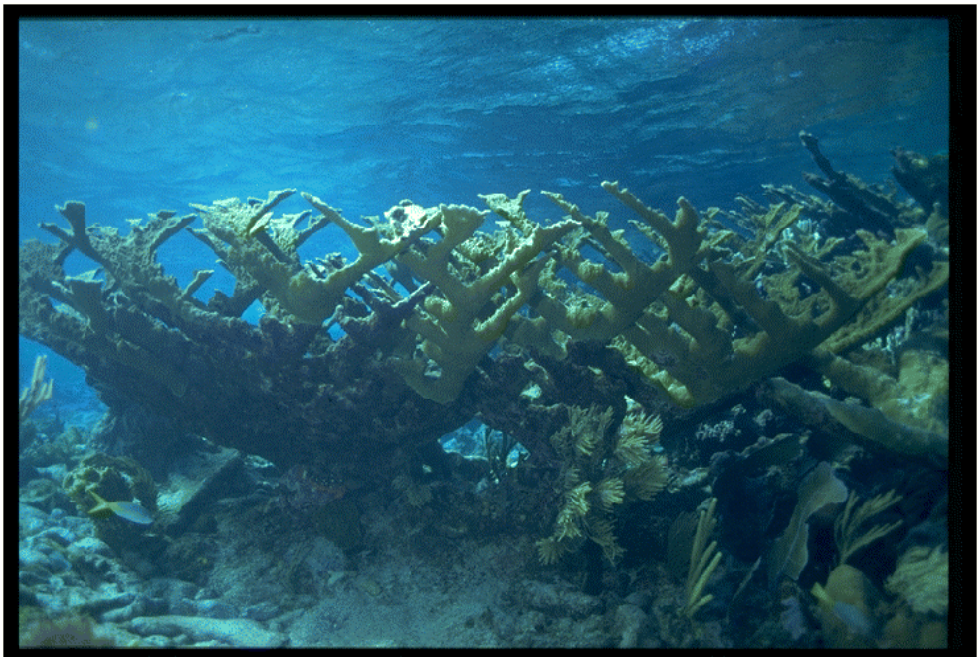
Classification Scheme for Marine Habitats of Belize



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Section 1. Introduction and Overview

1. Background

Generally speaking, the term "habitat" has a variety of meanings which differ according to a person's scientific discipline or personal preference. For example, an ecologist might equate habitat types with physical conditions such as gradients of wave exposure or inundation whereas a geologist may wish to place greater emphasis on geomorphology.

Many habitat classification schemes for tropical marine environments comprise several types of data. It is not uncommon to find a scheme based on a mixture of geomorphology, dominant substrata and species composition. This mixed approach essentially describes the distinguishing physiognomic properties of various habitats as seen underwater and / or from remote sensing. For example, "spur and groove" zones are clearly distinguishable from "dense seagrass beds" on an aerial photograph. However, this approach exhibits the short coming that data and descriptions are not consistent across the range of habitat types. Labeling an area as "dense seagrass" conveys biological information which lends itself to a biological interpretation (e.g. the expected species assemblages, productivity, etc.). Conversely, whilst a "spur and groove" zone may be visualised easily, this label does not provide any information about the species which inhabit the zone. In short, such habitat labeling constitutes an inconsistency when describing coastal biodiversity.

The concept of habitat embodied here is not dissimilar to previous approaches but the structure is systematic. Habitat may be defined as a description of benthic geomorphology and the associated composition of species (or life-forms) and substrata. Each habitat type thus possesses a geomorphological and benthic component and this is reflected by the labels assigned in this scheme.

A classification scheme should have the following properties:

- be clear and unambiguous
- be easily understood with intuitively interpretable classes.
- have a hierarchical structure to reflect different user needs and understanding and accommodate wider (e.g. regional) plans.
- have an objective basis, particularly at finer scales where the differences between classes become progressively subtle.
- be easily summarised for use in accuracy assessment and rapid field-survey.

Perhaps the most comprehensive classification scheme of recent years is that for the Tropical Pacific Islands (Holthus and Maragos, 1995). The scheme has a regional focus and encompasses many geomorphological categories. As such, it is too complex for practical usage at national and local scales. Whilst the scheme described here will fit into such a regional scheme, our focus is country-specific. At its most detailed level, the Pacific classification of Holthus and Maragos (1995) highlights, but does not define, "ecological units". The benthic classes described here are analogous to their ecological units although we define those for Belize in full (though this will be extended). A more detailed discussion of the role of habitat classification in coastal management is provided by Mumby and Harborne (1999).

2. Geomorphological classes

2.1 Defining geomorphological classes

The geomorphological classes used in this classification scheme are based on the relevant categories from Holthus and Maragos (1995).
The geomorphological classes are:

1. Backreef
2. Reef crest
3. Spur and groove
   - 3.1 Low relief spurs and grooves
   - 3.2 High relief spurs and grooves
4. Forereef
5. Escarpment
6. Patch reef
   - 6.1 Dense patch reef
   - 6.2 Diffuse patch reef
7. Lagoon floor
   - 7.1 Shallow lagoon floor
   - 7.2 Deep lagoon floor

Detailed descriptions of the geomorphological classes are given in Section 4 (Geomorphological Classes).

2.2 Hierarchical structure

The geomorphological component of the classification has a two-tiered structure. The terse level includes seven major classes which should be directly applicable to most remotely sensed imagery. Where appropriate, these categories are divided into more specific classes which will usually require extensive field data before they can be included on habitat maps.

3. Benthic classes

3.1 Defining benthic classes

Plant ecologists have classified species assemblages for many years (see Greig-Smith, 1983) and a variety of multivariate analyses exist for this purpose. More recently, these methods have been adopted by marine ecologists and provide a useful tool for objectively determining assemblages of species / substrata. Most of the reef classes described here were originally derived by clustering quantitative data from the Turks and Caicos Islands. 200 sites were surveyed using a minimum of six replicate 1 m^2 quadrats per site (Mumby *et al*., 1997). Cluster analysis of these data provided natural groupings of sites according to their species composition and substrata. To paraphrase Clarke (1993), "the data were allowed to tell their own story". These groups (clusters) were then examined in more detail to describe benthic categories. Benthic assemblages were derived at a species level but, for simplicity, a life-form level has been used to highlight the dominant characteristics of each class. However, characteristic species have been included in the descriptions of each class for added clarity.

Most of the classes described quantitatively from the Turks and Caicos are also found in Belize and this was verified using cluster analysis of ordinal (semi-quantitative) data collected by Coral Cay Conservation (CCC). CCC use volunteer divers to collect data in preparation for the establishment of marine protected areas throughout Belize. CCC's data provided an additional (semi-quantitative) means of describing benthic classes from the Turks and Caicos and also revealed new classes not previously reported. Definitions of the ordinal scale used by CCC are given in Table 1. Although these data are not as accurate as quadrat data, they have been shown

to be precise and appropriate for multivariate analyses (Mumby *et al*., 1995; Mumby *et al*., 1996). Seagrass habitats were derived from the draft classification scheme for Belize (CZMP, 1996).

Table 1. Definition of categories in the DAFOR scale used for surveying the benthos.

Category	Description
5	**D**ominant
4	**A**bundant
3	**F**requent
2	**O**ccasional
1	**R**are
0	Absent

DAFOR categories and percent cover values are correlated but not equivalent because DAFOR implicitly reflects the number of colonies (i.e. frequency) of a species or lifeform whereas percent cover concerns total cover irrespective of the number of colonies. Thus, we have provided both the mean percent cover and median DAFOR category of the characteristic species / lifeforms in each benthic class. The following numerical descriptors are given:

- mean density of soft corals,
- mean percent cover of characteristic benthic substrata and life-forms (although the mean values do not necessarily sum to 100%),
- median abundance category of characteristic benthic substrata and life-forms.

These descriptors allow the scheme to be applied to data arising from a wide range of survey techniques including quadrats, line and point-intercepts and CCC's standard survey protocol (CCC, 1995).

It is vital to understand the intended spatial scale of the classification scheme because the description of a habitat is scale dependent. For example, 2 m of sand followed by 2 m of sheet coral would comprise two separate habitats when viewed at the scale of metres. However, if viewed at a larger scale, it may be apparent that the patch of coral was surrounded by 50 m of sand, and therefore constituted a minor component of the seabed. To make the scheme consistent with general habitat mapping, the intended spatial scale is identical to the pixel size of a SPOT XS satellite sensor; 20 m x 20 m. In practice, surveyors should aim to estimate the relative frequencies / percent cover (depending on survey method) of obvious substrata and organisms within a 20 m square box.

The benthic classes described here are:

1. Coral classes
    - 1.1 Branching corals
    - 1.2 Sheet corals
    - 1.3 Ribbon and fire corals with green calcified algae
    - 1.4 Massive and encrusting corals
        - 1.4.1 Sparse massive and encrusting corals (1-5% coral cover)
        - 1.4.2 Dense massive and encrusting corals (> 5% coral cover)

2. Algal dominated
    - 2.1 Green algae
    - 2.2 Fleshy brown algae and sparse gorgonians (= 3 gorgonians m^{-2})
    - 2.3 *Lobophora*

2.4 *Euchema* and *Amphiroa*

3. Bare substratum dominated
   - 3.1 Bedrock / rubble and dense gorgonians (> 3 gorgonians m^{-2})
   - 3.2 Bedrock / rubble and sparse gorgonians (= 3 gorgonians m^{-2})
   - 3.3 Rubble and sparse algae
   - 3.4 Sand with sparse algae
   - 3.5 Mud
   - 3.6 Bedrock

4. Seagrass dominated
   - 4.1 Sparse seagrass (standing crop 1-10 $g.m^{-2}$; cover <30 %)
   - 4.2 Medium density seagrass (standing crop 11-80 $g.m^{-2}$; cover 30-70 %)
   - 4.3 Dense seagrass (standing crop >80 $g.m^{-2}$; cover >70 %)
   - 4.4 Seagrass with distinct coral patches

Detailed descriptions of the benthic classes are given in Section 5 (Benthic Classes).

3.2 Hierarchical structure

The benthic component of the classification scheme has a three-tiered hierarchical structure. The first (simplest) divides the benthos into classes dominated by either algae, bare substratum or seagrass or those where hard coral cover is diagnostic. This level should be applicable to remotely sensed imagery with little additional field data. Each of these four categories have been divided into several more detailed classes and occasionally further divided into sub-classes. Some of these detailed classes are not distinguishable in satellite imagery or aerial photography and can only be labeled where supported by field data.

It should be borne in mind that the hierarchical structure does not follow the hierarchical structure of the cluster analysis precisely. This is because some classes need to be assigned on an intuitive basis. For example, the following three classes clustered together on the dendrogram (i.e. their benthic composition was similar): "massive and branching corals", "bedrock and medium / dense gorgonians" and "bedrock, sparse gorgonians and algae". The first of these classes represents the “typical” coral forereef community. Like most reefs of the Western Atlantic, however, coral cover only reaches a maximum of approximately 30% and is in fact dominated by bare substratum (40%). To include such a class in the "bare substratum" category would possibly lead to confusion during surveying. For the purposes of conceptualisation, it has been moved to the "coral classes" group despite not being truly dominated by coral. No class was quantitatively dominated by hard corals (i.e. using percent cover) reflecting the overall dominance of macroalgae on Caribbean reefs (Hughes 1994). However, to describe reefs with the highest coral cover as *algal-dominated* may be politically unacceptable and confuse interpretation (*pers. obs.*). Thus, we have sacrificed systematic accuracy to aid intuitive acceptance of the scheme, adding the caveat that algal-dominated and bare substratum dominated reefs must have less than 1% coral cover.

4. Defining habitat classes

The derivation of habitat classes is summarised in Figure 1. However, users of the scheme should not need to repeat this procedure when assigning new field data to habitat types. This is because class attributes are described in sections 3-5 and most habitats should be recognisable with a quick visual assessment of the sea bed (e.g. using a class-bottomed bucket). The following guidelines should prove useful when employing the scheme:

- Individual couplings of geomorphological and benthic classes are not unique. For example, the forereef can be associated with a variety of benthic classes including bare substratum and those dominated by algae or corals.
- Where assignment of a label is uncertain, the designation should reflect this. For example, if the incline of the forereef is not known, the geomorphological component should be simply labeled as "forereef". Similarly, additional field data can refine the habitat map by allowing the use of more specific classes. For example, "massive and encrusting corals" may be refined to "sparse massive and encrusting corals".
- Where assignment of a label (or part of a label) is unknown, it should be indicated accordingly. The correct designation of such areas may be clarified at a later date.

Geomorphological classes and benthic classes are coupled using the "+" sign. Some example of habitat labels would therefore include:

- shallow lagoon floor + sparse seagrass
- reef crest + branching corals
- forereef + dense massive and encrusting corals

5. Extending the scheme

The scheme is not complete and requires review and input from other institutions conducting coastal surveys in Belize. The following modifications and additions are planned or suggested:

- further subdivision of some classes
- further survey work to extend and check the percent cover and median values given for each class
- provision of further photographic examples of each geomorphological and benthic class. These can be added as hard copy or on CD-ROM.

6. References

CCC. 1995. An overview of the methods used by Coral Cay Conservation for the mapping of marine habitats. pp 29.

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CZMP. 1996. Proposed classification system for Belize marine environments (to be expanded). UNDP / GEF Coastal Zone Management Project report. 1 pp.

Greig-Smith, P. 1984. Quantitative plant ecology. Blackwell Scientific Publications, Oxford. 359 pp.

Holthus, P.F and Maragos, J.E. 1995. Marine ecosystem classification for the Tropical Island Pacific. In Maragos, J.E. *et al*. (eds). Marine and Coastal Biodiversity in the Tropical Island Pacific Region. East West Center, Hawaii. pp. 239-278.

Hughes, T.P. 1994, Catastrophes, phase shifts and large-scale degradation of a Caribbean coral reef. Science **265**: 1547-1551.

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Mumby, P.J., Clarke, K.R. and Harborne, A.R. 1996. Weighting species abundance estimates for marine resources assessment. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **6**: 115-120.

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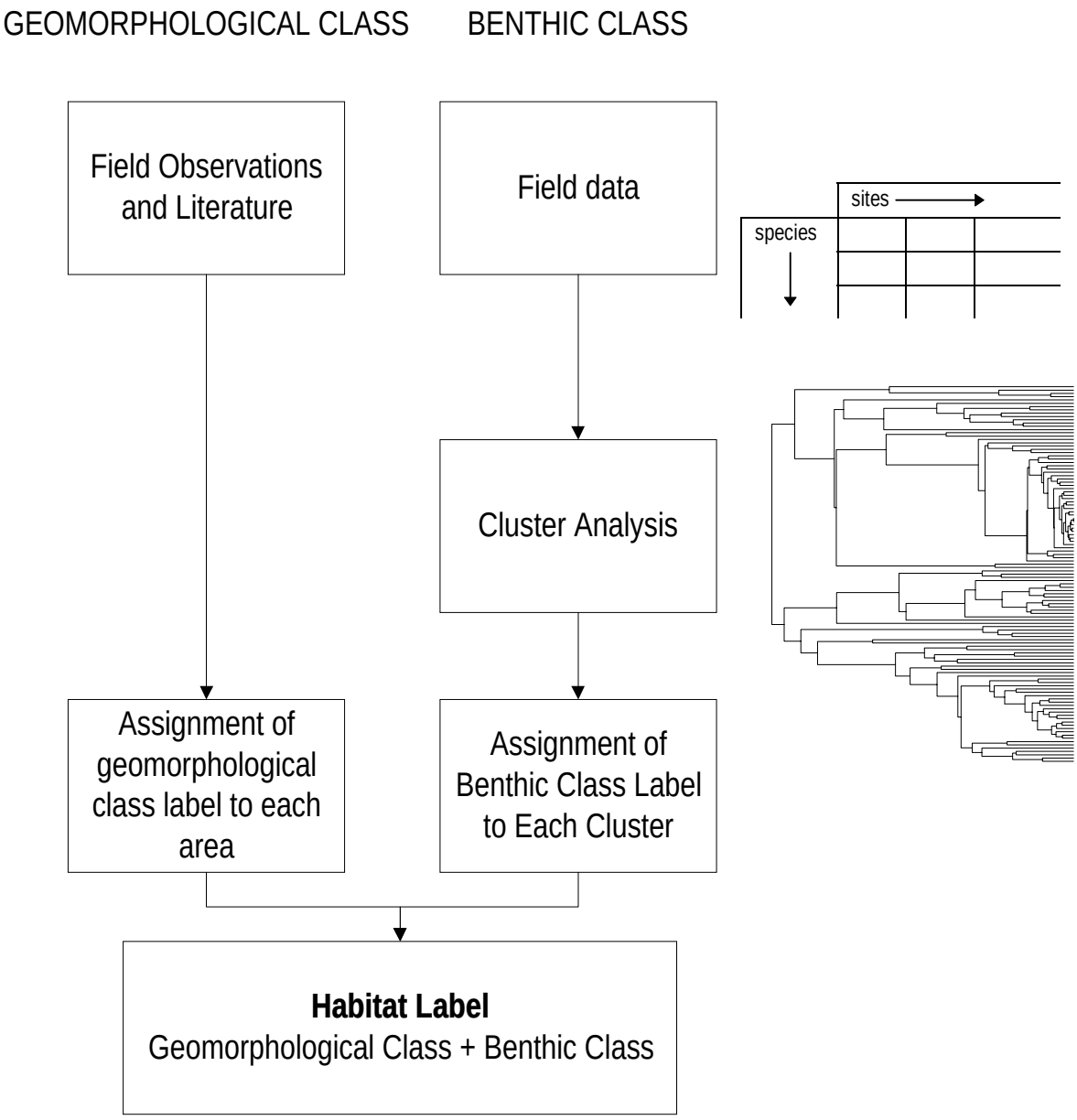

Figure 1. Derivation of habitat classification scheme

Section 2. Introduction to Class Descriptions

Sections 3, 4 and 5 consist of pages describing in detail the life-form categories used in this classification scheme, the geomorphological classes and the benthic classes respectively. To aid clarity of the scheme, each page contains a description and at least one photographic example of the life-form or class. The descriptions of each geomorphological and benthic class are divided into the following sections:

1. Description

The characteristic and dominant features of each class are described in tables using mean percent cover and median abundance categories of species, lifeforms and substrata, and densities (No. m^{-2}) of soft corals. * denotes that a category is likely to be present within a particular class but that it is not considered to be characteristic of that class. Photographs of typical examples are © Coral Cay Conservation or Peter Mumby unless otherwise stated.

2. Synonyms

In order to allow this classification scheme to be applied to earlier habitat maps, the synonyms for each geomorphological and benthic class have been listed. These were derived from the following classification schemes and reef descriptions which were either specifically for Belize or for the whole Caribbean:

Aronson R.B., Precht W.F. 1995. Landscape patterns of reef coral diversity: A test of the intermediate disturbance hypothesis. Journal of Experimental Marine Biology and Ecology **192**: 1-14.

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Gill A.B, Harborne A.R., Vierros M., Raines P.S. and Ridley J.M. 1996. Bacalar Chico Marine Reserve Project. Final report to the European Union. pp 62.

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McCorry D., Mumby P.J., Raines P.S. and Ridley J.M. 1993. South Water Cay Marine Reserve draft management plan. pp 122.

Mumby P.J., Baker M.A., Raines P.S. and Phillips A.T. 1994. The potential of SPOT panchromatic imagery as a tool for mapping coral reefs. *Proceedings of the Second Thematic Conference on Remote Sensing of Marine and Coastal Environments*. New Orleans. **1**: 259-267.

Rützler K. and Macintyre I.G. 1982. The habitat distribution and community structure of the barrier reef complex at Carrie Bow Cay, Belize. *Smithsonian Contributions to the Marine Sciences* **12**: 9-45.

Stoddart D.R. 1962. Three Caribbean atolls: Turneffe Atolls, Lighthouse Reef and Glover's Reef, British Honduras. *Atoll Research Bulletin* **87**:1-151.

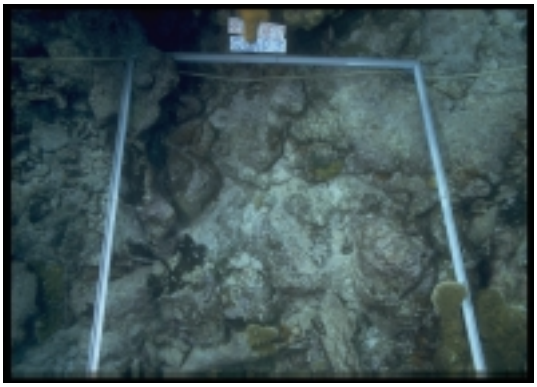
Sullivan K.M., Chiappone M., Delgado, G. and Schmitt, E. 1994. Rapid ecological assessment methodologies for marine ecosystems in the tropical Western Atlantic. TNC, Florida and Caribbean Marine Conservation Science Center, Coral Gables, Florida. pp 153.

3. Distributions

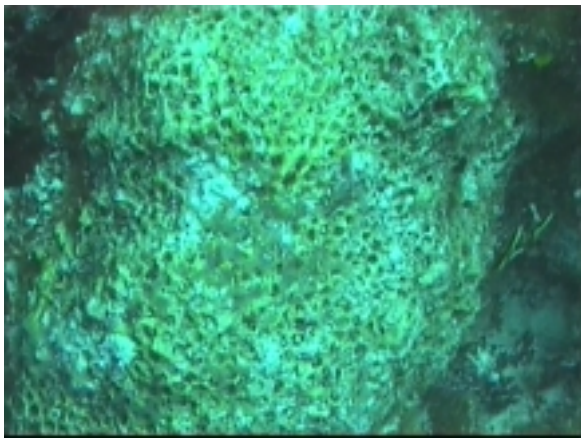
The distributions for each geomorphological and benthic class are based on (i) the authors' experience of the reef and atolls of Belize, (ii) the national map of marine habitats of Belize and (iii) existing literature and reports. The aim is to expand these sections following discussions with other researchers, further survey work and further remote sensing studies.

Section 3. Substratum and Biological Categories

Bedrock



Bedrock is defined as any exposed area of hard bare substratum without visible corallite structure.



Dead Coral

Dead Coral is defined as any area of hard bare substratum with visible corallite structure.
Photograph © Peter Mumby

Rubble

Rubble is defined as any area of loose bedrock or hard substratum.

Sand

Sand is defined as coarse sediment (diameter ≥1 mm).

Mud

Mud is defined as fine sediment (diameter <1 mm).

Hard Coral

Hard coral is defined as any scleractinian coral which secretes a calcified skeleton.

Gorgonian

Gorgonian is defined as any living colony in the order Alcyonacea (octocorals).

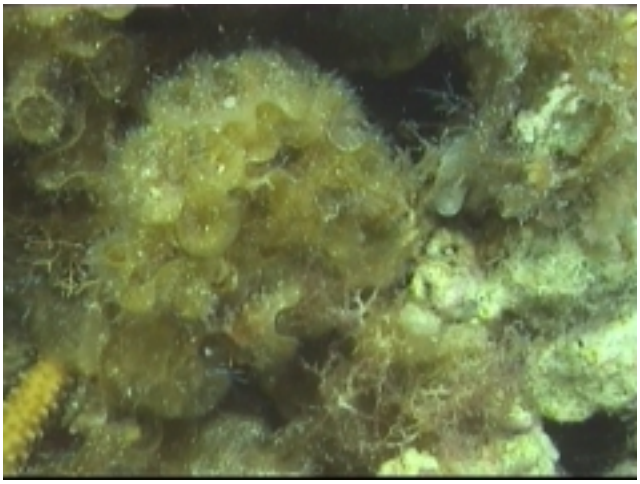
Sponge

Sponge is defined as any living member of the phylum Porifera. The life-forms used in this scheme are: tube (e.g. *Aplysina fistularis*), vase (e.g. *Callyspongia plicifera*), barrel (e.g. *Xestospongia muta*), rope (e.g. *Aplysina fulva*) and encrusting (e.g. *Clathria* spp.).

Green algae (non-calcareous)

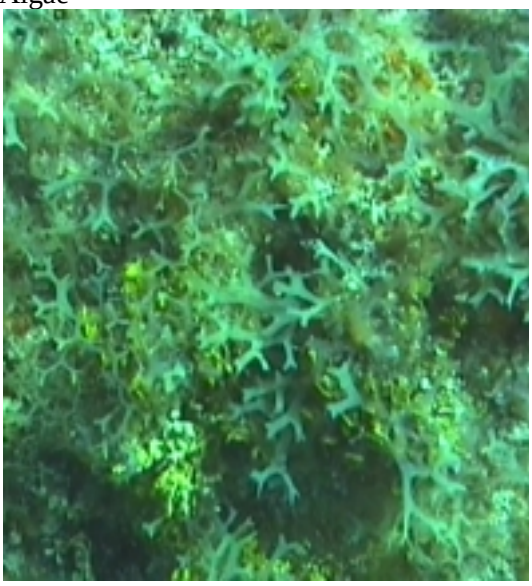
Green algae (non-calcareous) is defined as any chlorophyte which forms dense mats or turfs on the benthos (e.g. *Microdictyon marinum*).
Photograph © Edmund Green

Brown Fleshy Algae



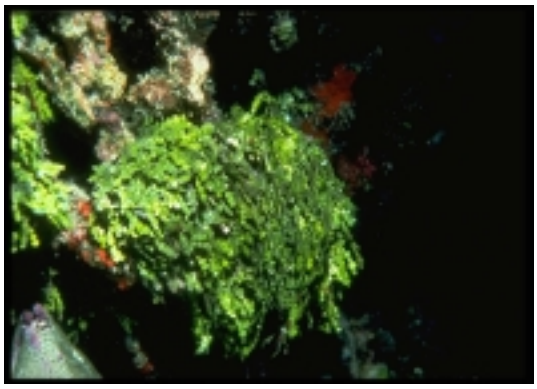
The term brown fleshy algae refers to phaeophytes with fleshy blades (e.g. *Lobophora variegata*, *Padina* spp.)
Photograph © Peter Mumby

Red / Brown Branching Algae



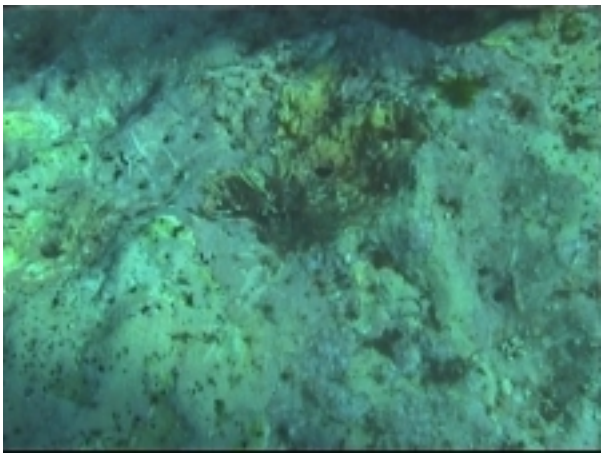
Red / brown branching algae is defined as any rhodophyte or phaeophyte with a branching morphology (e.g. *Laurencia* sp., *Dictyota* spp.).
Photograph © Peter Mumby

Green Calcified Algae



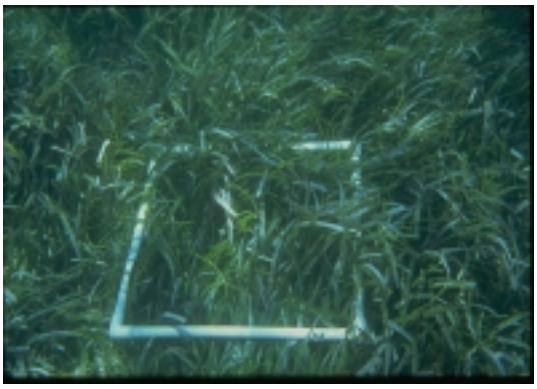
Green calcified algae is defined as any chlorophyte forming a calcareous skeleton (e.g. *Halimeda* spp., *Rhipocephalus* spp., *Penicillus* spp., *Udotea* spp.).

Red (crustose) Coralline Algae



Red coralline algae is defined as any rhodophyte forming a calcareous crustose skeleton (e.g. *Porolithon pachydermum*, *Sporolithon episporum*, *Hydrolithon boergesenii*).
Photograph © Peter Mumby

Seagrass

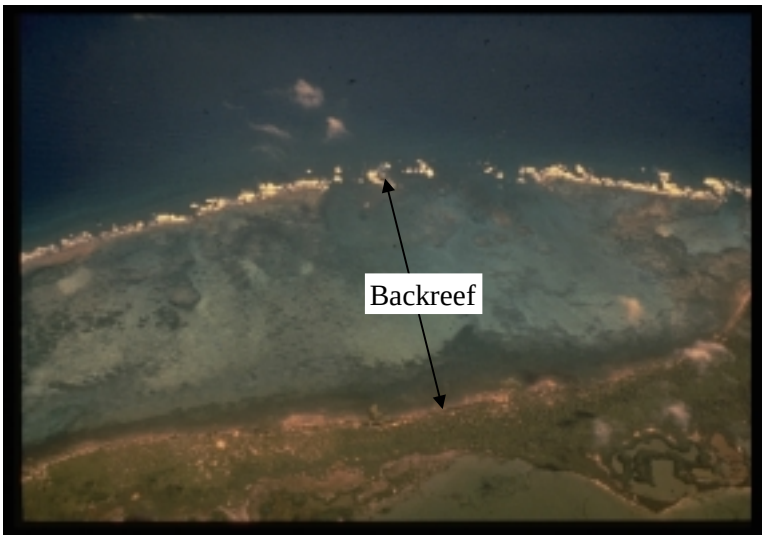


Seagrass is defined as any marine angiosperm (flowering plant). Dominant genera are *Thalassia* and *Syringodium* but the genera *Halophyla* and *Halodule* are also found in Belize.
Photograph © Edmund Green

Section 4. Geomorphological Classes

1. BACKREEF

Typical example



Description

Backreef is an obvious shallow zone which lies between the reef crest and lagoon (or land, for example, if near a Cay). It usually forms a pavement of hard substratum with or without rubble. Where there is no distinct backreef zone between the reef crest and the lagoon (e.g. behind reef cuts), the backreef category should not be used.

Synonyms

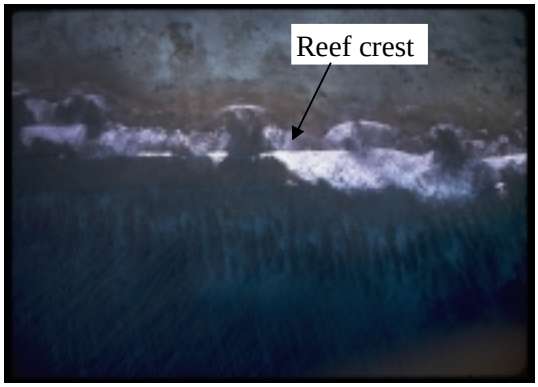
The use of “backreef” is consistent among schemes.

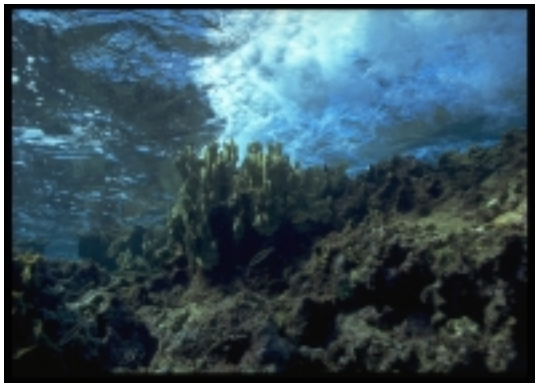
Distribution

Backreef is found along most of the barrier reef, some areas of Turneffe and is very pronounced around Glovers and Lighthouse atolls.

2. REEF CREST

Typical examples





Description

Reef crest is the shallowest and often emergent part of the reef and separates the forereef from the backreef and lagoon. Breaks in the reef where the crest is absent are known as “cuts”. The reef crest absorbs much wave energy and is an important coastal defence.

Synonyms

The use of “reef crest” is consistent among schemes.

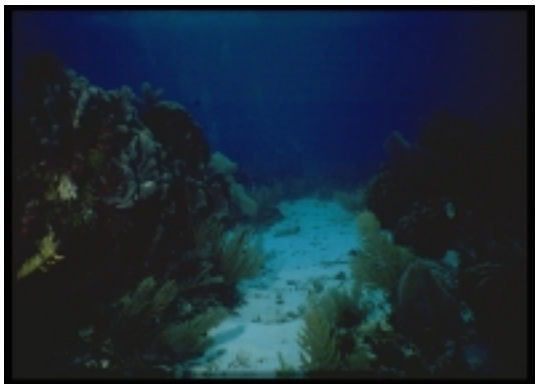
Distribution

Reef crest is found throughout the barrier reef and atolls.

3. SPUR AND GROOVE

Incorporates: 3.1 Low relief spur and groove and 3.2 High relief spur and groove

Typical examples



3.1 Low relief spur and groove

3.2 High relief spur and groove

Description

3. *Spur and Groove*
Spurs are usually formed by accreting hard corals and calcified green algae whereas the grooves usually contain sand or bare bedrock.
3.1 *Low relief spur and groove*: height of spurs < 5 m. Most commonly located immediately seaward of the reef crest at an orientation of 90° (i.e. at right angles to the reef crest). Wave energy can be high. For a more detailed description see Aronson and Precht (1995).
3.2 *High relief spur and groove*: height of spurs > 5 m. Much larger structures than the above and usually associated with the edge of the forereef, near the escparment. Make popular dive sites.

Synonyms

3.2 *High relief spur and groove* "Buttress and Valley" (Holthus and Maragos, 1995); "Spurs and grooves" (Gill *et al*., 1996).

Distribution

3.1 *Low relief spur and groove*: throughout barrier reef, some parts of Glovers Reef, and the north, east and south sides of Turneffe Atoll. Distribution on Lighthouse reef unknown.
3.2 *High relief spur and groove*: Caye Caulker, Ambergris Cay (including Hol Chan), some parts of Turneffe Atoll, Gladden Entrance.

4. FOREREEF

Typical examples

Description

Forereef is any area of the reef with an incline of between 0 and 45 degrees

Synonyms

Forereef is equivalent to: “outer fore-reef sub-zone” (McCorry *et al*., 1993), “inner fore reef” and included in “outer fore reef” (Rützler and Macintrye, 1982).

Distribution

Forereef is found seaward of the reef crest along the length of the barrier reef and the fringing reef at Turneffe, Lighthouse and Glovers atolls.

5. ESCARPMENT

Typical examples

Description

Escarpment is defined as any area of the benthos whose angle of slope exceeds 45°. While it is often associated with the drop-off wall of the barrier reef and atolls, its use is not confined to such areas (e.g. it applies to the sides of rhomboid reefs in the lagoon).

Synonyms

The use of “escarpment” is consistent among schemes. The term drop-off is synonymous with escarpment.

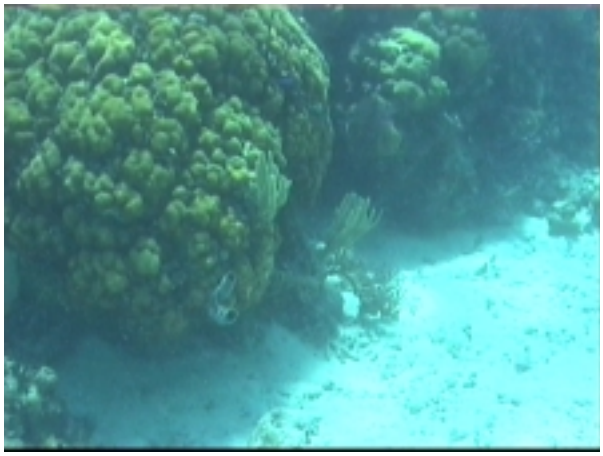
Distribution

Escarpment is found throughout the length of the barrier reef, around the atolls, and around rhomboid reefs. Steep escarpments are also found throughout the lagoon. Escarpments are difficult to represent on maps because their principal orientation is in the vertical plane (rather than the horizontal plane mapped using remote sensing).

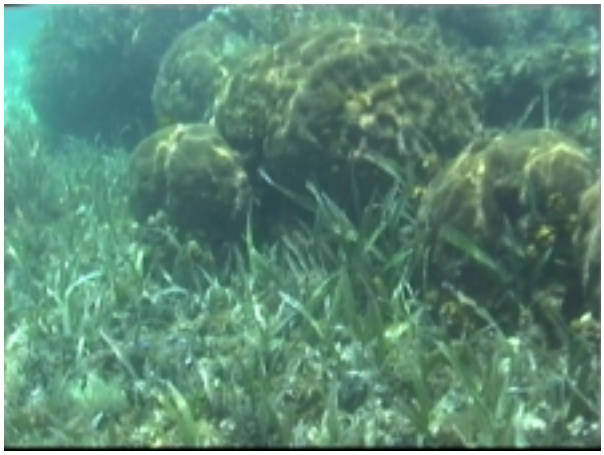
6. PATCH REEF

Incorporates: 6.1 Dense patch reef and 6.2 Diffuse patch reef

Typical examples



6.1 Dense patch reef



6.2 Diffuse patch reef

Description

6. *Patch reef*
Coral formations in the lagoon which are surrounded by either seagrass, sand or algae. Although patch reefs are usually formed by hard corals, the term still applies to areas where coral has died and is now colonised by other organisms (e.g. macroalgal dominated patch reefs at Glovers Atoll).
6.1 *Dense patch reef*: Area of aggregated coral colonies (living or dead) where colonies cover >70% of benthos. The remaining substratum within the patch (i.e. the substratum between groups of colonies) may include sand, seagrass or macroalgae. The patch is often surrounded by a halo of sand.
6.2 *Diffuse patch reef*: Area of dispersed coral colonies where <30% of benthos is covered by coral colonies. The remainder of the substratum is usually sand, seagrass or macroalgae.

Synonyms

The use of “patch reef” is consistent among schemes.

Distribution

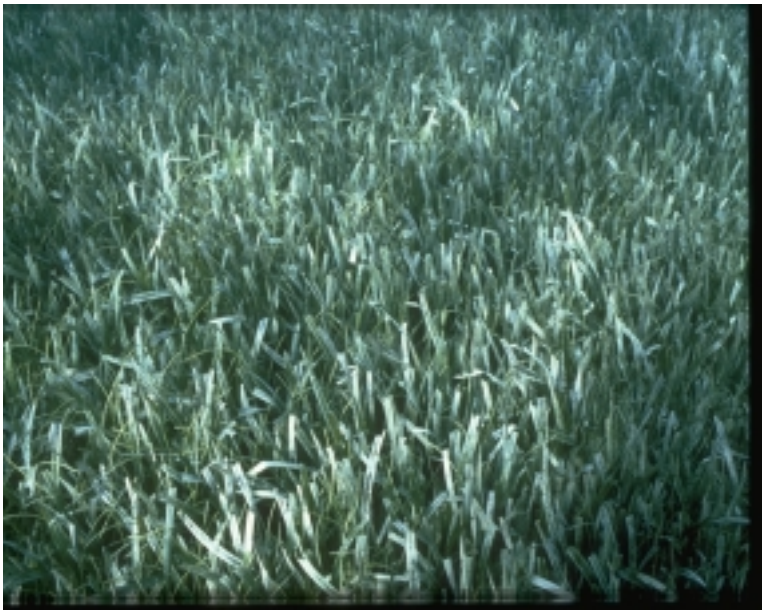
Patch reefs are distributed ubiquitously throughout Belize.

View of dense patch reefs from the surface. Note the cover of sand between clusters of corals.

7. LAGOON FLOOR

Incorporates: 7.1 Shallow lagoon floor and 7.2 Deep lagoon floor

Typical examples



Description

7. *Lagoon floor*
The lagoon floor where the angle of slope does not exceed 45°.
7.1 *Shallow lagoon floor*: depth <12 m.
7.2 *Deep lagoon floor*: depth >12 m.

A depth threshold of 12 m was chosen and this roughly corresponds to a change in benthic class from seagrass to mud.

Synonyms

The use of “lagoon” is consistent among schemes.

Distribution

7.1 *Shallow lagoon floor*: throughout continental shelf and atolls
7.2 *Deep lagoon floor*: mainly confined to the Inner Channel and Glovers Reef.

Section 5. Benthic Classes

Section 5 contains detailed descriptions of the four benthic categories and the 19 benthic classes contained within this classification scheme. The flow diagram on the following page provides an overview of these categories and classes and the key diagnostic features. The flow diagram is intended to familiarise the user with the benthic categories and classes prior to using the scheme, and also as a key for use during fieldwork. It is recommended that users copy and laminate the key for use either from a boat or during diving and snorkelling surveys.

1. CORAL CLASSES

As mentioned in the introduction, the coral classes are not always dominated by hard corals in terms of percent cover. Very few coral reefs in the Caribbean are truly *dominated* by hard corals yet to avoid calling any reef a *coral reef* would possibly confuse the intuitive understanding of the scheme. Therefore, the key diagnostic feature when assigning this category (and the individual classes 1.1 - 1.4) is a hard coral cover of greater than 1%, but which will normally be greater than 5% and may exceed 40%. Although a coral cover of 1% is low, coral colonies will still be obvious to a superficial inspection. This contrasts with the algal and bare substratum dominated classes where hard corals will not be apparent to a surveyor without a close examination of the benthic community.

The majority of coral dominated areas will have a diverse assemblage of soft corals and sponges although their abundance will vary widely. “Brown fleshy”, “Red / Brown branching”, “Green calcified”, and “Red coralline” algae are ubiquitous and may attain 40% cover in some cases. Bedrock and dead coral tend to be the most abundant substratum categories but rubble and sand are both likely to be present.

2. ALGAL DOMINATED

As stated above, most coral reefs of the Caribbean are in fact dominated by algae but referring to the areas populated by corals as “algal reefs” might be unacceptable politically and contravene standard practice. Therefore, the distinction made here between coral classes and algal-dominated is artificial, and the category algal-dominated is restricted to areas where algae dominate but hard coral cover is less than 1%. Algal cover may often be significantly higher than 50% and in some areas will be greater than 90%. The algal community may be dominated by one functional form (e.g. “Green calcifiedf”) or be comprised of a variety of categories.

Some hard corals may be present (but always at much less than 1% cover) and soft corals and sponges are usually visible and may even be diagnostic in some benthic classes. Seagrass may be present but coverage will always be less than 10%. The bare substratum will vary greatly between the benthic classes encompassed by this benthic category but will rarely exceed 30%.

3. BARE SUBSTRATUM DOMINATED

The bare substratum dominated benthic category is assigned to areas where the coverage of bare substratum exceeds 50% but may also be used where bare substratum cover is dominant but does not reach 50%. The category incorporates individual benthic classes which are dominated by either “Bedrock”, “Rubble”, “Sand” or “Mud” and in some cases the percentage cover may reach 100%.

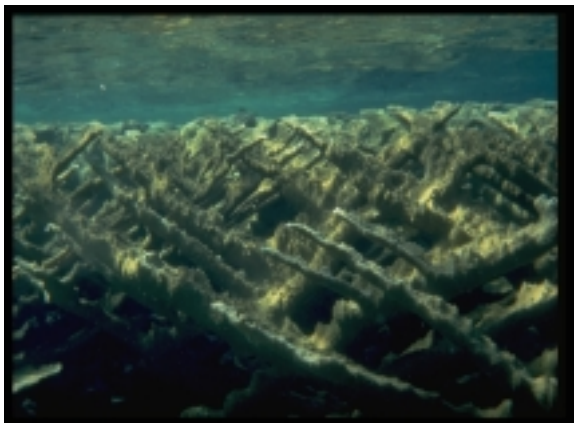
Hard corals may be present at low densities but their cover does not exceed 1%. Soft corals are the characteristic feature of benthic class 3.1 (Bedrock / rubble and dense gorgonians) but are often absent in other bare substratum dominated areas. Algae, of all growth forms, tend to be found in most areas assigned to this benthic category but rarely exceeds 10% cover. Seagrass may be present but will have much less than 10% cover.

4. SEAGRASS DOMINATED

The seagrass dominated benthic category is used for any area where seagrass cover exceeds 10%. Benthic classes 4.1 - 4.3 represent an incremental increase in seagrass cover up to a maximum of 100%. The substratum is usually sand or mud. With the exception of areas assigned to benthic class 4.4 (Seagrass with distinct coral patches) hard corals are either absent or infrequent and usually restricted to a few species. Soft corals and sponges may be present along with some algae, particularly the growth forms “Red / brown branching” and “Green calcified”.

1.1 BRANCHING CORALS

Typical examples



Description

This benthic class is visually dominated by patches of either *Acropora palmata* or *Acropora cervicornis* and occasionally by both species. If *A. palmata* dominates, other characteristic hydrocoral and coral species include *Millepora alcicornis, M. complanata, Agaricia tenuifolia, Diploria clivosa, Siderastrea radians* and *Dichocoenia stokesii*. Algal growth is abundant, particularly red coralline algae, brown fleshy algae and green calcified species such as *Halimeda opuntia*. Soft corals are present, particularly *Pseudoplexaura* spp. and *Gorgonia ventalina*. The encrusting sponge life form is the most common. The substratum is dominated by rock and dead coral. Stands of *A. cervicornis* are usually found in deeper, usually less turbulent water than *A. palmata* and are associated with small massive corals such as *Porites astreoides* and *Montastraea* spp., greater cover of brown fleshy algae and upright sponges.

	Substratum					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	*	50	*	*		30†	*	20		*	*	*	*
Median cover	*	2	*	*		2.5	*	1.5		*	*	*	*

† this benthic class tends to be extremely patchy and percent cover of coral may vary greatly between quadrats

Synonyms

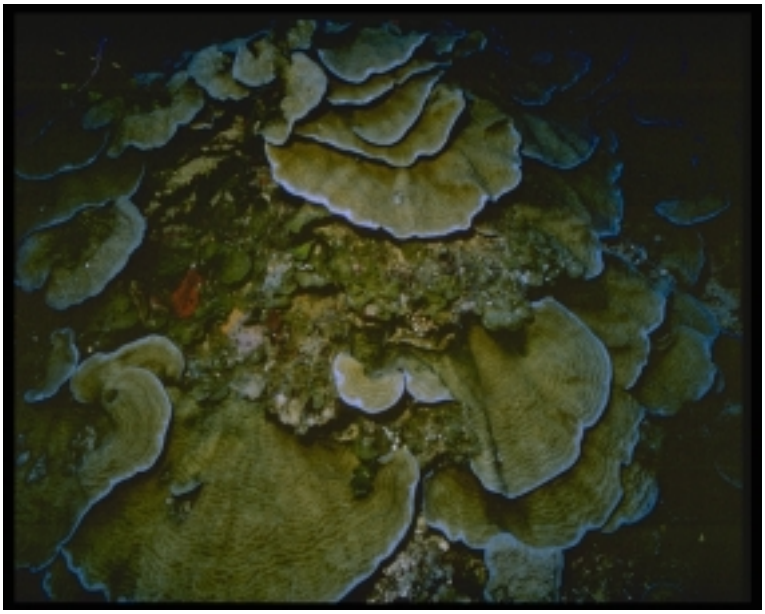
This benthic class is equivalent to "Acropora reef" (McCorry *et al*., 1993); "palmata zone", “cervicornis zone”, "mixed reef zone", and "mixed palmata zone" (Stoddart, 1962); “habitat 6” and “habitat 8” (Hay, 1981).

Distribution

The distribution of branching corals differs for *A.palmata* and *A.cervicornis*. *A. palmata* is ubiquitous along the length of the barrier reef and atolls where it is often the characteristic benthic community near the reef crest. Small patches of *A.cervicornis* are found throughout Belize but only constitute entire polygons on a habitat map where large aggregations are found, such as on the forereef of rhomboid reefs (e.g. the Pelican Cays).

1.2 SHEET CORALS

Typical examples



Description

This benthic class is characterised by colonies of *Agaricia lamarcki*, *A. grahamae*, *A. undata* or *A. purpurea*. Although coral cover may not be dominant, the coral community is diverse including *Montastraea annularis*, *M. cavernosa*, *Meandrina meandrites*, *Porites astreoides*, *Siderastrea siderea*, *Agaricia agaricites*, and *Colpophyllia natans*. Soft corals are abundant and usually include colonies of *Iciligorgia schrammi*. Algae tend to dominate the benthos, particularly the brown fleshy alga, *Lobophora variegata*, *Dictyota* spp., and *Halimeda* species. The sponge community is abundant and diverse. The substratum is dominated by bedock and dead coral. The sheet coral class is particularly common in deeper water and is usually associated with escarpments.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	20	*				20	2 m^{-2}	10		40	15	20	*
Median cover	2	*				2.5	2	2		3	2	3	*

Synonyms

This benthic class is equivalent to "coral drop-off" (Gill *et al.*, 1996).

Distribution

The sheet corals benthic class is usually restricted to the escarpment (drop-off) of the barrier reef and atolls. Individual colonies of sheet corals are common on most escarpments but this class should only be used where they are the dominant hard coral species.

1.3 RIBBON AND FIRE CORAL WITH GREEN CALCIFIED ALGAE

Typical examples

Description

This benthic class is dominated by *Agaricia tenuifolia* and algae from the genus *Halimeda*. Brown fleshy and red / brown branching algae are usually present. In shallow water some colonies of *Acropora* palmata, *Porites porites*, and *Millepora* spp. may be common. This class is often associated with the spurs of low relief spur and groove zones (for more detailed description, see Aronson and Precht, 1995).

	Substratum categories					Biological categories							
	Bedock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	*	10	*	*		40	*	10		15	*	20	
Median cover	*	1	*	*		3.5	*	1		1.5	*	2.5	

Synonyms

This benthic class is equivalent to "*Agaricia* / *Acropora* / *Millepora* reef" (McCorry *et al*., 1993); "reef-crest (*Agaricia*) zone" (Stoddart, 1962).

Distribution

The ribbon and fire corals with green calcified algae benthic class is commonly found in shallow water (both on the reef and in the back reef) along the length of the barrier reef. It is often located immediately seaward of a branching corals benthic class, dominated by *Acropora palmata*. It has also been found occasionally on Turneffe Atoll.

1.4 MASSIVE AND ENCRUSTING CORALS

Incorporates: 1.4.1 Sparse massive and encrusting corals & 1.4.2 Dense massive and encrusting corals

Typical examples

1.4.1 Sparse massive and encrusting corals

1.4.2 Dense massive and encrusting corals

Description

1.4 *Massive and encrusting corals* consists of a diverse community of species. The commonest coral species include *Montastraea annularis*, *M. cavernosa*, *Siderastrea siderea*, *Dichocoenia stokesii*, *Agaracia agaricites*, *Porites* spp., *Diploria* spp., and *Millepora alcicornis*. Fleshy brown algae, red/brown branching algae and green calcified algae are abundant. Soft corals are also common, particularly *Pseudoplexura* spp and *Pseudopterogorgia* spp. The substratum is dominated by bedrock and sand.

1.4.1 *Sparse massive and encrusting corals*: hard coral cover 1-5%.
1.4.2 *Dense massive and encrusting corals*: hard coral cover >5%.

Whilst branching, sheet and ribbon corals may be present, this benthic class is distinguished from classes 1.1 to 1.3 because none of these corals achieve visual dominance. *Sparse massive and encrusting corals* may be confused superficially with benthic class 3.2, *bedrock / rubble, sparse gorgonians, and algae (< 3 gorgonians m^{-2})* as these classes are similar. The main diagnostic feature of the latter class is the virtual absence of hard corals (<< 1% cover) while the former has > 1% coral cover which is visually apparent.

		Substratum categories					Biological categories							
		Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
1.4.1	Mean % cover	60	5	10	*		4	*	5		*	20	10	
	Median cover	2.5	1	1.5	*		2	*	1		*	2	1.5	
1.4.2	Mean % cover	40	*	*			18	8 m^{-2}	5		10	20	15	*
	Median cover	2	*	*			3	2	1		1.5	2.5	2	*

Synonyms

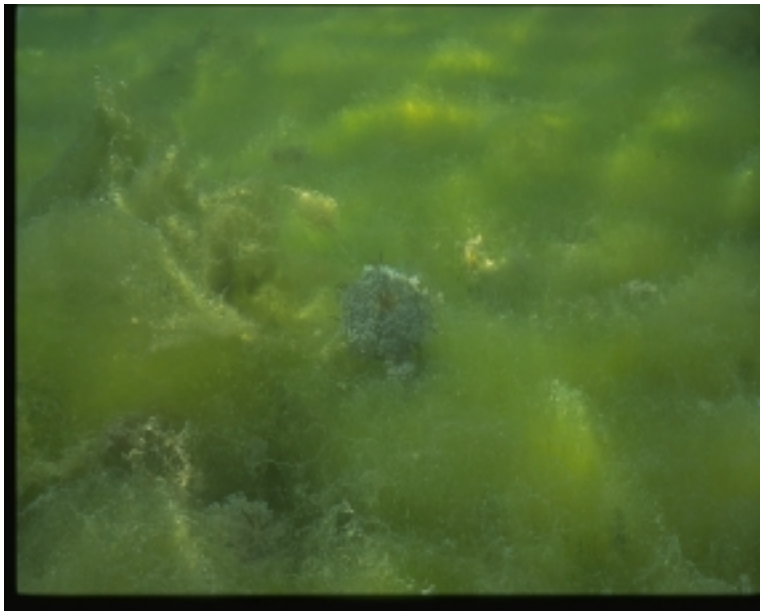
1.4 Massive and encrusting corals: is equivalent to "sand and coral matrix" (Gill *et al*., 1996); "live hard coral/gorgonians and sand" (McCorry *et al*., 1993); "live hard coral, dead coral and Halimeda derived sediment" (McCorry *et al*., 1993); "Montastrea reef" (Mumby *et al*., 1994); "inner reef zone", "Annularis zone", "main reef zone" (Stoddart, 1962).
1.4.1 Sparse massive and branching corals: is equivalent to "Gorgonian rich *Montastrea* reef" (McCorry *et al*., 1993); "low density sand and coral matrix" (CCC, 1995).
1.4.2 Dense massive and encrusting corals: is equivalent to "*Montastrea* reef" (McCorry *et al*., 1993); "high density sand and coral matrix" (CCC, 1995).

Distribution

1.4 Massive and encrusting corals is ubiquitous along the length of the barrier reef and atolls where it is often the dominant class on the forereef. The dense class tends to be more common than the sparse class on the forereef but less common on the backreef and lagoon.

2.1 GREEN ALGAE

Typical examples



Photographs © Matt Weedon and Edmund Green

Description

This benthic class is usually dominated by non-calcareous species such as *Microdictyon marinum* and *Cladophora prolifera* but calcareous genera such as *Halimeda* may also dominate. Habitats dominated by calcareous and non-calcareous green algae are not separated in the classification scheme because they cannot be distinguished reliably using remote sensing. However, surveyors may wish to make an additional note of the type of green algae since non-calcareous forms are capable of overgrowing corals and the extent of such habitats should be monitored. Gorgonians such as *Pseudoplexaura* spp., *Pseudopterogorgia* spp., and *Gorgonia ventalina* may also be common.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	5	*	*	5		*	7 m^{-2}	*	80	6	*	*	
Median cover	1	*	*	1		*	2.5	*	4	2	*	*	

Synonyms

This benthic class has not been previously described in Belize.

Distribution

The distribution of this class is poorly known but has been reported from rhomboid reefs and eutrophic shallow lagoons near mangrove stands (*pers. obs.*).

2.2 FLESHY BROWN ALGAE AND SPARSE GORGONIANS

Typical examples

Photograph © Edmund Green

Description

This benthic class is dominated by a high abundance of fleshy brown algae, particularly from the genera *Lobophora*, *Padina*, *Turbinaria*, and *Sargassum.* The gorgonians *Pseudoplexaura* spp., *Pseudopterogorgia* spp. and *Gorgonia ventalina* are present at fairly low densities (≤ 3 m^{-2}). The dominant underlying and exposed substrata are hard comprising of either dead coral, rubble or bedrock. Algal cover rarely exceeds 70%.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	<======	20	======>	*		*	2 m^{-2}	*	*	50	20	*	
Median cover	<======	2	======>	*		*	1.5	*	*	3.5	2	*	

Synonyms

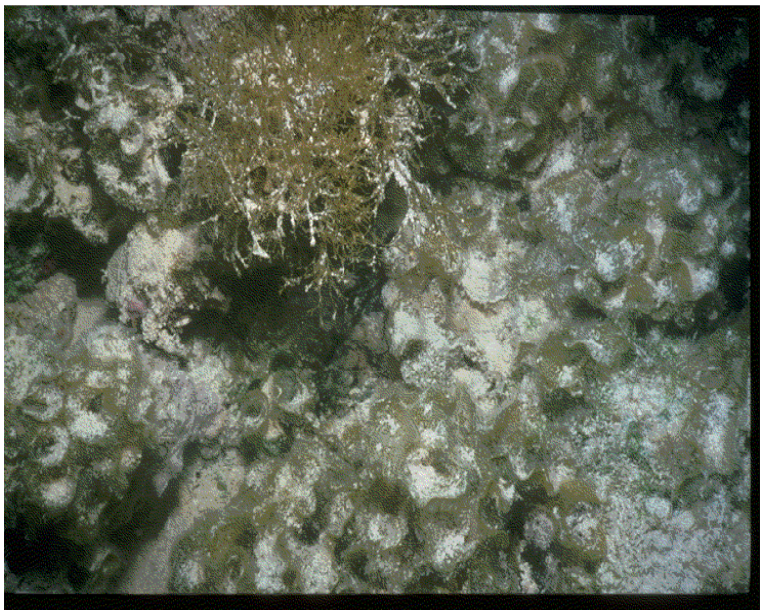
This benthic class is equivalent to "*Turbinaria* and *Porites* on carbonate pavement" (McCorry *et al.*, 1993); "*Turbinaria-Sargassum* rubble" (Macintyre *et al.*, 1987)

Distribution

This class can be found on backreefs and forereefs throughout the barrier reef and atolls (especially where the forereef is flat - e.g. Gladden entrance). It is also common on patch reefs at Glovers atoll.

2.3 *LOBOPHORA*

Typical examples



Photograph © Edmund Green

Description

The fleshy brown alga, *Lobophora variegata*, can form large monospecific beds in some lagoon and rhomboid reef areas associated with the barrier reef. In these areas, the alga has a foliose morphology (above) and can attain a percent cover of 100%. Scattered gorgonians may also be present.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover				5	*		*			90	*		
Median cover				1	*		*			5	*		

Synonyms

This benthic class is equivalent to “Sand bores and *Lobophora*” (McCorry *et al.*, 1993).

Distribution

This class is found almost exclusively in lagoon habitats. It is most abundant south of South Water Cay where it is found between the backreef and mangrove islands. It is also found near mangrove habitats, near the Inner Channel, and near the backreef on Glovers atoll.

2.4 *EUCHEMA* AND *AMPHIROA*

Typical examples

Note: *Amphiroa* with sponge (left), *Euchema* on seagrass and sponge (right)

Photographs © Edmund Green and Peter Mumby

Description

This benthic class is often made up of the calcified red algae *Amphiroa*, calcified green algae such as *Penicillus* spp., encrusting sponge, and sparse *Thalassia*. The alga *Euchema*, which is used to make the drink "seaweed", lies above the substratum. This class is found in sheltered, shallow lagoon environments.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Brown fleshy	Red / brown branching	Green calcified	Red coralline	Seagrass
Mean % cover				30			*	20	*	30	5	40	4
Median cover				2.5			*	2	*	2.5	1	3	1

Synonyms

This benthic class has not been previously described in Belize.

Distribution

The distribution of the *Euchema* and *Amphiroa* benthic class is poorly understood. It is known to exist in the backreef of Glovers Atoll but its extent is unknown.

3.1 BEDROCK / RUBBLE AND DENSE GORGONIANS

Typical examples

Description

This benthic class is dominated by bare bedrock or rubble and visually dominated by dense soft corals (> 3 m^{-2}), particularly *Pseudoplexaura* spp., *Pseudopterogorgia* spp. and *Gorgonia ventalina*. Few hard corals exist, differentiating this benthic class from 1.4.2.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	60	*	10	*		<1	8 m^{-2}	10		5	10	10	*
Median cover	3.5	*	1	*		0.5	4	1.5		0.5	1.5	1.5	*

Synonyms

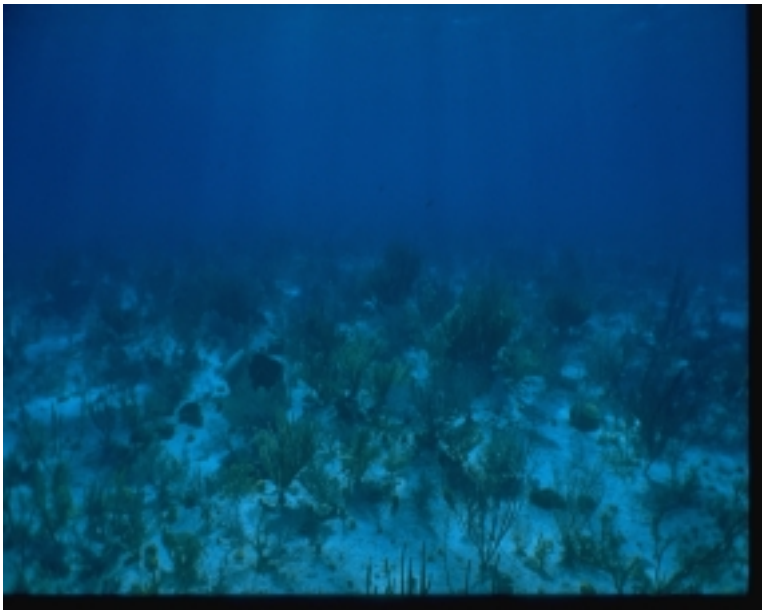
This benthic class is equivalent to "gorgonian plain", and "hard bottom with mixed corals, sponges and algae" (Gill *et al*., 1996); "dense hard-bottom communities" (Sullivan *et al*., 1994).

Distribution

This benthic class is known from the northern province of the barrier reef (particularly at Ambergris Cay), the northern section of Turneffe Atoll, and around the crests of some rhomboid reefs.

3.2 BEDROCK / RUBBLE AND SPARSE GORGONIANS

Typical examples



Photograph © Edmund Green

Description

This benthic class is dominated by bedrock which can exceed 80% cover. Gorgonians are common at low to medium densities (≤ 3 m^{-2}), particularly *Pseudoplexaura* spp., *Pseudopterogorgia* spp. and *Gorgonia ventalina*. Hard coral and algal cover is low. The class is distinguished from 1.4.1. by virtue of having much less than 1% hard coral cover (i.e. in practice, hard corals cannot easily be seen).

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	80			*		<<1	3 m^{-2}	*	*	*	*	*	
Median cover	4			*		0.5	2	*	*	*	*	*	

Synonyms

This benthic class is equivalent to "sparse hard-bottom communities" (Sullivan *et al*., 1994).

Distribution

This benthic class is known from the shallow forereef (<10m) of Ambergris Cay and forms wide “gorgonian plains” near rhomboid reefs.

3.3 RUBBLE AND SPARSE ALGAE

Typical examples

Photograph © Edmund Green

Description

The substratum of this benthic class is dominated by rubble and sand. Some red or brown branching algae, red crustose coralline algae, *Halimeda* spp., and seagrass may be present.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Brown fleshy	Red / brown branching	Green calcified	Red corallin e	Seagrass
Mean % cover	*	*	80	10		*			*	5	1	7	*
Median cover	*	*	4.5	1		*			*	1.5	1	1	*

Synonyms

This benthic class is equivalent to "sparse mixed community on rubble" (Gill *et al*., 1996); "reef rubble communities" (Sullivan *et al*., 1994); "sand & rubble zone" (Rützler and Macintyre, 1982.

Distribution

The rubble and sparse algae benthic class is known to exist on the back reef at Bacalar Chico and the barrier reef and on the escarpment of some rhomboid reefs.

3.4 SAND AND SPARSE ALGAE

Typical examples

Description

This benthic class is dominated by sand (over 90% cover). There is usually some sparse algae, particularly green algae (calcified or not calcified), and red or brown branching algae.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover			*	90	*				2	*	6	5	*
Median cover			*	5	*				0.5	*	1	1	*

Synonyms

This benthic class is equivalent to "sand with sparse mixed algae", "sand with algae and gorgonians", and "sand drop-off" (Gill *et al*., 1996); "sand", and "halophytic zone" (McCorry *et al*., 1993); "sand bed" (CCC, 1995); "sandy algal canopy" and "mixed algal canopy" (Sullivan *et al*., 1994);"deep sand" (Mumby *et al*., 1994); “bare sand” and “*Laurencia-Acanthophora* sand and gravel” (Macintyre *et al*., 1987).

Distribution

The sand and sparse algae benthic class is distributed ubiquitously throughout Belize.

3.5 MUD

Typical examples

Description

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Seagrass
Mean % cover				*	100							*	*
Median cover				*	5							*	*

Synonyms

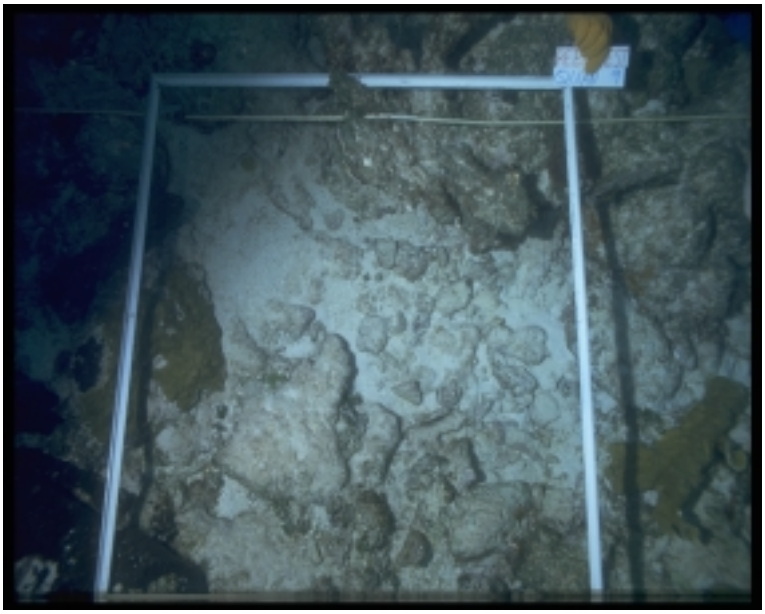
This benthic class is equivalent to "Algal dominated (*Penicillus* and *Udotea* spp.), sparse coverage" in McCorry et al., (1993).

Distribution

Mud is found in the Inner Channel and in the lagoon on Glovers atoll at a depth exceeding approximately 16 m.

3.6 BEDROCK

Typical examples



Description

In this benthic class, bedrock may attain 95% cover and often has a pavement-like appearance. The class is usually associated with areas of high turbulence (e.g. reef crests) where the cover of living organisms is low (< 10%). In reef crest areas, red crustose coralline algae such as *Porolithon pachydermum* tend to be common.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Red coralline
Mean % cover	90	*	*			*		*	*			*	10
Median cover	5	*	*			*		*	*			*	2

Synonyms

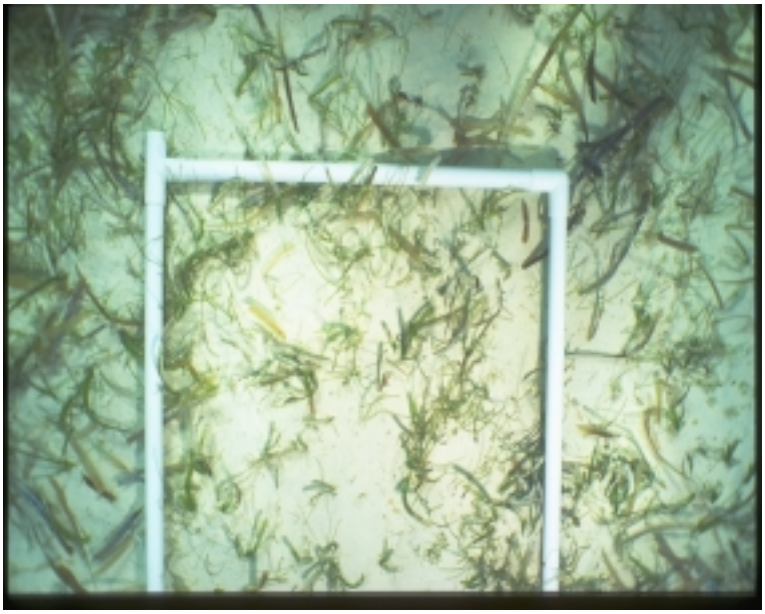
This benthic class is equivalent to “coralline-coral-*Dictyota* pavement” (Macintyre *et al*., 1987).

Distribution

This benthic class is most commonly found at the reef crest throughout the barrier reef and atolls.

4.1 SPARSE SEAGRASS

Typical example



Photograph © Edmund Green

Description

This benthic class is dominated by seagrass from the genera *Halodule*, *Halophila* and *Syringodium* and low densities of the genus *Thalassia*. Standing crop (dry weight) is 1-10 $g.m^{-2}$ and seagrass cover is < 30%. Corals are usually absent. Algae from the genera *Batophora*, *Laurencia*, *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand or mud.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Seagrass
Mean % cover				70	*			*	*		*	*	10-30
Median cover				4	*			*	*		*	*	1.5

Synonyms

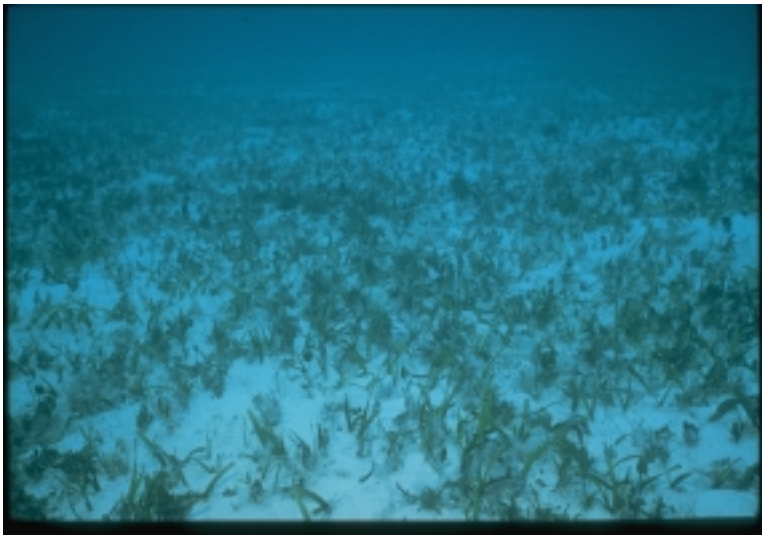
This benthic class has not been described explicitly in Belize.

Distribution

Sparse seagrass is found throughout the coastal zone of Belize.

4.2 MEDIUM DENSITY SEAGRASS

Typical examples



Photograph © Edmund Green

Description

This benthic class is dominated by seagrass from the genera *Syringodium* and *Thalassia*. Standing crop biomass is 11-80 $g.m^{-2}$ and cover is 30-70%. Some corals may be present, particularly *Manicina areolata*, *Siderastrea radians* and *Porites* spp. Some gorgonians from the genera *Pseudopterogorgia* and *Pterogorgia* may be present. Algae from the genera *Laurencia*, *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand - mud.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Seagrass
Mean % cover				60	*	*	*	*			*	*	30-70
Median cover				3	*	*	*	*			*	*	2.5

Synonyms

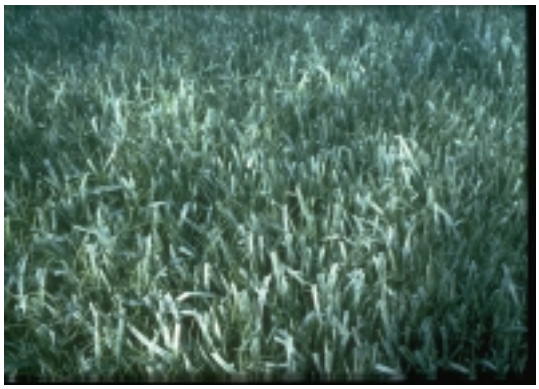
This benthic class is equivalent to "medium to dense seagrass" (Gill *et al*., 1996); "Porites / algae / seagrass" (McCorry *et al*., 1993); "seagrass bed" (CCC, 1995); "moderate to dense seagrass communities" (Sullivan *et al*., 1994); "seagrass" (Mumby *et al*., 1994); "sand & sea grass zone" (Rützler and Macintyre, 1982); "sand and rubble platform adjacent to cay" and "lagoon" (Stoddart, 1962).

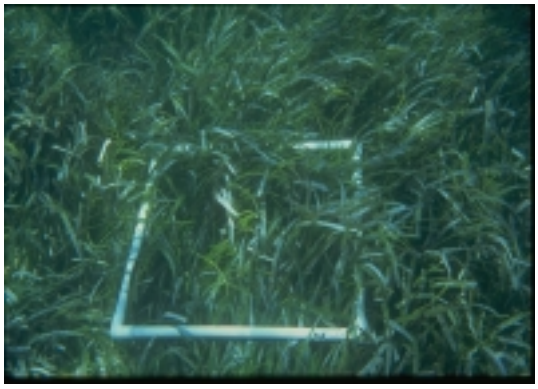
Distribution

Medium density seagrass is found throughout the coastal zone of Belize.

4.3 DENSE SEAGRASS

Typical examples





Photographs © Edmund Green

Description

This benthic class is dominated by seagrass from the genera *Syringodium* and *Thalassia*. Standing crop biomass is > 80 $g.m^{-2}$ in most areas but can exceed 300 $g.m^{-2}$ near mangrove systems (e.g. at Turneffe Atoll). Seagrass cover is > 70%. Algae from the genera *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand or mud.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Seagrass
Mean % cover				10	*						*	*	70-100
Median cover				1	*						*	*	4

Synonyms

This benthic class has not been described explicitly in Belize.

Distribution

Medium density seagrass is found throughout the coastal zone of Belize.

4.4 SEAGRASS WITH DISTINCT CORAL PATCHES

Typical examples

Description

Where aggregations of soft corals and / or hard corals are found interspersed with seagrass, the benthic class is referred to as “Seagrass with distinct coral patches”. Other seagrass classes (4.1-4.3) may have occasional solitary colonies of *Manicina areolata*, but these do not constitute aggregations. This benthic class is usually coupled with the geomorphological classes *diffuse patch reef* (if the benthos includes hard corals) or *lagoon floor* (if hard corals are absent). It may seem inconsistent that hard coral cover can exceed the 1% threshold of coral-dominated classes described above. An exception has been here for intuitive reasons; while corals may attain 3% cover, the visually dominant feature is still seagrass.

The commonest hard coral species are *Porites astreoides*, *Montastraea annularis*, *M. cavernosa*, *Siderastrea siderea*, *Dichocoenia stokesii* and *Millepora alcicornis*. Soft corals may be dominated by *Pseudoplexaura* spp. and *Gorgonia ventalina*.

	Substratum categories					Biological categories							
	Bedrock	Dead coral	Rubble	Sand	Mud	Hard coral	Soft coral	Sponge	Green algae	Brown fleshy	Red / brown branching	Green calcified	Seagrass
Mean % cover	*	*	*	*		< 3†	5 m^{-2}	*		*	*	*	*
Median cover	*	*	*	*		2†	2	*		*	*	*	*

† where the aggregations are dominated by soft corals, this is not appropriate.

Synonyms

This benthic class is equivalent to "seagrass with distinct coral heads" (Gill *et al*., 1996).

Distribution

This class is known to exist in the back reef at Bacalar Chico and is found widely around the rhomboid reefs such as the Pelican Cays.

Section 6. National Marine Habitat Map and Common Habitats

1. UNDP/GEF Coastal Zone Management Project's National Marine Habitat Map of Belize

This classification scheme was developed as a companion to the National Marine Habitat Map of Belize. This map was produced by Hugo Matus (UNDP/GEF Coastal Zone Management Project), Peter Mumby (University of Sheffield), Alastair Harborne (Coral Cay Conservation) and Edmund Green (University of Newcastle upon Tyne). The map was funded by the UNDP/GEF Coastal Zone Management Project and partly funded by a grant from the UK Department for International Development to the universities of Sheffield and Newcastle upon Tyne. The Land Information Centre (Ministry of Natural Resources) provided Landsat TM data for the barrier reef.

Field data collection was aided by: Alberto Patt (Hol Chan Marine Reserve), Coral Cay Conservation, The Wildlife Conservation Society, International Zoological Expeditions, Stephanie Auil-Marshlleck (CFRAMP), Gilly Llewellyn (Harvard University) and Jon Ridley (Coral Cay Conservation).

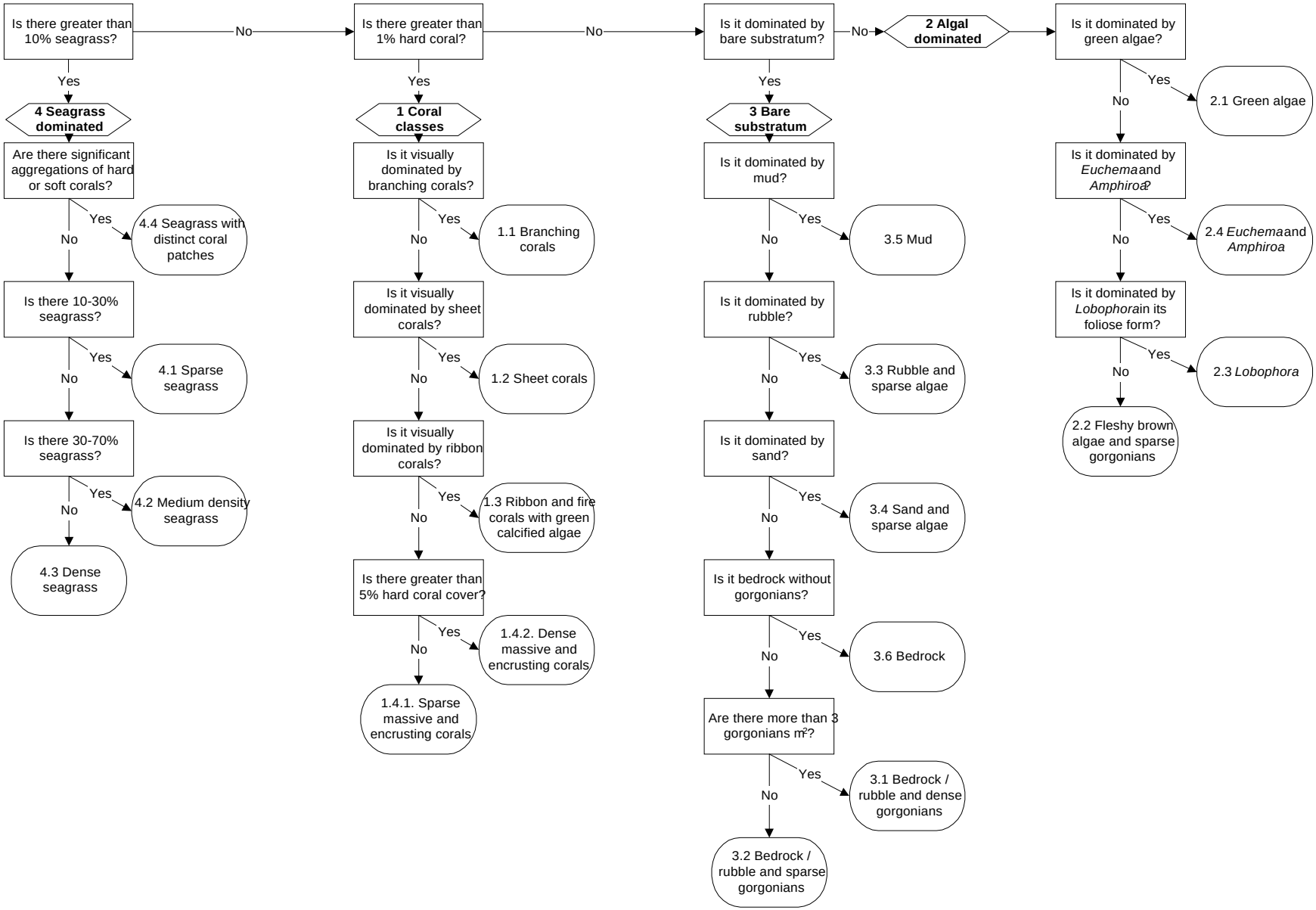
Enquiries concerning this map should be directed to Hugo Matus, Data Analyst for the UNDP/GEF Belize Coastal Zone Management Project.

2. Common Habitats

Field studies and preliminary examination of the National Marine Habitat Map suggest that the following habitats are most common.

Geomorphological Class	Benthic Class
Backreef	Fleshy brown algae and sparse gorgonians
Backreef	Sand and sparse algae
Backreef	Sparse massive and encrusting corals (<5% coral cover)
Reef crest	Branching corals
Reef crest	Fleshy brown algae and sparse gorgonians
Low relief spur and groove	Ribbon and fire corals with green calcified algae
High relief spur and groove	Dense massive and encrusting corals (>5% coral cover)
Forereef	Bedrock / rubble and dense gorgonians (>3 gorgonians m^{-2})
Forereef	Bedrock / rubble and sparse gorgonians (<3 gorgonians m^{-2})
Forereef	Dense massive and encrusting corals (>5% coral cover)
Forereef	Sparse massive and encrusting corals (<5% coral cover)
Forereef	Sand and sparse algae
Dense patch reef	Dense massive and encrusting corals (>5% coral cover)
Dense patch reef	Fleshy brown algae and sparse gorgonians
Diffuse patch reef	Seagrass with distinct coral patches
Diffuse patch reef	Sparse massive and encrusting corals (<5% coral cover)
Shallow lagoon floor	Dense massive and encrusting corals (>5% coral cover)
Shallow lagoon floor	Bedrock / rubble and dense gorgonians (>3 gorgonians m^{-2})
Shallow lagoon floor	Bedrock / rubble and sparse gorgonians (<3 gorgonians m^{-2})
Shallow lagoon floor	Dense seagrass

Shallow lagoon floor	Medium dense seagrass
Shallow lagoon floor	Sparse seagrass
Shallow lagoon floor	Seagrass with distinct coral patches
Deep lagoon floor	Sparse seagrass
Deep lagoon floor	Mud


Is there greater than 10% seagrass?
No
Is there greater than 1% hard coral?
No
Is it dominated by bare substratum?
No
2 Algal dominated
Is it dominated by green algae?
Yes
4 Seagrass dominated
Are there significant aggregations of hard or soft corals?
Yes
4.4 Seagrass with distinct coral patches
No
Is there 10-30% seagrass?
Yes
4.1 Sparse seagrass
No
Is there 30-70% seagrass?
Yes
4.2 Medium density seagrass
No
4.3 Dense seagrass
Yes
1 Coral classes
Is it visually dominated by branching corals?
Yes
1.1 Branching corals
No
Is it visually dominated by sheet corals?
Yes
1.2 Sheet corals
No
Is it visually dominated by ribbon corals?
Yes
1.3 Ribbon and fire corals with green calcified algae
No
Is there greater than 5% hard coral cover?
Yes
1.4.2. Dense massive and encrusting corals
No
1.4.1. Sparse massive and encrusting corals
Yes
3 Bare substratum
Is it dominated by mud?
Yes
3.5 Mud
No
Is it dominated by rubble?
Yes
3.3 Rubble and sparse algae
No
Is it dominated by sand?
Yes
3.4 Sand and sparse algae
No
Is it bedrock without gorgonians?
Yes
3.6 Bedrock
No
Are there more than 3 gorgonians m2?
Yes
3.1 Bedrock / rubble and dense gorgonians
No
3.2 Bedrock / rubble and sparse gorgonians
Yes
2.1 Green algae
No
Is it dominated by Euchema and Amphiroa?
Yes
2.4 Euchema and Amphiroa
No
Is it dominated by Lobophora in its foliose form?
Yes
2.3 Lobophora
No
2.2 Fleshy brown algae and sparse gorgonians