It occurred from the upper midlittoral to the infralittoral fringe, and was absent only at Station 10.

**DISTRIBUTION:** Hayward and Ryland (1979) considered this a circumpolar, arctic-boreal species with an eastern Pacific distribution from the Arctic to California and parts of Mexico that are affected by cold water upwelling. Morris (1980) considered *C. hyalina* to extend to temperate waters in the southern hemisphere. Osburn (1952) gave the range as cosmopolitan, with an eastern Pacific distribution from Alaska southward to the Galapagos Islands. A cosmopolitan distribution is open to question because as Ryland and Gordon (1977) noted, "The many published records under the name *H. hyalina* (or its equivalent) from all over the world represent several species."

*Celleporella reflexa* n. sp.  
Plates 6C-H, 12E

*Celleporella hyalina*, Dick and Ross, 1986: 89 (part).

**DIAGNOSIS:** Colony form ranges from aggregated to coherent (see Ryland and Gordon 1977); if overall form is coherent, at least portions of the colony are uniserial, biserial, or pluriserial. Colonies range from unilaminar to sparsely bilaminar to multilaminar. Female and male zooids occur among autozooids in the primary layer of older colonies. Incipient adventitious zooids occur in the grooves between larger zooids, and zoeciules are occasionally seen. Zooids have transverse rugae over the entire frontal surface. Marginal zooids sometimes have a lateral calcareous expansion. Ovicells are perforate. The ancestrula is schizoporellid and buds a single distolateral daughter zooid. Pore chambers are tubular.

**HOLOTYPE:** USNM 415798. On rock.

**TYPE LOCALITY:** Station 8 (57° 53.5'N, 152° 21'W), east shore of Spruce Island near Kodiak, Alaska; intertidal; type collected 10 Aug. 1984.

**ETYMOLOGY:** The specific name is from the Latin *reflexus* (turned back), referring to early astogenetic development.

**DESCRIPTION:** The colony is encrusting, aggregated to coherent, forming subcircular or irregular patches up to 3 cm across. Colonies which are primarily coherent show peripheral areas which are uniserial, biserial, or narrowly pluriserial. Young colonies are unilaminar and contain only autozooids. In later stages, male and ovicellate female zooids are budded among autozooids in the basal layer. Finally, a secondary layer is formed. Some colonies have only a few frontally budded male and female zooids in the secondary layer. Others have an extensive secondary layer containing primarily male and female zooids, but also autozooids. Autozooids are 0.55-0.88 mm long by 0.23-0.35 mm wide; hyaline when young; commonly opaque white with age; widest centrally, rounded distally, and attenuated proximally among two or three originating zooids; and separated by a groove. Each zooids interconnects with surrounding zooids by 15-23 tubular pore chambers (pl. 6H). The roofs of the chambers bear one or two openings which lead to the surface of the colony and appear as interzooidal chambers, cups or incipient adventitious zooids. Slitlike lacunae, slightly open or completely closed, occur in the wide portion of the wall between adjacent pore chambers. Occasionally zooids are widely spaced, with separate tubular connections between them; in this case, the lacunae are well developed and visible from the frontal side. The frontal wall is convex and sculptured its whole length with transverse rugae. A suboral umbo is generally lacking; if present, it is a small conical or nodular process. Marginal zooids in narrowly pluriserial extensions of the colony, where growth is directed forward rather than laterally, commonly have lateral calcareous expansions. The basal wall is incompletely calcified: the cauda and margins of the expanded portion are thinly calcified, leaving an oval area uncalcified in the distal portion of the zooid. A few minute pores are present in the basal calcification. The primary orifice of autozooids (pl. 6D) is subcircular, 0.10-0.12 mm long by 0.08-0.10 mm wide, with a deep, broadly U-shaped sinus. Between the sinus and orifice proper are cardelles pointing distally, with a minute indentation lateral to them; sometimes the cardelles are merely shelflike extensions of the orificial rim as in *C. hyalina*. Male zooids occur in both the basal and secondary layers. They vary in size from only slightly narrower and/or shorter than autozooids, to half the length. The orifice (pl. 6E) is similar in shape but much smaller than that of autozooids. Zoeciules

with a more reduced orifice (pl. 6F) also occur, but the distinction between them and male zooids is not clear-cut. There is a continuum of zooid size and orifice shape from the largest male zooids to the smallest zoocellules. Female zooids, whether in the basal or secondary layers, are short and triangular. The orifice (pl. 6G) is bow-shaped and has a broad, shallow proximal sinus. The ovicell is 0.15-0.20 mm long by 0.18-0.25 mm wide and uniformly perforated with 15-20 pores. The ancestrula is schizoporellid, about one-third the length of autozooids and wider in proportion to length, with a similar orifice. A single daughter zooid buds distolaterally (pl. 6C) from either side and itself produces buds, one of which arises laterally or proximolaterally and grows alongside the ancestrula, but in the opposite direction. The colony thus tends to develop first in two directions, parallel to the longitudinal axis of the ancestrula.

DISCUSSION: Bilaminar colonies of *C. reflexa* can be confused with *C. hyalina*; both have perforate ovicells. The transverse rugae of the zooids; the occurrence of male and female zooids in the primary layer; uniserial or narrowly pluriserial portions of the colony; and differences in astogeny distinguish the former from the latter. Unilaminar, aggregated colonies of *C. reflexa* might be confused with *Hippothoa expansa* Dawson or *H. minitumulosa* Morris, the zooids of which can have lateral calcareous expansions. However, ovicells of *H. expansa* are imperforate; males are absent in *H. minitumulosa*; and both species tend to be predominantly uniserial.

OCCURRENCE: This was a prominent species, occurring at Stations 2, 4, 7, 8, and 10-14, ranging in height from the mid-midlittoral to the infralittoral fringe.

DISTRIBUTION: We have intertidal specimens from the Blashke Islands near Wrangell and from Dutch Harbor, and there are specimens from Sitka in the University of Alaska collection (Nora Foster, collector). The known range extends from southeastern Alaska to the eastern Aleutian Islands.

Family SERTELLIDAE Jullien, 1903

Genus *RHYNCHOZOON* Hincks, 1895

*Rhynchozoon rostratum* (Busk)

Plate 61

*Lepralia rostrata* Busk, 1855b: 4.

*Schizoporella tumulosa* Hincks, 1882: 252.

*Rhynchozoon rostratum*, Osburn, 1952: 456, pl. 54, figs. 1-3; Soule, 1961: 43; Soule and Soule, 1964: 33.

*Rhynchozoon tumulosum*, Osburn, 1952: 458, pl. 54, figs. 4-5; Soule and Duff, 1957: 125; McCain and Ross, 1974: 14.

*Rhynchozoon* sp., Dick and Ross, 1986: 89.

DESCRIPTION: This description is based on a dead fragment approximately 0.25 cm<sup>2</sup> in area. The colony is unilaminar, encrusting on rock. Zooids are 0.43-0.60 mm long by 0.30-0.35 mm wide; ovate or hexagonal; and separated by deep grooves. The frontal wall is smooth; convex; imperforate; and bordered on each side by seven to nine areolar pores, between which run costate ridges onto the base of the umbo. A tall, blunt, heavy conical or cylindrical umbo occupies the distal third of the frontal wall, or sometimes the entirety. The primary orifice is circular or slightly wider than long, 0.12-0.13 mm in maximum dimension, with a broad, shallow median sinus occupying about half the proximal border. Small, blunt cardelles sometimes lie near the



proximolateral corners. The vestibular arch is denticulate. Spine scars on peripheral zooids indicate two oral spines. With age, a deep peristome develops due to thick frontal calcification. A suboral avicularium lies high in the peristome, at the base of the suboral umbo. It is lateral to the midline and directed laterally to either side, the rostrum raised and distally hooked. The mandible is nearly equilateral. Sometimes, there is a small uncinatate or cylindrical process at the edge of the peristome, opposite the avicularium. In a portion of the colony where the umbones are particularly tall, this process is enlarged, cylindrical, and nearly perpendicular to the colony surface; some zooids have such a process on each side of the secondary orifice. Some zooids bear a frontal avicularium, which arises from an areola. It is the same size as the suboral avicularium and lies atop a raised chamber. The mandible is equilateral. Ovicells are lacking in our specimen.

DISCUSSION: Our specimen compares favorably with those of *R. tumulosum* in Osburn's collection at the Allan Hancock Foundation. Soule and Soule (1964) synonymized *R. tumulosum* (Hincks) with *R. rostratum* and we accept their analysis. The important characters are a relatively large number of areolae, between which run prominent costae; a prominent suboral avicularian chamber which is conspicuous in young zooids but soon obscured by heavy frontal calcification; and the variable presence of umbonate or cylindrical processes around the orifice. Our specimen, with a circular or nearly circular primary orifice, is similar to *R. spicatum*. That species, however, has fewer and smaller areolar pores and weaker costae. *R. spicatum* is characterized (Osburn 1952) by a short (0.06-0.08 mm) mandible on the suboral avicularium. The length of the mandible in our material is 0.05-0.06 mm. Osburn (1952) implied that the mandible is longer in *R. tumulosum*, but his illustrations (pl. 4, figs. 4-5) indicate a short mandible. The only previous record of the genus in Alaska is *R. bispinosum* from Pavlof Bay on the Alaska Peninsula (Osburn 1952). Osburn expressed doubt concerning the identity of eastern Pacific records of *R. bispinosum* with *R. bispinosum* (Johnston).

OCCURRENCE: There was one dead colony fragment at Station 13.

DISTRIBUTION: This is a boreal-tropical species endemic to the eastern Pacific. *R. rostratum*, including *R. tumulosum*, is previously known from British Columbia southward to Columbia and the Galapagos Islands (Osburn 1952). We have additional specimens from the Blashke Islands in southeastern Alaska.

#### Family TEUCHOPORIDAE Neviani, 1895

#### Genus *LAGENICELLA* Cheetham and Sandberg, 1964

#### *Lagenicella neosocialis* n. sp.

Plates 12F, 13A

not *Lagenipora socialis* Hincks, 1877: 215.

*Lagenipora socialis*, O'Donoghue and O'Donoghue, 1923: 33, 1926: 74; Osburn, 1952: 488, pl. 60, figs. 3-4; Soule, 1961: 51; Dick and Ross, 1986: 89.

DIAGNOSIS: This species is *Lagenipora socialis* of previous Pacific Coast authors. The colony is encrusting, recumbent, coherent, unilaminar. The frontal wall is entirely perforated. The peristome is moderately tall; often flared and bluntly pointed on the proximal margin; sometimes costate; oriented at an angle to the frontal surface; and not rising appreciably above the ovicell. The ovicell is either immersed or suspended

from the distal wall of the peristome; this depends upon the degree of regularity of the substrate. The lateral oral avicularia are tilted toward the orifice and lie on a low, cylindrical, more-or-less bulbous process.

**HOLOTYPE:** USNM 415799. There are three colonies on a shell; the holotype is indicated by an arrow; the other two are part of the type series.

**TYPE LOCALITY:** Station 10 (57° 55.6'N, 152° 31.6'W), Neva Cove, Kodiak Island, west end of Narrow Strait, Alaska; intertidal; type collected 22 July 1982.

**ETYMOLOGY:** The species name is a combination of the Greek *neos* (new) and the Latin *socialis* (companionship), referring to a new species previously known as *Lagenipora socialis*.

**DESCRIPTION:** Colonies are 1-2 cm across, coherent, forming irregular unilaminar encrustations on rock or cylindrical encrustations on algal stems, and whitish in color. Zooids are 0.40-0.60 mm long by 0.25-0.40 mm wide, irregularly hexagonal or ovate, separated by grooves, well-calcified, vitreous and translucent when young, opaque white with age. The frontal wall is moderately and uniformly convex, and covered entirely with pores which, with advanced calcification, become infundibular. Zooids interconnect through minute basal septula, each having a few pores and leading to a tubular channel. There are six to eight septula in each lateral wall and two in the distal wall. The primary orifice is elliptical, 0.13-0.16 mm long by 0.10-0.13 mm wide. It is obscured by a moderately tall peristome which tilts distally. On each side of the peristome is a small avicularium tilted toward the orifice on a bulbous chamber. The rostrum forms an acute tip, and the rounded-triangular mandible points laterally. The peristome is truncate, or tapers to a rounded point on the proximal side, where it is sometimes flared; it is either smooth or costate. In fertile zooids, the ovicell connects with the chambers of the avicularia and completes the peristome distally. The peristome does not extend far above the ovicell. The ovicell is globose, hyperstomial, 0.15-0.19 mm long by 0.18-0.23 mm wide. In colonies encrusting flat surfaces, it is immersed, the top flush with the colony surface and margined by calcification from surrounding zooids, but not completely covered. On irregular surfaces, zooids are less recumbent, and the ovicell is suspended from the peristome. The ovicell has a semicircular or lunate tabula which is covered with small pores and sometimes has an areola at each side. The details of the peristome, degree of immersion of the ovicell, and shape of the tabula vary considerably with the age, habitat, and degree of wear of the colony. Embryos are yellow-orange or red-orange.

**DISCUSSION:** The eight species of *Lagenipora* treated by Osburn (1952) form a homogeneous group. They do not belong to *Lagenipora* Hincks, in which the frontal wall has marginal pores only, but rather to *Lagenicella* Cheetham and Sandberg, in which the frontal wall is regularly perforated. Several authors (Cheetham and Sandberg 1964, Gordon 1984) have placed species of *Lagenipora* treated by Osburn (1952) into *Lagenicella*. The Pacific Coast species originally identified by the O'Donoghues as *Lagenipora socialis* Hincks is also a *Lagenicella*; *socialis* is not an available name, and the species is here described as new. The identity of our material with *Lagenipora socialis*, Osburn, is based upon zooid size, colony form, and especially the commonly costate, sometimes flared, more or less acute proximal peristomial flange. Our specimens differ from Osburn's (1952) description in that the ovicells are commonly immersed, with only the top exposed at the colony surface. This seems to be related to the thick frontal calcification of our material. We have examined one collection of *Lagenipora socialis* (Allan Hancock Foundation Collection No. 1057) from Departure Bay, B.C., identified by Osburn. The peristomial tubes are

angled more distally than Osburn (1952) indicated in his description, as is the case in our material. The ovicell is usually distinct, suspended on the distal wall of the peristomial tube, but sometimes appressed to the frontal surface of the following zooid or even subimmersed. More complete immersion would require only increased thickening of the frontal wall, as in our material. Conversely, some marginal zooids in our specimens have the ovicell distinct and suspended from the distal side of the peristome, as is generally the case in Osburn's specimens. Osburn's (1952) statement that the ovicell opens well above the level of the primary orifice in all species of "*Lagenipora*" (= *Lagenicella*) is misleading. In both the Departure Bay specimens and ours, the top of the ovicell is at the level of the top of the peristome. In both, however, the formation of the ovicell and later the opening of the ovicell begin at the level of the primary orifice or slightly above it. The ovicell actually opens at the base of the peristome.

**OCCURRENCE:** This was a prominent species, occurring at all stations except 1 and 2, ranging in height from the upper midlittoral to the infralittoral fringe.

**DISTRIBUTION:** *L. neosocialis* is a boreal species endemic to the eastern Pacific. It is previously known from British Columbia to southern California (Osburn 1952) and Mexico (Soule 1961).

Family CELLEPORIDAE Johnston, 1838

Genus *CELLEPORINA* Gray, 1848

*Celleporina aspera* n. sp.

Plate 7E

*Costazia ventricosa*, Osburn, 1952: 511, pl. 63, figs. 4-5 (part); Dick and Ross, 1986: 89.

**DIAGNOSIS:** The colony forms low, coarse, nodular, multilaminar encrustations. Zooids are thick-walled and moderately large. The primary orifice is longer than broad, with a deep, broad, V-shaped proximal sinus. A pair of lateral oral avicularia are turned inward toward the orifice on bulbous chambers. The ovicell has a broadly lunate or semicircular tabula outlined by peripheral pores. Interzooidial avicularia are lacking.

**HOLOTYPE:** USNM 415800.

**TYPE LOCALITY:** Station 11 (57° 51.2'N, 152° 23.4'W), reef-flat along eastern shore of Termination Point, Kodiak Island, Alaska; intertidal, on rock; type collected 3 Nov. 1982.

**ETYMOLOGY:** The species name is from the Latin *asperus* (rough, uneven), referring to the rough, nodular aspect of the colony.

**DESCRIPTION:** The colony is coarse, white, multilaminar, forming flattened or nodular encrustations up to 10 cm long by 3.5 cm wide by 1.3 cm thick. Large colonies are composed of rounded nodules up to 2 cm across. Zooids at the colony margin are recumbent, 0.64-0.88 mm long by 0.38-0.50 mm wide, ovoid, separated by grooves. The frontal wall is convex, vitreous, and coarsely reticulate; pores lie along the margin, and a few may be present in the depressions of the reticulation. Thick frontal calcification soon covers the reticulation, leaving a smooth but coarsely rugose frontal wall perforated with small tubular pores, most but not all of which originate at the margin. Each lateral wall interconnects through approximately six minute circular

multiporous septula leading to tubular channels; similar connections are present in the distal wall. The primary orifice is 0.18-0.25 mm long by 0.13-0.18 mm wide; tilted downward distally; and ovoid, with a broad, deep V-shaped proximal sinus. A small cardelle is sometimes present at each edge of the sinus. A shallow, flaring peristome surrounds the orifice. Avicularia are paired and lie at the edge of the peristome, lateral to the orifice. The chamber is columnar or bulbous, and the semicircular mandible varies in position from parallel to the frontal surface and pointing laterally, to tilted inward above the orifice and pointing nearly vertically. Oral avicularia are sometimes lacking, but there are never more than two. With age, the colony becomes thickened or nodular as secondary layers of zooids build up. The zooids become increasingly vertically oriented until they are cylindrical and oriented perpendicular to the colony surface; only the orifice, the peristome, a narrow portion of frontal wall with a row or two of pores, and the ovicell are visible. Interzooidal avicularia are lacking. Ovicells are globose, raised or partly immersed, 0.38-0.45 mm wide by 0.25-0.33 mm long, with a semicircular or triangular (occasionally lunate or V-shaped) tabula. Small, more-or-less slitlike pores line the periphery of the tabula, with radiating ridges between them converging toward the center; sometimes they are absent. The proximal border of the ovicell bears a raised lip. Embryos are an unusual rose color. Ovicellate zooids often have a deep peristome enclosed by the ovicell distally, the avicularia laterally, and a raised flange proximally; the secondary orifice is in this case quadrate.

DISCUSSION: Osburn (1952) recognized six species of *Celleporina* (= *Costazia*, Osburn) on the Pacific Coast of North America, three of which appear well defined: *C. procumbens*, *C. surcularis*, and *C. nordenskjoldi*. The other three, *C. ventricosa*, *C. robertsoniae* and *C. costazi* (= *C. souleae* Morris), are problematic. Osburn (1952) identified *C. ventricosa* by its colony form, usually nodular and encrusting but sometimes erect and branching; by the large size and coarseness of the zooids; and by the deep V-shaped sinus in the primary orifice. He separated *C. costazi* from *C. robertsoniae* by colony form (pisiform, terete, or encrusting versus usually erect and branching); by the number of oral avicularia (two versus three); and by the position of the ovicell on the peristome (high versus low). Osburn (1952) indicated the two to be similar in size, shape of orifice, and the occurrence of interzooidal avicularia.

Morris (1979) reexamined the genus *Celleporina* on the Pacific Coast of North America and recognized five species which she separated on the basis of frontal wall pore pattern; ovicell pore pattern; shape and size of the orificial sinus; and shape, size, and angle of orientation of the oral avicularia. She named a new species, *Celleporina souleae*, which includes the *Costazia costazi* of earlier Pacific Coast authors, and suggested the name *Costazia robertsoniae* be dropped because the presence of three oral avicularia seemed to be a variable character occurring in other species as well. She incorporated previous records of *C. robertsoniae* with *Celleporina souleae* and *Celleporina ventricosa*. There are two well-defined species of *Celleporina* at Narrow Strait. One, which we have described as a new species, *C. aspera*, is invariably encrusting and nodular; it never has three oral avicularia; and it lacks interzooidal avicularia. The chambers of the oral avicularia are somewhat bulbous, and the mandibles are often turned inward toward the orifice. By Morris' (1979) diagnostic key it would have to be identified as *C. souleae*; however, the zooid measurements are much greater than, and do not overlap with, those she gave for *C. souleae*. It would probably have been assigned to *Celleporina ventricosa* by Osburn (1952) on the basis of colony form, zooid size, and shape of orifice, but it is almost certainly another species. *C. ventricosa*, originally described from the Arctic (Lorenz 1886), forms erect,

cylindrical, branched colonies (Kluge 1975, Powell 1968) with zooids up to 1.00 mm or more long and 0.87 mm wide. The primary orifice is quite characteristic, and differs from that indicated by both Osburn (1952) and Morris (1979); it is oblong-oval and has a constriction before the proximal margin, which bears a broad, shallow, V-shaped median sinus (Waters 1900: pl. 12, fig. 10). The ovicell is spherical, from half to two-thirds as wide as the zooid, with a generally narrow tabula. There are two oral avicularia. We have examined specimens of *C. ventricosa* from the Beaufort Sea and found them to conform closely to previous descriptions of arctic material (Waters 1900, Powell 1968, Kluge 1975). Osburn (1952) described *C. ventricosa* as generally nodular and encrusting, only occasionally erect and branching. He indicated zooids to be 0.55-0.70 mm long by 0.55 mm wide, smaller than arctic *C. ventricosa* as indicated by other authors and our own measurements; to have a primary orifice with a deep, evenly tapering, V-shaped proximal margin; and to have a fairly large tabula on the ovicell. Thus, while some of Osburn's (1952) records of *C. ventricosa* were probably correct, especially those of erect colonies from the Arctic, his records from southern Alaska to California are questionable. Many probably belong to *C. aspera*.

The other, less common *Celleporina* at Narrow Strait forms only erect, branching colonies. Zooids are moderately large and have two or three oral avicularia lying nearly horizontally on narrow pedicels. The primary orifice has a deep, V-shaped sinus. The ovicell has a large tabula. Both spatulate and circular interzooidal avicularia are seen in every colony. This species is identical to Morris' (1979) description of *C. ventricosa*, but for reasons already mentioned cannot be *C. ventricosa* (Lorenz). Our material fits Osburn's (1952) description of *C. robertsoniae* in all respects. We cannot agree with Morris (1979) in dropping the name *C. robertsoniae* and including previous records of that species in *C. ventricosa* and *C. souleae*. Although Morris (1979) raised some valid concerns about the type specimen of *C. robertsoniae*, Osburn (1952) also admitted that there were problems, but believed that his examination of a later specimen from the type locality as well as abundant additional material allowed him to define the species. The characters he listed appear to be constant over a considerable range; subtidal specimens we collected at Shannon Point, Washington, have the same assemblage of characters as those at Narrow Strait.

The question remains as to what separates *C. robertsoniae* from *C. souleae* Morris (= *C. costazi*, Osburn). Zooids of the type specimen of *C. souleae* (Allan Hancock Foundation Collection No. 184) have two or three oral avicularia with bulbous chambers and the mandibles turned inward; the colony forms a terete growth on a stem. These characters appear to be distinct from the more pedicellate oral avicularia and the erect growth form of *C. robertsoniae*. However, the type specimen of *C. souleae* also has a few circular and spatulate interzooidal avicularia which should not be present in that species (Morris 1979), but which are characteristic of *C. robertsoniae*. Measurements of zooid width, orifice dimensions, and dimensions of the interzooidal avicularia of the type specimen of *C. souleae* are much smaller and only slightly overlap with those of *C. robertsoniae* from Washington and Alaska. This difference in the coarseness of the zooids can be seen with the naked eye. These and some of the other Pacific Coast species of *Celleporina* will remain problematic until taxonomic studies have included an examination of the form and budding pattern of their ancestrulae.

OCCURRENCE: *C. aspera* was a prominent species patchily distributed in the lower midlittoral and infralittoral fringe. It was most abundant at exposed Stations 7, 8, and 9.

DISTRIBUTION: *C. aspera* is a boreal species presently known only from the eastern Pacific. It is widespread in Alaska, and many of Osburn's records of *C. ventricosa* from sub-arctic Alaska are probably this species. The southern extent of the range is unknown.

*Celleporina robertsoniae* (Canu and Bassler)

Plate 7G

*Costazia robertsoniae* Canu and Bassler, 1923: 181, pl. 39, figs. 10-12.

*Costazia robertsoniae*, Osburn, 1952: 507, pl. 62, figs. 1-2.

*Celleporina ventricosa*, Morris, 1979: 479 (part).

*Celleporina robertsoniae*, Dick and Ross, 1986: 89.

DESCRIPTION: The colony is erect, cylindrical, irregularly forked. Most of our specimens are young colonies, less than 2 cm high, consisting of a single cylinder, 5-7 mm in diameter, which is unbranched or ends in two to five lobes of varying size. One specimen is 5 cm high, with a major column 9 mm in diameter and many forked, cylindrical branches. Marginal zooids in very young colonies are decumbent, 0.63-0.75 mm long by 0.30-0.50 mm wide. As the colony rises from the substrate, the zooids become erect, the circular distal portion 0.38-0.58 mm across. The frontal wall of decumbent zooids is smooth, convex, with marginal pores and one or two parallel rows of pores inward from the margin; the centralmost area is imperforate. In erect zooids, the pores are carried toward the orifice by tubular extensions and form several concentric rows around it; the frontal wall is rugose or reticulate. The primary orifice is ovate, 0.16-0.20 mm long by 0.12-0.15 mm wide, with bracket-shaped cardelles and a deep V-shaped proximal sinus. In non-ovicellate zooids, the peristome is poorly developed on the proximal side, where there is only a slight lip; it is well developed laterally and distally as a circumoral rim. A pedicel on each side of the orifice bears a small avicularium with a semicircular or rounded-quadrate mandible; commonly there is a third avicularium proximal or distal to the orifice. The mandibles either lie parallel to the operculum or are turned slightly inward, and are directed laterally. With age, the peristome becomes deep, bounded proximally by a high flange, laterally by the avicularia, and distally by a high flange or the ovicell. The secondary orifice is rounded-quadrate. Two types of vicarious avicularia occur: one is circular, 0.10-0.20 mm across, with a semicircular mandible; the other is elongate, 0.28-0.53 mm long by 0.15-0.25 mm wide, with a spatulate mandible. Avicularia intermediate between the two types occur. Ovicells are 0.30-0.45 mm wide by 0.28-0.38 mm long, prominent at first but subimmersed with age. The tabula is semicircular and occupies half or more of the ovicell; slitlike pores line the distal curvature.

DISCUSSION: See *Celleporina aspera*.

OCCURRENCE: Several large colonies were found at Station 10 during preliminary sampling in 1982, but only three small colonies were found there during systematic sampling. Five additional colonies were found in incidental subtidal collections, four on *Fusitriton oregonensis* from Narrow Strait and one on a hydroid from the shelf around Kodiak Island.

**DISTRIBUTION:** This is apparently a boreal species endemic to the eastern Pacific. It has been previously recorded from British Columbia to the northern border of Mexico (Osburn 1952). We have additional specimens from Zaigot Bay and McLeod Harbor, Alaska.

Family MYRIOZOIDAE Smitt, 1868b

Genus *MYRIOZOELLA* Levensen, 1909

*Myriozoella plana* (Dawson)

Plate 6J

*Lepralia plana* Dawson, 1859: 256.

*Myriozoum crustaceum* Smitt, 1868b: 18, pl. 25, figs 88-91.

*Schizoporella crustacæa*, Kluge, 1975: 580, fig. 321.

*Myriozoella plana*, Osburn, 1952: 516, pl. 64, figs. 1-2; Dick and Ross, 1986: 89.

**DESCRIPTION:** Colonies are white; solidly attached to rock, shell, and algae; unilaminar at first, but bilaminar or multilaminar with age. The colony form is characteristic; the layers of zooids are circular, with each successive layer forming a smaller concentric circle over the previous one. Zooids are ovoid, 0.50-0.63 mm long by 0.28-0.35 mm wide. Zooidal boundaries are indistinct even in early stages. The frontal wall is well-calcified, convex when young, sparsely perforated by tubular pores. With age, the pore openings enlarge; the frontal surface becomes thick and reticulate; and zooidal boundaries are almost completely obscured. In some colonies, zooids bear one or two large frontal umbones, and have enlarged, umbonate avicularian chambers lateral to the orifice. The primary orifice is 0.10-0.13 mm in length and breadth; semicircular distally, with straight sides; and surrounded by a shallow, sloping peristome. The proximal margin is straight and bisected by a deep median sinus. The operculum is a rich brown color, in sharp contrast to the white walls of the zooid. To each side of the orifice is a slightly raised chamber bearing an avicularium on the distal side. The semicircular mandible is oriented at an angle to the colony surface and points proximally. Sometimes one or both avicularia are lacking. Scattered throughout the colony are vicarious avicularia with a semicircular or subspatulate mandible which is larger than the operculum of autozooids and oriented in any direction. Ovicells are hyperstomial, smooth, imperforate, deeply immersed by the thick reticulate calcification of surrounding zooids. Embryos are yellow-cream or light orange-yellow in color.

**OCCURRENCE:** This was a prominent species, present at all stations except Station 6, the highest. It was most abundant at scattered infralittoral fringe sites in both sheltered and exposed areas.

**DISTRIBUTION:** *M. plana* is a circumpolar, arctic-boreal species. Previous records from western North America are confined to Alaska and the surrounding waters: Bering Sea (Kluge 1975); Point Barrow and the Pribilof Islands (Osburn 1952); Kodiak, Orca, Yakutat, and Juneau (Robertson 1900).

## DISCUSSION

### *Quantitative Approach*

Quantitative study of rocky intertidal communities is difficult because of the high degree of spatial heterogeneity on rocky shores (Stephenson and Stephenson 1972). Rao and Ganapati (1985) used transects to study the distribution and abundance of bryozoans in rocky intertidal habitats along the Bay of Bengal, but such a technique was not suitable for this study. Although transects might have been utilized at some localities along Narrow Strait, they would have been impractical at others. For example, rocks with heavy bryozoan encrustations were so patchily distributed on reef-flats that transects or random quadrats would likely have encountered few or no bryozoans. No attempt was made to determine the absolute abundance of cheilostome bryozoans. Instead, a sample of the most heavily encrusted rocks of limited size was taken. This sample indicated not only the species composition and relative abundance of cheilostomes at a station, but also the maximum values of species richness and cover permitted by the habitat and stress factors peculiar to that station. Sampling was condensed into a two-month period to eliminate, as much as possible, the time factor. Ryland (1975) employed methods similar to those used in this study to estimate the relative abundance of bryozoans on a New Zealand reef-flat.

### *Substrate Availability*

The distribution and abundance of bryozoans are related to the availability of suitable substrate, physical stress gradients, and biotic factors. In the Kodiak area, only a fraction of the shoreline provides suitable substrate ideal for a diverse bryozoan fauna. Stretches of rocky shore are interrupted by beaches of sand or gravel which, due to their instability, lack bryozoans. With the exception of *Cryptosula okadai*, most species occur on the undersides of rocks or on rock fragments beneath larger rocks. This is not always the case; at Station 13, *Heteropora* sp., *Alcyonidium* sp., *Tegella aquilirostris*, and other species in addition to *Cryptosula okadai* were observed on the upper surfaces of stable boulders. Generally, however, stretches of cliffs and reef-flats, having predominantly exposed surfaces, are depauperate in bryozoans. Even shores with an abundance of smaller rocks may be depauperate if they are so exposed that the rocks are constantly shifted by wave action; if they are so sheltered that the rocks become sedimented in place, with no space beneath them; or if there is excessive freshwater influence from a stream outlet or due to seepage from the beach itself.

The insularity of the rocky intertidal probably plays some role in shaping the assemblage of bryozoan species at a given site. Stretches of rocky shore around islands, such as Eider Island in Narrow Strait, are literally islands separated from mainlands. Stretches of rocky shore separated by sand or gravel beaches are also islands, and so are separate bryozoan-covered boulders widely separated from one another on a reef flat. These categories of islands differ in size, in the distance between islands relative to their size, and in the relative importance of currents in transporting larvae from one island to the next. Most cheilostome larvae settle within a few hours of release (Hyman 1959, Ryland 1970). An uncolonized surface surrounded by bryozoan-encrusted rocks, as in a rock-pile, probably has a greater chance of being settled by larvae, and will attain a higher diversity, than a similar surface on a reef-flat distant from a large number of reproducing colonies. Eggleston (1972b) showed a direct relationship between the availability of suitable substrate and the density and



species richness of bryozoan assemblages in a subtidal community. Ryland (1967) documented the importance of the proximity of a reservoir of breeding colonies for colonization of settlement panels. In our study, the two widely separated reef-flat stations (9 and 11) had similar species richness (17-18 species) and grouped together in the cluster analysis, indicating that insularity influenced not only the diversity but also the species composition of their bryozoan assemblages. The combined richness of the two stations was 21 species, at least 14 (67%) of which occurred at both. This was a striking contrast to Sunny Cove and Icon Bay, which had identical richness (25 species), but had only 14 (39%) species in common of a total of 36 species. Perhaps some species have somewhat longer-lived larvae than others, and thus stand a greater chance of colonizing a suitable habitat distant from centers of larval production. Also, intertidal sites may be isolated from one another with respect to species which are restricted to the shore, but continuous with respect to species having subtidal distributions between the sites.

The individual rocks in a rock-pile represent islands on the smallest scale. Using settlement panels, Jackson (1977) demonstrated significant variations in recruitment rates, faunal composition, and diversity as a function of substrate area. The high variability in bryozoan species composition and abundance from one coral to the next in a cryptic reef community is a function of substrate area coupled with random priority effects and the subsequent biological interactions of encrusting species (Jackson 1984, Winston and Jackson 1984). The same factors probably shape the associations of encrusting organisms on individual rocks in the cryptic rock-pile habitat.

### *Physical Factors*

Stress gradients resulting from variations in height, wave exposure, salinity, current, and sedimentation are known to affect the distribution and abundance of intertidal organisms. Of these factors, only the effects of height were demonstrated at Narrow Strait; the effects of other factors were evident but unquantified. At both Icon Bay (Table 5) and Sunny Cove (Table 6), species richness decreased with increasing height. Species composition also changed, with some species abundant at, and apparently adapted to, higher levels. Height determines the amount of emergence which a species must undergo in a given period, and the stresses resulting from emergence include freezing, exposure to rainwater, and, to a lesser extent at Kodiak than at more southern latitudes, warming and desiccation. The 1982 Tide Table for Western Alaska showed that stations at -0.6 m emerged 33 times during the year; those at -0.3 m emerged 101 times; and those at 0.3 m emerged 421 times. The higher the station, the longer each emergence lasted.

Near-shore surface salinities in the Kodiak region range from 17-30 ppt, and therefore fall into the polyhaline category (Winston's 1977 classification). At times of high precipitation and runoff, salinities at certain sites, such as Sunny Cove, almost certainly reach pleiomesohaline concentrations (8-18 ppt), at least for short periods. All intertidal bryozoans at Narrow Strait are able to survive fairly extended, if not continuous, exposure to polyhaline water. Only seven species found there are included in Winston's (1977: Table 1) list of estuarine species. Our study increases by 49 the number of cheilostomes known to occur in water of diminished salinity. This is perhaps made possible by the low water temperature, which ranges from 3°C in winter to 12°C in summer. Winston (1977) noted that some less euryhaline species are able to

survive brackish water only in colder months, and that cyclostomes, with a low tolerance for brackish water, occur there only in cold-water regions. Permeability of living membranes generally decreases with decreasing temperature (Giese 1957), and this might explain the bryozoans' tolerance to fluctuations in salinity which likely occur at Narrow Strait with tide changes or excessive runoff.

### ***Biotic Factors***

Biotic factors also influence bryozoan associations. Other groups of encrusting organisms attained significant cover on the sample rocks. Unfortunately, only qualitative information on the abundance of these associated organisms was gathered. Without knowing the densities and covers of all the species on the rocks, it is difficult to interpret the results for cheilostomes alone. A calcareous sponge, *Leucosolenia* sp., was common throughout the study area, and its anastomosing networks of fine tubules covered considerable areas on some rocks. Two other sponges, including *Halichondria panicea* (Pallas), occurred but rarely formed significant cover. Several species of tubeworms were the main competitors with bryozoans for space. *Paradexiospira vitrea* (Fabricius) and *P. violacea* Levinsen were most abundant, with fewer *Pseudochitinopoma occidentalis* (Bush). A larger unidentified serpulid and a minute unidentified spirorbid also occurred. Combined tubeworm and bryozoan cover combined often approached 100%, especially at low, sheltered stations. There was much variability in the distribution of tubeworms, and some rocks from the midlittoral also had considerable cover. Some bryozoans, especially *Tegella aquilirostris*, *T. armifera*, and *T. arctica*, were able to form large colonies overgrowing tubeworms, but only rarely did the latter settle on bryozoans. In tubeworm-free areas on densely covered rocks, space was at a premium and competition among bryozoans intense. Several species of cyclostomes and small colonies of *Cribrilina annulata* were able to exist among the dense mats of tubes and may even have found a protected niche there.

Cyclostome and ctenostome bryozoans formed a significant part of the encrusting community at some stations. Generally the total density of cyclostomes was less than 15% that of cheilostomes, but at Stations 10, 12, and, 14 it ranged from 31-77%. Cyclostome cover was generally less than 6% that of cheilostomes, but ranged from 15-21% at the same three stations. At Stations 10 and 14, species richness of cyclostomes was approximately 40% that of cheilostomes. *Alcyonidium* spp. achieved combined densities of up to 15%, and covers of up to 14%, those of cheilostomes.

### ***Other Local Habitats***

The present study considered primarily rock substrate, though several species found on shells were included. One intertidal habitat not considered was the holdfasts of laminarian algae. Several species of laminarians are abundant in the infralittoral fringe along most of the shore of Narrow Strait. Although examined only cursorily, the holdfasts did not have any bryozoan species unique to that habitat, and the species diversity was much less than on rock. Holdfasts of subtidal algae washed ashore contained several species not found intertidally. Few bryozoans are found on the blades and stipes of intertidal algae in the Kodiak area, perhaps due to the extremely seasonal nature of the flora and the unfavorable effects of wave action.

A unique association of species occurred on the undersides of large boulders forming overhanging rock faces. This association was most evident in the summer and early fall, and apparently involved r-selected species which colonize readily and grow rapidly. It included *Tegella aquilirostris*, *Dendrobeatia lichenoides*, *Hippoporina vulgaris*, and *Cryptosula okadai*. The erect, flexible species *Tricellaria ternata*, *Scrupocellaria elongata* and *Crisia* sp. were much more common on overhanging faces than in the rock-pile habitat.

Compared to the intertidal region, relatively little is known of the subtidal bryozoan fauna in the Kodiak area. Osburn (1955) reported 113 subtidal species from the Point Barrow vicinity. More species should occur at similar depths in the Gulf of Alaska because it is warmer and contains both arctic-boreal and boreal elements. Schopf (1968) concluded that continental shelves (0-200 m) worldwide characteristically have a maximum of 30-100 species per station. High diversities would, of course, be conditional upon availability of abundant suitable substrate. Gordon (1987) reported a maximum of 127 species per station at depths of 0-500 m in the New Zealand region, and felt that this number was a result of comprehensive sampling rather than any intrinsic feature of the region. Cuffey and Turner (1987) found only 37 modern bryozoan species in sediment samples from the shelf east of Kodiak Island. Most of their material was recovered from pebbly comminuted sand bottoms. Areas with abundant cobble and mollusc shell substrates will likely yield much higher diversities.

### *Intertidal Adaptations*

Only two of the nominal subtidal species reported by Cuffey and Turner (1987) were found by us intertidally. Intertidal species are often specially adapted to withstand conditions peculiar to the shore. Inability to tolerate brackish water perhaps prevents many of the species from the Kodiak shelf from extending into intertidal areas. In the Fall, *Electra crustulenta* forms *hibernacula*, and *Harmeria scutulata* and *Hippoporina vulgaris* form peripheral zones of reduced or frontally thickened zooids which remain alive after the more central zooids have disintegrated. *H. scutulata* is primarily a subtidal species, and its heterozooids cannot be considered strictly an intertidal adaptation. *Celleporina aspera* and *Myrriozoa plana* attained their greatest covers at Station 8, an exposed site. Both have zooids with thick frontal walls and form robust encrusting colonies perhaps adapted to withstand wave action and sediment abrasion. *Tegella horrida*, another robust species, occurred only at Stations 7 and 8.

The following table shows the number and proportions of species having various colony forms:

	Species Percent	
Encrusting		
Patchy	48	84
Folicaceous	3	5
Ramifying	1	2
Nodular	1	2
Branched erect		
Fixed	1	2
Tufted	2	3
Articulated	1	2

The encrusting colony form was predominant, and the question arises as to whether it has adaptive value for an intertidal existence. The proportion (93%) of encrusting forms among the cheilostomes at Narrow Strait was higher than has been found in other studies, which included all orders of Bryozoa. Rocky shores in southwestern Wales have 63% encrusting forms (Ryland 1970) and those in northeastern New Zealand have 77% (Gordon 1987). Both authors noted that encrusting species generally predominate on hard substrates, irrespective of locality or depth. Thus, the high proportion at Narrow Strait may be related more to occurrence on rock than to intertidal adaptation. However, it is noteworthy that none of the erect forms (*Microporina articulata*, *Scrupocellaria elongata* var. *congesta*, *Tricellaria ternata* and *Celleporina robertsoniae*) was prominent. *Posterula sarsi*, which usually forms erect bilaminar colonies subtidally, occurred only as encrusting unilaminar sheets intertidally. And the two intertidal species of *Dendrobeatia*, a genus well represented subtidally in the North Pacific by flexible erect species, were both loosely encrusting forms.

### Regional Diversity

Total, or regional, diversity of many groups of organisms tends to increase from polar regions to the tropics (Fischer 1960), and this appears to apply to bryozoans. Kluge (1975) listed 322 species known in the Arctic. Gordon (1984) gave a figure of 672 species known in the New Zealand region, and he (personal communication) estimates a true diversity of around 1,000 species. Okada and Mawatari (1958) gave a figure of around 725 species for the Philippine-Indonesian region. Regional diversity has two components: within-habitat and between-habitat diversity (Whittaker 1965). There is evidence that, at saturation, the within-habitat diversity of some groups of organisms remains fairly constant over wide geographical areas—that is, that habitats of similar structure have similar species diversities (MacArthur 1965). This has been disputed by Ricklefs (1987), who cites examples that local (within-habitat) diversity fails to converge under similar physical conditions, and that it is influenced by regional diversity. Habitats of similar structure have higher diversity in areas where the regional diversity is higher. If Ricklefs' (1987) interpretation is valid, then the diversity of intertidal bryozoan assemblages should be higher in the tropics than at high-temperate latitudes, because the more diverse tropical shelf faunas would provide the raw material for evolution of a correspondingly greater number of species able to survive intertidally.

At Narrow Strait (latitude 57°N), there were 57 species of cheilostomes, and approximately 74 bryozoan species overall. This is a high diversity compared to that known intertidally in most other regions. Powell and Crowell (1967) recorded 18 cheilostome species, and 24 species overall, mostly on rock substrate in an extensive study of intertidal bryozoans in the Bay of Fundy (45°N). Gordon (1980) encountered 68 bryozoan species on a New Zealand reef-flat (36°S). Five species, all cheilostomes, occurred on algae; 44 species of cheilostomes and 63 species overall occurred on boulders. An additional four cheilostomes were encountered on shores within a few kilometers of the reef-flat, giving a local intertidal diversity of 72 bryozoan species. Ryland (1974b) found 24 bryozoan species on 26 fragments of intertidal coral boulders from the Low Isles (16°S), Great Barrier Reef, Australia, and several additional species at Green Island. He felt that larger collections would have yielded substantially more species, and implied that the diversity at a single locality may have been at least

40 species. Gontar (1981) reported eight intertidal bryozoan species from the Kurile Islands (45-50° N), but this low figure may have been due to low sampling effort. Winston (1982) found 35 cheilostome species, and 49 bryozoan species overall, on a variety of substrates in rocky intertidal habitats at four stations along 90 km of shore in the Indian River area, Florida (27° N). Cook (1985) found approximately 43 species of cheilostomes, and about 47 bryozoan species overall, at 20 rocky intertidal stations along the coast of Ghana (5° N); a variety of substrates were sampled. Rao and Ganapati (1985) found 19 species of cheilostomes, and 22 bryozoan species overall, in a series of transects in rocky intertidal at Visakhapatnam, Bay of Bengal (17° N). This information is summarized in Table 8.

Some of the difficulty in community ecology centers around defining a habitat. The rocky intertidal zone is as much a habitat as a coniferous forest or grassland, in that it has a demonstrably uniform structure worldwide (Stephenson and Stephenson 1972). However, the convergence in diversity and species composition between the two widely separate reef-flat stations at Narrow Strait probably resulted from similarities in substrate character and degree of wave exposure. Thus there is justification for considering reef-flats to be a habitat type distinct from other types of rocky shore. Gordon (1980) found 44 cheilostome species on a New Zealand reef-flat. The combined cheilostome diversity of the two reef-flat stations at Narrow Strait was only 21 species, indicating a decrease in diversity at the higher latitude if reef-flat is considered to be a single habitat. If rocky intertidal is considered to be a single habitat, then the diversity at Narrow Strait proves to be equivalent. Some species of Bryozoa are more substrate-specific than others, and thus we might consider algal substrates as a habitat distinct from rock substrates. For the following discussion, we will consider the rocky intertidal to be a single habitat type which can vary continuously along physical gradients such as substrate structure, exposure, and height.

Table 8 appears to indicate that intertidal bryozoans show no latitudinal cline in species diversity. Widely separate latitudes show equivalent richness (72-74 species at 36° S and 57° N; 40-50 species at 27° N, 5° N, and 16° S; 22-24 species at 45° N and 17° N). If there is a cline, it is probably bimodal, with diversities highest at north and south temperate latitudes and decreasing toward both the equator and the poles. Table 8 actually points out the paucity of intensive intertidal studies from which comparable

Table 8. Comparison of intertidal bryozoan species diversity from various parts of the world.

Locality (Study) <sup>1</sup>	Latitude °N/S	Length of Coast (km)	Substrate <sup>2</sup>	Bryozoan Species	Cheilostome Species
Narrow Strait (1)	57N	11	r	74	57
Bay of Fundy (2)	45N	360	a,c,r,w	24	18
Florida (3)	27N	90	a,c,h,r, sr,w	49	35
Bay of Bengal (4)	17N	0.5	r	22	19
Ghana (5)	5N	300	a,c,h,j, r,w	47	43
Low Isles, Queensland (6)	16S	1	c	40+	--
Northern New Zealand (7)	36S	<5	r,a	72	53

<sup>1</sup>Studies: 1, present study; 2, Powell and Crowell 1967; 3, Winston 1982; 4, Rao and Ganapati 1985; 5, Cook 1985; 6, Ryland 1974b; 7, Gordon 1980.

<sup>2</sup>Substrate type: a, algae; c, calcareous substrates such as barnacles, shells, corals, calcareous accretions; h, hydroids; j, *Julienella*; r, rocks; sr, sabellarid reef; w, wood.

information can be drawn. Some of the studies considered much longer sections of coast than others (e.g., 300-325 km along the Bay of Fundy and Ghana versus a few kilometers at Narrow Strait, New Zealand, and the Bay of Bengal). Overall diversity found along long stretches of coast will be greater than that found at point localities or along shorter stretches. For example, Winston (1982) found 49 species at four intertidal sites along 90 km of coast, but only 36 species at the most diverse single locality, Walton Rocks. The diversity recorded in an area increases with the amount of time a biologist devotes to studying that area. Many species which are rare intertidally may represent temporary incursions into the intertidal by commoner, immediately subtidal species. We think that intertidal bryozoan communities will prove to be richer in many parts of the world than the existing literature suggests. In any particular area, as at Narrow Strait, many stretches of shore will be relatively depauperate in bryozoans, but certain sites will have conditions suitable for high diversity. Comparison of these optimum sites worldwide will give a true indication of geographical trends in intertidal bryozoan diversity. Of the studies mentioned above, Powell and Crowell (1967), Winston (1982), and perhaps Rao and Ganapati (1985) may have been comprehensive enough to give comparable diversity values, but only that of Gordon (1980) was unequivocally so.

Lack of a latitudinal gradient in intertidal bryozoan diversity is best interpreted in terms of Sanders' (1968) stability-time hypothesis. This states that where physiological stresses are low, biologically accommodated communities evolve with time; where physiological stresses are high, due either to physical fluctuations or unfavorable physical conditions regardless of fluctuations, predominantly physically controlled communities tend to occur. The number of species present diminishes continuously along stress gradients. Rocky intertidal assemblages belong to predominantly physically regulated communities, and time on a short-term scale rather than evolutionary time affects diversity (Sanders 1968). Because of the instability of the environment, there is insufficient time for biologically accommodated communities to develop. This appears to place an upper limit on the number of bryozoan species which occur in a given intertidal area. The subtidal environment is stabler, and greater diversities are possible. Maturo (1968), for example, reported 77 bryozoan species on a single rock, measuring about 37 cm on a side, dredged from a depth of 26-30 m off North Carolina (34° N). Gordon (1987) reported a maximum of 127 species per station on shelf areas around New Zealand.

Differing diversities in various areas of the world reflect the combined effects of stress gradients peculiar to those areas, or to the particular sites studied. Poor or patchy habitats, sedimentation, variable salinity, and exposure may all reduce diversity. Freezing temperatures and ice scouring at high latitudes decrease diversity to zero. In the Bay of Fundy, the low diversity reported by Powell and Crowell (1967) is likely due to a combination of limited substrate, ice scouring in winter, and reduced salinity (Stephenson and Stephenson 1972, Winston 1977). Different parts of the world have different tidal curves and ranges, and this also may have an effect. The composition of bryozoan assemblages varied considerably with height at Narrow Strait, and a compressed tidal range might reduce the total number of species present. Greater periods of emergence and, therefore, greater stress would be expected with diurnal tides versus other types. Finally, Sanders (1968) pointed out that a greater seasonal change in water temperature takes place along the western edges of oceans at temperate latitudes than along the eastern edges. Considering this, Sanders predicted less diversity in shore faunas along the temperate Asian coast and eastern coast of

North America than along the outer European coast and the western coast of North America.

The intertidal bryozoan community at Narrow Strait is richer than most previously studied and may approach the upper limit of diversity under optimum conditions. The high diversity is likely due to the combined effects of an abundant, structurally varied substrate; a considerable tidal range resulting in a number of broad horizontal zones; and to moderately narrow temperature gradients. Sea temperature varies about 9°C from winter to summer. Air temperatures are moderately cold in winter and cool in summer. Temperature stress upon emergence is probably greater at both lower and higher latitudes. Ice scouring does not occur.

### *Future Studies*

One of the fundamental problems in ecology is to elucidate the factors responsible for observed patterns of species diversity. Bryozoans provide an ideal group for approaching the problem for several reasons. They are widespread, occurring from polar to tropical regions and from littoral to hadal depths. They are a moderately diverse phylum, with over 4,000 extant species (Ryland 1970). The adult forms are almost exclusively sessile, permitting quantitative study of a sort which is difficult with motile organisms. Intra- and inter-phyletic competition primarily involves a struggle for substrate and is readily quantifiable as the ability of one species to overgrow another, or prevent another from overgrowing it. Success is related to colony area and is also readily quantifiable. Bryozoans have left a substantial fossil record, and the relationship between the history of an area and its present diversity may be approached.

Future intertidal and subtidal studies should be conducted in a manner that will allow the results to contribute to the understanding of species diversity. Sampling intensity should be quantified, and the distribution and abundance of species should be related, at the very least, to their subhabitat type and substrate. Complete descriptions of the study area and its environment should be given. In our study, problems with the identification of certain species obscured some of the ecological results. Correct taxonomy is vital to the study of diversity, but important ecological information should not be buried in a systematic account of the species occurring in an area.

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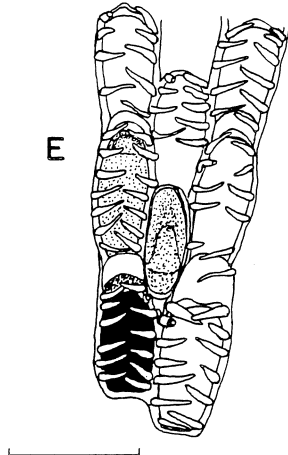
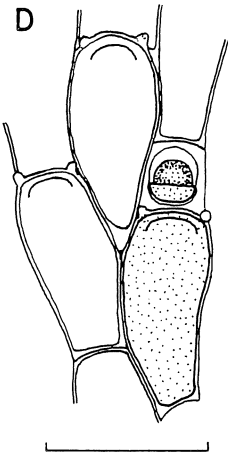
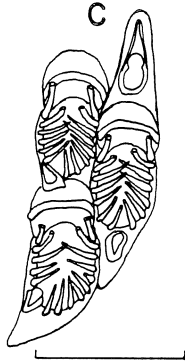
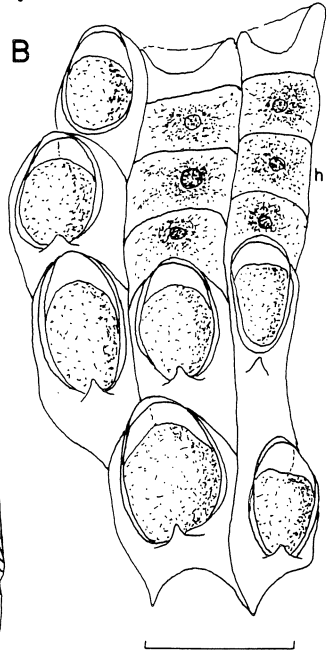
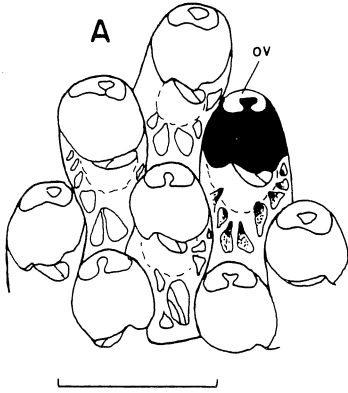
**Plate 1**

- A. *Desmacystis sandalia* (Robertson): zooids with ovicells (ov).
- B. *Electra crustulenta* (Pallas): portion of colony at growing edge showing autozooids and hibernacula (h).
- C. *Callopora craticula* (Alder): ovicellate zooids and a vicarious avicularium.
- D. *Terminoflustra membranaceotruncata* (Smitt): autozooids and a vicarious avicularium.
- E. *Hincksina longiavicularia* Gontar: portion of colony including several ovicellate zooids and a vicarious avicularium.

Scale bar: 0.50 mm.



# PLATE I

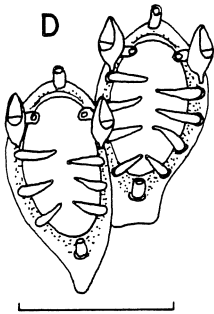
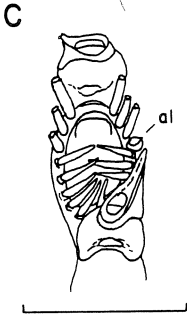
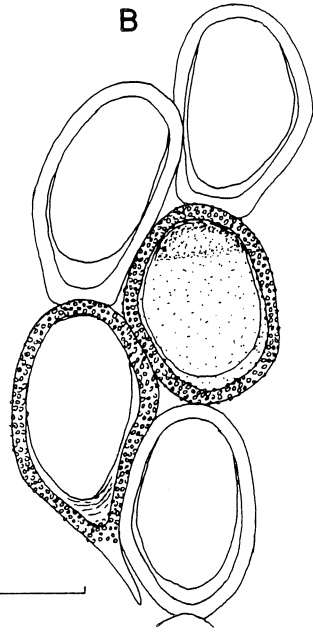
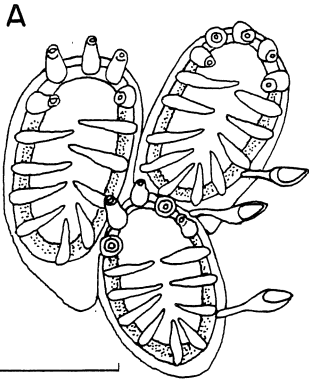


**Plate 2**

- A. *Cauloramphus pseudospinifer* Androsova: autozooids.
- B. *Callopora nuda* n. sp.: autozooids.
- C. *Callopora decidua* n. sp.: ovicellate zooids; note small lateral avicularium (al) and large frontal avicularium.
- D. *Cauloramphus spinifer* (Johnston): autozooids.
- E. *Cauloramphus spinifer* (Johnston): avicularium.
- F. *Cauloramphus magnus* n. sp.: avicularium.
- G. *Cauloramphus spectabilis* n. sp.: avicularium.
- H. *Cauloramphus pseudospinifer* Androsova: avicularium.
- I. *Cauloramphus variegatus* (Hincks): avicularium.

Scale bar: A-D, 0.50 mm; E-I, 0.25 mm.

# PLATE 2

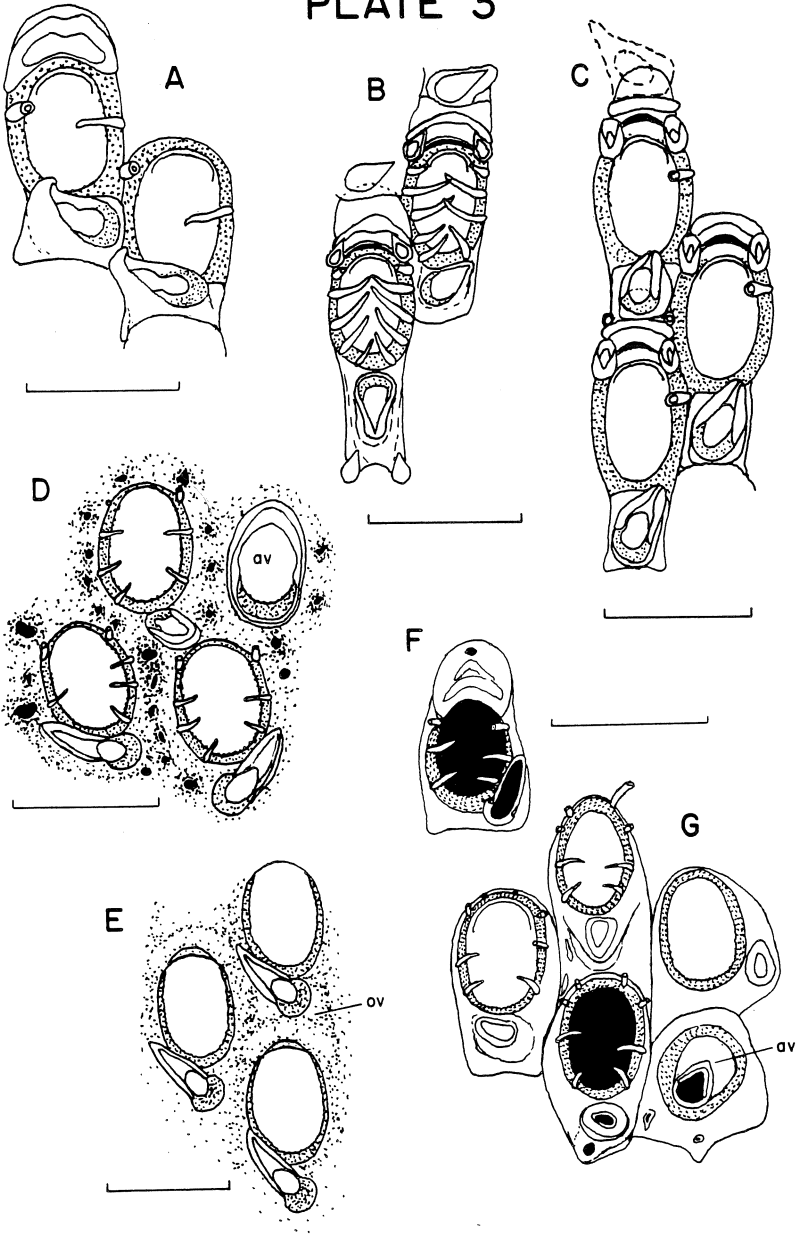


**Plate 3**

- A. *Tegella aquilirostris* (O'Donoghue and O'Donoghue): ovicellate and non-ovicellate zooids.
- B. *Tegella arctica* (d'Orbigny): ovicellate zooids.
- C. *Tegella armifera* (Hincks): ovicellate zooids.
- D-G. *Tegella horrida* (Hincks): D, portion of heavily calcified colony showing granulose frontal surface, lacunae, frontal avicularia, and one large vicarious avicularium (av); E, portion of heavily calcified colony with immersed ovicells (ov); F, young ovicellate zooid near growing edge of colony; G, young autozooids and one vicarious avicularium (av) near growing edge of colony; note smaller frontal avicularia.

Scale bar: 0.50 mm.

# PLATE 3



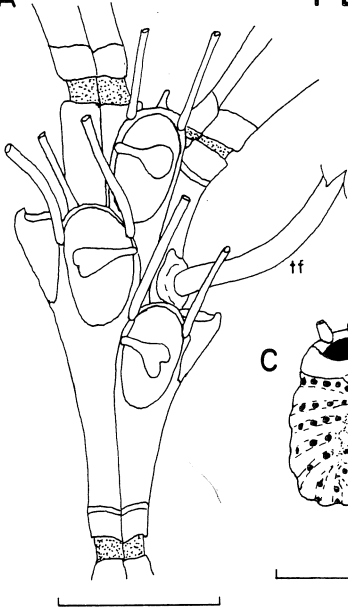
**Plate 4**

- A. *Tricellaria ternata* (Ellis and Solander): one internode of a branch, comprising three autozooids; note distally directed tendril fiber (tf).
- B. *Scrupocellaria elongata* var. *congesta* (Norman): portion of a branch showing ovicellate and non-ovicellate zooids.
- C. *Cribrilina annulata* (Fabricius): autozooid and reduced ovicellate zooid.
- D. *Dendrobeania lichenoides* (Robertson): ovicellate and non-ovicellate zooids.
- C. *Hippoporina apertura* (Osburn): portion of colony showing ovicellate and non-ovicellate zooids.

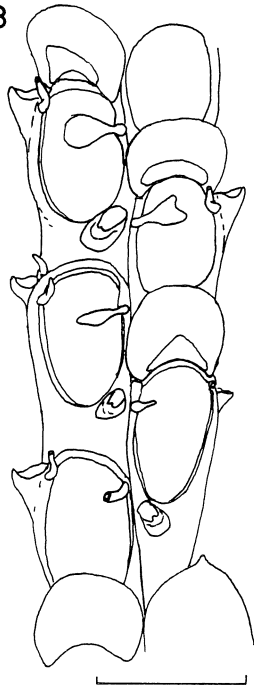
Scale bar: 0.50 mm.

PLATE 4

A



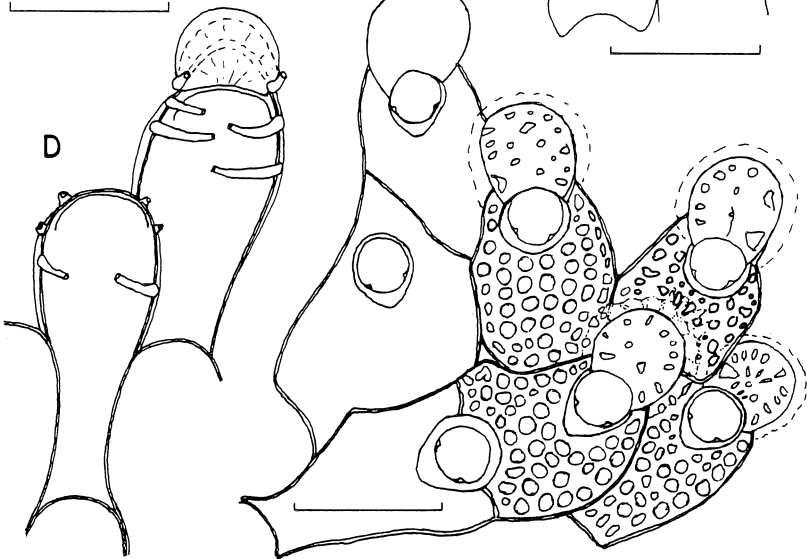
B



C



E



D

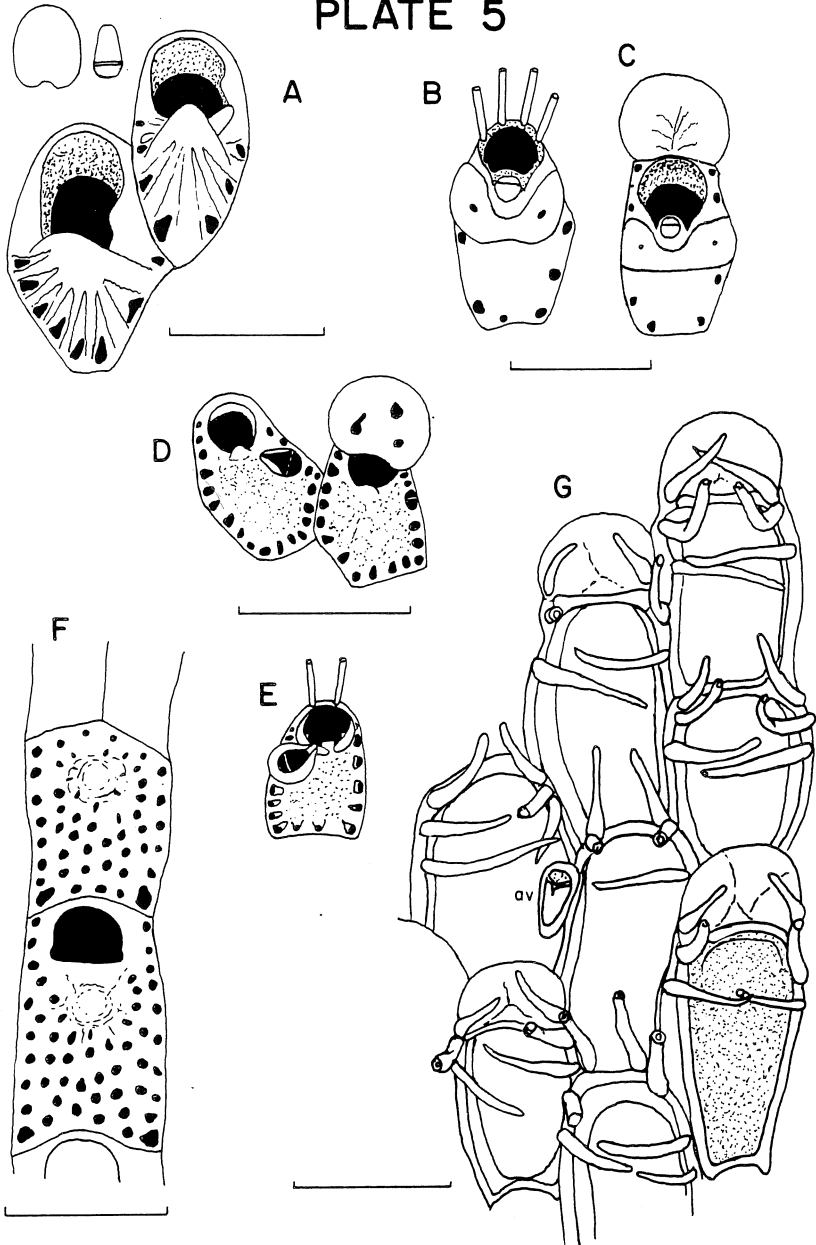
**Plate 5**

- A. *Rhamphostomella costata* Lorenz: autozooids; inserts show shapes of orifice (left) and suboral avicularium (right).
- B-C. *Porella columbiana* O'Donoghue and O'Donoghue: B, young zooid with spines and shallow peristome; C, older, ovicellate zooid with deep peristome.
- D-E. *Parasmittina trispinosa* (Johnston): D, older zooids—note small oval lateral avicularium; E, young zooid showing lyrula and cardelles; spines not yet lost.
- F. *Cryptosula okadai* n. nom.: autozooid and a kenozooid lacking an orifice.
- G. *Dendrobeania exilis* (Hincks): portion of colony showing ovicellate and non-ovicellate zooids; note marginal, sessile avicularium (av).

Scale bar: B-E, 0.25 mm; all others, 0.50 mm.



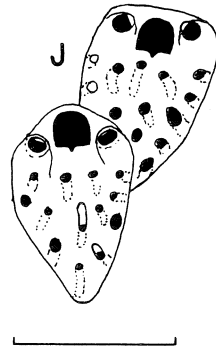
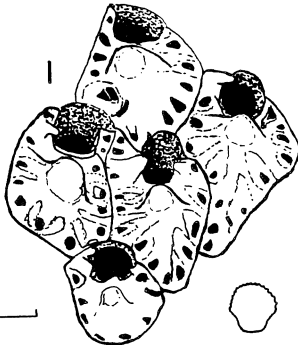
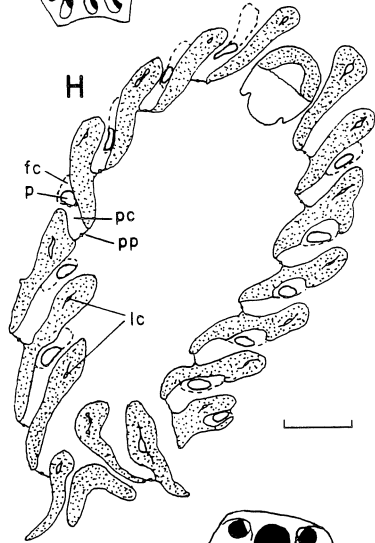
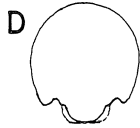
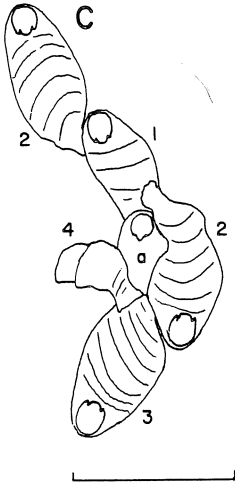
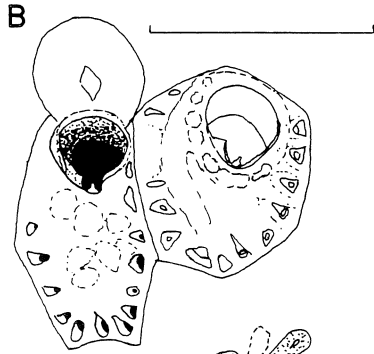
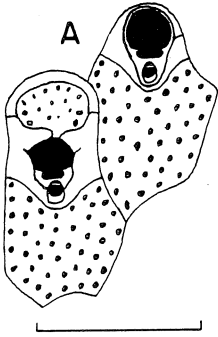
PLATE 5



**Plate 6**

- A. *Schizomavella porifera* (Smitt): ovicellate and non-ovicellate zooids.
- B. *Posterula sarsi* (Smitt): ovicellate and non-ovicellate zooids.
- C-H. *Celleporella reflexa* n. sp.: C, ancestrula (a) and subsequent zooids, generations from the ancestrula indicated by numbers; D, orifice shape of autozooid; E, orifice shape of male zooid; F, orifice shape of zoeciule; G, orifice shape of female zooid; H, frontal section of autozooid near base (viewed from basal side), showing arrangement of pore chambers; pc, tubular pore chamber; pp, pore plate; p, opening in roof of pore chamber leading to frontal cavity or incipient adventitious zooid; fc, frontal cavity; lc, lacunae.
- I. *Rhynchozoon rostratum* (Busk): old, well-calcified autozooids; insert shows shape of orifice.
- J. *Myriozoella plana* (Dawson): young autozooids.
- Scale bar: D-H, 0.10 mm; all others, 0.50 mm.

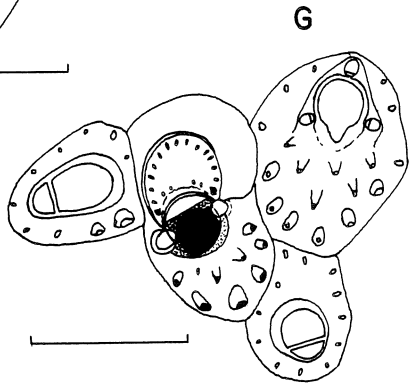
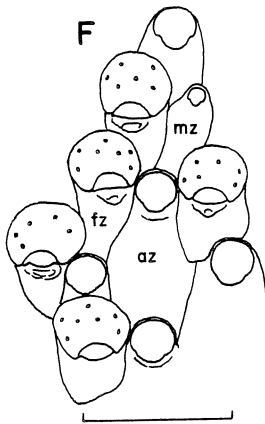
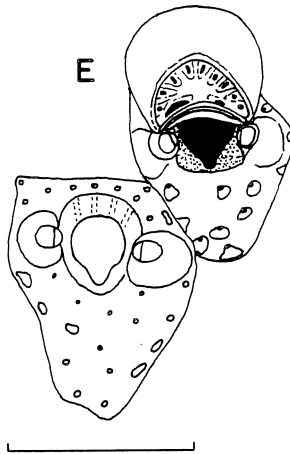
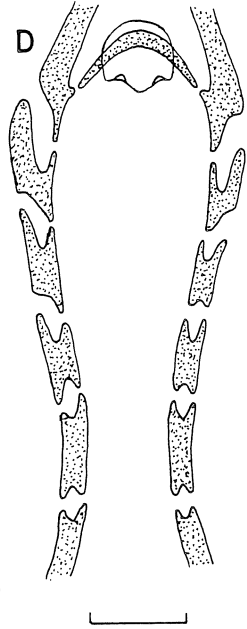
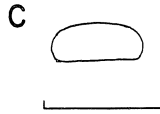
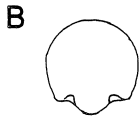
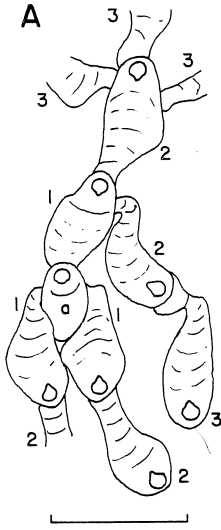
# PLATE 6



**Plate 7**

- A-D. *Hippothoa mawatarii* n. sp.: A, ancestrula (a) and subsequent zooids, generations from the ancestrula indicated by numbers; B, orifice shape of autozoid; C, orifice shape of female zoid; D, diagrammatic frontal section of autozoid near base (viewed from basal side), showing arrangement of pore chambers.
- E. *Celleporina aspera* n. sp.: ovicellate and non-ovicellate zooids.
- F. *Celleporella hyalina* (Linnaeus): autozooids (az), female zooids (fz), and male zooids (mz).
- G. *Celleporina robertsoniae* (Canu and Bassler): autozoid with three oral avicularia; ovicellate zoid; and two types of vicarious avicularia.
- Scale bar: B-D, 0.10 mm; all others, 0.50 mm.

# PLATE 7

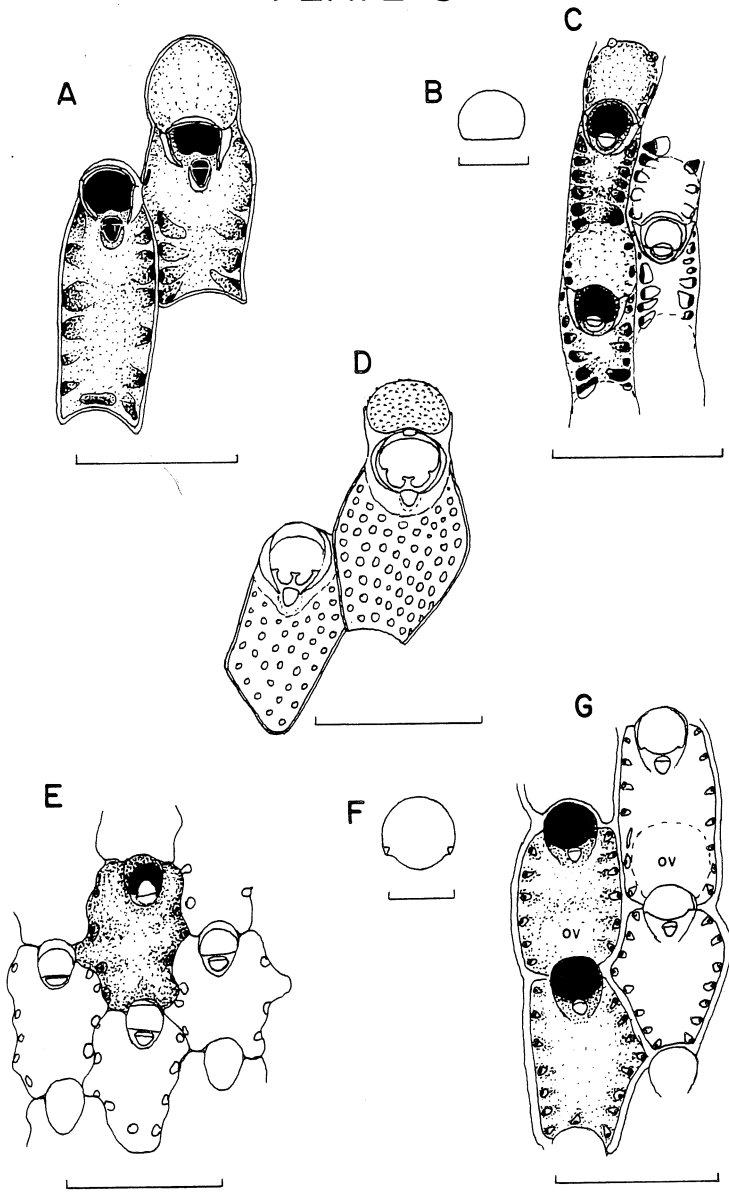


**Plate 8**

- A. *Porella acutirostris* Smitt: ovicellate and non-ovicellate zooids.
- B-C. *Porella alba* Nordgaard: B, shape of orifice; C, ovicellate zooids.
- D. *Smittina majuscula* (Smitt): ovicellate and non-ovicellate zooids.
- E. *Porella concinna* (Busk): portion of a colony showing autozooids.
- F-G. *Porella immersa* Mawatari: F, shape of orifice; G, portion of a colony; note immersed ovicells (ov).

Scale bar: B, F, 0.10 mm; all others, 0.50 mm.

# PLATE 8



**Plate 9**

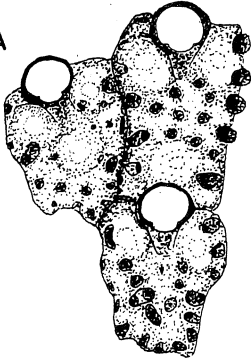
- A. *Stomachetosella cruenta* (Busk): autozooids.
- B. *Stomachetosella sinuosa* (Busk): ovicellate and non-ovicellate zooids.
- C. *Microporella californica* (Busk): ovicellate and two non-ovicellate zooids; note dark spine bases.
- D. *Harmeria scutulata* (Busk): autozooids and smaller marginal kenozooids.
- E. *Fenestrulina porosa* Canu and Bassler: ovicellate and non-ovicellate zooids.
- F. *Fenestrulina malusii* (Audouin): ovicellate and non-ovicellate zooids.
- G. *Cylindroporella tubulosa* (Norman): ovicellate zooids.

Scale bar: 0.50 mm.

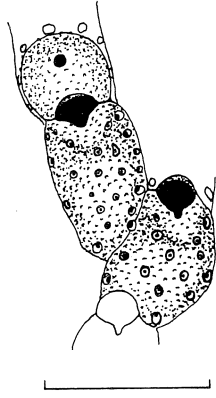


PLATE 9

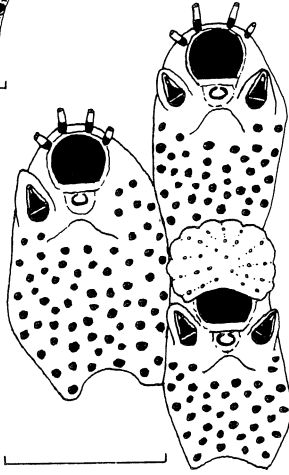
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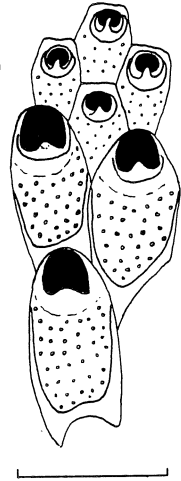
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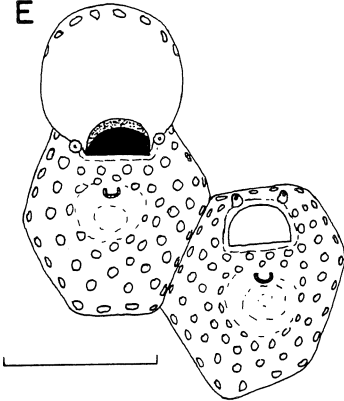
C



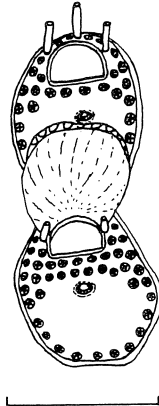
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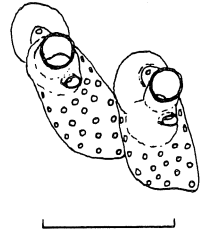
E



F



G

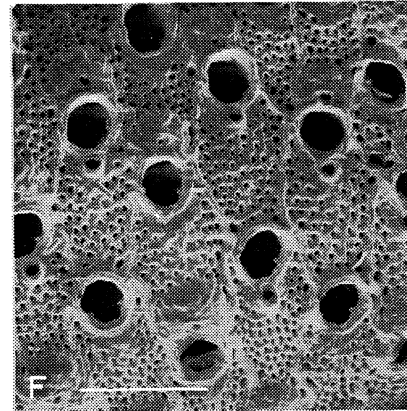
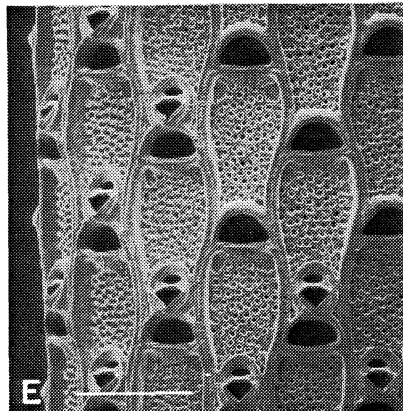
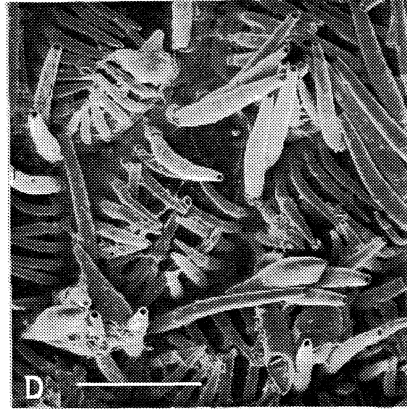
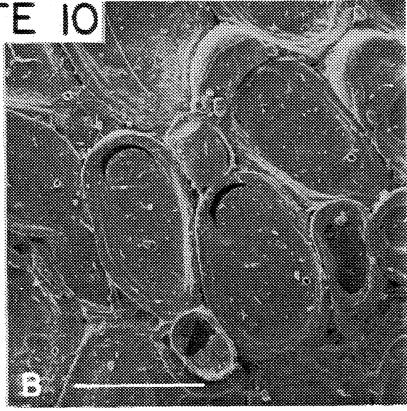
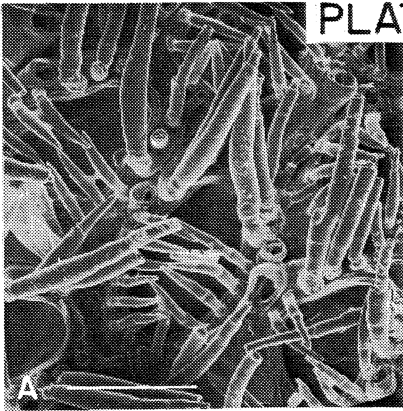


**Plate 10**

- A. *Callopora decidua* n. sp.: complete autozoid in center; note small avicularia lateral to orifice.
- B. *Callopora nuda* n. sp.: ovicellate and non-ovicellate zooids, with three vicarious avicularia
- C. *Cauloramphus magnus* n. sp.: portion of colony; note single pedunculate avicularium lying on surface.
- D. *Cauloramphus spectabilis* n. sp.: portion of colony; note large pedunculate avicularia at bottom right and left.
- E. *Microporina articulata* (Fabricius): portion of an internode showing autozooids and vicarious avicularia.
- F. *Codonellina argentea* (Hincks): portion of a colony with ovicellate and non-ovicellate zooids.

Scale bar: A, D, 0.25 mm; all others, 0.50 mm.

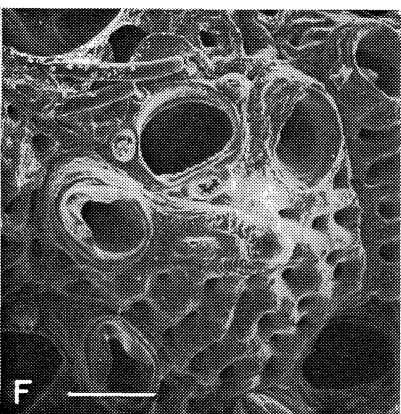
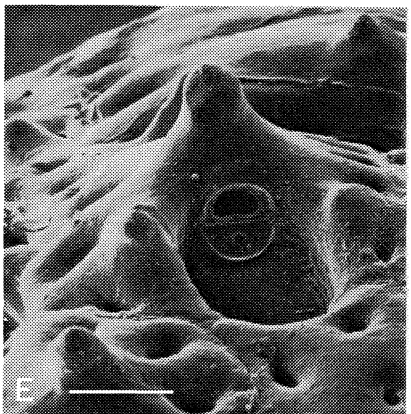
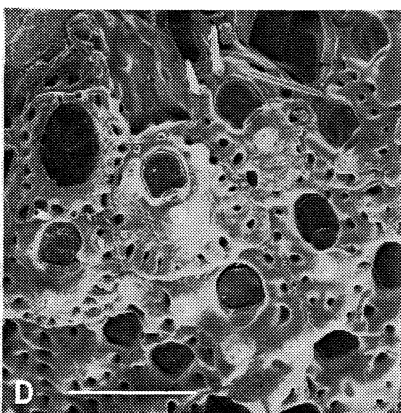
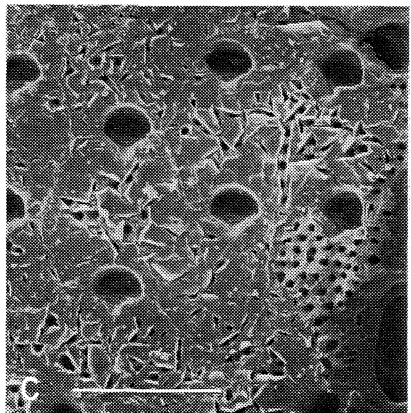
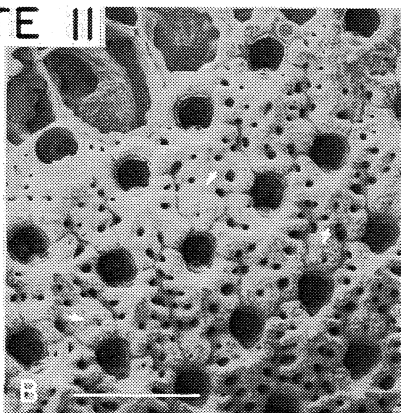
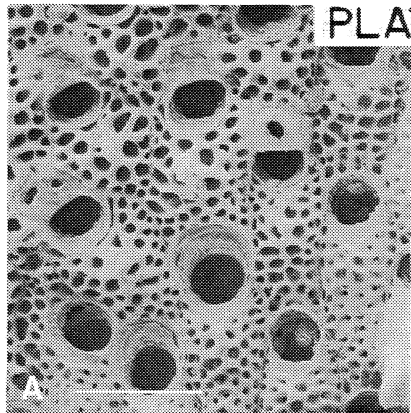
PLATE 10



**Plate 11**

- A. *Hippoporina vulgaris* n. sp.: portion of colony showing elongate propagative autozooids (bottom right) and shorter, buttressed ovicellate zooids (upper left).
- B. *Smittina bella* (Busk): portion of colony showing ovicells (arrows).
- C. *Stomachetosella sienna* n. sp.: portion of colony; note dried ectocyst peeling away.
- D-E. *Hippoporidra truculenta* n. sp.: D, portion of colony near growing edge; E, enlargement of orifice showing oral tubercles and suboral avicularium.
- F. *Microporella alaskana* n. sp.: single zooid near growing edge of colony.
- Scale bar: A-D, 0.50 mm; E, F, 0.10 mm.

PLATE II

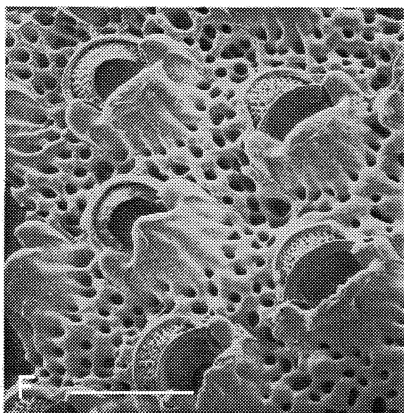
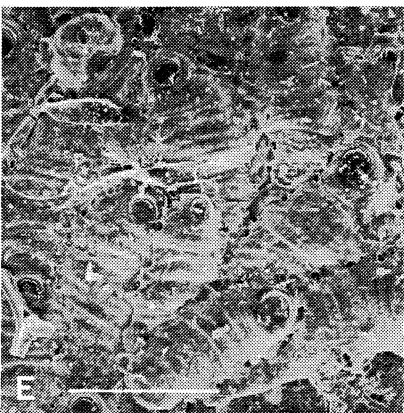
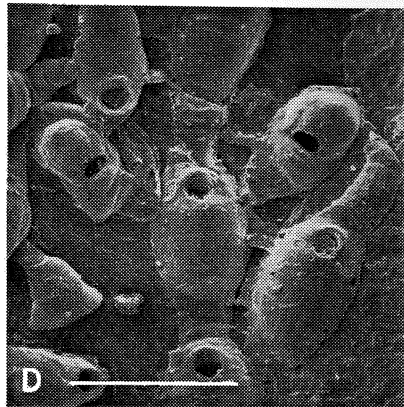
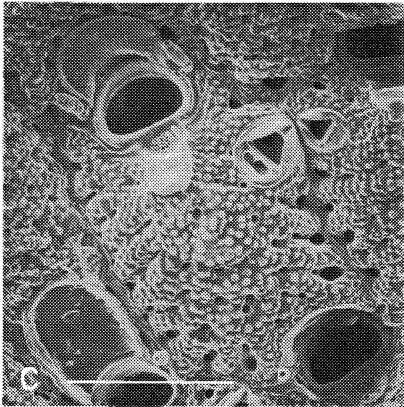
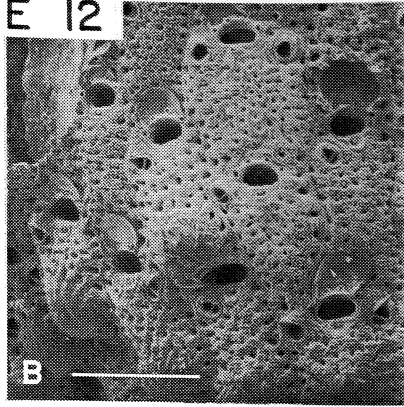
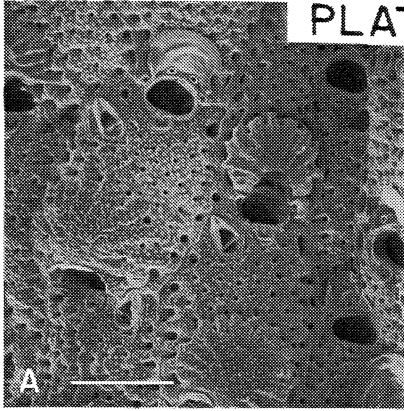


### Plate 12

- A-B. *Microporella germana* n. sp.: A, ovicellate zooids showing developmental stages of ovicells, culminating in subimmersed ovicell near left center; B, portion of colony; note presence of one or two avicularia per zooid.
- C. *Microporella neocribroides* n. sp.: zooid with developing ovicell.
- D. *Hippothoa mawatarii* n. sp.: portion of colony showing autozooids and female zooids; note Y-shaped branching pattern.
- E. *Celleporella reflexa* n. sp.: portion of colony showing autozooids, female zooid (upper left) and male zooid with reduced orifice (near center).
- F. *Lagenicella neosocialis* n. sp.: portion of colony showing the form of the perisotme.

Scale bar: A, C, F, 0.25 mm; B, D, E, 0.50 mm.

PLATE 12



**Plate 13**

- A. *Lagenicella neosocialis* n. sp.: ovicellate zooids.
- B. *Cauloramphus magnus* n. sp.: portion of colony treated with sodium hypochlorite.
- C. *Cauloramphus pseudospinifer* Androsova: portion of colony treated with sodium hypochlorite.
- D. *Cauloramphus spinifer* (Johnston): portion of colony showing arrangement of spines and pedunculate avicularia.
- E-F. *Cauloramphus variegatus* (Hincks): E, portion of colony showing arrangement of spines; note dark spine bases; F, portion of colony treated with sodium hypochlorite.

Scale bar: A, 0.25 mm; all others, 0.50 mm.



PLATE 13

