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The Ecology of *Cyclocardia ventricosa* (Gould, 1850) (Bivalvia: Carditidae) on the Southern California Borderland

by

GILBERT F. JONES AND BRUCE E. THOMPSON[1]

Department of Biological Sciences, University of Southern California,
Los Angeles, California 90089, U.S.A.

Abstract. The pelecypod *Cyclocardia ventricosa* (Gould, 1850) is a widely distributed member of the benthos of the southern California borderland. It is particularly prominent in three borderland habitats: the northern portion of the mainland shelf (Point Conception to Pitas Point); the slope adjacent to the central portion of the mainland shelf (Mugu Submarine Canyon to Dana Point), and the shelf of San Miguel and Santa Rosa islands. Its depth range on the borderland was 14 to 574 m, but 75% of the locations where it was collected were in depths of 200 m or less. Within the *Amphiodia-Cyclocardia* community on the northern portion of the mainland shelf, the dispersion of *C. ventricosa* was aggregated; elsewhere, where densities were lower, randomness characterized its distribution. Aggregated dispersion may be a function of the mode of reproduction of this species, which broods its young rather than having planktonic larvae. *Cyclocardia ventricosa* is associated with a diverse array of macrofaunal taxa which differ markedly from one habitat to another.

INTRODUCTION

THE PELECYPOD *Cyclocardia ventricosa* (Gould, 1850) is a prominent faunal element of the benthos of the southern California borderland. It has been collected in most of the major quantitative studies of the benthic macrofauna of this area (AHF:USC, 1965; HARTMAN, 1955, 1956, 1963, 1966; FAUCHALD, 1971; FAUCHALD & JONES, 1979a, b, 1983). The purpose of this paper is to review these findings and to document the distribution, abundance, spatial and temporal variation, feeding, reproduction and size distribution, and faunal associates of *C. ventricosa* in the region.

The present paper is based on data gathered during three major studies of the benthos of southern California. The Allan Hancock Foundation Survey of the Southern California Mainland Shelf (the State Project) was conducted between 1956 and 1961 (AHF:USC, 1965). This comprehensive survey was supported by the California State Water Pollution Control Board (now termed the State Water Quality Control Board) and the late Captain G. Allan Hancock. The two other major studies of the benthos of southern California were funded by the Bureau of Land Management: the Baseline Study (1975-1976) and the Benchmark Study (1976-1977). These two studies together are the largest investigations ever made in this marine region (FAUCHALD & JONES, 1979a, b, 1983).

[1] Current address: Southern California Coastal Water Research Project, 646 W. Pacific Coast Highway, Long Beach, California 90806, U.S.A.

MATERIALS AND METHODS

During the State Project, deep-water samples were collected aboard the research vessel *Velero IV* by a modified Hayward standard orange-peel bucket (OPB) with an areal coverage of about 0.25 m^2. The nearshore portion of the shelf was sampled from the motor launch of the R/V *Velero IV* using a $\frac{1}{10}$-m^2 Van Veen grab. The animals collected were limited by the size of the mesh, 1-mm, through which the sediment was screened aboard ship before preservation and sorting (AHF:USC, 1965; JONES, 1967, 1969).

Quantitative determinations were based on 335 OPB samples completely analyzed for all molluscan specimens larger than 1 mm from depths of 14 to 480 m (mean = 93.0 m). Van Veen grab samples were collected at 121 nearshore locations, in depths of 2.4 to 10.1 m (mean = 6.7 m).

In both the Baseline and Benchmark studies, samples were collected with a modified, $\frac{1}{16}$-m^2, USNEL-Reineck spade (or box) corer (HESSLER & JUMARS, 1974) aboard the R/V *Velero IV* and the R/V *Thomas G. Thompson*. A subsample of each core was removed for sedimentary analysis. Benthic samples were screened through 1.0-mm and 0.5-mm stainless-steel screens using the "overflow-barrel method" (FAUCHALD & JONES, 1983). The benthic macrofaunal invertebrates were narcotized for 20 min in 6% magnesium chloride in seawater prior to killing and fixation; specimens were killed and fixed in 10% buffered seawater-formalin; after 36 h, samples were transferred to 70% ethanol for preservation.

A rapid identification procedure was used to analyze the benthic samples (FAUCHALD & JONES, 1983). Some taxa were identified to the specific level, whereas others were identified only to the familial or generic level under the limitations of this method. All taxa were identified to species (where possible) for 165 of the 712 samples collected during the Baseline Study and for all of the 318 samples collected during the Benchmark Study.

The diet and mineral particle-size range used by *Cyclocardia ventricosa* were analyzed (THOMPSON, 1982). The gut contents of six specimens were examined microscopically (10–1000×) and the material categorized into five food groups: (1) detrital aggregates, (2) single mineral particles, (3) particulate organic material, (4) animal remains, and (5) Foraminifera. The proportion of each of the food groups in total sample volume was estimated visually to the nearest 10%. The sizes of mineral particles ingested were measured to the nearest 10 μm.

The spatial dispersion of *Cyclocardia ventricosa* was determined using an Index of Dispersion (FISHER, 1970; JUMARS, 1975).

The macrofaunal associates of *Cyclocardia ventricosa* on the slope adjacent to the central portion of the mainland shelf and the insular shelf were determined by classification analysis of the Baseline Study data. For this inverse classification, in which species were grouped according to their distribution among stations, the Bray-Curtis Index (BRAY & CURTIS, 1957) was used as the measure of ecological distance (SMITH, 1976). For the taxa associated with *C. ventricosa* in the *Amphiodia-Cyclocardia* community those listed in this paper are from table 9 of BARNARD & ZIESENHENNE (1961).

Sedimentary analyses were made by geologists at California State University, Northridge (Baseline Study) and University of California, Los Angeles (Benchmark Study).

The benthic macrofauna was sampled at over 700 locations during the Baseline Study; 546 of these sampling locations were grouped in 11 regular grids termed High Density Sampling Areas (HDSAs) and varying in size from 16 to over 100 sampling stations. Within these grids stations were arranged on 1.7-km (1-nautical mile) centers. Four of these HDSAs were on the mainland shelf and its slopes, one on the Santa Catalina Ridge, two on the insular shelf of the Channel Islands, and four on the Santa Rosa-Cortes Ridge.

During the Benchmark Study, replicate sampling was conducted at 21 sampling stations in six areas of the borderland: off Coal Oil Point and the slope of the Santa Barbara Basin (3 stations); off San Pedro, on the slope of the San Pedro Basin and within the basin (6 stations); south of San Miguel Island (2 stations); south of Santa Rosa Island (1 station); on the northern portion of the Santa Rosa-Cortes Ridge south of Santa Rosa Island, the slope of Santa Cruz Basin, and within the basin (3 stations); and on the southern portion of the Santa Rosa-Cortes Ridge, including Tanner Bank, the slope of San Nicolas Basin, and within the basin (6 stations). Sampling was conducted twice during the year, once in the period of low water temperature (early spring) and once in the period of high water temperature (early fall). Eight replicate samples were collected at each station during each sampling period.

RESULTS AND REVIEW

Geographic Distribution

The type locality of *Cyclocardia ventricosa* is Puget Sound, Washington (COAN, 1977). COAN (1977) indicated that the range of this species is from Kasitsna Bay, Cook Inlet, Alaska, south to Punta Rompiente, Baja California Sur.

Cyclocardia ventricosa is distributed throughout the borderland where it is a faunal element of several major habitats (Figure 1). With the ophiuroid *Amphiodia urtica*, *C. ventricosa* co-dominates a major faunal assemblage on the northern portion of the mainland shelf; this community inhabits about 11% of the area of the mainland shelf. To the south *Cyclocardia ventricosa* becomes increasingly more important as a member of the slope assemblages and less important as a member of the biota of the mainland shelf (BANDY, 1958; FAUCHALD & JONES, 1983). It is a frequent and abundant member of the benthos on the insular shelf of the outer Channel Islands: the shelf of San Miguel and Santa Rosa islands. Although it occurs on the ridge north of Santa Catalina Island, the Santa Rosa-Cortes Ridge, and Tanner Bank, it is neither frequent nor abundant on the ridges and banks. It was reported from one deep basin, the San Pedro Basin, but this single specimen probably does not represent a resident population (FAUCHALD & JONES, 1979b).

Cyclocardia ventricosa was collected at 75 (16%) of the 456 locations sampled during the State Project. Population densities ranged from 4 to 388 per m^2 (mean = 72/m^2). During the Baseline Study it was collected at 85 (11.9%) of 712 stations. Densities were highest on the northern portion of the mainland shelf—mean, 179.4/m^2 (range, 40–329/m^2)—but were similar on the slope adjacent to the central portion of the mainland shelf—41.6/

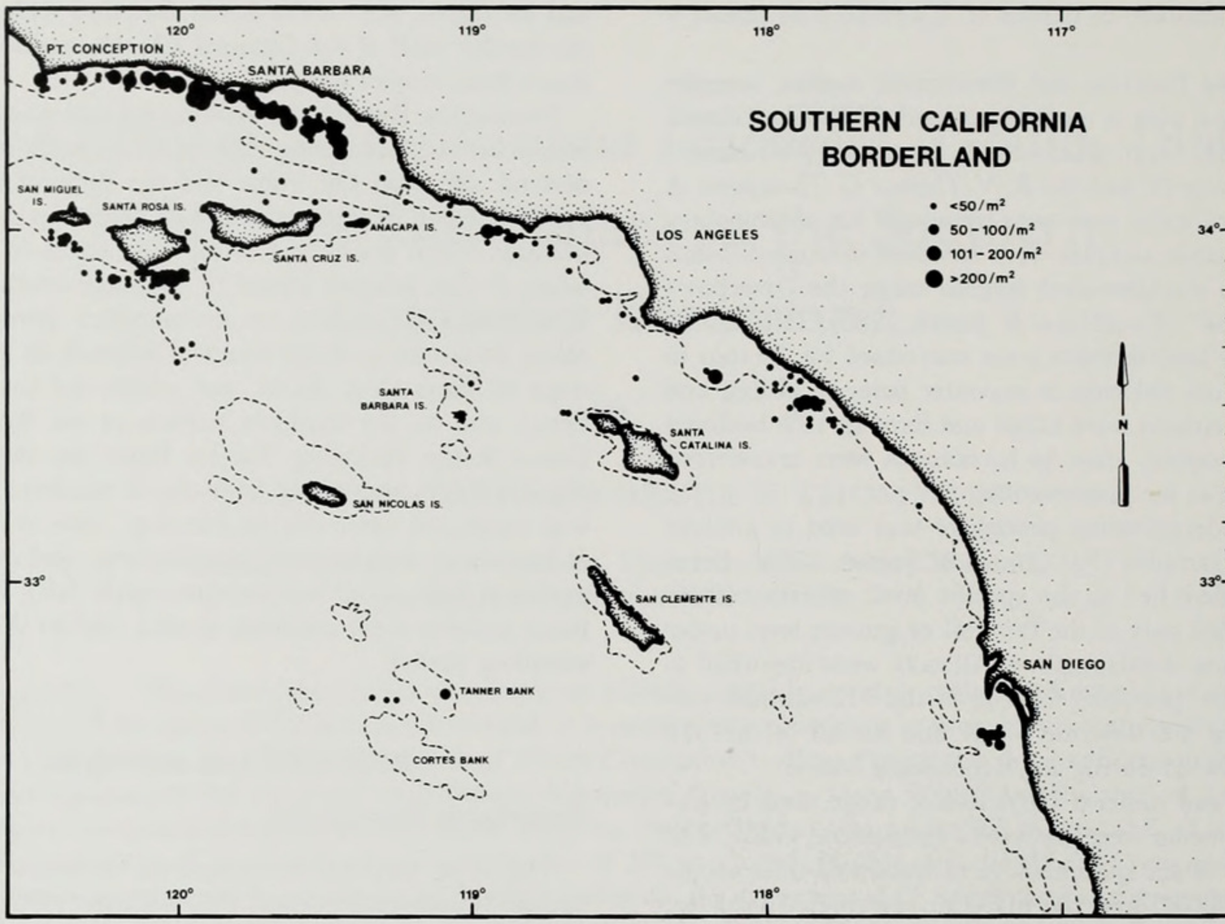

Figure 1

Chart of southern California borderland showing locations where *Cyclocardia ventricosa* was collected. Circle size reflects population density (see legend).

m^2 (range, 16–128/m^2)—and the insular shelf—40.7/m^2 (range, 16–272/m^2) (Table 1).

The northern portion of the mainland shelf is an equilibrium environment[2] only slightly altered by human activities. Except for areas of rock and relic sediments, sediments in this area are finer, lower in calcium carbonate, and higher in total organic content than on the insular shelf. Neither strong currents nor major upwelling are important factors in the area except near Point Conception. Slopes are characterized by sediment instability. Sediment is frequently transported downslope by turbidity currents or mass sediment flows creating unstable conditions. The insular shelf of the outer Channel Islands is primarily a nondepositional environment. Relatively strong currents result in winnowing of finer detrital sediments and the development of ripple marks. Sediments are frequently coarse and relatively high in calcium carbonate content. The area may be influenced by the persistent upwelling centers of the Point Conception area (EMERY, 1960; FISCHER *et al.*, 1983; R. C. DUGDALE, personal communication).

[2] An equilibrium environment is one in which deposition and erosion are balanced.

Distribution by Depth

Cyclocardia ventricosa inhabits primarily the shallower parts of the continental borderland in depths ranging from 14 to 574 m (Figure 2). Seventy-five percent of the stations where *C. ventricosa* was collected were in water depths of 200 m or less, with highest densities in depths less than 100 m (mean depth, 93 m). Mean depths varied by area: northern portion of the mainland shelf, 78 m; the insular shelf, 147 m; and the slope, 410 m (Table 1).

Distribution in Relation to Sediments

Sediments where this species was most frequent and abundant were coarsest on the insular shelf (average mean *phi* = 3.4; range, 1.4–4.4), were intermediate on the northern portion of the mainland shelf (average mean *phi* = 4.1; range, 3.3–5.4), and were finest on the slope adjacent to the central portion of the mainland shelf (average mean *phi* = 5.0; range, 3.6–7.2) (Table 1). An important difference between the insular shelf environment and the mainland shelf and its slopes is that the calcium carbonate content of the island shelves is much higher (23% compared to 2.8 and 2.9%).

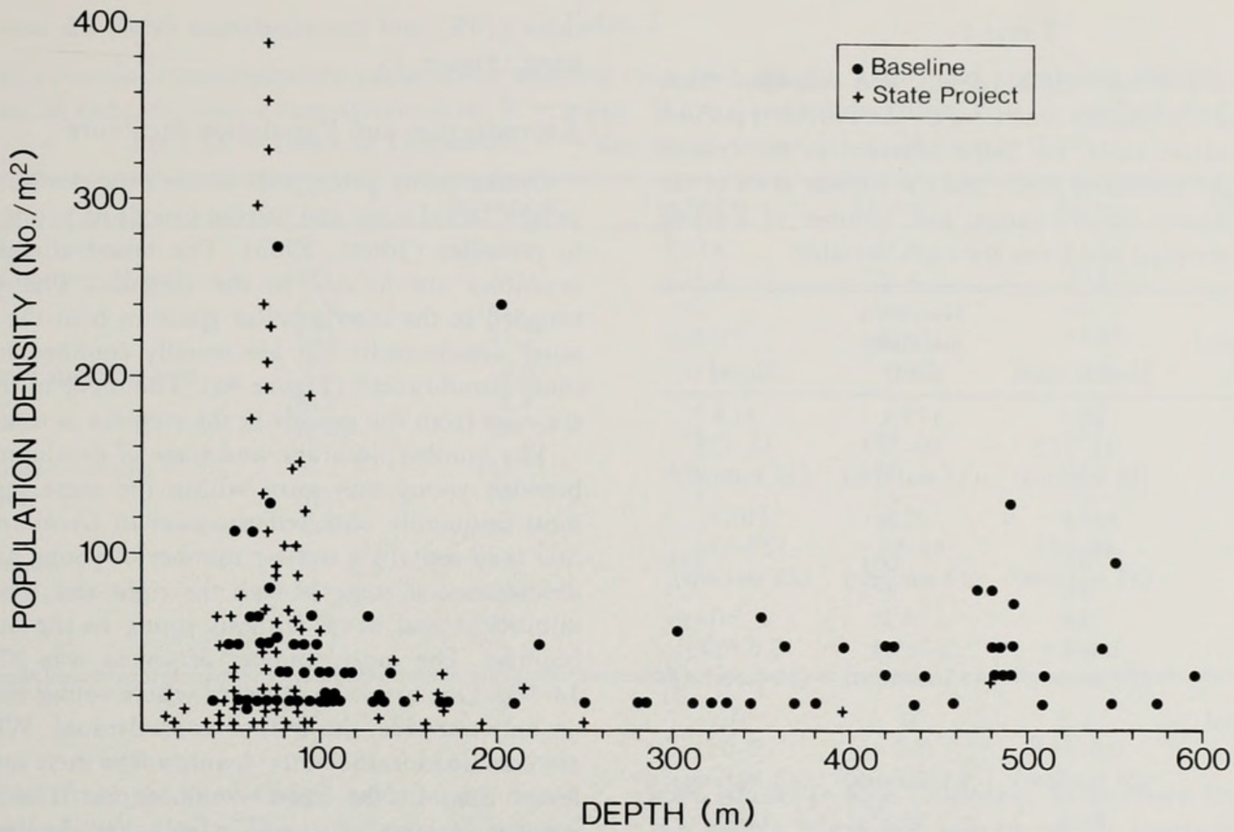

Figure 2

Depth distribution of *Cyclocardia ventricosa* on the continental borderland of southern California. The symbol (+) indicates the distribution of the samples collected during the State Project and the symbol (●) indicates the samples collected during the Baseline Study.

Temporal and Spatial Variation

Limited information is available on the temporal variation of *Cyclocardia ventricosa* populations. Only a single-year sequence was analyzed in each study (the State Project, Jones, 1964; AHF:USC, 1965; and the Benchmark Study, Fauchald & Jones, 1979b).

During the State Project 36 seasonal samples were collected at a nine-station grid within the *Amphiodia-Cyclocardia* community. The grid was located about six miles (9.7 km) offshore at a depth of 270 feet (93.9 m). Each grid consisted of three lines of three stations approximately 300 m apart. Sampling was conducted in September 1958, December 1958, March 1959, and June 1959.

A total of 1286 specimens of *Cyclocardia ventricosa* was collected in these samples, representing a mean population density of 144/m^2 (range, 0–268/m^2). Densities for each seasonal sample-set were fairly consistent: 124 to 156/m^2. However, within sample-set variation was substantial, as indicated by the ranges, standard deviations, and coefficients of variation (Table 2).

Cyclocardia ventricosa accounted for half of the total standing crop of the community (based on the grid sample annual means, 52.4 of 103.2 g/m^2). The mean standing crop values were nearly the same for each of the four seasonal sample-sets, 50.8 to 61.6 g/m^2 or 45 to 64% of the total standing crop.

The other community dominant, the smooth, red ophiuroid *Amphiodia urtica,* had a mean density of 144/m^2 (range, 12-232). The mean density in December (172/m^2) was the highest and the density in June (96/m^2) was the lowest. Ophiuroid standing crop (principally *A. urtica*) ranged from 0.8 to 16.8 g/m^2 with an annual mean of 7.2 g/m^2.

During the Benchmark Study, replicate samples were collected seasonally (winter and summer) at selected sampling locations (Table 3). Stations where *Cyclocardia ventricosa* was collected were located off Coal Oil Point (the northern portion of the mainland shelf), off San Pedro (the central portion of the mainland shelf), and south of San Miguel Island (the insular shelf). Generally, population densities were higher in the winter than in the summer. At two locations, one on the slope off San Pedro (Benchmark Station 827) and the other on the slope off Coal Oil Point (Benchmark Station 803), *C. ventricosa* was absent in the summer samples.

Within the *Amphiodia-Cyclocardia* community *C. ventricosa* had an aggregated dispersion pattern (Table 2). In other areas—the margin of the community (Benchmark Station 801), the insular shelf (Benchmark Station 806) and the slope adjacent to the mainland shelf (Benchmark Stations 803, 825, and 827)—eight of ten sample-sets exhibited insignificant departure from random dispersion (Table 3). The two exceptions were the summer sample-

Table 1

A comparison of the habitat, depth, and sediment characteristics of *Cyclocardia ventricosa* on the northern portion of the mainland shelf, the slope adjacent to the central portion of the mainland shelf, and the insular shelf of the Channel Islands. Mean, range, and number of stations sampled are given for each variable.

Environmental variable	Insular shelf	Northern mainland shelf*	Slope†
Number/m^2	40.7 16–272 (35 stations)	179.4 40–329 (13 stations)	41.6 16–128 (25 stations)
Depth (m)	147.0 48–472 (35 stations)	77.6 64–94 (13 stations)	410.2 127–594 (25 stations)
Mean *phi*	3.4 1.4–4.4 (28 stations)	4.1 3.3–5.4 (13 stations)	5.0 3.6–7.2 (18 stations)
Percent gravel	1.2 0.0–28.0 (28 stations)	0 0–0 (13 stations)	0 0–0 (18 stations)
Percent sand	83.0 54.0–94.0 (28 stations)	39.5 1.0–71.6 (13 stations)	18.8 1.0–73.0 (18 stations)
Percent silt	15.3 4.0–36.0 (28 stations)	49.7 19.2–91.1 (13 stations)	57.6 19.0–78.0 (18 stations)
Percent clay	4.0 2.0–11.0 (28 stations)	10.0 6.5–20.1 (13 stations)	18.2 5.0–33.0 (18 stations)
Percent $CaCO_3$	23.0 10.4–49.4 (28 stations)	2.8 1.1–8.2 (13 stations)	2.9 1.3–8.5 (12 stations)

* Thirteen representative samples collected from the *Amphiodia-Cyclocardia* community; State Project Data (BARNARD & ZIESENHENNE, 1961; AHF:USC, 1961).

† Slope = the slope adjacent to the central portion of the mainland shelf.

set at Station 806 and the winter sample-set at Station 803.

Mode of Life and Diet

Our observations of *Cyclocardia ventricosa* are consistent with those of YONGE (1969). In the laboratory *C. ventricosa* remains at the sediment-water interface only partially buried in the sediments, anterior end downward and valves partially separated. We suggest that this species obtains its food either from the sediment surface or the water column.

THOMPSON (1982) has described the diet of *Cyclocardia ventricosa.* The largest proportion of the gut contents of six specimens was detritus (detrital aggregates = 71%); the remainder of the contents included single mineral particles (19%) and foraminiferans (8%); 2% was not identified (Figure 3).

Reproduction and Population Structure

Unlike many pelecypods *Cyclocardia ventricosa* lacks a pelagic larval stage and instead broods its young from eggs to juveniles (JONES, 1963). The brood chambers of *C. ventricosa* are located in the ctenidia. The young are brooded in the interlamellar space in both the inner and outer demibranchs but are usually confined to only the inner demibranchs (Figure 4a). The mode of transport of the eggs from the gonads to the ctenidia is unknown.

The number, location, and stage of development of the brooded young may vary within the same female. The most frequently observed situation in *Cyclocardia ventricosa* is to contain a similar number of young at a similar developmental stage in both the right and left inner demibranchs and to be without young in the outer demibranchs. The mean number of young was 37.3 (range, 14–93). One case was observed where young were present on only one side, the left, of an individual. When young are contained in the outer demibranchs their numbers are fewer than in the inner demibranchs. The maximum number of brooded young in an outer demibranch was 12, while the inner demibranchs of the same specimen contained about 50 young each. No females were observed in which young were present in the outer demibranchs without also being present in the inner demibranchs.

Although different developmental stages may occur in the inner and outer demibranchs of the same individual, young within a single demibranch were always at the same stage of development. Differences between the right and left ctenidia were not observed. Females of *Cyclocardia ventricosa* from the same sample may contain young at very different stages of the developmental cycle.

Figure 4b is an illustration of the young of *Cyclocardia ventricosa* showing D-shaped differentiation of prodissoconch I and II and the initiation of the dissoconch with radial sculpture, and is typical of the most mature stage of brooded young.

Maternal care may be extended beyond brood protection. In a number of samples very young "free-living" specimens were observed to be attached to adults by byssal threads.

Reproducing females of *Cyclocardia ventricosa* were collected in all months of the year except June. Inasmuch as females may brood young of more than one developmental stage, and females from the same sample may have young of very different stages of development, it may be assumed that *C. ventricosa* reproduces continuously in southern California. The minimum size of females with brooded young is 10 mm. If males are sexually mature at this size, then the reproducing population would be nearly half (47%) of the population (JONES, 1964).

A size-frequency distribution was constructed for *Cyclocardia ventricosa* based on the 1286 specimens collected

Table 2

Amphiodia-Cyclocardia intracommunity variation in standing crop (wet weight, g/m^2) and population density (number/m^2) based on 36 samples from a nine-station grid: $\bar{X}$ = mean; SD = standard deviation; C.V. = coefficient of variation; and I.D. = Index of Dispersion. * = significant values ($\chi^2 \geq 20.1$), $\alpha = 0.01$.

		September	December	March	June	All seasons
Cyclocardia ventricosa	$\bar{X}$	57.2	50.8	61.6	51.2	52.4
Standing crop (g/m^2)	SD	34.0	31.2	22.4	20.8	30.0
	C.V.	61	52	43	40	58
	I.D.	71.2*	96.0*	40.6*	94.8*	—
Ophiuroid standing crop	$\bar{X}$	6.0	11.6	6.4	5.2	7.2
(g/m^2)	SD	2.4	2.8	3.2	2.4	3.6
	C.V.	27	24	42	63	44
Cyclocardia ventricosa	$\bar{X}$	148	140	156	124	144
(number/m^2)	SD	76	72	56	76	68
	C.V.	52	54	37	63	50
Amphiodia urtica	$\bar{X}$	144	172	160	96	144
(number/m^2)	SD	36	32	56	48	52
	C.V.	29	19	37	51	38
	I.D.	21.8*	39.5*	10.9	18.6	—

in 36 samples from the nine-station grid on the Santa Barbara shelf (JONES, 1964). The result was an inverted pyramid with the <4-mm size class having the least number of individuals and the 10–12-mm size class having the most (Figure 5). This population structure may be the result of the brood protection method of reproduction in this species with significantly fewer young being produced than in species with pelagic larvae.

Macrofaunal Associates

Determination of the organisms associated with *Cyclocardia ventricosa* has been made for three dissimilar borderland habitats where it is frequent and abundant: the *Amphiodia-Cyclocardia* community on the northern portion of the mainland shelf, the slope adjacent to the central portion of the mainland shelf, and the southern insular shelf of San Miguel and Santa Rosa islands. *Cyclocardia ventricosa* lives with a large number of taxa that differ from habitat to habitat (Table 4).

Only one other species, the pelecypod *Acila castrensis,* was an inhabitant of all three environments. Three species were common to both the *Amphiodia-Cyclocardia* community and the slope: the polychaetes *Pectinaria californiensis* and *Paraprionospio pinnata* and the pelecypod *Adontorhina cyclia.* Only one species, the pelecypod *Psephidia* sp., was common to both the *Amphiodia-Cyclocardia* community and the island shelf. Except for *Acila castrensis* no species was common to both the insular shelf and the slope.

SUMMARY

The pelecypod *Cyclocardia ventricosa* is distributed along much of the length of the coast of western North America, from Alaska to Baja California. In southern California it is a widely distributed member of the benthos. It is particularly prominent in three dissimilar habitats: the northern portion of the mainland shelf, the slope adjacent to the central portion of the mainland shelf, and the insular shelf of the outer Channel Islands. Densities are highest by far (mean = 179.4/m^2) on the northern portion of the mainland shelf where *Cyclocardia* co-dominates an outer-shelf assemblage with the ophiuroid *Amphiodia urtica.* In the other two environments the mean densities of this species average only about 25% of the north shelf value. The environmental conditions of these three environments differ substantially. The northern shelf is an equilibrium

Table 3

Average densities ($\bar{X}$/m^2) and Indices of Dispersion (I.D.) and seasonal comparisons of *Cyclocardia ventricosa* at Benchmark Study sampling sites for the winter and summer of 1977. * = significant values (3 d.f.), $\alpha = 0.05$, indicates clumped distribution.

Location and station (depth)	Winter 1977 $\bar{X}$/m^2	Winter 1977 I.D.	Summer 1977 $\bar{X}$/m^2	Summer 1977 I.D.
Mainland shelf and slope; Coal Oil Point				
801 (68 m)	64	5.5	24	7.3
803 (503 m)	144	9.2*	0	—
Mainland shelf and slope; San Pedro Bay and slope				
825 (256 m)	20	5.4	20	0.6
827 (504 m)	8	2.0	0	—
Insular shelves				
806 (99 m)	64	5.0	72	8.2*

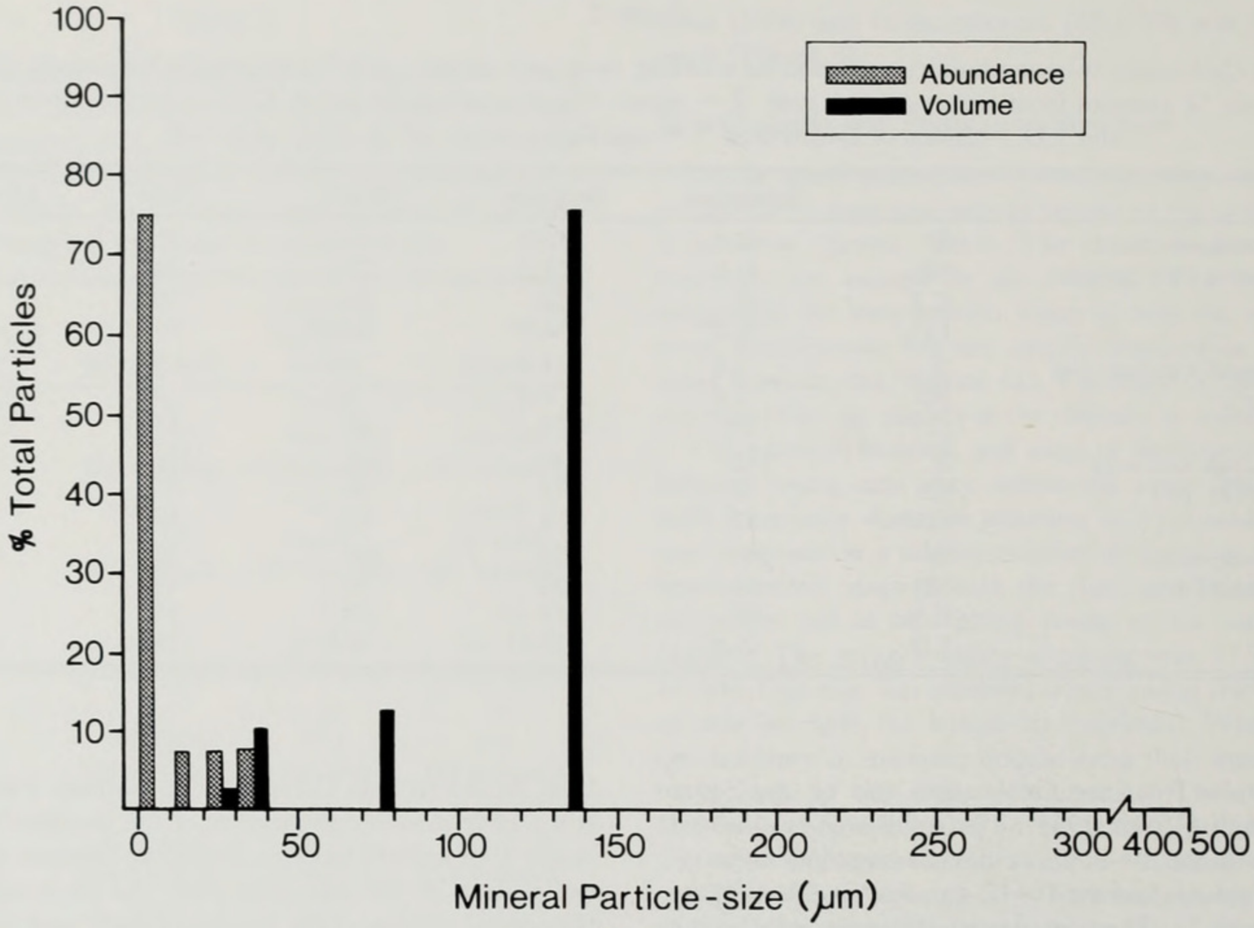

Figure 3

Average mineral particle-size distribution from guts of *Cyclocardia ventricosa.*

environment where deposition and removal of sediments are balanced. Sediments here are finer, lower in calcium carbonate and higher in total organic content than on the insular shelf. Unstable sediment conditions characterize the slope. In this environment, frequent transport downslope is caused by turbidity currents and mass sediment flows. Nondepositional environments characterize the insular shelf. Here relatively strong currents exclude the deposition of fine detrital sediments and lead to the development of ripple marks and the development of sediments with relatively high biogenic calcium carbonate. This area may be influenced by persistent upwelling.

The depth distribution of *Cyclocardia ventricosa* on the borderland was 14 to 574 m, but 75% of the locations where it was collected were in depths of 200 m or less.

Data are inadequate to make firm conclusions about the temporal variation of the population densities. Two estimates are available: one from the State Project and one from the Benchmark Study. Each represents observations from only a single year. The nine-station grid in the *Amphiodia-Cyclocardia* community on the northern portion of the mainland shelf sampled quarterly during the State Project revealed little seasonal variation; mean densities ranged from 124 to 156/m^2. During the Benchmark Study, densities were higher in the winter than in the summer at three locations, and at two sites on the slope *C. ventricosa* was absent in the summer.

A marked difference was evident in the spatial distribution of *Cyclocardia ventricosa.* Within the *Amphiodia-Cyclocardia* community its dispersion was aggregated. However, in the more marginal situations on the borderland, outside this community (the slopes adjacent to the mainland shelf and the insular shelf) where densities are lower, randomness characterized its distribution. Aggregation may be a function of the mode of reproduction of this species; brood protection and attachment of released young by byssal threads to the female parent might contribute to this mode of distribution. The areas where *C. ventricosa* distributions are random may be due to reduced reproductive activity.

Evidence suggests that *Cyclocardia ventricosa* lives at or near the sediment-water interface and feeds either in the water column or at the sediment surface or both. It may be classified as a filter feeder or surface deposit feeder but may functionally fill both roles.

Cyclocardia ventricosa is associated with a diverse array of macrofaunal associates in the three borderland habitats that were examined in detail. Prominent taxa associated with *C. ventricosa* varied considerably from location to location. Only one species, the pelecypod *Acila castrensis,*

Table 4

The macrofaunal associates of *Cyclocardia ventricosa* in three areas of the continental borderland: the northern portion of the mainland shelf, the slope adjacent to the central portion of the mainland shelf, and the insular shelf of the Channel Islands. Data for the northern portion of the mainland shelf from BARNARD & ZIESENHENNE, 1961, table 9.

Taxa	*Amphiodia-Cyclocardia* community	Slope*	Insular shelf
Polychaetes			
Aricidea sp.	X		
Chloeia pinnata	X		
Glycera capitata	X		
Onuphis sp.	X		
Pectinaria californiensis	X	X	
Pista sp.	X		
Prionospio steenstrupi	X		
Paraprionospio pinnata	X	X	
Sternaspis fossor	X		
Terebellides stroemi	X		
Travisia spp.	X		
Glycera branchiopoda		X	
Maldane glebifex		X	
Maldane sarsi		X	
Prionospio peruana		X	
Amphicteis scaphobranchiata			X
Asabellides lineata			X
Euchone sp.			X
Schistocomas hiltoni			X
Mollusks			
Acila castrensis	X	X	X
Adontorhina cyclia	X	X	
Axinopsida serricata	X		
Bittium subplanatum	X		
Mysella spp.	X		
Nucula spp.	X		
Psephidia sp.	X		X
Bathymedon roquedo		X	
Bittium paganicum		X	
Haliophasma geminata		X	
Limfossor fratulata		X	
Mitrella permodesta		X	
Alvinia rosana			X
Micronellum crebricinctum			X
Nemocardium centrifilosum			X
Nuculana hamata			X
Turbonilla (*Chemnitizia*) sp.			X
Crustacea			
Amelisca macrocephala		X	
Leucon subnasica		X	
Pseudomma berkeleyi		X	
Scleroconcha trituberculata		X	
Westwoodilla acutifrons		X	
Gnathia crenulatifrons			X
Melphisana bola			X
Pinnixa schmitti			X

Table 4 (Continued)

Taxa	*Amphiodia-Cyclocardia* community	Slope*	Insular shelf
Echinoderms			
Amphiodia urtica	X		
Amphipholis squamata	X		
Brisaster latrifrons		X	
Echiuroid			
Listriolobus hexamyotus		X	

* Slope = the slope adjacent to the central portion of the mainland shelf.

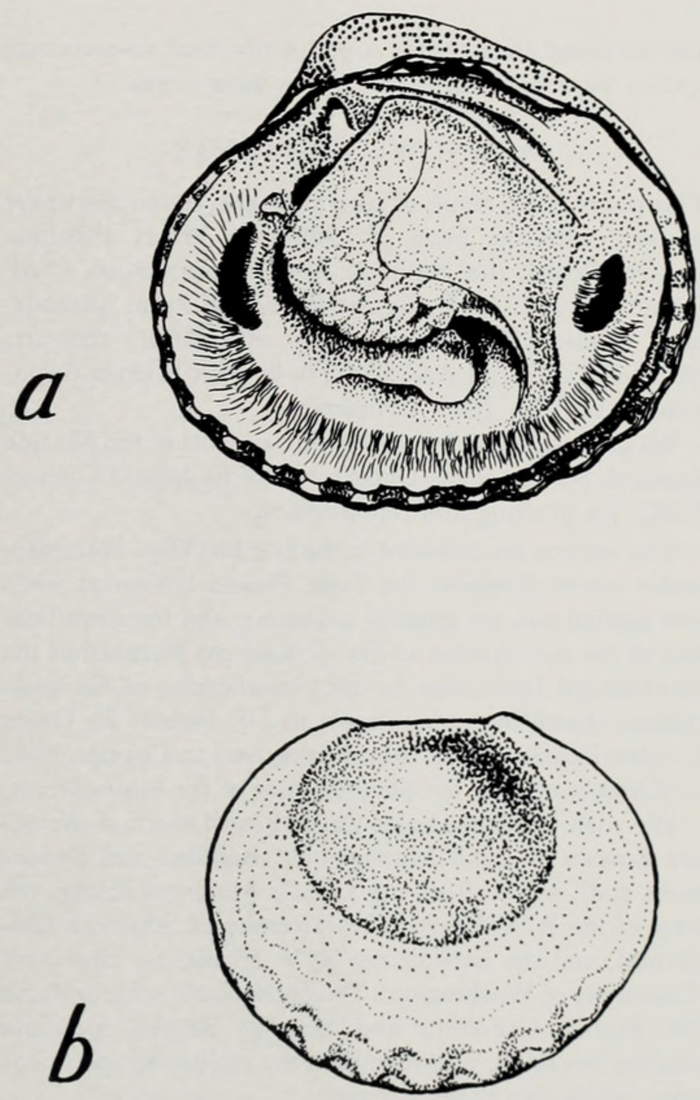

Figure 4

a. Adult female *Cyclocardia ventricosa* (Gould, 1850), with the left valve and mantle removed to show the inner demibranch with brooded young; length, 13.7 mm (after JONES, 1963). b. Young of *C. ventricosa* showing D-shaped differentiation of prodissoconch I and II and the initiation of the dissoconch with radial sculpture; length, 1.04 mm (after JONES, 1963).

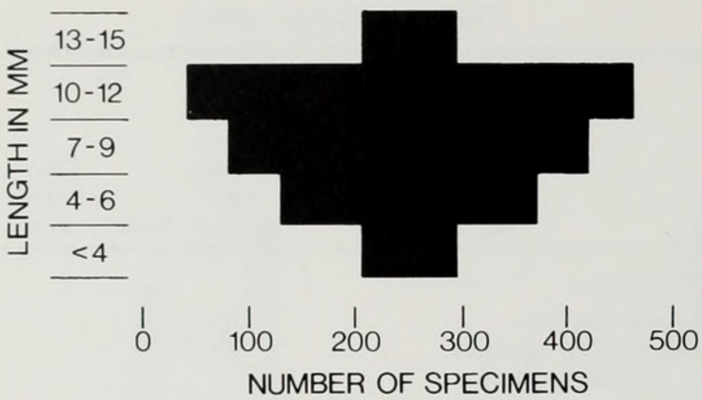

Figure 5

Pyramid graph showing the size distribution of *Cyclocardia ventricosa* in the *Amphiodia-Cyclocardia* community on the northern portion of the mainland shelf (based on length measurements of 1286 specimens from 36 OPG grid samples) (after JONES, 1964).

also occurred in all three areas. Only four co-occurring species were common to two of the three areas.

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