A STUDY OF INVERTEBRATES AS INDICES OF INTERTIDAL
ZONATION OF BAHIA LA CHOLLA, SONORA, MEXICO

by

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STATEMENT BY AUTHOR

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APPROVAL BY THESIS DIRECTOR

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Professor of Zoology

Date: 22 May 1957
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Introduction

The phenomenon of intertidal zonation has long been recognized by zoologists and has been a topic of research since 1832, when J. V. Audouin and Henri Milne-Edwards described five zones in the intertidal belt. The five zones they recognized were:
1) Balanus, 2) seaweed, 3) coralline, 4) Laminaria, and 5) oyster zone. An excellent historical summary of intertidal zonation is given in *Between Pacific Tides* by Ricketts and Calvin (1952). To some the problem of intertidal zonation has been thought to have been exhausted. After reading the literature I have come to the conclusion that there is yet much to be done with the problem of intertidal zonation, not only in the description of new areas, but in the interpretation of the observed and collected data.

Recently the problem of intertidal zonation has been extensively studied by T. A. and Anne Stephenson. Over ten thousand miles of rocky coasts have been described in their works and more is yet to be done. While their work has been primarily descriptive, the reasons for zonation still remain elusive to the workers.
After having postulated a universal classification for naming the intertidal zones on rocky coasts (Fig. 1), T. A. and Anne Stephenson (1949) have undertaken the tremendous task of describing the rocky coast lines of the world. Possibly a change will be made in their original classification when their work is completed, however, their findings correlate well with their original hypothesis.

**Fig. 1**

**Supralittoral Zone**
Upper limit of Littorina, etc.

**Supralittoral Fringe**
Upper limit of barnacles

**Midlittoral Zone**
Upper limit of laminarians

**Infrafittoral Fringe**

**Infrafittoral Zone**

Extreme high water of spring tides.

Littoral Zone

Extreme low water of spring tides.

Stephensons' universal classification for intertidal zonation on rocky coasts.
Papers by Maxwell Doty (1946) and John Colman (1933) offer the most accepted explanation for intertidal zonation that has yet been offered. According to Doty and Colman the discontinuities in zonation are a result of critical tide levels. Louis Hutchins (1947) suggests that zonation is due to temperature differences. Other possible factors suggested are exposure to sunlight, salinity, currents, substratum, and biocompetition. More than likely it is not due to any one factor, but a complex of many factors.

This study is concerned with the description of a rocky intertidal area along the northeastern shores of the Gulf of California. This paper has two primary objectives: 1) to describe a new area and to contribute information which will aid in further research by later workers in the field of marine zoology, and 2) to try to discover discontinuities in populations which might indicate vertical zonation of marine invertebrates. Along the California coast it is well known that these discontinuities of populations take levels at which the duration of the longest single continuous exposure to air makes a sharp increase.

In this study I am concerned with only the most common intertidal forms, using them as indices to identify the zones. Because of the short time involved in collecting, I am not able to give an extensive faunal list. A list is included, however, that is as complete as time would permit.
When working in a little known area such as the Gulf of California, one encounters many obstacles in the taxonomy of the animal groups. At this time I would like to express my sincere appreciation to Dr. S. Stillman Barry of Redlands, California, for his invaluable aid in identifying the mollusks discussed in this paper. I would also like to thank Dr. John F. Lance for his assistance with the geology of the area. Finally, I wish to express by sincere appreciation to Dr. Albert R. Mead for his patient guidance and critical assistance in the preparation of this paper.

Description of the Area

The Gulf of California lies in a climatic region which is comparable to that in which the Red Sea is located; but hydrographically the Gulf of California is entirely different from the Red Sea, the reason being that the Gulf of California is not separated from the adjacent ocean by a submarine ridge. From the mouth of the Gulf to 28°30' N the bottom of the Gulf is trough-shaped, with the greatest depth at the opening to the south. The soundings of the E. W. Scripps in 1939 and 1940 have shown, however, that the bottom is very irregular with several deeper basins, although at the entrance free communication with the waters of the Pacific exists above depths of nearly 3,000 m. A ridge running nearly north-south at long. 112°40' separates the northeast portion of the Gulf from the southwest portion,
the sill depth of the ridge being about 200 m. West of the ridge lies a deep trench between the peninsula of Lower California and the island of Angel de la Guardia. (Sverdrup, 1942).

Puerto Peñasco (Rocky Point), Sonora is located at the northern end of the Gulf at 31°20' N and 113°35' long. A paved highway connects Puerto Peñasco with the town of Sonoyta, Sonora, and extends north, where it crosses the international boundary into Arizona. Situated approximately five miles west-northwestward of Puerto Peñasco is Punta la Cholla, or Rocky Bluff, a headland of a series of low granitic hills of unknown age, the highest of which is 408 feet in elevation. On the north side of the point lies a small bight which is known locally as Bahía la Cholla. Bahía la Cholla, or Cholla Bay, is approximately two miles wide and three miles long. Along the north side of the bight are large sand dunes. Along the south side is a small settlement known as Punta la Cholla (Fig. 3).

Overlying the granitic rocks exposed in the intertidal belt just inside the entrance to the bight are isolated ledges of well indurated sandstone containing granitic pebbles. Along the west side of the headland numerous undercut and partially slumped ledges of fossiliferous sandstone are exposed in the intertidal.

The south side of the headland is exposed to the greatest amount of surf around the point, the north side being protected from the wind and ground swells of the Gulf. The surf, however, is very slight and in my own experiences at Cholla Bay, I have never seen a large surf, as one experiences along the open Pacific coast. The entire south side
Fig. 3

Cholla Bay Area (from Hartlein and Emerson, 1956, p. 160)
of the point is composed of very large granitic boulders and in the lower levels of the intertidal belt the granite forms ledges with many tidepools running parallel to the water's edge.

Cholla Bay is an area of very little rainfall (probably not over 3 inches a year), and there is no fresh water in the immediate area, the closest being a well about 20 miles north where water is obtained for the town of Puerto Penasco.

Not only does the area experience very little rainfall, but it is subject to extremely high temperatures. The lowest tides during the summer months occur early in the morning and in the winter months they occur late in the afternoon. However, even in the early and late parts of the winter months extreme temperatures are experienced by the exposed intertidal belt during the low spring tides. I have no recorded data for temperatures of the area, but I feel that the extremely high temperatures and the long length of time the intertidal belt is exposed account for the sparseness of the upper intertidal fauna.

The high temperatures of the area also cause a high rate of evaporation, resulting in an increase in salinity of the sea water. The salinity is especially high in the bay and in the tidepools. Below is a table (Fig. 4) showing the salinity of the water in Cholla Bay taken by the U. S. Geological Survey (McKee). Unfortunately, the table was not dated. Added to the table is the normal salinity for sea water as given by Sverdrup, et al. (1942). The borders of the east end of the Bay which are dry during low tides are covered with vegetation consisting of Saltwort (Elymus maratima), Salt Cedar (Monanthochloe littoralis), and
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<th>Mg</th>
<th>Na-K</th>
<th>CO₃</th>
<th>HCO₃</th>
<th>SO₄</th>
<th>Cl</th>
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Fig. 4

Analyses of water samples (ppm) from Cholla Bay, Sonora. (McKee, p. 38).
Glasswort (*Salicornia* sp.). All these plants have a high salt tolerance.

On the 1939 cruise of the *E. W. Scripps*, hydrographic data were collected at the north end of the Gulf of California, but unfortunately this material was never published. At this writing, the original manuscript was missing from the library of the Scripps Institute of Oceanography. Parts of the original data are scattered through Sverdrup, et al.; and on page 731 of *The Oceans* is a table giving temperature, oxygen and salinity of the water in various places in the Gulf of California. Given below (Fig. 5) are the figures from a station located in the deep trench south of Angel de la Guardia.

**Tides**

In Cholla Bay there are two high tides and two low tides in every lunar day of approximately twenty-four hours and fifty minutes. It is apparent, therefore, that on each succeeding solar day the corresponding tides occur fifty minutes later than on the previous day. The heights of the two daily tides are comparatively equal only during the half-moon periods. At the full and new moon periods there is a great difference between the levels of the tides, especially in the case of the low tides, due to the varying declination of the moon. During these periods there are very pronounced higher high and lower low tides with intervening lower high and higher low tides. For instance, on Dec. 8, 1956, there was no difference between the two high tides, and on the 18th of the same month there was a difference
### Table 1: E. W. Scripps VII-53
March 19, 1939
28°46.5' N, 113°08' W

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<tr>
<td>1270</td>
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<td>.76</td>
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</tr>
</tbody>
</table>

**Fig. 5**

Temperature, salinity and oxygen content of seawater south of Angel de la Guardia (Sverdrup, et al, 1942).
of 20 feet between the two low tides. From such conditions, it follows that there is a wide range in the extremes of the tides, but the mean range is much less in extent. For the year 1956, during which the greater part of this investigation was made, the extreme range of the tide was 20 feet while the mean range for the same period was 8.1 feet.

All the tidal figures were calculated from data given by the Coast and Geodetic Survey in the Pacific Tide Tables for Guaymas, Mexico, which is the port of reference for Puerto Penasco. All figures given here have been converted to a new number by using the maximal tide figures for both ports, and deriving the new figure by using a simple ratio. The maximal tide range at Guaymas is 4.4 feet, and at Puerto Penasco 20 feet.

As already mentioned, the tide is probably the most important factor in controlling the distribution of intertidal forms. E. F. Ricketts (unpublished manuscript) has constructed a diagram to show the time of exposure of organisms at different levels in the intertidal belt. His data were taken from the records of the tide recording machine at Crissy Wharf, just inside the Golden Gate at San Francisco, for the six-month period from January 1 to July 1, 1931. He calculated the number of hours of exposure at each 6 inch level and thus obtained the total for the six-month period. The diagram (Fig. 6) is given below because of its applicability to this region of study.

A study of this graph reveals the fact that the organisms below mean low water (the 0.0 of the tide tables) are exposed for relatively short periods of time. At the mean high water level (the 5.0 of the
Fig. 6

Exposure curve for the six-month period, January 1 to June 30, 1931, comprising an analysis of a tidal curve drawn from hourly heights as recorded by the Coast and Geodetic Survey tide machine at Crissy Wharf in San Francisco Bay. (Ricketts & Calvin, 1952)
tide tables) there is a definite upward bend of the exposure curve. Organisms above this level are exposed for relatively long periods of time.

It is a fact of the most profound ecological significance that at the levels noted in the last paragraph, there are also breaks in the sequence of the biotic communities. Below the mean lower low water line, one finds associations which extend below the littoral into the sublittoral. The area above the 5.0 level is inhabited exclusively by such forms as, for example, *Littorina planaxis*, which can withstand long periods of exposure.

It is interesting to note that, although *Littorina* is found in Cholla Bay, it is very scarce. This scarcity of *Littorina* in the Cholla Bay area may be accounted for by the extremely long periods of time the upper intertidal area is exposed to air and very high temperatures. Although I have not collected *Littorina* at Cholla Bay, they have been found there by Dr. S. S. Berry, living in narrow rocky crevices somewhat lower in the intertidal belt than one would normally expect to find them.

Fig. 7 shows the difference in the extent of the large spring tides which occur daily at Guaymas and Puerto Peñasco. Guaymas is approximately 250 miles south of Puerto Peñasco, and there is between two to three hours difference in the time of the tides, the tides being later at Puerto Peñasco.
Graph showing spring tides occurring simultaneously at Puerto Penasco (solid line) and Guayaquil (dotted line). Height given in feet.
Description of the Zones

The data collected were obtained on six field trips made over a period of 1½ years. Field trips were made on the following dates:

- Nov. 24-27, 1955
- Jan. 26-29, 1956
- Mar. 30-Apr. 3, 1956
- May 24-26, 1956
- Nov. 22-25, 1956
- Jan. 24-27, 1957

I will discuss the zones given by the Stephensons (1949) as I found them over the 1½-year period in the Cholla Bay area. The tide levels used here are only approximate figures, as there was no way of accurately measuring tide levels.

There were three areas chosen for concentration of study. These study areas are transects across the intertidal belt approximately ten feet wide and extending from the highest tide mark to the lowest tide mark. Study area #1 represents a protected rocky shore, study area #2 represents a protected pebble beach, and study area #3 is more typical of an open rocky coast.

Supralittoral Zone

This zone is never covered with sea water, but is subject to fine spray in rough weather. There is no supralittoral zone represented in study area #2, as the highest regions of this area are
represented by the midlittoral zone and are covered and uncovered twice daily by the tides.

The only species commonly found among the supralittoral rocks, above the high tide line, is Ligypia sp. These large isopods are found in rock crevices high above the spray zone. They apparently constitute a transition form between the marine and terrestrial life which has not as yet completely lost its affiliation with the marine habitat. These creatures are more easily found if looked for after darkness with the aid of a lantern. It is at that time they make their excursions into lower zones in search of particles of detritus which constitute their food.

Unidentified insects, lizards and fringillid birds also inhabit this zone.

**Supralittoral Fringe**

This zone is invaded in its lower portion by the high water of spring tides. Again, this zone is not represented in study area #2.

In study area #1 the entire area at first glance is seemingly barren. There are, however, a few scattered snails, *Tegula rugosa*, and a few small barnacles, *Gthamalus* sp.; and in the lowest level of this zone, one may find small hermit crabs inhabiting the shells of *Thericium*.

In study area #3 one commonly encounters three forms. The most obvious form is a large white barnacle (*Tetraclita?*) with strong ribbing
on its walls. This barnacle was found living only in study area #3. Common in this zone was the large black and white whorl-shell, *Nerita scabriscostata*, living in shaded places between rocks and in crevices. It is interesting to note that one finds only the large adult forms in this zone; the young presumably live in the lower portions of the intertidal belt. *T. rugosa* is also found in this area. It is not as common here as in study area #1. The reasons for this difference are not apparent.

**Midlittoral Zone**

This zone tends to be covered and uncovered every day by the tides, at least in part. The upper limit of this zone is determined by the upper limit of barnacles (*Chthamalus*), and its lower limit is determined by the distribution of any abundant, dominant organism. *Chthamalus* is the most abundant organism of this zone in study areas #1 and #3 (Fig. 8). Barnacles are absent in study area #2, probably due to the rolling action of the rocks over the substratum. However, a few barnacles may be found on the larger boulders. The presence of *Chthamalus* seems to be the controlling factor in the distribution of the predatory snail, *Acanthina angelica*, since this snail is apparently completely dependent upon *Chthamalus* as a source of food. It is a common occurrence to find *Acanthina* feeding with its spine, which is located at the lower edge of its aperture, through the valves of the barnacle.
Study area #3, showing the transition between the supralittoral fringe and the midlittoral. In the upper zone are the large white barnacles, and in the foreground are Chthamalus with Acanthina feeding on the small barnacles. The white diving mask in the right-center marks the division between the two zones.
Tegula rugosa finds conditions very favorable in this zone, being most abundant in study area #1. It is found abundantly grazing on the thin film of green algae covering the rocks (Fig. 9).

In study areas #1 and #3 one finds five species of the limpet, Acmaea. These five limpets are somewhat confined to vertical subzones of the midlittoral zone. In the upper region of the midlittoral zone are found two small, usually ribbed limpets, Acmaea nitella and A. turveri. Both of these limpets are found scattered throughout the midlittoral zone, but are most abundant in the upper portions of this zone. In the mid-midlittoral are found two other limpets, A. mesoleuca and Acmaea sp. (undescribed). One other limpet, A. dalliana, is confined to the lowest parts of this zone, and is most abundant in the zone below the midlittoral.

One other form that is very abundant in this zone is the snail Therlicium stercus-muscarum, which is so common throughout the entire intertidal belt. Whole areas may be literally covered with shells of this snail, but upon a closer examination one will discover that the majority of these shells are not occupied by their original owner, but by small hermit crabs.

In study area #1 other frequently occurring species include an orange encrusting sponge which is invariably found on the vertical face of the rocks, usually facing the seaward side. Scurrying over the rocks and dropping into crevices at the least disturbance are red or orange rock crabs approximately four to five inches across the back (Grapsus grapsus?). From under rocky ledges one may encounter the
Rocky area of the midlittoral in study area #1, showing the abundance of *Tegula* in this area.

In this area one does not find the definite domination of *Avrainia* as was present in study area #2. A *hirundo* and a *scirrhidae* are absent in this area.
extended purple, flowerlike tentacles of the sea cucumber (Holothuris lubrica).

In study area #2 (Fig. 10) one finds a varied and interesting cryptofauna. Because of the nature of the substratum, one finds very few sessile types of animals attached to the rocks. One does find, however, many attached forms which are capable of moving themselves in case the rocks should be overturned. The most common form found in this area is the chiton, Chiton virgulatus. One is not usually aware of this chiton's abundance until rocks have been overturned, or unless one goes out at night and sees them feeding on top of the rocks.

Other common inhabitants attached to the underside of the rocks are Acmaea mesoleuca, Acmaea sp., Physosoma sp., and Crepidula squama. Burrowing in the substratum under the rocks is another group of animals, including such forms as the clam Cardita affinis californica, the large polychaet worm Eurythoe complanata, and sabellid tube worms (Megalomma mushaensis?).

Taking refuge under the rocks are several abundant or conspicuous forms, including several species of brittle stars, the swimming clam Lima, small unidentified species of crabs and isopods, the lancelet Branchiostoma californiense, and the many rayed starfish Heliaster kubinii.

In this area one does not find the definite zonation of Acmaea as was present in study area #1. A. turveri and A. mitella are absent in this area.
Looking north across Cholla Bay, with study area #2 in the foreground. Only the upper portions of the midlittoral are exposed in this picture.
For the most part study area #3 is quite similar to study area #1, in that one encounters the same kinds of animals. One finds, however, a few forms which are found in this area only. The upper limits of this zone are two to three feet higher than in area #1, due to the fact that there is more surf keeping the upper portions wet for longer periods of time. The starfish are present in this area which are absent or scarce in the more protected sites. *Heliaster kubiniji* was found in study area #2, but not in the great numbers found in area #3. Also, the small, 5-rayed, orange starfish, *Phataria unifacilis*, is commonly found attached to the sides of the tidepools. Large green and red sea anemones are found in this habitat also, but they are not common, as is the case for the entire coelenterate group in Cholla Bay. Jellyfish seem to be completely lacking in waters surrounding Cholla Bay.

**Infra-littoral Fringe**

This zone is uncovered only at time of the lowest spring tides. Here one finds the greatest variety of animals, including forms which extend their range into this zone from the higher zones, forms which are "caught by surprise" by the very lowest spring tides and which are generally confined to the lower zones, and apparently animals which are found in only this area and may therefore be indicative of this zone. Since the infra-littoral zone is beyond the scope of this study, it is difficult to determine whether there is actually an infra-littoral fringe with its own characteristic animals, or whether this area is
merely a transitional zone between the zones above and below. Therefore, whether or not this zone actually exists, remains an uncertainty.

The greater portions of this zone in study areas #1 and #2 have a sandy substratum, except where there may be small flat outcropping of rock. Two conspicuous forms found in this area are the large snail, Muricanthus erythrostomum, and a large purple tectibranch (Dolabella sp.). Steinbeck and Ricketts (1941) refer to specimens of Muricanthus as Phyllonotus nigritus Philippi, and note that they were found abundantly on the reefs (?) feeding on Theridium stercus-muscarum (=Gerithium). Several specimens of the small brown and white murex, Phyllonotus princeps (Broderip), were also found.

Study area #3 is the only area that revealed a definite discontinuity of populations from the midlittoral zone. It is here that there were found an abundance of sea anemones, sponges and bryozoans.

The small, brown, colonial sea anemone, Palythoa sp., is very common on the side of ledges which are exposed to the surf. Where the action of the surf is great enough, these anemones may extend their range into the lower portions of the midlittoral zone. The large red and green sea anemone mentioned as being found in the midlittoral zone is even more abundant in this zone, being most frequently encountered in the bottom of tidepools where they are better protected from the direct force of the waves.

Two important bivalves present in this zone are Hipponix barbatus and H. serratus. Because of the unequal valves of these clams, they resemble somewhat the gastropod, Crepidula. H. barbatus
is important as a reef builder since it is a colonial form.

The highly ornamented and spiny limpet, *Crucibulum spinosum*, may be found attached to the underside of rocks. In this same place, one may encounter the large, flat limpet, *Acanthina dalliana*. A purple encrusting bryozoan is very common in this zone.
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Fig. 11 Diagram showing the vertical distribution of the common invertebrates of Cholla Bay.
Fig. 12 Map showing the three study areas and the nature of the substratum in the intertidal belt.

Rocky substratum [] Pebble beach [] Sandy substratum []
Discussion

In describing the areas studied I have described the zones only in relation to the most common invertebrate forms found; and it is upon the occurrence of these few common forms that the zones are identified. I am fully aware of the importance that some authors give to the seaweeds in delimiting zones; however, I have omitted the algae for two reasons. First of all, a study of the seaweed is a complete study in itself and is beyond the scope of this paper. Secondly, being scarce in this area, seaweed is a minimal factor in the lives of the invertebrates in the intertidal of this area in contrast to the more open type of rocky coast as one finds along the California coast.

When we compare the shores of Cholla Bay with the areas described by T. A. and A. Stephenson, we realize that this is not in the strictest sense the type of rocky coast they had in mind in setting up their universal classification. This coastline differs in that it has little of the continual pounding surf, that one encounters on the open rocky coast of California or the south African coast. The Gulf of California is relatively calm, and as a result, one would expect to find differences in the ecology of the fauna as compared to a more open type of rocky coastline.

If one is familiar with the fauna of an open coast, one first notices the absence of such common animals as Mytilus, Nitella,
Strongylocentrotus, Arbacia, etc., which are typical forms on open rocky coastlines. The absence of a form such as Mytilus, in turn, prevents the establishment of many other forms which are dependent upon this mussel for protected sites of attachment. The only common sessile form in the entire Cholla Bay area is the small barnacle, Chthamalus, which offers no place of protection for other animals. As a result, where Chthamalus is abundant on rocks, the area will be practically lacking in other animal forms with the exception of the snail Acanthina, which feeds on Chthamalus.

It can be said, in general, that the rocky areas have a paucity of marine animals, except for the pebble beach. There is a paucity only in the number of animals found, and not in the number of species to be found. For example, Dr. S. S. Berry has collected 800 species of mollusks alone from the entire Cholla Bay area. A study of pebble beaches revealed the fact that these areas are the richest sites for numbers of animals, since they provide excellent places for protection against desiccation between and under the pebbles. This intermediate type of habitat does show a zonation pattern; but it is complex and difficult to interpret due to the absence of any common sessile types. I have mentioned the pebble beach more as a point of interest rather than to attempt to show a definite zonation pattern. There would be nothing gained at this point in comparing this habitat with the rocky habitat. It is of interest to note that an attempt has been made by Guiler (1951) to correlate zonation on mud and salt marsh in Tasmania with the
Stephenson scheme.

Gislen (1944) believes that the intertidal zones should be named or based on mean sea level. Although this might be the most accurate method of measurement, it is very impracticable since there are so few ports of reference with tidal data. One can see immediately the difficulties that would arise if we were to use the tidal data at Guaymas for our tidal data Puerto Peñasco.

From what we know now, I believe that a universal scheme which would be applicable to different shores could be based only upon the tides as a universal factor. According to the Stephensons, the problem concerning the factors which control zonation is extremely complex, and it, therefore, becomes necessary to use index organisms as the next best factor in defining zonation. Even with the completion of the Stephensons' tremendous task of investigating the rocky shores of the world, there will remain much intensive work to be carried out on all types of coasts, particularly on muddy and sandy shores, before a comparison of the different types of shores can be made, and before an understanding of the facts can be obtained.

My own contributions give support to the Stephensons' hypothesis by clearly following the universal classification as proposed by them. Investigations in other rocky areas and in sandy areas in the Gulf of California are needed, however, in order to form an understanding of the basic aspects of intertidal zonation in that area. This understanding of zonation is essential, since it is fundamental to any study in marine ecology. This is particularly the case along the little investigated shores of the Gulf of California.
Summary

A brief general description of the coastline of Cholla Bay, Sonora, Mexico, is followed by a short account of the physical conditions and essential tidal information.

In accordance with the distribution of invertebrate organisms, the rocky shores are divided into the five zones proposed by T. A. and A. Stephenson, viz., (a) supralittoral zone, (b) supralittoral fringe, (c) midlittoral zone, (d) infralittoral fringe, and (e) infralittoral zone.

Zonation of animal life on the rocky shores of Cholla Bay, although the nature of the area is slightly different, is seen to fit into the scheme put forward by T. A. and A. Stephenson which they believe will have universal applicability as a method of describing rocky shore zonation.
List of the common littoral invertebrates in the Cholla Bay Region

Coelenterata
- Renilla sp.
- Polythoe sp.

Platyhelminthes
- Alleena mexicana Hyman
- Ommatoplane levig Hyman
- Pericelis eresti Hyman
- Pseudoceros mexicanus Hyman

Sipunculoidea
- Physcosoma sp.

Annelida
- Eurythoe complanata (Pallas)
- Megalomma mushaensis (Gravier)

Echinodermata
- Helaster kubinii Xantus
- Phasteria unifasciata (Gray)
- Astropecten armatus Gray
- Ophiocoma aethiops Lutken
- Encope grandis A. Agassiz
- E. californica Verrill
- Holothuria lubrica Selenka

Mollusca
Amphineura
- Ischnochiton sucosius Dall
- Chiton virgulatus Sowerby

Pelecypoda
- Cardita affinis californica (Deshayes)
- Protothaca sp.
- Lithophaga spatiosa (Carpenter)
- Hippopus barbatis Sowerby
- H. serratus Carpenter
List of invertebrates (cont.)

Mollusca (cont.)

Gastropoda

Acanthina anglica Oldroyd
  A. tuberculata (Sowerby)
Acmaea dalliana Pilsbury
  A. megoleuca Menke
A. mitella Menke
  A. turveri Hertlein
Acmaea sp. undescribed
Conus perplexus (Sowerby)
Crepidula aequa Berdilrop
Cucullium spinosum (Sowerby)
Cypraea annetae Dall
Diodora inequalis (Sowerby)
  D. fissurgella (Sowerby)
Dolabella sp.
Henitia sp. undescribed
Littorina sp.
Melongena patula Broderip and Sowerby
Muricanthus erythrostoma Swainson
Nerita scabricosta Lamarck
Neverita reclusiana (Deshayes)
Oliva peuplea DeClos
Phyllonotus princeps (Broderip)
Parametaria dupontii (Kiener)
Tegula rugosa A. Adams
Terebra variegata Gray
Thermaea stercus-muscarg (Vallencinnes)
Turbo calapoma fluctuosus Wood
Vermicularia aburna Reeve

Cephalopoda

Octopus bimaculatus Verrill

Arthropoda

Liguida occidentalis (Dana)
Othamalus sp.
Tetraclita sp.
Calcus californiensis Bouvier
Grapusus grapus (Linnaeus)
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