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Distribution and community structure of the reef corals of Ensenada de Utría, Pacific coast of Colombia

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Abstract: Two types of coral communities occur in the Ensenada de Utría National Park (Pacific of Colombia) reefs, which develop in shallow sheltered water, and smaller non-reefal communities along wave exposed basaltic blocks. Chola reef, the largest coral community (approx. 10.5 ha), is characterized by relative high coral cover (32.4%) and dominated by *Pocillopora damicornis*. Smaller in size (approx. 1.5 ha), Diego reef is mainly covered by dead *Pocillopora damicornis* and live *Psammocora (S.) stellata* (2%). The other non-reefal communities are characterized by isolated coral colonies and patches of *Pavona clavus*, *Pavona gigantea* and *Porites lobata*. Coral community deterioration at Utría is evident, specially in the reefs, where both natural and antropogenic disturbances (*e.g.* phytoplankton blooms, human induced siltation, dynamite fishing and probably El Niño 1982-83 warming event) seem to influence the community structure.

Key words: Utría, Colombian Pacific, coral reefs, community structure, reef deterioration.

Three main areas along the Pacific coast of Colombia have coral reef development (Prahl & Erhardt 1985). These are: Gorgona Island, Malpelo Island and the northern end of the coast from Cabo Corrientes (5° 28'N) to Punta Ardita (8°12' N). From these, Gorgona Island reefs are not only the best developed but also the most studied. Crossland (1927) was the first to report Pocilloporid corals for the island; however it was only until Prahl *et al.* (1979) when some aspects of the reef distribution and composition were described. Other works like those of Glynn *et al.* (1982), Cantera (1983), Prahl & Erhadrt (1985), Prahl (1986 a, b) and Prahl *et al.* (1988) have certainly added to the general knowledge of the ecology and community structure of these formations.

By contrast, the two other zones have been briefly studied, perhaps due to the lesser coral development and inaccessibility of the sites. Despite the biogeographical importance of Malpelo Island, no further research has been conducted after Birkeland *et al.* (1975). For the northern Colombian Pacific coast results of the Velero III, IV and T.E. Vega expeditions list coral species and describe subtidal profiles for certain localities (Durham & Barnard 1952). Recent works only provide a succint description of the coral communities of Ensenada de Utría (Prahl & Erhardt 1985, Prahl 1986 c, Vargas-Angel 1988).

Coral reefs along the northern Colombian Pacific are meager if compared to those of Gorgona Island. Development of coral reefs along this coast may be limited by lack of proper substrata, water turbidity and upwelling influence from the Gulf of Panamá. This work presents a first attempt to quantitatively describe the distribution and community structure of the main coral communities at Ensenada de Utría.

MATERIAL AND METHODS

Study area: Ensenada de Utría (6°4'N; 77°23'W) is located on the northern half of the Pacific coast of Colombia (Fig. 1). This region owes its fractured relief to the coastal mountainous range, Serranía del Baudó, which runs south from Gulf of San Miguel in Panamá (8°20'N) to Cabo Corrientes in Colombia (5°23'N). Geologically, Ensenada de Utría is a fault, formed during the late Cretaceous, associated with active tectonism as the coastal Serranía was uplifted (Galvis 1980). The main part of this mountainous range is composed of metamorphosed sediments of Mesozoic age, as well as upper Miocene and Eocene igneous formations (Gansser 1950, Oppenheim 1952).

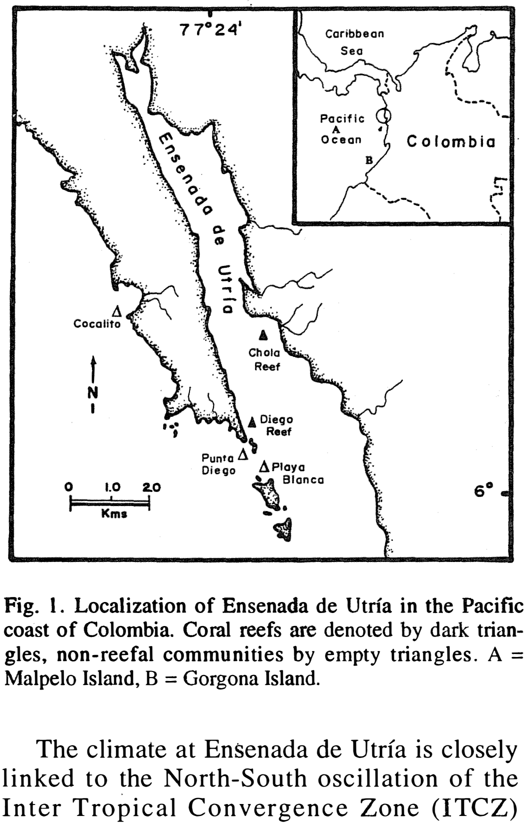

Fig. 1. Localization of Ensenada de Utría in the Pacific coast of Colombia. Coral reefs are denoted by dark triangles, non-reefal communities by empty triangles. A = Malpelo Island, B = Gorgona Island.

The climate at Ensenada de Utría is closely linked to the North-South oscillation of the Inter Tropical Convergence Zone (ITCZ) (Wirtky 1965, Glynn *et al.* 1982). The dry season occurs from January to April and the rainy season from May to December (Murphy 1939, West 1957). Annual rainfall is between 5000 mm and 7000 mm (West 1957); air temperature ranges from 21°C to 31°C with a mean of 25°C, and relative humidity varies from 40% during dry season to 80-100% during the rainy season (INDERENA and Fundación Natura unpublished data).

Methodology: The coral communities of Ensenada de Utría were located using previous works (Prahl & Erhardt 1985) and with the help of local fishermem. All sites were carefully inspected in order to obtain a qualitative picture of species distribution and abundance; only a quantitative study was conducted at Chola reef (Fig. 1), the largest coral reef at Utría.

Survey of coral communities took place from May 1988 to January 1989. At Chola reef a total of 136-10 m transects were run along three stations, at fixed 5 m intervals from the coast to the reef base. Number of species and live coral cover were recorded using a ten-meter long chain (1.1 cm link; see Porter 1972) laid on the reef, following the bottom contour and parallel to the shore. Survey of non-reefal communities was conducted in a more qualitative basis. A station was set where high concentration of scleractinians occurred. Similar to Chola reef, transects were run at fixed 5 m intervals, starting from the shore.

Species of *Pocillopora* were identified according to Cantera *et al.* (1989). Species diversity and evenness were calculated according to Shannon & Weaver (1948) and Pielou (1966), based on coral cover data, as in Loya (1972) and Porter (1972). Non parametric Kurskal-Wallis Analyses of Variance (Sokal & Rohlf 1969) were used to compare coral cover and species diversity between stations and reef zones (no transformation allowed data to comply with homogeneity of variances).

RESULTS

General description of coral communities: Mainly five sites where reef corals develop were identified at Utría, all dominated by *Pocillopora* (Fig. 1). The only two reefs, occur in calmed shelterd waters. The other three communities referred as non-reefal, consist of sparse coral patches and small build-ups over basaltic boulders.

Chola reef is the largest coral reef (approx 10.5 has) in Ensenada de Utría. It lies about 150 m off the coast, separated by a shallow channel (3-4 m depth) that receives substantial terrigenous run-off from La Aguara stream. Three main features can be distinguished: the reef flat (approx 1.0 - 2.0 m deep) which is subject to periodic low tide exposures, the reef slope (approx 2.0 - 5.0 m) and the reef base (approx. 5.0-7.0 m). Chola reef is mainly built by *Pocillopora damicornis* (Linnaeus).

Diego reef (Fig.1), was probably erroneosly positioned from aerial photographs by Prahl and Erhardt (1985), referring to it as Playa Blanca reef. Diego reef is small (approx 1.5 ha); the reef flat starts at about 100 m off the beach and extends for approximately 100 m at a depth of 2.0 - 2.5 m. The reef slope is steep and falls to approximately 6.0 to 8.0 m deep. Diego reef is covered mainly by coral rubble and crustose coraline algae. Live corals: *Psammocora (S.) stellata* (Verrill) and *P. damicornis,* comprise only 2% of total reef area.

Live coral cover is relatively low (8.9%-18%) along the non-reefal communities. Coral colonies at these sites grow between 1 m and 5 m deep, with other subtidal sessile invertebrates such as octocorals, barnacles and hydroids. Among these formations, Playa Blanca (Fig. 1) is the most deteriorated, probably due to tourism and coral collecting. Colonies of *Pocillopora capitata* (Verrill) were relatively more abundant in comparison to *P. damicornis*, *Pavona varians* (Verrill), *Pavona clavus* (Dana) and *Porites lobata* (Dana).

Reef corals at Cocalito (Fig. 1) grow over a submerged spur-like rocky ridge of about 200m long running off the beach. *P. capitata* and *P. damicornis* were abundant, while only a few colonies of *P. lobata*, *Pavona gigantea* (Verrill), *Pocillopora elegans* (Dana) and *P. stellata* were observed.

Live coral cover was highest (18%) at Punta Diego (Fig.1). This site appeared to be the best developed (both in live coral cover and richness) of the non-reefal formations. As in Playa Blanca and Cocalito, there were patches of stubby colonies of *P. capitata* and *P. damicornis* growing on shallow flattened rocky blocks subject to continuous wave action. Largest colonies of massive *P. clavus* (1.5 - 3.0 m) were observed at Punta Diego. Other reef corals: *P. varians*, *P. gigantea*, *P. elegans* and *P. stellata* also occurred at Punta Diego. The only colony (1.0 m diameter) of *Gardineroseris planulata* (Dana) was observed at Punta Diego. Live coral cover and species abundance for these non-reefal communities is shown in Table 1.

TABLE 1

Percent of live coral cover for the non-reefal communities at Utría estimated using chain-transects; np = species not sampled under transect at that site

Species	Percent Live Coral Cover		
	Playa Blanca	Punta Diego	Cocalito
Pocillopora damicornis	0.93	1.93	2.12
Pocillopora capitata	8.77	8.12	14.12
Pocillopora eydouxi	0.43	np	np
Pavona clavus	0.19	1.83	np
Pavona gigantea	np	0.17	0.54
Pavona varians	np	0.32	np
Porites lobata	0.97	np	1.09
Psammocora (S) stellata	0.11	0.06	0.13
Total	11.40	12.43	18.01

Community structure at Chola reef: Surveyed stations at Chola reef collected information on number of species and live coral cover at the north, center and south of the reef. For the purposes of this study, each station was divided into three zones: leeward (1.5 m-3.0 m), reef flat (0.5 m-1.5 m) and seaward (1.5 m-4.0 m) (Fig. 2).

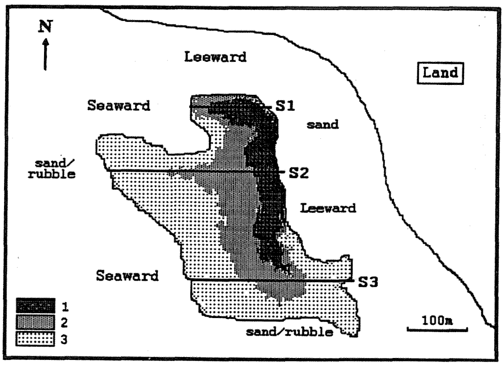

Fig. 2. Schematic distribution of coral cover along Chola reef. Transect stations are indicated by S1, S2, S3. **Legend:** 1- Mono-stands of *Pocillopora*; mean cover ≈50-90%. 2- Mixed zone of *Pocillopora* and *Psammocora*; mean cover ≈20-30%. 3- *Psammocora* and coral rubble; mean cover ≈5-10%.

High cover of *P. damicornis* was found in Station 1 (Fig.3). In the shallow reef flat and leeward zones corals grow over a mixed sand-rock substrate. *P. damicornis* grew thin-branched colonies, probably due to high levels of resuspended sediments (see: Veron & Pichon 1976, Prahl & Estupiñán 1990). *Psammocora (S.) stellata* occurred only in thirteen of thirty one transects, and always in low abundances.

Station 2 presented high live cover of *P. damicornis* at the leeward zone (approx. 60%). Along the reef flat and seaward zones, *P. damicornis* decreased substantially , whilst live cover of *Psammocora* increased (Fig. 3). *Pavona varians* and *P. capitata* only occured in one and seven transects, respectively, from forty-seven sampled in the reef flat zone. These two species represented less than 1% of total cover.

The leeward zone in Station 3 was characterized by low cover of all species (5-10%) (Fig. 3). Higher cover of *Pocillopora damicornis* and *Psammocora (S.) stellata* were present on the reef flat. This was the only zone in the entire reef to contain massive *P. gigantea.* This species occurred only in one of thirty one transects, representing less than 1% of total reef live coral cover. Live cover on seaward zone of station 3 was low as in station 2; in this two stations *Psammocora* was more abundant than *Pocillopora damicornis* (Fig. 3).

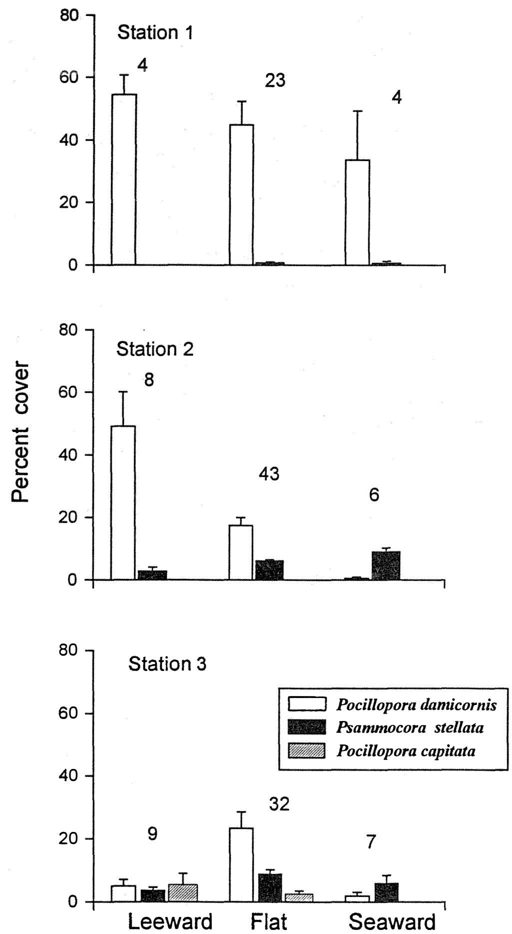

Fig. 3. Percent cover of coral species by zone at Chola reef. Standard error of mean and number of coral species present indicated above columns.

A total of five scleractinian species were found at Chola reef: *P. damicornis*, *P. capitata*, *P. stellata*, *P. varians* and *P. gigantea.* From these *P. damicornis* was dominant; absent only in thirteen of one hundred thirty five surveyed transects, and representing 80% of the total reef coral fauna. Spatial distribution of live coral coverage was highly variable due to a high degree of patchiness. All high coral cover areas (> 60%) at Chola reef occurred at dense mono-stands of *P. damicornis*, whereas the low live coral cover (< 10%) occurred where *P. damicornis* was less abundant or absent.

Total percent of coral cover was higher in Station 1 (45.3%± 5.8) than at stations 2 and 3 (26.5% ± 2.7 and 26.8% ± 3.5, respectively), however such differences were not significant (Kruskal-Wallis Anova, P > 0.05). By contrast, percent of cover was significantly different between reef zones (Kruskal-Wallis Anova, P < 0.05); being higher in the leeward and reef flat than at the seaward slope.

Species diversity varied inversely to percent of live coral cover. Transects with high coral cover at Stations 1 and 2 showed low diversity indices (0 - 0.7 Bits/Ind). Highest species diversity values (1.2 - 1.6 Bits/Ind) were found at stations 2 and 3 where coral cover was lower (10-30%) and coral species occurred in similar proportions (Fig. 4). Species diversity between stations did not differ significantly (Kruskal-Wallis Anova, P> 0.05). However, between reef zones, species diversity on the seaward slope (0.32 bits/ind ± 0.1) was lower, and significantly different than on reef flat and leeward edge (0.45 bits/ind ± 0.06; 0.62 bits/ind ± 0.05)(Kruskal-Wallis Anova, P< 0.05).

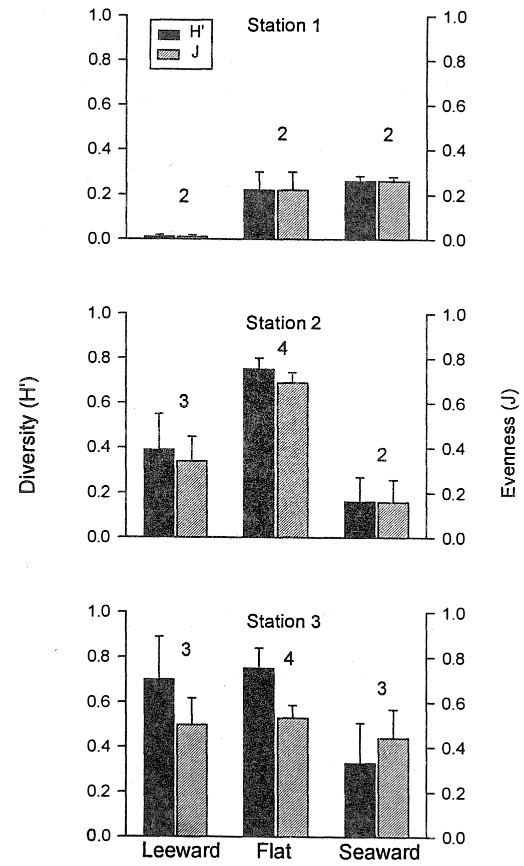

Fig. 4. Mean coral species diversity (H') (Black) and evenness (J') (hatched) for reef zones within each transect at Chola reef. Standard error of mean and number coral species present indicated above columns.

DISCUSSION

No apparent zonation pattern can be recognized for non-reefal coral communities at Utría. These formations consisted basically of coral aggregations on basaltic boulders. At these sites two species of *Pocillopora* (*P. capitata* and *P. damicornis*) were most abundant. Massive corals were common on shallow waters. *Porites lobata*, *Pavona clavus* and *P. varians* were never found beneath 3.0 m deep. This situation is in contrast with zonation patterns at other eastern Pacific coral communities like Malpelo, Galápagos and Cocos Islands , where massive corals account or used to account for the deep communities. (Bakus 1975, Birkeland *et al.* 1975, Glynn and Wellington 1983, Guzmán and Cortés 1989, 1992). Shallow and deep zonation of corals along the tropical eastern Pacific reefs are fairly well understood; predation, aggresivity and species tolerance to different physical environmental factors have been suggested as strong determinants of particular distribution patterns (Glynn *et al.* 1972, Glynn 1976, Wellington 1982, Guzmán 1988, Guzmán and Cortés 1989). Low coral cover at non-reefal communities in Utría may be the result of low coral recruitment rates associated to high settlement rates of fouling organisms, as observed in the Gulf of Panamá by Birkeland (1977, see also Birkeland 1987).

Coral species zonation at Chola reef is somewhat more defined. In general terms mean coral cover decreased from north to south, whilst species diversity and evenness increased. Statistical analyses however show no significant difference in coral cover or species diversity between stations; but suggest the presence of two major reef zones: 1) the live leeward slope and reef flat, which presents a highly variable cover pattern dominated by *P. damicornis*, and 2) the dead outer flat and seaward slope, characterized by low coral cover and the predomiance of *P. stellata*.

Present community structure and zonation pattern of Chola reef contrasts with previos descriptions by Prahl (1986c), who visted the area in 1981 (Prahl, pers. comm). Translating from Prahl (1986c, pag 96), we read: "Chola reef presents a mature structure, dominated by *P. damicornis*, *P. elegans* and *P. eydouxi* as well as *Psammocora (S.) stellata*. Massive Pavonids and *Porites panamensis* are also present in isolated formations entrusting along the seaward slope and base, or in clear areas where *Pocillopora* is absent". The present study found no live or dead colonies of ramose *P. elegans* or *P. eydouxi* in Chola reef. The only massive corals present were small colonies (10 - 20 cm diameter) of *Pavona varians* and *P. gigantea* on the reef flat. No dead evidence was found of the other massive corals (*Porites panamensis*, *Pavona clavus*) mentioned by Prahl (1986c).

Although there are no formal descriptions on Utría non-reefal communities prior to the present work (only scattered sampling conducted by Barnard and Durham 1952, but see Vargas-Angel 1988, 1989), general colony size and overall species richness suggests that particular conditions have caused selective mortality of reef corals (specially masive corals), leading to severe coral richness deterioration along Utría reefs in comparison to the non-reefal communities. Possible linkage with El Niño-warming (1982-83) can be suggested since this event caused catastrophic mortality of reef coral communities in Panamá, Colombia, Galápagos and Costa Rica (see summary in Glynn 1990). Other natural disturbances such as 1985 red tide which led to extense mortality of the reef corals in Panamá and Costa Rica (Guzmán *et al.* 1990), may have had similar consequences on the Colombian Pacific. Specially along the north end of the coast, where this type of phytoplankton blooms are not rare (W.Tavera and M. Asprilla, pers. comm.) probably due to the proximity of the upwelling influence of the Gulf of Panamá. It is very difficult trying to asses the effects of these natural disturbances on coral communities at Utría since there are no quantitative works prior to these events. However if such natural disturbances caused coral mortality at Utría, it is possible that differential factors or localized secondary disturbances (e.g. siltation, predation, erosion) allowed recovery of coral species in the non-reefal and fostered coral death at Diego and Chola reefs. Utría reefs, likewise most eastern Pacific coral reef communities exhibit highly variable coral cover patterns and low diversity and evenness. These features have been generally associated with both biotic and abiotic factors (Glynn 1976, Wellington 1982, Guzmán and Cortés 1989, Glynn 1990). To what extent present coral reef community structure at Utría is the result of natural and/or anthropogenic influences, still remains to be determined. Monospecificity is another trend that characterizes many easter Pacific coral reefs: *Porites lobata* for example, is the main reef builder along several reefs off the Pacific of Costa Rica (Guzmán and Cortés 1989, Cortés 1990). In Panamá and Gorgona Island, Colombia, reef frameworks are mainly composed by *P. damicornis* (Prahl *et al.* 1979, Glynn 1982, Glynn *et al.* 1982). Predominance of this species has been attributed to its rapid growth rate and aggresivity (Wellington 1980, 1982, Glynn and Wellington 1983) as well as its tolerance to sedimentation (Marshall and Orr 1931). At Chola reef *P. damicornis* is also the most abundant coral and perhaps the most tolerant species to local environmental conditions. Continuous monitoring during the study period showed that although five extreme low tides (-40cm) exposed the reef flat, coral mortality was never observed; in fact bleaching never resulted in coral death. Moreover, narrow belts along the leeward slope which presented highest leveles of resuspended sediments (see Vargas-Angel 1989 for data on sedimentation rates) showed higher coral cover (60 - 90%) than areas of the flat where sedimentation was lower.

It is a fact that distribution of main reef builder at Chola reef is highly patchy. Patchiness has been attributed to successional processes after disturbances (Connell and Slayter 1977, Foster 1980) and also has been recognized as an important preserver of diversity in intertidal and subtidal communities (Connell 1983). It is among these patches where most fish fauna tends to congregate at Chola reef; only few corallivores and grazers wander along the low coverage areas. If associated fauna contributes to control coral cover at Chola reef is not yet completely clear. However, high cover patches display a great number of territorial damselfish (*Stegastes acapulcoensis* Fowler) which constantly defended their algal lawns against corallivore and herbivore intruders. Low coverage areas on the other hand, face predatory and foraging activities mainly from the tetraodontid, *Arothron meleagris* (Bloch and Scheneider) and the triggerfish, *Pseudobalistes naufragium* (Jordan and Starks). It is possible that this activities have enhanced the development of dense patches and slow the recovery of dead areas.

Coral recruitment is also directly correlated with coral distribution; specially *Pocillopora* where fragmentation seems to constitute the primary means of reproduction in the Eastern Pacific (Richmond 1987, but see Glynn *et al.* 1991). Lack of mother colonies and perhaps high predation and grazing activities as observed in Galápagos and Panamanian reefs after El Niño 1982-83 (Glynn 1988, Glynn 1990), may also have been responsible for erosion and low coral cover present in Chola and Diego reefs.

Human induced disturbances have also caused coral demise at Utría reefs. Small scale land slides, coastal erosion and thus increased siltation have been the results of forest clearing and soil movements near Chola reef. These type of uncontrolled practices have not only threatened but killed entire reefs along the eastern Pacific (Prahl *et al.* 1979, Cortés and Murillo 1985, Cortés 1990). Furthermore, large craters (1.0 - 1.5 m diameter) along the outer Chola reef flat and seaward slope are the evidence of dynamite blasts implemented several years ago as fishing technique. Finally, coral communities at Utría have not been immune to coral collecting and plundering, specially by handcrafters who sell these items as souvenirs in nearby villages.

Within the north portion of the Pacific coast of Colombia, Utría can be considered as one of the most important coral development sites. It is characterized by high coral species richness (for the eastern Pacific) in a relative small area. However, present day ecological structure suggests that these communities have been severely disturbed. Fortunately, the area was declared as a National Park in October 1987. Therefore as long as human deleterious influence is reduced, and with the help of a feasible management plan, coral community recovery may be possible at Utría.

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RESUMEN

En el Parque Nacional Ensenada de Utría hay dos tipos de comunidades coralinas existen; los arrecifes de borde que se desarrollan en el interior de la ensenada y las formaciones en los bancos rocosos en las zonas externas. El arrecife de la Chola es la formación de mayor tamaño (aprox. 10.5 ha), con una cobertura coralina promedio relativamente alta (32.4%) dominada por *Pocillopora damicornis*. Más pequeño en tamaño (aprox. 1.5 ha), el arrecife de Diego está compuesto principalmente por algas incrustantes y una baja cobertura viva de *Psammocora (S.) stellata* (2%). Las otras comunidades que no forman arrecifes, muestran un desarrollo importante de corales masivos como: *Pavona clavus*, *P. gigantea* y *Porites lobata*. El deterioro de las comunidades coralinas de Utría es evidente, especialmente en los arrecifes, donde perturbaciones severas tanto naturales como antropogénicas (e.g. probablemente El Niño 1982-83, mareas rojas, sedimentación inducida por humanos, pesca con dinamita), parecen controlar la estructura y composición de éstas formaciones.

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