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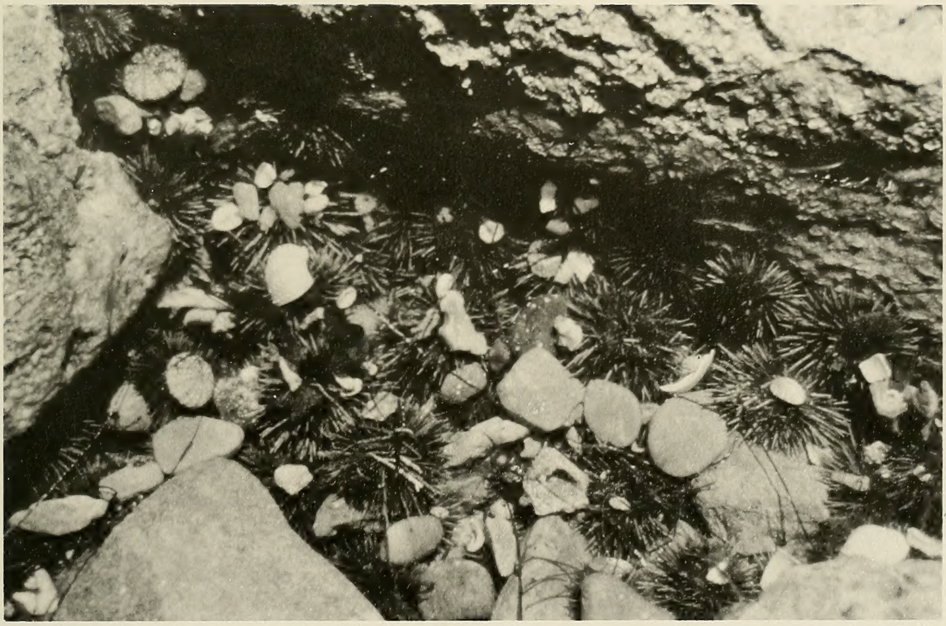

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The Distribution of Marine Sponges Collected from the 1976–1978 Bureau of Land Management Southern California Bight Program

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Abstract.—A total of 58 species, representing 48 genera of sponges, was collected from southern California (depth 0–1865 m) during 1976–1978. Twenty-two species show geographical range extensions and 12 species had depth range extensions. *Oxymycale* is synonymized under *Mycale. Stelleta clarella* is synonymized under *S. estrella.* The biogeography of sponges of the southern California borderlands is discussed.

There have been few papers on the marine sponges of southern California. Notable among these are De Laubenfels (1932), which reports on the largest collection of marine sponges from California and is considered the basic reference; an unpublished manuscript distributed at the Southern California Coastal Water Research Project Taxonomic Standardization Program (Bakus and Green 1977); Bakus and Abbott (1980); Green (1980); and Sim and Bakus (1986). The present manuscript summarizes information on the second largest collection of marine sponges from California and the largest collection ever reported from southern California. Although this collection is based in part on sponge fragments, it expands considerably our knowledge of local sponges.

The Southern California Bight Program, sponsored by the Bureau of Land Management (BLM, Los Angeles), Department of Interior, was designed to establish a data base documenting the existence and range of naturally occurring environmental variations and biological components in the Bight (Fauchald and Jones 1976). The Bight includes continental borderlands ranging as far as 100 miles offshore from Point Conception to the Mexican border (see Emery 1960). The Southern California Bight Program was initiated in 1975 after a lease sale for the development of energy resources in the Bight. The program ended in 1978. The biological portion of the program involved the study of benthic macrofauna in intertidal, shallow subtidal and deep offshore habitats. Depths at offshore sampling sites ranged from 7 to 1886 m (Fauchald and Jones 1976).

Sponges from the intertidal zone were collected by scientists from the University of California at Irvine (UCI). Offshore sponges were collected by scientists at the University of Southern California (USC). All specimens were identified by the authors at USC. The material is archived at the Smithsonian Institution (NNH Catalog Serial 31201 to 31364) and at the Allan Hancock Foundation (USC).

Methods and Materials

Porifera were sampled by biologists using a variety of methods (i.e., box core, rock dredge, otter trawl, SCUBA and rock scrapings) in intertidal, shallow subtidal, and deep waters of southern California. They were relaxed in $MgCl_2$, fixed in 10% formalin, and transferred to 70% ethanol for permanent storage. Permanent spicule slides were prepared (in duplicate for most species) and mounted in piccolyte.

The morphology and spicules of known species are described in detail in De Laubenfels (1932, 1955), Bakus (1966), Hartman (1975), Bakus and Green (1977), Sim and Bakus (1986) and others (see Literature Cited) and are not repeated here. The biology of some of these species is given in Bakus and Abbott (1980). Only commonly used synonyms are listed.

Many of the sponges examined consisted of only small fragments. It should be emphasized, however, that many temperate latitude marine sponges can be accurately identified from their spicules alone. One third of the sponges were unidentifiable to genus or species because of their fragmentary nature and small size. Most of these belong to the Class Calcarea, which are more difficult to identify based on their spicules alone because of the fewer number of spicule types represented in the Class. The use of a generic name followed by sp. indicates that only one species was found; unidentified congeneric species are indicated as sp. a, sp. b, etc. It is not known whether these may be new species because of insufficient material for study.

Spicule measurements (in micrometers) are presented as mean values (underlined) surrounded by values representing the range. Chord lengths are given for spicules traditionally measured in this manner (e.g., sigmas, chelas, toxas). Measurements of the longest ray (rhabd) are given for plagiotriaenes, pinules, stauractines, pentactines and hexactines. Measurement of each ray is given for tri- and quadriradiates. The total length of two opposing rays is presented when rays are of equal length, as in oxypentactines and oxyhexactines. The diameters of aster-type spicules are given. Distributional data on sponges from British Columbia were obtained from Austin (1982 and personal communication). Records from Cape San Quintin, Baja California are from an intertidal collection made on 26 November 1966 by G. Bakus and Roger Reimer.

Results

A list of intertidal and subtidal collecting stations is presented in Table 1. Station information for deep offshore stations is presented in Table 2. In the text, station numbers lacking parentheses refer to the BLM designations used by USC and UCI; the station numbers in parentheses refer to *Velero IV* designations.

Sponges arranged alphabetically by genera.

Table 1. Location of common shallow water sampling sites.[1]

Station number	Name	Latitude and longitude	Remarks
		Main coast	
1	Coal Oil Point	34°24′27″N, 119°52′40″W	3 km west of Goleta Pt., just below Deveraux school
2	Corona del Mar	33°35′14″N, 117°51′54″W	1.4 km SE of channel entrance to Newport Bay, near the mouth of Morning Canyon
3	Dana Point	33°27′25″N, 117°42′44″W	
4	Government Point	34°26′35″N, 120°27′06″W	1.8 km south of Coast Guard lighthouse
5	Los Angeles	33°43′11″N, 118°19′39″W	4 km NW of Los Angeles breakwater, at the base of Palos Verdes Hills, Whites Point
6	Malibu	34°00′42″N, 118°47′30″W	
7	San Diego	32°44′35″N, 117°15′15″W	Ocean Beach, south of Del Monte St.
		Offshore banks	
8	Cortez Bank A. north	32°29′N, 119°13′W	
	B. south	32°26′N, 119°5′W	
9	Tanner Bank north	32°42′N, 119°8′W	
	south	32°41.8′N, 119°7.8′W	
		Channel islands	
10	Anacapa Island	34°00′19″N, 119°25′05″W 34°00′24″N, 119°24′38″W 34°00′31″N, 119°24′21″W	0.7 km E of Cat Rock, inner and outer Frenchys Cove
11	San Clemente Island	32°00′06″N, 118°33′03″W	450 m E of Wilson Cove
12	San Miguel Island	34°02′55″N, 120°20′08″W	East of Cuyler Harbor
13	San Nicholas Island	33°12′54″N, 119°28′22″W	East of Dutch Harbor
14	Santa Barbara Island	33°28′43″N, 119°01′36″W	East side of Island, mouth of Cave Canyon
15	Santa Catalina Island	33°26′47″N, 118°29′04″W	1.3 km NE of Isthmus Cove, promontory demarcating northern boundary of Big Fisherman's Cove
16	Santa Cruz Island	33°57′43″N, 119°45′16″W	Willows Anchorage
17	Santa Rosa Island	33°53′51″N, 120°06′31″W	250 m S of Navy Base Pier, Johnson's Lee

[1] All sampling sites are intertidal except for station Nos. 8–9 which are subtidal, offshore banks.

Table 2. Location of offshore benthic and trawl sampling sites

Station no. BLM	Station no. Velero IV	Location	Latitude (N)	Longitude (W)	Depth (m)
		Benthic stations			
074	23206	Santa Rosa Island	33°54′00″	119°58′00″	49
079	23187	Santa Rosa Island	33°54′00″	120°03′00″	29
090	23042	Santa Rosa Island	33°53′00″	120°03′00″	51
103	22952	Santa Rosa Island	33°52′00″	119°57′00″	82
110	22962	Santa Rosa Island	33°52′00″	120°03′54″	71
155	23010	Santa Rosa Island	33°49′00″	119°54′00″	155
165	23000	Santa Rosa Island	33°49′00″	120°04′00″	113
219	24267	Santa Cruz Island	33°46′00″	119°51′00″	220
429	24089	Santa Catalina Island	33°30′00″	118°44′00″	274
704	24382	Cortez Bank	32°33′00″	119°18′00″	82
729	24389	Tanner Bank	32°37′00″	118°57′00″	667
740	24609	Tanner Bank	32°34′00″	118°56′00″	1189
742	24607	Tanner Bank	32°34′00″	118°58′00″	1098
	25762	Southeast of San Nicolas Island	32°58′15″	119°32′30″	373
80203		Coal Oil Point	34°23′00″	119°57′00″	340
80224		Coal Oil Point	34°23′00″	119°57′00″	337
80802		Santa Rosa Ridge	33°49′06″	119°59′54″	103
80807		Santa Rosa Island	33°49′06″	119°59′54″	103
80809		Santa Rosa Island	33°49′06″	119°59′54″	103
80829		Santa Rosa Island	33°49′06″	119°59′54″	104
80832		Santa Rosa Island	33°49′06″	119°59′54″	104
80835		Santa Rosa Island	33°49′06″	119°59′54″	106
81001		Santa Cruz Basin	33°46′06″	119°49′06″	481
81006		Santa Cruz Basin	33°46′06″	119°49′06″	466
81007		Santa Cruz Basin	33°46′06″	119°49′06″	463
81011		Santa Cruz Basin	33°46′06″	119°49′06″	439
81202		Santa Cruz Basin	33°46′00″	119°36′00″	1419
81206		Santa Cruz Basin	33°46′00″	119°36′00″	1864
83002		Point Conception	34°26′00″	120°28′00″	63
84703		San Nicolas Island	33°19′30″	119°45′00″	89
84803		San Nicolas Island	33°18′30″	119°38′00″	59
87801		San Barbara Island	34°08′12″	119°39′00″	288
		Otter trawl			
80535	26301	San Miguel Island	33°54′40″	120°19′12″	274
			33°54′40″	120°19′35″	
817	25381	Tanner Bank	32°38′36″	119°09′12″	201–229
			32°38′18″	119°08′42″	
81701		Tanner Bank			91
81734	26297	Tanner Bank	32°42′40″	119°13′54″	137–143
			32°43′00″	119°14′30″	
837	26305	Point Conception	34°24′30″	120°25′54″	183
83701		Point Conception			137

Marine Sponge Distributions and Spicule Measurements

Class CALCAREA Bowerbank
Order CLATHRINIDA Hartman
Family CLATHRINIDAE Minchin
Clathrina coriacea (Montagu, 1818)

Synonymy.—See Burton, 1963 and Fishel Johnson, 1976.

Distribution.—?Cosmopolitan. San Miguel Island, California to Cape San Quintin, Baja California, Mexico: low intertidal to 11 m.

Local occurrence.—Intertidal station Nos. 2, 7–8, 10, 12, 14, 17. Twenty-one specimens were examined.

Spicules.—Measured from five specimens from station 14 and one specimen from station 10.

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Triradiate	28	14–76–182	4–10–23
(regular)		14–75–140	5–10–23
		14–73–161	5–10–23
Triradiate	4	5–9–14	1–2–2
(regular)		9–10–11	2–2–2
		7–9–11	2–2–2
Triradiate	5	28–41–66	5–6–7
(sagittal)		23–42–59	7–7–7
		23–39–54	7–7–7

Remarks.—Color tan to white in alcohol. Encrusting with vents scattered over a smooth surface. Most triradiates of similar size and regular shape. There is a question of whether *C. coriacea sensu* Burton represents a complex of species (see Fischel Johnson 1978).

Order LEUCOSOLENIDA Hartman
Family LEUCOSOLENIIDAE Minchin
Leucosolenia eleanor (Urban, 1905)

Distribution.—British Columbia, Canada, to California, Japan; intertidal.

Local occurrence.—Corona del Mar and Santa Rosa Island, intertidal station Nos. 2 and 17. Four specimens were examined.

Spicules.—Triradiates (regular and sagittal), quadriradiates, and oxeas; spicules were not measured.

Remarks.—Color white to tan in life and in alcohol. Colony encrusting or attached by a narrow base, forming a three-dimensional lattice of slender branching and anastomosing tubes 2 mm or less in diameter (Burton 1963). Burton (1963) considered this species synonymous with *L. botryoides*. Several of Burton's synonymies have been questioned by other specialists (e.g., Hartman 1964; Fischel Johnson 1978a; Bakus and Abbott, 1980). We have retained the name *Leucosolenia eleanor* for specimens from the Pacific Ocean; *L. botryoides* is primarily known from the Atlantic Ocean and Mediterranean Sea.

Leucosolenia nautilia De Laubenfels, 1930

Distribution.—British Columbia, Canada to San Nicolas Island, California; 0 to 59 m.

Local occurrence.—Santa Barbara Island, intertidal station No. 14. Benthic station No. 84803, off San Nicolas Island, 59 m. Three specimens were examined. This is a new distribution record for southern California.

Spicules.—Measured from one specimen each from stations 14 and 84803.

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Oxea	3	520–1000–1009	7–8–11
Oxea	2	48	2
Triadiate	4	90–123–150	3–7–1
(regular)		95–116–152	3–8–12
		70–128–200	3–7–12
Triradiate	2	70–80–90	4–4–4
(sagittal alate)		50–55–60	4–4–4
		50–60–70	4–4–4
Quadriradiate	2	120	4
		60–86–111	4–6–9
		90–95–101	4–6–9
		broken	4–6–9

Remarks.—Color white in alcohol. Individual tube with apical oscular crown of oxeas. Thin and fragile; a few oxeas protruded from the surface. Burton (1963) considered *L. nautilia* synonymous with *L. botryoides.* However, he synonymized numerous species of Calcarea based on morphological characteristics alone. Fischel Johnson (1978a) found that the lumping of certain of these species was unwarranted. Consequently, we are retaining the name of *Leucosolenia nautilia* until further studies verify its correct taxonomic placement.

Order LEUCETTIDA Hartman
Family LEUCETTIDAE
Leucetta losangelensis (De Laubenfels, 1930)

Synonymy.—*Leuconia losangelensis* De Laubenfels, 1930.

Distribution.—Point Dume, California to Cape San Quintin, Baja California, Mexico; Gulf of California, Mexico; 0 to 111 m.

Local occurrence.—Intertidal station Nos. 2, 10–12, 16, 17. Seven specimens were examined.

Spicules.—Measured from one specimen each from stations 2 and 16.

Remarks.—Color white in life and in alcohol. Encrusting; body texture is crusty. Surface convoluted and bearing many oscules measuring up to 15 mm in diameter (Bakus and Abbott 1980). Some specimens have microtylostyles.

Order SYCETTIDA Bidder
Family AMPHORISCIDAE Dendy
Leucilla nuttingi (Urban, 1902)

Synonymy.—*Rhabdodermella nuttingi* Urban, 1902.

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Tritadiate (regular)	11	250–372–490	22–33–40
		235–344–460	22–32–40
		240–333–400	22–32–40
Triradiate (regular)	11	36–121–255	8–13–20
		24–113–255	7–11–16
		22–98–210	5–11–17
Triradiate (sagittal)	12	110–165–220	10–14–20
		110–157–200	10–14–20
		60–120–190	9–14–22
Triradiate (sagittal)	10	31–57–92	6–9–19
		32–68–108	6–10–17
		24–60–113	7–10–17

Distribution.—Amchitka, Alaska to Cape San Quintin, Baja California, Mexico; low intertidal to 155 m.

Local occurrence.—Intertidal station Nos. 1, 4, 10, 12–13. Benthic station Nos. 155 (23010), 074 (23206), and 80802, off Santa Rosa Island, 49 to 155 m. Sixteen specimens were examined.

Spicules.—Measured from four specimens from station 13.

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Triradiate (sagittal)	12	170–316–502	12–24–39
		70–151–340	9–21–36
		70–144–320	9–21–36
Triradiate (regular)	10	84–119–190	4–8–12
		60–84–120	5–7–9
		60–76–112	5–7–9
Quadriradiate	13	135–376–632	8–31–60
		98–264–470	8–28–55
		80–264–480	7–28–53
		12–71–200	5–21–48
Quadriradiate	5	300–406–490	30–49–58
		310–382–440	40–46–53
		330–396–460	41–44–51
		240–312–450	31–38–42
Oxea	10	41–79–208	2–2–2

Remarks.—Color tan to white in alcohol. Cluster of stalked vase-shaped tubes. Apical smooth osculum. The sagittal triradiates are the predominant spicule type. Some of them are sagittal-alate.

Family GRANTIIDAE Dendy
Leucandra heathi Urban, 1905

Synonymy.—*Leuconia heathi* (Urban, 1905), See Burton (1963).

Distribution.—Amchitka, Alaska to Cape San Quintin, Baja California, Mexico; 0 to 91 m. See O'Clair (1977).

Local occurrence.—Intertidal station Nos. 1–5, 7, 9–11, 14–17. Benthic station Nos. 110 (22962) and 704 (24382), Santa Rosa Island, 71 m, Cortez Bank, 82 m. Trawl station No. 81701, Tanner Bank, 91 m. A total of 52 specimens were examined.

Spicules.—Measured from four specimens from station 9 and one specimen from station 14.

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Oxea	17	940–2358–4982	31–59–84
Oxea	5	2308–2685–3058	2–6–8
Oxea	16	46–92–164	2–4–7
Triradiate (regular)	16	75–135–230 150–218–310 137–197–280	10–14–19 9–14–22 9–14–22
Triradiate (regular)	8	120–180–220 90–166–200 90–165–200	14–18–22 14–16–21 14–16–21
Triradiate (sagittal)	15	17–37–60 17–40–75 17–50–87	4–9–17 4–9–14 5–10–14
Quadriradiate	16	39–109–190 39–162–240 67–188–320 8–52–150	7–11–14 7–11–14 7–11–17 7–10–12

Remarks.—Color white in life and in alcohol. Pear-shaped vase with apical osculum surrounded by a fringe of oxeas. Thick oxeas project from surface; most are apically oriented. Regular triradiates and thick oxeas are predominant spicule types.

Family SYCETTIDAE Dendy
Scypha sp.

Local occurrence.—Santa Barbara Island, intertidal station No. 14. One specimen was measured.

Spicules.—

Spicule type	No. spicules measured	Length (each ray)	Diameter (each ray)
Triradiate	2	102–127–152	9–10–12
Quadriradiate	1	111	9
Oxea*	–	–	–

Remarks.—*Oxeas were not measured. This may be *Scypha coacta* (Urban), Originally described as *Sycandra coacta* by Urban (1905).

Class HEXACTINELLIDA Schmidt
Subclass HEXASTEROPHORA Schulze
Order DICTYONINA Zittel
Family APHROCALLISTIDAE Gray
Aphrocallistes vastus Schulze, 1886

Synonymy.—*Aphrocallistes whiteavesianus* Lambe, 1893.

Distribution.—Unimak Island, Alaska to offshore Pacific, Mexico; 38 to 1865 m.

Local occurrence.—Benthic station Nos. 81006, 81202 and 81206, Santa Cruz Basin, 466 to 1865 m; trawl station 817 (25831), Tanner Bank, 201–229 m. Four specimens were examined.

Spicules.—Measured from one specimen from station 25831.

Spicule type	No. spicules measured	Length	Diameter
Uncinate	11	320–692–1400	4–5–8
Diactine	10	295–386–520	6–8–11
Scopule	11	240–292–400	2–4–7
Pinule (longest ray)	10	70–128–250	4–5–9
Hexactine (longest ray)	8	90–159–350	4–4–6
Oxyhexactine	10	24–54–80	3–4–6
Tylohexaster	10		28–35–52

Remarks.—Color white in alcohol. Vase-shaped body. Spicules form a honeycomb-like skeleton that is characteristic of the species. The megascleres are acanthose. Oxyhexactines have short and thick rays (measurements of two opposing rays are given). This is the hexactinellid most commonly found along the Pacific coast of North America. It is especially abundant in some parts of Canada and the N.E. Gulf of Alaska (see Bakus and Green 1977 and reports cited therein). See Okada, 1932, for further details and De Laubenfels (1932) for the record from Mexico.

Order LYSSACINA Zittel
Family LANUGINELLIDAE Schulze
Staurocalyptus solidus Schulze, 1899

Distribution.—Jervis Inlet, British Columbia, Canada to Tanner Bank, California: 91 to 1373 m.

Local occurrence.—Benthic station No. 219 (24267); Santa Cruz Island, 220 m and No. (25765); southeast of San Nicolas Island, 1373 m. Trawl station Nos. 80535 (San Miguel Island), 81701 (Tanner Bank), and 81734 (Tanner Bank), 91 to 274 m. Eight specimens were examined.

Spicules.—Measured from one specimen each from stations 81701, 81734, and 24267.

Spicule type	No. spicules measured	Length	Diameter
Rhabdodiactine	10	2592–9134–22,920	9–22–44
Diactine	10	500–966–1800	9–11–13
Pentactine (longest ray)	5	2320–5016–7800	17–48–94
Pentactine (longest ray)	10	110–225–500	5–10–20
Stauractine (longest ray)	8	60–143–270	6–7–8
Hexactine (longest ray)	12	90–222–450	5–10–18
Oxypentactine	6	130–228–620	3–3–3
Oxyhexactine	10	88–116–156	3–3–3
Oxyhexaster	11		53–88–150
Discohexaster	10		60–87–104

Remarks.—Color dull, gray-white in alcohol. The body forms a fragile, cylindrical, hollow vase. Surface felt-like, from projecting spicules. The large pentacts are numerous but often broken. The smaller stauractines, pentactines and hexactines are acanthose. The discohexasters are smaller than those originally described for *S. solidus* (160 μm) or *S.* (*Rhabdocalyptus*) *dowlingi* (260 μm). This species may be synonymous with *S.* (*Rhabdocalyptus*) *dowlingi* (Lambe, 1894), which is recorded from California, British Columbia, and Alaska (De Laubenfels, 1932). Further study is needed to confirm this.

Class DEMOSPONGIAE Sollas
Subclass CERACTINOMORPHA Lévi
Order DENDROCERATIDA Minchin
Family APLYSILLIDAE Vosmaer
Aplysilla polyraphis De Laubenfels, 1930

Distribution.—Checklesit Bay, Vancouver Island, British Columbia, Canada to Santa Catalina Island, California; intertidal to 75 m.

Local occurrence.—San Nicolas and Santa Catalina Islands, intertidal station Nos. 13 and 15. Four specimens were examined. This is the first record of the species from southern California.

Remarks.—Color deep red-purple in life, animal soft and spongy, without spicules.

Order HAPLOSCLERIDA Topsent
Family ADOCIIDAE De Laubenfels
Sigmadocia sp.

Synonymy.—*Gellius* (old generic name) = *Sigmadocia* De Laubenfels, 1936.

Local occurrence.—San Clemente Island, intertidal station No. 11. Benthic station No. 80832, off Santa Rosa Island, 104 m. Trawl station No. 81701, off Tanner Bank, 91 m. Three specimens were examined.

Spicules.—Measured from one specimen each from stations 80832, 81701 and 11.

Spicule type	No. spicules measured	Length	Diameter
Oxea	14	110–217–280	2–7–9
Sigma	9	13–42–62	

Remarks.—Color white in alcohol. The oxeas are bowed. There was insufficient material to determine the species.

Toxadocia sp.

Local occurrence.—San Clemente and Santa Catalina Islands, intertidal station Nos. 11 and 15. Two specimens were examined.

Spicules.—Measured from one specimen from station 11.

Spicule type	No. spicules measured	Length	Diameter
Oxea	4	70–85–90	2
Toxa	2	14–23–32	

Remarks.—Color white in alcohol. Small fragments. Three undescribed species of *Toxadocia* are known from British Columbia (Austin 1982) and one of the three from central California (see Hartman 1975). Ristau (1978) described *T. zumi* from central and southern California.

Toxadocia cf. *borealis* (Lambe, 1895)

Synonymy.—*Toxachalina borealis* Lambe, 1895. *Gellius borealis* Koltun, 1959.

Distribution.—Kiska Island, Aleutian Islands, Alaska, to Tanner Bank, California; subtidal to 1189 m.

Local occurrence.—One specimen from benthic station No. 740 (24609), off Tanner Bank, 1189 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	10	590–606–630	13–14–15
Toxa	10	52–11–170	

Remarks.—Color white in alcohol. Small fragment.

Family HALICLONIDAE De Laubenfels

Haliclona sp. a

Local occurrence.—One specimen from Santa Catalina island, intertidal station No. 15.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	6	60–111–130	1–2–3

Remarks.—This sponge was found growing on another sponge (*Stelletta estrella*), an uncommon phenomenon in cold temperate waters. It has an isodictyal (triangular) reticulation of one spicule thick.

Haliclona sp. b

Local occurrence.—One specimen from benthic station No. 79 (23187), Santa Rosa Island, 29 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	1	182	30

Remarks.—Oxeas thick and form a one spicule thick isodictyal reticulation.

Haliclona sp. c

Local occurrence.—Santa Cruz Island; intertidal station No. 16. Two specimens were examined and their spicules measured.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	10	66–95–120	4–5–6

Remarks.—Oxeas slightly bowed or arched, forming an isodictyal reticulation two spicules thick. This species is most similar to *Haliclona enamela* De Laubenfels, 1930 (see De Laubenfels 1932).

Haliclona sp. d

Local occurrence.—Benthic station Nos. 80807 and 81007, off Santa Rosa Island and Santa Cruz Basin, 103 m and 463 m. Two specimens were examined and their spicules measured.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	7	200–281–350	7–10–13

Remarks.—The reticulation is one spicule thick, occasionally two spicules thick, and ranges from isodictyal to polygonal in form.

Haliclona cf. *permollis* (Bowerbank, 1866)

Distribution.—Cosmopolitan? Intertidal to 51 m.

Local occurrence.—Intertidal station Nos. 4, 5, 7, 10, 11, 13, 15. Eleven specimens were examined.

Spicules.—Measured from two specimens each from stations 5, 7, 10 and 11.

Spicule type	No. spicules measured	Length	Diameter
Oxea	33	70–105–130	2–4–6

Remarks.—Oxeas bowed or arched, forming a triangular reticulation one spicule thick. Color in life tan, orange or light lavender. This species may represent a complex of species distributed around the world; it needs intensive study.

Haliclonissa sp.

Local occurrence.—One specimen from San Miguel Island; intertidal station No. 12. This is the first record of *Haliclonissa* in California, other species having been described from South America.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	14	300–324–360	4–7–9
Oxea	1	94	2

Remarks.—The small oxea probably is a juvenile form. Anastomosing tracts five spicules thick. Color light orange in alcohol.

Order HALICHRONDRIDA Topsent
Family HALICHONDRIIDAE Vosmaer
Halichondria panicea (Pallas, 1766)

Distribution.—?Cosmopolitan. Amchitka Island, Alaska to Cape San Quintin, Baja California, Mexico, Gulf of California; intertidal to 113 m. See O'Clair (1977).

Local occurrence.—Los Angeles and San Nicolas Island, intertidal station Nos. 5 and 13. Benthic station No. 165 (23000), Santa Rosa Island, 113 m. Three specimens were examined.

Spicules.—Measured from one specimen each from stations 5 and 13.

Spicule type	No. spicules measured	Length	Diameter
Oxea	13	160–313–420	1–5–11

Remarks.—*Halichondria panicea* may comprise a complex of similar species. Whether deeper subtidal specimens are conspecific with intertidal ones is uncertain (Curt Smecher, personal communication).

Family HYMENIACIDONIDAE De Laubenfels
Hymeniacidon sinapium De Laubenfels, 1930

Distribution.—Cape San Quintin, Baja California, and the Gulf of California, Mexico; intertidal to 103 m.

Local occurrence.—Intertidal station Nos. 4, 5, 11, 12, 15, 17. Benthic station No. 80802, Santa Rosa Ridge, 103 m. Fifteen specimens were examined.

Spicules.—Measured from one specimen each from stations 12, 15 and 17, two specimens from station 11, and three specimens from station 4.

Spicule type	No. spicules measured	Length	Diameter
Style	18	130–317–460	5–7–10
Style	12	96–178–290	1–2–4

Remarks.—Color orange in life, brown in alcohol. It is uncertain whether the subtidal specimen from Santa Rosa Ridge is *H. sinapium* or an undescribed species.

Oxeostilon sp.

Local occurrence.—One specimen from San Clemente Island, intertidal station No. 11.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	10	154–193–240	2–4–7
Style to Subtylostyle	10	680–1397–2600	4–6–9

Remarks.—This is a new distribution record for the Pacific Coast of North America. Several species of *Oxeostilon,* some of which are undescribed, are known from the Gulf of California by the first author. Color in life red-brown; fleshy dermis.

Order POESCILOSCLERIDA Topsent
Family CLADORHIZIDAE De Laubenfels
Asbestopluma lycopodium (Levinsen, 1886)

Synonymy.—*Esperia bihamatifera* Levinsen, 1886. *Esperella occidentalis* Lambe, 1894. *Lycopodina lycopodium* (Lundbeck, 1905).

Distribution.—Arctic Ocean (widespread) to San Nicolas Island, California; subtidal to 1134 m.

Local occurrence.—Benthic station Nos. 429 (24089), 219 (24267), 81007, 84803, off Santa Catalina, Santa Cruz and San Nicolas Islands, 59 to 463 m. Four specimens were examined.

Spicules.—Measured from one specimen each from stations 24089 and 24267.

Spicule type	No. spicules measured	Length	Diameter
Style	12	480–1087–2480	7–13–22
Bipocillum	10	6–9–11	
Palmate Anisochela	10	7–10–11	
Forcep	13	15–24–38	

Remarks.—This is the first record of *Asbestopluma* from California. De Laubenfels (1935) described *A. biserialis californiana* from a depth of 4100 m off Pacific Mexico, and Austin (1982) reports *A. lycopodium* from British Columbia. Body consists of a slender trunk with short lateral projections diverging in all directions. Color tan in alcohol.

Cladorhiza sp.

Synonymy.—*Exaxinata* De Laubenfels, 1936.

Distribution.—Arctic Ocean (widespread), boreal waters, and deep seas.

Local occurrence.—Stations 742 (24607) and 740 (24609); Tanner Bank, 1098 to 1189 m. Three specimens were examined.

Spicules.—Measured from one specimen from station 24607.

Spicule type	No. spicules measured	Length	Diameter
Oxea	20	110–330–640	3–5–9

Remarks.—This is the first record of *Cladorhiza* from the Pacific coast of North America. The specimen appears to lack the characteristic anchorate chelas. Body is subspherical with lateral projections, and it sits on a stem. Color white in alcohol.

Family CLATHRIIDAE Hentschel
Axocielita originalis (De Laubenfels, 1930)

Synonymy.—*Esperiopsis originalis* De Laubenfels, 1930. *Axocielita hartmani* Simpson 1966.

Distribution.—Barkley Sound, British Columbia, Canada to Cape San Quintin, Baja California, Mexico; low intertidal to 75 m.

Local occurrence.—Intertidal station Nos. 1, 3–6, 10, 12–13, 16, 17. Twenty-five specimens were examined.

Spicules.—Measured from five specimens from station 4, two specimens from station 1, and one specimen each from stations 3, 5, 10, 12, 16 and 17.

Spicule type	No. spicules measured	Length	Diameter
Style	31	110–166–350	7–10–14
Subtylostyle	24	90–134–200	2–3–5
Palmate Isochela	16	11–16–24	
Toxa	16	35–94–150	

Remarks.—Color orange to red in life.

Esperiopsis cf. *typichela* Lundbeck, 1905

Distribution.—White and Barents Sea, Laptev Sea, east of Greenland; 36 to 542 m.

Local occurrence.—One specimen from benthic station No. 80835, off Santa Rosa Island, 106 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Style	6	330–343–350	2.4
Palmate Isochela	3	60–62–65	
Palmate Isochela	4	19–20–22	

Remarks.—This represents a new distribution record for California and a range extension from the Arctic to California. Some species of *Esperiopsis* may be synonymous with *Axocielita* (see De Laubenfels 1936, and Hartman 1975).

Leptoclathria asodes (De Laubenfels, 1930)

Synonymy.—*Eurypon asodes* De Laubenfels, 1930. *Leptoclathria* = *Microciona* (see Lêvi 1960).

Distribution.—Sanich Inlet, British Columbia, Canada to Santa Barbara Island, California; intertidal.

Local occurrence.—Intertidal station Nos. 10, 14, 16. Five specimens were examined. This is the first record of this species from southern California.

Spicules.—Measured from three specimens from station 14 and one specimen each from stations 10 and 16.

Spicule type	No. spicules measured	Length	Diameter
Acanthostyle	16	97–$\underline{193}$–300	7–$\underline{12}$–30
Tylostyle to Subtylostyle	12	130–$\underline{191}$–270	2–$\underline{3}$–6
Palmate Isochela	10	10–$\underline{11}$–14	

Remarks.—Color orange-red in life, drab pink in alcohol. Encrusting; surface irregular with raised ridges.

Microciona microjoanna De Laubenfels, 1930

Distribution.—San Juan Island, Washington, to Cortez Bank, California; low intertidal to 82 m.

Local occurrence.—San Clemente Island; intertidal station No. 11. Benthic station No. 704 (24382), Cortez Bank, 82 m. Two specimens were examined.

Spicules.—Measured from one specimen each from stations 11 and 24382.

Spicule type	No. spicules measured	Length	Diameter
Style	6	160–$\underline{350}$–620	7–$\underline{9}$–11
Subtylostyle	6	210–$\underline{245}$–300	2–$\underline{2.5}$–3
Acanthostyle	7	110–$\underline{126}$–160	7–$\underline{9}$–11
Toxa	6	24–$\underline{78}$–133	
Palmate Isochela	4	14–$\underline{16}$–18	
Sigma	2	13–$\underline{14}$–15	

Remarks.—Body rather flattened and encrusting, measuring up to 2 cm thick and 7 cm in diameter (Bakus and Abbott 1980). *Microciona microjoanna* is but one of ten intertidal red to orange-red encrusting sponges along the California coast. Others include *Acarnus erithacus, Antho lithophoenix, Axocielita originalis, Lissodendoryx topsenti, Microciona parthena, Ophlitaspongia pennata, Plocamia karykina, Plocamilla illgi,* and *Plocamissa igzo.* In addition, the N.W. Atlantic *Microciona prolifera* grows on oysters in San Francisco Bay.

Microciona parthena De Laubenfels, 1930

Distribution.—Central California to Tanner Bank; intertidal and shallow subtidal.

Local occurrence.—North Tanner Bank, subtidal station 9a. Three specimens were examined.

Spicules.—Measured from three specimens from station 9a.

Spicule type	No. spicules measured	Length	Diameter
Style	13	230–441–600	8–21–31
Substylostyle	12	240–345–583	2–3–6
Acanthostyle	10	84–107–157	4–7–10
Palmate Isochela	12	26–28–29	
Toxa	18	20–116–330	1–3–6

Remarks.—Color in life red, tan to orange in alcohol. Surface with hispid tubercles.

Ophlitaspongia pennata (Lambe, 1895)
californiana De Laubenfels, 1932

Synonymy—See Bakus (1966) for extensive synonymy. *Ophlitaspongia* = *Microciona* (see Simpson 1968). See also Lévi (1960).

Distribution.—Windfall Island, Alaska to Santa Rosa Island, California; throughout the Gulf of California, Mexico; intertidal to 51 m.

Local occurrence.—Intertidal station Nos. 4, 10–12, 15. Benthic station No. 090 (23042), Santa Rosa Island, 51 m. Ten specimens were examined.

Spicules.—Measured from two specimens each from station Nos. 4 and 12, and one specimen each from stations 10, 11, and 15.

Spicule type	No. spicules measured	Length	Diameter
Subtylostyle	21	130–230–420	9–13–20
Subtylostyle	9	130–179–250	1–3–5
Toxa	12	77–96–130	
Toxa	7	30–47–55	

Remarks.—Body forms a firm crust measuring up to 5 mm thick and from several centimeters to nearly 2 m in diameter; surface often with a stellate pattern formed by radiating excurrent grooves around the shallow depressions of the oscules (Bakus and Abbott 1980). Color dark orange to orange in life, orange in alcohol.

Plocamilla illgi Bakus, 1966

Distribution.—Barkley Sound, British Columbia, Canada to Pt. Conception, California; intertidal to 220 m.

Local occurrence.—Intertidal and subtidal station Nos. 4, 9, and 12. Benthic station Nos. 103 (22952) and 219 (24267), 82 to 220 m. Trawl station no. 81701, 91 m. Six specimens were examined. These specimens represent a range extension for the species, originally known only from Washington (Bakus 1966), but later from central California (Hartman 1975).

Spicules.—Measured from one specimen each from stations 4, 9, 12 and 24267.

Spicule type	No. spicules measured	Length	Diameter
Style	8	222–376–680	6–9–11
Style	10	140–200–240	2–3–4
Style (with microspined head)	7	190–369–770	10–12–16
Acanthostyle	11	83–130–196	5–9–14
Acanthostrongyle	10	87–129–160	9–10–11
Raphide	4	61–76–100	1
Palmate Isochela	14	16–21–35	
Toxa	11	18–68–130	

Family MYCALIDAE Lundbeck
Mycale paradoxa De Laubenfels 1935

Synonymy.—*Oxymycale* Hentschel = *Mycale* Gray.

Distribution.—Tanner Bank, California to western Mexico; depth to at least 143 m.

Local occurrence.—Trawl station Nos. 81701 and 81734, Tanner Bank, 91 to 143 m.

Description.—*Mycale paradoxa* is shaped like a small potato and measures up to 8 cm in length and 3 cm in diameter. It is somewhat rough to the touch, slightly friable, and its consistency is moderately firm. Color in alcohol is white; color in life is undescribed.

The sponge surface has a short plush of spicule fibers that are arranged perpendicular to the surface. The plush is largely due to the absence of a dermal membrane over much of the sponge. The dermal membrane is thin and consists of a complex fibrous network; it lacks spicules. Dermal pores are numerous and measure up to 20 μm in greatest diameter. Subdermal spaces commonly occur between the ascending spicule fibers. Oscules are common, elevated up to 2 mm above the sponge surface, and measure up to 2 mm in diameter.

The choanosome has a moderately dense mesenchyme. Vertical spicule tracts are arranged about 1 mm apart and measure up to 0.5 mm in diameter. They contain numerous oxeas and styles. All spicule types listed below occur in the mesenchyme between the tracts. Excurrent canals measure up to 3 mm in diameter and are common.

Spicules.—Measured from one specimen each from stations 81701 and 81734.

Spicule type	No. spicules measured	Length	Diameter
Oxea to Style	10	635–1018–1760	14–24–34
Style (juvenile)	5	410–524–750	3–5–8
Arcuate Anisochela	10	38–84–120	
Palmate Anisochela	10	24–56–110	
Sigma	10	19–27–36	
Raphide	18	28–33–40	

The styles have a relatively small rounded end. Some of the sigmas are contorted.

Remarks.—*Mycale paradoxa* was collected in waters off the west coast of Mexico in 1911 by the R/V *Albatross* (De Laubenfels 1935). As far as is known, this is the first time it has been recorded since its original description. Koltun (1959) distinguished *Oxymycale* from *Mycale* on the basis that the former genus contains oxeas and the latter styles, with no species showing a transition between the two. *Mycale paradoxa* contains both oxeas and styles in large numbers. Moreover, *Oxymycale strongylophora* De Laubenfels 1954 contains strongyles as principal spicules. Raphides and anisochelas in rosettas may occur both in species of *Oxymycale* and *Mycale.* Because of this, *Oxymycale* Hentschel, 1929 is considered to be but a variant of *Mycale* Gray, 1867 and is synonymized under the latter generic name.

Mycale psila (De Laubenfels, 1930)

Synonymy.—*Esperella serratohamata* Lambe, 1895. *Paresperella psila* De Laubenfels, 1930.

Distribution.—Long Beach, Vancouver Island, British Columbia, Canada to Cape San Quintin, Baja California, Mexico; intertidal to 63 m.

Local occurrence.—Benthic station No. 83002, Pt. Conception, 63 m, north Tanner Bank, subtidal station 9a. Two specimens were examined.

Spicules.—Measured from one specimen each from stations 83002 and 9a.

Spicule type	No. spicules measured	Length	Diameter
Subtylostyle	15	290–353–450	4–8–9
Sigma (serrated)	10	32–42–55	
Sigma (serrated)	10	110–192–250	
Palmate Anisochela	10	10–23–30	

Family MYXILLIDAE Topsent

Acarnus erithacus De Laubenfels, 1927

Distribution.—Forester Island, Alaska to Cape San Quintin, Baja California, Mexico and Gulf of California, Mexico; low intertidal to 700 m.

Local occurrence.—Intertidal station Nos. 1, 4–5, 12–13. Sixteen specimens were examined.

Spicules.—Measured from five specimens from station 12, two specimens each from stations 4 and 13, and one specimen from station 1.

Spicule type	No. spicules measured	Length	Diameter
Style	16	183–277–330	7–12–17
Style	14	120–259–710	2–4–7
Acanthocladotylote	22	80–107–154	2–4–7
Subtylote	9	90–170–240	2–4–7
Palmate Isochela	25	11–16–19	
Toxa	21	9–57–90	
Toxa	7	174–270–340	

Remarks.—The intertidal specimen was encrusting; yellow-orange in life and light tan in ethanol. Some subtylotes have microspined heads.

Hymedesmia sp.

Local occurrence.—One specimen from off Santa Rosa Island, benthic station 80809, 103 m. This represents a new generic record for southern California.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Acanthostyle	4	440–570–710	11–14–17
Acanthostyle	4	140–163–200	9–9–9
Acanthostrongyle	4	70–119–150	9–10–11
Tornote	3	270–273–290	5–5–5
Arcuate Isochela	4	41–44–46	

Iophon pattersoni (Bowerbank, 1866)

Synonymy.—For an extensive synonymy, see Bakus (1966).

Distribution.—British Columbia, Canada to the Gulf of California, Mexico; 15 to 970 m.

Local occurrence.—One specimen from trawl station No. 83701, off Pt. Conception, 137 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Acanthostyle	10	260–299–320	10–11–15
Acanthosubtylostyle	10	260–288–300	2–6–7
Subtylote	10	230–249–380	6–7–9
Palmate Anisochela	10	16–26–30	
Bipocillum	10	10–13–18	

Remarks.—Subtylotes with microspined heads.

Lissodendoryx sp. a.

Local occurrence.—One specimen from Anacapa Island, intertidal station No. 10.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Subtylostyle	4	220–227–240	5–5–5
Arcuate Isochela	8	18–21–24	
Arcuate Isochela	1	9	

Remarks.—The small chela may be an aberrant form or a contaminant. Some of the subtylostyles are polytylote. Color in life light orange.

Lissodendoryx firma (Lambe, 1895)

Synonymy.—*Lissodendoryx noxiosa* De Laubenfels, 1930.

Distribution.—Kiska and Amchitka, Alaska to Cortez Bank, California; intertidal to 26 m.

Local occurrence.—Government Point, near Pt. Conception, intertidal station No. 4. South Cortez Bank, subtidal station 8b. Ten specimens were examined. This represents a new distribution record for southern California.

Spicules.—Measured from seven specimens from station 4.

Spicule type	No. spicules measured	Length	Diameter
Style	13	210–239–310	5–7–10
Juvenile Style	8	140–209–250	2–3–5
Subtylote	10	200–220–250	2–4–7
Arcuate Isochela	11	18–22–24	
Anisochela	5	16–17–20	
Sigma	11	35–44–56	

Lissodendoryx topsenti (De Laubenfels, 1930)

Synonymy.—*Tedania topsenti* De Laubenfels, 1930. *Kirkpatrickia topsenti* (De Laubenfels, 1930).

Distribution.—Pescadero Pt. to Coal Oil Pt., California; intertidal and shallow subtidal.

Local occurrence.—One specimen from Coal Oil Pt., intertidal station No. 1. This represents a new distribution record for southern California.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Acanthostyle	4	180–210–221	4–5–6
Style to Subtylostyle	10	140–208–260	2–4–6
Subtylote	10	199–210–225	2–3–5

Remarks.—Some of the subtylotes have acanthose heads. Bakus (1966) tentatively placed this species in *Kirkpatrickia* and Hartman (1975) tentatively placed it in *Lissodendoryx.*

Myxilla incrustans (Esper, 1805–1814)

Synonymy.—See Bakus (1966) for extensive synonymy.

Distribution.—Arctic Ocean to Cape San Quintin, Baja California, Mexico; low intertidal to 512 m.

Local occurrence.—Benthic station Nos. 87801, 80203, and 80224, off Santa Barbara Island and Coal Oil Pt.; 288 to 340 m. Three specimens were examined.

Spicules.—Measured from one specimen from station 80203.

Spicule type	No. spicules measured	Length	Diameter
Acanthostyle	10	290–315–350	8–10–15
Tornote	10	173–189–200	5–5–6
Sigma	11	28–34–45	
Sigma	9	12–16–22	
Arcuate Isochela	11	30–44–65	
Arcuate Isochela	9	13–15–20	

Family PLOCAMIIDAE Topsent

Plocamia karykina (De Laubenfels, 1927)

Synonymy.—*Plocamia karykinos* De Laubenfels, 1927.

Distribution.—Anthony Island, Queen Charlotte Island, British Columbia, Canada to the central west coast of Baja California, Mexico; 0 to 12 m.

Local occurrence.—Intertidal station Nos. 10, 12–17. Subtidal on north and south Cortez Bank, stations 8a–b. Twenty-six specimens were examined. This represents a new distribution record for southern California, although the species has been described from Mexico (Brusca 1980).

Spicules.—Measured from three specimens from station 15, two specimens each from stations 8 and 12, and one specimen each from stations 16 and 17.

Spicule type	No. spicules measured	Length	Diameter
Subtylostyle	32	94–178–330	5–11–19
Subtylostyle	13	51–132–240	2–2–4
Tylote	24	108–154–195	7–11–20
Palmate Isochela	11	13–15–17	
Toxa	21	14–50–94	

Remarks: Color orange in life, tan in alcohol. The larger subtylostyles and the tylotes may have slightly acanthose heads.

Plocamissa igzo (De Laubenfels, 1932)

Synonymy.—*Plocamia igzo* De Laubenfels, 1932. *Plocamionida igzo* De Laubenfels, 1936.

Distribution.—Pt. Pinos to Santa Cruz Island, California, Gulf of California, Mexico; 0 to 30 m.

Local occurrence.—Intertidal station Nos. 10, 13, and 16. Seven specimens were examined. This represents a range extension from central to southern California.

Spicules.—Measured from two specimens from station 10 and one specimen from station 16.

Spicule type	No. spicules measured	Length	Diameter
Acanthotylostyle	13	130–222–360	9–12–17
Style	24	70–148–260	1–4–7
Tylote	15	80–104–120	6–8–12
Anchorate Isochela	21	10–12–14	

Remarks.—Color orange in life, tan in alcohol. Some of the tylotes have a microspined head. Some styles are long and undulating.

Order AXINELLIDA Bergquist
Family RASPAILIIDAE Hentschel
Hemectyon hyle De Laubenfels, 1930

Distribution.—Flamingo Island, Queen Charlotte Islands, British Columbia, Canada to Tanner Bank, California and the Gulf of California, Mexico; subtidal to 89 m.

Local occurrence.—BLM Benthic station No. 84703, San Nicolas Island, 89 m; south Tanner Bank, subtidal station 9b. Two specimens were examined.

Spicules.—Measured from one specimen each from stations 84703 and 9b.

Spicule type	No. spicules measured	Length	Diameter
Style	10	380–645–1045	12–17–25
Style	10	260–450–620	2–4–7
Acanthostyle	17	106–254–420	6–16–34
Raphide	10	72–107–180	1–2–4

Remarks.—Color in life orange. Acanthostyles with spines primarily near the pointed end.

Subclass TETRACTINOMORPHA Lévi
Order HADROMERIDA Topsent
Family CLIONIDAE Gray
Cliona sp.

Local occurrence.—Cortez Bank subtidal station No. 8; San Miguel Island, intertidal station No. 12. Three specimens were examined.

Spicules.—Measured from one specimen from station 8 and two specimens from station 12.

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	9	120–181–235	2–3–5
Subtylostyle to Style	9	85–152–228	2–3–5
Spiraster	9	25–45–62	1–2–2

Remarks.—Boring; found in a barnacle; color yellow in life and in alcohol.

Family SPIRASTRELLIDAE Fidley and Dendy
Spheciospongia confoederata De Laubenfels, 1930

Distribution.—Central California to Cape San Quintin, Baja California; intertidal to 26 m.

Local occurrence.—Intertidal station Nos. 1, 2, 11, 13. Eleven specimens were examined. This represents a new distribution record for southern California.

Spicules.—Measured from four specimens from station 1 and three specimens from station 13.

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	23	198–306–455	5–6–9
Tylostyle	6	90–200–272	1–2–2

Remarks.—Hartman (1975) states that the generic placement of this species is uncertain. Color orange-yellow in life, tan in alcohol. Smooth surface and firm texture.

Spirastrella sp.

Local occurrence.—Intertidal station Nos. 4, 12–13, 17. Fourteen specimens were examined.

Spicules.—Measured from eleven specimens from station 12.

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	36	46–162–390	1–3–8
Spiraster	35	19–44–89	1–2–4

Remarks.—Color tan to dark tan-orange in life, tannish white in alcohol. Spicules similar to *Cliona* sp., however, specimen found encrusted on rock rather than shell. This is the first record of *Spirastrella* on the Pacific coast of North America. *Spirastrella coccinea* is described from the Gulf of California, Mexico (see Dickinson 1945 and Hofknecht 1978).

Timea authia De Laubenfels, 1930

Distribution.—Laguna Beach to Cortez Bank, California; intertidal to 82 m.

Local occurrence.—One specimen from benthic station No. 704 (24382), Cortez Bank, 82 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Subtylostyle	10	380–536–790	7–10–18
Style	10	320–487–730	4–7–10
Spheraster	10		32–48–61
Tylaster	10		10–12–18

Remarks.—Only one small fragment was collected. According to De Laubenfels

(1932), color in life is orange, consistency spongy and friable; the sponge may reach 2.5 mm in thickness and 3–4 cm in diameter.

Family SUBERTIDAE Schmidt

Prosuberites sp.

Local occurrence.—Benthic station Nos. 729 (24389), 81001, and 81011, Tanner Bank and Santa Cruz Basin, subtidal to 667 m. Three specimens were examined.

Spicules.—Measured from one specimen each from stations 24389 and 81011.

Spicule type	No. spicules measured	Length	Diameter
Style	13	610–2263–4960	7–16–40
Subtylostyle	10	150–278–650	3–8–11

Remarks.—Grey-white in alcohol; attached to rock. Dermal membrane has a plush of spicules. The heads of the subtylostyles are mucronate.

cf. *Pseudosuberites* sp.

Local occurrence.—One specimen from Coal Oil Point, intertidal station No. 1. This represents a new generic range extension for California.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	1	480	13

Remarks.—Tylostyles are tangentially arranged but in confusion in the dermal membrane. *Pseudosuberites pseudos* Dickinson, 1945, is very common in the Gulf of California, Mexico, where subtidal specimens grow to form massive heads nearly 1 m across (Brusca, 1980). See also Hofknecht (1978). *Pseudosuberites carnosus* is recorded from British Columbia (Austin 1982).

Suberites ficus (Johnston, 1842)

Distribution.—Widespread in northern seas, Bering Sea to San Nicolas Island, California; 0 to 1100 m. This species is common in Washington (see Bakus 1966) and part of the Gulf of Alaska (see Bakus 1977, and reports listed therein).

Local occurrence.—One specimen trawled off Point Conception, BLM station 837 (26305), 183 m.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	10	190–424–680	7–9–11
Tylostyle	10	120–413–657	1–3–4
Strongyle	10	20–30–48	1–2–2.5

Remarks.—Sponge growing on gastropod shell. The strongyles are centrotylote. Koltun (1966) consideres *S. ficus* to be a synonym of *S. domuncula,* whereas

Hartman (1958) treats them as separate species. Austin (1982) lists *S. domuncula* from the Bering Sea to Washington.

Suberites sp.

Synonymy.—See Hartman (1958) and Koltun (1966).
Distribution.—Central California to San Nicolas Island, California, intertidal.
Local occurrence.—Intertidal station Nos. 1, 4, 10, 12, 13, 17. Thirty-two specimens were examined.
Spicules.—Measured from four specimens from station 12, two specimens from station 1, and one specimen from station 13.

Spicule type	No. spicules measured	Length	Diameter
Tylostyle	33	160–384–580	2–7–14

Remarks.—Color tan to pink in alcohol. Surface smooth, consistency firm. Found growing on rock. They appear to be the intertidal *Suberites* sp. described from central California by Hartman (1975), a new range extension for southern California.

Family TETHYIDAE Gray
Tethya aurantium (Pallas, 1766)

Synonymy.—See Koltun (1966).
Distribution.—Widely distributed, including the White Sea, Barents Sea, Atlantic Ocean, Mediterranean, New Zealand, Canada (British Columbia), California, Mexico (Gulf of California); 0 to 440 m.
Local occurrence.—One specimen from north Tanner Bank, subtidal station 9a.
Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Strongyle (fusiform)	10	580–1112–2320	2–11–22
Tylostrongyle	10	1400–1965–2400	30–38–46
Spheraster	10		32–57–77
Spheraster	10		10–12–14

Remarks.—Color yellow in alcohol. Surface with small circular elevations crowded together.

Order CHORISTIDA Sollas
Family PACHASTRELLIDAE Hentschel
Pachastrella dilifera De Laubenfels, 1934

Distribution.—West Indies and Gulf of California, Mexico; subtidal to 250 m.
Local occurrence.—One specimen from north Tanner Bank, subtidal station 9a. 81734 (26297) 137–143 m.
Spicules. —

Spicule type	No. spicules measured	Length	Diameter
Oxea	10	2365–2734–3240	40–55–72
Oxea	10	170–199–220	4–6–7
Quadriradiate (longest ray)	20	190–390–680	30–44–72
Amphiaster	10		10–18–50

Remarks.—Small oxeas are slightly acanthose. This is a new distribution record for this genus on the Pacific coast of North America. *Pachastrella dilifera* may be synonymous with the widely distributed *P. monilifera* Schmidt, 1868 (see Koltun 1966).

Pachastrella dilifera De Laubenfels, 1934

Distribution.—Santa Catalina Island to Tanner Bank, California and the Gulf of California, Mexico; intertidal to 143 m.

Local occurrence.—Santa Barbara and Santa Catalina Islands, intertidal station Nos. 14 and 15. San Nicolas Island, Benthic station 84803, 59 m; Tanner Bank, trawl station 81734 (26297), 137–143 m. Four specimens were examined.

Spicules.—Measured from one specimen each from station 14, 81734 and 84803.

Spicule type	No. spicules measured	Length	Diameter
Oxea	8	800–1125–1280	14–17–22
Oxea	12	160–504–1160	6–8–11
Oxea	10	68–96–120	2–4–5
Quadriradiate (calthrop longest ray)	10	110–208–290	14–19–24
Quadriradiate (calthrop ray)	11	17–29–38	3–4–5
Aster	7		12–19–29

Remarks.—Color white or tan in alcohol. Body lamellar with scalloped edges. Oscula on one side of body. The smaller size category of calthrop has a very short fourth ray and may be branched at the ends. Specimens with large oxeas have small calthrops and vice versa.

Family STELLETTIDAE Carter

Penares cortius De Laubenfels, 1930

Distribution.—Sea of Japan; Johnstone Strait, British Columbia, Canada to Cortez Bank, California; Gulf of California, Mexico; intertidal to 160 m.

Local occurrence.—San Clemente and Santa Barbara Islands, intertidal station Nos. 11 and 14. South Cortez Bank and north Tanner Bank, subtidal stations 8b and 9a. This represents a new distribution record for southern California.

Spicules.—Measured from one specimen each from stations 8b, 9a, and 11.

Spicule type	No. spicules measured	Length	Diameter
Dichotriaene (rhadb)	10	110–172–320	17–29–48
Oxea	10	560–710–990	9–14–22
Strongyle (curved)	10	84–155–190	6–7–10
Strongyle (curved)	10	27–66–120	2–3–5
Rhabd (bent)	1	84	7
Oxyspheraster	11		6–12–19

Remarks.—Color gray to brown in life and in alcohol. Surface smooth. This sponge measures up to 4 cm thick and 10 cm in diameter (De Laubenfels 1932). The strongyles are bicurvate; some of the smaller ones are centrotylote.

Stelletta clarella De Laubenfels, 1930

Synonymy.—*Stelletta estrella* De Laubenfels, 1930.

Distribution.—Dixon Entrance, British Columbia, Canada to Cortez Bank, California; Gulf of California, Mexico; intertidal to 41 m.

Local occurrence.—Intertidal and subtidal station Nos. 1, 8a, 9a, 11, 14–16. Fifteen specimens were examined.

Spicules.—Measured from 4 specimens from station 15, three specimens from station 14, and one specimen each from stations 8a and 16.

Spicule type	No. spicules measured	Length	Diameter
Oxea	24	1118–2231–3119	17–29–52
Oxea	20	50–263–850	2–5–7
Ortho- to Plagiotriaene (rhabd)	28	220–915–3960	2–20–40
Dichotriaene (rhabd)	5	550–992–1880	22–27–33
Euasters	29		5–10–18

Remarks.—Color white, tan or purplish brown in alcohol. Surface, hispid. A few large pieces were examined; according to De Laubenfels (1932), specimens may exceed 4 cm in thickness and 7 cm in diameter.

Examined specimens possess characters intermediate between *S. clarella,* described from central California, and *S. estrella,* described from southern California. Like *S. estrella,* specimens lack anatriaenes. Unlike *S. estrella,* but like *S. clarella,* the clads of the triaenes are not reduced. It is proposed that *S. clarella* and *S. estrella* are varieties of the same species based on their similar morphology, depth distribution, and intermediate character of spicules in specimens examined for this study. *Stelletta clarella* has page priority over *S. estrella*; it is proposed herein that *S. estrella* is synonymous with *S. clarella.*

Family GEODIIDAE Gray

Geodia mesotriaena von Lendenfeld, 1910

Distribution.—Southeastern Alaska to Tanner Bank, California; Gulf of California, Mexico; low intertidal to 369 m.

Local occurrence.—San Clemente, San Miguel and Santa Catalina Islands, intertidal station Nos. 11, 12, 15. Trawl Station Nos. 81701 and 81734, Tanner Bank, 91 to 143 m. Six specimens were examined.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Anatriaene	7	3216–5288–7600	13–17–22
Protriaene	5	1280–2996–5040	12–22–32
Plagiotriaene	10	1720–2690–4080	50–65–90
Oxea	8	2880–4228–9800	17–39–52
Oxea to Style	11	90–325–780	2–9–12
Sterraster	14		35–73–120
Spheraster	10		10–14–19
Oxyaster	10		14–20–26

Remarks.—A bent triaene measured 2160 by 58 μm. Color white in alcohol. Surface covered with a plush of dermal spicules. Chunks of specimens were collected. Older specimens may exceed 6 cm in thickness and 20 cm in diameter. *Geodia mesotriaena* (Hentschel 1929) from the Arctic Ocean is distinct from *G. mesotriaena* von Lendenfeld, 1910 from California and should be given a new specific name, according to Koltun (1966).

Order SPIROPHORIDA Lévi
Family TETILLIDAE Sollas
Tetilla arb De Laubenfels, 1930

Synonymy.—*Craniella arb* (De Laubenfels, 1930)

Distribution.—Pescadero Point to Point Cenception, California; Gulf of California, Mexico; intertidal to 150 m.

Local occurrence.—One specimen trawled off Point Conception, station 83701, 137 m. This represents a new distribution record for southern California.

Spicules.—

Spicule type	No. spicules measured	Length	Diameter
Oxea	10	2120–3192–7880	16–20–27
Oxea	10	460–704–1280	6–7–10
Anatriaene (broken)	10	1720–2786–3800	5–6–8
Protriaene (broken)	10	1080–3376–7440	5–11–17
Protriaene	10	350–579–830	2–3–5
Sigma	4	9–9–9	

Remarks.—Color tan in alcohol. Anatriaenes and protriaenes reach several millimeters in length; all of the larger triaenes were broken. Dr. William Austin (pers. comm.) considers the *Tetilla arb* of Washington and British Columbia to be *Craniella villosa.*

Discussion

A total of 58 species, representing 48 genera of sponges, was collected from southern California during 1976 to 1978, by the Bureau of Land Management

(BLM) Southern California Bight Program. *Oxymycale* Hentschel, 1929, is synonymized under *Mycale* Gray, 1867, and *Stelletta clarella* is synonymized with *S. estrella.* There were 27 new geographical range extensions, as follows: *Leucosolenia nautilia, Aplysilla polyraphis, Toxadocia* cf. *borealis, Haliclonissa* sp., *Oxeostilon* sp., *Asbestopluma lycopodium, Cladorhiza* sp., *Esperiopsis* cf. *typichela, Leptoclathria asodes, Plocamilla illgi, Mycale paradoxa, Hymedesmia* sp., *Lissodendoryx firma, Lissodendoryx topsenti, Plocamia karykina, Plocamissa igzo, Spirastrella* sp., cf. *Pseudosuberites* sp., *Suberites* sp. *Pachastrella dilifera, Penares cortius,* and *Tetilla arb.* Of these, four species were previously known only from subtropical or tropical waters (*Oxeostilon* sp., *Mycale paradoxa, Spirastrella* sp., and *Pachastrella dilifera*), and four species were previously known only from Arctic waters (*Toxadocia* cf. *borealis, Asbestopluma lycopodium, Cladorhiza* sp., and *Esperiopsis* cf. *typichela*). The latter four species exhibit the deep submergence pattern typical of Arctic species found in lower latitudes, yet one specimen of *A. lycopodium* was taken from a depth of but 59 m and a specimen of *E.* cf. *typichela* from 106 m. The remaining species showing range extensions are reported from British Columbia and central California. Twelve of them had depth range extensions.

Many of the sponges in the northern Baja California borderlands would be expected to be the same as those in southern California, especially off Guadalupe and San Martin Islands, Jasper Seamount, and the basins thereabout. This is based on data from the R/V *Albatross* and other marine collections during the past century, as well as information on subsurface current patterns (Emery 1960; Maloney and Chan 1974). Since the same shallow water zoogeographic province extends from Pt. Conception, California to approximately Magdalena Bay, Baja California (Briggs 1974; Brusca and Wallerstein 1979), most of the same species would be expected to be found in the borderlands of even central Baja California, and in the waters off Cedros, Benito, Natividad and Asuncion Islands and Henderson Seamount. This is supported in part by sponge collections made by the first author. Some sponges of southern California may also occur in even deeper waters in southern Baja California, off Magdalena, Santa Margarita, and Creciente Islands and the Crest Seamount.

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A New Species of the Genus *Lebbeus* (Caridea: Hippolytidae) from the Northeastern Pacific

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Abstract.—A new shrimp, *Lebbeus catalepsis*, is described. Found very low in the intertidal zone in rocky, high energy areas in the Strait of Juan de Fuca, it is closely related to *Lebbeus lagunae* (Schmitt) recorded from California. Notes on color, habitat, and behavior are included.

Shrimps of the genus *Lebbeus* (White 1847) are small to medium sized species occurring primarily in temperate or arctic regions of the north Pacific and north Atlantic oceans. Recent taxonomic works dealing with this genus include Wicksten (1978), Butler (1980), and Wicksten and Mendez (1982).

Collections made in the low intertidal in the Strait of Juan de Fuca revealed the presence of an undescribed species of *Lebbeus*, the first member of this genus to be recorded intertidally in the Pacific northwest.

Lebbeus catalepsis, new species
Figs. 1, 2A–F, 3A–G

Type material.—Holotype male, carapace length 4.1 mm. Strait of Juan de Fuca, between Sekiu and Neah Bay, Washington (48°19′N, 124°28′W); low (−0.3 m) intertidal, 23 December 1984, Gregory C. Jensen, collector. National Museum of Natural History, Smithsonian Institution, USNM no. 228141. Also allotype, ovigerous, carapace length 4.2 mm, same location and date, USNM no. 228142. Seven paratypes each deposited at the U.S. National Museum of Natural History (USNM 228143; 228144), California Academy of Sciences (CAS 060416-060418), and British Columbia Provincial Museum (BCPM 985-530-1; 985-531-1). Transparencies of common color morphs deposited with paratypes.

Description.—Integument thick, surface smooth; plumose setae on carapace and abdomen, much more numerous in males. Rostrum extremely reduced, composed of a short, sharp spine less than 0.1 carapace length. Carapace with 2–3 curved dorsal spines in males, 3–4 in females. Supraorbital spines extremely large; suborbital lobe bluntly pointed in dorsal view. Antennal and pterygostomian spines strong, sharp.

Abdominal somites lacking carinae; dorsal surface of second abdominal somite with deep transverse sulcus. Pleura of first four abdominal somites of female somewhat rounded; males generally more angular but not sharply pointed. Pleuron of abdominal somite 6 strongly produced posteriorly in both sexes. Pleura of abdominal somites 1–6 tipped with clusters of plumose setae, increasing in number and size from anterior to posterior somites and more developed in males. Sixth abdominal somite with large posteroventral spine; ventral surface with median process tipped with spines and plumose setae. Telson 1.2–1.5 times longer than

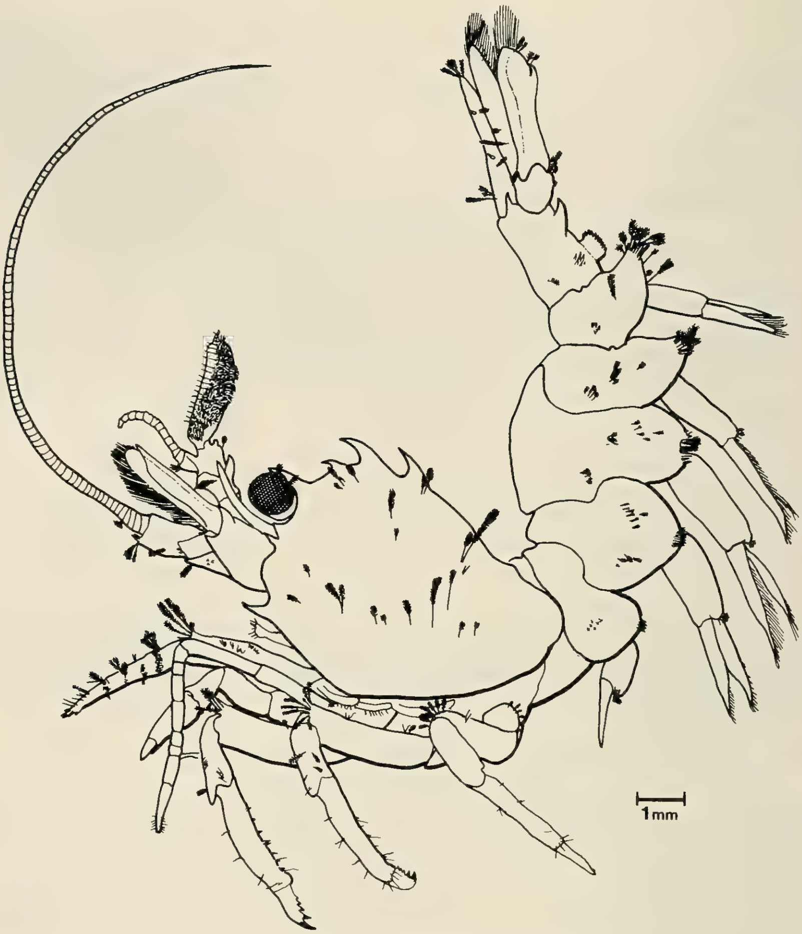

Fig. 1. *Lebbeus catalepsis,* male holotype.

6th abdominal somite; armed with two pairs of dorsolateral spines. Tip of telson with two pairs of stout, terminal spines and produced into a blunt spinous process mesially; three pairs of plumose setae between spines and mesial lobe, inner pair longest.

Eye large, with pigmented, faceted cornea; eyestalk with dorsal plumose setae.

Basal article of antennular peduncle with small ventromesial spine. Stylocerite somewhat blunt, curved dorsally, and reaching third article of the antennular peduncle. Article 2 wider than long, with strong dorsolateral spine; article 3 with small distal dorsal spine, sometimes obsolescent. Dorsolateral flagellum proximally composed of 20–22 thickened segments; ventral margin with extremely thick, plush assemblage of aesthetascs. Distal portion minute, slender, with only 3–4 segments. Ventromesial flagellum shorter, slender; composed of 11–18 segments.

Basicerite of antenna large, armed with strong ventrolateral and dorsolateral teeth; carpocerite exceeding middle of antennal scale and with distal plumose setae. Antennal scale about twice as long as wide in females and more than 2.9

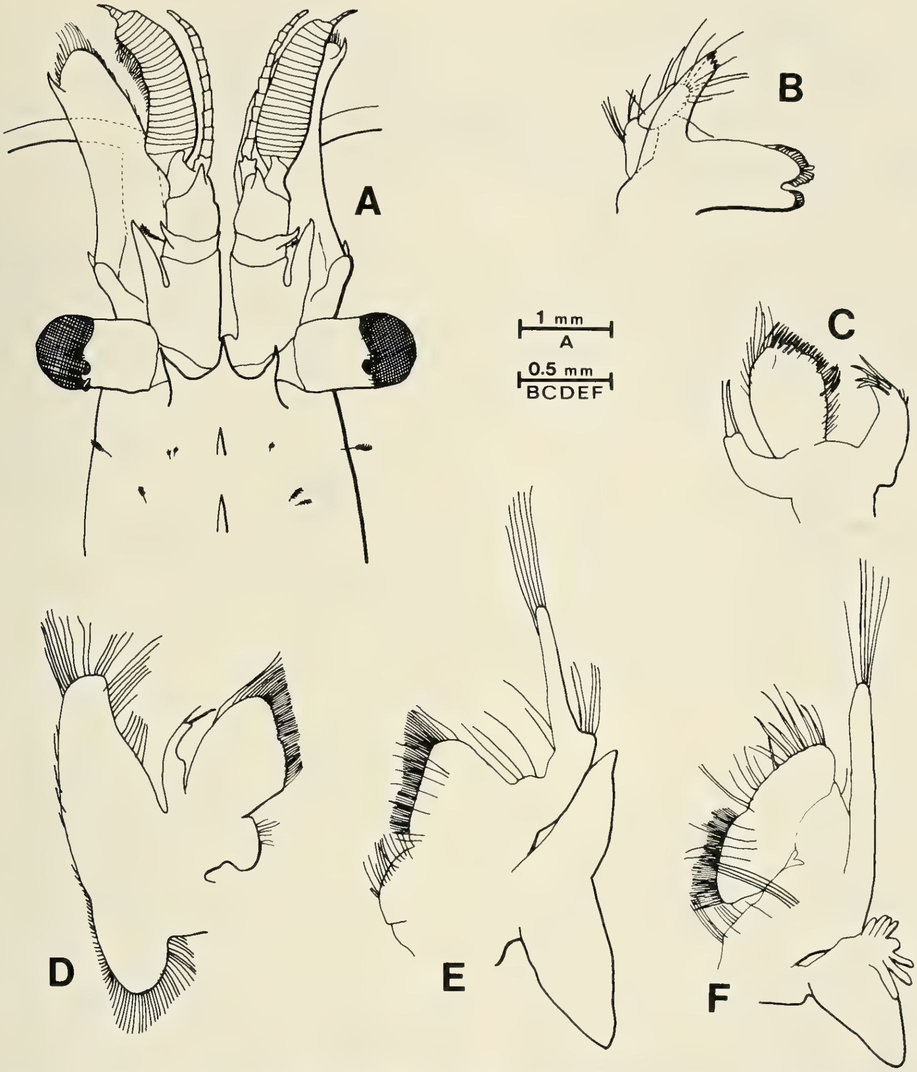

Fig. 2. *Lebbeus catalepsis,* male paratype: A, frontal region in dorsal view; B, mandible; C, first maxilla; D, second maxilla; E, first maxilliped; F, second maxilliped.

times in males; outer margin very concave in males, only slightly in females. Tip of spine curved mesially, not exceeding lamella. Flagellum slender, about equal total body length.

Mandibles with two segmented palp and slender incisor with 4 distal teeth; molar large, subcylindrical, and armed with denticles.

First maxilla with palp bearing 2 long setae, inner much thicker than outer. Proximal endite slender, tipped with long setae. Distal endite broad, suboval; long setae scattered distally and many short spines along mesial margin.

Second maxilla with palp tipped by 2 long setae. Basal endite entire with slight median notch, densely setose; coxal endite small with few setae. Anterior lobe of

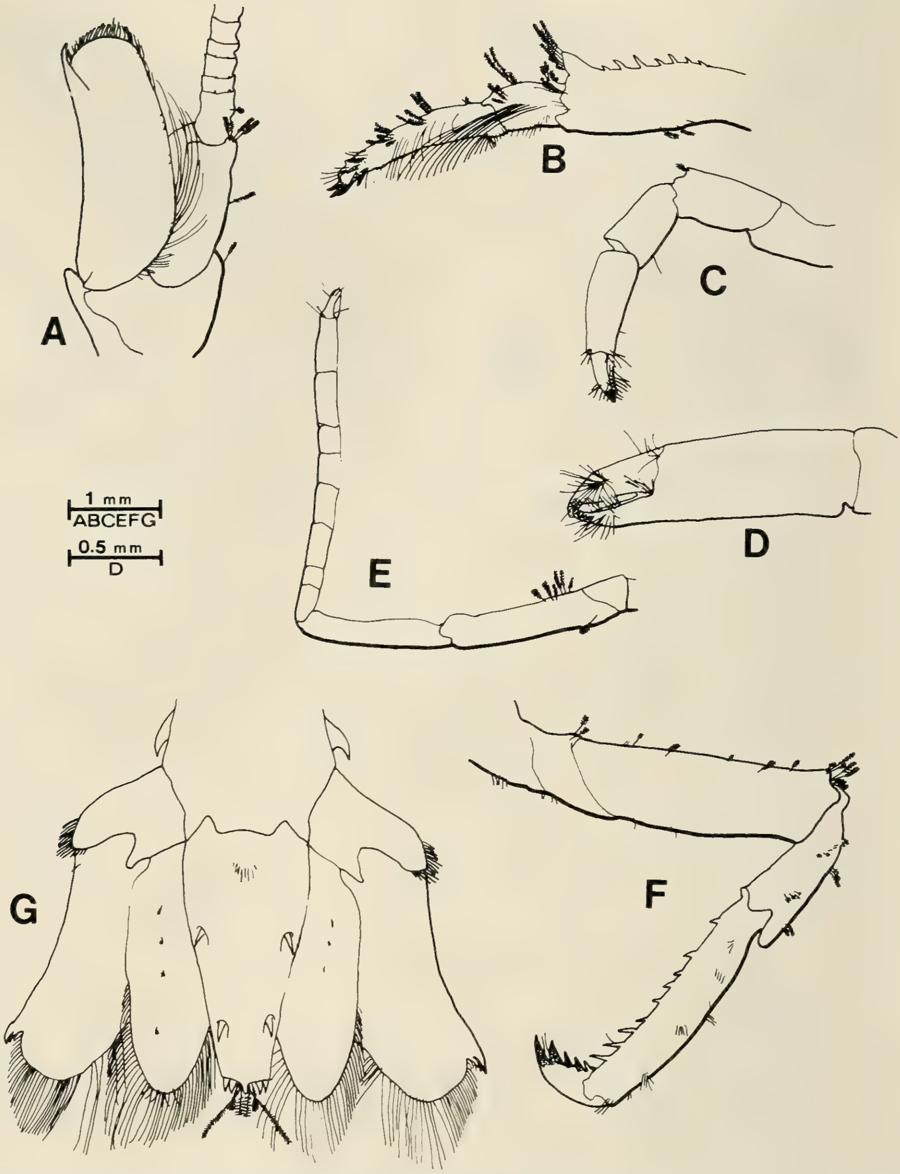

Fig. 3. *Lebbeus catalepsis,* male paratype: A, antennal scale; B, third maxilliped; C, first pereopod; D, chela of first pereopod; E, second pereopod; F, third pereopod; G, dorsal view of telson and uropods.

scaphognathite long, narrow, anterior and mesial margins with long setae; short setae along lateral margin; posterior lobe rounded, with long setae.

First maxilliped with large basal endite, densely setose on mesial margin. Exopod well developed, tipped with long setae; proximal lobe with long setae. Epipod large, bilobed.

Second maxilliped armed with dense spines and setae mesially. Exopod well developed, tipped with long setae. Epipod with small distal podobranch.

Third maxilliped stout; dorsal surface with clusters of plumose setae. Ultimate article tipped with 6 strong, corneous spines. Penultimate article about twice as long as wide; antepenultimate article with dorsal spines. Coxa with epipod.

First pereopods chelate, equal in length. Dactyl corneous, 0.35–0.6 length of palm; palm about 2.2 times longer than wide. Carpus 1.4–1.7 times longer than wide; merus with length about 2.4 times greater than width. Coxa with epipod.

Second pereopods long, slender, chelate. Dactyl 0.6 or less length of palm; palm about 3.75 times longer than wide. Merus 5–6 times longer than wide and 0.6 length of carpus; coxa with epipod.

Third pereopods very stout; dactyls bifid, preceeded by three corneous spines on flexor margin. Propodus with 13–16 spines on flexor margin, increasing in size distally and with last 3 or 4 in pairs; extensor margin with plumose setae. Carpus shorter than propodus, with some tufts of plumose setae. Merus 3.5–4.0 times longer than wide, with large cluster of plumose setae on dorsal, distal margin; coxa with epipod.

Fourth and fifth pereopods similar to third but decreasing in size and lacking epipods.

Pleopods of females normal, with exopods slightly longer than endopods. First pleopod of male with bifid endopod; inner lobe tipped with hook-like setae and exceeding outer lobe. Second pleopod of male with large, stout appendix masculina, 0.8 length of appendix interna and tipped by many long spinules.

Uropods equal in length, slightly exceeding telson; exopods with concave outer margins ending in a large lateral spine and small inner spine. Basal section of uropods blunt, tipped with setae.

Eggs nearly round, about 0.52 × 0.56 mm.

Total body length to 20 mm.

Color.—Male *Lebbeus catalepsis* are frequently transparent with a greenish-yellow cast; some blotches of brown, orange, pink, or white may also be present. The legs and antennae are generally banded with brown. Females are extremely variable, ranging from olive brown to a bright pinkish purple matching coralline algae common in their habitat. The carapace and abdomen may be either a solid color or mottled, or may be a combination of colors and transparent areas. There is usually a white or transparent "saddle" near the cardiac region and extending through the first or first and second abdominal somites. The third maxilliped is a bright white, starting with the distal half of the antepenultimate article and often extending to the tip of the maxilliped.

The pleura of female specimens are usually strongly pigmented, rather than transparent as in the males. This coloration may serve to camouflage developing embryos, as suggested for other hippolytid shrimp (Bauer 1981).

Remarks.—*Lebbeus catalepsis* is found in the low intertidal zone (−30 cm) in rocky, wave-washed areas of the Strait of Juan de Fuca. Specimens were captured by scraping the sides and edges of large rocks with a fine-meshed net, and were most frequently encountered in channels lying parallel to the water's edge. The species was easily distinguished in the field by its defensive "cataleptic" position (Butler 1980), not commonly observed in other intertidal species in the region. Other species of hippolytids taken in the same area included *Heptacarpus carinatus, H. brevirostris, H. stylus, H. pugettensis,* and *Spirontocaris prionota.*

Captive animals rarely move and cling tightly to any available substrate, probably an adaptation to the high energy environments in which they are found. They react strongly to the approach of another individual and repeatedly strike them with rapid movements of the second antennae; this results in the immediate departure of the other shrimp.

Etymology.—The specific name is in reference to the cataleptic position. This is a defensive position assumed by some species of shrimp in which the abodmen is raised, bringing the telson near the head (Butler 1980). Specimens of *Lebbeus catalepsis* kept alive in captivity for over six months were never observed to change from this position.

Systematics.—The extremely short rostrum, composed of a simple spine, easily distinguishes *Lebbeus catalepsis* from all other species of *Lebbeus* in the Pacific northwest. *Lebbeus catalepsis* is closely related to a southern California species, *L. lagunae* (Schmitt), recorded from Pacific Grove to Punta Banda, Baja California (Wicksten 1982). *L. catalepsis* lacks the large, decurved spines below the articular knobs on the posterolateral margin of the fourth and fifth abdominal somites of *L. lagunae.* The telson of *L. catalepsis* bears only two pairs of dorsal spines, compared to three pairs in *L. lagunae.* In addition, the stylocerite of *L. catalepsis* reaches the third article of the antennular peduncle, while in *L. lagunae* it rarely exceeds the first article. Females of the two species also differ in the pleuron of the second abdominal somite. In female *L. lagunae* the lower anterolateral margin is concave and preceeded by a thick patch of setae; the surface of the pleuron bears many dense patches of setae. In female *L. catalepsis* the anterolateral margin is convex, lacks setae, and the lateral surface of the pleuron has only one patch of setae.

Wicksten (1978) observed a live *L. lagunae* and noted that it kept the abdomen elevated above the substrate; the shrimp was very well camouflaged and caught amongst algae. Thus, strong similarities between the two species may be behavioral as well as morphological.

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Effects of Stochastic Processes on Rocky-Intertidal Biotas: An Unusual Flash Flood near Corona del Mar, California

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Abstract.—A localized storm on 9 May 1977 produced deluge-level quantities of rain (2.56 cm within 3 h) causing flooding of the rocky shoreline at Corona del Mar, California. Unlike the patterns observed throughout 1975 and 1976 and at a comparable site 40 km to the north during the same time period, the sea urchin *Strongylocentrotus purpuratus* experienced a significant decrease in cover (from about 2.0% to less than 0.1%, $P < 0.05$, ANOVA) in the lower intertidal zone (MLLW to +0.3 m) and disappeared entirely within the +0.3 to +0.6 m interval. Belt transects documented an average of 90.5% mortality, whereas a census of the total area between the two permanent transect lines revealed 93.6% of the *S. purpuratus* to be dead. A biotically similar area beyond the periphery of the region flooded (20 m north of the north transect line) experienced only 1.1% mortality of *S. purpuratus.* Ephemeral macrophytes characteristic of disturbed environments, *Ulva californica/Enteromorpha* sp. (combined) and Ectocarpaceae, increased significantly in mean overall cover (14.6% and 8.9%, respectively) following the flood, as did newly recruited barnacles. However, the majority of persistent macrophytes, such as *Hydrolithon decipiens,* blue-green algal crusts, and *Gelidium coulteri/pusillum,* showed slight (but not significant) declines in mean cover (1.3%, 7.8%, and 5%, respectively). Therefore, stochastic events can have highly-localized species-specific catastrophic effects on intertidal populations which may set in motion subsequent changes to overall community structure that would be difficult to understand if a program of infrequent sampling was used.

The goal of this study was to assess changes in rocky-intertidal biotas as a direct consequence of a freshwater flood. Replicated nondestructive analyses (see Littler and Littler 1985) were contrasted during mid-March (prior to the flood of 9 May 1977) and late May 1977 near the mouth of Morning Canyon, Corona del Mar, a system intensively studied by us since July 1975 (Littler 1977, 1978, 1979). The first assessment of the rocky-intertidal biota in the vicinity of Corona del Mar (0.4 km northwest of the area sampled here, Fig. 1) was performed by Dawson (1959, 1965) in an attempt to compile baseline data on the intertidal macrophytes of Southern California. Dawson concluded that a general reduction in macroalgal species had occurred throughout Southern California since the 1895–1913 collections of W. A. Setchell and N. L. Gardner. Subsequent to Dawson's surveys (1959, 1965), Corona del Mar was reinvestigated during three separate studies (Widdowson 1971; Nicholson and Cimberg 1971; Thom and Widdowson 1978). Nicholson and Cimberg (1971) recorded a 68% reduction of algal taxa since 1959, including a shift toward turf-forming species. Widdowson (1971) also concluded

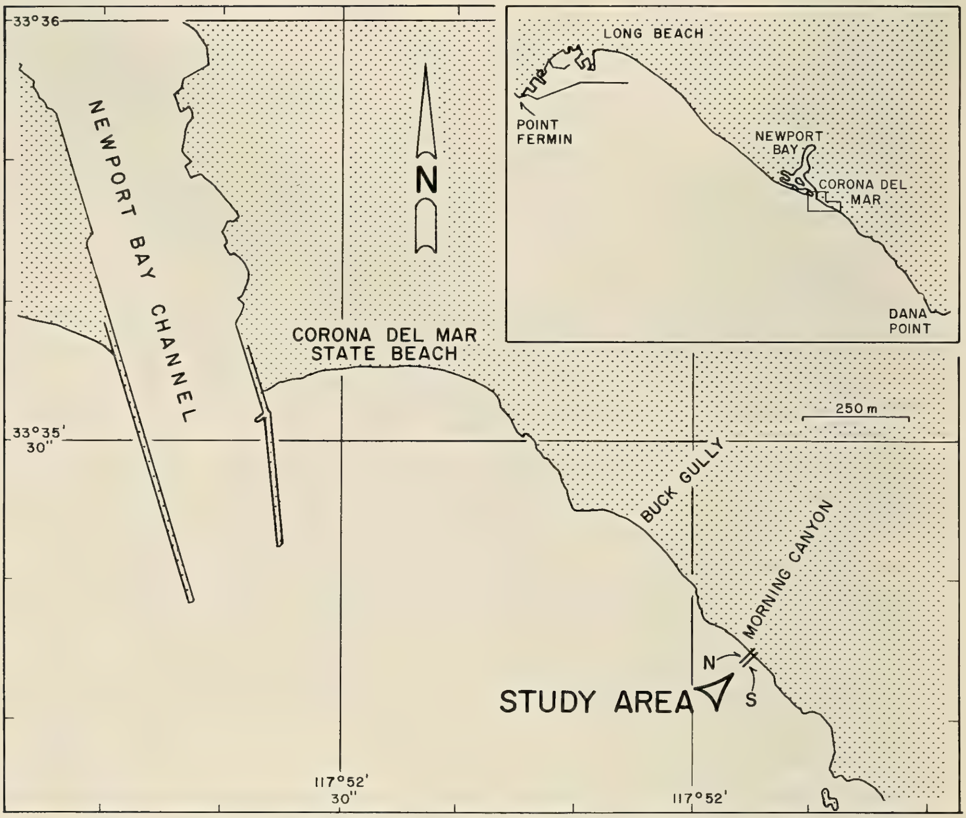

Fig. 1. Location of the Corona del Mar study site and permanent transect lines.

that considerable decreases had occurred, with Corona del Mar ranking third in greatest percentage of species lost relative to other regions of Southern California. In agreement, Thom and Widdowson (1978) noted that massive and foliose intertidal algae in the area had been replaced by turf-like forms (along with articulated corallines).

Information exists concerning the effects of various physical/chemical disturbances such as sewage pollution (e.g., Borowitzka 1972; Munda 1974; Littler and Murray 1975; Murray and Littler 1978, 1984), sand scouring and sediment burial (e.g., Daly and Mathieson 1977; Seapy and Littler 1982; Taylor and Littler 1982; Littler et al. 1983), substratum instability (e.g., Sousa 1979, 1980; Littler and Littler 1984), extreme aerial exposure (e.g., Seapy and Littler 1982), and sediment inundation (Seapy and Littler 1982; Stewart 1983; Littler et al. 1983) on the population dynamics and diversity of intertidal seaweeds. However, the impact of freshwater flooding in the intertidal has not been measured.

On 9 May 1977, a localized rainstorm occurred in which deluge-level quantities of rain fell ($2.56 \text{ cm} \cdot 3 \text{ h}^{-1}$) causing Morning Canyon to flood and produce torrents, which eroded a large gully in the sandy beach (Figs. 2A and B) and flooded the study site. No accumulation of sediments occurred anywhere in the intertidal zone. We suspected that the stresses imposed by such a large freshwater inundation

Fig. 2. (A) View of study site from Morning Canyon. (B) Beach above study site showing erosional path of the flash-flood. (C) Windrows of recently killed *Strongylocentrotus purpuratus* tests cast onto beach two days after the flood. (D) Population of healthy *S. purpuratus* in deep lower shore pool in the path of inundation.

would kill the more stenohaline populations. Indeed, two days after the storm, windrows of recently killed sea urchins were cast up on the shore, but only above the study site near the eroded portion of the beach (Fig. 2C). Consequently, we documented the effects of this stochastic disturbance on a rocky-intertidal biota for which an extensive historical baseline of descriptive information was available.

Study Area

The site selected for study at Corona del Mar, California (Figs. 1 and 2A) lies near the mouth of Morning Canyon (approximately 33°35′14″N and 117°51′54″W), located 1.4 km southeast of the entrance channel to Newport Bay. The intertidal zone extends over a horizontal distance of about 25.0 m with a slope of 3.4 degrees. Although spring tides at the site have an amplitude greater than 1.5 m, the tidal range of our quadrats was MLLW to +0.9 m levels. A sandy beach covered the upper intertidal zone. The rocky portion studied consists of siltstone and conglomerate, covered almost entirely by granitic boulders (0.5 to 1.0 m in diameter).

Environmental Data

Long-term records of mean monthly air and seawater temperatures (12 to 21°C and 15 to 19°C, respectively) reflect a reasonably constant system, with January to February being the coldest and August the warmest periods of the year (Kimura 1974; U.S. Department of Commerce 1970). Records of seawater salinity near the study site are available for 1961 (Scripps Institution of Oceanography 1962) and show little fluctuation (33.3 to 33.7 ppt). Physical data recorded during the course of the study were consistent with the previous records. For example, sea-water temperatures and salinities were always lowest during January 1976 (mean of 13.6°C and 32.0°C), while the highest temperature (19.4°C) occurred in July 1975 and the maximum salinity (33.5 ppt) was recorded for March 1976. At the time of the first post-storm assessment (11 May 1977), the salinity was 23.5 ppt, the lowest measured. The temperature of both water and air was 18.0°C and the relative humidity was 72%. The shoreline near Corona del Mar is exposed to moderate wave action, because of the ameliorating effects of the offshore Channel Islands on the prevalent southerly swell, and has been classified as a protected outer coast (see Ricketts et al. 1968).

Methods

The survey methods employed were identical to those used during the previous two years (a total of eight quarterly assessments) at the same site. Undisturbed photogrammetric sampling of the rocky intertidal and tidepool habitats was conducted during all site visits using the same permanently marked 0.15-m^2 quadrats. This method is accurate and reproducible with $\pm 5\%$ of the cover (% absolute) values scored for abundant taxa (Littler 1980a). Because the identical plots could be re-occupied, very little variance due to sampling design was introduced. Consequently, the changes documented for species occurring in more than trace amounts are within $\pm 5\%$ of the actual cover present. Similar taxa that could not be visually distinguished in the field were combined in the analyses of data.

Undisturbed Samples

Two parallel transect lines 25 m long and 5.0 m apart were established. The upper and lower ends of each line were permanently marked by drilling and cementing eyebolts into the substratum, with the highest point (+0.9 m) being that containing epilithic marine organisms, the lowest position (MLLW) being delimitated by the lowest substrata exposed to air during the initial site visit (July 1975). Each line was laid perpendicular (205° from magnetic north) to the shore by means of a sighting compass, and corners of quadrats were permanently marked at 1.0-m intervals with hard-rock cement. A total of 43 emergent-rock quadrats was provided by this means with 4 located in the upper (+0.6 to +0.9 m) interval, 23 between +0.3 to +0.6 m, and 16 between MLLW to +0.3 m; 8 quadrats fell within tidepools and were not analyzed. The densities and/or cover for the various taxa in each quadrat were averaged and analyzed by ANOVA (Sokal and Rohlf 1981) to detect statistically significant changes at the populational level.

The 2 identical transects and 43 quadrats assessed by nondestructive techniques (Littler and Littler 1985) during 13–18 March 1977 were re-occupied on 20 May 1977. Sampling consisted of photographing each quadrat during low tide in infrared and color with 35-mm cameras equipped with electronic strobes. The species composition, locations, and visual estimates of cover were recorded in the field. These field notes were then used with the photographs in the laboratory to determine percent cover and density (number of individuals$\cdot m^{-2}$).

In addition to the above analyses, two 50 cm-wide belt transects (25 m^2 total area) were run (11 May 1977) centered on each of the permanent transects to quantify mortality effects on *Strongylocentrotus purpuratus* (Stimpson). Also, the total area between the two lines was searched and scored for *S. purpuratus* and compared with an equal-sized area (125 m^2) of the same intertidal system just 20 m to the north of the freshwater-impacted region. A parallel study conducted 40 km to the north at Whites Point (Murray and Littler 1984) provided comparative data.

Results

General observations two days after the flood indicated that: (1) all beach drift sea urchins were recently killed (tests mostly intact and pigmented, Fig. 2C), (2) all *Strongylocentrotus purpuratus* among crevices on emergent rock beyond 20 m from the flood site and in large-volume tidepools were healthy (Fig. 2D), (3) the coralline alga *Hydrolithon decipiens* (Foslie) Adey throughout the intertidal was mostly dead or dying (bleached), (4) the brown alga *Sargassum muticum* (Yendo) Fensholt in the large upper intertidal pool was in poor health and becoming extensively overgrown by the green algae *Ulva californica* Wille and *Enteromorpha* sp., (5) the anemone *Anthopleura elegantissima* (Brandt) experienced no mortality and several had ingested small *S. purpuratus,* and (6) the sea star *Pisaster ochraceous* (Brandt) appeared healthy, but of 15 examined none were feeding even though surrounded by dead and dying *S. purpuratus.*

Species normally present in samples but absent 11 days after the flood included four mobile gastropods (*Haliotis cracherodii* Leach, *Hipponix cranioides* Carpenter, *Littorina planaxis* Philippi, and *Opalia funiculata* (Carpenter)), the mobile crab *Pugettia producta* (Randall), and an unknown bryozoan. Also absent was the bivalve *Glans carpenteri* (Lamy), which had been present during the three preceding periods of study. All of these were present in their characteristic abundances both to the north and south (20 m distant) of the flooded habitat.

Macrophyte taxa characteristic of disturbed environments, *Ulva californica/ Enteromorpha* sp. (combined) and Ectocarpaceae, showed significant ($P < 0.05$, ANOVA) increases in absolute cover on former sea urchin territories (overall mean increases of 14.6% and 8.9%, respectively) following the disturbance (cf. Fig. 3). However, the majority of macrophytes, such as *Hydrolithon decipiens,* blue-green algae, and *Gelidium coulteri* Harvey/*G. pusillum* (Stackhouse) Le Jolis remained similar in absolute cover (slight declines not significant, $P > 0.05$) following the rainstorm. Abundances of these algae 20 m to the north and south of the transect site were also visually similar to those recorded during March 1977.

Few changes in absolute macroinvertebrate cover patterns were evident (Fig. 4) except that *Strongylocentrotus purpuratus* decreased dramatically from about 2.0% to less than 0.1% cover in the lower intertidal (MLLW to +0.3 m) and disappeared entirely from the +0.3 m to +0.6 m interval (significant at $P < 0.05$). Although not shown graphically because of their high abundances, the barnacles *Chthamalus fissus* Darwin/*C. dalli* Pilsbry (combined) and *Tetraclita rubescens* Darwin had some mortality of established individuals, but this was offset by large cover increases (66.1% and 85.1%, respectively, relative to their previous values) in the upper intertidal due to recruitment of juveniles. Adult *Anthopleura elegantissima* did not change ($P > 0.05$) following the runoff.

Density is perhaps the most sensitive measure of changes in mobile macroinvertebrate populations over short periods of time and the patterns of density for

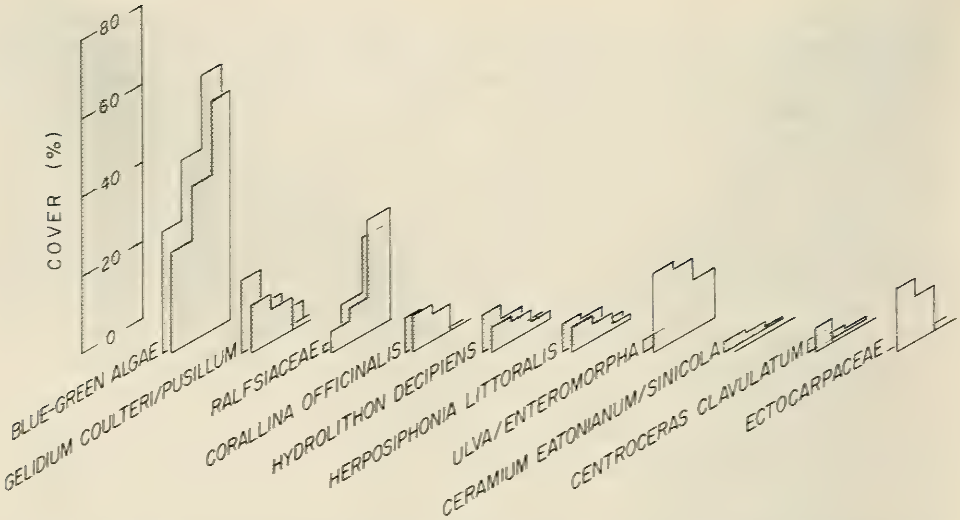

Fig. 3. Macrophyte cover on emergent substrata plotted over three tidal intervals before (shaded histograms in rear) and after the flash flood. From left to right (and front to back), the first third of each histogram indicates the mean for mean-lower-low-water (MLLW) to +0.3 m, the middle third = +0.3 to +0.6 m, and the last third = +0.6 to +0.9 m.

March 1977 and May 1977 (Fig. 5) showed some important differences. Macroinvertebrates that increased in numbers (significant at $P < 0.05$, ANOVA) throughout all intervals were the mobile species: *Collisella limatula* (mean increase of $27 \cdot m^{-2}$), *Pagurus samuelis* (increase of $22 \cdot m^{-2}$), *C. conus/C. scabra* (increase of $49 \cdot m^{-2}$), and the sessile barnacle *Tetraclita rubescens* (increase of $1500 \cdot m^{-2}$); the last clearly related to recruitment of juveniles on the upper shoreline. The two species showing pronounced decreases (significant at $P < 0.05$, ANOVA) in terms of both cover and density (cf. Figs. 4 and 5) were *Eupomatus* (*Hydroides*) *gracilis* (Bush) (mean decrease of $74 \cdot m^{-2}$) and *Strongylocentrotus purpuratus* (decrease of $60 \cdot m^{-2}$) in the interval from MLLW to +0.3 m.

The most dramatic effects over relatively broad areas of the intertidal (Fig. 5) were revealed by the density counts of *Strongylocentrotus purpuratus* immediately following the storm. Our belt transects documented an average of 90.5% mortality (19 recently killed out of 21 urchins), whereas a census of the total area between the two permanent transect lines revealed 96.3% of the *S. purpuratus* to be dead (52 dead out of 54 urchins). An equal area just beyond the region flooded (20 m north of the north transect line) contained only 1.1% dead *S. purpuratus* (6 dead out of 539 urchins). As mentioned, there were several hundreds of *S. purpuratus* tests cast in windrows on the beach above the study lines (Fig. 2C). The deepest tidepools on the lower portions of the shore (Fig. 2D), although lying in the direct path of the flood waters, contained abundant populations of healthy *S. purpuratus*.

Discussion

Information is scanty on the effects of unpredictable catastrophic events on rocky intertidal biotas; in particular, the effects of freshwater inundations are largely undocumented. There is a burgeoning literature on the role of generalized

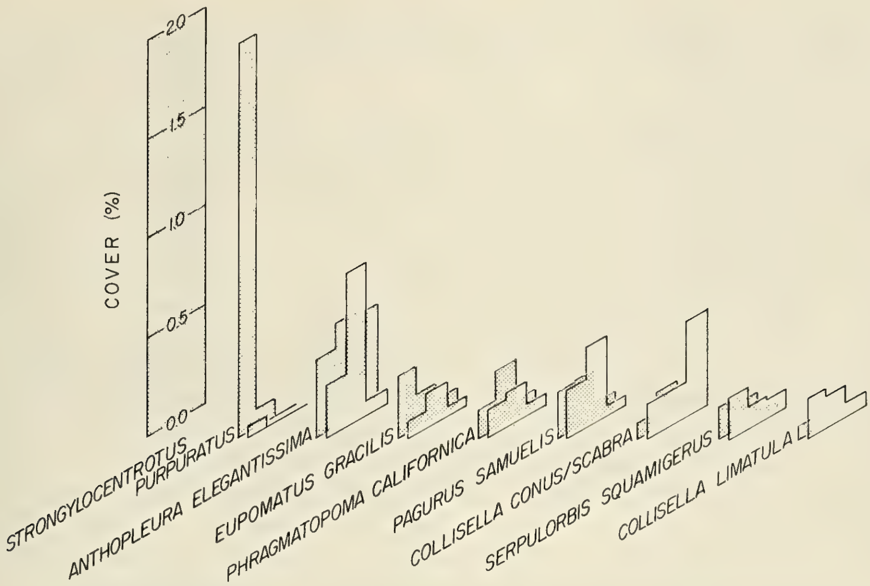

Fig. 4. Macroinvertebrate cover (features are the same as those given in Fig. 3).

disturbance gradients relative to the maintenance of species diversity. However, the phenomenon documented here is relatively species selective, although presumably not an isolated occurrence (cf. Sousa et al. 1981).

It would have been optimal if we had been able to compare the transect area affected by the flood with an identical control area unaffected by the flood (both before and after). However, since this was not possible, we used (1) an adjacent unflooded control area (visually similar) established after the flood, (2) a comparable but not identical control area 40 km to the north (i.e., Whites Point, Murray and Littler 1984), and (3) the previous two years of detailed seasonal data at Corona del Mar in which no flooding occurred. Our method of nondestructive sampling, by utilizing the identical sampling locations that were precisely relocated and reassessed, provided a powerful tool for the quantification of natural changes in the intertidal standing stocks, because variance due to sampling design was virtually eliminated.

Throughout the two years of quarterly sampling at this site prior to the flood, seasonal patterns tended to be both minor and predictable (Littler 1977, 1978). Historically, plant cover at Corona del Mar increased annually during spring to late summer followed by slight declines in late fall and early winter associated with aerial exposures during daytime low tides and some rock tumbling due to storm waves. Animal cover typically showed little seasonal change, except for vertical migratory movements of mobile limpet species (Seapy and Hoppe 1973) and a sporadic winter to spring recruitment of barnacles (Littler 1980a), that appeared to be minimally affected by the flood. Intertidal standing stocks of other Southern California systems (Gunnill 1980; Littler 1980a; Seapy and Littler 1982; Littler et al. 1983; Murray and Littler 1984) tend to follow a similar trend.

Unlike the patterns observed during 1975 through 1976 (Littler 1977, 1978) and at nearby Whites Point (where no comparable rainstorm occurred, Murray

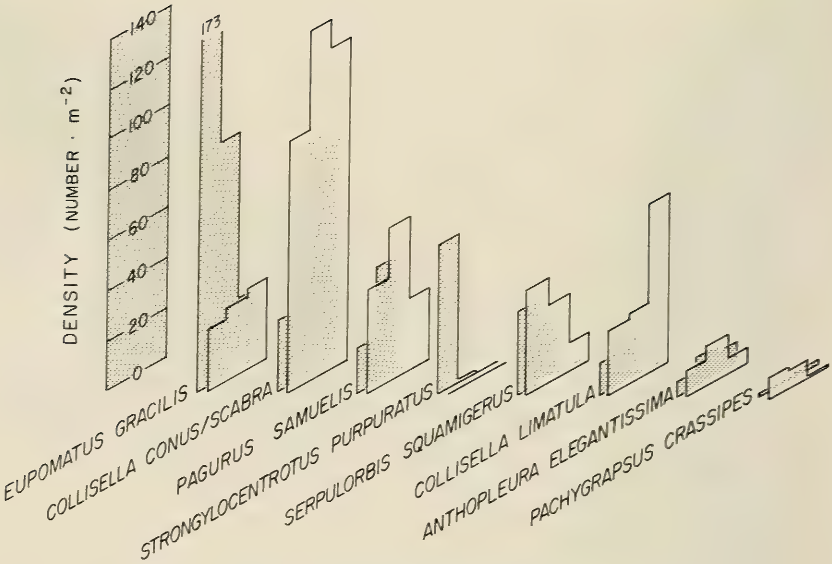

Fig. 5. Macroinvertebrate densities (features same as Fig. 3).

and Littler 1984), the thin sheet-like and microfilamentous algae, mainly *Ulva/Enteromorpha* and Ectocarpaceae, appeared abundantly in former sea urchin territories following the mass mortality of *Strongylocentrotus purpuratus.* Such algal forms have been shown (Sousa et al. 1981) to be maintained in low abundances by *S. purpuratus* when populations of the herbivore remain at high levels. From early February to late May 1977, *S. purpuratus* populations were assessed (Murray and Littler 1984 at a comparable intertidal study site just 40 km to the north, Fig. 1) by the identical methods used here and showed very little variability (0.2% cover and $16 \cdot m^{-2}$ density in February versus 0.8% cover and $13 \cdot m^{-2}$ density in late May, not significant, $P > 0.05$, ANOVA). The sheet form *Ulva californica* was uncommon at Whites Point and increased only slightly (from <0.01% to 0.6% absolute cover, $P > 0.05$), whereas Ectocarpaceae and *Enteromorpha* sp. consistently remained at only trace levels. The three persistent perennial taxa *Hydrolithon decipiens,* blue-green crust, and *Gelidium coulteri/pusillum* that decreased slightly at Corona del Mar, underwent a combined relative increase of one third during the same period at Whites Point (0.9 to 1.2%, 22.9 to 23.8%, and 0.4 to 6.3% absolute cover, respectively).

Dawson (1959, 1965) analyzed groups of intertidal organisms and reported a decline in leafy red algal forms and increased growth of jointed calcareous corallines in Southern California near sites of sewage discharge. Since then, changes in terms of gross morphological groupings of algal taxa have been evaluated (Widdowson 1971; Thom and Widdowson 1978; Sousa et al. 1981; Murray and Littler 1984) subsequently for the same regions of Southern California. Shifts from biotically competent strategists (sensu Grime 1979) in favor of stress-tolerant and opportunistic forms have been reported (Seapy and Littler 1982; Littler et al. 1983) for rocky intertidal communities subjected to extreme heating and desiccation stresses as well as to extensive sand inundation. Biotic patterns within sewage-polluted rocky intertidal communities (Littler and Murray 1975; Murray and Littler 1984) also showed similarities in terms of the adaptive strategies of the dominant forms.

Sheet and filamentous algae such as *Ulva/Enteromorpha* and Ectocarpaceae possess a number of characteristics associated with opportunism, including high productivity and low biomass per unit area (Littler 1980b; Littler and Arnold 1982; Littler et al. 1983) and rapid colonization of disturbed substrata (Castenholz 1967; Crapp 1971; Dayton 1971; Littler and Murray 1975; Murray and Littler 1978; Sousa 1979; Littler and Littler 1981). Opportunistic reproductive strategies have been indicated for both *Enteromorpha* sp. (Fahey 1953) and *Ulva* sp. (Littler and Murray 1974). In this regard, free space, experimentally cleared throughout several seasons next to the same transects studied here (Murray and Littler 1979), was first colonized by these same species of opportunistic algae. *Enteromorpha, Ulva,* Ectocarpaceae, and Ralfsiaceae (cf. Northcraft 1948; Dayton 1975; Littler and Murray 1978; Dethier 1981) as well as the barnacles *Chthamalus fissus/dalli* and *Tetraclita squamosa* (Hines 1978; Taylor and Littler 1982) have high and nearly continuous reproductive output.

Opportunistic forms are typically delicate and susceptible to mechanical removal by grazers (Littler and Littler 1980; Sousa et al. 1981). However, such rapidly growing algae have the potential (Hay 1981; Taylor et al. 1986) to be competitively superior to long-lived herbivore resistant species in the absence of grazing. It has been shown that perturbations occurring at different times of the year in Southern California can profoundly alter subsequent patterns of community recovery (Emerson and Zedler 1978). When *Strongylocentrotus purpuratus* was experimentally removed in Southern California (Sousa et al. 1981), opportunistic Ulvaceae and Ectocarpaceae also rapidly increased their abundances. However, sea urchin removals during August ultimately led to mature communities containing abundant, long-lived, turf-forming Rhodophyta that recruit between September and December (Sousa 1979); whereas, the same perturbation conducted in December led to significantly greater coverages of the brown algae *Egregia* and *Halidrys* (Sousa et al. 1981).

In summary, the natural elimination of a predominant grazer such as *Strongylocentrotus purpuratus* at Corona del Mar quickly resulted in a localized increase of delicate high producing macrophytes (Littler 1980b; Littler and Littler 1980) and highly-reproductive macroinvertebrates (e.g., barnacles) that correspond to the opportunistic strategists documented in successional studies (Murray and Littler 1979). The population census, in support of the community cover and density data, indicates that freshwater inundation of the intertidal zone can result in highly localized catastrophic effects on intertidal organisms (*S. purpuratus* in particular). Therefore, stochastic events that acutely disturb specific intertidal populations may set in motion subsequent changes to overall community structure that would be difficult to interpret from a program of infrequent sampling.

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The Geologic Significance of *Libythea collenettei* (Lepidoptera: Libytheidae) Endemic to the Marquesas Islands, South-Central Pacific

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Abstract.—*Libythea collenettei* of the Marquesas Islands is an isolated eastern Polynesian species that was probably derived from *L. geoffroy batchiana* of eastern Indonesia. Its approximate 9000 km eastward dispersal is probably related to seafloor spreading and fault-displacement history of the Campanian-Cenozoic South Pacific rather than to man, birds, aerial and ocean currents, or migration transport.

The purpose of this paper is to discuss the possible origin and dispersal of the distinctive butterfly *Libythea collenettei* Poulton and Riley from the remote Marquesas Islands. In biogeography it is customary to attribute such a distribution to aerial, oversea, or landbridge dispersal. However, plate tectonics is another possible alternative. As such, this hypothesis represents an important contribution to our understanding of the distribution of the twelve relict species of the small butterfly family Libytheidae.

Libythea collenettei

In a recent review of the zoogeography of libytheid butterflies (Shields 1985), *Libythea collenettei* endemic to the Marquesas Islands was not assigned to a definitive systematic position (figs. 1, 2). Since then, additional study indicates that it is most likely a species derived from *L. geoffroy* Godart which occurs in the Oriental region, New Guinea, north margins of Australia, and Melanesia to the west. In the precise shape (and positioning) of the forewing fused apical spots, *collenettei* is closest to *geoffroy.* The two are also similar in ventral hindwing gray scaling, numerous dark transverse striae and row of white spots on the underside, reduced palpi, and densely hairy second segment of the palpus. Measurements of the figured *collenettei* female appear in Table 1.

Although American *Libytheana* are also sometimes extensively orange-brown or brown in coloration (*terena* Godart, *fulvescens* Lathy), *collenettei* does not approach them in forewing apical spot pattern. Unlike *collenettei,* these have greatly elongated labial palpi, a pronounced forewing apex, and no prominent white band on the underside of the secondaries. These groups appear to be at opposite ends of an evolutionary spectrum (Shields 1985, 1986). Other native butterflies from the Marquesas (*Hypolimnas, Atella, Badamia*) also display affinities with the western Pacific and not the Americas (Poulton and Riley 1928, 1935). Waterhouse (1937) recognized that *collenettei* was related to *geoffroy,*

Fig. 1. Female paratype *Libythea collenettei,* Hooumi Valley, Nukuhiva, Marquesas, 18 January 1925, leg. C. L. Collenette, St. George Expedition, BMNH, upperside.

though admittedly they bear little superficial resemblance to each other (Poulton and Riley 1928). The latter give a detailed type description for *collenettei* and some biological data. Three females were captured and are in the BMNH and 7–9 others reportedly were seen near sea level at Hooumi Valley and on a 1200 ft ridge above Typee (=Taipi) Valley, easternmost coastal Hukuhiva, the largest Marquesas island, mid-January, 1925, by Collenette. No other specimens are known to me. The nearest *geoffroy* are far to the west in the Loyalty and Solomon Islands.

Another reason why *collenettei* is more likely related to *geoffroy* than to *Libytheana* is the distribution and relationship of its probable larval foodplant, *Celtis pacifica* Planchon. *C. pacifica* is known only from the Tonga Islands, Tahiti,

Fig. 2. Same, underside.

Table 1. Measurements of *L. collenettei* paratype.[1]

Length of primary	19 mm
Length of secondary	15 mm
Width of primary	13 mm
Width of black band on secondaries	3 mm
Length of white band on secondaries	6 mm
Width of white band on secondaries	slightly less than 1 mm
Width of head, including eyes	3 mm
Length of thorax	5 mm
Length of antenna	10.5 mm
Antennal club length	1 mm
Length of last segment of palpi	just under 2 mm
Entire length of palpi	3 mm
Length of abdomen	ca. 7 mm
Foreleg femur	2 mm
tibia	1.5 mm
tarsus	2 mm
Midleg femur	3 mm
tibia	2.5 mm
tarsus	3 mm
Hindleg femur	2 mm
tibia	2 mm
tarsus	3 mm

[1] The genitalia was not dissected because of the great rarity of *collenettei* specimens. Regrettably, no males are known for comparative purposes. The antennal club is dark red-brown in color, with the last segment at the tip a light brown. The antennal club has 10 segments.

Marquesas (Nukuhiva, Hivaoa, Uahuka, Mohotani), and Pitcairn Island. Some authors place *C. pacifica* close to *C. paniculata* Planchon, but Leroy (1948) treats it as a synonym of *C. philippensis* Blanco, from the western side of the tropical Pacific. *C. philippensis* was recently discovered to be a larval foodplant of *L. geoffroy* in Papua New Guinea by M. J. Parsons (*in corres.*).

Of all the *geoffroy* subspecies, *collenettei* most closely resembles *batchiana* Wallace from Halmahera, Batjan, Buru, Obi, Sulu Mangoli, and Morty Island. General suffusion of the orange-brown spots of *batchiana* could produce *collenettei,* with long isolation also giving reduction in forewing apex, size, hindwing crenulations, antennal club segments, etc.

No *Libythea* fossils are known for the South Pacific; indeed, very few butterfly fossils of any sort have been preserved (Shields 1976b). However, the earliest known *Celtis* fossil, *Celtis* near *cinnamomea* Lindl., occurs in the uppermost Cenomanian (92–94 m.y. ago) of Borneo (Muller 1968).

The remote Marquesas Islands lie some 9000 km ESE of Halmahera and ca. 7000 km west of Lima, Peru. Predominant winds and ocean currents that might have carried floating trees or natural rafts are from the west coast of South America to the Marquesas (Critchfield 1974), substantiated by Thor Heyerdahl's *Kon Tiki* voyage. Tropical cyclone tracks are generally southeast in the South Pacific but are WNW through Indonesia (Visher 1925). Transportation by Polynesian and Melanesian canoes seems highly improbable in being too recent to account for the degree of differentiation shown by the Marquesan libytheid. Bird transport (Amadon 1948) seems improbable due to the frailty of the immature stages of butterflies and the vast distances involved. Thus none of these agencies appears responsible for transporting *geoffroy batchiana* to the Marquesas unless they followed radically different paths in the past. Indeed, Gustav Arrhenius of Scripps Institution of Oceanography has shown that "fossil" ocean currents, discovered through the study of Foraminifera and other surface drifters that died and settled to the bottom, leaving their skeletons in marine sediments, did indeed follow radically different paths than present ones. Inferred surface currents of the oceans for Late Cretaceous and Tertiary times do lead to a modified pattern but with the major gyres rotating largely in the directions they do today (Fell 1967). This leaves only a geologic interpretation as the most viable hypothesis (*geoffroy* is not known to migrate).

Indonesia has long been regarded as the center of dispersal for the Pacific island molluscan faunas (Ladd 1960). The land leech subfamily Domanibdellinae is distributed in New Guinea, New Britain, Fiji, and the atoll of Palmyra Island in the Line Islands, with extensions of two groups into Wallacea and the Oriental Region (Moluccas, Salawati Island, Philippines, Malay Peninsula, Celebes, Borneo) (Richardson 1975). As with the *L. collenettei* situation, these two organisms are unlikely to be transported by birds, aerial or sea currents, migration, or man and require a geologic explanation instead.

Because of the high degree of differentiation of *L. collenettei* compared with most other libytheid species, it must have been isolated for quite some length of time. The geological interpretation possibility will be explored here.

South Pacific Tectonics

During Paleocene and Eocene time (65 to 37.5 m.y. B.P.), a major reorganization of global plate motion occurred (Rona and Richardson 1978). This produced an 8000 km NW–SE trending Emperor fracture zone system that split the Pacific plate and accumulated 1700–1900 km of dextral offset between the two halves (Farrar and Dixon 1981). This model realigns the Marquesas Islands with the south end of the Line Islands 65 m.y. ago. The average maximum volcanism age recorded for the northern Line Islands is 81–83 m.y. B.P. with an oldest date of 93.4 m.y. (Jarrard and Clague 1977; Schlanger et al. 1984), thus possibly the oldest volcanic age for the Marquesas Islands as well. I have postulated that 81.5 m.y. ago was the minimum age that *Libythea geoffroy* extended to easternmost Gondwanaland based on a zoogeographical analysis (Shields 1985). The high degree of individual island endemism in plants; certain groups like flat-worms, land snails, and atyid decapods; and the presence of granite and gneiss, hanging valleys, high waterfalls, and exceptionally deep canyons favor a continental origin for the Marquesas (Chubb 1930; Mumford 1936). Thus the K-Ar dated volcanics (3.02–4.22 m.y.) for Nukuhiva (Duncan and McDougall 1974) probably overlie and conceal older rocks. Nukuhiva itself is situated on 51 m.y. old ocean crust (Crough and Jarrard 1981, fig. 2).

The Marquesas fracture zone dextrally offsets the Marquesas Islands from the north end of the Tuamotu and Society Islands by ca. 2000 km (Meyerhoff and Meyerhoff 1974, fig. 33; Duncan and Compston 1976, fig. 1). Tahiti is unusual for Pacific islands in yielding K-Ar ages of 147 $\pm$ 2 and 156 $\pm$ 15 m.y.; no fossiliferous formations older than Cretaceous are known for other Pacific islands (Krummenacher and Noetzlin 1966). Continental rocks are known for the Marquesas, Society, and Tonga Islands (Shields 1976a). The Tuamotu Islands, however, are no older than 53.5 m.y. (Jarrard and Clague 1977). In Sr, Pb and Nd ratios, the Marquesas are particularly comparable to the data of the Society Islands and may have originated from similar sources (Vidal et al. 1984). The Marquesas fracture zone terminated near the Tonga Islands slightly before 76 m.y. ago (Winterer 1976, fig. 4). Thus 81.5 m.y. ago, the Line, Marquesas, and Society Islands would have coalesced at the present location of the Tonga Islands at "The Elbow."

Restoring the Marquesas adjacent to the Tonga Islands brings the Marquesas to a position along the Tethyan Shear Zone (Wilson 1963, figs. 1, 2). The western Pacific andesite line is sinistrally offset ca. 7000 km by this shear zone (see Stiasny 1939; Sugisaki 1972, fig. 1). Realigning the Tonga Trench andesite line with the Yap and Philippine Trench andesite line would finally place the Marquesas *L. collenettei* adjacent to Halmahera, etc., where *L. geoffroy batchiana* occurs today. This andesite line separates continental from oceanic crust (Hedervari 1972). Andesites do occur in the Tonga Islands (Sugisaki 1972). Seafloor spreading in the Southwest Pacific marginal basins took place during the Cenozoic and thus is compatible with this reconstruction (see Falvey 1975; Weissel 1977; Carney and Macfarlane 1978; Weissel and Watts 1979; Kroenke and Eade 1982).

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Accepted for publication 25 August 1986.

Erratum: Figure 12 in the article entitled "Rediscovery of *Radiocentrum avalonense* (Hemphill in Pilsbry, 1905) (Gastropoda: Pulmonata)" by F. B. Hochberg, Jr., Barry Roth, and Walter B. Miller (Bull. S. Calif. Acad. Sci. 86(1):8) has a misspelling in one of the desert names. The correct spelling should be Chihuahuan Desert.

INSTRUCTIONS FOR AUTHORS

The BULLETIN is published three times each year (April, August, and November) and includes articles in English in any field of science with **an emphasis on the southern California area**. Manuscripts submitted for publication should contain results of original research, embrace sound principles of scientific investigation, and present data in a clear and concise manner. The current AIBS *Style Manual for Biological Journals* is recommended as a guide for contributors. Consult also recent issues of the BULLETIN.

MANUSCRIPT PREPARATION

The author should submit *at least two additional copies with the original,* on 8½ × 11 opaque, nonerasable paper, double spacing the entire manuscript. ***Do not break words at right-hand margin anywhere in the manuscript.*** Footnotes should be avoided. **Manuscripts which do not conform to the style of the BULLETIN will be returned to the author.**

An abstract summarizing in concise terms the methods, findings, and implications discussed in the paper *must* accompany a *feature article. Abstract should not exceed 100 words.*

A feature article comprises approximately five to thirty typewritten pages. Papers should usually be divided into the following sections: abstract, introduction, methods, results, discussion and conclusions, acknowledgments, literature cited, tables, figure legend page, and figures. Avoid using more than two levels of subheadings.

A research note is usually one to six typewritten pages and rarely utilizes subheadings. Consult a recent issue of the BULLETIN for the format of *notes.* Abstracts are not used for notes.

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Taxonomic procedures: Authors are advised to adhere to the taxonomic procedures as outlined in the International Code of Botanical Nomenclature (Lawjouw et al. 1956), the International Code of Nomenclature of Bacteria and Viruses (Buchanan et al. 1958), and the International Code of Zoological Nomenclature (Stoll et al. 1961). Special attention should be given to the description of new taxa, designation of holotype, etc. Reference to new taxa in titles and abstracts should be avoided.

The literature cited: Entries for books and articles should take these forms.

McWilliams, K. L. 1970. Insect mimicry. Academic Press, vii + 326 pp.

Holmes, T. Jr., and S. Speak. 1971. Reproductive biology of *Myotis lucifugus.* J. Mamm., 54:452–458.

Brattstrom, B. H. 1969. The Condor in California. Pp. 369–382 *in* Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii + 635 pp.

Tables should not repeat data in figures (line drawings, graphs, or black and white photographs) or contained in the text. The author must provide numbers and short legends for tables and figures and place reference to each of them in the text. Each table with legend must be on a separate sheet of paper. All figure legends should be placed together on a separate sheet. **Illustrations and lettering thereon should be of sufficient size and clarity to permit reduction to standard page size**; ordinarily they **should not exceed 8½ by 11 inches** in size and after final reduction lettering must equal or exceed the size of the typeset. All half-tone illustrations will have light screen (grey) backgrounds. Special handling such as dropout half-tones, special screens, etc., must be requested by and will be charged to authors. **As changes may be required after review, the authors should retain the original figures in their files until acceptance of the manuscript for publication.**

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A cover illustration pertaining to an article in the issue or one of general scientific interest will be printed on the cover of each issue. Such illustrations along with a brief caption should be sent to the Editor for review.

PROCEDURE

All manuscripts should be submitted to the Technical Editor, Jon E. Keeley, Biology Department, Occidental College, 1600 Campus Road, Los Angeles, California 90041. **Evaluation of a paper** submitted to the BULLETIN begins with a critical reading by the Editor; several referees also check the paper for scientific content, originality, and clarity of presentation. Judgments as to the acceptability of the paper and suggestions for enhancing it are sent to the author at which time he or she may be requested to rework portions of the paper considering these recommendations. The paper then is resubmitted and may be re-evaluated before final acceptance. **Authors are requested to submit the names, addresses and specialities of three persons who are capable of reviewing the manuscript.**

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CONTENTS

COVER: Population of healthy *Strongylocentrotus purpuratus* in deep lower shore pool in the path of a flash flood on the rocky shore at Corona del Mar, California. Photo from Mark M. Littler and Diane S. Littler.