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IN THE GULF OF CALIFORNIA

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ABSTRACT

The fauna and flora of Bahía Pulmo are presented, and the construction of the reefs is discussed. Based on available data, it seems apparent that at least two (if not more) of the reefs of this region are true coral reefs although quite young and limited in size.

RESUMEN

Se presenta la fauna y la flora de la Bahía Pulmo y se discute la construcción de los arrecifes. Basándose en los datos disponibles parece que cuando menos dos (sino más) de los arrecifes de esta región pueden ser considerados como verdaderos arrecifes de coral, aunque muy jóvenes y limitados en tamaño.

INTRODUCTION

Pulmo Reef, located between La Paz and Cabo San Lucas, Baja California Sur (23°26' N, 109° 25' W) supports the most extensive growth of coral in the Gulf of California (Fig. 1). However, there is some controversy as to whether Pulmo Reef is a true "coral reef" in the strictest definition of the term. For example, Rosenblatt (1976) stated, "there is but one true coral reef in the eastern Pacific, and that is at the isolated and oceanic Clipperton Island". Squires (1959), who described the Pulmo reefs during the Puritan - American Museum of Natural History Expedition to western Mexico, noted that the Pulmo reefs were not coral reefs in a constructional sense despite the abundance of hermatypic (reef-building) corals on the reefs. Outside of Squires' detailed description published accounts of the Pulmo reefs have been largely anecdotal. The earliest, and most picturesque account is that of Steinbeck

and Ricketts (1941) who visited the region in 1940. Oceans magazine published a picture essay on the reefs in 1973, followed by a letter by D. G. Lindquist commenting on the article a year later.

The literature on the coral fauna of the Panamic and Gulf of California regions has been adequately discussed and summarized by Durham (1947) and Durham and Barnard (1952). Significant publications since those papers, dealing with eastern Pacific Corals, include: Glynn and Stewart (1973), Glynn (1972), Glynn, Stewart and McCosker (1972), as well as several concerned with the seastar Acanthaster (Barham, Gowdy and Wolfson, 1973; Porter, 1972; Dana and Wolfson, 1970; and, Glynn, 1973, 1974).

It is the purpose of this paper to document, for the first time, the biota that actually comprises the reefs of Bahia Pulmo, and in so doing shed light on the present controversy.

METHODS AND MATERIALS

The El Pulmo Reefs were visited in 1971, 1972, 1973 and 1974. Preliminary lists of algae, macro-invertebrates and shore fishes collected and observed during these visits were compiled. Extensive data on invertebrates and algae were collected during an intensive three day survey (March 4 to March 6) by members of the 1974 Scripps Alpha Helix Baja California Expedition. Over the three days an estimated 50 man-hours were spent collecting and observing intertidally and underwater. The fish species list is based upon two rotenone collections at depths to 5 m and over 50 man-hours of underwater observation on July 31, 1972 and June 23, 1973.

RESULTS AND DISCUSSION

The reefs of Bahia Pulmo consist of a series of eight long bars of extruded igneous rock, upon which coral and other animal and plant life flourishes. All eight bars begin well up on the beach and can be easily seen, resembling dark, rocky dikes protruding up and out of the beach sand and continuing on into the sea. The outermost bar is a continuation of the north point of Punta Los Frailes. It runs nearly the entire length of the bay and forms a submerged "barrier reef", that is actually broken up into a series of alternating bars with short, sandy stretches in between. The depth of the top of this outermost reef is 25-30 feet at the southern end (near Punta Los Frailes) and about 65 feet at the northernmost end (seaward of Cabo Pulmo, a steep, rocky headland). The depth of the sandy breaks in the reef, as well as the sand patches either side of the reef, at the southern end, is about 50 feet. Squires gave depths and even local names for many of the reefs of Bahia Pulmo and the only cases where our depth

measurements are in direct conflict with his are for the two southernmost short reefs, inside the long "barrier reef". We measured the tops of these two short reefs at 20 feet, at low water, as opposed to 36 feet as recorded by Squires.

These two southernmost short reefs are covered with a luxuriant growth of the corals Pocillopora elegans, Porites californica and Pavona gigantea. The coral growth on these two reefs is equal to or considerably greater in volume than the rock dike upon which it rests. As one proceeds northward from these two southern reefs the amount of coral growth decreases, becoming progressively less until the last reef is reached, which has little coral growth, consisting largely of scattered patches of Porites and Pavona. This decrease in coral growth northward in the bay is probably related to the fact that these reefs also become progressively shallower, the tops of the more northerly ones being exposed at low spring tides, particularly shoreward. Squires gave the depth of the northernmost reef ("La Barra Grande") as 38 feet; however, during the low spring tides of March, 1974, the upper portion of nearly the entire reef was exposed. Likewise, during low tides the landward portions of nearly all of the more northern reefs became exposed. It is quite likely that Squires' depth measurement for the northernmost reef was taken near the extreme end, as the top of the reef drops off.

The question of whether or not the reefs of Bahia Pulmo should be considered true "coral reefs" is only partly one of definition. Yonge (1973) has pointed out that there is no systematic distinction between hermatypic (reef-building) and ahermatypic corals. The coral reefs of Bahia Pulmo are admittedly quite young, probably less than 20,000 years old, and possibly less than 5,000. This apparent youth has contributed to the problem of what proper name should be applied to the reefs. Squires refers to them as "El Pulmo Reefs", "reef suites" and "coral communities", but he stated that constructionally they are not true coral reefs. From our observations, however, they do indeed appear to be constructional, rather than erosional coral reefs. The reefs do lack certain features generally seen in more highly developed coral reefs. For instance, there has not been enough time for them to contribute significantly to local beach sediments, and they do not possess the usual abundant growth of coralline red algae seen on coral reefs in the west Atlantic or Indo-Pacific regions. They do, however, support a substantive pelecypod fauna (principally Spondylus and Lithophaga) that contributes to the coral reef nature of the community. Squires defined a coral reef as follows: "A community, dominated by corals in which there is a degree of interdependence between members of the constituent flora and fauna. To this is added the provision that the community must have an appreciable areal dimension and definable continuity". The two southernmost

reefs of Bahia Pulmo do fit this and other definitions of coral reefs we have encountered (Steen, 1971), and by T.F. Goreau's

system of coral reef classification the Pocillopora in this region may be considered as "primary reef builders" (see Goreau, 1963; Goreau and Yonge, 1968; Yonge, 1973, and: Yonge, 1974).

Of the 121 species of macroscopic invertebrate animals recorded from Pulmo Reef, 40 were found in intimate association with the coral heads (see Table 1). The remaining animals were found in association with rocks or the sand bottom. The dominant corals of the Pulmo reefs are Pocillopora elegans, Porites californica and Pavona gigantea. Porites californica apparently has a number of different and rather striking growth forms depending on local environmental conditions and can be found occurring as: (a) a thin encrustation; (b) a squat or tall (often nodular) columnar formation, or; (c) a tall pedunculate growth.

It is of interest that no one in our party reported observing Acanthaster ellisii (the eastern Pacific Crown-of-thorns seastar) on coral, rather, it was always seen on rocks or on a sandy substrate. Dana and Wolson (op. cit.), Barham, Gowdy and Wolfson (op. cit.), Glynn (op. cit.), and Porter (op. cit.), however, have all reported this seastar as a regular predator on corals in the southern parts of the Gulf of California, and south to Panamic waters.

The 108 species of shore fishes sighted or collected in the Bahia Cabo Pulmo region in two brief site visits does not constitute a complete check list for fishes of the area (see Table 2). Nevertheless, it is indicative of the richness of the coral community compared to other rocky shore communities in the Gulf of California.

Certain species typically associated with coral reefs were found at the Pulmo Reefs. They include the parrotfishes, Scarus perrico, S. ghobban, S. rubroviolaceus, and S. compressus, the moray, Echidna zebra, the surgeonfish Prionurus punctatus, the moorish idol, Zanclus canescens, the hawkfish Cirrhitichthys oxycephalus and the puffer Arothron meleagris. Trans-Pacific fishes in the eastern Pacific tend to be coral reef inhabiting species, associated with islands, and these species become common in the La Paz to Cabo San Lucas region of the Gulf of California. Some of the species recorded by Greenfield et al. (1970) at the Isla Jaltemba coral formation, south of San Blas, Nayarit, Mexico, also occur in this region of Baja California. They attribute the establishment of trans-Pacific fishes in the eastern Pacific to such isolated coral formations.

Whether or not the Pulmo coral formations may be classified as true "coral reefs" may be a moot point; however, they clearly function as coral reefs judging by the species richness and coral associated fauna and flora.

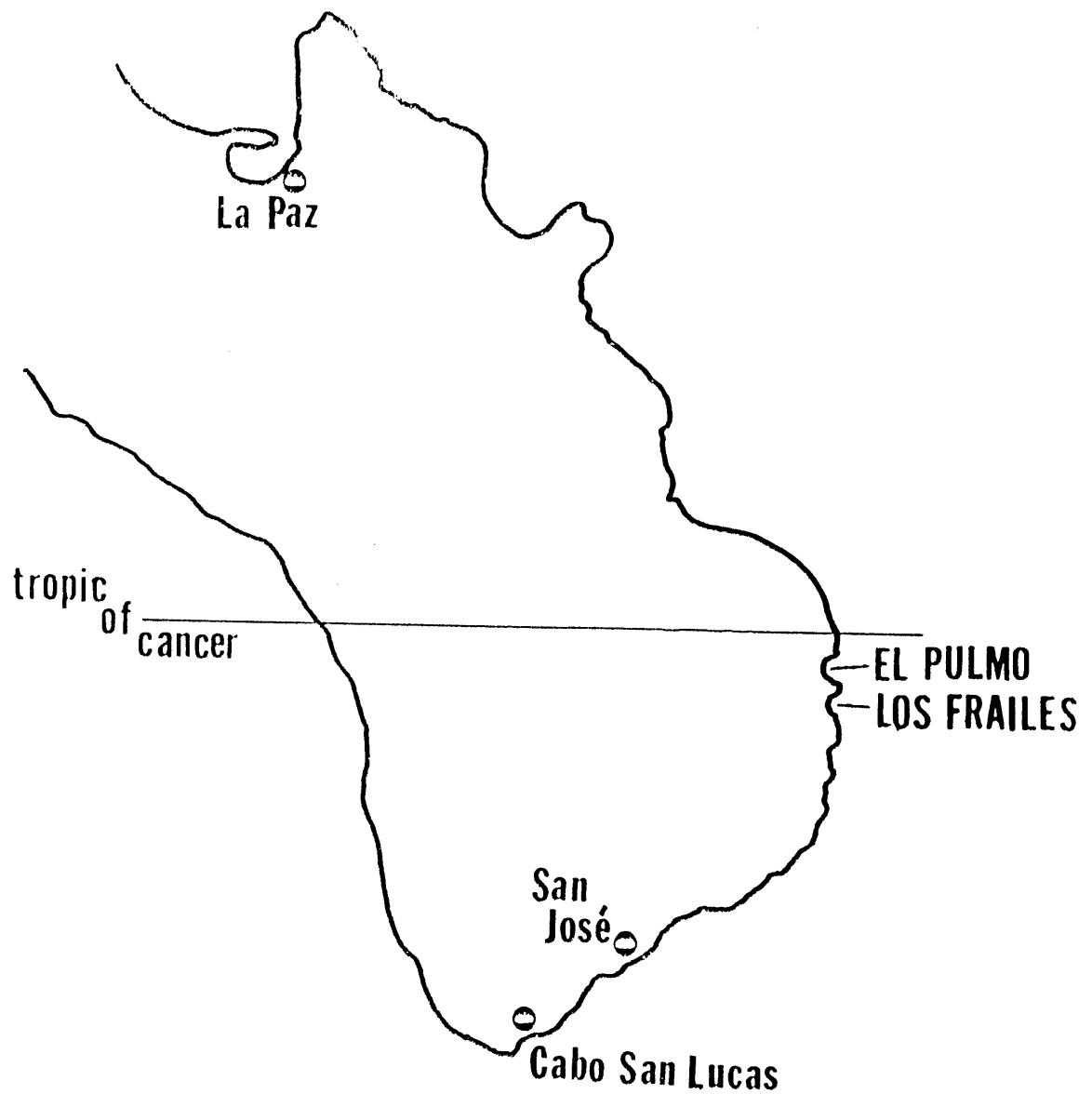


Fig. 1. Southern tip of Baja California showing location of Bahia Pulmo.

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Table 1. Species list of macroinvertebrates and algae
- compiled during a site visit to Pulmo Reef by the
Alpha Helix, March 4-6, 1974.

- C- Common (i.e. seen or collected in large numbers by
members of the survey team)
FC- Fairly common
UC- Uncommon (i.e. rarely seen; few specimens recorded)
CR- Typically found in association with coral heads,
during this survey.

ALGAE

Phylum Chlorophyta
Enteromorpha intestinalis
Codium setchellii
Codium simulans

Phylum Chrisophyta
Dictyota flabellata
Dictyota crenulata
Dictyota sp.

Padina durvillaei

Phylum Rhodophyta
Pterocladia pyramidale
Centroceras clavulatum
Laurencia decidua

Phylum Cyanophyta
Lyngbya sp.

INVERTEBRATES

Phylum Porifera

Class Demospongia

Tedania sp. (UC)
Verongia aurea (C)
Hymeniacidon sp. (UC)

Class Calcarea

Leucetta losangelensis (FC)
Leucosolenia sp. (UC)

Phylum Cnidaria

Class Hydrozoa

- Aglaophenia propinqua (FC)
Aglaophenia diegensis (C)

Class Anthozoa

- Bunodosoma californica (C)
Calliactis variegatus (UC)
Pocillopora elegans (C; CR)
Pocillopora robusta (UC; CR)
Porites californica (C; CR)
Pavona gigantea (C; CR)
Tubastrea tenuilamellosa (UC; CR)
Psammocora sp. (C; CR)
Gorgonia sp. (C; CR)
Gorgonia admasi (C; CR)

note: four other species of gorgonians were taken, all in association with coral heads, but their identity remains unknown. The gorgonian fauna of the eastern Pacific is very poorly known.

- Ptilosarcus sp. (UC)
Stylatula elongata (C)

Phylum Annelida

Class Polychaeta

- Megalomma sp. (C)
Spirobranchus sp. (C)
Harmothoe sp. (C; CR)
Eurythoe complanata (C; CR)
Family Nereidae (C)
Family Onuphidae (C)
Family Lumbrineridae (C)

Phylum Mollusca

Class Gastropoda

- Diodora digueti (C; CR)
Collisella discors (FC)
Collisella atrata (C)
Nerita funiculata (C)
Littorina aspera (C)
Liocerithium judithae (C)
Cheilea cepacea (C)

Pterynotus macleani (C; CR)
Neorapana muricata (C; CR)

Muricanthus nigritus (C; CR)
Muricanthus princeps (UC; CR)
Neorapana tuberculata (FC)
Hexaplex erythrostomus (FC; CR)
Hexaplex reguis (UC; CR)
Conus brunneus (FC)
Conus princeps (FC)
Melongena patula (C)
Berthellina ilisima (UC)
Pleurobranchus aroelatus (UC)
Tylodina fungina (UC)
Tridachiella diomedea (C; CR)
Hypselodoris californiensis (UC)
Dendronotus sp. (UC)
Arminia californica (UC)

Class Pelecypoda

Lithophaga aristata (C: boring into Spondylus)
Spondylus calcifer (C; CR)
Mactrellona exoleta (FC)

Phylum Nemertea

Lineus geniculatus (UC)
Baseodiscus mexicanus (UC)

Phylum Sipunculida

Phascolosoma agassizii (FC; CR)

Phylum Entoprocta

Zoobotryon pellucidum (C)

Phylum Arthropoda

Class Crustacea

Subclass Cirripedia

Tetraclita squamosa (C)
Chthamalus sp. (C)
Chthamalus fissus (C)
Balanus tintinnabulum (C)
Balanus amphitrite (C)

Subclass Malacostraca

Order Isopoda

Ligia occidentalis (C)

Order Decapoda

Suborder Natantia

Alpheus sp. (C; CR)Lysmata californica (FC)Gnathophyllum panamense (FC)

Suborder Reptantia

Section Anomura

Axius vivesi (FC)Dardanus sinistripus (UC)Calcinus californiensis (UC)Calcinus sp. (UC)Clibanarius diqueti (C)Paquiristes sp. (FC)Coenobita compressus (C)Megalobra chium sinuimanus (FC; CR)Megalobra chium smithi (UC; CR)Petrolisthes crenulatus (UC; CR)Petrolisthes sp. (FC)

Section Branchyura

Xanthodes hebes (C)Trapezia ferruginea (C; CR)Trapezia digitalis (UC; CR)Daira americana (FC; CR)Eriphia squamata (FC; CR)Stenorhynchus debilis (C; CR)Mithrax sinensis (FC; CR)Grapsus grapsus (UC)Ocypode occidentalis (FC)

Phylum Echinodermata

Class Asteroidea

Heliaster kubiniji (UC)Pharia pyramidata (C)Phataria unifascialis (C; CR)Amphiaster insignis (C)Acanthaster ellisii (FC)

Othelia tunuispina (UC)
Henricia? (UC)

Class Holothuroidea

Selekothuria lubrica (C; CR)
Brandtothuria impatiens (C)
Vaneyothuria zaca (UC)
Holothuria inornata (C; CR)
Labidodemas americanum? (C; CR)
Isostichopus fuscus (FC)
Chiridota aponocrita (C)
Euapta godeffroyi (C; CR)
Neothyone gibbosa (FC)

Class Ophiuroidea

Ophionereis annulata (C; CR)
Diopederma danianum (UC)
Ophiocoma alexandri (C)
Ophiocoma aethiops (C)
Ophiactis simplex (C; CR)

Class Echinoidea

Tripneustes depressus (C; CR)
Toxopneustes rosus (C; CR)
Echinometra vanbrunti (FC)
Diadema mexicanum (C; CR)
Eucidaris thouarsii (C; CR)

Phylum Chordata

Class Ascidiacea

Aplidium spp. (C; probably several species)
Ascidia interrupta (FC)
Rhopalaea sp. (UC)
Distaplia sp. ? (UC)

In addition to these marine plants and animals the terrestrial xeric snail Rabdotus harribaueri (Jacobson 1958) was collected along the bay shore.

Table 2. Fishes collected and observed on Pulmo Reef during site visits in July 1972 and June 1973.

Subphylum Vertebrata

Class Chondrichtys

Family Carcharhinidae

Carcharhinus limbatus

Family Dasyatidae

Urolophus concentricus

Family Myliobatidae

Aetobatus narinari

Class Osteichthyes

Family Muraenidae

Muraena lentiginosaGymnothorax castaneusGymnothorax panamensisEchidna zebraEnchelycore octavianusAnarchias galapagensisUropterygius sp. 1Uropterygius sp. 2

Family Clupeidae

Harengula thrissina

Family Gobiesocidae

Gobiesox pinnigerGobiesox adustusArcos erythropsTomicodon boehlkeiTomicodon eos

Family Antennariidae

Antennarius sanguineus

Family Ophidiidae

Ogilbia sp.

Family Atherinidae

Atherinops sp. (?)

Family Belontiidae

Tylosurus sp.

Family Exocoetidae

Hyporhamphus sp.

Family Holocentridae

Myripristis leiognathos
Holocentrus suborbitalis

Family Syngnathidae

Doryrhamphus melanopleura

Family Scorpaenidae

Scorpaena mystes
Scorpaenodes xyris

Family Serranidae

Epinephelus labriformis
Epinephelus itajara

Mycteroperca rosacea

Family Grammistidae

Rypticus bicolor

Family Pseudogrammidae

Pseudogramma thaumasium

Family Apogonidae

Apogon retrosella

Family Carangidae

Trachinotus rhodophus
Scelene brevoorti
Caranx caballus
Gnathanodon speciosus

Family Lutjanidae

Hoplopagrus guntheri
Lutjanus argentiventris
Lutjanus novemfasciatus
Lutjanus viridis

Family Pomadasyidae

Anisotremus interruptus
Anisotremus taeniatus
Haemulon sexfasciatum
Microlepidotus inornatus

Family Sciaenidae

Umbrina roncadore
Pareques viola

Family Mullidae

Mulloidichthys dentatus

Family Kyphosidae

Hermosilla azurea
Kyphosus elegans

Family Ehippidae

Chaetodipterus zonatus

Family Chaetodontidae

Holacanthus paseer
Pomacanthus zonipectus
Heniochus nigriröstris

Family Pomacentridae

Abudefduf troschelii
Nexilarius concolor
Pomacentrus rectifraenum
Pomacentrus flavilatus
Microspathodon dorsalis
Microspathodon bairdii
Chromis atrilobata

Family Cirrhitidae

Cirrhitus rivulatus
Cirritichthys oxycephalus

Family Mugilidae

Mugil cephalus

Family Labridae

Thalassoma lucasanum
Thalassoma lutescens
Bodianus diplotaenia
Halichoeres chierchiae
Pseudojulis sp.

Family Scaridae

Scarus perrico
Scarus ghobban
Scarus rubroviolaceus
Scarus compressus

Family Dactyloscopidae

Dactylagnus mundus

Family Blenniidae

Hypsoblennius brevipinnis
Ophioblennius steindachneri
Entomacrodus chiostictus
Plagiotremus azaleus

Family Tripterygiidae

New genus, n. species

Axoclinus carinalis
Axoclinus n. sp.
Enneanectes n. sp.

Family Clinidae

Labrisomus xanti
Labrisomus multiporosus (?)
Labrisomus striatus
Malacoctenus hubbsi
Malacoctenus tetranemus
Malacoctenus margaritae
Paraclinus sini
Paraclinus mexicanus
Xenomedea rhodopyga
Starksia spinipenis

Family Chaenopsidae

Acathemblemaria crockeri
Acathemblemaria macrospilus

Coralliozetus angelica
Coralliozetus micropes

Family Gobiidae

Bathygobius ramosus
Gobiosoma nudum (?)
Elacatinus puncticulatum
Elacatinus n. sp.
Gymnocleotris seminudus
Chriolepis zebra

Family Acanthuridae

Prionurus punctatus
Zanclus canescens

Family Balistidae

Sufflamen verres

Family Tetraodontidae

Arothron meleagris
Canthigaster punctatissima

Family Diodontidae

Diodon holocanthus
Diodon hystrix

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