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ECOLOGY OF RECENT OSTRACODES OF THE TODOS
SANTOS BAY REGION, BAJA CALIFORNIA, MEXICO

By RICHARD H. BENSON



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PALEONTOLOGICAL CONTRIBUTIONS

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ECOLOGY OF RECENT OSTRACODES OF THE TODOS SANTOS BAY REGION, BAJA CALIFORNIA, MEXICO

By RICHARD H. BENSON

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ABSTRACT

Recent ostracodes (46 species, 31 genera) belonging to 6 principal biofacies were collected from an estuary, salt-water lagoon, and large open bay on the west coast of Baja California, 60 miles south of San Diego, California. These include a brackish-water biofacies, a salt-water lagoon and salt-marsh biofacies, and an open-bay mega-biofacies with 4 biofacies and a subfacies which are dependent on depth, vegetation, and substratum.

Living and dead ostracodes were collected and studied from 316 samples of the top 1 cm. of sediment at 170 stations. Depth ranges from supratidal to 215 fathoms in Todos Santos Bay, salinity from 0.5 parts per thousand (o/oo) in the Rio San Miguel estuary to 37 o/oo in the salt-water lagoon of the Estero de Punta Banda, and temperature from 50°F. in the deeper parts of the bay to 85°F. in the salt-water lagoon (estero). The substratum consists of rock, cobbles, coarse to fine sand to poorly sorted

very fine silt and clay, with the finer sediments predominant. The vegetation primarily comprises eel grass, coral-line algae, *Laminaria*, and *Macrocystis*.

Among the ostracodes 28 species belonging to 19 genera show sufficient ecologic restriction and stratigraphic range to be used as biofacies indicators in ancient sediments, several of the species ranging back into the Pliocene. Salinity and depth of water are the two factors that seem most to affect the distribution of ostracodes in the areas studied. The distribution of structural types of plants greatly influences the distribution of the ostracodes that live closely associated with them. Many forms reflect in their carapace morphology their life mode as living on or among plants (phytal), in or on sand bottom (endopsammon, epipsammon), and in or on mud bottom (endopelos, epipelos). The distribution of certain sediment types of the substratum can be correlated with the abundance as well as the character of some biofacies.

PART I. GENERAL DISCUSSION

INTRODUCTION

As stratigraphic investigations place increasing emphasis on lateral facies variation of ancient sediments, a need has developed for more critical examination of Recent processes and faunal distributions. Microfossils are widely used because they can be obtained undamaged and in quantity with modern drilling techniques. Ostracodes are found abundantly in most sedimentary rocks of aqueous origin from the Ordovician Period to the present and they have already been shown to be very useful as stratigraphic indices. The purpose of this investigation is to determine the factors that influence the distribution of Recent ostracode species in one area of known environment so that these ostracodes can later be used as biofacies indicators for the interpretation of past environments.

The large open Bahia de Todos Santos and its adjacent Estero de Punta Banda and the Rio San Miguel were chosen for this study because the invertebrate fauna is relatively undisturbed by man; they are easily accessible by land and display a wide variation of water depth, temperature, salinity, and bottom sediments over a short distance; and many of the ostracode species represented in the faunules have been previously described.

PREVIOUS STUDIES

ECOLOGY OF OSTRACODES

BRADY & ROBERTSON'S (1870) and BRADY'S (1870) reports on the Ostracoda and Foraminifera of tidal rivers in England were the first studies containing ecological data, and in 1872 BRADY & ROBERTSON gave a summary of the distribution of Recent British ostracodes. G. W. MÜLLER (1894) made the first thorough study of general ostracode ecology, modes of life, and detailed morphology of the Recent ostracodes in the Bay of Naples, Italy. G. O. SARS (1928) in his report on the Crustacea of Norway devoted most of his study to the morphology of the ostracodes but gave some data and opinions as to their habitat. However, a large percentage of these species are planktonic. PRATJE (1931) gave a summary of the relationships of ostracode species in gravelly sections of the north German coast. REMANE (1933, 1940) contributed a great deal of ecological information about ostracode species in his general report on the shallow-water marine organisms of the North and Baltic Seas. ELOFSON'S (1941) detailed study of the distribution of Swedish ostracode species in the Skagerak, Baltic Sea area, is the most exhaustive published study on the ecology of Recent ostracodes.

In 1952 ROME published a report on the ecology of many of MÜLLER'S (1894) species with a few new ones from the Mediterranean coast of Monaco. TRIEBEL (1941) compared ancient and modern forms to determine fossil ostracode orientation and commented on some phases of ecology. ROTHWELL (1948) published four abstracts on the ecology of Pacific Coast species. KUMMEROW (1949) pub-

lished two works, one on fossil brackish-water ostracodes, the other a review of development of German work on ostracodes; both of these were severely criticized by TRIEBEL (1950) for making serious mistakes by ignoring the studies on Recent ostracode ecology. SOHN (1951) published a summary of the salinity data from previous published studies which was later appended by HOWE (1952). HORNIBROOK (1952a) in his study of the Tertiary and Recent Ostracoda of New Zealand gives depth range and some data of ecologic value. RÖTTGART in 1952 published a study on the brackish-water ostracodes on the coast of Schleswig-Holstein, Germany. In a paleoecological study GOERLICH (1953) reported on the role of ostracodes as salinity indicators in the middle Oligocene and middle Miocene strata of Bavaria. Another study of fossil Miocene Ostracoda, in the eastern United States, was reported by DORIS MALKIN; it included a very brief summary of previous ecologic results and noted the need for additional information. The following year she and F. M. SWAIN began to study the ecology of the ostracodes of the northern coast of the Gulf of Mexico under the American Petroleum Institute Project 51, from which information has been made available but only the work done by SWAIN (1955) has been published. C. W. WAGNER (1957) described the ecology of many type species of important genera in the Low Countries. The description of these genera along with the work done by KEIJ (1957) has made the classification of many of the forms in the present work much easier.

RECENT OSTRACODES OF PACIFIC COAST

The first studies of ostracodes from the Pacific Coast were made by G. W. MÜLLER (1895), who described the morphology of two planktonic species from the western coast of Mexico and Central America. JUDAY (1906) described several planktonic species from near San Pedro, California, and later (1907) several littoral species from the San Diego area, none of which were seen in the Bahia de Todos Santos region. In 1928, SKOGSBERG published the description of several new species from tidal pools at Pacific Grove and Carmel Bay, California, of which two were found in Todos Santos Bay. VERNA Z. LUCAS (1931) reported 22 species of ostracodes from the Vancouver Island region, Canada. LEROY (1943) described the Pliocene and Pleistocene Ostracoda of Cali-

fornia, some of which are also found in Recent sediments of Avalon Bay, Santa Catalina Island, San Pedro Channel, and the Todos Santos Bay region. A brief ontogenetic study of several species of this faunule was added later (LEROY, 1945). ROTHWELL (1948) published two abstracts on the ecologic study of ostracodes in the samples collected by NATLAND (1933) from the San Pedro Channel and some of his own collection of live specimens from Newport Bay, California. In 1949 CROUCH published a brief taxonomic study on the Pliocene ostracodes of California. SKOGSBERG (1950) published descriptions of a few new species of planktonic Podocopa.

ACKNOWLEDGMENTS

The initial sample collecting was conducted from research vessels of the Scripps Institution of Oceanography of the University of California. Laboratory facilities were furnished by Scripps' Marine Foraminiferal Laboratory and the Geology Department of the University of Illinois.

The investigation was suggested by H. W. SCOTT, while I was a student at the University of Illinois and was carried to its conclusion under the direction of F. H. T. RHODES, now of the University of Wales, whose guidance and encouragement are greatly appreciated. Acknowledgment is also made to G. W. WHITE for constructive criticism; F. B. PHLEGER, under whose direction the field material was gathered; F. P. SHEPARD, whose cooperation made it possible for me to come to California; and P. C. SYLVESTER-BRADLEY for suggestions concerning taxonomy. R. C. MOORE has aided in shaping features of the text.

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DESCRIPTION OF STUDY AREA

TODOS SANTOS BAY

Todos Santos Bay is located about 60 nautical miles south of the boundary between the United States and Mexico on the Pacific Coast of the peninsula of Baja California, at latitude $31^{\circ}40'$ to $31^{\circ}56'$ N. and longitude $116^{\circ}36'$ to $116^{\circ}50'$ W. (Fig. 1). It has an area of about 90 square miles and is formed by a large indentation of the arid mountainous coastline. The bay is bounded on the south by the finger-like projection of Punta Banda

and guarded on the west by the two small Todos Santos Islands (Fig. 2).

NORTHERN COAST

Todos Santos Bay is bordered on the north by narrow beaches, terraces, and sea cliffs cut into Tertiary sediments and dioritic mountains. Just north of Punta San Miguel, bordering the northernmost side of the study area, are several very well-developed elevated marine terraces probably formed by eustatic changes in sea level during the

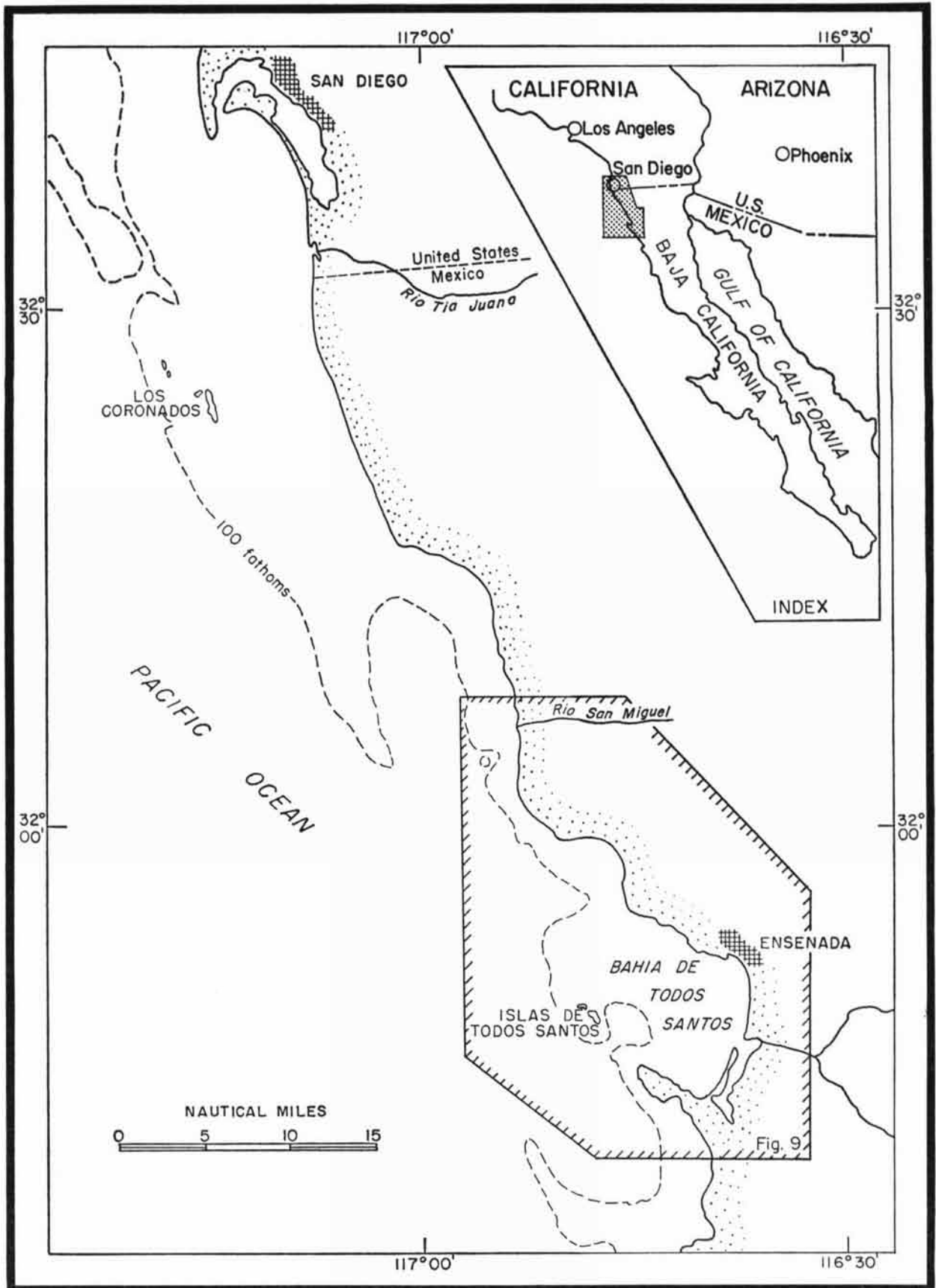


FIGURE 1. Location of the study area in Baja California 60 miles south of the United States-Mexico boundary on the Pacific Coast.

Pleistocene. These were not examined closely, but they appear to be relatively undisturbed structurally, which perhaps indicates that although earthquakes are quite common, no major structural displacement has occurred in the immediate area since at least early Pleistocene time.

From El Sauzal east to near Punta Morro, the beach is very narrow. It is formed by wave erosion cutting into the 20-foot high sea cliffs of interbedded Tertiary (Commodu Formation, BEALE, 1948, p. 74) marine sandstones and coarse alluvial conglomerates of the narrow piedmont. The coarse sand beach is littered with well-rounded cobbles and boulders.

The beach from Punta Morrow to Ensenada is rocky, with the strand cut close to the base of dioritic intrusive hills, probably the westward extension of the Ensenada Mountain complex. The beach is composed mainly of coarse sand or clean-washed rock with numerous small sea stacks. The piedmont laps around the western end but is very narrow. The algal growth is much thicker than it is farther west but not as luxuriant as that on the eastern side of the south Todos Santos Island.

EASTERN COAST

The northern half of the eastern coast of Todos Santos Bay, from the town of Ensenada to the mouth of the Estero de Punta Banda and the Rio San Antonio, consists of a very wide strand of a white well-sorted medium-sized sand beach. This is backed by a series of rather low dunes and a low tableland piedmont running up to the foot of the Ensenada Mountains, which reach an elevation of 3,654 feet within about 10 miles of the coast.

The Rio San Antonio is formed by the junction of the Rio San Carlos, which originates in the Ensenada Mountains, and the Rio Santa Clara, which forms a wide valley separating the Punta Banda and Ensenada ranges. This junction is only a few miles upstream from the point at which the Rio San Antonio enters the Estero de Punta Banda. Although the Rio San Antonio only has running water for a short time during the rainy season, it seems adequate, with the help of tidal currents, to keep the estero open to the sea at its mouth. The Rio Santa Clara drains a large arid area and its valley appears to be more structural than erosional. Baiadas are well developed along the valley side of the range that forms Punta Banda.

The southern half of the eastern coastline of the bay consists of a sand spit which originates at the foot of Punta Banda and projects northward to the entrance of the estero. The spit is 5 miles long and about half a mile wide at its widest point near the distal end. It is formed by the combined action of longshore currents running counter to the main clockwise current of the bay, and the tidal currents to and from the estero, helped intermittently by the discharge of the Rio San Antonio. The wind always present in this area at the change of day has formed small (10-foot) dunes, which are held in check by small clumps of short grasses.

SOUTHERN COAST

The southern boundary of Todos Santos Bay is formed by the finger-like projection of the high ridge of Punta Banda, caused by a range of mountains running normal to the general trend of the Baja California peninsula. It is probably the result of one of the many transverse faults characteristic of the Pacific Coast shoreline. This range's highest measured elevation is at Mt. Soledad (3,484 feet), a few miles to the southeast, and is 1,264 feet at its diamond-head end just before plunging into the 1,230-foot-deep submarine canyon that separates Punta Banda from the South Todos Santos Island. The coastline of Punta Banda on both the northern and southern shores is very irregular and rocky, with steep jagged sea cliffs, broken only locally by a few small crescent beach pockets, and terminating in numerous sea stacks.

The mountain ridge that forms Punta Banda is composed of a wedge of steeply dipping Upper Cretaceous sandstones and limestones, which have been described briefly by WHITE (1885), FAIRBANKS (1893), HENDERSON & HANNA (1933, p. 7), and correlated with the Chicago Group of California (BEALE, 1948, p. 42). This unit is separated by a fault midway along the northern side of Punta Banda from a horizontal reddish unfossiliferous fanglomerate which is possibly correlated with the Trabuco Formation in the Santa Ana Mountains to the north (HERTLEIN & GRANT, 1944, p. 39). This unit lies unconformably on a pre-Cretaceous diorite which is exposed in the sea cliffs. Several small rudistid reefs have been noticed by PHLEGER (personal communication) but have not been examined. The top of Punta Banda is truncated by an old beach terrace, which is cov-

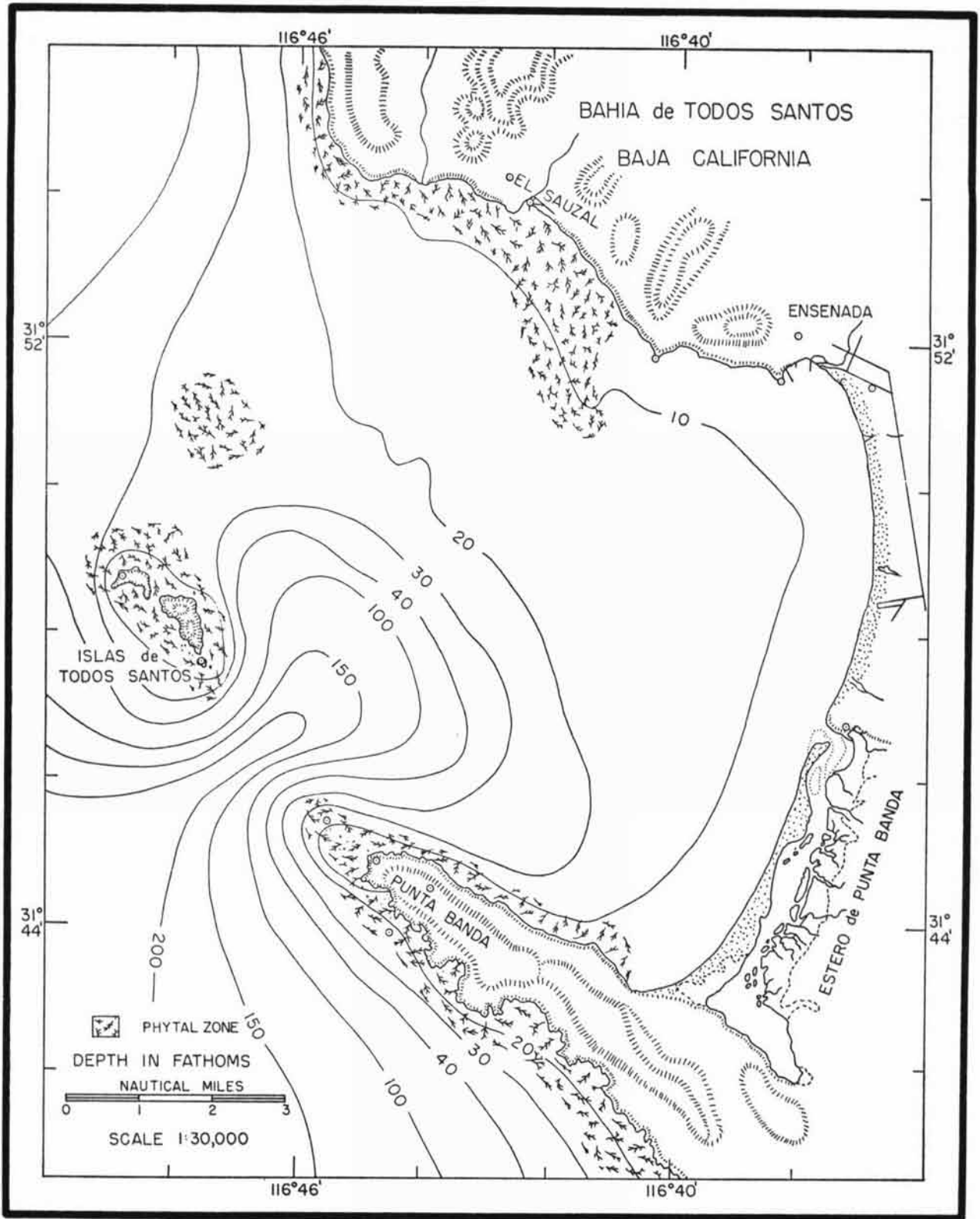


FIGURE 2. Bathymetry of Todos Santos Bay and distribution of attached plant life (mostly *Macrocystis* and *Laminaria*).

ered with alluvium, and exhibits a rounded topography.

TODOS SANTOS ISLANDS

Almost directly in line with Punta Banda and about $3\frac{1}{2}$ miles to the northwest lie the two small Todos Santos Islands. These are separated from the sea stacks and large rocks at the end of Punta Banda by a deep submarine channel and from each other by a shallow pass.

The southern island is the larger of the two. It trends northwest and is about $2\frac{1}{2}$ miles long and $1\frac{1}{2}$ miles wide with a maximum elevation of 313 feet. It is composed principally of rhyolitic volcanic material, some of which is in the form of explosion breccia; the rest has a massive structure. The periphery of the island has been eroded to form steep, high, blocky cliffs and sea stacks with a few small coarse-sand-to-cobble beach pockets. The upper slopes on the northern end are well rounded and covered with short grasses, shrubs, and ice-plants, but the southern end of the island is jagged and precipitous. The southwestern side is continually pounded by the wind and sea, whereas the northeastern or lee side is usually calm and deep close to shore. The rocky tidal pools on this side are rich in fauna and flora.

The northern island, $1\frac{1}{2}$ miles long by half a mile wide, is low, flatly truncated on top, and steep-sided. It is composed of poorly stratified unfossiliferous sandstones and conglomerates (LINDGREN, 1888-89, p. 172) which dip gently to the northwest. The aspect of its beaches is much like that of the beach along the northern shore of the bay. WALTON (1954) suggested that the northern island may represent the distal end of an alluvial fan because of its structural position and the presence of mud cracks. NELSON (1921, p. 85) had thought that the two islands were connected to Punta Banda by a submarine ridge, but this supposition has been disproved. WALTON suggested that there may have been a continuous ridge prior to a lowering of sea level, at which time a canyon was cut through. The present position of the northern island and its composition point to the possibility that it originally was an outwash deposit from the direction of Punta Banda. LINDGREN correlated the sediments of the northern island with those on Punta Banda but evidence seems insufficient to justify such correlation. The relation-

ship of the volcanic southern island is also obscure. It may be that faulting has played a larger role than thought previously.

SUBMARINE TOPOGRAPHY

The bottom of Todos Santos Bay is generally shallow, funnel-shaped, and open on the west side, emptying between the straits of Punta Banda and the Todos Santos Islands through a deep, narrow submarine canyon (Fig. 2). It is very shallow and gently sloping in the eastern part. Over a large shelflike area on the open western side, it is as deep as 25 fathoms and begins to form the upper part of the channel depression at about 30 fathoms in the southwest portion of the bay. It plunges to 215 fathoms in the narrow channel midway between the steep pointed projections of the southern island and Punta Banda and immediately opens out after passing the straits.

The canyon, which is only a few hundred yards wide at its deepest point, has slopes that steepen to a 30° angle. Whereas the lower part of the channel might possibly be regarded as being in the eroding stage, since the angle of slope of the very fine sediments far exceeds that of the angle of repose, the upper part of the canyon, which is uniformly shaped with gently sloping sides, is in the transition stage between deposition and erosion, and deposition alone (WALTON, 1954).

ESTERO DE PUNTA BANDA

On the southeastern side of Todos Santos Bay, behind the sand spit projecting northward from the slope of Punta Banda, lies the shallow Estero de Punta Banda, an L-shaped salt-water lagoon, 5 miles long and about 2 miles wide (Fig. 3). It is bounded on the west by the bar and on the east by a salt marsh completely covered by high spring tides and penetrated by many narrow tidal channels. The lagoon is bounded on the south by the Punta Banda ridge and on the north by the escarpment of the tableland. The Rio San Antonio discharges into it at its northern end but the effect is intermittent and restricted to the rainy season, although it may help greatly in determining the location of the mouth of the estero and in helping to keep it open with the tides.

The estero is subject to many extremes in temperature and salinity. As it is very shallow and the climate is arid for most of the year, it serves

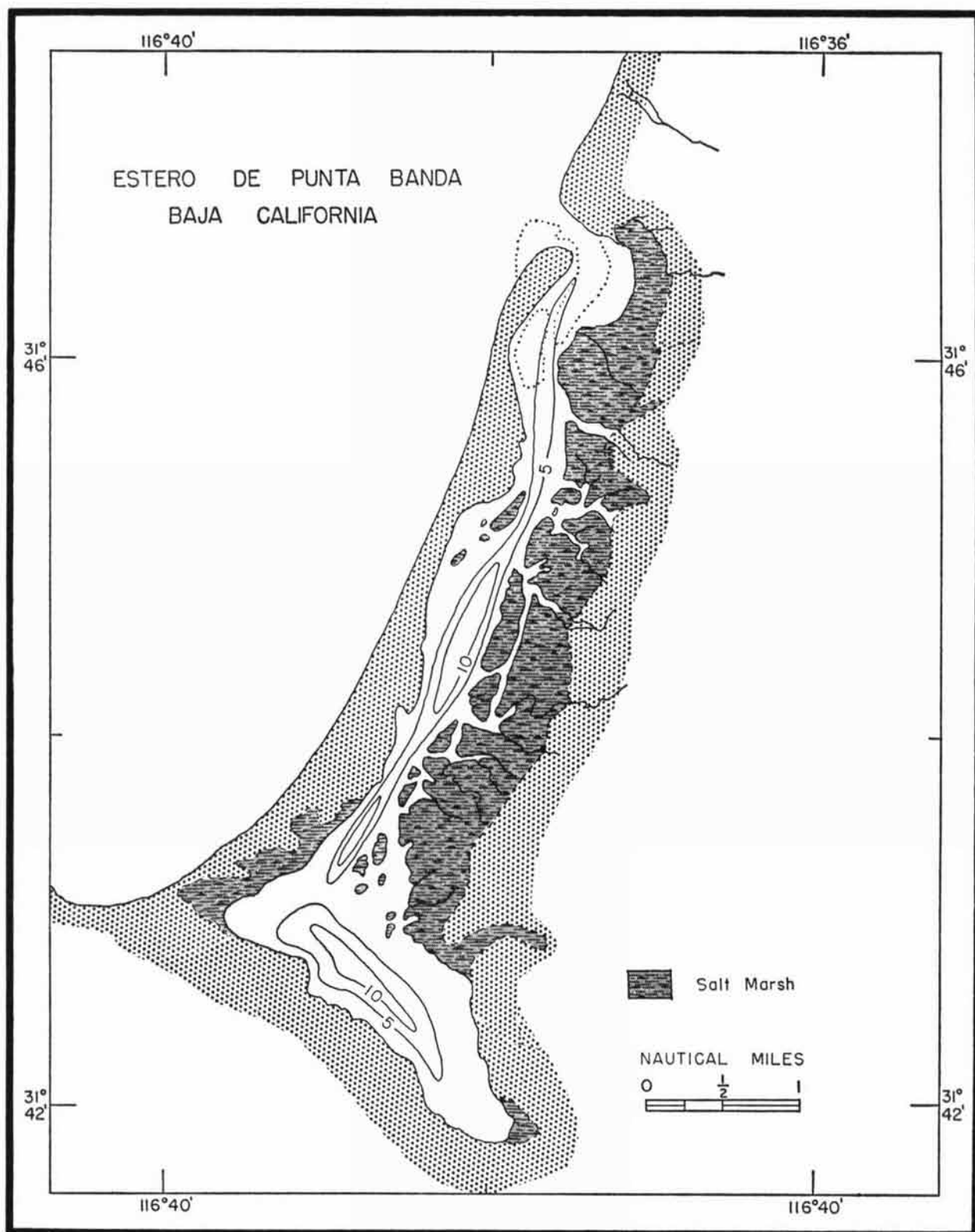


FIGURE 3. Distribution of salt-water lagoon and salt marsh of the Estero de Punta Banda at low tide. The marsh normally is covered at high tide.

as an evaporating basin, but during the rainy season the water temporarily turns brackish, at least in the upper layer.

The estero is covered in the southern and eastern parts by eel grass and splotches of coralline algae. No peat is being formed and the clay-mud bottom is firm. The tide shows a little lag as compared with that of the bay and has a maximum range of about 3.5 feet. The bottom is medium sand near the very shallow entrance and in the main channel. It is primarily a soft clay-rich mud in the shallow areas to the south and east of the main channel. The currents, affected by tidal changes, are swift in the main channel, and rapidly changing cold currents in the deeper waters are common.

RIO SAN MIGUEL LAGOON

About 10 miles north of Todos Santos Bay, on a rocky stretch of the Baja California coast, the youthful Rio San Miguel drains a large section of western mountain slope and discharges into the Pacific Ocean. It is a rather small stream but has a continuous flow.

At a lower sea-level stage, the stream cut much deeper, but has now filled the lower end of its valley with poorly sorted sand, so that it reaches base level a few miles inland and overflows on its alluvial plain. A sand spit growing across its

mouth helps form a shallow, brackish-water lagoon (Fig. 4). Discharge is continuous but increases during the rainy season and widens the narrow exit of the lagoon at the spit which may have been partially closed during the drier part of the year. Because the sea does not have unimpeded access to the lagoon, the water is usually only slightly brackish (oligo-miomesohaline).

Vegetation in the lagoon itself consists of abundant short aquatic grasses somewhat like those of the estero.

The pH ranges from 7.0 to 10.08 and is very irregular in distribution. The low pH is thought to be caused by the large amount of decayed organic material neutralizing the otherwise slightly basic water. The high pH is caused by the presence of road limestone dumped at the water's edge in the building of the now-abandoned causeway.

The dissolved oxygen ranges from a depleted 2.79 ml/L (at the station that had a low pH) to a high 7.47 ml/L (at the farthest station upstream). As dissolved oxygen in the sea usually varies from about 3 to 8.5 ml/L, the lagoon can be said to have a relatively high content, probably owing to the abundant aquatic vegetation. The station that had the highest pH also had a very high dissolved-oxygen content. Saturation at 24°C. in 0 o/oo chlorinity is 29.38; therefore the water is far from saturated.

ENVIRONMENTAL FACTORS

SALINITY

The salinity of Todos Santos Bay is rather uniform during February, being about 33.40 o/oo according to WALTON (1955). PAUL HORROR (personal communication) found that the salinity varied very little—from 33.40 during the winter to 33.70 o/oo during the summer.

The greatest variation in salinity of the three areas studied occurs in the Estero de Punta Banda. WALTON (1955) found that in November the salinity near the mouth ranged from 33.40 to 33.98 o/oo. No salinity samples were taken when the Rio San Antonio was discharging, but it is probable that the salinity decreases greatly near the mouth for very short periods after hard rains until the tides can mix the water layers and flush out the brackish waters. The salinity recorded away from the main channel of the estero, back in

the tidal channels, and in the very shallow areas was consistently above 34.00 o/oo and measured up to 37 o/oo. This is to be expected in a large shallow basin where evaporation greatly exceeds precipitation and both fresh and marine waters flow in during most of the year.

The salinity was measured in terms of chlorinity in the Rio San Miguel Lagoon (Fig. 12) by STEWART (personal communication). The farthest station upstream in the main river channel had the lowest chlorinity recorded (0.4 o/oo), and there was a progressive increase downstream to the main part of the estuary where the chlorinity was generally between 0.8 and 0.9 o/oo. At one station in the main part of the lagoon and in the shallow side channels, the chlorinity reached above 1.0 o/oo to 1.2 o/oo. According to REDEKE (1922, 1933) and VALIKANGAS (1933), that part of the estuary and

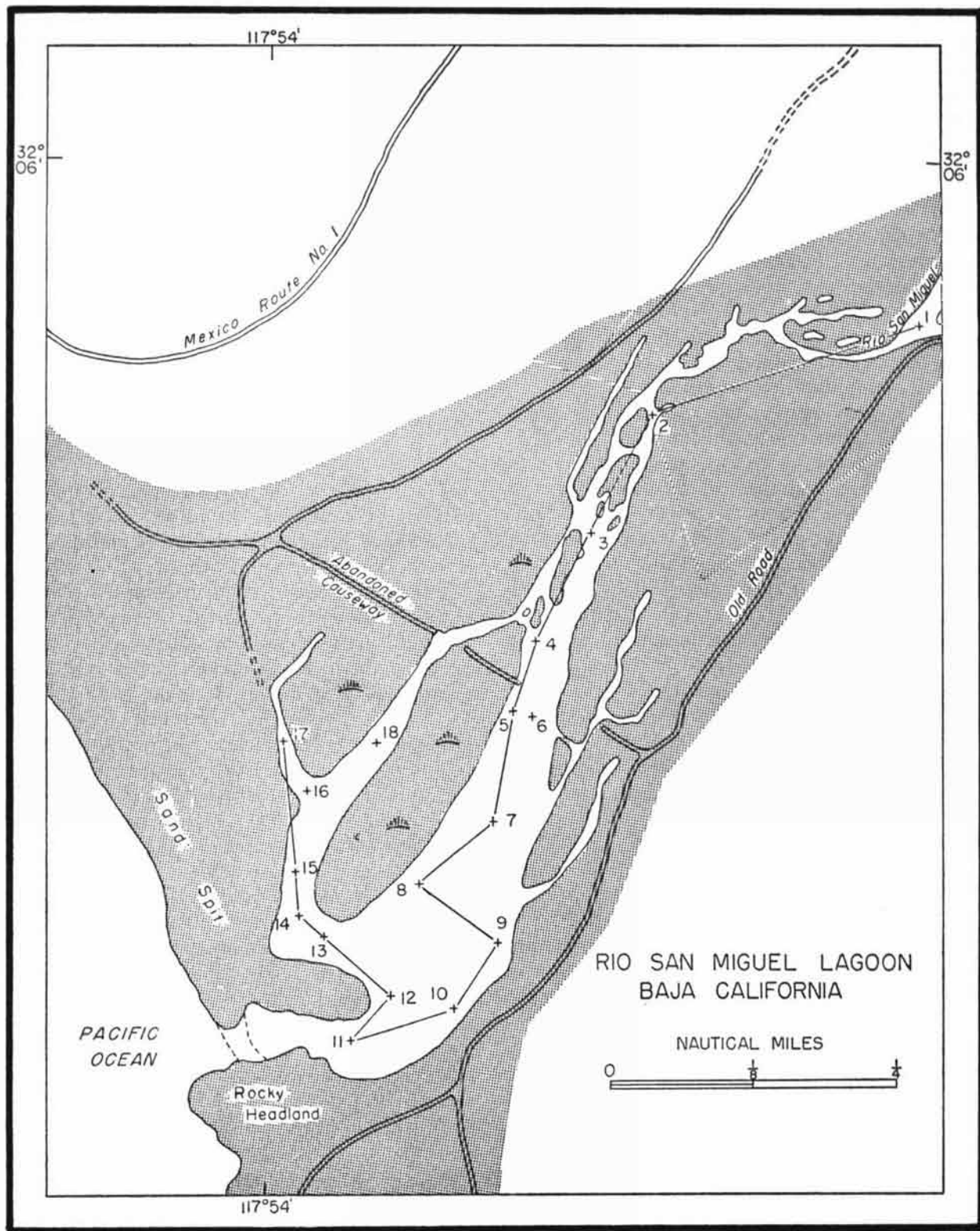


FIGURE 4. Location of sampling stations and population profile in the Rio San Miguel Lagoon.

lower part of the river with chlorinities between 0.1 o/oo and 1.0 o/oo (0.5-3.0 o/oo salinity) would be classified as oligohaline or mesohaline alpha brackish water and that part above 1.0 o/oo to 5.5 o/oo (3.0-8.0 o/oo salinity) would be classified as miomesohaline brackish water.

TEMPERATURE

In Todos Santos Bay the annual variation in surface temperature is about 10°F. The recorded maximum is 67°F. During February, March, and April, the surface temperatures are strikingly uniform (about 58°F.) over the bay (WALTON, 1955) and are generally warmer (61°F.) in June and July, particularly around the inner part of the bay and along Punta Banda (65°F.).

The bottom temperature, which ranges from 50°F. in the submarine channel to more than 55°F. near the shore line (Fig. 5), is more important to benthonic forms than the surface temperature. The annual variation of bottom temperature over different parts of the bay is a little more erratic than that of the mean, but in general the range is from about 2°F. in the deeper parts of the channel to about 10°F. near the shore line. It is interesting to note that maximum bottom temperature during August corresponds closely to the surface temperature maximum over a great deal of the shallower area of the bay, which shows the disappearance of the thermocline. The thermocline is shallowest during February and March and deepest and most compressed during the summer. The mixed layer frequently becomes as much as 200 feet thick in winter and as little as 10 feet thick in summer. The effect of the warm waters from the estero is noticeable in the bay during the summer.

Upswelling is characteristic of the waters on the south side of Punta Banda during June and July. A 10-degree difference in surface temperature is common during these months between the northern and southern sides of the peninsula. Dr. CARL HUBBS (personal communication) has noted as much as 21 degrees difference. The upswelling subsides during February, March, and April. There is little difference in water temperature between the northern and southern shores.

The wide temperature range in the Estero de Punta Banda is affected by the change in seasons, depth of water, and proximity to the mouth. No seasonal temperature data were obtained; all tem-

peratures were taken in November 1952 and 1954. An increase of 5 degrees was noted in the surface water during the hottest part of a November day when the air temperature reached 68°F. This is probably at least double on some summer days. There was an 8-degree difference in temperature between the shallow and deep waters of the estero. The maximum recorded water temperature was 85°F., in the upper end of the estero, and the minimum 61°F., near the entrance (WALTON, 1955).

The only water temperature data available for the Rio San Miguel estuary were taken during October 1953. The recorded maximum bottom temperature was 75°F., the minimum 65°F.—a 10-degree variation. The deeper, running water was cooler and the shallow, standing water warmer.

CURRENTS AND CLIMATOLOGICAL DATA

There are very few detailed data on the currents or the climate in the immediate region of Todos Santos Bay, but some observed and recorded information can be outlined here.

The California current outside the bay brings cooler waters from the north and moderates the water and air temperatures in the bay area. The influence of the marine climate extends only a few miles inland. The higher elevations have a cooler climate and more rainfall, but much of the runoff soaks into the ground before reaching the ocean.

The current in the bay flows generally clockwise around the northern side of Punta Banda where there is a slight buildup in water level against the shore. This condition is reflected in a slight depression on the south side (CARL HUBBS, personal communication), but there may be some equalizing during the summer upwelling. No measurements have been taken.

The climate at Todos Santos Bay is very much like that of San Diego, California, 60 miles to the north. Meteorological data for San Diego, taken from the records of the U.S. Weather Bureau, are: mean annual temperature 68.5°F.; average annual rainfall 9.9 inches; annual rate of evaporation about 40 inches; prevailing wind from the northwest at about 8.5 miles per hour.

SUBSTRATUM AND SEDIMENTATION

Sixty-seven samples taken from the grid pattern in Todos Santos Bay were analyzed by WAL-

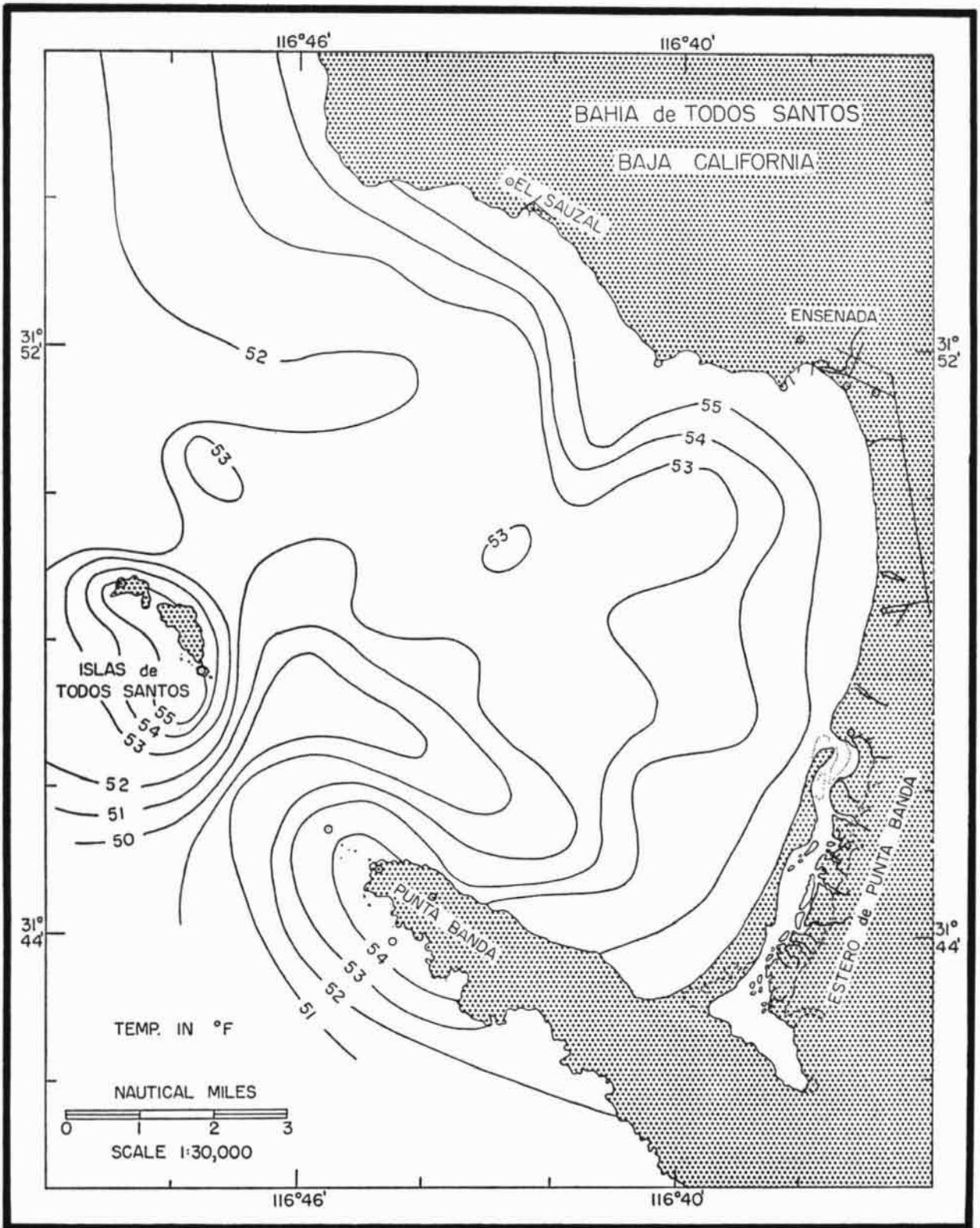


FIGURE 5. Mean annual temperature in degrees Fahrenheit of the bottom waters of Todos Santos Bay.

TON (1955) in his study of the substratum. The data collected by WALTON were plotted to show the related distribution of the various sediment size groups (Fig. 6). No samples were obtained from bay stations 40, 41, 82, 98, 99, 100, 106, or 107 because the corer could not hold the sediment. When the orange-peel dredge was used, pieces of rock material, pebbles, and other coarse sediments were found. The substratum from the Estero de Punta Banda and the Rio San Miguel lagoon were not analyzed in detail, but they are described under the general description of each area. A table of station locations and exact sediment size distribution is given at the end of this report.

Standard methods of analysis were used on 10-cc. samples. The size of these samples, though small, proved adequate for making a general survey of the nature of the substratum.

From the sieve and pipette analyses were calculated the phi notations of KRUMBEIN (1936), where $\phi = -\log_2$ of the diameter in millimeters. Three of the five descriptive parameters described by INMAN (1952, p. 132-138) were used—the measure of central tendency (phi median diameter— $Md\phi$), measure of dispersion or sorting (phi deviation— $\sigma\phi$), and measure of skewness (phi skewness— $a\phi$). The relationship of these parameters is as follows:

$$\begin{aligned} Md\phi &= \phi_{50} \\ a\phi &= \frac{1}{2} (\phi_{84} - \phi_{16}) \\ \sigma\phi &= \frac{M\phi - Md\phi}{\sigma} \end{aligned}$$

where ϕ_{16} , ϕ_{50} , and ϕ_{84} represent the 16, 50, and 84 percentiles and $M\phi$ the phi mean (INMAN, 1952, p. 130).

WALTON (1955) plotted the phi median against the phi deviation and phi skewness and found that the sediments of the bay area fit generally into three groups:

Group I. Sediment relatively coarse, $Md\phi = 1\phi$ to 3ϕ ; sorting poor, phi deviation usually less than 0.50ϕ ; generally skewed to the coarser grain sizes; many samples contain many pebbles and cobbles; large Foraminifera (as well as ostracode) population, abundant shell fragments, presence of attached and encrusting benthonic forms indicating little or no transportation; low in glauconite content.

Group II. Phi median from 3ϕ to 4ϕ ; well sorted, phi deviation generally below 0.50ϕ ; little skewness. Fine gray silts and sands; angular quartz grains; low percentage of dark minerals; mica content increases offshore; low organic content (low ostracode population).

Group III. Phi median greater than 5ϕ ; poorly sorted, phi deviation greater than 1ϕ ; generally skewed to the finer sizes; few organic remains other than Foraminifera (low ostracode population), high mica content. WALTON (1955) found what he described as fecal pellets in great abundance and deduced a great reworking of the sediments, probably by worms. This has been shown not to be the case; what he thought were fecal pellets were a concentration of montmorillonite with illite in a pellet configuration. Burning shows no carbon content, which would be expected in fecal pellets.

The phi median was replotted from WALTON's data (Table 1) with additional sampling, and the following differences were noted. A coarse silt zone was found in the shallower part of the channel depression, the sediment around the island was subdivided into zones of increasing coarseness, and a slight difference in location of medium-size sand was found on the northern side of Punta Banda more nearly coinciding with the distribution of the fine sand grading into very fine sand.

The analysis of the "fecal pellet" material showed it to consist of the clay minerals montmorillonite and illite in about a 1 to 1 ratio. Not enough material was tested to indicate much about the origin of the clay except that it resulted from normal transportation processes.

The bay sediments are almost entirely detrital and have been transported into the area by currents and streams from adjacent areas. With the exception of the "Group I" sediments between the northern coast and Todos Santos Islands, all the sediments decrease in phi median away from possible source areas. The "Group I" sediments do not seem to be in equilibrium with their present environment (WALTON, 1955) and are probably "relic" sediments, i.e., the product of a previous set of sedimentary conditions no longer effectual.

The surrounding streams bring in small amounts of fine sediments during the rainy season. The rate of sedimentation all over the bay

TABLE 1. Station Locations and Sediment-Size Distribution

Location of Stations				Sediment-Size Distribution		
Station No.	N. Lat.	W. Long.	Depth (fms.)	Mdφ	φ	φ
24	31°50'25"	116°37'00"	5			
25	31°49'55"	116°38'00"	10			
26	31°49'30"	116°39'05"	12			
27	31°49'05"	116°40'10"	14			
28	31°48'35"	116°41'10"	15			
29	31°48'10"	116°42'15"	18			
30	31°47'40"	116°43'20"	31			
31	31°47'15"	116°44'25"	127			
32	31°46'50"	116°45'25"	147			
33	31°46'15"	116°46'35"	195			
34	31°43'50"	116°39'00"	3	2.37	.87	.18
35	31°44'15"	116°41'00"	8	1.76	.50	0
36	31°44'50"	116°42'10"	19	3.20	.40	0
37	31°44'45"	116°43'10"	25	2.98	.70	-.01
38	31°45'25"	116°44'00"	35	3.68	.60	-.33
39	31°45'50"	116°45'25"	68	3.85	1.40	0
40	31°46'25"	116°46'30"	205	No sample obtained		
41	31°47'00"	116°47'45"	39	No sample obtained		
42	31°47'20"	116°48'55"	39	.97	1.43	-.05
43	31°48'10"	116°49'12"	40	.25	1.10	.26
44	31°48'10"	116°47'35"	25	-.50	3.10	-.09
45	31°47'35"	116°46'25"	141	5.95	1.80	.13
46	31°47'00"	116°45'05"	150	5.41	1.84	.40
47	31°46'40"	116°44'20"	108	5.45	1.36	.25
48	31°45'50"	116°42'50"	30	4.28	.72	.22
49	31°45'40"	116°45'05"	28	3.75	.70	-.06
50	31°45'20"	116°41'25"	20	3.27	.34	.11
51	31°44'45"	116°40'15"	12	2.92	.38	-.10
52	31°44'20"	116°39'20"	6	3.57	.25	.04
53	31°45'15"	116°38'40"	7	3.27	.24	-.05
54	31°45'40"	116°39'55"	11	3.22	.34	0
55	31°46'25"	116°40'30"	18	3.50	.29	0
56	31°46'45"	116°41'40"	24	4.27	.46	.23
57	31°47'15"	116°42'45"	31	4.65	.61	.32
58	31°47'40"	116°44'15"	96	5.06	1.26	.47
59	31°48'15"	116°45'00"	110	5.45	1.70	.34
60	31°48'25"	116°45'55"	110	5.85	1.55	-.03
61	31°49'00"	116°46'50"	92	5.23	1.11	.23
62	31°49'25"	116°47'55"	23	1.45	.50	0
63	31°50'40"	116°47'30"	22	2.16	.60	.03
64	31°50'15"	116°46'55"	24	2.10	.70	-.04
65	31°49'30"	116°45'25"	28	3.49	.72	.48
66	31°49'05"	116°44'15"	27	4.20	.31	.26
67	31°48'25"	116°43'25"	24	3.99	.36	.11
68	31°48'15"	116°41'55"	19	3.91	.28	.08
69	31°47'40"	116°41'15"	19	4.02	.42	.28
70	31°47'00"	116°40'30"	17	3.57	.19	0
71	31°46'35"	116°39'25"	12	3.42	.61	-.05
72	31°46'15"	116°38'20"	5	3.10	.33	0
73	31°47'15"	116°37'45"	5	2.80	.28	0
74	31°47'40"	116°39'10"	12	3.70	.32	0
75	31°48'00"	116°39'40"	15	3.65	.32	.03
76	31°48'25"	116°40'55"	16	3.63	.27	.14
77	31°48'50"	116°41'40"	16	3.77	.29	0
78	31°49'05"	116°42'45"	17	3.92	.34	0
79	31°48'50"	116°43'55"	20	3.98	.37	.03
80	31°50'40"	116°45'05"	22	2.47	.50	-.14
81	31°50'50"	116°45'55"	22	No sample obtained		
82	31°51'20"	116°47'25"	22	No sample obtained		
83	31°52'20"	116°47'15"	26	1.92	.50	-.18
84	31°51'40"	116°45'50"	22	2.40	.73	-.05
85	31°51'15"	116°44'35"	20	2.40	.57	-.07
86	31°50'55"	116°43'25"	20	3.51	.76	-.06
87	31°50'30"	116°42'15"	12	3.93	.34	-.06
88	31°49'50"	116°41'05"	16	3.73	.38	0
89	31°49'25"	116°40'25"	15	3.70	.44	.12

Location of Stations				Sediment-Size Distribution		
Station No.	N. Lat.	W. Long.	Depth (fms.)	Mdφ	φ	φ
90	31°49'00"	116°39'25"	13	3.61	.36	.33
91	31°48'40"	116°38'40"	11	3.62	.34	-.03
92	31°48'05"	116°37'20"	6	3.20	.28	-.03
93	31°49'05"	116°37'25"	6	3.48	.30	-.07
94	31°49'30"	116°38'05"	10	3.65	.41	.09
95	31°49'50"	116°39'00"	13	3.72	.50	.12
96	31°50'25"	116°40'30"	15	3.91	.48	.16
97	31°50'35"	116°41'25"	15	3.93	.39	-.01
98	31°51'15"	116°42'20"	16	No sample obtained		
99	31°51'50"	116°43'10"	19	No sample obtained		
100	31°52'25"	116°44'30"	19	No sample obtained		
101	31°52'45"	116°45'25"	21	No sample obtained		
102	31°53'20"	116°46'40"	26	2.25	.48	-.12
103	31°54'00"	116°45'45"	19	2.49	.42	-.05
104	31°53'35"	116°44'30"	13	2.55	.65	-.23
105	31°53'15"	116°43'45"	12	1.34	.93	.24
106	31°52'35"	116°42'30"	12	No sample obtained		
107	31°52'00"	116°41'20"	9	No sample obtained		
108	31°51'15"	116°40'10"	11	3.65	.38	-.10
109	31°51'05"	116°39'10"	10	3.44	.50	-.10
110	31°50'35"	116°38'05"	8	3.87	.49	.02
111	31°50'10"	116°37'15"	6	3.47	.45	-.02
137	31°45'40"	116°48'15"	230	No sample obtained		
149	31°42'30"	116°42'15"	28	No sample obtained		
310	31°41'10"	116°45'20"	175	No sample obtained		

from these sources and from beach erosion is thought to be rather slow, but no figures are available. The estero serves as a catch basin for the Rio San Antonio, and the other streams do not noticeably affect the distribution of the coarser sediments. The upper part of the channel seems to be filling in with silt. The coarser sediments around the islands, the northern coast of the bay, and Punta Banda are the result of wave action eroding their periphery. The finer sediments have been winnowed away. Erosion appears to be going on in the lower part of the submarine channel but details are not known.

WALTON noted a submarine outcrop on the northern side of the bay, but its effect on the sedimentation is not known.

FIELD METHODS

Samples collected in Todos Santos Bay number 250, taken from 19 control stations, 4 tidal pool stations, 11 seasonal traverse stations, and 77 stations spaced throughout the bay on a one-mile grid. (Fig. 7). Forty-one samples were collected from as many localities in the main channel, the salt marsh, and the tidal channels of the Estero de Punta Banda (Fig. 8). The sampling was spaced so as to gather material from all environments of the three areas. After examining the

samples collected by WALTON from the bay and the estero, return collecting trips were made to the areas to fill in the gaps and collect larger samples. Eighteen samples were collected from as many localities in the Rio San Miguel lagoon (Fig. 4); as the results of examining STEWART's samples from the Rio San Miguel seemed sufficient and time was short, no more samples were collected there.

The samples collected in the bay were obtained by WALTON (1955) and the author by using a small coring device designed by PHLEGER (1951). It is possible to get a uniform sample of $1\frac{3}{8}$ -inch diameter and 1-cm. length with the Phleger bottom sampler and a measuring device designed by WALTON (a brass sleeve, which envelopes the core liner with a rotating blade, slices an equal amount off the upper end of each sample) (Figs. 6, 7).

Where the sediment was too coarse for the Phleger sampler, an orange-peel dredge was used, modified to prevent washing out the finer sediments on the way to the surface. Cores were taken from the slice of bottom obtained by the dredge by inserting the core liner into the material and taking off the top 1 cm. just as with the Phleger sampler.

Because a 10-cc. sample usually is not large enough for ostracode work, a special trip was made to collect larger samples to serve as a control on the previous samples. These were taken on a 3-legged traverse through those parts of the bay crossing each biofacies. The Phleger bottom sampler was used as before but a larger core was taken (about 50 cc.) and the top 3 cm. was obtained from the orange-peel-dredge sample (31 sq. in.). No attempt was made to compare quantitatively the two types of samples. The larger samples could not be made uniform in size. Comparison of the percentage of various forms in the different-sized samples yields a qualitative estimate of their distribution.

In the Estero de Punta Banda and the Rio San Miguel, samples were obtained by using the core liner from the Phleger bottom sampler and pushing it into the sediment by hand. In many cases this involved diving in the deeper water. The cores were extruded, measured, and placed in a mason jar. They were preserved in a 10 percent solution of neutralized Formalin; a small amount of sodium carbonate was added to keep them from turning acidic.

Care was taken with all samples to siphon off all but 1 inch of the water present immediately above the water-sediment interface in the core liner after letting the swimming forms settle to the bottom as much as possible. This material was preserved with the sample in order to study the living ostracodes present when the sample was taken.

All locations were established by dead reckoning, sextant, and polaris fixes (when visibility permitted) and by using bottom topography followed by a trace fathometer. Depths were established by hand line and fathometer. Surface temperatures were taken at all stations from samples of water taken from the estero and the lagoon with a bucket and a line. Salinities and chlorinities taken by WALTON and STEWART were established in the Scripps Institution of Oceanography laboratory from samples of bottom water from the study areas. Bottom temperatures were estimated from Scripps bathythermographs or taken with a thermometer *in situ*. All samples from Todos Santos Bay were taken from aboard the oceanographic vessel *E. W. Scripps*; those in the Estero de Punta Banda were taken from an outboard motor boat. The pH of the overlying water at the stations in the lagoon was taken in the field by the Beckman colorimetric method (SVERDRUP *et al.*, 1942, p. 194); the dissolved oxygen in the water was determined in ml/L by the Winkler method (THOMPSON & ROBINSON, 1932).

LABORATORY WORK

Sixty-seven samples from the grid pattern of the bay were subjected to grain-size analysis by WALTON (1954, p. 14) by means of the wet-sieving method, which was checked and found to be approximately accurate by dry-sieving and settling-tube analyses. Five sieve sizes, 1.0 mm., 0.177 mm., 0.125 mm., 0.088 mm., and 0.062 mm., were used for all samples. When the coarser fraction of sediment (more than 0.177 mm.) exceeded 15 percent by weight, it was sieved through a bank of coarser sieve sizes of $\frac{1}{2}$ - ϕ intervals. When the finer size fraction (less than 0.062 mm.) exceeded 15 percent by weight, it was analyzed by the pipette method (KRUMBEIN & PETTIJOHN, 1938, p. 162-67).

The clay fraction of the poorly sorted medium and coarse silt areas of Todos Santos Bay were

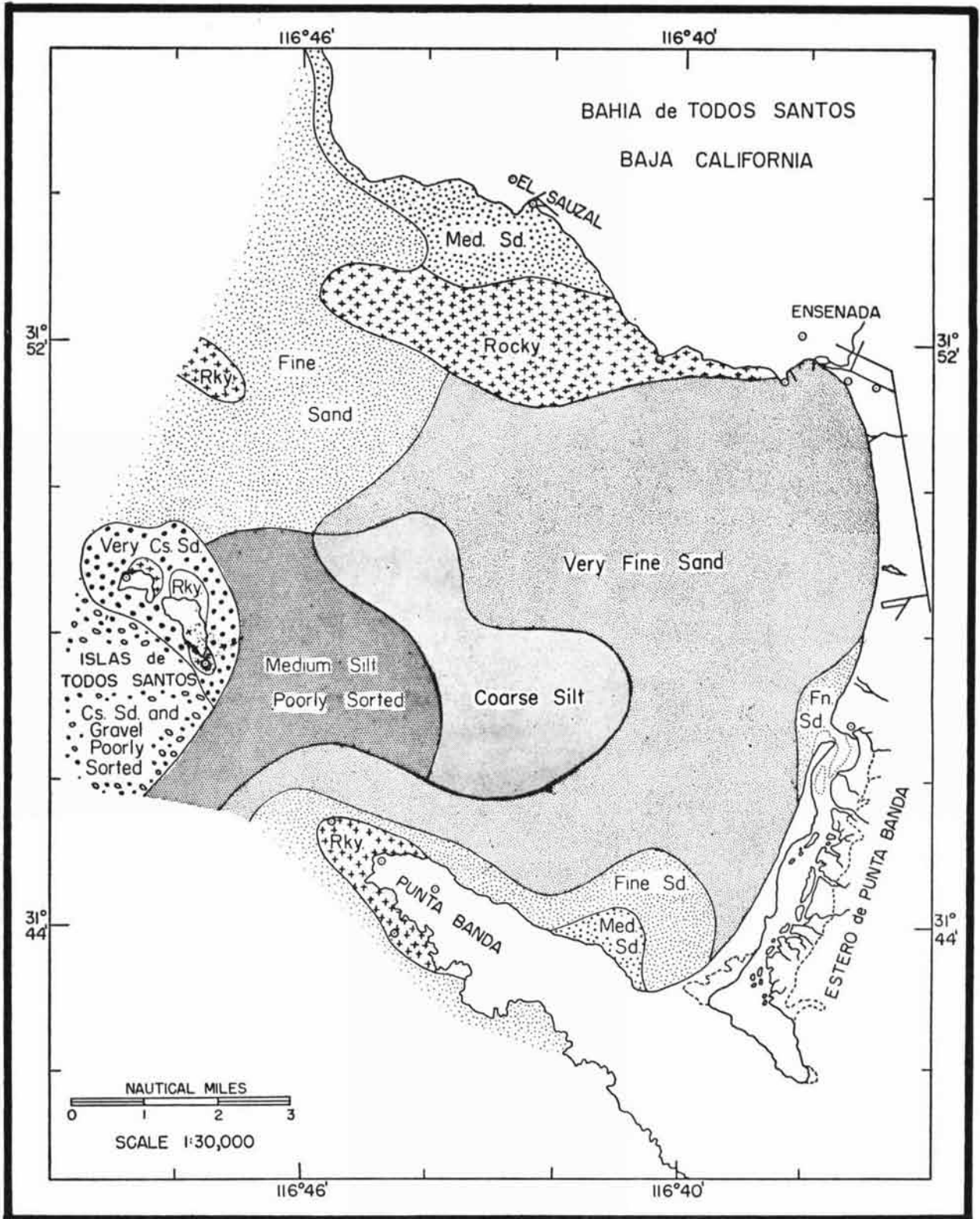


FIGURE 6. Distribution of bottom sediments according to grade size (Wentworth scale) in Todos Santos Bay.

analyzed by x-ray, heated over an open flame to check for organic content, and placed in acid to check for calcium-carbonate content.

The samples collected were first wet-sieved. The first five samples believed to be heavily populated were examined for specimens in all size ranges. None was found below the 0.125-mm. size, so in the remaining samples only the sediment in sieves coarser than this size range was examined for ostracodes. The sample was then subjected to a solution of rose bengal, a protoplasm-selecting red stain recommended by WALTON (1952), for at least 20 to 30 minutes. The samples were then rewashed to remove excess stain and dried slowly in a gas oven.

All specimens were then picked and mounted on a microfossil slide. After the taxonomic classification had been established, the living and dead populations of each station were plotted according to species on a large chart of all the stations. Because the stain did not function as hoped in separating the living from dead forms in the majority of stations, the total population was summarized and replotted (Fig. 11).

PROBLEMS OF TECHNIQUE AND METHOD

The importance of recognizing the ratio between living and dead specimens in Recent sediments has been demonstrated by studies with Foraminifera and ostracodes (PARKER *et al.*, 1952-3; MALKIN, 1954). The rose bengal stain did not seem to take effect uniformly, which made it impossible to accurately separate the living and dead individuals in many samples. Some of the stained forms were very worn and obviously had been dead for some time. Others were stained in splotches on the exterior of the shell, and yet the closed valves contained the remains of fresh, unstained appendages and other soft parts. Difficulty came in judging those separated valves that were partially or faintly stained. A census of the stained living faunule was abandoned after several attempts. The complete carapaces with preserved soft parts were counted, but it was evident that many of the valves and their included soft parts had become separated when the sample was dried. As a compromise, the stations that seemed to display evidence of living

individuals of a particular species were indicated on a map of the distribution of that species. It is not suggested that the use of rose bengal is unsatisfactory in determining the live/dead ratio, but only that care be exercised when examining the stained as well as the unstained specimens.

Another problem was that of judging the size of the sample that should be taken to obtain a clear picture of the distribution of a population. The 10-cc. size sample, from which WALTON counted as many as 18,000 dead specimens, was sufficient for studying Foraminifera. The largest number of ostracodes found in any one sample was 158, and this was exceptional. ELOFSON (1941) and MUELLER (1894) used a sled-type dredge, which does not quantitatively sample the ostracode population and is not satisfactory for obtaining all types of ostracodes.

Recovery of the upper few centimeters of the sediments by coring methods becomes more and more difficult with an increase in tube diameter and is greatly affected by the type of sediment. Perhaps one method that may be practical is to take a very large sample with a 10-inch diameter modified orange peel, take 2 cm. off the top layer, and project the population on the basis of an actual count of 300 specimens. It would probably be the best compromise for studying the effect of environment on kind rather than numbers of forms. The live/dead ratio could still be computed.

This study and WALTON's agree that the actual number of dead specimens in a sample is not only influenced by the level of productivity of the faunule involved but also by the rate of sedimentation in the area. In a paleoecological study, the number of specimens per unit volume of a given faunule is possibly only partially indicative of the population density of the past living population. An analysis of the character of the dead faunule will yield a great deal of information about the past living faunule. WALTON found that the distribution of the dead population of Foraminifera corresponded very closely to the total population of both living and dead, although the maximum of live population density did not always equal that of the dead population (WALTON, 1955). An analysis of the relationship and distribution of the biofacies over the area as a whole is important in evaluating any one part.

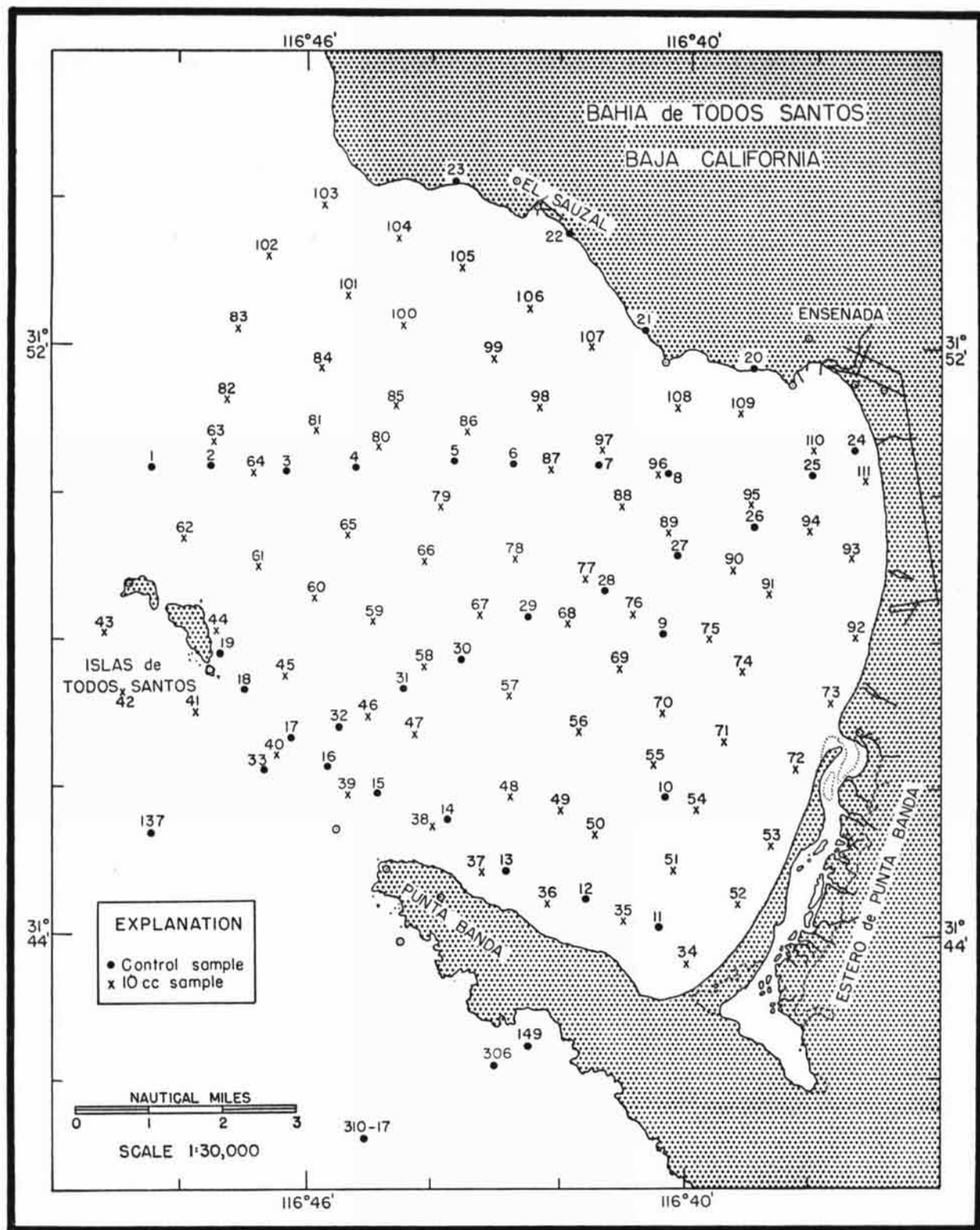


FIGURE 7. Sample collecting stations in Todos Santos Bay.

PART II. OSTRACODE ECOLOGY

Almost no other micro-organism abundantly preserved as fossils has as great an ecologic and stratigraphic range as the Ostracoda. Ostracodes are found in rock strata ranging in age from Ordovician to Recent and are represented in all types of aquatic habitats from abyssal to lacustrine.

Almost all ostracodes found in Recent sediments are benthonic, near-bottom pelagic, or dependent on bottom-growing vegetation. Their distribution is directly or indirectly controlled by the same bottom conditions of depth, temperature, salinity, etc., that controlled ancient sediments. They are small and abundant and can be collected and handled in large numbers much more easily than larger organisms. The average life span and the area traversed by the individual is great enough to be affected by the extremes of environmental conditions. Molting from 7 to 11 times enables an individual to have several traces of his existence. Ostracode carapaces are far less numerous than the tests of Foraminifera with which they are frequently associated, but they cross the brackish-water zone—a barrier to most Foraminifera. Also, much more is known about the living ostracode than the living Foraminifera because the Ostracoda have been studied to a much greater extent.

SCHENK (1940, p. 1760) states that ostracodes are less sensitive to environmental change than Foraminifera, but comparison of the ecology of the two faunules of the Todos Santos Bay region shows that neither has a particular advantage. Both forms showed about equal reaction to change. As a group, however, the ostracodes seem to have proportionally more benthonic members, few or none of which have planktonic larval stages (MÜLLER, 1894, p. 423). The individual ostracode as an ecologic unit seems to be representative of a longer time and a larger area than a single foraminifer and statistically it is much easier to handle.

With a change in the species concept in modern taxonomy, the species described in the past as eurythermic and eurybathic are now being found to be much more restricted ecologically than thought previously. It is fruitless to survey the older literature to find close relationships between species and detailed environments, as their ranges are far too great. Most genera are too all-inclusive for very

detailed ecologic work. As work on taxonomy progresses more and more species and genera become useful biofacies indicators for use in stratigraphy as well as Recent biogeography.

DORIS MALKIN CURTIS (1954) has suggested that generic assemblages might prove useful for indicating certain environments on the coast of the Gulf of Mexico, since consideration of several genera helps to modify the determined range of any one. In applying this idea to the faunule of the present study, one can see that there are immediate exceptions but that it might give generally satisfactory results. A genus is a subjective category and can change with the addition of more species, so at present it is probably better to use species as far as possible for any paleoecological interpretation until the generic categories become better stabilized. The ranges of many species considered in this study extend back to the Pliocene and possibly the Miocene. With knowledge of their Recent distribution and ecology, they could well be used to help reconstruct some of these past environments of the Pacific Coast area.

Very little work has been done on the ecologic niche of the ostracode in the marine community. REMANE (1940) has contributed far more than anyone else on this subject as he studied all the animals present along the north German coast. MÜLLER (1894), ELOFSON (1941), and others have been primarily interested in the ecology of ostracodes. With the development of the self-contained underwater breathing apparatus, it will be possible to examine areas heretofore explorable only with the dredge or coring tube, and the whole biotope can be explored.

Although time did not permit building and maintaining an aquarium for this study, as was done by KESLING (1951), both its usefulness and the problems involved were examined. The raising of live ostracodes in aquaria has been much neglected, and much information could be gained by this kind of study. The molting process of marine forms is practically unstudied other than from a statistical examination of their shed carapaces. The physical factors of their environment could be varied and their adaptability to new conditions examined. This type of study would have to be carried on at a marine laboratory, as it

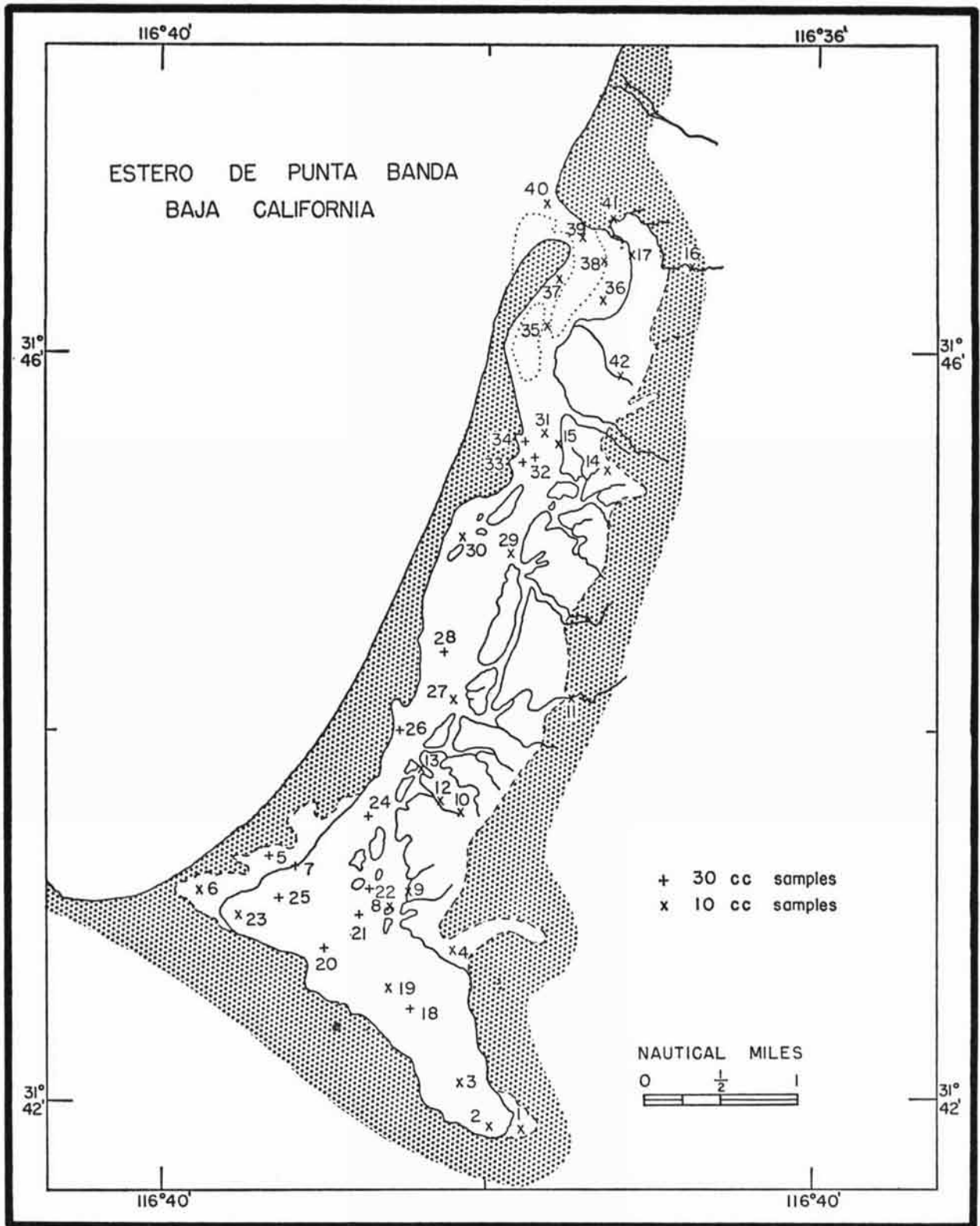


FIGURE 8. Sample collection stations in the saltwater lagoon and marsh of the Estero de Punta Banda.

seems impractical to maintain a marine aquarium away from a constant source of salt water.

Nearly all the specimens found in the Todos Santos Bay region could be classified or identified to the species level. Many specimens were immature instars; however there was no great difficulty in identifying most of them, as the species characteristics were usually well differentiated even in the very early stages if the sexual characteristics were not. This fact was noted by ELOFSON (1941) and referred to by MALKIN (1953). However, the assignment of some species, of which no adult specimens were found, to a particular genus was difficult because the hinge was not fully developed.

GENERAL RESPONSES

PHYSIOLOGIC VARIATION

It has been assumed in this study, as by ELOFSON (1941), that each species in the study area reacts uniformly to its environment throughout its range and that there are no physiologic or ecotypic variations within a species. It has been well demonstrated, however, by several workers on other marine forms (REMANE, 1933, p. 167; WESENBERG-LUND, 1926, p. 203; SHELFORD, 1916), that many species are composed of physiologic races over their entire geographic range but that others are constant (RUNNESTRÖM, 1930, p. 22). To the ecologist, the reactivity of the whole species is the important and fundamental unit (REMANE, 1933, p. 167). The reactivity of each species should be considered tentative until its range is determined.

MORPHOLOGIC ADAPTATION

The adaptation of certain ostracode structures to fit a particular environment was described by MÜLLER (1894). He noted that the appendages of the major groups conformed to the swimming, crawling, and digging habits of the users. ELOFSON (1941) and REMANE (1933, p. 174) later showed that the sculpture of the carapace also conformed somewhat to the bottom-sediment type or to the occurrence in algae. Their observations are briefly that forms living in softer and finer sediments tend to have stronger hinges; the greatest number of smooth-shelled species are found in the phytal (habitat characterized by marine vegetation) and

soft-bottom biofacies, but that the number of smooth-shelled species decreases with augmented stability and larger sand content of the substratum, perhaps climbing again in extremely shelly regions; that frictionless burrowing forms seem to be restricted to fine sediment; forms that are independent of substratum include the wanderers with rough valves, where friction is not a factor, and those with smooth but thick valves; plant dwellers (phytal) are usually thin and light-shelled; however some forms that live in the interstices of sand (endopsammon) also have light and thin valves; nearly all boreal ostracodes that swim are relatively light and usually smooth; sand dwellers are the shortest and smallest, soft mud burrowers (endopelos) are the longest and thinnest, and algal forms (phytal) are medium in length and usually broad. KUMMEROW (1940, p. 124) believes that equality of valves is a characteristic feature of nektonic ostracodes, but as TRIEBEL (1950, p. 90) has pointed out, this feature is common in forms of all habitats. TRIEBEL has also pointed out that the fine reticulate or longitudinal ribbing common to many ostracode species is not a hydrodynamic feature, as stated by KUMMEROW (1939, p. 85), but serves only as a reinforcement to an otherwise-thin valve.

KUMMEROW considered only fossil forms, and many of his ecologic interpretations of shell sculpture have little support from observation of the habits of Recent ostracodes. His assumption that the larger forms would sink more readily into the soft muds is largely false, as most of these forms are burrowers (TRIEBEL, 1950, p. 93). He is, however, probably correct in part (1949, p. 230) in suggesting that certain structures such as alae and some costae help the surface wanderers to keep upright on very soft bottoms. *Cytheropteron*, or *Pterygocythereis*, which have alate venters, were found on the finer-grained soft substrata in Todos Santos Bay. Most of the findings of the other workers mentioned were substantiated in the ostracodes of the Todos Santos Bay region.

In attempting to plot the size of the carapace versus the grain size or the roughness versus the grain size, etc., with a much larger number of specimens than used by REMANE or ELOFSON, there was found to be a wide scattering of points with many exceptions but with a general trend agree-

ing with the previous work. It is doubtful whether these generalities would be very useful in interpreting past environments of particular genera and species of unknown habits without a great deal of tolerance. However, it is possible that in considering the prevailing structural type of a large-enough assemblage, a more accurate assumption might be made. As stated by ELOFSON (1940, p. 422, translated from German), "One can demonstrate in many cases a far-reaching coherence in structure between living species of the same biotope as well as a clear relation between this and the character of the biotope."

GENERAL PROBLEMS IN MARINE OSTRACODE ECOLOGY

Because correct classification of the forms involved is fundamental to ecologic studies in both Recent and ancient sediments, a detailed taxonomic study should always precede an ecologic one. In the past, many paleontologists have only superficially described the carapace of their species, making lower-level classification possible, but not giving enough information to relate these groups on a higher level. As a result, workers like MÜLLER (1894) and BLAKE (1933) have considered the higher classifications (based on paleontologic comparisons) incorrect and used the soft parts for comparative purposes. There has been a difference of opinion by paleontologists and neontologists as to the correct classification of some ostracodes. More recently, however, steps have been taken to emphasize the importance of coincidence between these two disciplines and the correspondence and the interdependence between soft and hard parts of the ostracode morphology (TRIEBEL, 1949; HARDING & SYLVESTER-BRADLEY, 1953). The classification and description of new forms as well as the identification of previously described species will be made easier by a more thorough examination and description of the carapace, particularly noting features useful to the paleontologist.

In studying the relationship between the distributions of the living and dead specimens from Todos Santos Bay, it was noticed that these did not exactly coincide. Seasonal changes affect the distribution of the living forms, so that no one form saturated all its environmental range at any one time. TRESSLER & SMITH (1948), in studying

the seasonal distribution of the brackish-water ostracodes of Chesapeake Bay, and MALKIN (1954) and SWAIN (1955) in studying the Gulf Coast ostracodes, also noticed considerable variation in the density of a living population, which seems to indicate migration over different parts of the area with seasonal change. It is probable then that ostracodes live in swarms that move about, so that study of the live population over an area during only one time in a season would not be indicative of its distribution during a longer period of time. For this reason, the importance of the dead population as a record of the movement or the entire distribution of a species or assemblage should be emphasized. There is little doubt that the distribution of the dead population can be altered somewhat by preservation, scattering by currents, and pollution by fossil specimens forming a thanatocoenosis (death assemblage). In the Todos Santos Bay area these factors are not believed to be active enough to alter the whole picture very significantly, as WALTON's (1954) study of the living Foraminifera of this area showed a good correlation between the distribution of the living population and the total population.

The greatest value obtained from studying the distribution of living specimens is to prove that the fossil record in the underlying Recent sediments can represent a biocoenosis (life assemblage). MALKIN (1954) found that counts of live individual of species in the Gulf Coast area coincides approximately with those of the dead specimens of the same species, and that the absence of live forms of a rare form was not significant. However, in the present study it is felt that rare species with no living representatives should not be emphasized as ecologic indicators, since they could well be fossil and not modern.

In only one place in the Todos Santos Bay region was there any evidence of a thanatocoenotic assemblage. At the lower end of the submarine canyon there were many dead representatives of the environments in the headward reaches of the canyon, in addition to the predominant *Cytherop-teron-Brachycythere schumannensis* living assemblage. WALTON (1955) suggests a thanatocoenotic or fossil assemblage for the Foraminifera of the "Group I" sediment area on the western open side of the bay, but no evidence was found to support

its occurrence among the ostracodes. Although the dead population was greater in proportion to the living one, there were ample living representatives of each species. This is the area of "relic" sediments where sedimentation is exceedingly slow. This supports WALTON's contention that the live/dead ratio is as much a function of rate of sedimentation as of the productivity of a population.

INFLUENCE OF VARIABLE ENVIRONMENTAL FACTORS IN DISTRIBUTION OF OSTRACODES

Environmental factors considered in this study include the physical factors of depth, temperature, substratum, salinity, light, oxygen in solution, and hydrogen-ion concentration, and organic factors, which include the dependence of some ostracodes on the distributions of plant dominants of the plant habitats (phytal), the food supply, and the social relationship of ostracodes with other organisms.

The effect of these factors is usually a function of several, if not all, of them. An attempt to isolate one factor as the cause of the presence or absence of an organism is usually indecisive. Also, it is often the range of variability of the factor concerned and not its mean, average, or immediate value that is important. Although many animals adapt themselves to extreme environments, very few can exist in rapidly changing ones. Where averages are given in this report they are to be considered as the best approximations available for inadequate data.

DEPTH

It is believed that the zoning effect of depth on the ostracodes observed in Todos Santos Bay as well as other areas (ELOFSON, 1941; REMANE, 1933), is the result of a combination of the changes in many factors and independent of an increase in bathymetric pressure alone. As in most marine invertebrates, the internal pressure of the ostracodes is equal to the external sea pressure at all depths. The pressure threshold that might affect the physiology of protoplasmic development exists in depths far greater than those of the bay area.

Decreasing wave action, light penetration, the limit of distribution of the euphotic zone and eventually the phytal biotope, and moderation of bottom temperature are all factors affected by

depth. In Todos Santos Bay, the sediments that constitute the substratum, in and on which the ostracodes live, decrease in grain size with depth. All these factors together help to bring about a differentiation of the ostracode populations into grading zones or biofacies closely corresponding to the neritic environments as described by the Committee on Classification of Marine Ecology and Paleoecology (1950-51, p. 126). Theoretically, the environmental conditions are distinct enough from supratidal to bathyal benthic for the making of many subdivisions, but in the bay region only three zones or biofacies seem to have been differentiated on the basis of depth. These are transitional and include the littoral zone, and Biofacies I and IV.

The densest populations occur in Todos Santos Bay above 35 fathoms, up to and including the intertidal zones of the salt marsh and the estuary. HORNIBROOK (1952a) found the faunule richest between 28 and 142 fathoms in New Zealand waters, whereas MALKIN (1952) found it poorer with increasing depth over 200 meters (33 fathoms). These results emphasize the variation that does occur because of the location of a particular area in a greater system of currents, latitude, oceanographic province, etc.

TEMPERATURE

Differentiation in the horizontal distribution of species over a large geographic range in the sea is directly attributable to variations in their tolerance to meet changing conditions of temperature. In a local area the effect of temperature at shallow depths is measured by the amount of annual variation and, although responsible for the kinds of species generally present, its most noticeable effect on ostracodes is on their season of propagation. The point in their life cycle when they are most sensitive to temperature extremes is believed to be in the ostraconaulius (first instar) stage (ELOFSON, 1941, p. 440; APPELÖF, 1912, p. 307; FORSMAN, 1938, pl. 12; RUNNSTRÖM, 1928, p. 40). TRESSLER & SMITH (1948), after studying seasonal distribution of the ostracodes, conclude that temperature change is the most important ecologic factor, that variation in density and salinity are less effective, and that pH and transparency have no noticeable direct effect.

The periodicity and seasonal distribution of the Todos Santos Bay region ostracodes were checked only superficially. The seasonal traverse made by WALTON, from which the samples were obtained (stations 24 through 310), went through a rather barren area as far as ostracodes are concerned. The only general statement that can be made from the data collected is that the season of propagation seems to start in early summer; specimens collected in the fall were mostly in a later instar stage. The greatest annual temperature variation (10°F.) would not seem sufficient to exclude many stenothermal species. *Cytheropteron* sp. A, *Brachycythere schumannensis* and *C. newportense* were found only in deep water where the annual variation was only 2°F., so they seem to be the only stenothermal species in Todos Santos Bay. The species that inhabit the Rio San Miguel lagoon and the Estero de Punta Banda are certainly examples of the most eurythermal forms in the area. As ELOFSON (1941, p. 445) discovered for the Swedish marine ostracodes, most species of the shallower neritic region are moderately eurythermal; the relatively few stenothermal species are restricted to the deeper waters. There are few vegetative stenothermal warm- or cold-water species but a large number of propagative stenothermal warm and cold species. ELOFSON found only two species (*Cythere lutea* and *Loxiconcha impressa*) whose general distribution corresponded to their reproductive temperature ranges. It was not so much the temperature that controlled the general distribution of the eurythermal species as the salinity gradient (ELOFSON, 1941, p. 486).

SUBSTRATUM

Most types of marine ostracodes, other than the few planktonic species and those living on plants, live in, on, or immediately above the bottom. As the vegetation growing on the bottom is usually dependent on the sediment type of the substratum as well as the hydrography for its distribution, the distribution of the phytal ostracodes is secondarily controlled by the underlying sediment type.

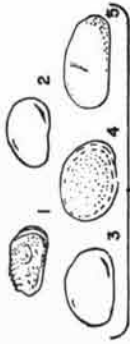
ELOFSON (1941, p. 415) demonstrated the importance of the substratum in determining the distribution of a species by finding comparable sandy habitats occurring relatively undisturbed in shallow water and at 130 m. depth. ELOFSON and RE-

MANE (1940, p. 60-88) both showed the correlation of morphologic types as well as some genera and species to particular sediment types. MALKIN (1954) and SWAIN (1955) did not find any pronounced correlation between the distribution of ostracodes and the character of the substratum. In Todos Santos Bay and the Estero de Punta Banda, the type of sediment composing the substratum shows marked influence on the distribution of some biofacies and on changes in density of the general population either by affecting the ostracodes themselves or the algae with which some of them are associated. The poorly sorted organic-rich sands of the Rio San Miguel lagoon are thought to be primarily responsible for supporting the lagoon's heavy population. In areas where the sediment is being continually deposited in great amounts, the general population of all organisms is low.

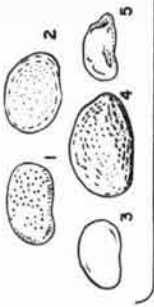
In Todos Santos Bay, the distribution of the species that compose Biofacies I (Figs. 9, 10) closely approximates the medium- and fine-sand distribution (Fig. 6) and also, with two exceptions, that of WALTON's "Group I" sediments. This is partially because both the sediments and the biofacies are found in shallow water near the coast. However, projection of Biofacies I south from the northern coast on the open western side of the bay seems to show a trend in the dependence (primary or secondary as with the marine plant habitat) of the biofacies on the substratum sediment type. The distribution of the species of Biofacies II (Fig. 10) seems to be generally restricted to the edges of the area of the very fine sand (Fig. 6) or WALTON's "Group II" sediments; these species are absent adjacent to the well-sorted shallow sterile littoral sandy area on the eastern side of the bay.

The significance of Biofacies III, whose characteristic feature is the lack of an endemic population, is believed to be connected with sediment type, but the exact cause of this rather barren area is not known. The living population relative to the dead one is rather large, which might indicate a relatively rapid rate of sedimentation or the sweeping action of the currents, but the entire population is exceedingly low. This sediment size is not known to be offensive to ostracodes as a whole. *Palmenella*, which is a characteristic genus of Biofacies II, is known to be epipelitic (REMANE, 1933, p. 176), like some species of *Cytheropteron*.

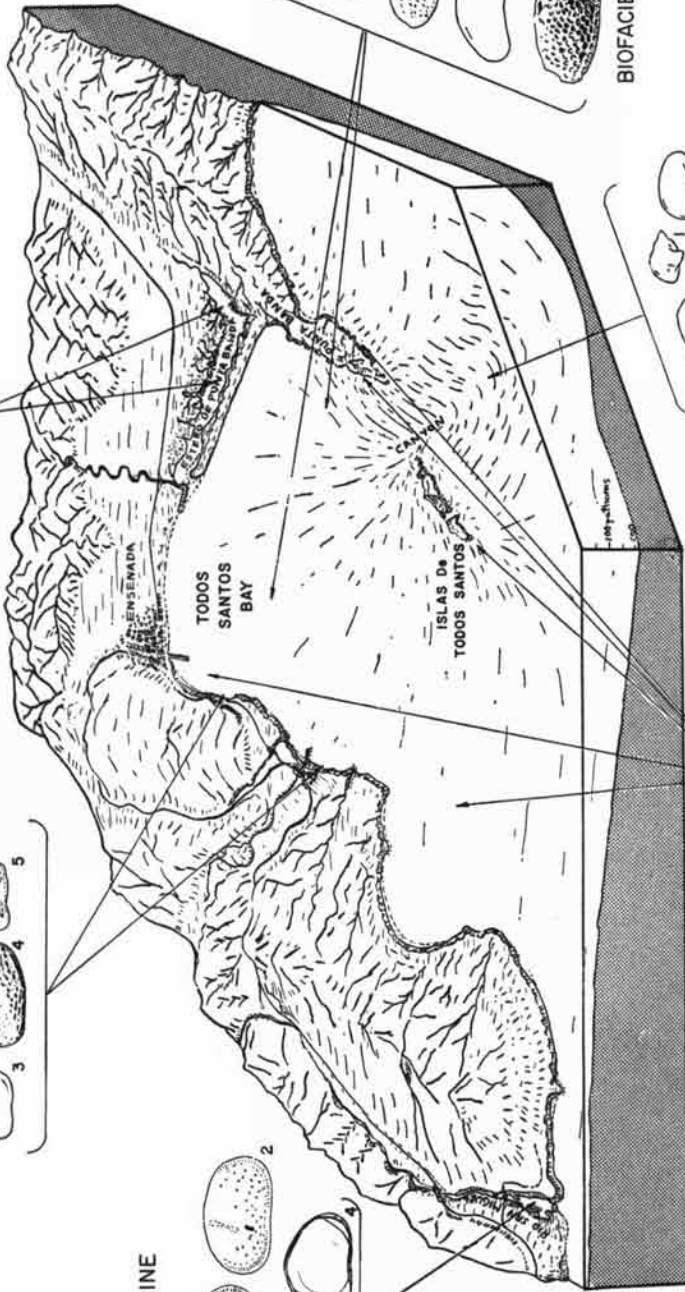
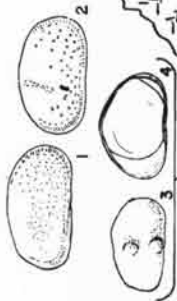
SALT WATER LAGOON & MARSH



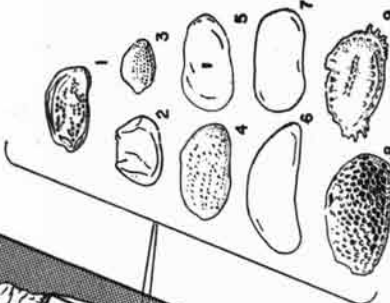
ROCKY TIDE POOLS



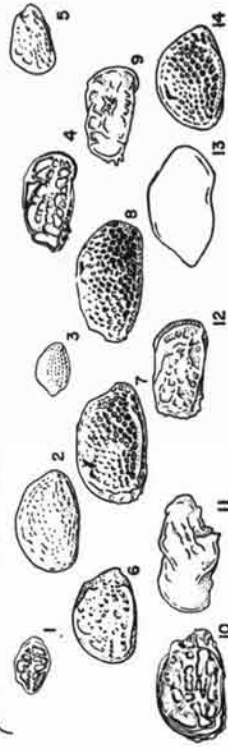
ESTUARINE



BIOFACIES II (shallow shelf, fine sands and silts)



BIOFACIES IV (deeper water)



BIOFACIES I (shallow shelf, coarse sands)

There is evidently an unknown factor that restricts the forms to the edge of the area. The large strip of very fine well-sorted sand along the eastern side of the bay is thought to be sterile, deprived of nutrients, because of the lack of potential cation exchange in the almost pure silica sand material, which could not serve to hold the nutrient cations for use as needed.

The poorly sorted medium-silt area in the lower part of the submarine canyon helps to support the stenothermal epipelos and endopelos species that compose Biofacies IV. Temperature and substratum are the controlling factors for the restriction of this faunule.

In the Estero de Punta Banda, the substratum composition only locally influences the density of populations. Very few specimens were found near the entrance, probably because it is an area of well-sorted sand and strong tidal currents, although other factors may be equally important. Few specimens were found in the bare hard-mud tidal channels, but the population increased as the sand content increased and the hardness of the bottom decreased.

Some genera which have member species represented in the Todos Santos Bay area have been observed in other areas (ELOFSON, 1941; REMANE, 1933, 1940) as being characteristic of particular substratum types, and it is probably valuable to summarize these findings. Species of *Cyprideis* were found living in strongly mud-mixed sand: *Cythereis*, *Cytheropteron*, *Loxoconcha* associated with mud, with or without sand, but with a certain stability or firmness; *Palmenella*, *Cythereis*, *Paracypris*, *Cyprideis*, *Loxoconcha*, *Cytherella*, and *Hemicythere* burrowing in the top few centimeters of soft mud (endopelos); *Hemicythere* and

Cypridea living on the surface of sand layers (epipsammon); *Cythereis* and *Cytherura* climbing and crawling between sand grains or shell particles or both (endopsammon).

SALINITY

The salinity over the bottom of Todos Santos Bay is consistently normal marine and its effect on the ostracode population is generally uniform. The Estero de Punta and the Rio San Miguel, however, have marked extremes in salinity, and their faunas are believed to be largely controlled by these conditions.

Ostracodes are poikilosmotic (isotonic with their surroundings) but their distribution is greatly affected by a decrease and to some extent by an increase in normal marine salinity. Most marine species are stenohaline; a few are euryhaline forms. Brackish-water forms are mostly euryhaline. The threshold from salt water to fresh water is the most difficult ecologic transition for marine invertebrates to cross (REMANE, 1940, p. 1). Hol-euryhaline forms are generally rare among invertebrates and are unknown in ostracodes.

KUMMEROW stated (1949, p. 287) on the evidence of the fossil record that the ostracodes have never developed a stable race of brackish-water forms and that there were no morphologic distinctions separating these forms from those of salt and fresh water. It is evident, however, in the literature on Recent ostracodes, as pointed out by TRIEBEL (1950, p. 88) and substantiated by this and other Recent studies on the ecology of ostracodes (ELOFSON, 1941; REMANE, 1940; SWAIN, 1955; BRADY & ROBERTSON, 1873; KLIE, 1938), that a very well established faunule is endemic to the

FIGURE 9. Distribution of the various ostracode biofacies in the Todos Santos Bay Region and their major constituents. Species found in the individual biofacies are listed below.

- BIOFACIES I. (1) *Hemicytherura* sp. cf. *H. clathrata*; (2) *Brachycythere lincolnensis*; (3) *Cytherura bajacala*; (4) *Bradleya diegoensis*; (5) *Quadracythere regalia* (molt); (6) *Hemicythere jollaensis*; (7) *Quadracythere regalia* (adult); (8) *Hemicythere californiensis*; (9) *Bradleya pennata*; (10) *Bradleya aurita*; (11) *Paracytheridea granti*; (12) *Cythereis glauca*; (13) *Bairdia* sp. aff. *B. verdesensis*; (14) *Brachycythere driveri*.
- BIOFACIES II. (1) *Brachycythere* sp.; (2) *Palmenella carida*; (3) *Cytherura bajacala*; (4) *Leguminocythereis corrugata*; (5) *Cytherura* sp. cf. *C. gibba*; (6) *Paracypris pacifica*; (7) *Cytherella banda*; (8) *Hemicythere californiensis*; (9) *Pterygocythereis semitranslucens*.
- BIOFACIES IV. (1,3) *Cytheropteron pacificum*; (2) *Bythocypris actites*; (4) *Cytheropteron newportense*.
- SALT-WATER LAGOON AND MARSH. (1) *Puriana pacifica*; (2, 3) *Xestoleberis aurantia*; (4) *Loxoconcha lenticulata*; (5) *Cyprideis (Goerlichia) castus*.
- ROCKY TIDE POOLS. (1) *Haplocytheridea maia*; (2) *Loxoconcha lenticulata*; (3) *Xestoleberis aurantia*; (4) *Brachycythere lincolnensis*; (5) *Caudites fragilis*.
- ESTUARINE. (1) *Cyprideis (Goerlichia) miguelensis*; (2) *Cyprideis (Goerlichia) stewarti*, (3) *Cyprideis (Goerlichia) sp.*; (4) *Cypridopsis vidua*.

brackish-water zone. Many species of the genera *Cyprideis*, *Haplocytheridea*, *Perissocytheridea*, *Cytheridea*, and *Heterocypris* have been previously described from brackish waters. Several more predominantly fresh-water and marine genera have occasional brackish-water species.

ELOFSON (1941, p. 455) found that the vertical and horizontal distribution of salinity and the ostracode distribution ran fairly parallel. The ostracodes associated with the vegetation growing in areas of rapid change and those living in shallow water are euryhaline forms. He also found that the ostracode population decreased as the salinity decreased, but this is contrary to the findings of SWAIN (1955) and those of this study. This may be due, as suggested by SWAIN, to an increase in nutrients in a river's mouth, but it may also be due to lack of competition with other micro-organisms. ELOFSON was dealing with a very large area (the Baltic Sea) where the salinity decreased slowly and was far from any particularly high nutrient source. All studies agree that the number of species decreases with a decrease in salinity, with the greatest drop noted by ELOFSON between pliomessohaline and miomessohaline (VÄLIKANGAS, 1933) waters (about 10 o/oo salinity or 6 o/oo chlorinity).

In the Estero de Punta Banda, where the salinities are generally higher than normal marine, there exists a group of endemic species that compose a distinct biofacies. A great range of temperature is observed and the salt-marsh flora is a dominant feature. The wide variation in salinity probably serves to keep out stenohaline marine forms, whereas the temperature, flora, and changing substratum mold the character of the faunule locally. Also, the tidal range subjects some of the faunule to periodic exposure as well as high salinities. No comparable faunule has been previously described, except possibly the salt-marsh faunule of BRADY & ROBERTSON (1870) and a brief unpublished list of forms by ROTHWELL from Mission Bay, San Diego County, California. As only the latter location was visited and salinity data are not available from the other area, it is only assumed from the homologous structure of their faunules and their general appearance that they have the same conditions as the estero. As can be observed from the plot of this faunule (Fig. 11), its member species are fairly characteristic of the estero but

show transition into other shallow-water biofacies such as are found in the tide pools on the north side of the bay.

Although fresh-water species (with the exception of a few specimens of *Cypridopsis vidua* found in the Rio San Miguel lagoon) were not studied in this report, it should be noted that they represent a very distinct ecologic and taxonomic unit and are very important indicators for paleoecological studies. They are mainly of the family Cypridae. SWAIN (1955) found that they occur in waters of up to 18 o/oo salinity, which helps to explain their occasional appearance in estuarine environments.

LIGHT

The distribution of the euphotic zone and the transparency of water do not seem to have a direct effect on the general or seasonal distribution of ostracodes (TRESSLER & SMITH, 1948, p. 48), but they do have a decisive secondary effect on the distribution of the marine flora which in turn controls the distribution and abundance of the phytal biofacies. Most parts of Todos Santos Bay have remarkably clear water, so light is probably effective to a depth of at least 25 or 30 fathoms. This may in part help to explain the denser ostracode population down to that depth around the Todos Santos Islands and over to the northern coast.

DISSOLVED OXYGEN AND HYDROGEN-ION CONCENTRATION

The amount of dissolved oxygen in the water does not seem to play an important role in the distribution of the ostracodes in any of the environments investigated. Some species live in low-oxygen environments and even in euxinic environments (ELOFSON, 1941). The effect of dissolved oxygen may be masked by temperature in some brackish-water environments, as they were found to act together in Chesapeake Bay (TRESSLER & SMITH, 1948, p. 48). In their study, variation in the hydrogen-ion concentration showed no effect on the seasonal distribution of the ostracodes. It was found during this study using aquaria that *Cypridopsis vidua*, a fresh-water species found in the Rio San Miguel lagoon, could not thrive in a pH below 7.0. The distribution of dissolved oxygen and the hydrogen-ion concentration showed no correlation with the distribution of species or in-

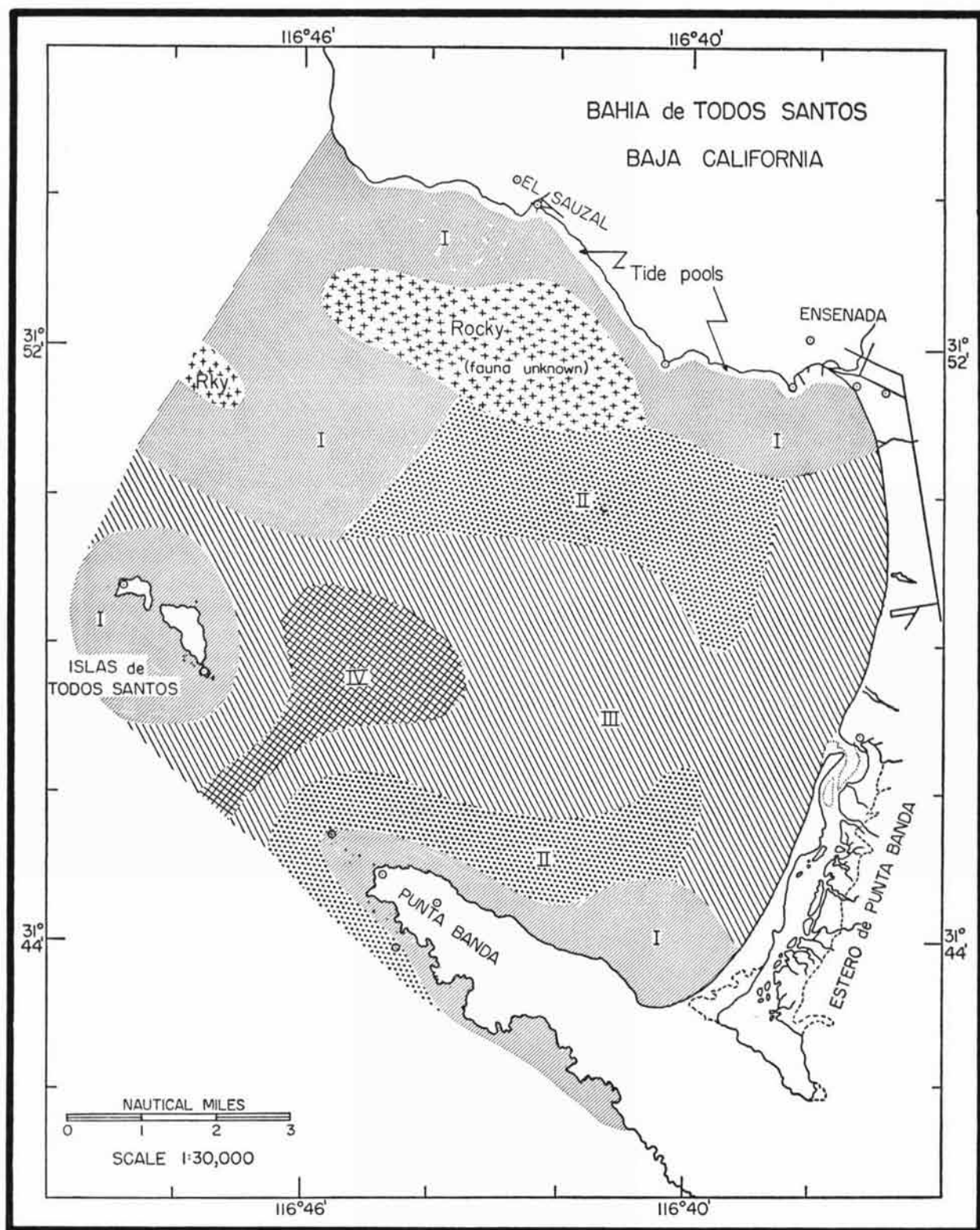


FIGURE 10. Areal distribution of the ostracode biofacies of Todos Santos Bay. Biofacies I, II, and IV conform approximately to lateral variations in depth and type of bottom sediment. Biofacies III is an area where virtually no ostracodes were found.

dividuals in the Rio San Miguel. Measurements were not taken in other areas.

PLANTS

There is no direct correlation between the distribution of a particular species or genus of marine algae and the distribution of a species or genus of ostracodes (ELOFSON, 1941). The general structure of the plant (which provides support but not nourishment) seems to be the principal attraction for some types of ostracodes. There is a definite development in some areas of a heavily populated phytal biofacies. ELOFSON used the term *phytal* to include those species of ostracodes that lived in the grasses and vegetation that grow on the bottom of the sea. The distribution of this habitat is dependent on the distribution of the marine algae and the epiphytes growing on the dead and decayed vegetation, all of which are eventually dependent on depth, euphotic zone, and kind of substratum.

It was discovered that eel grass generally covers the estero areas and provides an ecologic niche for many of the species of ostracodes found there. In the upper end of the estero, coralline algae grow in small clumps in the midst of the eel grass. These clumps support large numbers of one species, *Loxoconcha lenticulata*, living in its spongy porous structure. The frilly or porous-structured algae in tidal pools invariably yielded greater numbers of specimens. Although no ostracodes were found on the *Macrocystis* and *Laminaria* specimens examined, it may be that species of Biofacies I in Todos Santos Bay do live at times in or on these plants.

The distribution of the dominant plant biotope in the bay is not well known, that represented on Figure 2 being compiled from U.S. Hydrographic Office Chart 1149 and from observation. Occasionally the orange-peel dredge brings up a small plant fragment but rarely enough to map. It is believed that the euphotic zone will permit sparse growth far in excess of charted growth, perhaps to a depth of 30 fathoms, particularly on the western side of the bay.

Certain genera of ostracodes found by ELOFSON (1941, p. 411) to have species typical of the phytal biofacies are also believed to be dependent on plants for support in Todos Santos Bay. These are the genera *Cythereis*, *Loxoconcha*,

Xestoleberis, *Scherochilus*, and possibly *Cytherura*. *Haplocytheridea*, which was very abundant in the north-shore tidal pools, showed a very pronounced dependence on the coralline algae.

Plants appear to be a major biologic factor influencing the distribution of the ostracodes in the Todos Santos Bay region, as also observed by ROTHWELL (1948, p. 1380) for other areas along the California coast.

NUTRIENT AND FOOD SUPPLY

The factor above all others that determines the total population and productivity of an area is the available nutrient supply for the resident organisms. The most productive areas are those near an upwelling of cold water, which brings up in solution nitrates and phosphates generated in the depths.

The upwelling on the southern side of Punta Banda is probably the source of the nutrient supply for Todos Santos Bay. The Rio San Miguel lagoon is fed by the river, which drains a mineral-rich headland low in organic production. The area around the islands of the bay and Punta Banda are very luxuriant, whereas the inner reaches of the bay are less so. The Estero de Punta Banda probably receives a normal supply of nutrients from both the bay and the inland drainage.

It is not easy to be certain concerning the nourishment of the ostracodes. Examination of the stomach and its contents very seldom provides a clue. It is either empty or the food is so small that the original nature cannot be determined (MÜLLER, 1894, p. 17). Some species are mud gulpers; only one genus, *Cypridina*, is thought to be parasitic (ELOFSON, 1941, p. 468). MÜLLER has observed that the members of the subgenus *Doleria* feed on annelid worms. CANNON (1934, p. 763) has observed *Cypridina* feeding on detritus. Small diatoms have been found in the stomachs of species of *Cytherura* and *Loxoconcha* (MÜLLER, 1894) and polychaete setae in the stomach of a species of *Cytheropteron*; *Philomedes* is a plant sucker (ELOFSON, 1941, p. 468).

OSTRACODE BIOFACIES

ROTHWELL (unpublished manuscript) collected six samples of living ostracodes in the San Diego area and arranged a chart similar to the one in the

present report showing a differentiation of the marine ostracode faunule into three major biofacies. They were classified as (1) salt-water lagoon and salt-marsh channel remotely connected to the sea; (2) salt-water bay mouth and open ocean, rock bottom sublittoral near-tide mark, eel grass and coralline algae association; and (3) open sea, exposed continental shelf (16 to 32 fathoms).

The faunules of the Todos Santos Bay and Rio San Miguel areas have been studied and found to be divided into six major biofacies with several minor subdivisions (Figs. 9, 11). These include a brackish-water estuarine biofacies, a salt-water lagoon and salt-marsh biofacies, and four biofacies in an open marine bay. Many of the features of these biofacies have been discussed above under the environmental factors, so only the characteristic features will be given here.

BRACKISH-WATER ESTUARINE BIOFACIES (RIO SAN MIGUEL LAGOON)

The estuary of the Rio San Miguel (Fig. 4) serves very well for the study of oligohaline and mesohaline brackish-water forms without pollution from the adjacent marine biofacies as encountered by BRADY & ROBERTSON (1870, p. 2), because the sand spits cuts off the free washing-in of marine forms. Although it is out of direct tidal influence most of the time, its chlorinity was recorded up to 1.25 o/oo, which seems to keep out most fresh-water ostracodes (Fig. 12). The high population found here is due to the lack of strong currents, quiet sheltered pools, abundant vegetation, poorly sorted bottom, and high nutrient supply, all of which are optimum conditions for the growth of ostracodes (BRADY & ROBERTSON, 1870, p. 3). The endemic faunule (Fig. 11) includes *Cyprideis* (*Goerlichia*) *stewarti*, *C.* (*Goerlichia*) *miquelensis*, n. sp., *C.* (*Goerlichia*) sp., with the fresh-water species *Cypridopsis vidua*.

SALT-WATER LAGOON AND SALT-MARSH BIOFACIES (ESTERO DE PUNTA BANDA)

The estero probably contains only one major biofacies (Fig. 9), but there is a tendency for it to be divided into a main channel faunule, and a marsh and tidal channel faunule (Fig. 11). All the species found in the estero (Figs. 13-15) are

endemic except *Loxococoncha lenticulata* and *Xestoleberis aurantia*, n. sp., which are also open-bay forms. These include *Xestoleberis banda*, n. sp., a rather rare species, *Puriana pacifica*, n. sp., and *Cyprideis* (*Goerlichia*) *castus*, n. sp. Eel grass and coralline algae are the dominant plant forms whose distribution exerts a strong influence on the local distribution of a few species. The absence of forms near the mouth of the estero is attributed to the occasional lowering of the salinity by the intermittent discharge of the Rio San Antonio and to the well-sorted sterile substratum.

The Foraminifera, identified by WALTON (1954) from the estero, found associated with the ostracodes in the marsh region include *Arenoparella mexicana* (KORNFELD), *Discornenopsis* cf. *aguayoi* (BERMUDEZ), *Jadammina polystoma* BARTENSTEIN & BRAND, *Triloculina* sp., and *Trochammina inflata* (MONTAGU). Those from the main channel include *Cibicides flecheri* GALLOWAY & WISSLER, *Discorbis* spp., *Nonionella basispinata* (CUSHMAN & MOYER). Species common to both include *Elphidium tumidum* NATLAND, *Miliammina fusca* (H. B. BRADY), and *Proteonina* sp.

OPEN-BAY MEGABIOFACIES (BAHIA DE TODOS SANTOS)

This megabiofacies includes several subdivisions or biofacies (Figs. 10, 11), differentiated by the combined effects of depth, temperature, phytal distribution, and substratum. It is equivalent in rank to each of the two preceding biofacies. These biofacies are, as the name implies, transitional, and the boundaries are somewhat arbitrary. There are many species found in several subdivisions; they were selected as indicators on the basis of abundance. Figures 16 through 20 refer to the percentage of the various species taken as cross-sections through various parts of Todos Santos Bay. A compilation of the distribution of the ostracodes in NATLAND's (1933) samples from the San Pedro Channel by ROTHWELL (1944) shows these species to have a rather constant selection of habitat which agrees with their distribution in Todos Santos Bay.

The ostracodes found in the tidal pools (Fig. 11) on the northern side of the bay were abundant where the flora was abundant along the stable rocky section of coast but were absent on the un-

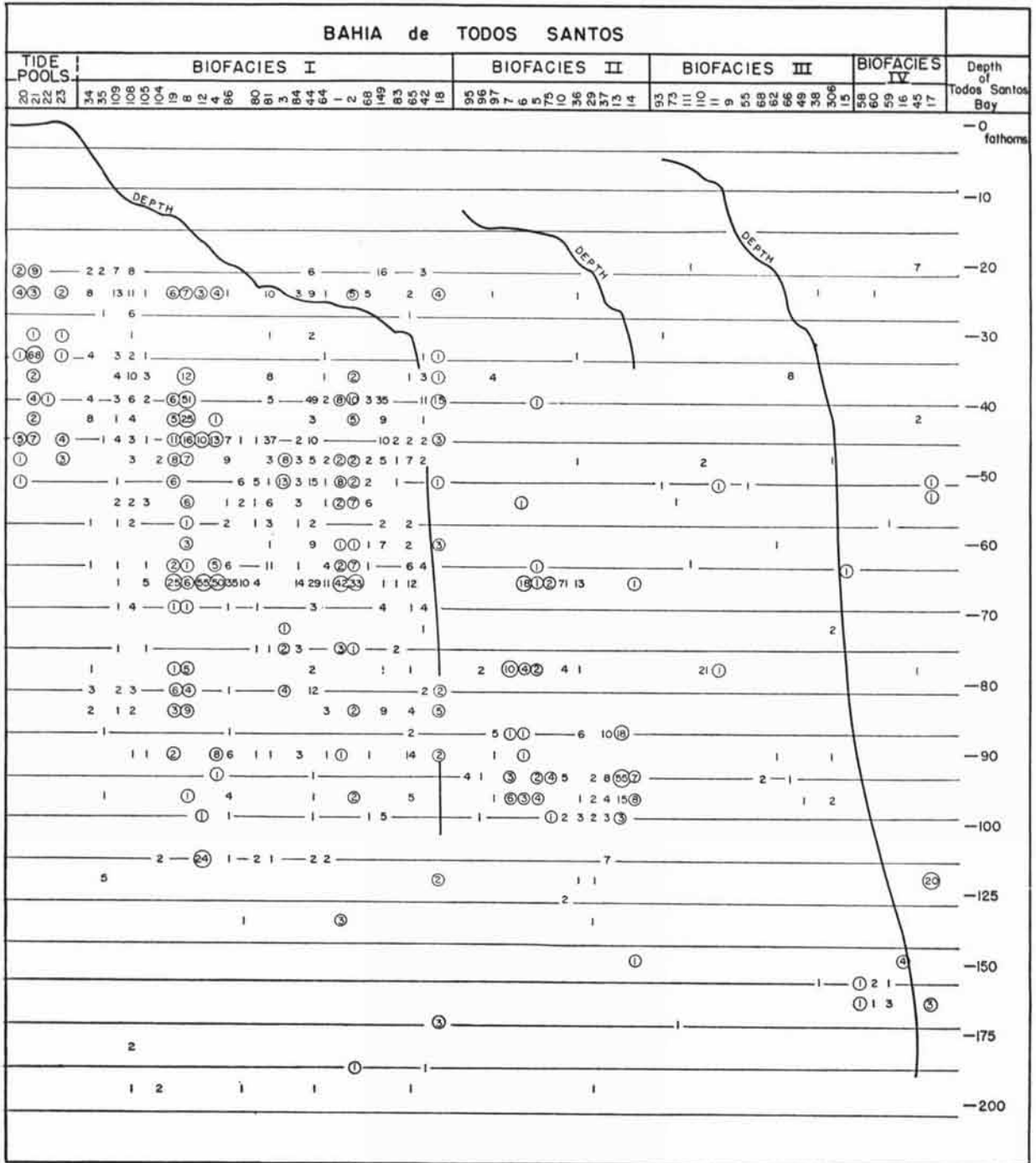


FIGURE 11. (continued from facing page.)

stable sandy beaches with large cobbles except in tide pools. This faunule does not form a discrete biofacies but merges seaward with Biofacies I (Figs. 17, 19) and is therefore ranked as a sub-facies. *Haplocytheridea maia*, n. sp., is abundantly associated with the coralline algae of the tidal pools and is considered an indicator species of the littoral zone. This is a very rigorous environment subjected to occasional pounding by waves, isolation at low tide, and great temperature variations.

ELOFSON (1941, p. 486) has described a sharp break in the distribution of the Swedish ostracodes at the outer edge of the mixing zone where effective wave base does not strike bottom. This phenomenon does not seem to be present in Todos Santos Bay. Detailed sampling was not done in the area because the bottom is rocky over a large area. The exact depth of wave action is not known, so its effect could not be accurately gauged.

Biofacies I includes those species that occur on the northern side of Punta Banda, between the Todos Santos Islands and the northern coast of the bay (Figs. 10, 11). It corresponds generally with the marginal bay facies of WALTON (1954). Its distribution is believed to reflect the medium and fine sandy substratum, a mild temperature variation, and the known and supposed plant distribution. This is an area of high open-shelf productivity in all forms. Characteristic of this environment are the ostracode species *Quadracythere regalia*, n.sp., *Bairdia* aff. *B. verdesensis*, *Bradleya aurita*, *Brachycythere lincolnensis*, *Paracypris pacifica*, *Bradleya diegoensis*, *Cythereis glauca*, *Brachycythere* sp., *Hemicythere jollaensis*, and *Hemicytherura* cf. *H. clathrata*. Found associated with the ostracodes are the foraminiferal species *Angulogerina angulosa* (WILLIAMSON), *Cassidulina subglobosa* H. B. BRADY, *Cibicides flecheri* GALLOWAY & WISSLER, *Cibicidina nitidula* BANDY, *Elphidium tumidum* NATLAND, *Rotalia* spp., *Bolivina striatella* CUSHMAN, *Textularia* cf. *schenccki* CUSHMAN & VALENTINE, *Bolivina vaughni* NATLAND, *Bifarina hancocki* CUSHMAN & McCULLOCH, and *Planulina exorna* PHLEGER & PARKER.

Biofacies II (Figs. 10, 11) is represented by the ostracode species *Cytherura* cf. *C. gibba*, *Leguminocythereis corrugata*, and *Palmenella carida*, n. sp. It is restricted to the central part of Todos Santos Bay in the zone of very fine sand on the

inner margin of Biofacies I. The depth, temperature, and other environmental factors are not peculiar to this environment. It contains only a few forms and is bordered by the very productive Biofacies I on one side and the barren Biofacies III on the other. Probably these species cannot compete effectively with those of Biofacies I and their tolerances will permit them only limited penetration of the environment of Biofacies III, so they form an intermediate biofacies of their own. None of WALTON's foraminiferal facies can be correlated with Biofacies I.

Biofacies III is characterized by the lack of an endemic ostracode fauna (Fig. 11) and is restricted to the inner part of the bay, to the area of very fine sand. No single environmental factor can be shown to be responsible for this barren area unless the substratum is nonfertile. None of WALTON's foraminiferal facies conforms to the distribution of this ostracode biofacies.

Biofacies IV is composed of the ostracode species that are restricted to the fine poorly sorted silt substratum of the deeper part of Todos Santos Bay in the submarine canyon (Fig. 11). These deep-water stenothermal species include *Brachycythere schumannensis*, *Cytheropteron pacificum*, *Bythocypris actites*, n.sp., and *Cytheropteron ensenadum*, n.sp. They are generally associated with the foraminiferal species of WALTON's (1955) outer bay facies, which include *Reophax gracilis* (KIAER), *Uvigerina perigrina* CUSHMAN, *Recurvooides* spp., *Chilostomella ovoidea* REUSS, *Bolivina acuminata* NATLAND, *B. pacifica* CUSHMAN, *Bulimina denudata* CUSHMAN & PARKER, and *Globobulimina* spp.

Dr. S. C. KENDEIGH (personal communication), after examining this report, noted a close similarity in the distribution of the salt-marsh and open-bay ostracode biofacies and the *Macoma-Paphia* and *Pandora-Yoldia* biociations of the bivalve-annelid biome. He also suggested that the brackish-water estuarine biofacies may be an ecotone of the pond-marsh biofacies.

SUMMARY AND CONCLUSIONS

The ostracodes of three areas on the west coast of Baja California, Mexico, 60 miles south of San Diego, California, were studied and the variability of the live and dead faunules with respect to environmental change were recorded in order to

determine their usefulness as biofacies indicators. These areas have a wide range of depth, salinity, temperature, vegetation, and substratum conditions and include estuarine open-bay and salt-water-lagoon environments. Found were six principal biofacies with several possible subdivisions, including an estuarine biofacies, a salt-water-lagoon and salt-marsh biofacies, and an open-bay megabiofacies with four main biofacies and one lesser facies (Fig. 9) dependent on depth, vegetation, and substratum.

From 170 stations in the above environments, 316 samples were collected, of which 6,700 specimens representing 46 species were identified. Four hundred and eleven bathythermographs were analyzed with 57 direct temperature readings. The sediments of 67 of the bay's 111 stations were analyzed. Depths to 215 fathoms were noted, salinities from 0.5 to 37 o/oo, and bottom temperatures from 50 to 85°F. (average mean about 55°F. and variation about 10 degrees). The sediments include a wide range of clastics.

Conclusions on the distribution and ecology of the ostracodes are:

1. Twenty-eight ostracode species of 19 genera showed sufficient ecologic restriction to be used as biofacies indicators in sediments of past environments ranging back to the Pliocene, as summarized on Figure 11. The brackish-water estuarine biofacies, the salt-water-lagoon and salt-marsh biofacies, and the open-bay megabiofacies could easily be determined in the fossil state. The interpretation of the subdivisions of the four open-bay biofacies might be difficult because of the influence of the rate of sedimentation, in which case the relative abundance of specimens of certain species would not be indicative of the living population.

2. The dead population distribution can be used in most cases to interpret environmental conditions, but the population density could indicate the rate of sedimentation as well as productivity of the species.

3. Live and dead counts are necessary to eliminate fossil species and certify the presence of biocoenoses.

4. Many forms reflect in their carapace morphology their life mode as phytal, endopsammon, epipsammon, epipelos, or endopelos.

5. Until more genera and higher taxonomic categories are better defined, species serve as the best biofacies indicators.

6. Several stenobathyal ostracode species in the bay were found in deep water; the distribution of all species reflected depth in a general way.

7. Temperature, although important in defining the general character of the faunule in the area and determining the season of propagation of some species, could not be directly correlated with the distribution of any one species.

8. The distribution of certain sediment groups or types of substratum was correlated with the abundance as well as the character of some biofacies.

9. A marked lateral or vertical change in the salinity was immediately reflected in the character of the ostracode faunule. Salinity was the one factor that most affected the distribution of the ostracodes.

10. There is, contrary to some reports, an endemic and abundant brackish-water ostracode faunule.

11. Variations in dissolved-oxygen content and hydrogen-ion concentration are not important direct factors in the distribution of ostracodes.

12. The distribution of certain structural types of plants greatly influences the distribution of plant-dependent ostracodes.

GLOSSARY

adont hinge.—Simple hinge consisting of bar and groove.
amphidont hinge.—Hinge with crenulate, post- or knob-like terminal dental elements, intermediate element subdivided into a single smooth anterior socket and post-jacent groove.

antimerodont hinge.—Hinge with crenulate terminal dental elements and intermediate crenulate groove.

biociation.—Animal community representing highest degree of organization and development possible for a given habitat; climax community.

biocoenosis.—Assemblage of organisms found occurring together in normal ecologic relationships; life assemblage.

biofacies.—Assemblage of fossil or dead organisms repeatedly found together, typical of certain kinds of environmental conditions; may comprise single species or group of species belonging to one or more phyla; interrelationships less well known than those of a living community, biociation or biome.

biome.—Group of related biociations representing highest order of interrelated organization of population.

- ecotone.**—Transition assemblage of organisms between adjacent biomes.
- endemic fauna.**—Fauna restricted to a particular habitat.
- endopelos.**—Habitat within a clay substrate.
- endopsammon.**—Habitat within a sand substrate.
- entomodont hinge.**—Hinge with crenulate terminal dental elements, separated by intermediate element consisting of an anterior crenulate socket and posterior crenulate groove.
- epipelos.**—Habitat on top of a clay substrate.
- epipsammon.**—Habitat on top of a sand substrate.
- estero.**—Estuary (Spanish); in this paper signifies salt water lagoon.
- euphotic zone.**—Zone of light in upper reaches of aquatic environment.
- eurybathyal species.**—Species tolerant to great changes in depth.
- euryhaline species.**—Species tolerant to great changes in salinity.
- eurythermal species.**—Species tolerant to great changes in temperature.
- faunule.**—Part of a fauna; may be only representatives of one taxa of a community.
- hemiamphidont hinge.**—Amphidont hinge with smooth anterior dental element and crenulate or lobed posterior element.
- holamphidont hinge.**—Amphidont hinge with smooth terminal dental elements.
- holomerodont hinge.**—Hinge with crenulate terminal dental elements and intermediate crenulate bar.
- isotonic.**—Equal in salinity.
- merodont hinge.**—Hinge composed of three elements, anterior and posterior being crenulate.
- mesohaline.**—Moderately brackish, with salinity ranging from approximately 3 to 16.5 o/oo (Redeke, 1933).
- miomesohaline.**—Moderately brackish, typical, less than pleiomesohaline, with salinity from about 3 to 8 o/oo (Valikängas, 1933).
- oligohaline.**—Slightly brackish, with salinity ranging from 0.5 to 3. o/oo (Valikängas, 1933).
- paramphidont hinge.**—Amphidont hinge with crenulate or lobed terminal dental elements.
- pleiomesohaline.**—Moderately brackish, almost marine, with salinity from 8.0 to 16.5% (Valikängas, 1933).
- phytal.**—Habitat with marine algae as the dominant environmental factor.
- poikilosmotic.**—Signifying balanced salinity of body fluids within an organism, as compared to salinity of its external environment.
- stenobathyal species.**—Species narrowly restricted as to depth.
- stenohaline species.**—Species narrowly tolerant of changes in salinity.
- stenothermal species.**—Species tolerant to no or only very slight changes in temperature.
- thanatocoenosis.**—Group of organisms, usually fossil, found occurring together but not representing a living relationship; a death assemblage.

PART 3. SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille, 1806

Suborder PLATYCOPA Sars, 1866

Family CYTHERELLIDAE Sars, 1866

Genus CYTHERELLA JONES, 1849

Cytherella JONES, 1849, p. 28; SARS, 1865, p. 125; MÜLLER, 1894, p. 386; MÜLLER, 1912, p. 390.
Type species. *Cytherina ovata* ROEMER, 1840.

Diagnosis. Distinguished from other genera of the Suborder Platycopa by its thick-shelled ovate, usually smooth to punctate carapace; the right valve almost always over-reaches the left; hinge is never more complicated than just a bar and groove; adductor muscle scar pinnate or feather-shaped, aggregate, double row of small scars; sexual dimorphism. *Pennsylvanian? to Recent.*

The genus *Cytherella* is believed to be a burrower (ELOFSON, 1941, p. 426) and to be restricted to marine salinities (SOHN, 1951, p. 64). It has been identified in a shallow lagoon and at a depth of 300 fathoms (HORNIBROOK, 1952). It probably prefers fine-grained sediments.

CYTHERELLA BANDA Benson, n. sp.
 Pl. 1, Fig. a-c; Pl. 8, Fig. 14

Diagnosis. The distinguishing feature of this species is its outline, smooth surface, and blunt but rounded posterior end as seen in dorsal view.

Description. Carapace of adult moderately large, subrectangular, rounded in lateral view, subcuneiform in dorsal view. Uniform height, thickest in posterior; left valve slightly larger than right; dorsal margin parallel and nearly straight, very slight slope in the posterodorsum of some specimens; anterior and posterior ends broadly rounded; surface smooth porcellaneous with very few normal pore canals seen; shell very frequently subtransparent with the muscle scar visible from the exterior. Hinge, ridge, and groove with the ridge in the right valve; complex lobate, ovate muscle scar; narrow marginal area; radial pore canals obscured if present.

Dimensions. Length of adult specimen 0.87 mm.; height 0.43 mm.; thickness 0.36 mm.

Material. Specimens examined 95, of which 60 were living when the sample was taken.

Remarks. Very similar to *C. abyssorum* SARS, 1928, but has no dull areas that take the form of small pits and is not nearly so angular, particularly in the dorsal view. Named for Punta Banda.

Occurrence. Found in Todos Santos Bay and the Estero de Punta Banda at depths of a few feet in the main channel estero to 20 fathoms in the bay. It has a wide temperature tolerance as noted by its presence in the estero, and is found in the bay occasionally around the islands and commonly in the northeastern sector; generally restricted to the very fine sand to coarse silt. Probably a burrowing form. For faunule association see Figure 11.

Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea ALEXANDER, 1929, p. 55; HOWE, 1934, p. 27; SEXTON, 1951, pp. 808-816; MUNSEY, 1953, p. 2.
Type species. *Cythere williamsoniana* JONES, 1849, p. 31, pl. 7, fig. 26a-i.

Diagnosis. Distinguished from *Cytherella* and other genera of the suborder Platycopa by the prominent ridges on the surface of the carapace. *Jurassic? to Recent.*

CYTHERELLOIDEA CALIFORNICA LeRoy, 1943

Pl. 1, Fig. 2; Pl. 8, Fig. 13
Cytherelloidea californica LEROY, 1943a, p. 357, pl. 58, figs. 32-35; text-fig. 2b.

Remarks. The distinctive surface ridge pattern enables this species to be identified.

Dimensions. Length of adult specimen 0.73 mm.; height 0.43 mm.; thickness 0.30 mm.

Material. Specimens collected 38, of which only 4 were living.

Occurrence. Previously reported by LEROY (1943a, p. 357) from Avalon Bay, Santa Catalina Island, and Monterey Bay, California, and by ROTHWELL (1944) from the first locality at a depth of about 10 fathoms. Found sparsely distributed in Todos Santos Bay. Not enough specimens were found to give much information about its ecology. Depth range 10 to 20 fathoms, dead shells found at 150 fathoms, mean annual temperature range, indefinite.

Suborder PODOCOPA Sars, 1866

Family CYPRIDIDAE Baird, 1850

Subfamily CYPRIDOPSISINAE Kaufmann, 1900

Genus CYPRIDOPSIS Brady, 1867

Type species. *Cypridopsis vidua* O. F. MÜLLER, 1776, p. 199.

Diagnosis. Distinguished from other simple, unornamented groups by its strongly arched dorsum, inflated valves, distinctive adductor muscle scar pattern, and wide anterior duplicature and vestibule.

A very common fresh-water form observed all over the world. A few species have been noted (BRADY & ROBERTSON, 1870, p. 2; 1872, p. 49) from brackish-water estuarine environments (*C. obesa* and *C. aculeata* LILLJEBORG). The presence of *C. vidua* MÜLLER in a brackish-water environment is unusual.

CYPRIDOPSIS VIDUA (O. F. Müller, 1776) Brady, 1867

Pl. 1, Fig. 3a,b; Pl. 8, Fig. 8
Cypris vidua O. F. MÜLLER, 1776, Zool. Danicae Prodromus, p. 199; MÜLLER, 1785, p. 55; ZADDACH, 1844, p. 35; BAIRD, 1849, pp. 152-53; pl. 19, figs. 10-11; ZENKER, 1854, p. 79; CHYZER, 1858, p. 512; CLAUS, 1868, p. 151, pl. 1, figs. 6-8; FRIC, 1872, p. 227; CHAMBERS, 1887, p. 155; UNDERWOOD, 1886, p. 337.
Monoculus vidua (O. F. MÜLLER) JURINE, 1820, p. 175.

Cypridopsis vidua (O. F. MÜLLER) BRADY, 1867; KESLING, 1951, pp. 1-324, figs. 1-36, pls. 1-96.

Cypridopsis (sic) vidua (O. F. MÜLLER) FERGUSON, 1944, p. 719.

non *Cypridopsis obesa* BRADY & ROBERTSON, 1870, p. 15.

non *Cypridopsis helvetica* KAUFMANN, 1900a; KAUFMANN, 1900b, p. 310.

Cypridopsis postula FURTOS, 1933, pp. 431-32.

?*Cypridopsis crassipes* MASI, 1909, pp. 372-74, pl. 12, fig. 8.

Pionocypris vidua (O. F. MÜLLER) BRADY & NORMAN, 1896, p. 726; NORMAN & SCOTT, 1906, p. 113; SAWAYA, 1942.

Dimensions. Length of adult specimen 0.70 mm.; height 0.47 mm.; thickness 0.43 mm.

Material. Specimens collected 16, of which 9 were living.

Occurrence. This fresh-water species is very abundant and widely distributed in America and Europe. A few specimens were found living on the marsh grasses in the Rio San Miguel lagoon (Fig. 12). It may be dependent on the fresh upper bay of water that overrides the denser more-saline brackish layer. WAGNER (1957, p. 27) reports this species from the Low Countries living in slightly brackish water. HOFF (1942) notes that *C. vidua* was never found in water of low pH, as was true here also.

Subfamily CYPRIDINAE Baird, 1850

Genus PARACYPRIS Sars, 1865

Paracypris SARS, 1865, p. 11; BRADY & NORMAN, 1889, pp. 31-33;

G. W. MÜLLER, 1894, p. 243; G. W. MÜLLER, 1912, p. 125.

Aglaia BRADY, 1868a, p. 90.

Phlyctenophora BRADY & NORMAN, 1889, p. 94, 95.

Type species. *Paracypris polita* SARS, 1865, p. 12.

Diagnosis. Distinguished from other closely related genera by its large, usually posteroventrally pointed, smooth carapace; valves subequal, with anteromarginal region of the left valve overreaching the right; hinge adont; marginal area broad, with large anterior and posterior vestibules; adductor muscle scar pattern consists of anterior row of three or four with two posterior.

Thought to be typically marine (SOHN, 1951, p. 64) and to be both a burrower (ELOFSON, 1941, p. 426) and a dweller on top of a mud bottom (REMANE, 1940, p. 123). Depth range is uncertain.

PARACYPRIS PACIFICA LeRoy, 1943

Pl. 1, Fig. 4; Pl. 8, Fig. 17

Paracypris pacificus LEROY, 1943a, p. 358, pl. 61, figs. 15-18; text-fig. 2z.

Dimensions. Length of adult specimen 0.87 mm.; height 0.43 mm.; thickness 0.40 mm.

Material. Specimens collected 56; about 25 were stained but only 5 had both valves intact.

Occurrence. Previously reported as abundant in Recent sediments by LEROY (1943a, p. 359) and ROTHWELL (1944) at a depth of 8.5 mm.; also from a tidal pool and in 33 fathoms of water near La Jolla, and from the entrance of the harbor at San Diego, California. It is widely scattered in Todos Santos Bay (Fig. 10). There is a close correspondence between the distribution of this species and the known marine plant distribution. The substratum ranges from coarse to very fine sand. The faunule association corresponds closely to that given by LEROY for the Pleistocene (Fig. 11).

Family BAIRDIIDAE Sars, 1888

Genus BYTHOCYPRIS Brady, 1880

Bythocypris BRADY, 1880, p. 45; SARS, 1887, p. 290; G. W. MÜLLER,

1894, p. 275; G. W. MÜLLER, 1912, p. 249.

Type species. *Bythocypris reniformis* BRADY, 1880, p. 46, pl. 5, fig. 1.

Diagnosis. Species belonging to the marine genus *Bythocypris* are all characterized by having a smooth reniform to subtriangular carapace, of which the dorsal and ventral margins of the left valve overreach the right. They possess an adont hinge; circular, aggregate adductor muscle scar pattern, large anterior vestibule and numerous radial pore canals. *Paleozoic-Recent*.

BYTHOCYPRIS ACTITES Benson, n.sp.

Pl. 1, Fig. 7a,b; Pl. 8, Fig. 6

Diagnosis. *Bythocypris* characterized by its small size and beak-shaped posterior.

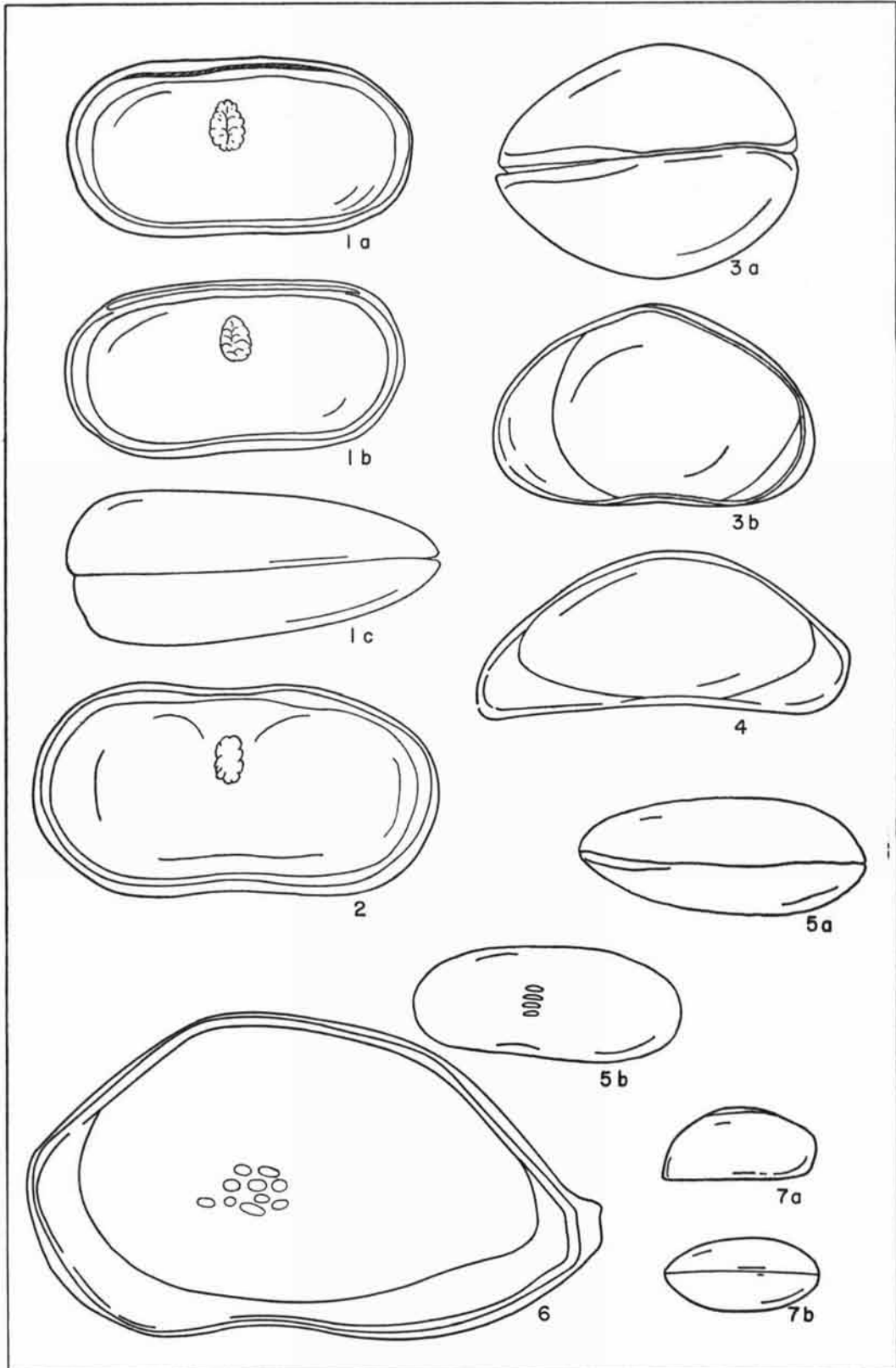
Description. Carapace small, delicate-shelled, modified obovate in lateral view; elliptical in dorsal view; subcircular in end view. Greatest height and thickness in middle

EXPLANATION OF PLATE 1

CYTHERELLA, CYTHERELLOIDEA, CYPRIDOPSIS, PARACYPRIS, BAIRDIA, BYTHOCYPRIS

(All illustrated forms are from the Todos Santos Bay Region, $\times 75$)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Cytherella banda</i> BENSON, n.sp.; 1a, interior lateral view of left valve; 1b, interior lateral view of right valve; 1c, dorsal view	39	of left valve	40
2.— <i>Cytherelloidea californica</i> LEROY; interior lateral view of right valve	39	5.—Genus B sp. A; 5a, dorsal view; 5b, exterior lateral view of left valve showing muscle scar pattern	72
3.— <i>Cypridopsis vidua</i> (O. F. MÜLLER); 3a, dorsal view; 3b, internal lateral view of right valve	39	6.— <i>Bairdia</i> aff. <i>B. verdesensis</i> LEROY; interior lateral view of right valve	42
4.— <i>Paracypris parifica</i> LEROY; interior lateral view		7.— <i>Bythocypris actites</i> BENSON, n. sp.; 7a, external lateral view of right valve; 7b, dorsal view	40



BENSON—Ecology of Recent Ostracodes, Baja California

portion. Dorsal margin uniformly arched; ventral margin straight; anterior end broadly rounded; posterior end broadly rounded, terminating in a right angle with the venter; left valve slightly overlaps right at mid-dorsum. Surface smooth, featureless. Hinge, simple; no muscle scar observed; no duplicature; radial pore canals obscure.

Dimensions. Length of adult specimen 0.43 mm.; height 0.27 mm.; thickness 0.17 mm.

Material. Specimens examined 19; 11 were stained and had both valves intact.

Remarks. This species is smaller and more capsule-shaped than *B. reniformis* BRADY, the type species, and blunter than *B. elongata* LEROY. Name: *actites* (Gr., dweller of the sea coast).

Occurrence. Found in the shallower waters of the channel region of Todos Santos Bay and on the south side of Punta Banda. Depth range from 30 to 100 fathoms; mean annual bottom temperature 50° to 52°F., annual variation 2 to 4 degrees in the bay and up to 10 degrees on the south side of Punta Banda; substratum principally medium-to-coarse silt with clay. Restricted to deeper, cooler part of the bay. Frequently associated with *Cytheropteron pacificum* and Genus B, sp. A.

Genus BAIRDIA McCoy, 1844

Bairdia MCCOY, 1844, p. 164; BRADY, 1880, p. 47; KELLETT, 1934, pp. 120-138; SCOTT, 1944, pp. 162-171; EDWARDS, 1944, p. 506; SYLVESTER-BRADLEY, 1950, pp. 751-756; text-figs. 1-5.

Type species. *Bairdia curta* MCCOY, 1844, p. 164.

Diagnosis. Recognized by its large subrhomboidal to subtriangular, smooth or punctate carapace with a rounded anterior, arched dorsum and posterior caudal extension; left valve overlaps right along dorsum and venter, adont hinge, broad anterior and posterior duplicature and vestibules, circular adductor muscle scar pattern with many scars. *Silurian to Recent.*

The genus *Bairdia* has been described as typically shelf-marine in habitat, completely confined to the bottom, and unable to swim (MÜLLER, 1894, p. 13).

BAIRDIA sp. aff. B. VERDESENSIS LeROY, 1943

Pl. 1, Fig. 6; Pl. 8, Fig. 16

Bairdia verdesensis LEROY, 1943a, p. 358, pl. 60, figs. 5-9; text-figs. 2 f.g.

Dimensions. Length of adult specimen 1.22 mm.; height 0.81 mm.; thickness 0.58 mm.

Material. Specimens examined 246; about 200 are thought to have been living or only recently dead when collected; 76 of these were whole specimens.

Remarks. This form appears to be a variation of the species described by LEROY, who regarded small spines on the posterior ventral portion as diagnostic. These were found on many of the smaller instars but never on a large specimen. Short, simple, radial pore canals were observed confined mainly to the anteroventral margin.

Occurrence. Previously described by LEROY (1943a, p. 358) as being common in Avalon Bay, Santa Catalina Island, at a depth of about 5 fathoms, and by ROTHWELL (1944) from near Long Beach, California, four specimens near 10 fathoms, near Avalon Bay 100 specimens at about 10 fathoms, from Mission Bay, San Diego, California, near the mouth of the bay. Found abundantly near shore at the eastern side of south Todos Santos Island in about 20 fathoms of water, across the bay to the northern side in shallow water of about 10 fathoms. Found in the rocky tide pool of bay station 22, although common in the western part of the bay at about 25 fathoms and on the south side of Punta Banda. Limited to a substratum of fine to very fine and coarser sand in the tide pools where it was associated with coralline algae; mean annual bottom temperature 50° to 55°F., variation from 4 degrees on the open western side of the bay to 10 degrees in the tide pools. Commonly associated with the ostracode species *Quadracythere regalia*, *Brachycythere lincolnensis*, *Bradleya aurita*, *Hemicythere californiensis* and others (Fig. 11).

Genus TRIEBELINA van den Bold, 1946

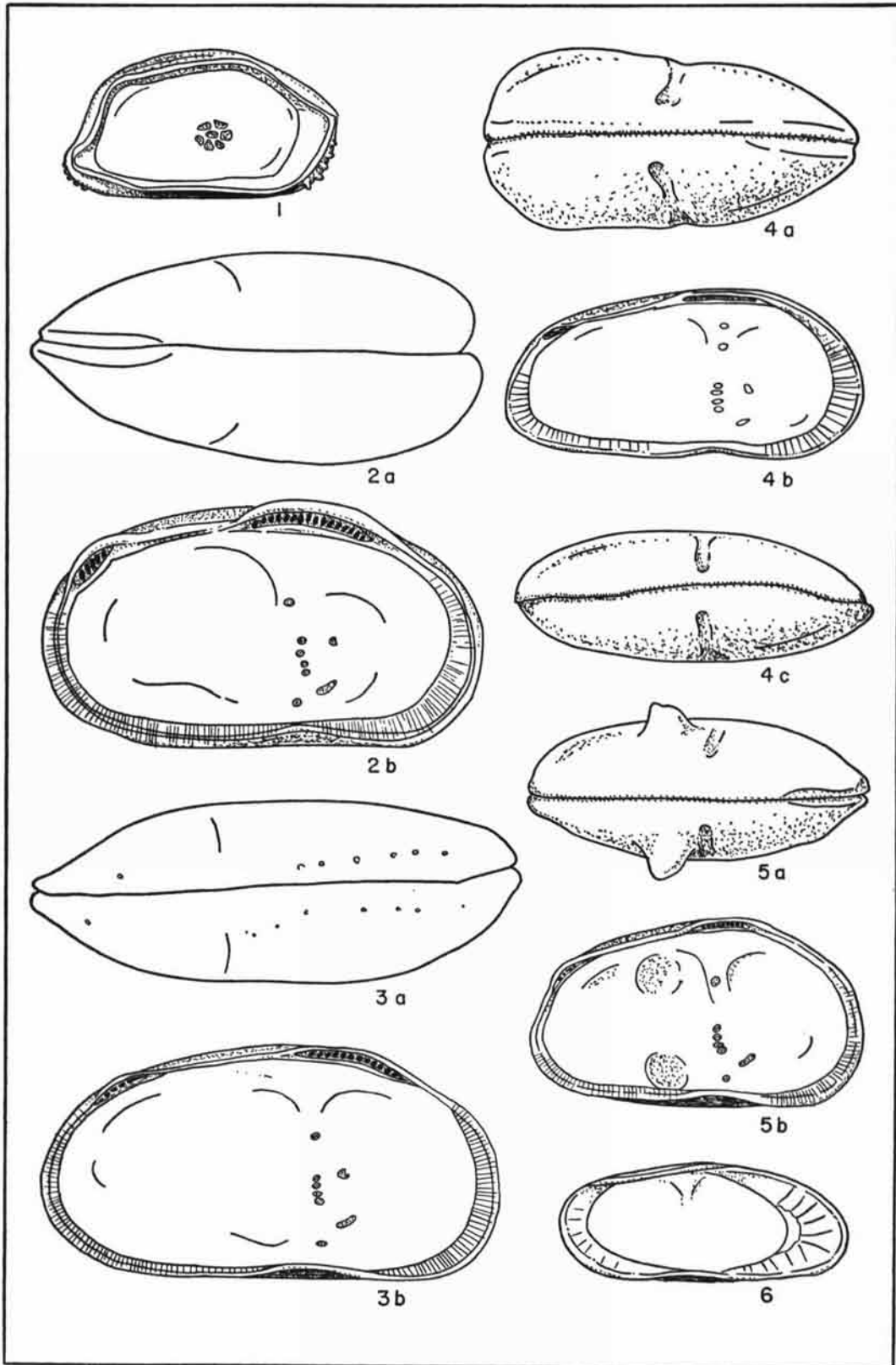
Triebelina VAN DEN BOLD, 1946, p. 73, 74; TRIEBEL, 1948, pp. 17-18. *Glyptobairdia* STEPHENSON, 1946, p. 345.

EXPLANATION OF PLATE 2

TRIEBELINA, CYPRIDEIS (GOERLICHIA), HEMICYTHERIDEIS

(All illustrated forms are from the Todos Santos Bay Region, ×75)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Triebelina reticulopunctata</i> BENSON, n. sp.; interior lateral view of left valve showing muscle scar pattern and adont hinge	44	left valve	45
2.— <i>Cyprideis (Goerlichia) stewarti</i> BENSON, n. sp.; 2a, dorsal view; 2b, interior lateral view of left valve	45	4.— <i>Cyprideis (Goerlichia) castus</i> BENSON, n. sp.; a, dorsal view of female; b, interior lateral view of left valve of female; c, dorsal view of male	46
3.— <i>Cyprideis (Goerlichia) miguelensis</i> BENSON, n. sp.; 3a, dorsal view; 3b, interior lateral view of		5.— <i>Cyprideis (Goerlichia)</i> sp.; 5a, dorsal view showing nodes; 5b, interior lateral view of left valve ..	46
		6.— <i>Hemicytherideis</i> sp.; interior lateral view of left valve	44



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Type species. *Triebelina indopacifica* VAN DEN BOLD, 1946, p. 74, pl. 7, figs. a-c.

Diagnosis. Distinguished by the irregular ridges, plications or reticulate surface ornamentation from other bairdioid carapaces with vestibules, adont hinges, circular aggregate muscle scars, and left-over-right valve overreach. *Eocene to Recent.*

TRIEBELINA RETICULOPUNCTATA Benson, n.sp.
Pl. 2, Fig. 1; Pl. 8, Fig. 4

Diagnosis. Recognized by its elongate subrectangular solid shape with wide flat dorsum and venter, coarsely punctate, approaching reticulate surface and marginal spines.

Description. Carapace medium-sized, robust, subrectangular with tapering ends in dorsal view, subquadrate in end view. Greatest height just forward of center; greatest length below center; greatest thickness in posterior region. Dorsal margin subangular, broadly arched in center, with a long anterodorsal slope, and moderately pronounced anterior cardinal angle; ventral margin straight, arching upward at the ends; anterior end broadly rounded from anterodorsal slope to venter, usually denticulate to spinose; posterior end shows pronounced caudal extension at the postero-center, denticulate to spinose. Surface uniformly and coarsely punctate, approaching reticulate. Hinge, ridge, and groove; prominent selvage; muscle scar (Pl. 2, Fig. 1), narrow vestibule in posterior and anterior ends with a moderately wide marginal area narrowing in the central region of the venter.

Dimensions. Length of adult specimen 0.60 mm.; height 0.33 mm.; thickness 0.27 mm.

Material. Specimens examined 6; only one had both valves intact; none was stained.

Remarks. This species has no cardinal teeth and the hinge is adont as described by TRIEBEL (1948, p. 17). It has no cardinal teeth as described by STEPHENSON (1946, p. 345) for his genus *Glyptobairdia*, although the outline and shape is similar to the types of both. Different from *T. indopacifica* in that its surface is not nodose and the ventral ridge is absent. Both forms are bairdioid in shape and have a reticulate surface. The exterior of *Triebelina reticulopunctata* closely resembles *Glyptobairdia howei* STEPHENSON (1946, pl. 42, fig. 6) but no pronounced ventral ridge is present.

Occurrence. Found in Todos Santos Bay on the north and south sides of the Todos Santos Islands and at one station in the southeast corner of the bay. Rare; depth range principally from 5 to 25 fathoms.

Family CYTHERIDAE Baird, 1850

Subfamily CYTHERIDEIDINAE Puri, 1952

Genus HEMICYTHERIDEIS Ruggieri, 1952

Cytherideis [part] JONES, 1856, pp. 158-8, pl. 7 [synonym of *Cyprideis* cf. SYLVESTER-BRADLEY, 1953]

Hemicytherideis RUGGIERI, 1952, pp. 57-64; SWAIN, 1955, p. 631; WAGNER, 1957, p. 44.

Type species. *Cytherideis elongata* BRADY, 1868.

Diagnosis. Distinguished by its elongate, cylindrical, smooth to punctate carapace, with a moderately wide and welded duplicature except for a small anterior vestibule. The hinge of the left valve consists of a very long anterior tooth overlain by a narrow accommodation groove that grades toward the posterior into a median bar which terminates at a short loculate socket. *Jurassic to Recent.*

This genus seems to be restricted for the most part to littoral and lagoonal environments very often associated with sandy bottoms. Reported by ELOFSON (1941), WAGNER (1957, p. 44) and SWAIN (1955, p. 631) from these environments in waters confluent with the North Sea and San Antonio Bay, Texas.

Remarks. SWAIN (1955) expanded the family Xestoleberididae to include the genus *Hemicytherideis* RUGGIERI because of the similarity of the hinge structures. I do not agree with this classification, at least for the present, since *Xestoleberis* Sars possesses a relatively simple merodont hinge and *Hemicytherideis* has a more complicated, possibly compound hinge. The marginal areas are quite dissimilar, also, *Xestoleberis* typically having a wide vestibule and *Hemicytherideis* almost none.

HEMICYTHERIDEIS sp.
Pl. 8, Fig. 15; Pl. 2, Fig. 6

Because it is thought that no mature specimens were found, this species will not be named at this time.

Description. Carapace small, robust, subelliptical in lateral view; elliptical in dorsal view; circular in end view. Greatest height at anterior cardinal angle, greatest thickness near center in specimens found. Dorsal margin straight; ventral margin straight, with long lip in center; long anterodorsal slope grading into narrow elliptical anterior end; posterior end rounded. Surface punctate. Hinge indistinct, simple and probably immature; small vestibule in anterior end; wide anterior and posterior marginal areas; long straight, widely scattered, usually obscure radial pore canals; muscle scar pattern obscure.

Dimensions. Length of largest specimen 0.57 mm.; height 0.20 mm.; thickness 0.20 mm.

Material. Specimens examined 11; only 3 had both valves intact and were stained.

Occurrence. Found in Todos Santos Bay in the north-west shallower portion from the Todos Santos Island to the northern shore of the bay. Depth range from 5 to 25 fathoms, mean annual bottom temperature variation from 52° to 55°F., annual variation 4 to 10 degrees; substratum coarse to very fine sand. Faunal association indicated in Figure 11.

Subfamily CYTHERIDEINAE Sars, 1923

Genus CYPRIDEIS Jones, 1856

Cyprideis JONES, 1856, p. 20; *ibid.*, GOERLICH, 1952, p. 185.

Anomocytheridea STEPHENSON, 1938, p. 141.

Type species. *Candona torosa* JONES, 1850; GOERLICH, 1952, p. 187; WAGNER, 1957, p. 39, pl. xiv.

Occurrence. Almost entirely restricted to brackish water and one of the few that are endemic to this environ-

ment. The type species is quite widespread geographically and is reported by REMANE (1940, p. 2) to have a salinity range touching briefly both fresh and normal marine water. He (op.cit. p. 104) has observed it between the supra- and eulittoral zones, where the salinity would be increased by evaporation. BRADY & ROBERTSON (1870, p. 1) have observed it in stagnant water of salt marshes of the river mouths of England. REMANE (1940, p. 61, 123) describes these forms as both burrowers (endopsammon) and bottom-dwellers on sand (epipsammon) as well as mud (epipelos). WAGNER (1957, p. 39) reports having found *C. torosa* living in salinities as great as 30 o/oo. SWAIN (1955, p. 676) described a coarsely pitted species which he says is conspecific with *C. littoralis* from the brackish area of San Antonio Bay, Texas.

Subgenus GOERLICHIA Keij, 1957

Goerlichia KEIJ, 1957, p. 69.

Type species. *Cytheridea williamsoni* BOSQUET, 1852.

Diagnosis. The subgenus *Goerlichia* KEIJ shares the same kind of broadly ovate, usually smooth or pitted carapace, with narrow welded duplicature and adductor muscle scar pattern of a vertical row of four scars with two scars in front, like the subgenus *Cyprideis* JONES. *Goerlichia*, however, possesses a hinge with a simple crenulate median bar between two terminal loculate grooves in the left valve, as opposed to a compound notched groove and low crenulate bar forming the median element of the left valve of *Cyprideis*; also, the numerous short radial pore canals are straight and simple in *Goerlichia*, in contrast to the bulbous canals of *Cyprideis*. *Eocene to Recent.*

The Belgian Tongrian deposits, in which the type species of this subgenus was found, are believed to be brackish wherever nodose immature forms occur (KEIJ, 1957, p. 72). This was found to be the case in the Rio San Miguel.

CYPRIDEIS (GOERLICHIA) STEWARTI Benson, n.sp. Pl. 2, Fig. 2a,b; Pl. 9, Fig. 17

Diagnosis. Distinguished by its smooth, robust, regularly ovate, somewhat shortened and wider carapace with a small S_2 sulcus.

Description. Carapace large, robust, regularly ovate, somewhat shortened in lateral view; thick ovate in dorsal view; subcircular in end view. Female slightly larger and more inflated in posterior than male. Greatest height in anterior half, greatest thickness just posterior to mid-point. Dorsal margin broadly arched but changing slope swiftly at both ends, venter straight; posterior and anterior ends subequal, well rounded. Surface generally smooth, with numerous normal pore canals, a small S_2 sulcus apparent in region of adductor muscle scars. Hinge typical for the genus but more robust than ordinary; anterior element of right valve contains about fourteen denticles; posterior element contains about five, medial element very slightly serrate. Adductor muscle scar pattern typical for genus (Pl. 2, Fig. 2b); narrow duplicature, line of concrescence

coincides with inner margin; radial pore canals numerous, straight, simple, all around free margin.

Remarks. *C. Goerlichia stewarti* differs from *C. (G.) williamsoni*, the type species (KEIJ, 1957, p. 70), in that the anterior is higher than the posterior, and from *C. (G.) apostolescui* in its much shorter medial hinge element and a rounded venter. *C. (G.) stewarti* is very similar to *Cyprideis beaconensis* (LEROY) in shape, robustness and marginal area. LEROY (1943, p. 359), however, describes the hinge as having a compound medial element of a serrate groove and bar, which would place it in the subgenus *Cyprideis* JONES, 1857, as restricted by KEIJ (1957, p. 69).

Dimensions. Length of adult female specimen 0.93 mm.; height 0.53 mm.; thickness 0.47 mm.

Material. Specimens examined included 903 late instars; about 350 had both valves intact and are thought to have been living when collected. Also 1823 early, unidentified instars of the genus as a whole were collected.

Occurrence. Previously found by LEROY (1943a, p. 359) in Recent lagoonal deposits at Sunset Beach, Orange County, California, and Richardsons Bay, Tamalpais quadrangle, California. Found in the Rio San Miguel lagoon where it was very abundant. Most abundant in chlorinity above .9 o/oo and absent in chlorinity below .6 o/oo; not found in marine environments. Upper salinity tolerance unknown. Associated with *Cyprideis miguelensis* and occasionally with *Cypridopsis vidua*. Lives in and on fine sands and silts, associated with the abundant lagoonal grasses. Considered to be a characteristic brackish-water form. Very similar to *C. torosa*, which has been found extensively in Europe restricted to brackish water.

CYPRIDEIS (GOERLICHIA) MIGUELENSIS Benson, n.sp. Pl. 2, Fig. 3a,b; Pl. 9, Fig. 16

Diagnosis. Distinguished in its large, slim, elongate carapace; compressed subangular posteroventer of the right valve and relatively smooth surface with numerous normal pore canals.

Description. Carapace large, slim, compressed in the posteroventer, thin-shelled, elongate, ovate in lateral view; thin, elliptical in dorsal view; oval-shaped in end view. Female slightly larger than male, and more inflated in posterior end. Greatest height in anterior half, greatest thickness in posterior. Dorsal margin broadly arched; ventral margin straight, with a slight lip just anterior to middle; anterior end broadly rounded, posterior end broadly rounded in left valve but subangular in the posteroventer of the right valve where compressed. Surface generally smooth, with broadly scattered large punctae and numerous small normal pore canals. Very slight sulcus in area of adductor muscle scars. Hinge hemimerodont; left valve contains elongate anterior socket with twelve included notches linked to shorter loculate posterior socket with six included notches by long, narrow, thin, elevated bar that originates as a development of the selvage and travels over both sockets straight across the dorsum. Right valve contains two crenulate, elongate teeth, complement of left valve. Adductor muscle scar pattern (Pl. 2,

Fig. 3a); narrow duplicature, line of concrescence coincides with inner margin; radial pore canals, straight, hair-like, numerous, closely spaced, all around free margin.

Dimensions. Length of adult male specimen 0.97 mm.; height 0.50 mm.; thickness 0.40 mm.

Material. Late instars examined 310, of which 121 were living when collected.

Remarks. This species was placed in this subgenus primarily for the lack of a vestibule (GOERLICH, 1952, p. 187) and its hinge structure. The margin is narrower, the carapace less massive and more elongate than *C. (G.) stewarti* and has a depressed posteroventer. Named for the location of Rio San Miguel lagoon.

Occurrence. Restricted to the brackish Rio San Miguel lagoon, associated with *C. (G.) stewarti*, although in lesser abundance. Not found in a chlorinity below .6 o/oo; most abundant in a chlorinity above .9 o/oo; lives on and burrows in the richly organic fine sands and silts.

CYPRIDEIS (GOERLICHIA) CASTUS Benson, n. sp.
Pl. 2, Fig. 4a,b,c; Pl. 9, Fig. 10

Diagnosis. Distinguished from others of the subgenus *C. (Goerlichia)* by its moderate size; elongate uniformly inflated carapace, wider marginal area, and rather well-developed sulcus.

Description. Carapace medium-size, thin-shelled, elongate in lateral view; slim, ovate in dorsal view, female generally much thicker, more inflated in posterior end; subcircular to ovate in end view. Greatest height anterior of middle, greatest thickness in posterior end of female, middle of male. Female: dorsal margin straight in middle and broadly arching at ends, slight, very short anterior slope. Male: dorsal margin broadly arching. Ventral margin straight, with small lip just anterior of middle for both sexes. Anterior and posterior margins tapering, narrow, rounded in male; more blunt, more broadly rounded in female. Surface finely punctate, numerous, normal pore canals. Well-developed long, narrow sulcus in mid-section of centrodorsal region. Hinge hemimerodont, like that of *Cyprideis* sp. A; muscle scar pattern (Pl. 2, Fig. 4b);

line of concrescence coincides with inner margin; radial pore canals numerous, straight, moderately spaced, all around free margin.

Dimensions. Length of adult, female specimen 0.80 mm.; height 0.39 mm.; thickness 0.41 mm.

Material. Specimens examined 33; of which 11 had both valves intact.

Remarks. *C. (G.) castus* has no vestibule and its hinge is closest to that of *C. (Goerlichia)*. More elongate and smaller, with a more pronounced sulcus than in *C. (G.) stewarti*.

Occurrence. Endemic to the salt-water-lagoon biofacies of the Estero de Punta Banda where it is generally rare. Found in abundance at only one station in the salt marsh and tidal channel area. Most commonly associated with *Puriana pacifica*.

CYPRIDEIS (GOERLICHIA) sp.
Pl. 2, Fig. 5a,b; Pl. 9, Fig. 13, 15

Diagnosis. Recognized by its generally compressed carapace, comparatively sharply arched dorsum, and two moderately large conical nodes located near the dorsal and ventral margins just posterior of the mid-line.

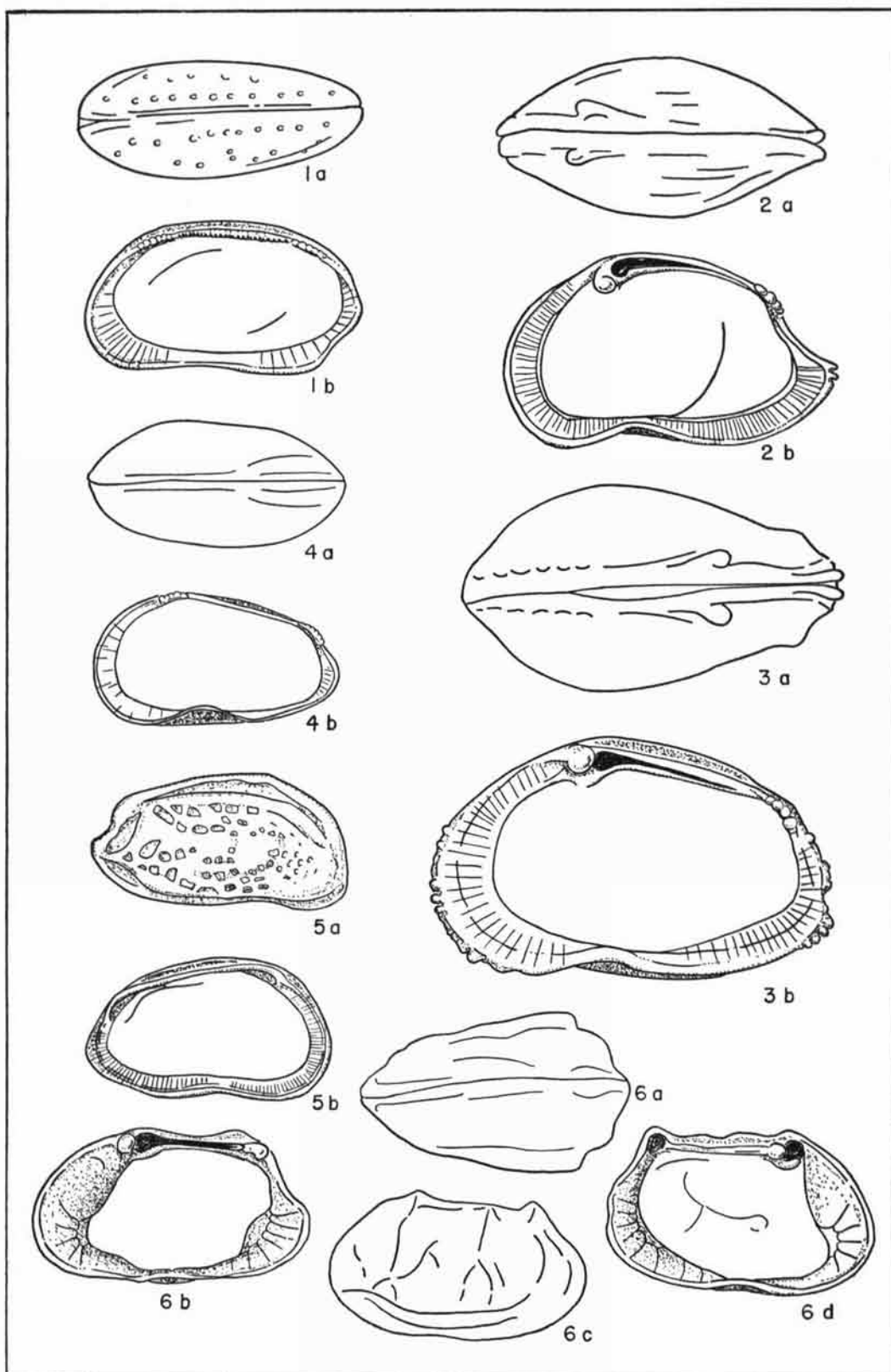
Description. Carapace medium-size, thin-shelled, sub-pentagonal in dorsal view; elliptical in dorsal view; oval-shaped in end view. Greatest height in anterior region; greatest thickness in center in male, in posterior in females, which is only observed sexually dimorphic difference. Dorsal margin sharply arched, with short anterior slope and long gently arched posterior slope, ventral margin straight, with small lip just anterior of center; broadly rounded anterior margin and blunt posterior. Surface punctate, with numerous normal pore canals; shallow narrow sulcus developed at mid-dorsum; two large truncated conical nodes developed just posterior of center near dorsal and ventral margins. Hinge hemimerodont; left valve contains elongate anterior socket with nine included notches linked to shorter lanceolate, posterior socket with five included notches by long, narrow, thin, elevated bar which originates as an extension of the selvage and travels over both sockets straight across dorsum.

EXPLANATION OF PLATE 3

HAPLOCYTHERIDEA, BRACHYCYTHERE, PALMENELLA

(All illustrated forms are from the Todos Santos Bay Region, X75)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Haplocytheridea maia</i> BENSON, n. sp.; 1a, dorsal view; 1b, interior lateral view of right valve	48	4b, interior lateral view of right valve	48
2.— <i>Brachycythere lincolniensis</i> LEROY; 2a, dorsal view; 2b, interior lateral view of right valve	49	5.— <i>Brachycythere</i> sp.; 5a, exterior lateral view of right valve; 5b, interior lateral view of left valve	50
3.— <i>Brachycythere schumannensis</i> LEROY; 3a, dorsal view; 3b, interior lateral view of right valve	49	6.— <i>Palmenella carida</i> BENSON, n. sp.; 6a, dorsal view; 6b, interior lateral view of right valve; 6c, exterior lateral view of left valve; 6d, interior lateral view of left valve	50
4.— <i>Haplocytheridea palda</i> BENSON, n. sp.; 4a, dorsal			



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Right valve contains two crenulate teeth, complement of left valve. Muscle scar (Pl. 2, Fig. 5b); line of concrescence coincides with inner margin, radial pore canals, straight, numerous, closely spaced all around free margin.

Dimensions. Length of adult specimen 0.80 mm.; height 0.40 mm.; thickness 0.40 mm.

Material. Specimens examined 282; only 8 had both valves intact and are thought to have been living.

Remarks. This form, of which the nodes are the characteristic feature, is found associated with forms of the same small size, on which no nodes occur. It is probable that the latter are the early instars of either *C. (G.) stewarti* or *C. (G.) miguelensis*, in which the diagnostic species characteristics do not occur until the late instar stages; it is possible that the nodose form is a small discrete species or that the nodes represent an early instar development which disappears at or near maturity, or that it is a variation within the early instar of *C. (G.) stewarti* or *C. (G.) miguelensis*. For this latter case, MÜLLER (1912, p. 226) noticed this same problem with two forms of *C. torosa littoralis* (BRADY) in which one was nodose, the other smooth, and emphasized that they were transitional with one another. SÄRS (1928, p. 158) holds that they are separate species. HIRSCHMANN (1909, 1912) found a transition between the two forms and GOERLICH (1952) recommended that they be treated as one species. TRIEBEL (1941) thought that the growth of these nodes varied directly with the decrease in salinity as an adaptation to density. The status of this nodose form as a valid species is therefore doubted and its inclusion here as a discrete category is for convenience.

Occurrence. Found only in the shallow, brackish waters of the Rio San Miguel lagoon where it lives in and on the highly organic sandy and silty bottom. Found most abundantly in chlorinities above 0.9 o/oo and rarely below 0.6 o/oo. Maximum chlorinity tolerance unknown; not found in normal marine salinities.

Genus HAPLOCYTHERIDEA Stephenson, 1936

Cytheridea BOSQUET (part), 1852, p. 37.

Cytheridea (Haplocytheridea) STEPHENSON, 1936, p. 700.

Cytheridea (Leptocytheridea) STEPHENSON (part), 1937, p. 156.

Cytheridea (Phractocytheridea) SUTTON & WILLIAMS, 1939, p. 571.

Haplocytheridea STEPHENSON, 1944a, p. 159; STEPHENSON, 1946, p. 321.

Type species. *Cytheridea montgomeryensis* HOWE & CHAMBERS, 1935, p. 17, pl. 1, fig. 1; pl. 2, figs. 1-3, 7, 9; pl. 6, figs. 17, 18.

Diagnosis. Recognized by its subovate carapace with a holomerodont hinge. Its other characters are very like the genus *Cytheridea*. *Jurassic to Recent.*

This genus is not well known ecologically. MALKIN (personal communication) thinks its distribution is not environmentally controlled. SWAIN (1955, p. 617) reports *H. bassleri* STEPHENSON and *H. bradyi* from marshes and in shallow parts of San Antonio Bay, Texas, around Matagorda Island. It would seem that this is a shallow-water genus.

HAPLOCYTHERIDEA MAIA Benson, n.sp.

Pl. 3, Fig. 1a,b; Pl. 9, Figs. 7, 9

Diagnosis. Recognized by its truncate posteroventer, smooth carapace with large widely spaced normal pore canals, and convex ventral margin.

Description. Carapace medium-sized, robust, subreniform in lateral view; subelliptical in dorsal view; oval in end view. Greatest height and thickness in middle; valves subequal in size. Dorsal margin gently arched; ventral margin gently arched; ventral margin concave; anterior margin broadly rounded toward dorsum, more angular toward venter; posteroventral margin truncate, postero-dorsal margin broadly rounded. Surface smooth with widely spaced prominent normal pore canals. Hinge holomerodont, typical for genus; marginal area wide in anterior and posterior ends; line of concrescence coincides with inner margin; radial pore canals straight, numerous, moderately spaced. Interior of valves shallow, smooth; adductor muscle scar pattern obscure.

Dimensions. Length of adult specimen 0.63 mm.; height 0.33 mm.; thickness 0.23 mm.

Material. Specimens examined 89; of which 75 were stained, and 69 had both valves intact.

Remarks. Very different from *H. montgomeryensis* HOWE & CHAMBERS in that it has a truncate rather than subarcuate posterior, the surface is uniformly punctate and has no pitted furrows, and the outline is subreniform as opposed to elongate, subpyriform. The hinge is the same in both species.

Occurrence. Almost entirely restricted to the littoral zone and in the shallow waters on the northern side of the Todos Santos Bay and the northern side of Punta Banda. Particularly abundant in the rocky tide pools with coarse sand bottom and rich in algae. Depth range generally less than 10 fathoms; mean annual bottom temperatures 55° + F.

HAPLOCYTHERIDEA PALDA Benson, n.sp.

Pl. 3, Fig. 4a,b; Pl. 9, Fig. 4

Diagnosis. Recognized by its delicate, usually transparent carapace, distinctive shape, and faint accentuated longitudinal riblets on the reticulate surface.

Description. Carapace medium-sized, tumid, subrectangular in lateral view; oval in dorsal and end views. Greatest height in anterior region; greatest thickness near center or slightly toward posterior end; valves subequal. Dorsal margin straight to gently arched; ventral margin straight with deep lip just anterior of center; anterior margin broadly rounded; posterior margin with slight caudal extension. Surface has faint reticulate network with accentuated longitudinal riblets. Hinge holomerodont, typical for genus; narrow marginal area; inner margin coincides with line of concrescence; radial pore canals faint, straight, moderately spaced. Interior of valves deep; muscle scar pattern obscure.

Dimensions. Length of adult specimen 0.63 mm.; height 0.30 mm.; thickness 0.26 mm.

Material. Specimens examined 9; three had both valves intact.

Remarks. Shape quite different from *H. montgomeryensis* Howe, although the hinges are the same. The surface has elongate ribs as opposed to transverse furrows. The shape and surface is very similar to *Cythereis evergreenica* (STADNICHENKO) as described by STEPHENSON (1946, p. 338, pl. 45, fig. 6) but the hinges are different.

Occurrence. Found at one location in the Estero de Punta Banda in the upper part of a marsh channel at station 11.

Genus PARACYTHERIDEA Müller, 1894

Paracytheridea MÜLLER, 1894, p. 340.

Type species. *Paracytheridea depressa* MÜLLER, 1894, p. 341, pl. 26, figs. 16-26; pl. 29, figs. 4, 8. *Cytheropteron bovetensis* SEGUENZA, 1880, p. 65, pl. 17, fig. 54.

Diagnosis. Recognized by its elongate, subrectangular carapace with a pronounced dorsal caudal extension, and posteroventral alar process. *Upper Cretaceous to Recent.*

Not much is known about the ecologic range of this genus. The species found in Todos Santos Bay is definitely restricted to shallow water. SWAIN (1955, p. 623-25), however, found two species, *P. troglodyta* SWAIN and *P. vandenboldi* PURI living in the brackish waters of San Antonio Bay, Texas.

PARACYTHERIDEA GRANTI LeRoy, 1943

Pl. 10, Fig. 9

Paracytheridea granti LEROY, 1943a, p. 361, pl. 61, figs. 11-14; pl. 62, figs. 3, 4; fig. 2d.

Dimensions. Length of adult specimen 0.87 mm.; height 0.43 mm.; thickness (approx.) 0.37 mm.

Material. Specimens examined 58; one had both valves intact and could be presumed living when caught.

Occurrence. Previously identified by ROTHWELL (1944) from San Pedro channel offshore from Long Beach, California, at depths from 10 to 30 fathoms. Found widely but not abundantly distributed in Todos Santos Bay from the southwestern side of the Todos Santos Island north and east toward Ensenada with a few specimens on the northern side of Punta Banda. Depth range generally from 3 to 30 fathoms; mean annual bottom temperature range 52° to 55°F., variation 4 to 10 degrees; bottom types from coarse gravel and sand on the southwestern side of the islands to very fine sand in the northeastern area of the bay. Commonly associated with *Brachycythere driveri*, *B. lincolnensis*, *Cythereis glauca*, *Bradleya diegoensis* and *Hemicythere jollaensis* of Biofacies I, but not with *Leguminocythereis corrugata* as reported by LEROY (1943a, p. 36).

Subfamily BRACHYCYTHERINAE Puri, 1954

Genus BRACHYCYTHERE Alexander, 1933

Brachycythere ALEXANDER, 1933, p. 204; MURRAY & HUSSEY, 1942, pp. 164-182; STEPHENSON, 1946, pp. 306-307, 331-332; MUNSEY, 1953, pp. 10-11.

Type species. *Cythere sphenoides* REUSS, 1854, p. 141, pl. 26, fig. 2.

Diagnosis. Identified by its heavy smooth to reticulate carapace sometimes with a ventral keel; its strong hemi-

amphidont-like hinge with a serrate groove and lobed posterior tooth in the right valve; broad marginal area, welded duplicature, long numerous radial pore canals. The adductor muscle scar pattern consists of four vertical scars with two anterior. *Upper Jurassic to Recent.*

BRACHYCYTHERE LINCOLNENSIS LeRoy, 1943

Pl. 3, Fig. 2a,b; Pl. 11, Figs. 5, 9

Brachycythere lincolnensis LEROY, 1943a, p. 364, pl. 61, figs. 1-5; pl. 62, figs. 1, 2; fig. 21m.

Dimensions. Length of adult specimen 0.90 mm.; height 0.53 mm.; thickness 0.43 mm.

Material. Specimens examined 169; about 100 were stained; 55 had both valves intact.

Occurrence. Previously described by LEROY (1943, p. 304) as being found in Recent deposits offshore from Santa Catalina Island and by ROTHWELL (1944) from this locality and offshore of Long Beach, California, at a depth of from 15 to 65 fathoms and a similar form from the entrance of Mission Bay, San Diego, California, and in tidal pools and offshore of La Jolla, California. Widely distributed over Todos Santos Bay from the islands northward to the coastal tide pools and on the north and south sides of Punta Banda. Depth range generally from 30 fathoms to intertidal; mean annual temperature range from 52° to 55°+F., variation from 4 to 10 degrees, found within and without the observed distribution of phytal; bottom sediment ranges from very coarse sand to very fine sand. Commonly associated with *Hemicythere californiensis*, *Quadracythere regalia*, *Bradleya aurita*, and *Bairdia verdesensis*, less frequently associated with *Cythereis glauca*, *Paracytheridea granti* and others (Fig. 11).

BRACHYCYTHERE SCHUMANNENSIS (LeRoy), 1943

Pl. 3, Fig. 3a,b; Pl. 11, Fig. 11

Brachycythere lincolnensis schumannensis LEROY, 1943a, p. 364, pl. 59, figs. 1-6; figs. 2i,j.

Dimensions. Length of adult specimen 0.87 mm.; height 0.57 mm.; thickness 0.47 mm.

Material. Specimens examined 69; only 10 had both valves intact.

Remarks. This species was previously described as a subspecies of *B. lincolnensis* (LEROY, 1943, p. 364). However, it is now believed to be morphologically distinct and because it is found living in the same area with *B. lincolnensis* it is now considered a separate species.

Occurrence. Not previously reported from Recent sediments. Found in the lower part of the channel between Punta Banda and Todos Santos Islands in Todos Santos Bay generally at a depth of 150 fathoms or more, but also found in shallow water (3 to 100 fathoms) on the north and south sides of Punta Banda. Substratum at depth poorly sorted medium silt to fine sand in shallow water; mean annual bottom temperature ranges from 50° to 55° F., annual variation from 2 to 8 degrees. Commonly associated with *Cytheropteron* sp. A and *Cytheropteron newportense*.

BRACHYCYTHERE DRIVERI LeRoy, 1943

Pl. 11, Fig. 10

Brachycythere driveri LEROY, 1943a, p. 361, pl. 61, figs. 6-10; pl. 62, figs. 17, 18, fig. 2y.

Dimensions. Length of adult specimen 0.80 mm.; height 0.57 mm.; thickness 0.47 mm.

Material. Specimens examined 16; only one had both valves intact.

Occurrence. Previously identified by ROTHWELL (1944) from the San Pedro channel offshore from Long Beach, California, at depth from 10 to 30 fathoms and from the San Diego harbor entrance at a depth of 16 fathoms. Found in Todos Santos Bay principally on the open west side generally at a depth of 20 to 35 fathoms and restricted to a fine-sand substratum. Mean annual bottom temperature ranges from 52° to possibly 54°F., seasonal variation about 5 degrees. Associated faunule shown in Figure 11.

BRACHYCYTHERE SP.

Pl. 3, Fig. 5a,b; Pl. 11, Fig. 2

Description. Carapace small, sturdy, subtriangular in lateral view; subcuneiform in dorsal and end view because of projecting posterodorsal costae. Greatest height near anterior cardinal angle; greatest thickness just posterior of center. Dorsal margin broadly arched; ventral margin broadly arched except for central lip; anterior margin more narrowly but well rounded; posterior margin contains subdued posteroventral caudal extension. Surface subreticulate to uniformly punctate except for subdued smooth lateral ridge which broadens subcentrally; posterodorsal costa present but ventral costa absent. Hinge immature (Pl. 3, Fig. 5b). Muscle scar pattern obscure or not well developed; very thin vestibule between line of concrescence and inner margin around entire free margin; marginal area moderate; uniform radial pore canals numerous, straight, and uniformly spaced all around margin.

Dimensions. Length of adult specimen 0.53 mm.; height 0.30 mm.; thickness 0.23 mm.

Material. Specimens examined 52, of which 13 had both valves intact.

Remarks. Very similar to *Brachycythere schumannensis* LEROY except that it is consistently smaller and has a posterodorsal costa. The possibility that it is an early instar of *B. schumannensis* LEROY, because of the similarity of the two species and because no adult hinge forms were found, is lessened because their ecologic ranges are quite different. If the early instars of a benthonic species have a different habitat than the adults, it has not been previously reported.

Occurrence. Collected from Todos Santos Bay principally from offshore of Todos Santos Islands, just southwest of Ensenada and south of Punta Banda. Depth range from 5 to 30 fathoms, mean annual bottom temperature range from 52° to 55°F.; annual variation 3 to 10 degrees; substratum includes coarse to very fine sand. Associated faunule shown in Figure 11.

Subfamily CYTHERINAE (Dana, 1852) Sars, 1925

Genus PALMENELLA Hirschmann, 1916

Palmenella HIRSCHMANN, 1916, p. 580; TRIEBEL, 1949, p. 188.
Kyphocythere, Sars, 1925, p. 180.

Types species. *Cythereis limicola* NORMAN, 1865; TRIEBEL, 1949, p. 190, pl. 2, figs. 1-6d.

Diagnosis. Distinctive characters of this marine genus include: ovate to subquadrate carapace with a slight upturning at posterior end; surface ornamented with ventral longitudinal ridge or ridges, possible presence of lobes or knobs; very limited vestibule or none, moderately wide duplicature, particularly wide in anterior; hinge holamphidont with serrate groove. *Miocene to Recent.*

Palmenella limicola (NORMAN) was observed by ELOFSON (1941, p. 426) and REMANE (1940, p. 123) as being a burrower and living on a fine-grain or mud substratum.

PALMENELLA CARIDA Benson, n.sp.

Pl. 3, Fig. 6a-d; Pl. 10, Figs. 4, 6

Diagnosis. Recognized by its distinctive surface ornamentation which is accentuated by a series of irregularly oriented hairlike riblets with two ventral costate and two broad vertical ridges originating near the cardinal angles.

Description. Carapace medium-sized, moderately thick-shelled, subquadrate in lateral view; subovate in dorsal view except for ventral costae slightly projecting near the posterior end; subtriangular in end view. Greatest height at cardinal points, greatest thickness in posterior end. Dorsal margin undulate, with two peaks at cardinal angles, ventral margin straight to broadly arched with small lip near center; anterior margin broadly convex in both valves; posterior margin subrounded in left valve but showing slight posteroventral caudal extension in right valve. Surface with finely punctate matrix and very irregular network of tiny riblets; two longitudinal costae, concentric with ventral margin, one usually much more pronounced than other; two broad vertical ridges or plications originating near cardinal angles; considerable variation found in details of network. Hinge holamphidont; left valve with circular anterior socket with large rounded postjacent knoblike tooth connected to subcircular posterior socket set in posterior cardinal peak by elevated, moderately rounded, smooth bar paralleling dorsal margin but separated from it by narrow undulating margin. The hinge of the right valve compliments that of the left; the posterior tooth is simple and rounded. This differs slightly with that of the type species, which has been described as schizodont (SYLVESTER-BRADLEY, personal communication). Adductor muscle scar pattern poorly developed and obscured by very irregular interior surface; interior cavity deep in ventral portion; inner margin coincides with line of concrescence except for development of narrow vestibule in posterior end and short relatively deep one in anterior end; marginal area very wide in anterior and posterior ends; radial pore canals few, straight, widely spaced, with funnel-shaped distal ends, and radiating mostly from vestibules; selvage poorly developed. Widening of posterior only sexual dimorphism observed.

Dimensions. Length of adult specimen 0.60 mm.; height 0.36 mm.; thickness 0.36 mm.

Material. Specimens examined 60; about 30 were stained; 24 had both valves intact.

Remarks. The general shape, arrangement of the radial pore canals, vestibules, ventral costae, hinge and marginal outline of *P. carida* are very similar to *P. limicola* (NORMAN) as illustrated by TRIEBEL (1949, p. 189, pl. 2, fig. 5a-6d). It differs from it in that the surface of *P. carida* is broadly plicate with fine irregular riblets rather than nodose, and the median sulcus is absent.

Occurrence. Found abundantly in the central portion of Todos Santos Bay with *Leguminocythereis corrugata* restricted generally to the distribution of very fine sand. Depth range from 10 to 30 fathoms; mean annual bottom temperature from 52° to 53°F., annual variation from 4 to 8 degrees. Commonly associated with *L. corrugata* and frequently with *Cytherura* sp. cf. *C. gibba* (Fig. 11) of Biofacies II.

Subfamily LOXOCONCHINAE Sars, 1926

Genus LOXOCONCHA Sars, 1865

Loxococoncha Sars, 1865, p. 61, Sars, 1926, pp. 217-222; *ibid.*, ALEXANDER, 1936, p. 693; MURRAY, 1938, p. 586-587; EDWARDS, 1944, pp. 526-527.

Type species. *Cythere rhomboidea* FISCHER, 1855=*Cythere impressa* BAIRD, 1850 (non McCoy)=*Loxococoncha bairdi* MÜLLER, 1894.

Diagnosis. Distinguished by its massive rhomboidal or subovate carapace with a broadly rounded venter frequently possessing a narrow to wide rim which merges imperceptibly with the main region with little break in slope. Hinge gonygodont; duplicature broad, with anterior and narrow posterior vestibules joined with free margin by a few straight, simple radial pore canals; adductor muscle scar patterns, four vertical scars with an anterior reniform scar. Pronounced sexual dimorphism. *Cretaceous to Recent.*

Species of this genus live in a wide range of environments. Three species, *L. elliptica* BRADY, *L. impressa* (BAIRD), and *L. pusilla* (BRADY & ROBERTSON), have been reported from brackish salt marsh and estuarine environments, whereas the majority of species are found in normal salinities. HORNIBROOK (1952) found *L. punctata* ranging in depth from supralittoral to 142 fathoms. *L. lenticulata* was found to range from a supersaline environment in a shallow lagoon to a depth of 30 fathoms. Some species are burrowers (ELOFSON, 1941, p. 426) and some are surface crawlers (KLIE, 1937a, p. 50) on several types of substratum from sand to highly organic mud without sand (but with a certain stability or firmness). MALKIN (personal communication) does not consider this genus an indicator of a particular environment. WAGNER (1957, pp. 64, 67) reports *L. elliptica* as eurythermal and euryhaline. SWAIN (1955, p. 629) reports two species living in the brackish San Antonio Bay, Texas.

LOXOCONCHA LENTICULATA LeRoy, 1943

Pl. 4, Fig. 3a-d; Pl. 8, Figs. 9, 10

Loxococoncha lenticulata LeRoy, 1943a, p. 360, pl. 60, figs. 19-23; pl. 61, figs. 24-26; pl. 62, figs. 13, 14; figs. 2f,g.

Dimensions. Length of adult female specimen 0.67 mm.; height 0.43 mm.; thickness 0.40 mm.; length of adult male specimen 0.67 mm.; height 0.36 mm.; thickness 0.33 mm.

Material. Specimens examined 311; of these 204 had both valves intact.

Occurrence. First reported by LeRoy (1943, p. 361) in Recent sediments from Avalon Bay, Santa Catalina Island, and Monterey Bay, California, and by ROTHWELL (1944) from Mission Bay, San Diego County, California (a salt-water lagoon), from tidal pools at La Jolla, California, and from the San Pedro channel at about 25 fathoms. Found abundantly in the Estero de Punta Banda (Fig. 14) and in Todos Santos Bay in tidal pools, marsh channels, salt-water lagoons, and open sea. Depth range from intertidal to about 30 fathoms, most abundant in the grasses and algae of shallow salt-water lagoons. In the upper part of the estero, it was particularly selective of one kind of very dense coralline algae which grows in patches in shallow water surrounded by large areas of sparse eel grass. It seems to be rather eurythermal and euryhaline, and was found on a wide variety of bottoms ranging from rock and coarse sand to very fine sand and soft plastic mud. The latter may not be too indicative, however, as the plant type (spongy rather than grass-like) may be more important. Found throughout the estero in marsh channels, the main channel, intertidal areas, and in the bay from the islands north and the rocky shore and on the northern side of Punta Banda. Found associated with a variety of ostracode and foraminiferal species.

Subfamily CYTHERURINAE Müller, 1894

Genus CYTHERURA Sars, 1866

Cytherura Sars, 1865, p. 60; ALEXANDER, 1936, pp. 690-691; STEPHENSON, 1946, pp. 316-317.

Type species. *Cythere gibba* O. F. MÜLLER, 1785, p. 66, pl. 7, figs. 7-9.

Diagnosis. Distinguished by a caudal process with openings into the interior of a reticulate, ridged, spiny or smooth carapace; the absence of a vestibule with a wide duplicature; numerous long radial pore canals; hinge antimeridont; adductor muscle scar pattern consists of posterior row of four with one anterior scar. *Cretaceous to Recent.*

The genus *Cytherura* has representative species in both brackish and marine environments. *C. robertsoni* BRADY (BRADY & ROBERTSON, 1872, p. 49) and *C. gibba* (O. F. MÜLLER) (TRESSLER & SMITH, 1948, p. 47) have been reported from brackish estuarine waters. *C. nigrescens* (BAIRD) and *C. cellulosa* (NORMAN) are considered as littoral by BRADY & ROBERTSON (1872). HORNIBROOK (1952) has identified *C. costellata* BRADY from the intertidal zone to a depth of about 150 fathoms. ELOFSON (1941) described *C. angulata* as living on epiphytes in and just beyond the phytal zone, and other species as climbing and crawling between coarse grains of sand and shell fragments (mesopsammon). REMANE (1940, p. 154) reported *C. nigrescens* living in the phytal. MALKIN (1954, p. 7) does not consider this genus itself representative of any particular environment. SWAIN (1955, p. 626) found that *C. johnsoni* MINCHER, composed up to 25

percent of the brackish-water fauna of the lower part of San Antonio Bay, Texas.

CYTHERURA sp. cf. *C. GIBBA* (O. F. Müller), 1785
Pl. 7, Fig. 8a,b; Pl. 9, Fig. 12

Cythere gibba O. F. MÜLLER, 1785, p. 66, pl. 7, figs. 7-9.
Cythere gibbosa MILNE-EDWARDS, 1840, p. 408.
Cytherura gibba (O. F. MÜLLER), SARS, 1865, p. 69; G. W. MÜLLER, 1912, p. 268; ALEXANDER, 1936, p. 690, 1; TRESSLER & SMITH, 1948, p. 20, pl. 3, fig. 24.

Dimensions. Length of adult specimen 0.67 mm; height 0.36 mm.; thickness (approx.) 0.30 mm.

Material. Specimens examined 42; only one had both valves intact.

Remarks. The original types are very poorly illustrated, and the original material was not examined. The forms identified were most closely allied to the specimens illustrated and described by SARS (1928, pl. XCIII). The shape and form are similar but the surface ornament, which is subdued on SARS' specimens, is only faint and not always present on the Todos Santos Bay form. It is definitely not the same form as that identified and illustrated by TRESSLER & SMITH (1948, p. 20, pl. III, fig. 24).

Occurrence. Found in the central portion of Todos Santos Bay and on the north side of Punta Banda. Depth range 10 to 25 fathoms; mean bottom temperature range 52° to 55°F., annual variation 4 to 10 degrees; substratum fine and very fine sand; probably a burrower. This species is found in the lower limits of the range of many of the species found on the shallow portion of the bay. The nature of the substratum seems to be an important factor. Frequently associated with *Leguminocythereis corrugata* and *Palmenella carida* in Biofacies II (Fig. 11).

CYTHERURA BAJACALA Benson, n.sp.
Pl. 4, Fig. 7a-c; Pl. 9, Figs. 1, 11, 14

Diagnosis. Recognized by its tumid subspatulate shape and its delicate longitudinal ribbing.

Description. Carapace small, tumid, broadly subspatulate in lateral view; males short, subrectangular in dorsal view; females more inflated in posterior end, subcircular in end view. Greatest height and thickness posterior. Dorsal margin evenly arched; ventral margin sinuate, with long lip anterior to center; anterior narrowly rounded; posterior pointed with small caudal extension. Thin longitudinal and concentric riblets, with faint connecting transverse riblets ornamenting surface with smooth caudal extension. Hinge typical for genus; marginal area wide in anterior and posteroventral regions with narrow vestibule; muscle scar pattern and radial pore canals obscure.

Dimensions. Length of adult female specimen 0.53 mm.; height 0.27 mm.; thickness 0.27 mm.

Material. Specimens examined 49; of these 20 had both valves intact.

Remarks. The shallow median sulcus seems to develop as the form matures and is missing in the early instars. The surface ornament is similar to *C. elongata* EDWARDS (1944, p. 526, pl. 88, figs. 21-25) but much more rounded in the posterior and not as elongate.

Occurrence. Found in the western and seaward side of Todos Santos Bay and on the north and south side of Punta Banda. Sparse population density and widely distributed; generally restricted to a fine sand substratum; probably a burrower; depth range generally 15 to 25 fathoms, mean annual bottom temperature range 52° to 54°F., annual variation 4 to 8 degrees. Faunal association, Biofacies I (Fig. 11).

Genus HEMICYTHERURA Elofson, 1941

Hemicytherura ELOFSON, 1941, p. 314; HORNIBROOK, 1952, p. 58.
Type species. *Cythere cellulosa* NORMAN, 1865, p. 22, pl. 5, figs. 17-20; pl. 6, fig. 17.

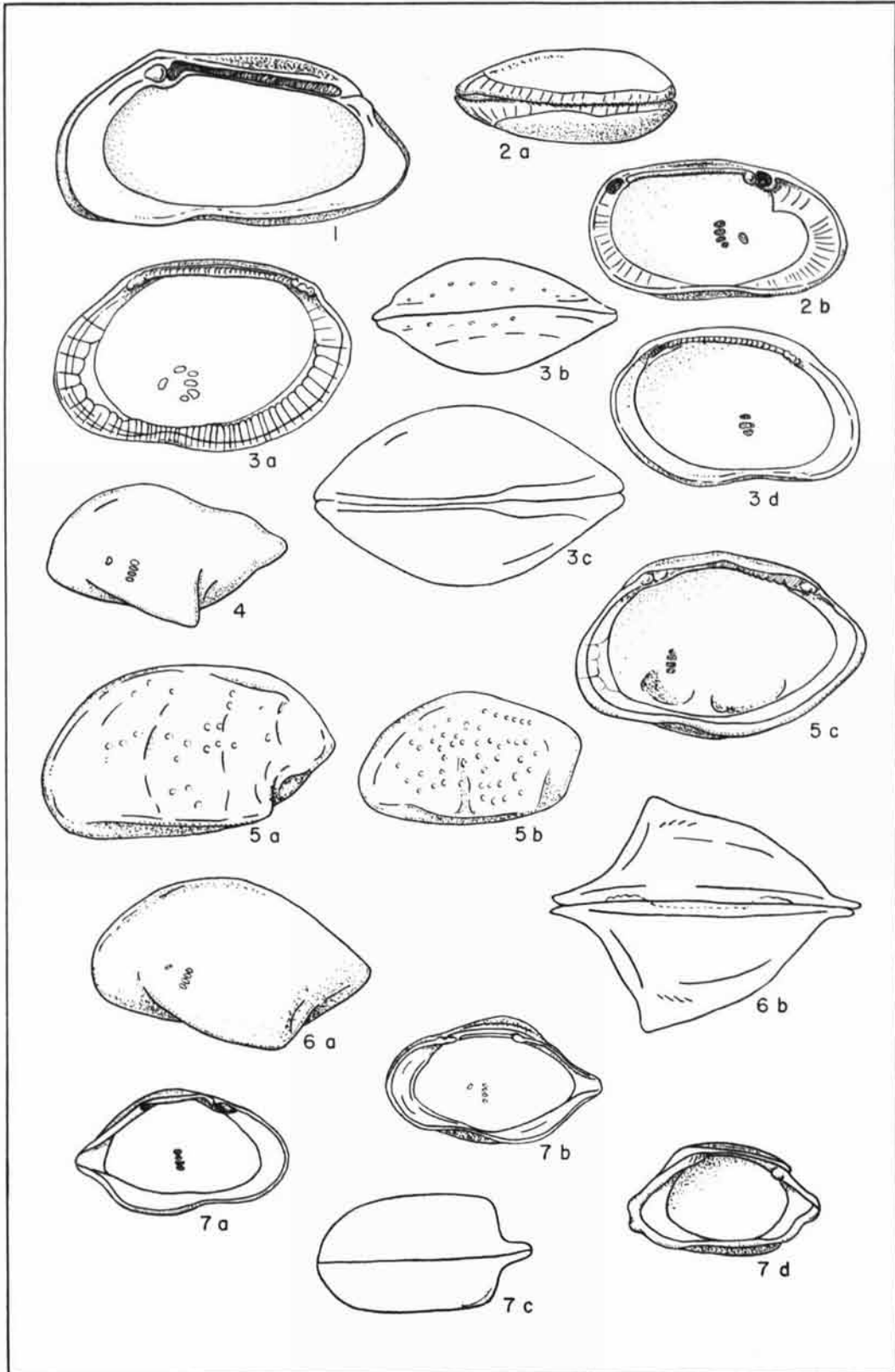
Diagnosis. Recognized by its small, very heavy, ridged carapace possessing a distinct caudal process, with the

EXPLANATION OF PLATE 4

LEGUMINOCYTHEREIS, BASSLERITES, LOXOCONCHA, CYTHEROPTERON, CYTHERURA, HEMICYTHERURA

(All illustrated forms are from the Todos Santos Bay Region, X75)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Leguminocythereis corrugata</i> LEROY; interior lateral view of right valve	68	5.— <i>Cytheropteron newportense</i> CROUCH; 5a, exterior lateral view of left valve of adult; 5b, exterior lateral view of left valve of an early instar; 5c, interior lateral view of an adult specimen showing hinge	54
2.— <i>Basslerites delreyensis</i> LEROY; 2a, dorsal view; 2b, internal lateral view of left valve showing muscle scars	69	6.— <i>Cytheropteron ensenadense</i> BENSON, n. sp.; 6a, exterior lateral view of left valve; 6b, dorsal view	54
3.— <i>Loxoconcha lenticulata</i> LEROY; 3a, interior lateral view of right valve of adult; 3b, dorsal view of adult; 3d, interior lateral view of left valve of instar	51	7a-c.— <i>Cytherura bajacala</i> BENSON, n. sp.; 7a, interior lateral view of left valve; 7b, interior lateral view of right valve; 7c, dorsal view	52
4.— <i>Cytheropteron pacificum</i> LEROY; exterior view of left valve showing muscle scars	54	7d.— <i>Hemicytherura</i> cf. <i>H. clathrata</i> (SARS); interior lateral view of right valve	54



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right valve over-reaching the left on the dorsal margin. Hinge antimeridont, but crenulations are not always easy to observe; small anterior and posterior vestibules under a moderately broad duplicature with several long radial pore canals. *Eocene to Recent*.

Little is known about the ecology of this genus. *H. pentagona* (HORNIBROOK, 1952) has been reported with a wide depth range, from intertidal to depths up to 150 fathoms. Believed to be confined to normal marine salinities. It has been identified from the Baltic (ELOFSON, 1941) to New Zealand (HORNIBROOK, 1952). WAGNER (1957, pp. 77, 78) reports finds no deeper than 15 fathoms in the Low Countries region.

HEMICYTHURURA sp. cf. H. CLATHRATA (Sars), 1865

Pl. 4, Fig. 7d; Pl. 7, Fig. 2; Pl. 9, Fig. 3

Cytherura clathrata Sars, 1865, p. 77; BRADY, 1868a, p. 446, pl. 29, figs. 43-46; Sars, 1928, p. 215, pl. 100, fig. 5; LUCAS, 1931, p. 11.

Dimensions. Length of largest specimen 0.43 mm.; height 0.27 mm.; thickness (approx.) 0.20 mm.

Material. No complete specimens were found; specimens examined 30; stained 20.

Remarks. *H. sp. cf. H. clathrata* (Sars) exhibits a variable surface sculpture. Since the original type specimens were not studied and the species as a whole should probably be redefined, the present specimens are only compared with this species.

Occurrence. ELOFSON (1941) reported *H. clathrata* in the Skagerak area of the Baltic Sea. WAGNER (1957, p. 78) found this species living in depths to fifteen fathoms. A form similar to it was found in Todos Santos Bay, sparsely distributed, on the northern shelf area, on the lee side of the south Todos Santos Island and on the north and south sides of Punta Banda. Depth range from 5 to 25 fathoms; mean annual bottom temperature range 52° to 53°F., variation 4 to 10 degrees; bottom types from very coarse sand on the lee side of the south Todos Santos Island to very fine sand just offshore near Ensenada; distribution does not closely correspond to the known distribution of the phytal in the above areas. Commonly associated with *Brachycythere lincolnensis*, *Hemicythere californiensis* and other ostracode species of Biofacies I (Fig. 10, 11).

Genus CYTHEROPTERON Sars, 1866

Cytheropteron Sars, 1865, pp. 79-80; Sars, 1926, p. 232; ALEXANDER, 1933, p. 181; MARTIN, 1939, pp. 176-182; STEPHENSON, 1946, p. 318.

Type species. *Cythere latissima* NORMAN, 1865, p. 19, pl. 6, figs. 5-8. Syn. *Cytheropteron convexum* Sars, 1866.

Diagnosis. Recognized by its smooth, pitted or reticulate carapace with a caudal extension and a winglike (alar) projection outward from the ventral region. It also possesses small anterior vestibules, relatively few simple or bifurcating radial pore canals, antimeridont hinge with notched median groove, and an adductor muscle scar pattern composed of four vertical posterior scars with one anterior. *Cretaceous to Recent*.

This genus is considered by MALKIN (1954, p. 7) as indicator of marine offshore open-shelf environment and

was noted by her (1951, p. 772) as having a depth range of 10 to 50 fathoms. One species was reported by HORNIBROOK (1952) as having been found at 300 fathoms; two species were found in the present study to be fairly restricted, ranging from 100 to 200 fathoms. Believed to be restricted to a fine-grained substratum. ELOFSON (1941) reports that species in the Baltic prefer a mud-without-sand substratum with a certain firmness. REMANE (1940, p. 118) describes *C. latissimum* and *C. alatum* Sars as living on top of mud (epipelos). BÖHL (1928) is the only author who has reported a brackish-water occurrence; others (MÉHES, 1936; ELOFSON, 1941; MÜLLER, 1894) have found this genus only in marine waters. ELOFSON (1941, p. 468) noted that some Baltic species may feed on worms, as polychaete setae were found in their stomachs. WAGNER (1957, p. 90) reports species found in the Low Countries area living down to 75 fathoms. This genus may prove useful as a deep water indicator.

CYTHEROPTERON PACIFICUM LeROY, 1943

Pl. 4, Fig. 4; Pl. 8, Fig. 11

Cytheropteron minutum LeROY, 1943a, p. 361, pl. 60, figs. 28-30. *Cytheropteron pacificum* LeROY, 1943b, p. 629.

Dimensions. Length of adult specimen 0.53 mm.; height 0.30 mm.; thickness 0.60 mm. across alae.

Material. Specimens examined 19; only one had both valves intact.

Occurrence. Not previously reported from Recent sediments. Found generally in the shallower waters of the channel region of Todos Santos Bay and on the south side of Punta Banda. Depth range 30 to 150 fathoms; mean annual bottom temperature from 50° to 52°F., annual variation 2 to 4 degrees in the bay and up to 10 degrees on the south side of Punta Banda; substratum medium-to-coarse silt with clay. More restricted to deeper and cooler waters than most of the ostracodes of the bay region. Frequently associated with *Bythocypris acties* and *C. newportense* in Biofacies IV (Fig. 10, 11).

CYTHEROPTERON NEWPORTENSE Crouch, 1949

Pl. 4, Fig. 5a-c; Pl. 8, Fig. 12

Cytheropteron newportense CROUCH, 1949, p. 597, pl. 96, figs. 2-4.

Dimensions. Length of adult specimen 0.57 mm.; height 0.40 mm.; thickness 0.33 mm.

Material. Examined 15 single valves.

Occurrence. Not previously reported from Recent sediments. Found in the lower part of the channel between Punta Banda and Todos Santos Islands in Todos Santos Bay and in the northeast-central part of the bay. Generally restricted to poorly sorted medium silt and very fine sand substratum. Depth range from 13 to 225 fathoms, mean annual bottom temperature range from 50° to 53°F., annual variation from 2 to 6 degrees. Frequently associated with *Brachycythere schumannensis* and *Cytheropteron ensenadense* in Biofacies IV (Figs. 10, 11).

CYTHEROPTERON ENSENADENSE Benson, n.sp.

Pl. 4, Fig. 6a,b

Diagnosis. Recognized by its broadly arched dorsum, short broad alae, and stubby posterior.

Description. Carapace small, thin-shelled, fragile, sub-rhomboidal in lateral view; alate in dorsal view; subtriangular in end view. Greatest height in middle. Dorsal margin high and strongly arched, with anterodorsal slope; ventral margin broadly convex; with short posterior upswing; anterior margin shortly rounded; posterior margin with short blunt caudal extension. Shell opaque, inflated with broad angular alar process. Surface smooth, with very minute closely spaced punctae. Hinge typical for the genus; muscle scars and radial pore canals obscure; line of conchescence coincides with inner margin; marginal area very narrow.

Dimensions. Length of adult specimen 0.50 mm.; height 0.43 mm.; span of alae 0.53 mm.

Material. Specimens examined 25; of these 2 had both valves intact.

Remarks. This species has a higher dorsum and shorter alae than *C. pacificum* LEROY and it is less angular and perforate than *C. neuportense* CROUCH.

Occurrence. Found principally in the deeper part of the channel between Punta Banda and Todos Santos Islands and in the deeper waters off the south shore of Punta Banda. Depth range from 100 to 250 fathoms; mean annual bottom temperature range from 50° to 52° F., annual variation from 2 degrees in the channel to 10 degrees on the south side of Punta Banda; substratum principally medium-sized silt with clay. Frequently associated with *Bythocypris actites* and *C. pacificum* in Biofacies IV (Figs. 10, 11).

Subfamily XESTOLEBERIDINAE Sars, 1928

Genus XESTOLEBERIS Sars, 1865

Xestoleberis Sars, 1866, p. 66, 167; MÜLLER, 1894, p. 332.
Type species. *Cythere aurantia* BAIRD, 1838, p. 143, pl. 5, fig. 26.

Diagnosis. Recognized by its small inflated, tumid, smooth, unornamented carapace, which, except for a small overlap on the dorsal margin, is equivalved and possesses an antimeridion hinge. A wide anterior duplicature forms a large anterior vestibule separated from the free margin by short widely spaced radial pore canals. The adductor muscle scar pattern consists of a vertical row of four scars with two anterior and one ventral scars. A distinctive reniform spot in the anterior dorsal areas is frequently present. *Upper Cretaceous to Recent.*

Species of this genus seem to be fairly well restricted to shallow marine waters or salt-water lagoons. Probably directly dependent on the distribution of algal growth or the phytal zone. ELOFSON (1941) and REMANE (1940, p. 154) have observed *X. aurantia* (BAIRD) and *X. dispar* Sars living in the phytal of the Baltic and North Seas. LUCAS (1931) describes *X. depressa* (BAIRD) from the *Laminaria* zone and *X. aurantia* was considered as a littoral species by BRADY & ROBERTSON (1872, p. 49). WAGNER (1957, pp. 94, 96) reports finding *X. aurantia* (BAIRD) having a depth range of 0-15 meters and living in brackish-water with salinities ranging down to 3 o/oo; and *X. depressa* Sars living in waters from 10 to 25 meters depth, never in salinities less than 10 o/oo.

XESTOLEBERIS AURANTIA (Baird), 1838

Pl. 5, Fig. 1a-d; Pl. 8, Figs. 2, 7

Diagnosis. This group or species was very difficult to classify. The only truly diagnostic feature of *X. aurantia* was a consistently larger size than *X. banda*, with a considerable gap between the two size ranges. It is probable that the specimens assigned to *X. aurantia* may actually constitute more than one species, but as no gap was found in the distribution of their extremely variable shape, they are for convenience listed under one species.

Description. Carapace small, thin-shelled, reniform; ovate in dorsal and end view. Greatest height in middle; greatest thickness, center in males, posterior in females, valves equal. Dorsal margin highly to evenly arched; ventral margin almost straight, with slight concavity near anterior end; anterior margin parabolic; posterior end well-rounded to blunt, with posteroventral angle. Surface smooth, with scattered small punctate. Hinge merodont but not well developed, with crenulate bar in right valve; contains distinct undulation in dorsal view. Adductor muscle scar pattern includes four oblong scars in vertical row anterior of middle; wide duplicature in anterior and posterior ends with well-developed vestibule; short widely spaced radial pore canals at regular intervals.

Dimensions. Length of adult specimen 0.53 mm.; height 0.33 mm.; thickness 0.33 mm.

Material. Specimens examined 242; of these 180 had both valves intact.

Remarks. Both JUDAY (1907, p. 136, pl. 18, fig. 12) and LUCAS (1931, p. 12) have described the species *X. dispar* MÜLLER, *X. depressa* Sars, and *X. aurantia* (BAIRD), of *Xestoleberis* from the west coast of North America. In Sars' (1865, p. 66) definition of the genus for the reception of the latter two species, he gave as the diagnostic feature the relative shape of the posterior end of the carapace. In trying to apply this particular diagnosis to the forms found in the Todos Santos Bay region, there is so much variability and continuity between the depressed end, characteristic of *X. depressa*, and the undepressed more angular end, characteristic of *X. aurantia*, that this method of distinguishing the species was impractical. Therefore, all forms of *Xestoleberis* except *X. banda* were lumped under one heading, *X. aurantia*, the first named of these two species.

Occurrence. Found in Todos Santos Bay and in the Estero de Punta Banda. Commonly associated with species of Biofacies I and the salt-water lagoon and salt-marsh biofacies (Fig. 14). Believed to be restricted to the phytal zone.

XESTOLEBERIS BANDA Benson, n.sp.

Pl. 5, Fig. 2a,b; Pl. 8, Fig. 1, 3

Diagnosis. Differentiated from *X. aurantia* (BAIRD) and other members of its genus by its small size and the consistent presence of a blunt posterior end forming a subdued beak.

Description. Carapace very small, tumid, reniform; moderately elliptical in dorsal view; subovate in end view. Greatest height in middle, greatest thickness in middle or

posterior, valves equal. Dorsal margin broadly arched; venter undulate; anterior well rounded; posterior subangular, blunt, with subdued posteroventral beak. Surface smooth. Hinge poorly developed, almost desmodont with tiny crenulations along a smooth bar; no duplicature or vestibule, narrow marginal area; radial pore canals obscure. Muscle scar as in *X. aurantia*.

Dimensions. Length of largest specimen 0.33 mm.; height 0.20 mm.; thickness 0.167 mm.

Material. Specimens examined 80; of these 25 had both valves intact.

Remarks. (Also see diagnosis under *X. aurantia*.) The difference of distribution and lack of any continuity in molt sequence between this species and *X. aurantia* throws doubt on the possibility that *X. banda* is an immature form of *X. aurantia*.

Occurrence. This newly described form was found only in two localities, both in the intertidal zone of the upper end of the Estero de Punta Banda away from the main channel. This is a very severe environment of extreme daily temperatures, tidal, and salinity variations.

Subfamily PARADOXOSTOMATINAE Müller, 1894

Genus SCLEROCHILUS Sars, 1866

Sclerochilus Sars, 1866, p. 89; BRADY, 1868a, p. 455; G. W. MÜLLER, 1894, p. 281; G. W. MÜLLER, 1912, p. 260.
Type species. *Cythere contorta* NORMAN, 1861, p. 150, pl. 3, fig. 15.

Diagnosis. Recognized by the smooth, elongate, subspatulate, usually hyaline carapace containing a broad duplicature and vestibule; large straight radial pore canals, often grouped in two's and three's; adductor muscle scar pattern consists of at least four vertical scars possibly with two more anterior. *Pleistocene to Recent.*

Very little is known about the ecology of this genus. Described by SOHN (1951, p. 64) as living in a shallow marine environment approaching littoral. *S. contortus* (NORMAN), the type species, was reported by ELOFSON (1941) to live on the epiphytes associated with the phytal

zone. WAGNER (1957, p. 101) found *S. contortus* living among plants between 5 and 30 meters, never in salinities less than 17 o/oo.

SCLEROCHILUS NASUS Benson, n.sp.

Pl. 5, Fig. 3a,b; Pl. 9, Fig. 2

Diagnosis. Recognized by its broadly rounded postero-dorsum and venter and its elongate shape.

Description. Carapace medium-sized, elongate, transparent, subspatulate in lateral view; narrow, elliptical in dorsal and end view. Greatest height just posterior of middle, greatest thickness posterior. Dorsal margin straight; ventral margin broadly convex; anterior margin subsemicircular; posterior margin parabolic with well-rounded postero-dorsum and venter. Subsurface smooth, with widely spaced coarse normal pore canals. Hinge adont; narrow marginal area except in anterior where it widens and leaves outer lamella to form narrow vestibule; adductor muscle scar pattern included four small scars, forming one ovate cluster, just anterodorsal to center; radial pore canals in groups of two to four, regularly spaced.

Dimensions. Length of adult 0.64 mm.; height 0.29 mm.; thickness 0.24 mm.

Material. Specimens examined 19; all had both valves intact.

Remarks. The carapace of the species of genus *Sclerochilus* is rather featureless and perhaps not sufficiently complex to justify the formation of very many species. Previous descriptions have not placed sufficient emphasis on the details of the margin, duplicature, etc., so that *S. nasus* is differentiated from other species of the genus only on the basis of the carapace outline, although the other features have been described and illustrated.

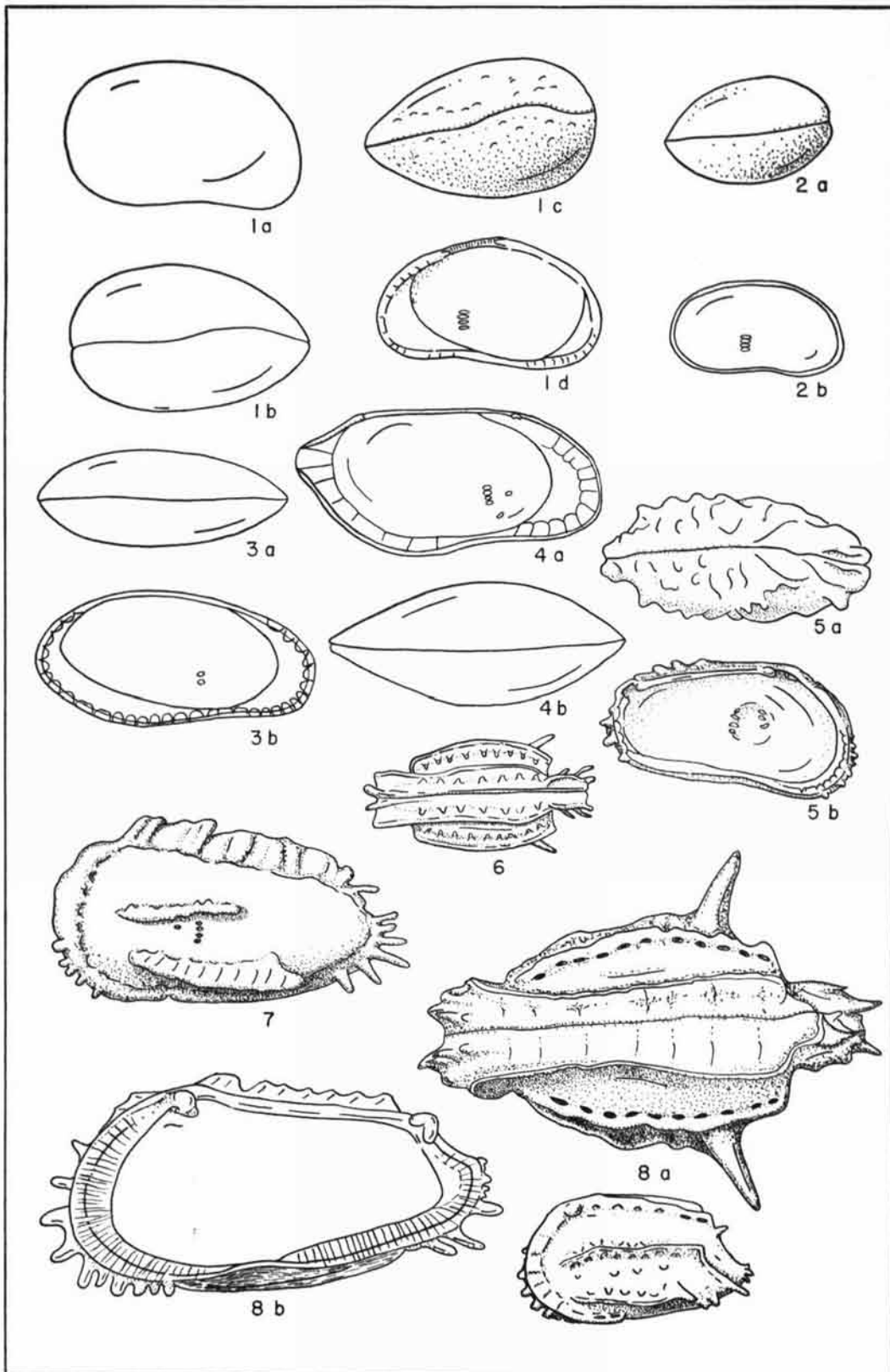
Occurrence. Found in Todos Santos Bay primarily in the samples of seasonal traverse in shallow water of 20 fathoms or less. Generally restricted to a very fine sandy substratum; mean annual bottom temperature range from 52° to 55°F., seasonal variation from 6 to 10 degrees. Rare.

EXPLANATION OF PLATE 5

XESTOLEBERIS, SCLEROCHILUS, PELLUCISTOMA, PURIANA, PTERYGOCYTHEREIS

(All illustrated forms are from the Todos Santos Bay Region, X75)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Xestoleberis aurantia</i> (BAIRD); 1a, exterior lateral view of right valve; 1b, dorsal view; 1c, dorsal view; 1d, interior lateral view of right valve	55	5.— <i>Puriana pacifica</i> BENSON, n. sp.; 5a, dorsal view; 5b, interior lateral view of left valve showing muscle scar pattern	60
2.— <i>Xestoleberis banda</i> BENSON, n. sp.; 2a, dorsal view; 2b, interior lateral view of right valve	55	6-8.— <i>Pterygocythereis semitranslucens</i> CROUCH; 6, dorsal view of an early instar; 7, external lateral view of adult left valve showing development of median frill; 8a, dorsal view; 8b, internal lateral view of right valve showing lobed posterior tooth and discrete lower bar of hinge	58
3.— <i>Sclerochilus nasus</i> BENSON, n. sp.; 3a, dorsal view of immature instar; 3b, interior lateral view of left valve of adult	56		
4.— <i>Pellucistoma scrippsii</i> BENSON, n. sp.; 4a, interior lateral view of left valve; 4b, dorsal view	58		



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Genus PELLUCISTOMA Coryell and Fields, 1937

Pellucistoma CORYELL & FIELDS, 1937, p. 17; VAN DEN BOLD, 1946, p. 35.
Type species. Pellucistoma howei CORYELL & FIELDS, 1937, p. 17.

Diagnosis. Characterized by having a small smooth subovate carapace with caudal process above the mid-line; hinge described as a long serrate bar and groove with an anterior tooth and socket; a wide duplicature, particularly in the anterior region, sometimes with an irregular line of concrescence. *Miocene to Recent.*

PELLUCISTOMA SCRIPPSI Benson, n.sp.
 Pl. 5, Fig. 4a,b; Pl. 9, Figs. 5, 6

Diagnosis. Recognized by its gently arched postero-dorsum, generally smoothly curved lateral outline, and high posterior.

Description. Carapace medium-sized, opaque, very thin-shelled, spatulate in lateral view; narrow, elliptical in dorsal and end view; valves equal. Greatest height and thickness in posterior. Dorsal margin broadly arched; venter sinuous; anterior margin subparabolic, pointing slightly downward; posterior margin broadly parabolic. Surface smooth, with widely scattered coarse normal pore canals. Hinge adont; inner margin coincides with line of concrescence except in anterior where narrow vestibule is developed; marginal area moderate except in anterior where it widens; muscle scar pattern obscure; radial pore canals obscure.

Dimensions. Length of adult specimen 0.69 mm.; height 0.33 mm.; thickness 0.27 mm.

Material. Specimens examined 17; of these 8 had both valves intact.

Remarks. Similar to the type species, *P. howei* CORYELL and FIELDS (1937, p. 17), except that it is more elongate, and its postero-dorsum is gently convex rather than concave, making its posterior rounded rather than caudate or acuminate.

Occurrence. Found in Todos Santos Bay in the shallower northeastern area and on the south side of Punta

Banda. Not very common. Depth range 5 to 20 fathoms; mean annual bottom temperature from 52° to 55°F., annual variation from 4 to 6 degrees; substratum predominantly very fine sand. Associated with *Basslerites delreyensis*, *Leguminocythereis corrugata*, and *Palmenella carida* in Biofacies I and II (Fig. 11).

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948**Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948****Genus PTERYGOCYTHEREIS Blake, 1933**

Pterygocythereis BLAKE, 1933, p. 239; TREIBEL, 1941, p. 385-386; SYLVESTER-BRADLEY, 1948, p. 793; KEIJ, 1957, p. 94.
Type species. Cythereis jonesi BAIRD, 1850.

Diagnosis. Distinguished from other genera of the subfamily Trachyleberidinae by its subquadrangular carapace, which is subtriangular in dorsal view owing to development of prominent alae or lateral spines. Surface smooth or ornamented with secondary alae, spines or ridges. Hinge holamphidont. *Upper Cretaceous to Recent.*

This genus is believed to be entirely marine and associated with fine-grained sediments. One species, *P. velivola* (BRADY), reported by BRADY (1880) from the Pacific off Mexico (long. 137°, lat. 10°) in 25 fathoms of water.

PTERYGOCYTHEREIS SEMITRANSLUCENS (Crouch), 1949
 Pl. 5, Figs. 6, 7, 8a,b; Pl. 10, Figs. 10-13

Trachyleberis semitranslucens CROUCH, 1949, p. 292, pl. 96, fig. 1.

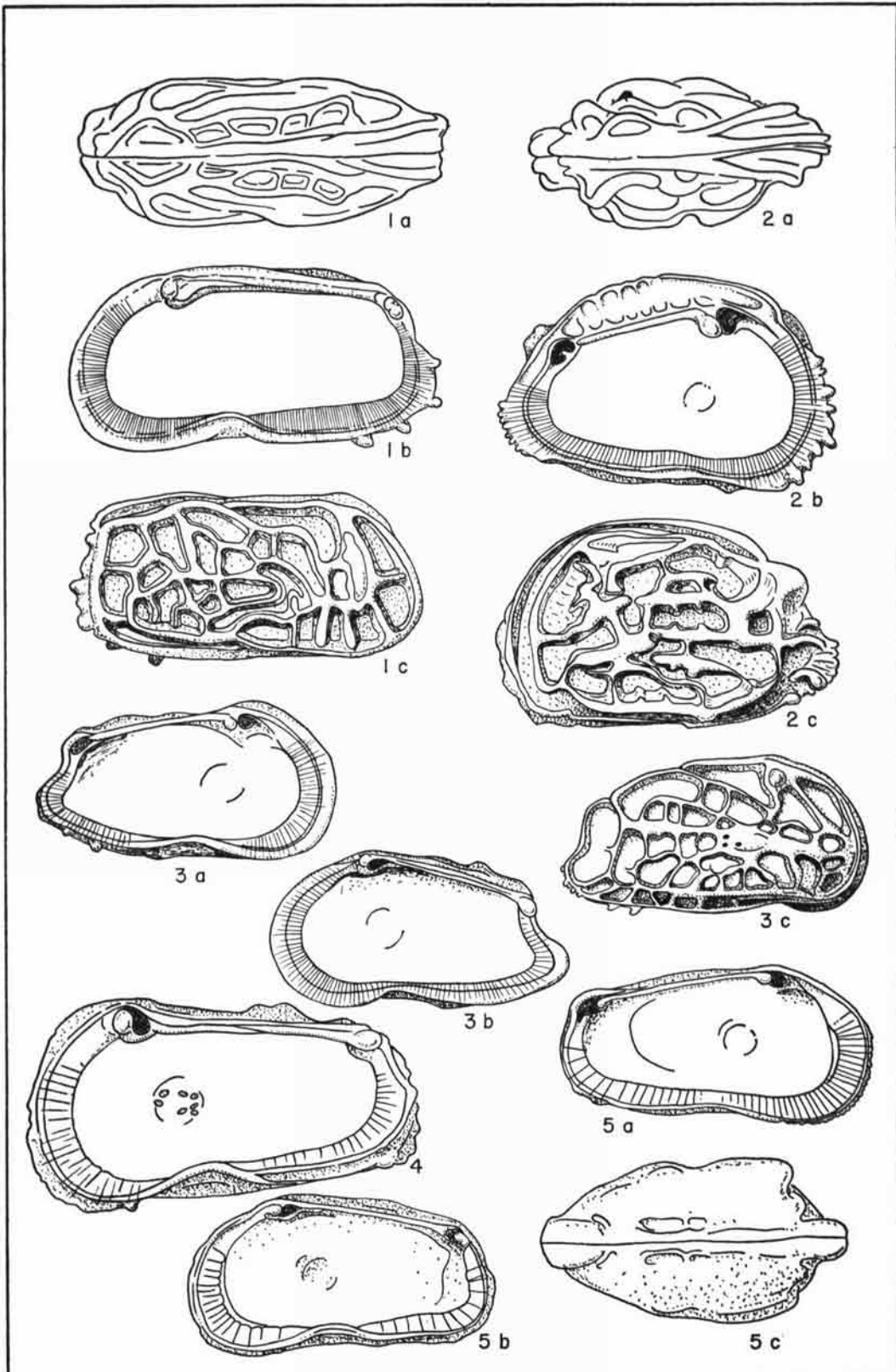
Diagnosis. Recognized by a prominent rather delicate elevated rib (or the remnants of it) running parallel to the margin from the posterior cardinal angle around the anterior end and terminating or gradually diminishing near the postero-venter, and also by two longitudinal elevated ribs or costae (or their remnants), one located near the venter and the other centrally, and by the two large anteroventral spines.

Description. Carapace large, robust, subrectangular in lateral view; subcuneiform in dorsal view, with large,

EXPLANATION OF PLATE 6**CYTHEREIS, BRADLEYA**

(All illustrated forms are from the Todos Santos Bay Region, X75)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Cythereis glauca</i> SKOGSBERG; 1a, dorsal view; 1b, interior lateral view of right valve showing hinge; 1c, exterior lateral view of right valve showing variation in the exterior shell sculpture	62	3.— <i>Bradleya diegoensis</i> (LEROY); 3a, interior lateral view of left valve; 3b, interior lateral view of right valve; 3c, exterior lateral view of right valve	63
2.— <i>Bradleya aurita</i> (SKOGSBERG); 2a, dorsal view; 2b, interior lateral of left valve view, showing hinge and dorsal marginal area; 2c, exterior lateral view of left valve showing variation in the shell sculpture	63	4.— <i>Bradleya pennata</i> (LEROY); interior lateral view of right valve	63
		5.— <i>Bradleya</i> cf. <i>B. schencki</i> (LEROY); 5a, interior lateral view of left valve; 5b, interior lateral view of right valve; 5c, dorsal view	63



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anteroventral spines near the anterior; subrectangular to truncate, triangular in end view. Greatest height at anterior cardinal angle, greatest thickness in region of large anteroventral spines; valves subequal in size. Dorsal margin straight, even; ventral margin broadly curved, with central lip; anterior margin broadly rounded, with eight to twelve spines around lower part; posterior margin with large caudal extension and several large projecting spines. Surface wrinkled and plicated, with prominent rather delicate elevated rib (or broken portions of it, as it is usually broken off in mature specimens) running parallel to margin from posterior cardinal angle around anterior end, terminating or gradually diminishing near the posteroventer; two longitudinal elevated ribs or costae (or their remnants), one located near the venter and one centrally. Hinge typical for genus except for angular (Pl. 5, fig. 8b) or lobed posterior tooth, lower bar discrete. Inner margin coincides with line of concrescence; marginal area moderately wide; muscle scar pattern and radial pore canals obscured by thick, opaque shell in adult forms, transparent in molts.

Dimensions. Length of adult specimen 1.10 mm.; height 0.56 mm.; thickness (excluding spines) 0.51 mm.

Material. Specimens examined 43; of these 15 had both valves intact.

Remarks. This species resembles very closely *Cativella navis* CORYELL and FIELDS (1937, p. 9, fig. 9a), but it is even closer to the form described as *Navecythere delicata* by CORYELL and FIELDS (1937, p. 7, fig. 7a,b,c) which was later recognized as an early instar of *C. navis* by STEPHENSON (1946, p. 304). The general shape and hinge indicate its closest affinities with *Pterygocythereis* BLAKE.

Occurrence. *Pterygocythereis semitranslucens* was previously observed by CROUCH (1949, p. 598) in Recent sediments from Cristobal Bay, Baja California. It is found in Todos Santos Bay principally in the eastern part, commonly restricted to the very fine sandy bottom. Generally

rare, it is frequently associated with *Leguminocythereis corrugata* and *Palmenella* sp. A (Figure 10) in Biofacies II. Depth range 5 to 30 fathoms.

Genus PURIANA Coryell & Fields in Puri, 1953

Favella CORYELL & FIELDS, 1937, p. 8; EDWARDS, 1944, p. 523-24 [preoccupied by *Favella* JÖRGENSEN, 1925, Prot., *vide* Neave, Nomenclator Zoologicus, vol. 2, p. 401].

Puriana CORYELL & FIELDS in PURI, 1953 (by CORYELL), p. 751. *Type species.* *Favella puella* CORYELL & FIELDS, 1937.

Diagnosis. Distinguished from other genera of the family Trachyleberididae by its moderately small, inflated, quadrate carapace ornamented with ridges, plications, knobs, subcentral tubercle, prominent rim on the anterior margin and four or five heavy spines on the posterior margin. Hinge holamphidont; narrow duplication with slight vestibule and few radial pore canals. *Miocene to Recent.*

Found living off the Texas coast in three stations in less than ten fathoms (SWAIN, 1955, p. 634). Believed to be representative of a shallow near-shore environment.

PURIANA PACIFICA Benson, n.sp.

Pl. 5, Fig. 5a,b; Pl. 10, Fig. 1

Diagnosis. Recognized by a rim concentric with the anterior margin of the carapace, its broad subdued subcentral protuberance, and irregular short and comparatively erratic plications of the surface.

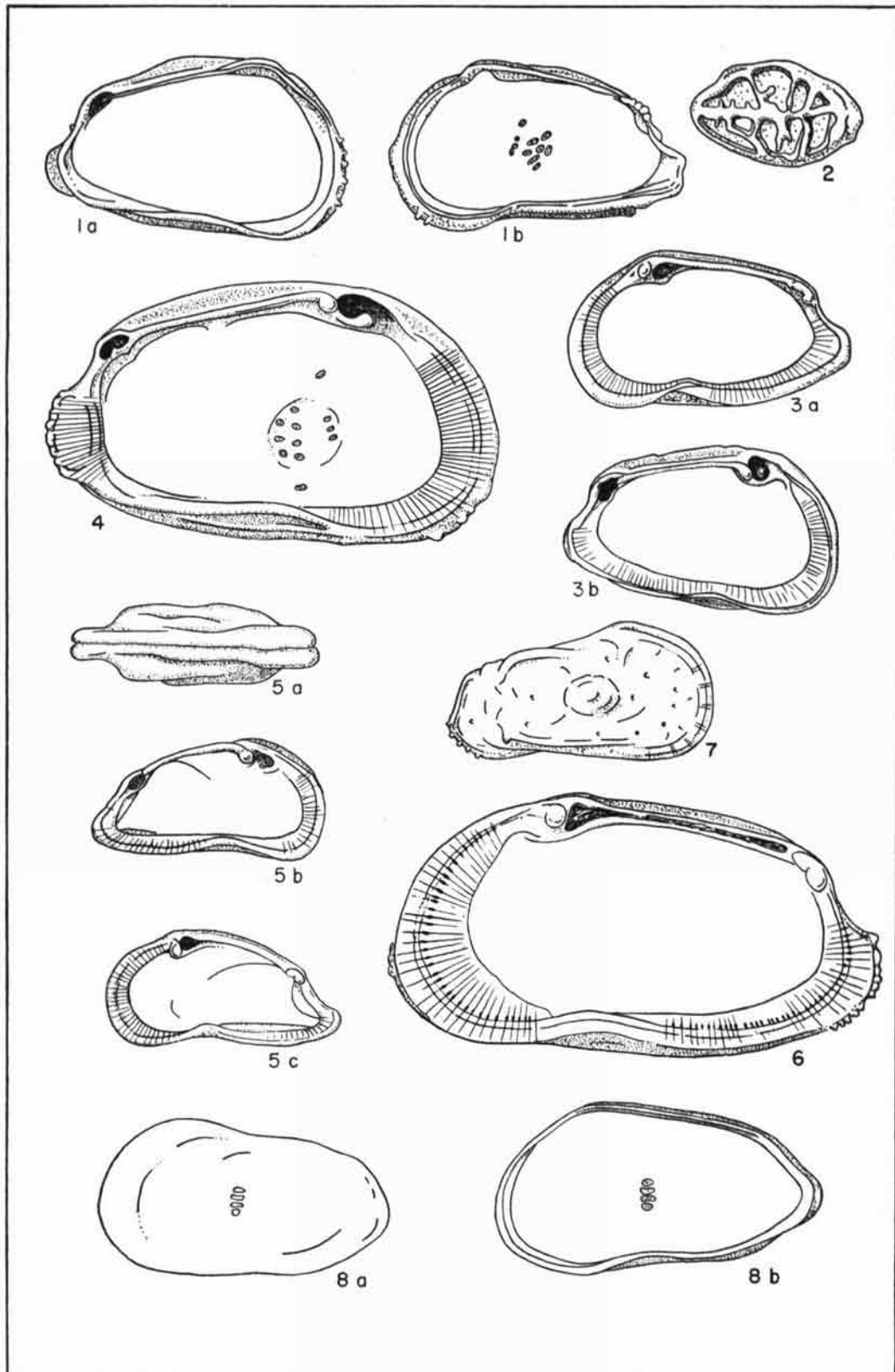
Description. Carapace moderately small, elongate, subrectangular in lateral view; elliptical in dorsal view; subcircular in end view. Greatest height at anterior cardinal angle; greatest thickness at subcentral protuberance and posterior end; valves equal in size. Dorsal margin straight; ventral margin straight, with slight central lip; anterior margin well rounded, with six or seven short denticles; posterior margin subangular, with three or four small spines. Surface rough, with short rounded tuber-

EXPLANATION OF PLATE 7

QUADRACYTHERE, HEMICYTHERURA, HEMICYTHERE, CAUDITES, CYTHERURA

(All illustrated forms are from the Todos Santos Bay Region, X75)

FIGURE	PAGE	FIGURE	PAGE
1,6.— <i>Quadracythere regalia</i> BENSON, n. sp.; 1a, interior lateral view of left valve; 1b, interior lateral view of immature specimen showing muscle scar pattern and incomplete hinge development. 6, interior lateral view of mature specimen showing mature hinge	64	4.— <i>Hemicythere californiensis</i> LEROY; interior lateral view of left valve showing hinge; muscle scar pattern and variation in caudal extension	65
2.— <i>Hemicytherura</i> cf. <i>H. clathrata</i> (SARS); exterior view of right valve	54	5.— <i>Caudites fragilis</i> LEROY; 5a, dorsal view; 5b, interior lateral view of left valve; 5c, interior lateral view of right valve	66
3.— <i>Hemicythere palosensis</i> LEROY; 3a, interior lateral view of right valve; 3b, interior lateral view of left valve	66	7.—Genus A sp. A; exterior lateral view of right valve	71
		8.— <i>Cytherura</i> cf. <i>C. gibba</i> (O. F. MÜLLER); 8a, exterior lateral view of left valve; 8b, interior lateral view of right valve showing simple hinge	52



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cles and plications and marked by a broad, subdued, wrinkled, subcentral protuberance and rim concentric with anterior margin. Hinge holamphidont; left valve small, angular, open-sided; anterior socket with small elongate rounded postjacent bulb-shaped tooth connected to raised subangular elongate open-sided posterior tooth by long, elevated, smooth bar paralleling dorsal margin but separated from it by narrow area; right valve contains two teeth and one socket, complementary to left valve. Viewed from interior, valves moderately deep and smooth, with a subcentral pit containing muscle scar pattern as negative of exterior subcentral node; muscle scar pattern consists of four posterior scars and three anterior on edge of subcentral pit; inner margin coincides with line of concrescence except in anteroventral and posterior regions where narrow vestibule is developed with widely spaced funnel-shaped straight radial pore canals; marginal area narrow.

Dimensions. Length of adult specimen 0.60 mm.; height 0.33 mm.; thickness 0.30 mm.

Material. Specimens examined 190; of these 172 had both valves intact.

Remarks. Very closely related to *T. rugipunctata* (ULRICH & BASSLER), which has an anterior rim and is plicate but with plications much more strongly developed. Many specimens have been identified by ROTHWELL (1944) from the Recent of southern California as *Cythereis* aff. *rugipunctata* ULRICH & BASSLER (ROTHWELL'S form 368). I have not seen his specimens, but I have collected specimens from Mission Bay, San Diego Co., California, and believe this species to be conspecific with ROTHWELL'S undescribed form.

Occurrence. This newly described form was found to be restricted to the upper more saline end of the Estero de Punta Banda in the main channel. Found associated with the ostracodes *Xestoleberis aurantia*, *Loxococoncha lenticulata*, and occasionally with *Cyprideis castus* (Fig. 11). It seems to be a good indicator of a salt-water-lagoon environment. Very abundant in the estero and also in Mission Bay, San Diego County, California.

Genus CYTHEREIS Jones, 1849

Cythereis JONES, 1849, p. 14, 15; ALEXANDER, 1934, p. 218; EDWARDS, 1944, p. 521; VAN DEN BOLD, 1946, p. 29; STEPHENSON, 1946, p. 334; HORNIBROOK, 1952a, p. 35.

Type species. *Cytherina ornatissima* REUSS, 1845, pl. 24, figs. 12, 18; TRIEBEL, 1940, pl. 2, figs. 27-30.

Diagnosis. Distinguished from other genera of the subfamily Trachyleberidinae by its heavy subquadrangular carapace with an anterior marginal rim and ornamented with two or three longitudinal ridges like *Costa NEVIANI* and a subcentral tubercle like *Trachyleberis* BRADY or *Puriana* CORYELL & FIELDS. Hemiamphidont hinge; welded duplicature. *Upper Jurassic to Recent.*

Knowledge of the ecology of *Cythereis* is rather uncertain at present because most of the descriptions of habitats were given for forms which after reexamination will probably be reassigned to *Trachyleberis*, *Bradleya*, *Quad-*

racythere, and *Cythereis*. Therefore the following observations were pre-1948, the time of SYLVESTER-BRADLEY'S revision of the genus *Trachyleberis* and HORNIBROOK'S (1952a) description of *Bradleya* and *Quad-racythere*.

The range of environments inhabited by species assigned to the genus *Cythereis* is large and varied. SOHN (1951, p. 64) lists species from fresh, brackish, and marine waters. *C. longiductus*, *C. glauca*, *C. pacifica*, *C. montereyensis*, and *C. polita*, all described by SKOGSBERG, have been reported from the littoral zone living among algae along the coast of California. *C. glauca* has been noted in the present study along with *C. aurita* as being found at depth on the shelf, and probably the other species described by SKOGSBERG live in deeper water also. *C. angulata* is described by ELOFSON (1941, p. 426) as living on a variety of bottom types from very coarse sand to clay-rich mud, with some crawling between the sand grains (mesopsammon). REMANE (1940, p. 123) lists some species of *Cythereis* as epipelos.

CYTHEREIS GLAUCA Skogsberg, 1928

Pl. 6, Fig. 1a-c; Pl. 10, Fig. 8

Cythereis glauca SKOGSBERG, 1928, p. 110, pl. 3, figs. 2, 6, 7; pl. 4, fig. 4; LUCAS, 1931, p. 6; LEROY, 1943, p. 368, pl. 61, figs. 19-23; pl. 62, figs. 11, 12; fig. 2v,w.

Trachyleberis glauca (LEROY), CROUCH, 1949, p. 597.

Dimensions. Length of adult specimen 0.80 mm.; height 0.40 mm.; thickness 0.37 mm.

Material. Specimens examined 40; of these 19 had both valves intact.

Remarks. CROUCH included *C. glauca* SKOGSBERG under the genus *Trachyleberis* without giving a reason, but he probably believed, as did SYLVESTER-BRADLEY (1948, p. 792), that *Cythereis* does not occur in Recent sediments. It cannot be assigned to the genus *Trachyleberis* because the carapace is not tuberculate (PURI, 1953a) and the posterior tooth is lobate. The placement here of *C. glauca* back in the genus *Cythereis* follows the division of these closely allied forms on the basis of hinge and sculpture development as described by HORNIBROOK (1952a, p. 35) on the basis of the lobed posterior tooth. This seems to be the best temporary placement. As this whole group is undergoing rapid revision, later workers may feel that ornamentation can be used as the dominant character to guide classification of this form.

Occurrence. Previously reported by SKOGSBERG (1928, p. 110) from a tidal pool at Carmel Bay, Pacific Grove, California, by LEROY (1943a, p. 369) from Avalon Bay, Santa Catalina Island, and identified by ROTHWELL (1944) from Avalon Bay at a depth of about 10 fathoms and possibly offshore of Long Beach at a depth of about 25 fathoms. Found in Todos Santos Bay principally near shore at about 20 fathoms, or on the lee side of the southern Todos Santos Island, and midway between the island and the northern shore of the bay on its open western side. Depth range generally 20 to 30 fathoms; mean annual bottom temperature 52° to 53°F., variation 2 to 4 degrees; bottom principally very coarse sand near the island to fine sand to the north; distribution rather closely coincides with the known marine plant distribu-

tion in the areas involved. Commonly associated with *Bradleya diegoensis*, *Brachycythere lincolnensis*, *Hemicythere californiensis*, and *Hemicythere jollaensis*, less commonly with other species (Fig. 11) in Biofacies I.

Genus BRADLEYA Hornibrook, 1952

Bradleya HORNIBROOK, 1952, p. 38.

Type species. *Cythere arata* BRADY, 1880; p. 101, pl. 24, fig. 2a-c; HORNIBROOK, 1952a, p. 39.

Diagnosis. Distinguished from other genera of the subfamily Trachyleberidinae by its smooth to reticulate carapace with distinct dorsal and ventral keels. *Upper Cretaceous to Recent.*

BRADLEYA AURITA (Skogsberg), 1928

Pl. 6, Fig. 2a-c; Pl. 11, Fig. 4

Cythereis aurita SKOGSBERG, 1928, p. 120, pl. 6, fig. 5; fig. 21; *ibid.*, LUCAS, 1931, p. 6.

Dimensions. Length of adult specimen 0.77 mm.; height 0.53 mm.; thickness 0.40 mm.

Material. Specimens were examined 64; of these 15 had both valves intact.

Remarks. This species is placed in the genus *Bradleya* because the hinge structure is intermediate between the genera *Trachyleberis* and *Cythereis* and because it has ribbing as opposed to spines or tubercles for surface ornament (HORNIBROOK, 1952a, p. 38). Hinge close to *B. dictyon* (BRADY) as described by HORNIBROOK (1952, p. 39) but otherwise quite different. *B. aurita* (SKOGSBERG) has thin very prominent ribbing, compared to the wide ribbing found on *B. dictyon*, and its dorsal and ventral costae are more subdued than the flange development of *B. arata* (BRADY). The subcentral tubercle is less pronounced. SYLVESTER-BRADLEY (personal communication) has suggested that this form might be placed in the subfamily Hemicytherinae but in lieu of further evidence it is left in the subfamily Trachyleberidinae.

Occurrence. Previously described by SKOGSBERG (1928, p. 120) from a tidal pool at Pacific Grove, California, associated with calcareous algae and *Macrocystis*. Found in Todos Santos Bay in a rocky tidal pool on the northern shore, on the lee side of the southern Todos Santos Island, where there were abundant *Macrocystis*, one station on the open western side of the bay, and just offshore from the coast just west of Ensenada. Depth range intertidal to usually about 20 fathoms. Whether this species lives on *Macrocystis* or on the bottom is not known, although the sculpture is not one of a phytal zone ostracode.

BRADLEYA DIEGOENSIS (LeRoy), 1943

Pl. 6, Fig. 3a-c; Pl. 11, Fig. 6

Cythereis diegoensis LEROY, 1943a, p. 369, pl. 58, figs. 26-31; fig. 2c. *Trachyleberis diegoensis* (LEROY), CROUCH, 1949, p. 597.

Dimensions. Length of adult specimen 0.57 mm.; height 0.33 mm.; thickness (approx.) 0.27 mm.

Material. Specimens examined 99; of these 24 had both valves intact.

Remarks. *B. diegoensis* is included in the genus

Bradleya because its hinge is intermediate in development between the genera *Cythereis* and *Trachyleberis* (HORNIBROOK, 1952, p. 38).

Occurrence. Widely distributed, although not abundant, in Todos Santos Bay on the north and west and on the northern and southern sides of Punta Banda. Rarely found in the north coast tidal pools, most abundant on a traverse along lat. 31° 50'. Depths generally range from about 5 to 25 fathoms; mean annual bottom temperature 52° to 55°F., variation 4 to 10 degrees. Closely associated with the known marine plant distribution; bottom sediments range from very coarse on the lee side of the Todos Santos Islands to fine and very fine sand over the rest of the bay. Commonly associated with *Cythereis glauca*, *Hemicythere californiensis*, *Hemicythere jollaensis*, and *Brachycythere lincolnensis* (Fig. 11) of Biofacies I.

BRADLEYA PENNATA (LeRoy), 1943

Pl. 6, Fig. 4; Pl. 10, Fig. 7

Cythereis pennata LEROY, 1943a, p. 370, pl. 59, figs. 34-37, pl. 62, figs. 19, 20; fig. 2h.

Trachyleberis pennata (LEROY), CROUCH, 1949, p. 597.

Dimensions. Length of adult specimen 0.87 mm.; height 0.57 mm.; thickness 0.50 mm.

Material. Specimens examined 10; of these 2 had both valves intact.

Remarks. *B. pennata* is included in the genus *Bradleya* because its hinge is intermediate in development between the genera *Cythereis* and *Trachyleberis* and its surface ornament is riblike rather than tuberculate.

Occurrence. Previously identified by ROTHWELL (1944) from the San Pedro channel offshore from Long Beach, California. Only a few specimens found in Todos Santos Bay. Depth about 25 fathoms, substratum fine and very fine sand. Faunule association above in Figure 11.

BRADLEYA sp. cf. B. SCHENCKI (LeRoy), 1943

Pl. 6, Fig. 5a-c; Pl. 9, Fig. 8

Cythereis schencki LEROY, 1943a, p. 371, pl. 58, figs. 9-14; fig. 2u. *Trachyleberis schencki* (LEROY), CROUCH, 1949, p. 597.

Dimensions. Length of adult specimen 0.87 mm.; height 0.40 mm.; thickness 0.37 mm.

Material. Specimens examined 46; of these 10 had both valves intact.

Remarks. The type specimens were not examined. Seemingly the only difference between the two forms is the degree of development of the ridges on the exterior surface. This feature is plainly evident in LEROY's illustrations (1943, p. 58); however it is very subdued on the Todos Santos forms. It is possible that they may be varieties of a single species but this has yet to be shown.

Occurrence. Previously identified by ROTHWELL (1944) from the San Pedro channel offshore in about 20 fathoms from Long Beach, California. Found sparsely distributed in the northwestern sector of Todos Santos Bay. Depth range generally from 8 to 25 fathoms; mean annual bottom temperature 52° to 55°F.; substratum generally coarse-to-fine sand. Faunule association (Fig. 11).

Genus QUADRACYTHERE Hornibrook, 1952

Quadracythere HORNIBROOK, 1952a, p. 43-44.

Type species. *Cythere truncula* BRADY, 1898, p. 444, pl. 47, figs. 16, 17.

Diagnosis. Distinguished from other genera of the subfamily Trachyleberidinae by its holamphidont hinge with a lobed posterior tooth, distinct caudal process, and pronounced ventral and dorsolateral keels. *Eocene to Recent.*

QUADRACYTHERE REGALIA Benson, n.sp.

Pl. 7, Figs. 1, 6; Pl. 11, Figs. 1, 3, 12

Diagnosis. Recognized by its fine uniformly reticulate surface pattern and the rimlike development of two ribs of the network concentric with the anterior margin.

Description. Carapace medium-large, robust, subrectangular in adults to subtriangular in earlier molts in lateral view; elliptical in dorsal view; ovate in end view. Greatest height at anterior cardinal angle; greatest thickness in posterior end; left valve slightly larger than right. Dorsal margin straight in right valve, broadly convex in left valve; ventral margin broadly curved, anterior cardinal angle pronounced in some specimens; posterior margin denticulate, with short caudal extension, exact shape varies somewhat from blunt to quite angular. Surface uniformly reticulate, with rimlike development of two ribs of reticulate network near and concentric with anterior margin; prominent ventral costa ending sharply near posterior end and short prominent-to-subdued posterodorsal hornlike costa, usually better developed in immature instars. Hinge typical for genus; inner margin

coincides with line of concrescence; margin area wide, particularly in anterior end; radial pore canals numerous, closely spaced, straight, with slight swellings near midpoint; muscle scar pattern obscure; selvage prominent.

Dimensions. Length of adult specimen 1.00 mm.; height 0.53 mm.; thickness 0.50 mm.

Material. Specimens examined 81; of these 6 had both valves intact.

Remarks. This species has a hinge, general shape, and reticulate surface that place it in the genus *Quadracythere* HORNIBROOK (1952a, p. 42). It does not have a prominent dorsal flange or costa as does *Q. clavala* HORNIBROOK or *Q. radizea* HORNIBROOK, and its dorsal margin is more even than that of most of the other species of the genus. It is more elongate, and its reticulate surface is more uniform than *Q. truncula* HORNIBROOK. Its relationship to the species described from New Zealand is obviously distant but it agrees more closely with *Quadracythere* than with *Cythereis*, *Trachyleberis*, *Bradleya*, or any other genus of the subfamily.

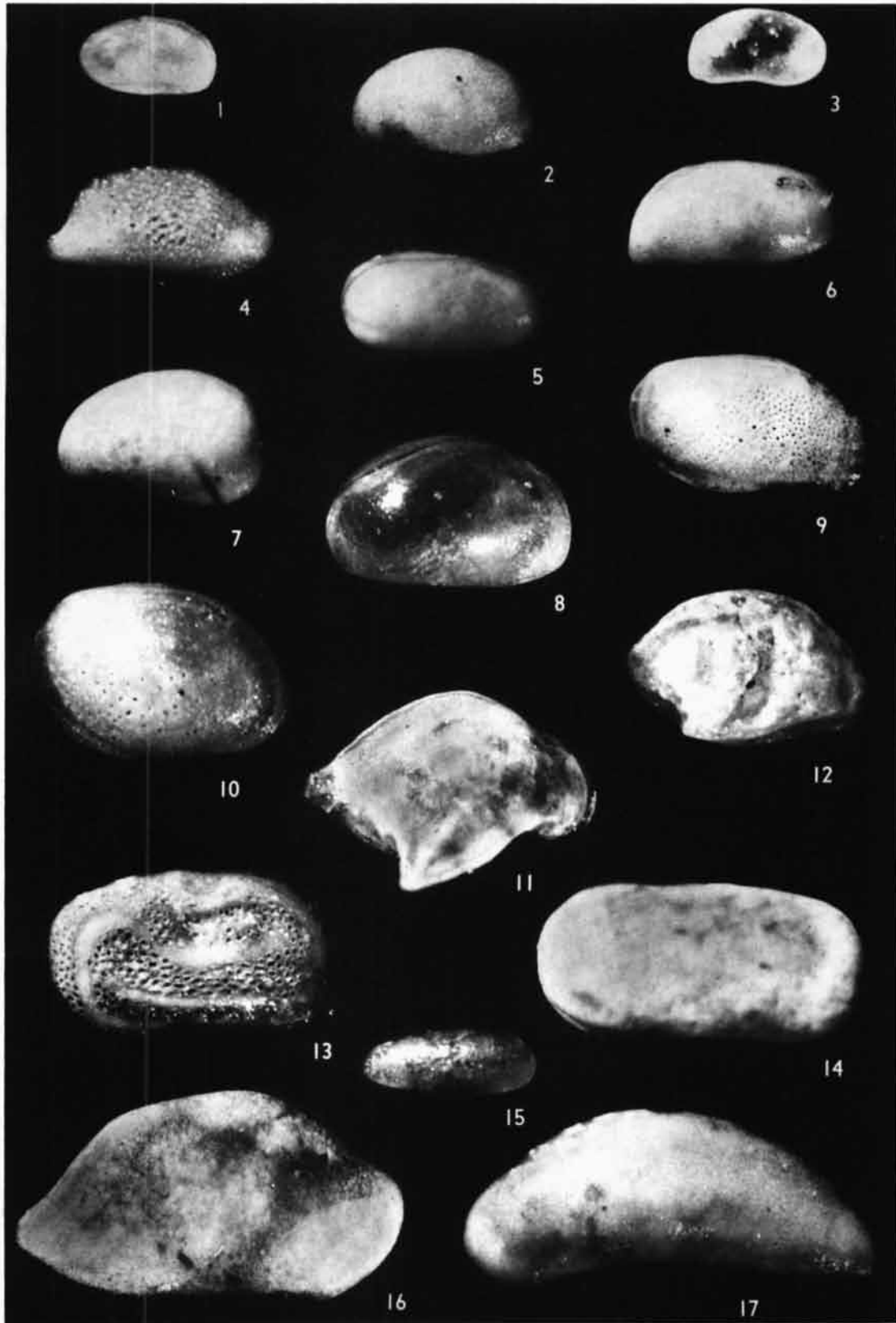
Occurrence. Found widely distributed over the northwestern half of Todos Santos Bay in the tidal pools near El Sauzal and shallow waters near Ensenada across the bay to the islands (Fig. 11). Lives on bottom types of very fine to medium-sized sand; mean annual temperature 52° to 55°F.; depths generally not in excess of 30 fathoms. Associated with the ostracodes *Bairdia* aff. *B. verdesensis*, *Bradleya aurita*, and occasionally with *Bradleya diegoensis*, *Cythereis glauca*, *Brachycythere lincolnensis*, and others of Biofacies I.

EXPLANATION OF PLATE 8

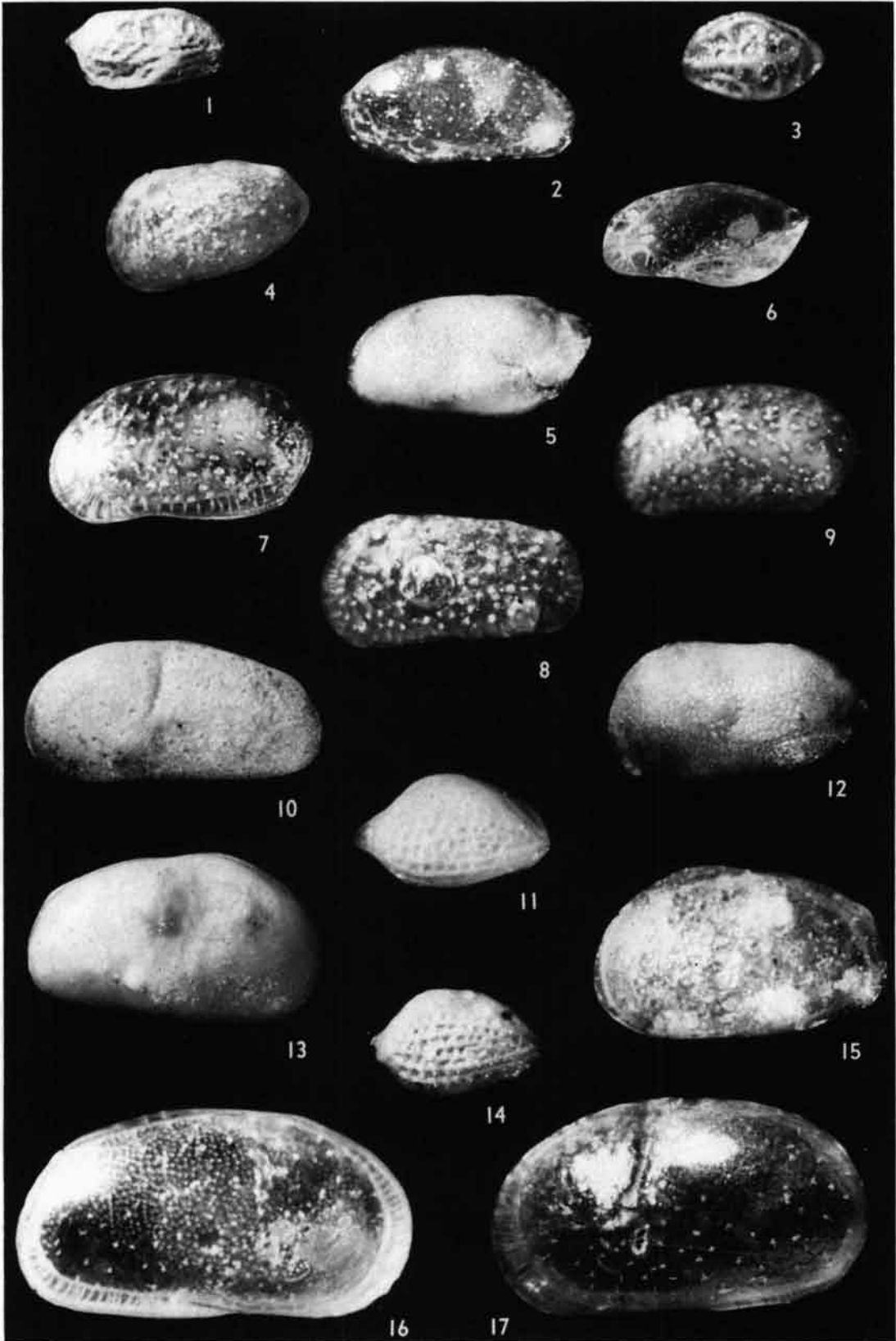
XESTOLEBERIS, TRIEBELINA, BASSLERITES, BYTHOCYPRIS, CYPRIDOPSIS, LOXOCONCHA, CYTHEROPTERON, CYTHERELLOIDEA, CYTHERELLA, BAIRDIA, PARACYPRIS

(All illustrated forms are from the Todos Santos Bay region, ×60)

FIGURE	PAGE	FIGURE	PAGE
1,3.— <i>Xestoleberis banda</i> BENSON, n. sp.; 1, external lateral view of right valve; 3, internal lateral view of left valve	55	exterior lateral view of the right valve of another valve of another variation	51
2,7.— <i>Xestoleberis aurantia</i> (BAIRD); 2, external lateral view of left valve; 7, external lateral view of left valve	55	11.— <i>Cytheropteron pacificum</i> LEROY; exterior lateral view of the right valve	54
4.— <i>Triebelina reticulopunctata</i> BENSON, n. sp.; exterior lateral view of right valve	44	12.— <i>Cytheropteron newportense</i> CROUCH; exterior lateral view of the right valve	54
5.— <i>Basslerites delreyensis</i> LEROY; exterior lateral view of right valve	69	13.— <i>Cytherelloidea californica</i> LEROY; exterior lateral view of the right valve	39
6.— <i>Bythocypris actites</i> BENSON, n. sp.; exterior lateral view of right valve	40	14.— <i>Cytherella banda</i> , BENSON, n. sp.; exterior lateral view of the left valve	39
8.— <i>Cypridopsis vidua</i> (O. F. MÜLLER); exterior lateral view of the right valve	39	15.— <i>Hemicytherideis</i> sp.; exterior lateral view of left valve	44
9,10.— <i>Loxoconcha lenticulata</i> LEROY; 9, exterior lateral view of one variation of the right valve; 10,		16.— <i>Bairdia</i> aff. <i>B. verdesensis</i> LEROY; exterior lateral view of the right valve	42
		17.— <i>Paracypris pacifica</i> LEROY; exterior lateral view of left valve	40



BENSON — Ecology of Recent Ostracodes, Baja, California



BENSON — Ecology of Recent Ostracodes, Baja, California

Subfamily HEMICYTHERINAE Puri, 1953

Genus HEMICYTHERE Sars, 1925

Hemicythere Sars, 1925, p. 182; Klie, 1929, p. 282; Tressler, 1941, p. 100; Edwards, 1944, p. 517; Van Den Bold, 1946, p. 28; Puri, 1953, p. 172.

Type species. *Cythere villosa* Sars, 1866, p. 42.

Diagnosis. Recognized by its sometimes large, almond-shaped, almost smooth to pitted or reticulate carapace with a slight caudal extension. The hinge is holamphidont except for a lobed posterior tooth; the duplicature broad and welded to the outer lamella, radial pore canals numerous; the adductor muscle scar pattern consists of at least five vertical scars with three anterior (*H. californiensis* has more in addition to these, see below). *Eocene to Recent.*

Species of this genus have been described from marine and brackish-water habitats. Remane (1940, p. 61) describes some species as burrowers and others as living on the surface of the bottom. Elofson (1941) has observed the former habit but not the latter. Tressler & Smith (1948, p. 47) describe *H. truitti* from the brackish waters of Chesapeake Bay, but Malkin (1953, p. 772) considers this genus indicative of a deeper marine environment.

HEMICYTHERE JOLLAENSIS LeRoy, 1943

Pl. 11, Figs. 7, 8

Hemicythere jollaensis LeRoy, p. 365, pl. 59, figs. 28-33; pl. 62, figs. 15, 16; fig. 2q.

Dimensions. Length of adult specimen 0.77 mm.; height 0.47 mm.; thickness 0.43 mm.

Material. Specimens examined 46; of these 16 had both valves intact.

Occurrence. Previously identified by Rothwell (1944) from the San Pedro Channel near Long Beach, California, at a depth of about 25 fathoms, from the San Diego harbor

entrance at 16 fathoms, and in tidal pools and offshore at 33 fathoms near La Jolla, California. Found in Todos Santos Bay on the open western side around toward the north shore. Depth range between 3 and 25 fathoms; mean annual bottom temperature 52° to 55°F., variation from 4 to about 10 degrees; found only on fine to very fine sandy bottoms; distribution exceeds known phytal distribution. Commonly associated with *Bairdia* aff. *B. verdesensis*, *Hemicythere californiensis*, and others of Biofacies I.

HEMICYTHERE CALIFORNIENSIS LeRoy, 1943

Pl. 7, Fig. 4; Pl. 11, Fig. 13

Hemicythere ? californiensis LeRoy, 1943a, p. 366, pl. 61, figs. 29-33; pl. 62, figs. 5, 6; fig. 2o,p.

Hemicythere californiensis LeRoy, Puri, 1953b, p. 174.

Dimensions. Length of adult specimen 1.00 mm.; height 0.57 mm.; thickness 0.53 mm.

Material. Specimens examined 470; of these 96 had both valves intact.

Occurrence. Previously reported by LeRoy (1943, p. 367) in considerable numbers from Avalon Bay, Santa Catalina Island, and identified by Rothwell (1944) in great numbers from 10 to 30 fathoms depth in the San Pedro Channel off Long Beach, California, and from 16 fathoms depth at the harbor entrance at San Diego, California. Found widely distributed and in great numbers in Todos Santos Bay. Depth range generally 6 to 30 fathoms, most abundant between 20 and 25 fathoms; mean annual bottom temperature 52° to 55°F., variation from 4 to 10 degrees; bottom types range from very coarse to very fine sand. Commonly associated with *Brachycythere lincolniensis*, *Hemicythere jollaensis*, *Cythereis glauca*, *Bradleya diegoensis*, *Paracypris pacifica*, and less frequently with other species of Biofacies I.

EXPLANATION OF PLATE 9

CYTHERURA, SCLEROCILUS, HEMICYTHERURA, HAPLOCYTHERIDEA, PELLUCISTOMA, BRADLEYA, CYPRIDEIS (GOERLICHIA), CYTHERURA

(All illustrated forms are from the Todos Santos Bay region, X60)

FIGURE	PAGE	FIGURE	PAGE
1,11,14.— <i>Cytherura bajacala</i> Benson, n. sp.; 1, exterior lateral view of right valve of a rare, possibly dimorphic variation in surface sculpture; 11, exterior lateral view of right valve; 14, exterior lateral view of right valve	52	9, exterior lateral view of left valve showing normal pore canals	48
2.— <i>Sclerocilus nasus</i> Benson, n. sp.; exterior lateral view of right valve	56	8.— <i>Bradleya</i> cf. <i>B. schencki</i> (LeRoy); exterior lateral view of left valve	63
3.— <i>Hemicytherura</i> cf. <i>H. clathrata</i> (Sars); external lateral view of right valve	54	10.— <i>Cyprideis castus</i> Benson, n. sp.; exterior lateral view of left valve	46
4.— <i>Haplocytheridea palda</i> Benson, n. sp.; exterior lateral view of left valve	48	12.— <i>Cytherura</i> cf. <i>C. gibba</i> (O. F. Müller); exterior lateral view of left valve	52
5,6.— <i>Pellucistoma scrippsi</i> Benson, n. sp.; 5, exterior lateral view of left valve, slightly cracked; 6, exterior lateral view of left valve	58	13,15.— <i>Cyprideis</i> (<i>Goerlichia</i>) sp.; 13, exterior lateral view of right valve; 15, exterior lateral view of left valve	46
7,9.— <i>Haplocytheridea maia</i> Benson, n. sp.; 7, exterior lateral view of right valve; 9, exterior lateral view of left valve	48	16.— <i>Cyprideis</i> (<i>Goerlichia</i>) <i>miguelensis</i> Benson, n. sp.; exterior lateral view of right valve	45
		17.— <i>Cyprideis</i> (<i>Goerlichia</i>) <i>stewarti</i> Benson, n. sp.; exterior lateral view of left valve	45

HEMICYTHERE PALOSENSIS LeRoy, 1943

Pl. 7, Fig. 3a,b

Hemicythere palosensis LeRoy, 1943a, p. 365, pl. 60, figs. 14-18; fig. 2c.**Dimensions.** Length of adult specimen 0.67 mm.; height 0.40 mm.; thickness (approx.) 0.33 mm.**Material.** Only 4 single valves were found.**Occurrence.** Previously reported as rare by LeRoy (1943a, p. 365) from Avalon Bay, Santa Catalina Island, at a depth of 8.5 meters and bottom temperature of 62°F. It is also rare in Todos Santos Bay where it is found at a depth of from 3 to 20 fathoms and a mean annual bottom temperature of 53° to 55°F., with the substratum varying from coarse to fine sand.**Genus CAUDITES** Coryell and Fields, 1937*Caudites* CORYELL & FIELDS, 1932, pp. 10-11; VAN DEN BOLD, 1946, p. 31; PURI, 1953, p. 176.**Type species.** *Caudites medialis* CORYELL & FIELDS, 1937, p. 11, fig. 12a-d.**Diagnosis.** Recognized by its elongate subtriangular, thick-shelled carapace with a ventral caudal process; holamphidont hinge with ovate posterior tooth; and wide duplicature. *Eocene to Recent.***CAUDITES FRAGILIS** LeRoy, 1943

Pl. 7, Fig. 5a-c; Pl. 10, Fig. 3

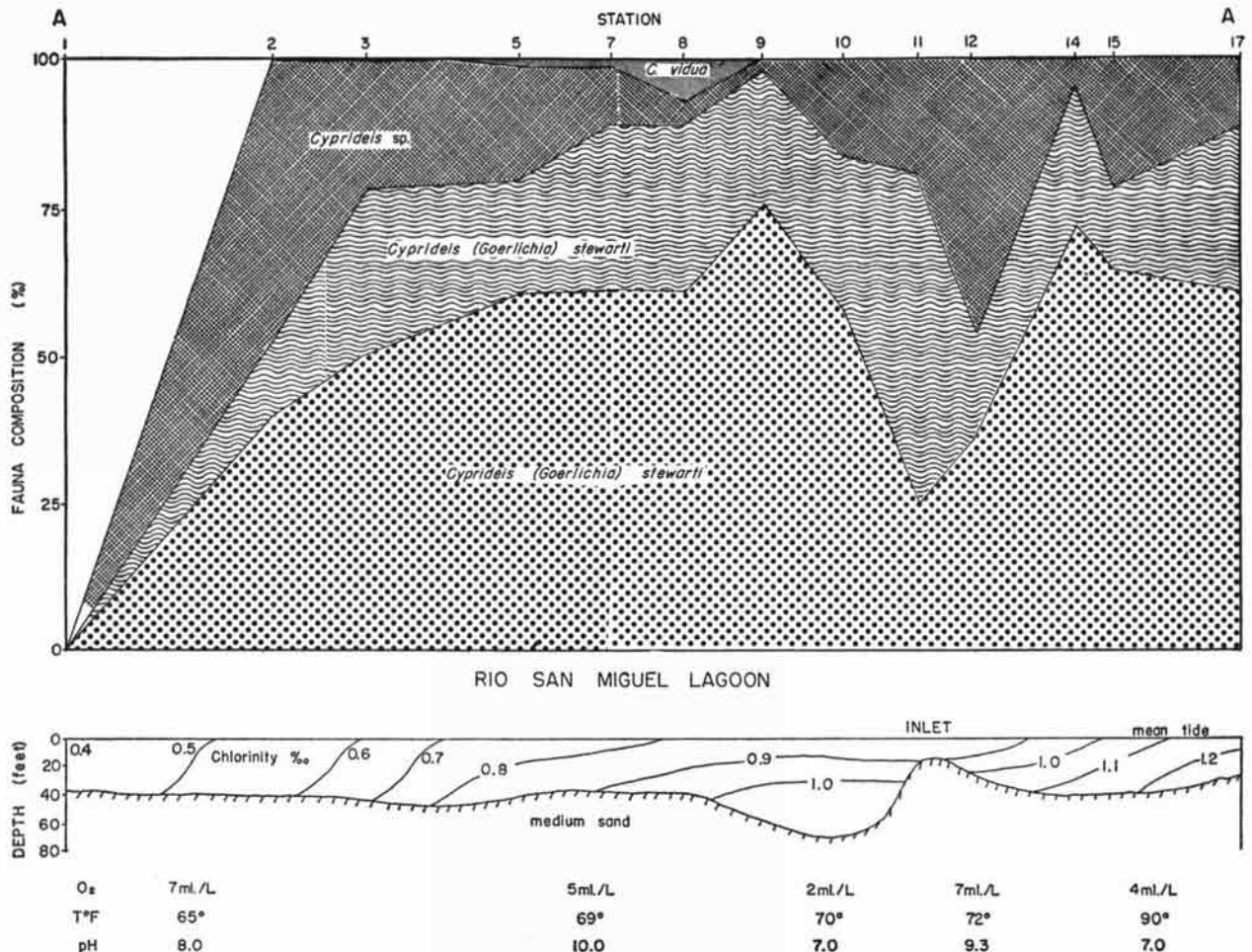
Caudites fragilis LeRoy, 1943a, p. 372, pl. 60, figs. 10-13; fig. 2r,s.**Dimensions.** Length of adult specimen 0.57 mm.; height 0.33 mm.; thickness 0.23 mm.**Material.** Specimens examined 15; of these 6 had both valves intact.**Occurrence.** Reported previously by LeRoy from Monterey Bay. Rare in Todos Santos Bay; a few specimens sparsely scattered in tide pools and in shallow water (less than 20 fathoms); substratum usually fine to very fine sand; mean annual bottom temperature 52° to 55°F.

FIGURE 12. Population profile in Rio San Miguel Lagoon (location indicated in Fig. 4). The graph illustrates the indigenous character of the faunule occupying this restricted environment.

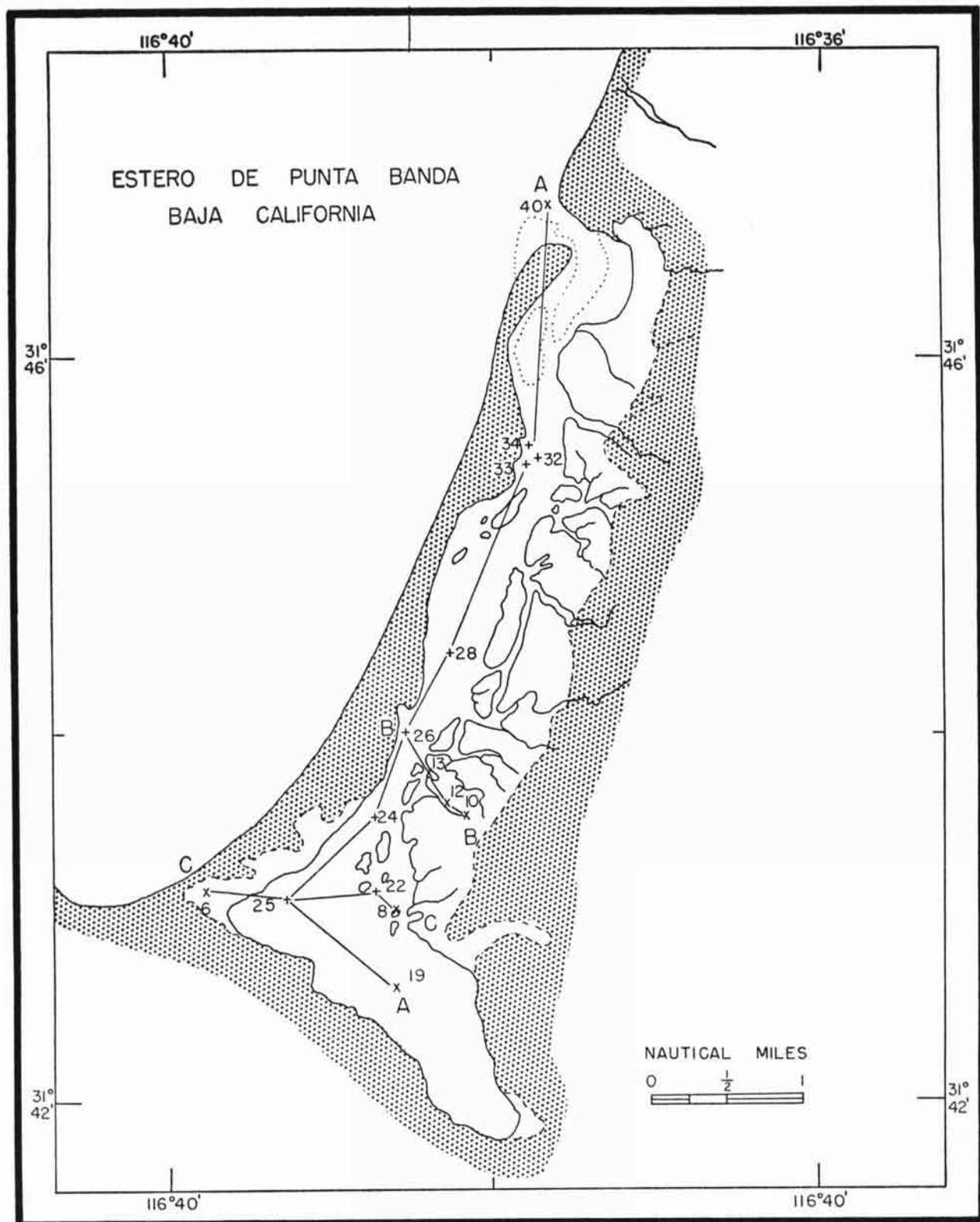


FIGURE 13. Location of population profiles in the Estero de Punta Banda. The profiles (Figs. 14, 15) show the local predominance of certain ostracode species and emphasize a sharp contrast between this general assemblage and those of other biofacies.

INCERTAE SEDIS

Genus LEGUMINOCYHEREIS Howe, 1936

Leguminocythereis HOWE, 1936, HOWE & LAW, 1936, p. 61.
 Type species. *Leguminocythereis scarabaeus* HOWE & LAW, 1936, p. 61.

Diagnosis. Recognized by its ovate to elongate carapace with characteristic reticulation or ridges. The hinge resembles that of *Trachyleberis* (holamphidont). Duplication broad and welded to outer lamella, radial pore canals few. *Upper Eocene to Recent.*

LEGUMINOCYHEREIS CORRUGATA LeRoy, 1943
Pl. 4, Fig. 1, Pl. 10, Fig. 5

Leguminocythereis corrugata LEROY, 1943a, p. 372, pl. 59, figs. 7-12; pl. 62, figs. 7, 8; fig. 2x.
 non *Leguminocythereis* ? *corrugata* SWAIN, 1946, p. 379, pl. 54, fig. 14a-c; pl. 55, fig. 5a-b.

Dimensions. Length of adult specimen 0.80 mm.; height 0.43 mm.; length 0.33 mm.

Material. Specimens examined 111; about 50 were stained; 24 had both valves intact.

Occurrence. Identified by ROTHWELL (1944) from San Pedro channel offshore from Long Beach, California. Found in the central portion of Todos Santos Bay with *Palmenella* sp. A, restricted to the distribution of very fine sand. Depth range from 10 to 30 fathoms; mean annual bottom temperature ranges from 52° to 55°F., annual variation from 4 to 8 degrees. Very abundant and widely distributed off the inner area of the bay. Commonly associated with *Palmenella carida* and *Cytherura* cf. *C. gibba*.

Genus BASSLERITES Howe in Coryell and Fields, 1937

Basslerites HOWE in CORYELL & FIELDS, 1937, p. 11.
Basslerella HOWE, 1935, p. 30; (non) *Basslerella* KELLETT, 1935.
 Type species. *Basslerella miocenica* HOWE, 1935, pp. 30-31, pl. 1, figs. 19, 24-26.

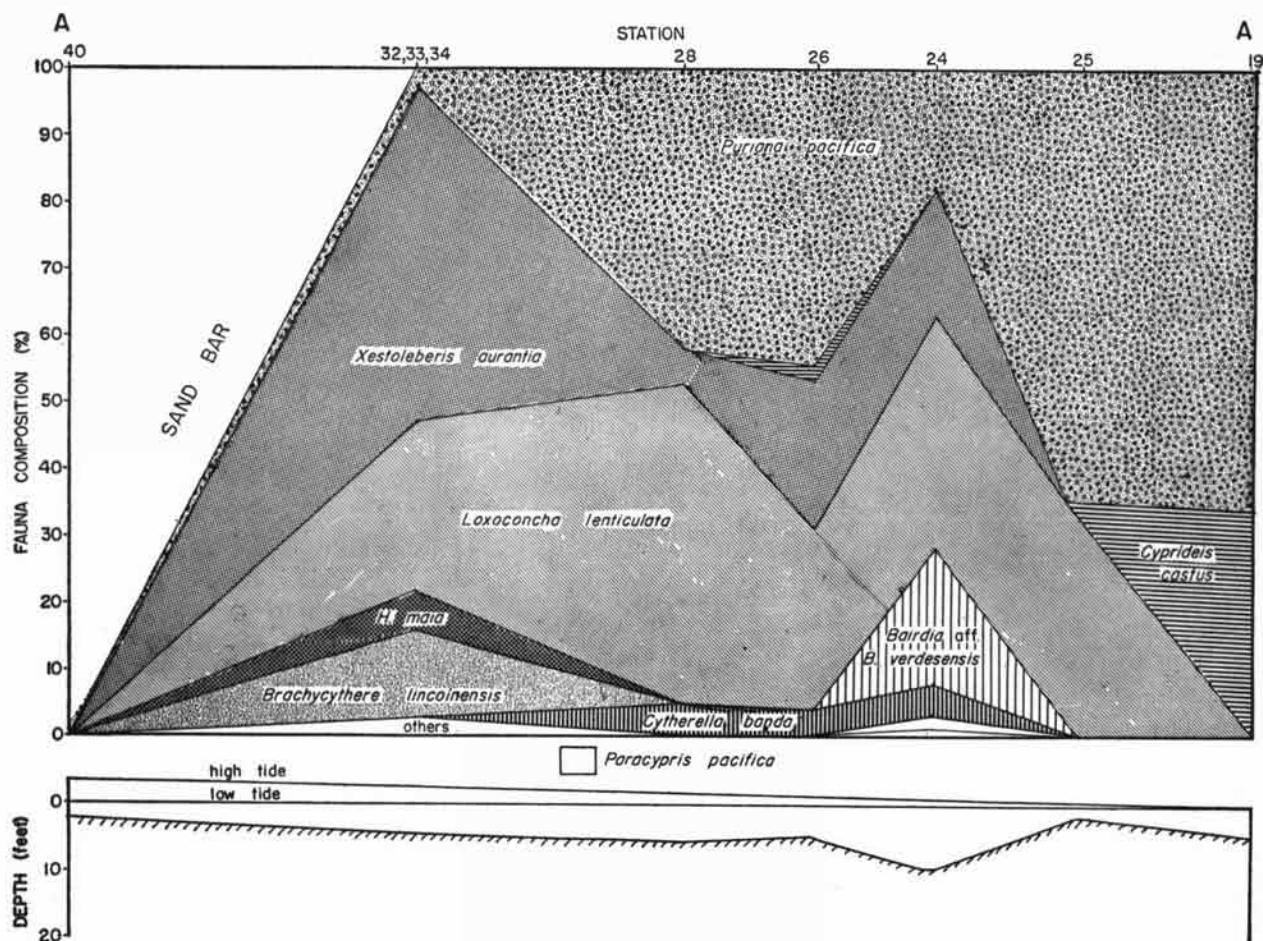


FIGURE 14. Population profile in the Estero de Punta Banda. The graph shows the relative increase of endemic species away from the connection of the lagoon with Todos Santos Bay (Fig. 13).

Diagnosis. Recognized by its elongate, ovate, usually smooth carapace with a hemiamphidont hinge; moderate duplicatures and shallow vestibules joining free margin by a few straight, simple radial pore canals; adductor muscle scar pattern, four vertical scars with a heart-shaped scar anterior. *Miocene to Recent.*

BASSLERITES DELREYENSIS LeRoy, 1943

Pl. 4, Fig. 2a,b; Pl. 8, Fig. 5

Basslerites delreyensis LeRoy, 1943, p. 368, pl. 59, figs. 23-27; pl. 62, figs. 21, 22; fig. 2k.

Dimensions. Length of adult specimen 0.57 mm.; height 0.30 mm.; thickness 0.27 mm.

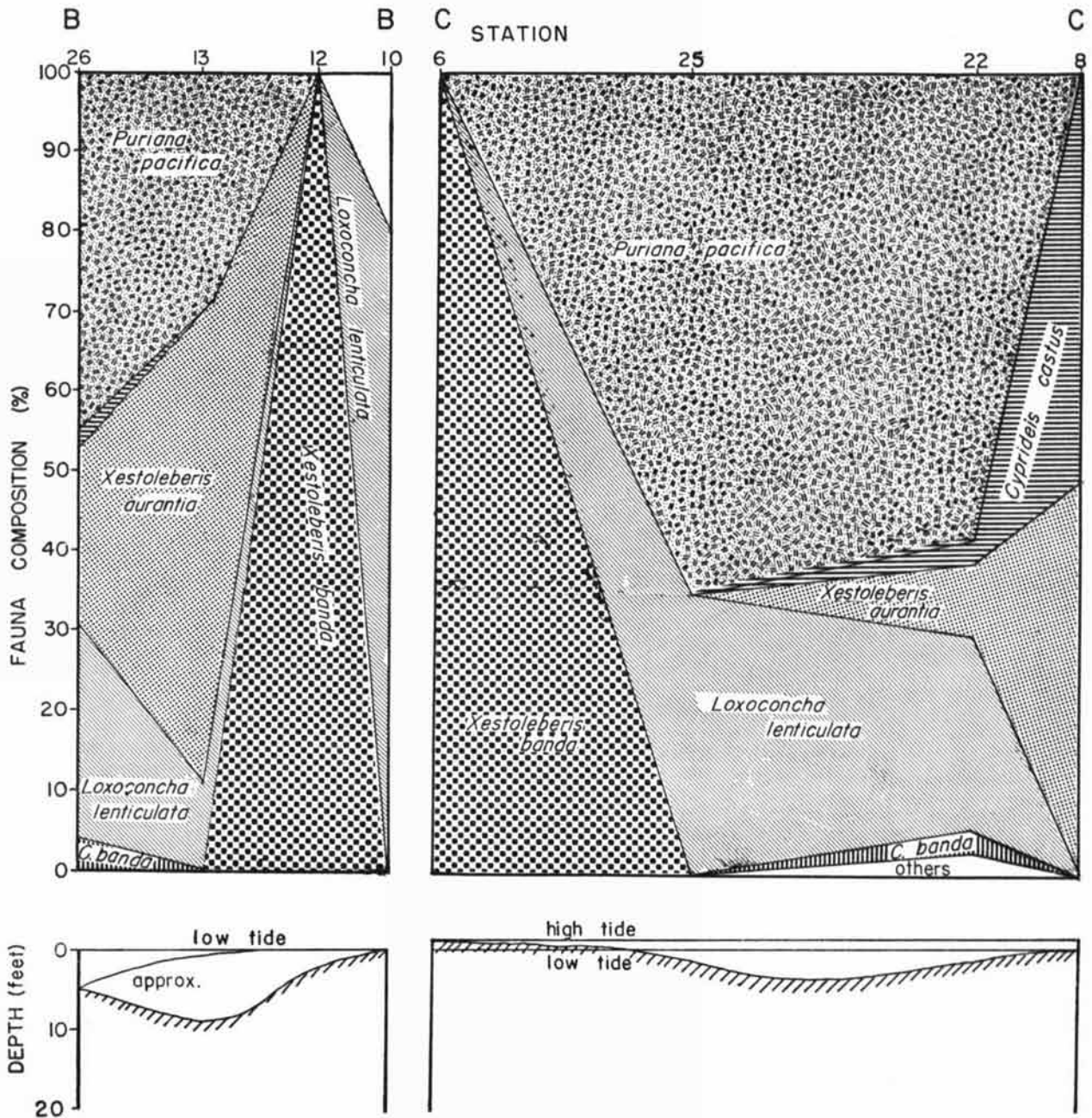


FIGURE 15. Population profiles in the upper end of the Estero de Punta Banda (Fig. 13).

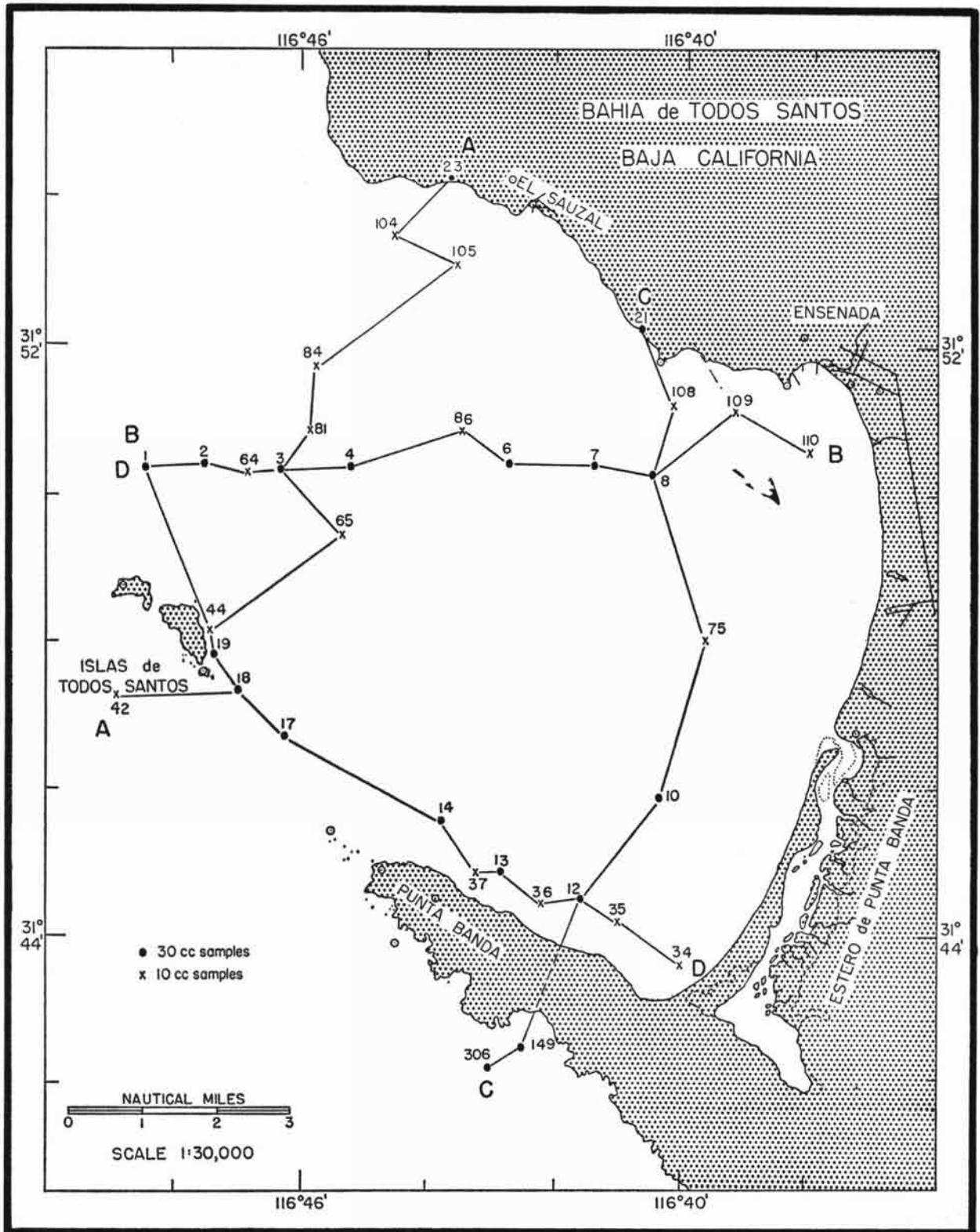


FIGURE 16. Location of population profiles representative of Todos Santos Bay.

Material. Specimens examined 88; of these 80 had both valves intact.

Occurrence. Not previously reported from Recent sediments. Found in great abundance in the sublittoral environment (depth generally less than 10 fathoms) in the extreme northeastern part of Todos Santos Bay just south of Ensenada near the mouth of the Ensenada River. Found occasionally more to the center of the bay, mean temperature 55°F.; temperature variation about 10 degrees; very fine sand bottom. Found occasionally with *Quadracythere regalia*, *Haplocytheridea maia*, and *Schlerochilus nasus*.

GENUS A, SP. A

Pl. 7, Fig. 7; Pl. 10, Fig. 2

Diagnosis. Recognized by its delicate transparent carapace with very fine plications, subcentral protuberance, and posterodorsal and ventral ridges, which may terminate in a small spine.

Description. Carapace medium-sized, usually transparent, very thin, subrectangular in lateral view; subcuneiform in dorsal view, subtriangular in end view. Greatest height at anterior cardinal angle; greatest thickness in posterior end; valves subequal. Dorsal and ventral margins straight; anterior margin well rounded; posterior end with short caudal extension, finely denticulate. Surface very finely and randomly plicate with prominent subcentral protuberance and posterodorsal and -ventral ridges which may terminate in small spine. Hinge immature, taxodont, "archocytheroid"; marginal area very narrow; line of concrescence coincides with inner margin; short straight radial pore canals in anterior and posterior margins; muscle scar pattern obscure; interior with subcentral pit coinciding with exterior subcentral protuberance.

Dimensions. Length of largest immature instar 0.57 mm.; height 0.30 mm.; thickness 0.23 mm.

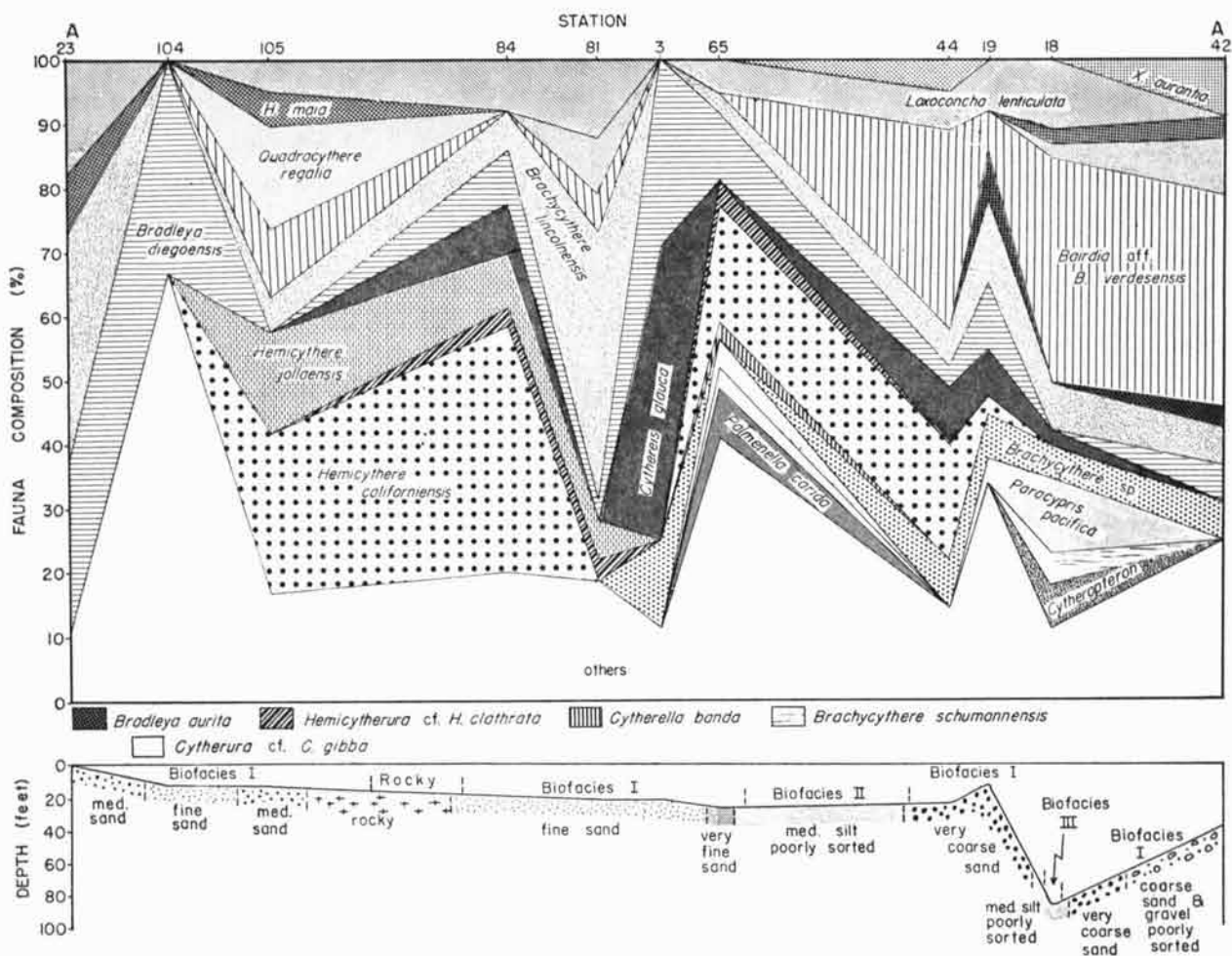


FIGURE 17. Population profile A-A showing percentages of species found in samples along a traverse from the north shore of Todos Santos Bay south of Todos Santos Islands and the distribution of the biofacies and the bottom sediments (Fig. 16).

Material. Specimens examined 17; of these 5 had both valves intact.

Remarks. This species has an archcytheroid hinge and therefore is probably an immature form of one of the genera *Trachyleberis*, *Cythereis*, *Quadracythere*, or *Bradleya*. This form is noted because of its presence. Only a few specimens were found and could not be identified. No attempt was made to classify them.

Occurrence. This rather uncommon species was found in Todos Santos Bay from offshore on the southwestern side of the islands northeast to near Ensenada with a few specimens on the south side of Punta Banda (Fig. 11). Two dead valves were found at 200 fathoms. Depth range 5 to 25 fathoms; mean annual temperature generally 54° to 55°F., annual variation about 10 degrees; substratum ranges from coarse sand and gravel near the islands to very fine sand near the anchorage at Ensenada. Commonly associated with species of Biofacies I.

GENUS B, SP. A
Pl. 1, Fig. 5a,b

Diagnosis. Recognized by its very elongate, oblong, lateral outline with narrow shortly rounded anterior and posterior ends.

Description. Carapace small, translucent, oblong in lateral outline; elliptical in dorsal and end view. Dorsal and ventral margins straight and parallel, ends slightly tapered

and rounded; greatest thickness in middle; left valve overlaps right. Surface smooth. Hinge desmodont; muscle scar pattern includes four elongate scars arranged in a vertical row near middle; marginal area narrow, widens at anterior and posterior ends to form narrow vestibule; inner margin coincides with line of concrescence; radial pore canals obscure.

Dimensions. Length of largest specimen 0.60 mm.; height 0.23 mm.; thickness 0.20 mm.

Material. Specimens examined 28; of these 5 had both valves intact.

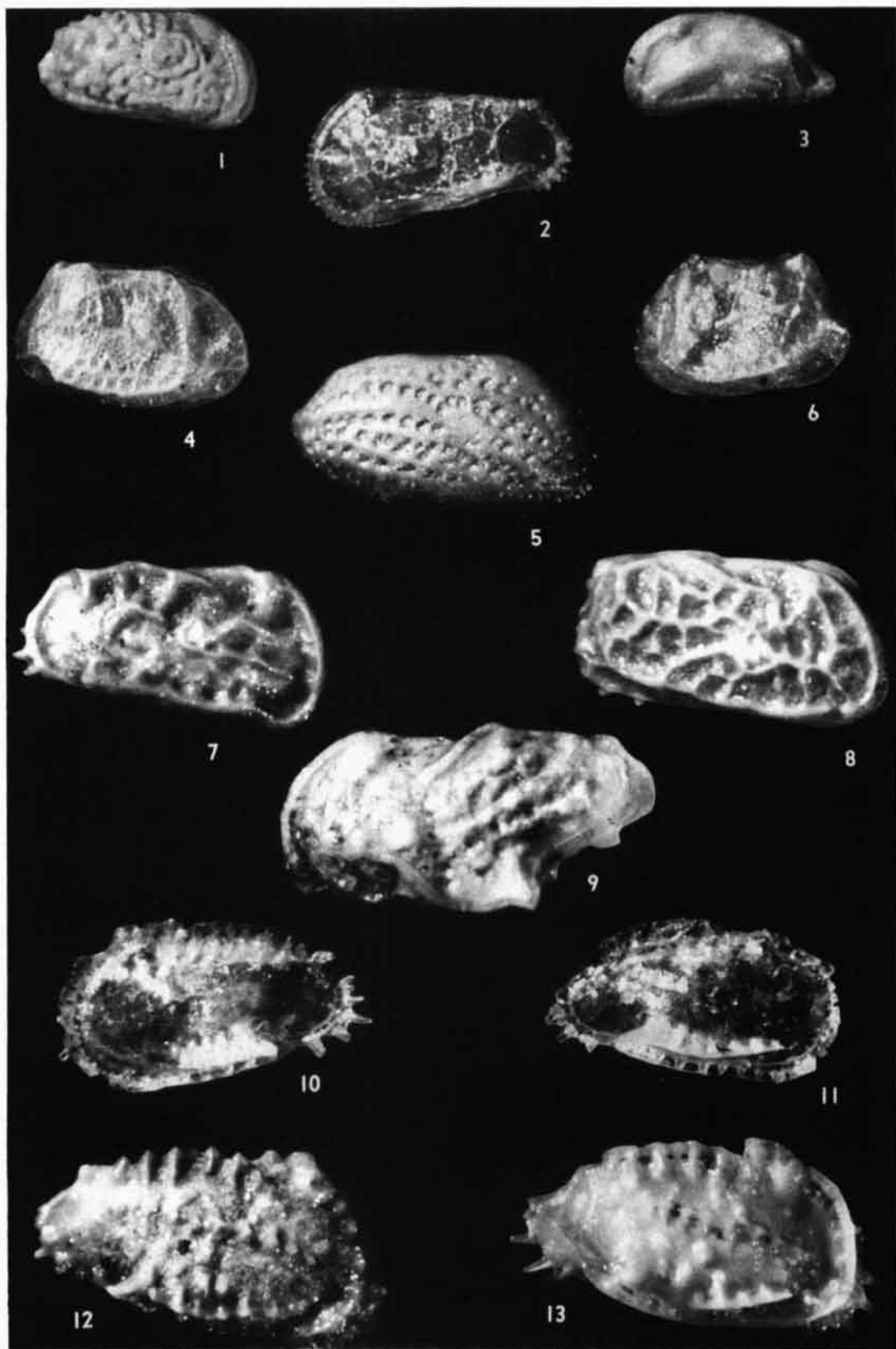
Remarks. The classification of this species is in doubt since its general shape, outline, and muscle scar do not correspond to known genera, and not enough evidence is present to justify the erection of a new one. Very similar to the genus *Campylocythere* in outline and muscle scar but the hinge is desmodont rather than heterodont. Perhaps no adult instars were found or this form may precede *Campylocythere* in hinge development.

Occurrence. This species was found in Todos Santos Bay in a very small area in the center and on the south side of Punta Banda (Fig. 11). Depth range 20 to 30 fathoms; mean annual bottom temperature 52° to 53°F., annual variation about 4 degrees in the bay and about 10 degrees on the south side of Punta Banda; substratum ranges from fine to very fine sand. Faunule association very sparse.

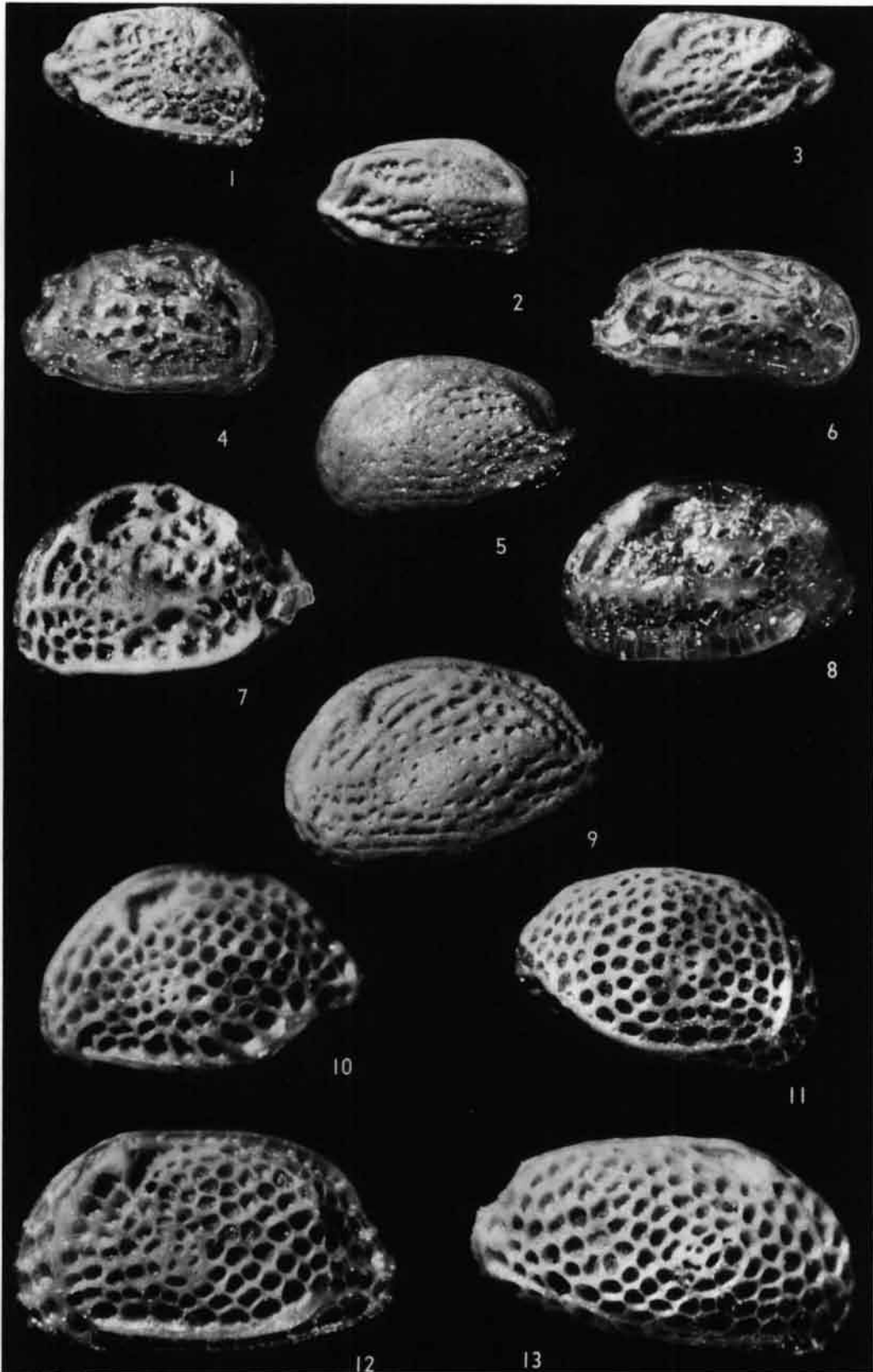
EXPLANATION OF PLATE 10

PURIANA, CAUDITES, PALMENELLA, LEGUMINOCYHEREIS, BRADLEYA, CYHEREIS, PARACYTHERIDEA, PTERYGOCYHEREIS
(All illustrated forms are from the Todos Santos Bay region, $\times 60$)

FIGURE	PAGE	FIGURE	PAGE
1.— <i>Puriana pacifica</i> BENSON, n. sp.; exterior lateral view of right valve	60	8.— <i>Cythereis glauca</i> SKOGSBERG; exterior lateral view of right valve	62
2.—Genus A sp. A; exterior lateral view of left valve	71	9.— <i>Paracytheridea granti</i> LEROY; exterior lateral view of left valve	49
3.— <i>Caudites fragilis</i> LEROY; exterior lateral view of left valve	66	10-13.— <i>Pterygocythereis semitranslucens</i> (CROUCH); 10, exterior lateral view of left valve of early instar; 11, exterior lateral view of right valve of early instar; 12, exterior lateral view of right valve of an older adult specimen with a worn carapace; 13, exterior lateral view of right valve showing spines and frills	58
4,6.— <i>Palmenella carida</i> BENSON, n. sp.; 4, exterior lateral view of right valve; 6, exterior lateral view of left valve	50		
5.— <i>Leguminocythereis corrugata</i> LEROY; exterior lateral view of right valve	68		
7.— <i>Bradleya pennata</i> (LEROY); exterior lateral view of right valve	63		



BENSON — Ecology of Recent Ostracodes, Baja, California



BENSON — Ecology of Recent Ostracodes, Baja, California

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EXPLANATION OF PLATE II

QUADRACYTHERE, BRACHYCYTHERE, BRADLEYA, HEMICYTHERE

(All illustrated forms are from the Todos Santos Bay region, X60)

FIGURE	PAGE	FIGURE	PAGE
1,3,12.— <i>Quadracythere regalia</i> BENSON, n. sp.; 1, exterior lateral view of right valve of early instar; 3, exterior lateral view of left valve of early instar; 12, exterior lateral view of left valve of adult	64	6.— <i>Bradleya diegoensis</i> (LEROY); exterior lateral view of right valve	63
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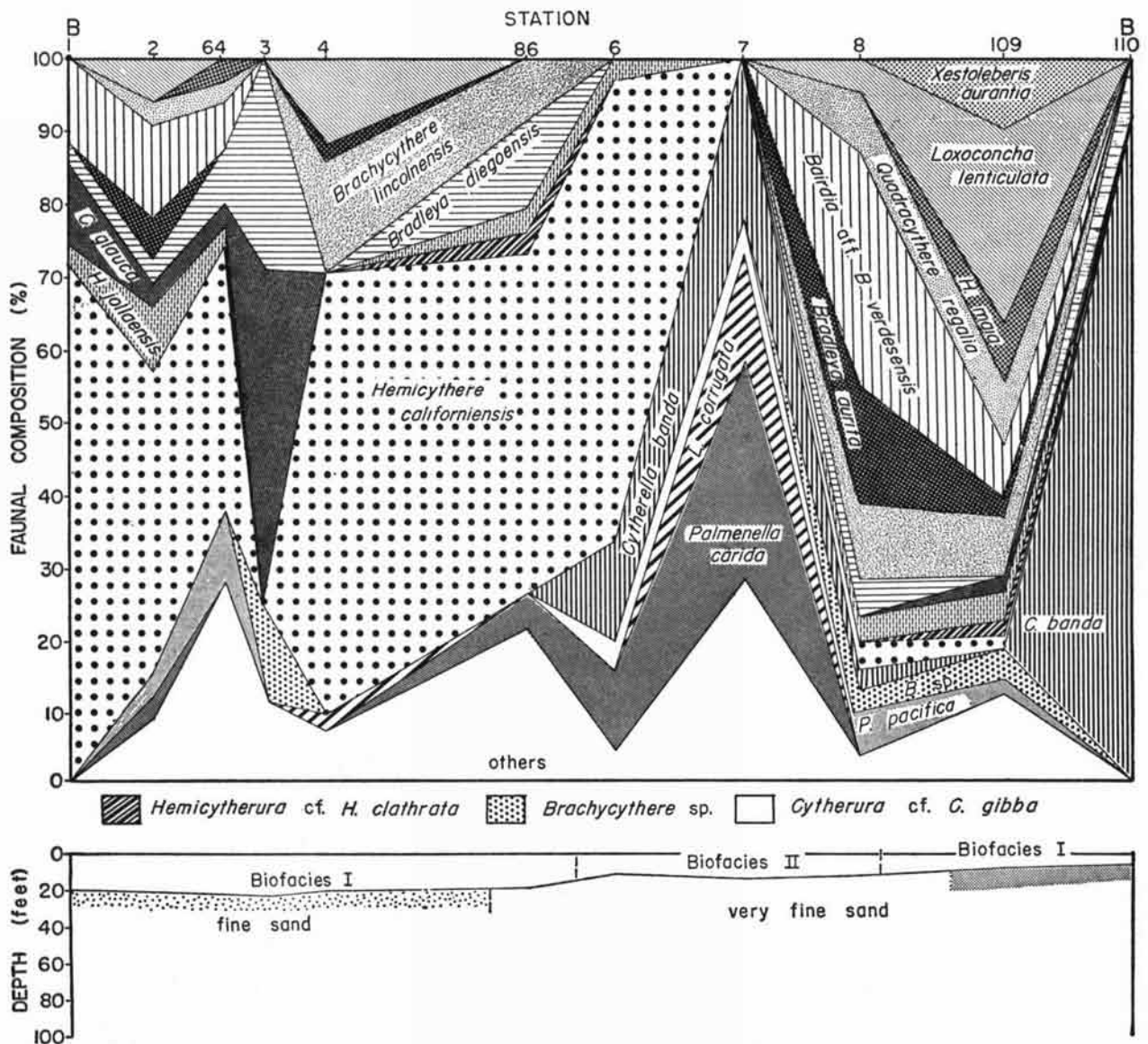


FIGURE 18. Population profile B-B showing percentages of species found in samples along a traverse from the west open side of Todos Santos Bay east almost to the beach at Ensenada (Fig. 16). The lower profile shows the distribution of included biofacies and bottom sediments.

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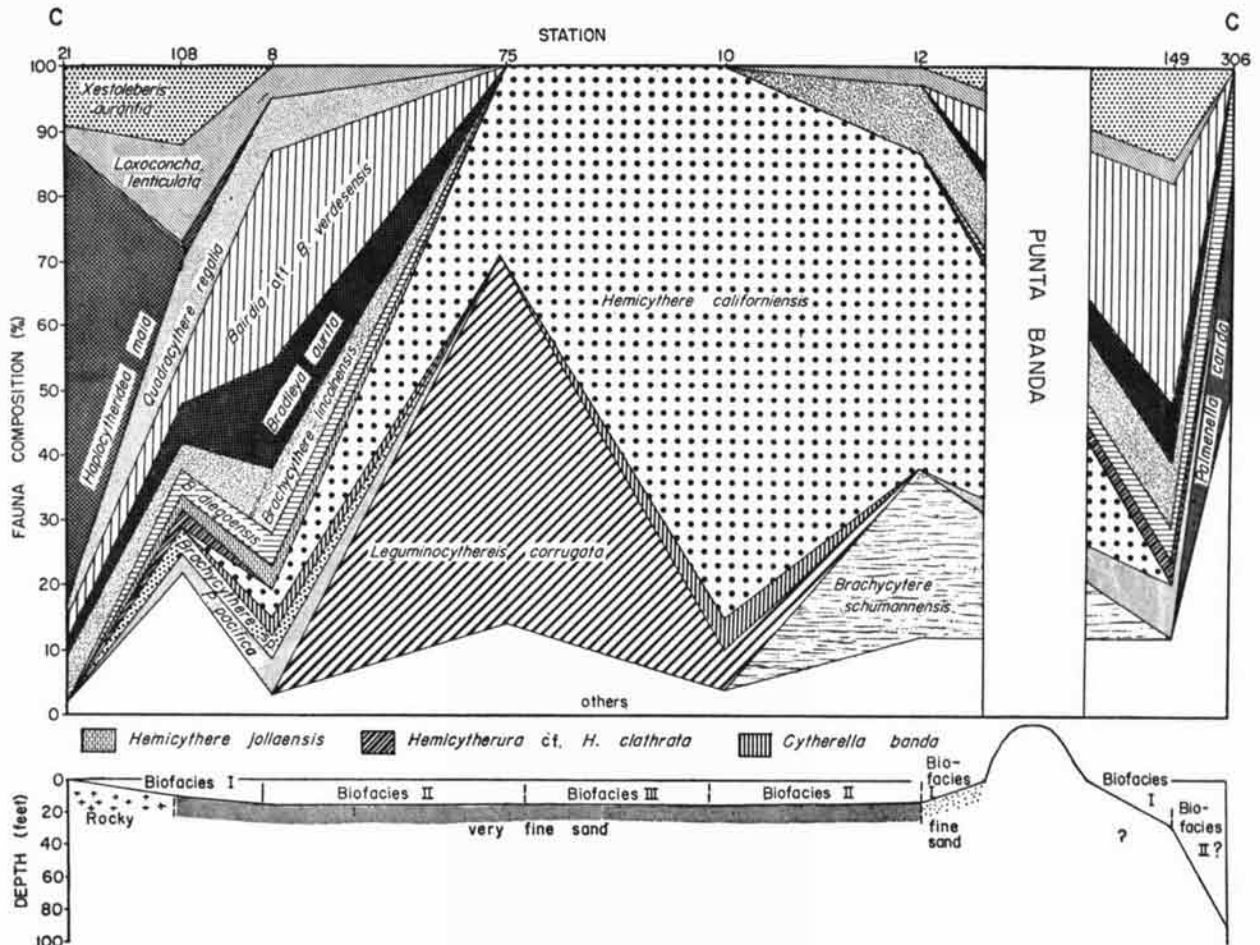


FIGURE 19. Population profile C-C showing percentages of species found in samples along a traverse from the northeast corner of Todos Santos Bay south across Punta Banda out into the Pacific (Fig. 16). The lower profile shows the distribution of included biofacies and bottom sediments.

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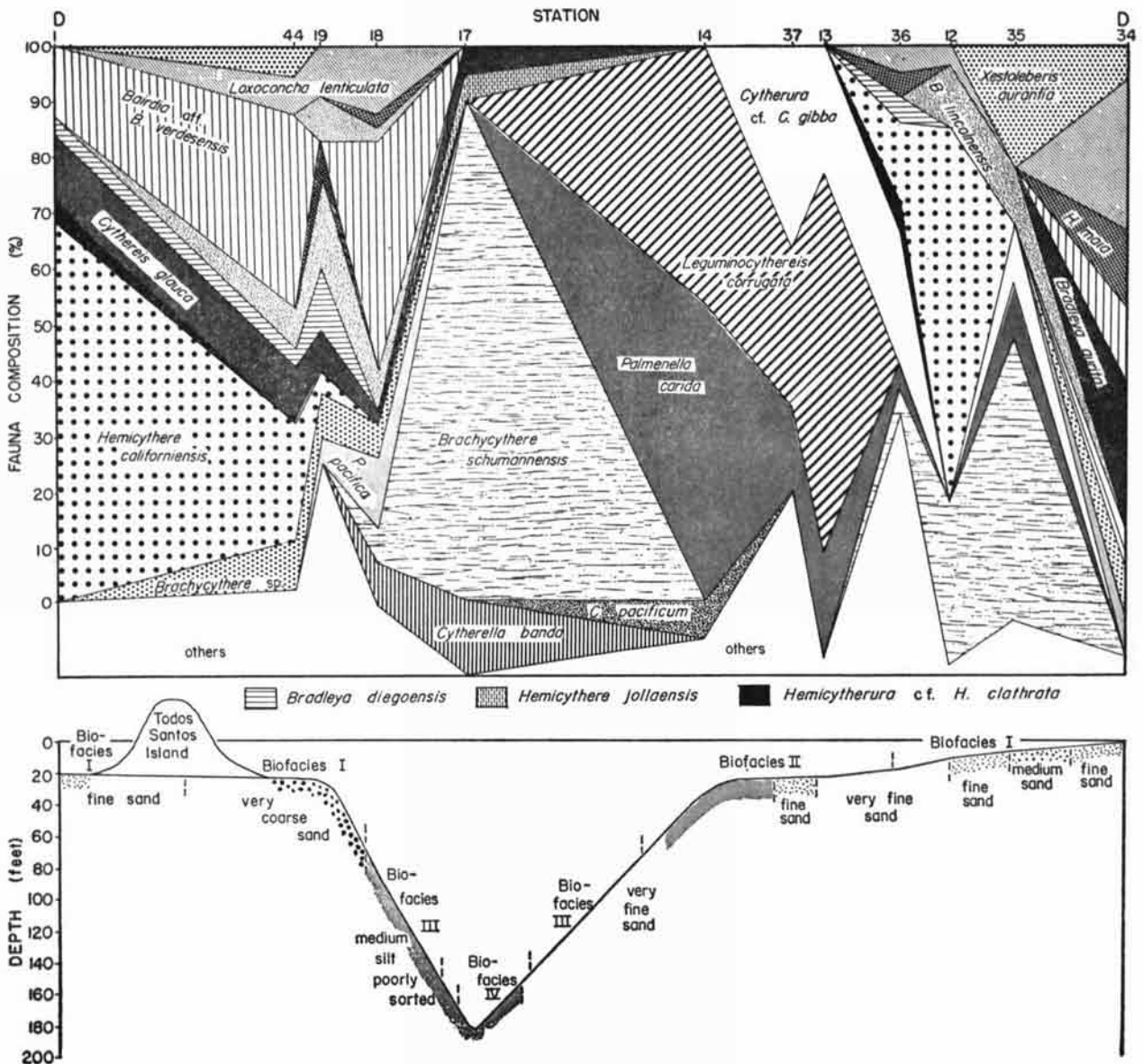


FIGURE 20. Population profile D-D showing percentages of species found in samples along a traverse from the west open side of Todos Santos Bay southeast along side of Todos Santos Islands crossing the submarine canyon to run parallel to Punta Banda and ending in the southeast corner of the bay (Fig. 16). The lower profile shows the distribution of included biofacies and bottom sediments.

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