TROPICAL MARINE ORGANISMS AND COMMUNITIES

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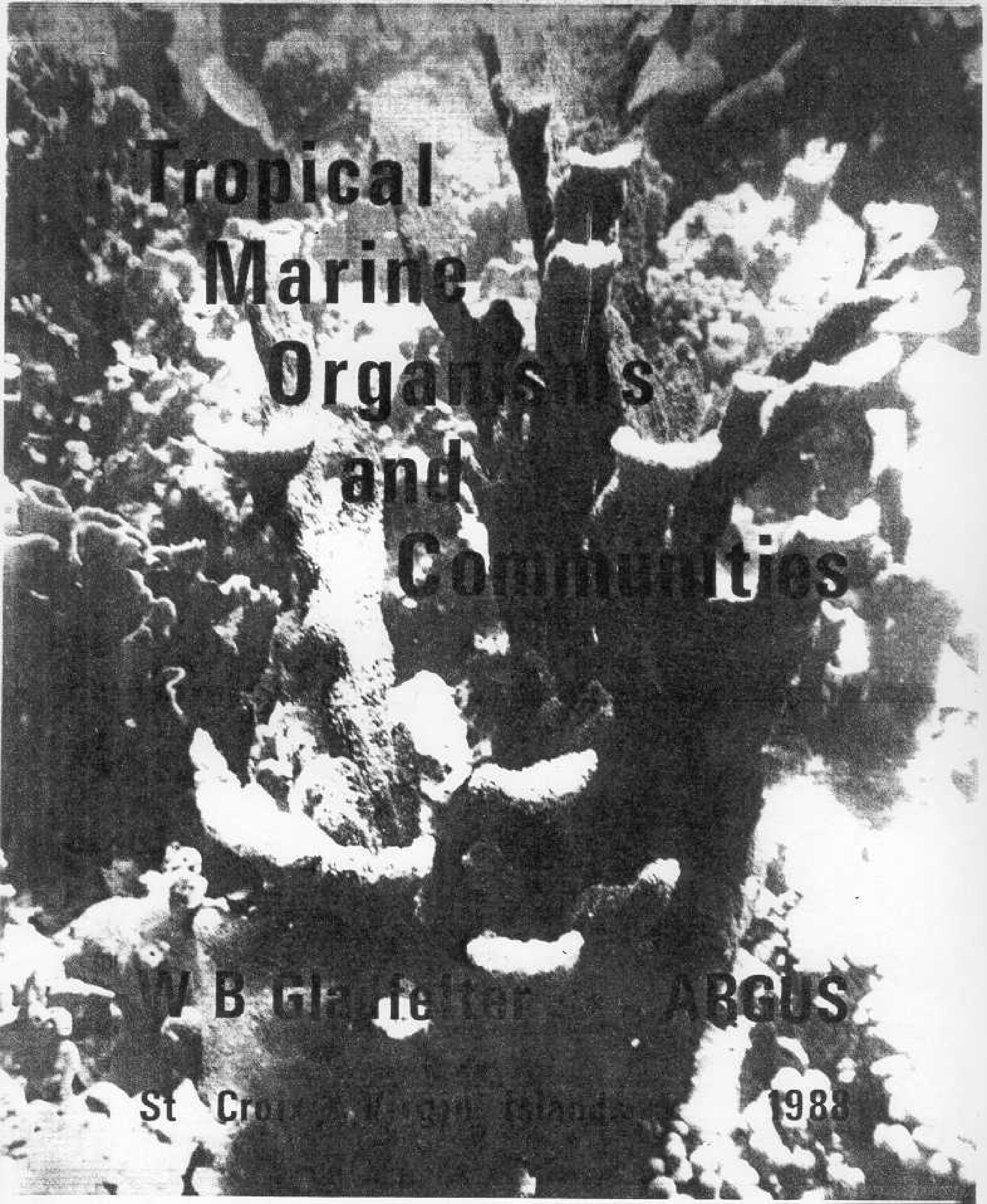

Tropical Marine Organisms and Communities

W B Gladfelter   ARGUS

St Croix, Virgin Islands   1988

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ANNOTATED CHECKLIST OF MARINE ORGANISMS OF ST CROIX, VIRGIN ISLANDS

The following is a master list of the common, conspicuous or otherwise important or interesting shallow-water marine invertebrates of the West Indies in general and St. Croix in particular. The organisms are presented in taxonomic outline so that their relationships can be readily seen. Some of the higher taxa have been superceded in the technical literature but have been used herein because of their greater usefulness to the nonspecialist. Some higher taxa without known local representation have been omitted. The ranks of higher taxa have been abbreviated as follows: K = kingdom; Ph = Phylum; Cl = Class; O = order; F = family.

There is no well established set of vernacular names for most marine invertebrates and plants (in contrast to vertebrates). Therefore the scientific, latinized form is used below. The scientific name of an organism consists of two words: the genus (plural = genera) and the species. Both are underlined or italicized. In the account below, for simplicity, the generic name is often used alone except when there is more than one species dealt with in the same genus.

K Monera: prokaryotes, with no nuclear or other internal cell membranes
- Ph Cyanophyta (=Cyanobacteria; blue-green algae)
  - *Microcoleus*: "slimy" filamentous masses on intertidal rocks
  - *Trichodesmium*: planktonic; tufts of fine brown filaments
  - *Oscillatoria*: rings and halos on dying coral heads ("black band disease")
- Ph Eubacteria (bacteria)
- Ph Prochlorophyta: prokaryotes with pigments similar to those of higher plants
  - *Prochloron*: tiny single green cells in atrial spaces of certain didemnid ascidians

K Protista: unicellular or cell colonies without somatic differentiation; mostly microscopic; protozoans, etc.
- Ph Chrysophyta (diatoms): planktonic and benthic; unicellular "plants" with sculptured SiO_2 test
- Ph Pyrrhophyta (dinoflagellates)
  - *Ceratium*: 3-horned armored form (i.e. with cellulose plates)
  - Gymnodinium: naked form occurring in reef cnidarians as zooxanthellae
  - *Gambierdiscus*: large benthic form implicated in ciguatera (tropical fish poisoning)
- Ph Sarcodina (amoebas, etc.)
  - Cl Foraminifera (forams): large multinucleate amoebas with perforated $CaCO_3$ shell often visible to unaided eye
    - *Homotrema*: encrusts in dark cavities or under rocks; important component in algal ridges, stratified with crustose red algae forms maroon sand grains when eroded
    - *Sorites*: flat spiralled shell to about 1 mm long in lagoonal sand; other forms up to 5 mm may be common
    - *Globigerina*: planktonic, taken offshore; with several unequal spherical chambers

A variety of other crustose and free-living forms occur in a number of environments

Cl Radiolaria (radiolarians): planktonic forms with radial SiO_2 skeletal rays

Ph Ciliophora (ciliates and suctorians): nearly ubiquitous on various substrata; includes stalked and unstalked forms; a good source is necrotic marine organisms such as dying hydroids or on "white band disease"-affected A palmata

K Plantae (true plants): multicellular (usually), with photosynthetic pigments in plastids; generally attached to substrata; many important plants in tropical waters deposit $CaCO_3$ skeletons or inclusions, which then become important components of benthic sediments

Ph Rhodophyta (red algae): reddish, brownish or greenish; filamentous, branched or crustose; phycobilins as accessory photosynthetic pigments; nonmotile gametes

O Nemalionales

Liagora: flaccid pinkish-white clumps

Galaxaura: clumps of stiff pinkish orange tubular branches

Asparagopsis: seasonal on high energy reefs; like soft little fir trees with reddish midrib

O Gelidiales

Gelidiella: on intertidal beachrock; stiff midrib with bipinnate branching

O Cryptonemiales

Peyssonelia: forming colorful orange or purple crusts in shaded areas

(the following genera are corallines, belonging to the family Corallinaceae; all deposit $CaCO_3$)

Amphiroa: with stiff delicate dichotomous branches

Corallina: on shallow carbonate pavements; flattened and segmented

Jania: very delicate paintbrush-like form

Melobesia: small crusty patches on turtle grass blades

Lithophyllum: and other crustose corallines: often forming thickened crusts on dead coral and reef surfaces; major reef-builders

O Gigartinales

Hypnea: hooked branch tips

Gracilaria: robust branches, on deeper flats

O Rhodymeniales

Coelothrix: with iridescent blue tips

O Ceramiales

Centroceras: with nearly microscopic cross-banding

Ceramium: similar but without cross-banding

Martensia: delicate lacy pink form, seasonally common

Dasya: very fine filamentous tufts

Acanthophora: firm brownish stems with stubby forked lateral branches

Bryothamnion: on wave-swept pavements

Laurencia: a number of species, mostly firm and bushy

Ph Pheophyta (brown algae): tan or brown in color due to accessory pigments; includes many robust forms; $CaCO_3$ deposition not prevalent

O Ectocarpales

Ralfsia: small dark brown patches on rocks

O Dictyotales

Dictyota: flat, brown and dichotomously branched

Dilophus: similar but with tapering tips

Dictyopteris: similar, but with midribs

Padina: curled broad blades with conspicuous concentric bands, common intertidally

Stypopodium: also with concentric bands, blades more linear

Lobophora: similar to Padina but without bands

O Dictyosiphonales

Colpomenia: hollow tan lumps

O Fucales

Sargassum: quite large and robust, with crinkly blades off tough central stem; with tiny spherical floats when reproductive

Ph Chlorophyta (green algae): bright to dark green in color; with chlorophyll b; includes a number of important calcareous forms; includes a number of coenocytic forms (i.e. with incomplete cell boundaries)

O Ulotrichales

Enteromorpha: thin and tubular

Ulva: delicate flat green blades

O Cladophorales

Chaetomorpha: long green stringy masses

Cladophora: moss-like clumps

O Siphonocladales

Batophora: small whorls

Neomeris: tiny green or white thin clubs

Acetabularia: distinctive small parasols

Ernodesmis: articulated green branches

Valonia: turgid, thin-walled shiny-surfaced spheres

Dictyosphaeria: granular crinkly hollow green lumps

O Siphonales

Bryopsis: very delicate dark green feathers

Caulerpa: with extensive tubular stolons; diversity of thallus forms

C racemosa: pea-like thalli

C microphysa: similar but more tapering at base

C prolifera: thalli blade-like and smooth

C cupressoides: linear serrated thalli

C sertularioides: feather-like

C mexicana: similar but lateral branches wider and overlapping

Codium: very dark green felt-like lumpy masses or erect branches

Avrainvillea: upright dark green felt-like fans

Udotea: similar but paler and stiffer

U cyathiformis: goblet-shaped

Penicillus: like green shaving brushes anchored in sediment

Halimeda: with heavily calcified flat or cylindrical segments; important contributor to "coral" sand

Ph Tracheophyta (vascular plants)

Cl Angiospermae

Seagrasses: grass-like marine plants in several families other than true grasses; blades arise from extemmsive root systems

Thalassia (turtle grass): blades flat and wide (ca. 1 cm)
Syringodium (manatee grass): blades round in x-sec (ca. 1 mm)
Halodule (shoal grass): narrow flattened blades less than 1 mm
Halophila: delicate oval blades to a few cm long; generally in shaded areas or deeper water
Rupia: in shallow brackish or temporary lagoons or salt ponds

Mangroves: trees of salty soil that grow along the edges of quiet lagoons, usually zoned landward in the following order:
Rhizophora (red mangrove): grow in seawater to a depth of more than 1 m; with extensive proproots
Laguncularia (white mangrove): bordering quiet bays and seasonal salt ponds
Avicennia (black mangrove): grow where only occasionally submerged; with extensive pneumatophores rising from surrounding soil
Conocarpus (buttonwood): most landward

K Fungi: multinucleate, with nuclei in walled mycelia; nutrition by absorption (little-known but occur in a variety of marine associations (e.g with sponges and corals)

K Animalia (= Metazoa): multicellular animals with somatic differentiation

SubK Parazoa: body of cellular level of organization with very limited tissue development; no known nervous system, integration by non-nervous cellular conduction; no digestive or other systems; origin possibly different from that of other metazoa

Ph Porifera (sponges): body permeated by canal systems open to the outside, water driven through by flagellated collar cells within the canal system; supported by system of inorganic spicules organic fibers or both

[NOTE: Many of the following identifications have been kindly provided by Dr. K. Ruetzler of the U.S. National Museum]

Cl Calcarea: with $CaCO_3$ spicules; mostly small and cryptic forms
Leucosolenia: small white clumps of anastomosed tubes
Clathrina: similar but more anastomosed; bright yellow
"Scypha": small vaselike forms

Cl Hexactinellida: deep-sea glass sponges; occur below SCUBA depths

Cl Demospongiae: includes nearly all local sponges; with SiO_2 spicules and/or protein spongin fibers. Spicules often differentiated as large megascleres and tiny microscleres. The following sequence of orders proceeds roughly from more primitive forms with predominantly spicule skeletons to more advanced forms with predominantly spongin skeletons

O Homosclerophorida
Plakortis: firm dark brownish lumps with one or few small oscules

O Choristida
Geodia: with distinctive cortex of packed spherical microscleres (sterrasters)

O Spirophorida
Cinachyra: orange sphere with external pits and radial organization; with triaene megascleres

O Hadromerida
Spirastrella: red or dark orange, very firm encrusting a few mm

thick; with spiraster microscleres
Cliona: excavating in to $CaCO_3$ substrates
C lampa: visible as small red chimneys
C caribbea: dark brown, often extensive crust
C delatrix: reddish with large central oscule and numerous incurrent "cushions"
Anthosigmella: forms extensive tan mats in high energy zones
Tethya: with pronounced radial organization and strongyloxea megascleres
T crypta: very dark brown usually covered with layer of sand
T sp: small orange or green spheres common on shallow reefs under rubble; buds extensively
Spheciospongia: very large firm form with cluster of oscules at top (not to be confused with spongier I strobilina)
[uncertain status]
Chondrilla: smooth tan form common inshore; no megascleres, only euaster microscleres; one of preferred foods of hawksbill turtle
O Axinellida: with clear radial organization of fiber skeleton
Pseudaxinella
Ptilocaulis
O Halichondrida
O Poecilosclerida
Agelas: with distinctive acanthostyle megascleres
A dispar
A confera
A clathrodes: large orange "elephant ear" sponge of deeper reefs; also, cryptic reddish porous form
Mycale
M laevis: orange under ledges of Montastrea annularis
M laxissima: maroon vase sponge of deeper reefs
M "angulosa": very slimy lavender form
Neofibularia: large brown TOXIC to the touch, with sandpaper-like surface
Clathria: reddish encrusting on gorgonian axes
Ulosa
U ruetzleri: very soft papillate orange form
U arenosa: small soft lavender frosted tubes
Rhaphidophlus (= Thalysias): reddish orange slender, firm elongate branches with scattered oscules
O Haplosclerida
Haliclona: small spongy cushions, purple or green
Amphimedon
A compressa: upright maroon spongy fingers to 40 cm or more with scattered oscules; very common
A complanata: similar but dark brown and sticky
Desmapsamma: pink "frosted" surface, soft and spongy with scattered oscules; common
Pellina (= Adocia): nearly black; very firm
Spinosella (= Callyspongia)
S vaginalis: gray, upright flattened with distinctive small cones and ridges on surface
S plicifera: iridescent lavender vase sponge with maze-like exterior

Niphates

N digitalis: open gray cups with granular outer surface

N erecta: similar but finger-form

Cribrochalina: brown "ear" sponge; crumbly texture

Siphonodictyon: excavating sponge with yellow chimneys

Xestospongia: very large "basket" sponge

Ectyoplasia (= Hemectyon): brownish orange with numerous small volcano-like oscules

Monanchora: soft encrusting form, reddish with "frosty" white; quite common

O Dictyoceratida: skeleton of spongin fibers only, generally well developed

Dysidea

D etherea: small bright blue and very soft

D janiae: symbiotic with coralline alga Jania

Oligoceras: soft dark brown and filled with sand grains

Ircinia: extremely tough organic skeleton; nearly impossible to cut or tear

I strobilina: charcoal gray, with cluster of small oscules at top; to quite large size (do not confuse with Spheciospongia) with distinctive, almost honeycomb-like external surface

I felix: more brownish, with single scattered oscules

O Dendroceratida: without spicules or spongin; thin and soft

Halisarca

Chelonaplysilla

O Verongida: includes many of the large "tube" sponges; spongin skeleton only, generally reduced to a rather open network of stiff fibers; external surface typically smooth and glossy

Aplysina: large firm tube sponges

A lacunosa: tube sponge with conspicuous external pits; generally brownish to yellowish

A fistularis: similar but smoother surface and yellow

A cauliformis: slender and elongate, lavender or brownish-yellow with regularly spaced small oscules

Verongula: typically with glossy honeycomb-like exterior

V gigantea: large often thin-walled and open bowl-shaped; greenish

V rigida: tan firm with pronounced honeycomb surface

V reiswigi: similar to previous but darker purple-green and less pronounced ridges

Igernella: upright lobes with distinctive pinkish purple glossy surface

Pseudoceratina: very firm smallish tubes, yellow oxidizing to dark blue

Smenospongia: firm bright yellow globular with small oscules

Cl Sclerospongiae (coralline sponges): very similar to demosponges in general organization but deposit a basal $CaCO_3$ exoskeleton in addition to having SiO_2 spicules; most likely should be included among the demosponges

Ceratoporella: in dark areas of deeper reefs

SubK Eumetazoa: with tissue differentiation and an organized nervous system; the first two phyla or Radiata have a fundamental radial body symmetry without development of a head

Ph Cnidaria (= Coelenterata): polypoid and medusoid forms, solitary or in bud colonies, all with stinging capsules (=nematocysts)

Cl Anthozoa: relatively large polypoid forms, frequently in bud colonies (gorgonians, corals, etc); the overwhelming majority of reef cnidarians; internal cavity (= gut or gastrovascular cavity) subdivided by radial partitions (= mesenteries or septa (these are reflected in the sclerosepta of corals); SEE KEY TO ANTHOZOA

SubCl Octocorallia (= Alcyonaria): always colonial; polyps generally small, with 8 bipinnate tentacles

O Telestacea: generally white, polyps connected by simple basal tubes

<u>Telesto</u>: sometimes common on shaded man-made structures (piers, ship bottoms)

O Gorgonacea (gorgonians: sea whips, sea fans, etc): form upright flexible branched colonies or encrusting mats; with supporting skeleton of densely packed microscopic spicules

SubO Scleraxonia: no protein axial skeleton

<u>Briareum</u>: purple, encrusting or finger-like forms very common in most reef habitats

<u>Erythropodium</u>: forms pinkish encrusting mats

<u>Iciligorgia</u>: upright, maze-like fan on certain dropoff reefs (eg. Salt River, St. Croix)

SubO Holaxonia: protein axial skeleton present in all branches

<u>Plexaura</u>: colony highly branhced, branches slender, slightly rough; not slimy

<u>P flexuosa</u>: whitish

<u>P homomalla</u>: dark brown, pigment rubs off on fingers

<u>Plexaurella</u>: slender to fat pinkish branches, not highly branched; surface like very fine sandpaper; calyces slit-like

<u>Pseudoplexaura</u>: generally lavender with tan polyps, slender branches, usually slimy

<u>Eunicea</u>: generally dark brown, often robust, with prominent calyces

<u>Muricea</u>: prickly surface, caused by calyx spines

<u>Pterogorgia</u>: with very flattened branches, polyps tiny in grooves along edges

<u>Pseudopterogorgia</u>: sea "plumes" with bipinnate branching; reaching very large size

<u>Gorgonia</u>: sea fans, in yellow or purple

<u>Ellisella</u>: deeper water species (eg. Cane Bay) with very slender branches, often under ledges

O Alcyonacea (fleshy corals): occasionally taken in deeper water; diverse and abundant in Indo-Pacific

SubCl Hexacorallia = Zoantharia: diverse polypoid forms, many of which have a basic 6-part radial symmetry

O Ceriantharia (cerianthids): : elongate tube-dwelling forms, usually emergent at night only

<u>Isarachnanthus</u>: nocturnally emergent from intertidal to deeper reefs

O Zoanthidea (zoanthids): colonial, anemone-like forms often forming rubbery mats

<u>Zoanthus</u>: color-coded colonies often forming extensive mats often in shaded areas

<u>Palythoa</u>

P caribbea: tan tough colonial form superficially resembling the coral M cavernosa
P grandis: small clusters of a few large polyps; well-spaced slender tentacles
Parazoanthus: commensal in some species of sponges
P parasiticus: maroon or tan
P swiftii: as above, more superficial; yellowish
O Antipatharia (black corals): form large upright branched colonies at depths generally > 15m (50ft)
Stichopathes: unbranched whiplike colonies to >3 m
Antipathes: several species, variously branched
O Actiniaria (sea anemones): solitary, usually large polyps of diverse form
Stoichactis: broad, flat reef anemone with numerous stubby tentacles covering disc most common in shallow water (shoreline or reef crest)
Homostichanthus: similar to above but whitish and with six deep folds in margin; in grass or sand flats
Phymanthus: sits in sand pockets on reefs; with short pointed ring of marginal tentacles
Telmatactis: with relatively few blunt tentacles, under rocks in in shallow water, or on deeper reefs in crevices
Lebrunea: with zooxanthella-laden pseudotentacles, expanded by day, contracted by night
L danae: pseudotentacles highly branched and alga-like
L coralligens: tiny, in small reef crevices
Alicia: uncommon, nocturnal in grassbeds; very large
Bunеodopsis: small wart-like forms on plants of lagoon or reef; expand into transparent polyp in dark; very common; sting
Anemonia: maroon, intertidal under ledges or on wave-swept coasts
Bunodosoma: common intertidal anemone, tan with banded tentacles
Heteractis: pinkish transparent with white balls of stinging capsules on tentacles
Bartholomea: similar but with with white rings
Condylactis: large form with greenish thick tentacles often tipped with purple
Calliactis: on shells occupied by hermit crabs
Aiptasia: abundant in quiet inshore water, docks, etc
O Corallimorpharia: clone-forming anemone-like forms without basilar muscles for crawling about
Rhodactis: with forked stubby tentacles on disk and spectacular feeding response in dark
Paradiscosoma: no obvious tentacles
Ricordea: small with disk covered with tiny rounded tentacles
Pseudocorynactis: with transparent tentacles tipped with orange knobs
O Scleractinia (= Madreporaria; stony corals): colonial, anemone-like forms that secrete a basal $CaCO_3$ skeleton with pits or cups containing radial sclerosepta
[in the list below, corals have been grouped in categories of general form, which often do not reflect natural relationships]

Head Corals (distinct calyces)
- Stephanocoenia: small head coral of deeper water, white with tan polyps; bleaches when touched
- Siderastrea
  - S siderea: a moderately important reef builder, forms large heads with small funnel-shaped calyces
  - S radians: forms small flat patches in turbid shallow environments; also forms rounded coralliths in some shallow backreef areas
- Favia: forms small golf-ball like colonies on shallow reefs
- Montastrea
  - M annularis: the major reef-builder in the Western Atlantic; may form enormous heads
  - M cavernosa: much larger, elevated calyces
- Dichocoenia: with oblong calyces

Finger Corals
- Madracis
  - M decactus: deeper or shade environments, olive colored encrusting or with stubby thumb-like projections
  - M mirabilis: also of deeper water, heads of numerous parallel pencil-like branches, pale yellow in color
- Porites
  - P porites: (finger coral) may form enormous mounds in shallow water
  - P furcata: like previous but with more open branching and tapering tips
  - P divaricata: generally in grassbeds but can form shore-fringing reef-like masses
  - P astreoides: forms lime-green (or sometimes tan) heads

Acroporid corals (with axial polyp and growth axis)
- Acropora: branched corals with one or few axial polyps; axial growth component much greater than normal component, leading to very high skeletal extension rates
  - A palmata (elkhorn coral): forms enormous branched colonies that dominate shallow windward reefs
  - A cervicornis (staghorn coral): with long slender cylindrical branches, forming thickets on deeper reefs and sand flats
  - A prolifera: similar to previous but with much greater degree of branching and in shallower water

Plate corals
- Agaricia: typically forms flattened plates that extend along edge
  - A agaricites (lettuce coral): forms flattened plates or crinkly lumps on shallower reefs
  - A lamarcki: dominates deeper dropoff reefs at >20m
- Helioseris: glossy flattened plates in shaded cavities

Brain corals
- Colpophyllia: with very broad meandrine systems
- Diploria
  - D strigosa: the commonest of the brain corals sometimes forming nearly spherical heads to 1 m or more in diameter (eg at Buck I., St. Croix)
  - D clivosa: with narrower systems than the previous, more

irregular surface, greenish "valleys"

D labyrinthiformis: with secondary V-shaped depression in middle of meandrine "ridges"

Manicina: usually on sandflats or grassbeds, smallish colonies often with conical base (for stability on soft bottoms)

Meandrina: brain coral with very prominent smooth sclerosepta

Dendrogyra (pillar coral): brain coral forming erect cylindrical pillars often more than 1 m high

Fleshy corals (members of the family Mussidae which share several important features: "puffy" tissue surface; "aggressive" behavior, etc.

Scolymia: large solitary forms often in shaded areas

Mussa: "colony" of closely spaced but separate corallites

Isophyllastrea: "head" type with single calyces

Isophyllia: simple meandrine systems in which a few calyces are confluent

Mycetophyllia: most meandrine of the fleshy corals

M lamarckiana

M ferox: maze-like flattened surface

M aliciae: similar but ridges very broken up

Forms with prominent, terminal polyps

Eusmilia: each branch tipped with a calyx (& polyp)

Tubastrea: orange, ahermatypic species in shaded or high energy areas with reduced light

Cladocora: in deeper grassbeds (not known from St.Croix)

Cl Hydrozoa: generally small benthic colonial forms with complete or reduced medusae in life cycle

[a variety of taxonomic schemes are available, the following is only one of several]

O Athecata (= Anthomedusae): polyps generally without theca; medusae tall and bell-shaped with marginal eyespots

Myrionema: hydranth small (1 - 2 mm) brownish and daisy-like; shallow water; with zooxanthellae

Halocordyle: colonies featherlike to about 10 cm; hydranths large and white; common

Turritopsis: branched colonies with pinkish hydranths

Solanderia: large, sea-fan-like hydroid found in areas of vertical boulders (e.g. Hamm's Bluff, St. Croix)

corymorphid sp.: grow singly from tips of live gorgonians

corynid sp: grow in red encrusting sponge Monanchora

O Chondrophora: closely allied to the previous; float on sea surface

Porpita: large flat floating hydranth; purple with dense large marginal tentacles; 2 - 3 cm; wash onto beaches leaving transparent chitinous skeletal disc (ca. 1 cm)

O Thecata (= Leptomedusae); medusae with more flattened bells and marginal statocysts; polyps generally with thecae

Sertularella: flexible, feather-like colonies

Cnidoscyphus

Plumularia

O Milleporina (firecorals): large colonial hydrozoans with massive $CaCO_3$ skeleton; polyps living in tiny pits arranged in circular systems

Millepora (firecoral): smooth tan colonies with polyps barely visible as tiny white threads; STING!

M complanata: upright plate-like colonies; dominant on shallow forereefs
M alcicornis: colonies variously branched (and encrusting, especially on gorgonians)
M squarrosa: lumpy, pinkish form found under ledges
O Stylasterina: another group with $CaCO_3$ skeleton
Stylaster: delicately branched purple, pink or whitish colonies (to 10 cm); generally in shaded areas
O Limnomedusae: planktonic, especially taken in nocturnal tows
O Trachymedusae: planktonic, mainly offshore
Liriope: umbrella-shaped with 4 long tentacles; a few mm
O Narcomedusae: planktonic, mainly offshore
O Siphonophora: complex colonial planktonic forms with elaborate polymorphism, complex behavior and usually a potent sting
Physalia (Portuguese-man-of-war): large, with greatly elongated tentacles and purple float; sometimes washes ashore; a number of other small, planktonic forms occur offshore
Cl Scyphozoa (jellyfishes): large medusoid forms with tiny benthic solitary polyps
O Stauromedusae: attached, trumpet-shaped polypoid forms occasionally found on seagrass blades
O Cubomedusae (sea wasps): fairly large, elongate transparent medusae with 4 long tentacles (or groups of tentacles) and a potentially DANGEROUS sting
Charybdea: sporadically occur in shallow water
O Coronatae: offshore planktonic and deep-sea forms; occasionally taken in plankton tows
O Semaeostomae (Jellyfishes): with massive frilly oral arms and marginal tentacles
Aurelia: pale blue form to 25 cm with 4 horseshoe-shaped gonads and abundant tiny marginal tentacles
Cyanea: darker blue form with masses of long tentacles; feeds on other jellyfishes [known from V.I. but not St. Croix]
O Rhizostomae (Jellyfishes): without marginal tentacles
Cassiopeia: atypical in its habit of lying inverted on lagoon bottoms [perennial population inside Romney Pt., St. Croix]
Ph Ctenophora (comb jellies): transparent gelatinous planktonic forms sometimes abundant outside reefs; have 8 iridescent comb rows (of enlarged ciliary combs); fragile, fragments of comb rows taken in plankton tows
O Cydippida: firm spherical forms to about 1 cm
O Lobata: with enlarged, flap-like lobes
Hormaphora: has spectacular swimming escape response when touched
Bolinopsis
O Cestida: resembles a tapering transparent ribbon; swims by undulating
O Beroida: like simple sac with greatly enlarged mouth; feeds on other ctenophores
Beroe

The following animals have a basically bilateral body symmetry, generally possessing a head with concentration of sense organs and nervous structures; body tissues are organized into organ systems.

Ph Platyhelminthes (flatworms)
Cl Turbellaria (free-living, i.e. nonparasitic, flatworms)
O Polycladida: large (up to several cm) often brightly colored, broad and extremely flat; may resemble nudibranch molluscs; may swim when disturbed
Pseudoceros: with many large and colorful spp (ocasionally found swimming in water column)
Ph Nemertea (ribbon worms): highly elongate and elastic, slow-moving unsegmented worms found among rocks or in sediments; may reach many m long though most are less than 1 m; most are predaceous on other worms
Ph Chaetognatha (arrow worms): transparent, rod-like planktonic forms up to several cm; important predators on small planktonic crustacea
Ph Entoprocta: nearly microscopic stalked, polyp-like forms with characteristic "nodding" behavior, which can be observed in the field on close observation
Loxosoma: locally common on a variety of large sponges
Ph Priapulida: small group of sediment burrowing worms with robust proboscis [known from the West Indies but not St. Croix]
Ph Nematoda (roundworms): abundant in many micro-environments but generally microscopic

Additional, related phyla are undoubtedly present: Ph Rotifera; Ph Gastrotricha; Ph Kinorhyncha; because of their microscopic size they are generally overlooked.

The following phyla or Eucoelomata all are characterized by the presence of an internal body cavity formed within the body mesoderm; two main groups or Superphyla are recognized by the mode of formation of this body cavity (=coelom) and other early developmental features.

SuperPh Deuterostomia: generally with radial, indeterminate cleavage of blastomeres; enterocoelous coelom; mouth formed as secondary opening of gut in embryo
Ph Echinodermata: benthic forms mostly with pentamerous radial body symmetry as adults, but bilateral as larvae; with complex coelom of several main divisions including a water vascular system
Cl Crinoidea (sea lilies and feather stars): attached by aboral cirri; deep-sea forms with stalk between body and cirri; with bipinnately branched arms
Nemaster: body in reef crevice, arms emergent, orange, yellow or gray; at depths > 5 m
N rubiginosa: orange or yellow pinnules
N discoidea: gray pinnules
Analcidometra: on gorgonians at depths > 20 m; swims
Cl Asteroidea (seastars or starfish): with rigid, generally 5-rayed body with broad junction between body and rays
O Phanerozonia
Astropecten: burrows in sand, emergent at night; flat and gray large marginal skeletal plates

Linckia: with long slender arms and great powers of regeneration: often found as "comet", i.e. a single arm regenerating a disc and 4 arms; in reef rubble or crevices

Oreaster: large (to 30 cm), orange; with broad-based arms; common on sand flats or grass beds

Cl Ophiuroidea (brittlestars and basketstars): with 5 highly flexible and mobile arms attached narrowly to body

O Ophiurae: arms flex mainly in horizontal plane; most local spp

Ophiothrix: delicate, with long slender arm spines; frequently living on sponges or firecorals

Ophiocoma: robust, dark brown forms common under reef rubble, with well-developed lateral arm spines

Ophioderma: with very short arm spines and finely granular disc; common under reef rubble

O Euryalae: arms flex in all planes

Ophiomyxa: large and slimy

Astrophyton (basketstar): arms highly branched; to >.5 m; contracted in knotlike mass by day; expanded on prominent reef structure by night; generally on outer reefs

Cl Holothuroidea (sea cucumbers): elongate echinoderms with skeleton reduced to small spicules (usually)

O Dendrochirota: sedentary, usually under rocks with large bushy tentacles upturned for suspension feeding

Thyone: upper subtidal zone on waveswept beachrock and under boulders; catch fragments of drift algae; black

O Aspidochirota: free-crawling, often very large; feeding tentacles short and bushy, apposed to substrate for deposit feeding

Holothuria mexicana: large, very tough and stiff form to .5 m long; dark above and pale below

Astichopus multifidus: large soft and brownish with pointed papillae with "bosses"

Actinopyga agassizi: large and soft with papillate surface; on sand flats in deeper water

Isostichopus badinotus: firm; irregular pointed papillae with "bosses"

O Apoda: elongate, thin-walled forms with bipinnate tentacles; generally "sticky" due to presence of anchor-shaped spicules

Euapta: to > 1 m long; primarily nocturnal

Synaptula: one of those delightful small forms generally overlooked but one which rewards its observer; to about 1 cm; in clumps of shallow- water vegetation (e.g. Galaxaura)

O Molpadonida: good-sized sand-burrowing forms lacking body tube feet and with very reduced tentacles

O Elasipoda: deep-sea forms often with exotic processes extending from body wall [below SCUBA depths only]

Cl Echinoidea (sea urchins, sand dollars, etc.): body enclosed in skeletal test covered externally with movable spines; primitive forms have elaborate jaw [taxonomy presented below is largely antiquated but is most useful for the nonspecialist]

SubCl Regularia (sea urchins, sea eggs)): test with radial symmetry; herbivores or detritvores generally living on substrate surface (i.e. not burrowing)

O Cidaroidea

Eucidaris (pencil urchin): with widely spaced, thick, blunt spines used to wedge it in crevices; test clothed in short flat spines

O Aulodonta

Diadema: with very long slender, extremely sharp spines that STING on contact; black (or gray or banded); formerly abundant on reefs and grassbeds

Astropyga: similar to above, but reaches much larger size; young individuals with stiking symmetrical red banding pattern; in "herds" on deeper sand flats or grassbeds

O Camarodonta

Lytechinus: pale, with pinkish or greenish tinge

Tripneustes: large whitish, short-spined urchin common on grassbeds or sometimes on shallow reefs

Echinometra: medium-sized urchin with somewhat oval test and stout fairly pointed spines; dark red or black

E lucunter: abundant on intertidal beachrock or shallow subtidal on high energy coasts

E viridis: in deeper water, and with longer, greenish spines

SubCl Irregularia: with secondarily derived bilateral symmetry superimposed on 5-part radial symmetry; anus shifted posteriorly from aboral pole; clothed by "furry" cover of greatly shortened spines; lantern reduced or absent; aboral portions of ambulacra modified as petals (regions of respiratory tube feet); usually in sediments

O Holectypoida

Echinoneus: small oval urchin (to 2 cm generally); anus posterio-ventral; no petals; no lantern; under reef rubble

O Clypeastroida (sand dollars, sea biscuits): with petals, lantern, anus posterio-ventral

Clypeaster

C rosaceus (sea biscuit): greatly thickened sand dollar; dark brown, "furry", generally burrows very shallow or not at all

C subdepressus: wider and flatter than above with relatively smaller petals

Mellita: very flat form with perforations and slits in edge of test

O Cassiduloida: resemble sand dollars but anus posterior, no lantern, petals open-ended, and specialized locomotory area on ventral side of test

Cassidulus: locally common in coarse sand of shallow high energy areas [not known naturally from St. Croix]

O Spatangoida (heart urchins): most highly modified of irregular urchins; mouth shifted forward; anterior petal modified as groove giving test a heart-shaped aspect from above; tube feet and spines modified into many different types

Meoma: largest of local spatangoids; common brown form that usually burrows only as deep as test height

Plagiobrissus: long, flat, fast-moving deep-burrowing spatangoid with scattered elongate defensive spines on aboral surface; test very fragile

Brissus: deeper burrowing medium-sized form usually evidenced only by cleaned test

Moira: short, "chunky" form

Ph Hemichordata (acorn worms): soft, sand-burrowing worms with bulb-like proboscis, collar and long trunk with gill slits anteriorly; leave coiled sand castings on sand surface; body of larger forms sand-filled and easily fragmented

Balanoglossus: with rounded, knob-like proboscis; common in coarse sand

Ph Chordata: with pharyngeal gill slits, notochord and dorsal hollow nerve cord present at least in embryo

SubPh Urochordata: above features usually present only in larva; adult sac-like with enlarged, perforated pharynx for filter-feeding; many forms colonial

Cl Larvacea: planktonic; small forms to a few mm which retain larval tail in adult; secrete complex mucus "house" which serves as food filter; common in plankton without "house"

Cl Thaliacea: planktonic; medium- to large-sized gelatinous colonial forms; individuals usually tubular and open-ended

O Pyrosomida: large, to many m long with individuals embedded in large gelatinous cylindrical matrix

O Doliolida: barrel-shaped with parallel barrel-stave-like muscle bands

O Salpida: similar to above but less symmetrical and muscle bands not parallel

Cl Ascidiacea (ascidians, sea squirts): sessile forms encased in organic tunic (the taxonomy here is quite specialized and it is more useful to recognize 3 "functional" groups:)

Solitary forms: individuals large (a few to many cm) and generally separate, without physiological connections

Ascidia nigra: dark blue to black, 5 - 8 cm high

Ascidia sp.: pale green translucent tunic; cryptic

Herdmania momus: orangish in color with tough leathery test; a number of individuals may adhere together; body with characteristic "fir tree" like spicules of vaterite (a form of $CaCO_3$)

Microcosmos: similar to above but test usually heavily fouled; without fir-tree spicules

Social forms: individuals medium-sized (1 mm to 1 cm); separate but connected by basal stolons

Clavellina: individuals about 1 cm high, usually more or less transparent

Perophora: individuals usually 1 - 2 mm high; green

Compound forms: individuals generally tiny, embedded in common tunic; generally flat and encrusting; numerous species

didemnids (Didemnidae): colonies generally very thin and flat, tough, with tiny star-shaped spicules; numerous spp (some of the smaller forms harboring Prochloron)

Trididemnum solidum: forms thin tough sheets on coral reefs; often abundant, pale greenish

botryllids (Botryllidae): flat colonies often red, orange or brown colored; with zooids in systems with common excurrent apertures

Distaplia: small purplish spherical colonies; often on rock walls

SubPh Cephalochordata (lancets, amphioxus): small fish-like forms found in coarse sand or occasionally plankton tows

SubPh Vertebrata (vertebrates): chordates with segmented vertebral column and musculature; cranium
- Cl Chondrichthys: fishes with cartilaginous skeleton, separate gill clefts, placoid scales
  - O Selachii
    - SubO Squali (sharks)
    - SubO Raji (rays)
- Cl Osteichthys (bony fishes): more or less bony skeleton; gill clefts covered by operculum; scales not placoid (in the synopsis below only those groups with local representation are given)
  - O Isospondyli
    - F Elopidae (tarpon) large schooling predators often near shore
    - F Clupeidae (herring) often forming huge shoals near shore
    - F Engraulidae (anchovy) same
  - O Iniomi
    - F Synodontidae (lizardfish) sedentary predators on fish
  - O Apodes (eels)
    - F Congridae (conger eels, garden eels) the latter form colonies on deeper sand flats
    - F Ophichthidae (snake eels) generally on sand or grass either free-roving or burrowed in
    - F Muraenidae (moray eels) common predators of reef crevices; often nocturnally active
  - O Synentognathi
    - F Belonidae (needlefish) often common just below water surface where they prey on small fishes; escape threats by skimming across water surface with powerful body thrusts
    - F Hemirhamphidae (halfbeak; ballyhoo) just below water surface
    - F Exocoetidae (flying fish) offshore primarily; escape threats by soaring great distances in air
  - O Solenichthys (tubenoses)
    - F Aulostomidae (trumpetfish) common reef predators with stealthy behavior
    - F Fistulariidae (cornetfish) mainly in grassbeds
    - F Syngnathidae (pipefish and seahorse) in grassbeds or around human structures (e.g pier pilings)
  - O Berycomorphi
    - F Holocentridae (squirrelfish) large-eyed, red nocturnal predators on crustacea
  - O Percomorphi
    - F Atherinidae (silverside) small silvery schooling fishes
    - F Mugilidae (mullet) mostly in inshore turbid habitats
    - F Sphyraenidae (barracuda) large predator, intimidating but not dangerous in clear water
    - F Serranidae (groupers) large-mouthed predators, often secretive in habits, lurking under ledges, etc.
    - F Grammidae (grammas) swim inverted under overhangs
    - F Grammistidae (soapfish)
    - F Priacanthidae (glasseye) very-large-eyed nocturnal form
    - F Emmelichthyidae (boga) schooling cigar-shaped plankton-feeders active by day and night
    - F Apogonidae (cardinalfish) small nocturnal forms, often with pattern of identifying black bars or spots
    - F Branchiostegidae (tilefish) construct coral-rubble burrows

- F Cirrhitidae (hawkfish)
- F Carangidae (jack) free-swimming predators
- F Scombridae (mackerel) often solitary, above- or off- reef predators
- F Lutjanidae (snapper) primarily predators on fishes
- F Haemulidae (grunt) invertebrate eaters that often form large daytime resting schools especially when young
- F Sparidae (porgy) often solitary foragers over sand
- F Sciaenidae (drums, croakers) generally nocturnal
- F Mullidae (goatfish) forage on small invertebrates by disturbing sand with muscular "whiskers"
- F Pempheridae (sweeper) nocturnal plankton-feeders, forming large daytime schools in caves
- F Gerreidae (mojarra) forage over flat bottoms
- F Kyphosidae (chub) schooling herbivores generally found in high energy areas (shallow reef-crests, etc.)
- F Ephippidae (spadefish) large, tame schooling forms frequently found along shelf edges
- F Chaetodontidae (butterflyfish, angelfish) colorful reef-dwellers often occuring in pairs; former eat various small invertebrates, latter sponges
- F Pomacentridae (damselfish) diverse family including a number of brownish highly aggressive territorial "gardeners" and plankton-feeding forms
- F Labridae (wrasse) often slender, elusive opportunists
- F Scaridae (parrotfish) generally large herbivores often foraging in group
- F Opistognathidae (jawfish) dwell in vertical tunnel in reef or rubble habitat
- F Blenniidae, Clinidae and Chaenopsidae (blennies): include a variety of small cryptic reef dwellers
- F Gobiidae (goby) large diverse group of small to tiny forms often with very specialized habits
- F Acanthuridae (surgeonfish) schooling grazers with defensive spine at base of tail

O Scleroparei generally "bizarre" forms often common at F'sted pier
- F Dactylopteridae (flying gurnard): enlarged pectoral fins
- F Scorpaenidae (scorpionfish) highly camouflaged predator with venomous dorsal spine

O Heterosomata
- F Bothidae (left-eyed flounder) asymmetrical forms with right side apposed to substrate

O Discocephali
- F Echeneidae (remoras) with specialized head disc to attach to large fishes, sea turtles etc.

O Plectognathi generally armored slow-moving forms
- F Balistidae (triggerfish, filefish): with large erectile first dorsal spine
- F Ostraciontidae (trunkfish, cowfish): with box-like subdermal bony skeleton (similar to turtle shell)
- F Tetraodontidae (puffer)
- F Canthigasteridae (sharp-nosed puffer)
- F Diodontidae (porcupinefish, burrfish): spiny puffers

O Xenopterygii

F Gobiesocidae (clingfish)
O Pediculati
F Antennariidae (frogfish)
F Ogcocephalidae (batfish)
Cl Reptilia
O Chelonia (turtles)
F Chelonidae (sea turtles: green, hawksbill, loggerhead)
F Dermochelidae (leatherback turtle)
O Crocodilia (marine crocodiles) found in mangrove areas through the Caribbean to S. Florida; ENDANGERED
Cl Aves (birds)
O Procellariiformes
F Procellariidae (shearwaters, petrels)
F Hydrobatidae (storm petrels)
O Pelecaniformes
F Pelecanidae (pelicans)
F Fregatidae (frigatebirds)
F Sulidae (boobies)
F Phaetontidae (tropicbirds)
O Charadriiformes
F Laridae (gulls and terns)
Cl Mammalia
O Cetacea
SubO Odontoceti (toothed whales; porpoises)
SubO Mysticeti (baleen whales)
O Carnivora
SubO Pinnipedia (seals)
O Sirenia (manatee)
SuperPh Lophophorata: with developmental characteristics intermediate between deuterostomes and protostomes; possess lophophore
Ph Phoronida: small tube-dwelling worms; occurrence in question
Ph Bryozoa: colonial forms with tiny polyp-like zooids encased in little chambers; encrusting and branched forms
<u>Trematooecia</u>: a thickly encrusting, calcareous form which fluoresces; colonies up to fist-sized
<u>Zoobotryon</u>: a bushy fouling form common on docks,etc with abundant clear stolons, tiny individual zooids arising especially near tips; zooids more readily emergent than other species
Ph Brachiopoda: [not recorded from St. Croix but expected under ledges and <u>Agaricia</u> plates in deep water]

SuperPh Protostomia: with spiral determinate cleavage pattern of blastomeres; schizocoelic coelom formation
Ph Mollusca: soft-bodied forms usually enclosed in or retractible into external shell(s)
Cl Aplacophora: tiny wormlike forms without shells
Cl Monoplacophora: deep-sea limpet-like forms with serial repetition of body parts [neither this nor the former known from St. Croix]
Cl Polyplacophora (chitons): with 8 shell plates, common sedentary forms on rocky shores
<u>Chiton</u>: several common spp on rocky shores
<u>Acanthochitona</u>: with several pairs of clusters of bristles on

girdle; in burrows in shallow coralline algae ridges
Ischnochiton: common under shallow rocks; relatively swift-moving (i.e. for a chiton)

Cl Gastropoda (snails, slugs): with single asymmetrically coiled shell or none

SubCl Prosobranchia (marine snails)

O Archeogastropoda: with one or two bipectinate ctenidia; primitive inhabitants of rocky substrates; usually herbivorous grazers

SuperF Fissurellacea (keyhole limpets): flat to openly conical forms with aperture at top of shell

Fissurella and Diodora: most of the common intertidal keyholes

F punctata: flattened concave form found under E lucunter

Lucapina suffusa: fleshy orange keyhole, mantle covers shell

SuperF Patellacea (true limpets)

Acmaea: flattened, cap-shaped forms, mostly in very shallow water

SuperF Trochacea

Cittarium: (topshell, whelk) large, globular blackish form with circular horny operculum;most abundant on high energy shores and algal ridges

Astraea (starshell): several species with generally pinkish fluted shells and convex calcareous opercula

Turbo: shells found in some shallow reef areas by octopus holes

SuperF Neritacea (nerites)

Nerita: several spp of forms abundant on rocky shores

Neritina: on shallow mud flats

Puperita: small and white with delicate black lines; in tide pools

O Mesogastropoda

SuperF Littorinacea abundant on intertidal rocky shores

Littorina: this and the next 3 dominate the upper to mid
Nodilittorina: intertidal zone
Echininus:
Tectarius:

SuperF Cerithiacea

vermetids: with irregularly coiled shells anchored to rock; one species forms reef-like masses

Cerithium: abundant in grassbeds; shells used by sipunculids, tanaids, hermit crabs and others

SuperF Scalacea

Epitonium: delicate white shell with pronounced axial ribs

Janthina: a pelagic open-ocean surface form that lives attached to a bubble float; washes ashore

SuperF Aglossa

Stilifer: a tiny parasite sometimes common on E lucunter

SuperF Hipponicacea

Hipponix: abundant on shallow rocky shores, overgrown and often hard to see

SuperF Calyptraeacea

Calyptraea: shells occasionally washed ashore

Crepidula: live attached to shells of other molluscs with elarged, filter-feeding gill

SuperF Strombacea

Xenophora (carrier shell): cements foreign shells around edge of shell

Strombus: large-lipped (when adult) herbivorous snails

S gigas (queen conch): commercially important as food item

S costatus (milk conch)

S gallus (rooster-tail conch)

S raninus (turkey wing conch)

S pugilis (West Indian fighting conch)

SuperF Cypraeacea generally smooth-shelled forms that often draw mantle over shell; prey on fleshy colonial invertebrates

Cypraea (cowry)

Cyphoma (flamingo tongue): common grazer on gorgonians

SuperF Atlantacea (heteropods) planktonic predators

SuperF Naticacea

Natica (moon snail) globular smooth shelled predators on bivalves; lay eggs in sand "collar"

SuperF Tonnacea

Cassis (helmet snails) predators of sea urchins

Charonia (tritons) predators of starfishes

Cypraecassis (helmet-cowry)

O Neogastropoda (= Stenoglossa)

SuperF Muricacea

Murex: with pronounced shell spines

Purpura: intertidal predators of other snails

Thais: same

SuperF Buccinaceae

Fasciolaria (tulip): predator of other molluscs

Vasum

SuperF Volutacea

Oliva: smooth-shelled spindle-shaped burrowers in sand

SuperF Conacea (= Toxiglossa)

Conus: highly specialized predators with radula teeth modified as harpoons

SubCl Opisthobranchia (sea slugs): shell reduced or lost; hermaphroditic

O Cephalaspidea

Bulla: shells abundant on some low energy beaches

O Anaspidea (sea hares) soft-bodied herbivores that can secrete a purple dye

Aplysia: deep-bodied with large purple "ocelli"

Dolabrifera: flat and rough surfaced

O Sacoglossa

Tridachia: "frilly" forms that store and use chloroplasts derived from their food (green algae)

O Thecosomata (shelled pteropods): planktonic forms with transparent shells of various shapes; swim with two large anterior flaps (of foot)

O Nudibranchia (nudibranchs) colorful shell-less forms that generally feed on sedentary invertebrates

SuperF Doridacea flattened forms with circlet of retractile anal gills

SuperF Dendronotacea with highly branched dorsal processes (cerata) in which nematocysts of cnidarian prey are stored

SuperF Eolidacea similar to previous but processes not branched

SubCl Pulmonata (a few marine forms)

Cl Bivalvia (= Pelecypoda): 2-valved shell connected by elastic hinge ligament; body completely enclosed by valves

O Protobranchia: primitive forms with aspidobranch type ctenidium

O Filibranchia: usually on or in hard substrates; generally do not burrow; without siphons; ctenidium filibranch type; the forms below are all inhabitants of reef environments, attached on the surface or in crevices:

Lima: common in reef cavities; with red mantle cavity

Lithophaga: bores into carbonate substrates

Isognomon: flat mangrove oyster

Pinna: with thin fan-shaped shell; often in grassbed

Spondylus: spiny oyster, anchored to concrete piling

Lopho: "jagged jawed" oyster often anchored to gorgonians

Pteria: with one pronounced "wing" near hinge; also on gorgonians

O Eulamellibranchia: often burrow in sediments; often with mantle fusion, forming siphons; with eulamellibranch type ctenidia

Codackia: this and the following are common in lagoonal grassbeds but are rarely found live; their shells are numerous on beaches

Tellina

Linga

Chione

Teredo(shipworm): bores into wood in the sea

Cl Scaphopoda (tusk shells): small burrowing molluscs (to a few cm) with slender conical shell open at each end

Cl Cephalopoda: molluscs capable of powerful swimming, with large, well-developed eyes and elaborate food- catching tentacles surrounding mouth

SubCl Coleoidea: forms with reduced shell

O Sepioidea: with reduced shell retaining septa or partitions for buoyancy

Sepia (cuttlefish): open-sea forms with "cuttlebone" an oval floatation chamber of many closely spaced septa; occasionally wash ashore

Spirula: an open-sea squid with internal, spiral chambered shell which washes ashore after the animal dies

O Teuthoidea (squids)

Sepioteuthis: the common lagoonal squid, robust and colorful; often spends the day in shade of coral structures or docks

O Octopoda

Octopus: an active benthic predator, usually nocturnal which leaves a "midden" of mollusc and crustacean shells by its cave

Ph Sipuncula (sipunculids or peanut worms): small, unsegmented peanut-like worms that nestle in crevices or burrow; anterior end of body invaginates into trunk

Paraspidosiphon: with antero-dorsal and posterior horny plates; bore into $CaCO_3$ substrates

Phascolosoma: nestles in crevices

Phascolion: occupies vacated snail shells

Sipunculus: large elongated form which burrows in sand or grass

Ph Echiura: chunky, unsegmented worms with trough-like proboscis; burrow or nestle

Ph Annelida (segmented worms): generally elongate worms with segmented bodies and paired lateral appendages

Cl Polychaeta (bristleworms): marine annelids with lateral paired appendages and well-developed clusters of bristles from each [This is a very diverse group, especially well-represented as nestling and burrowing forms often of small size; most of the families form discreet, identifiable units that can be grouped into several "ecological types" as given below]

Free-crawlers

F Amphinomidae (fireworms)

Hermodice: reddish or brownish, to large size (25 cm) with dense bundles of irritating white CaCO3 chaetae: BEWARE!

F Syllidae

Syllis

S spongicola: abundant small white worm in the stinging sponge Neofibularia

other forms (spawning behavior) are common in the nocturnal plankton

F Polynoidae (scaleworms): cryptic forms with two rows of enlarged circular scales on dorsum

F Eunicidae and related families: large worms free-crawling in coral rubble

Burrowers

F Glyceridae: with enormous eversible proboscis

Tube-dwelling deposit feeders

F Terebellidae: in sand-grain tubes or burrows; with a cluster of highly extensile feeding tentacles at anterior end

Eupolymnia nebulosa (spaghetti worm): with numerous highly extensile white feeding tentacles which it extends from its tube beneath rock

F Pectinariidae

Pectinaria: forms a marvellous conical tube of precisely fitted sand grains which it carries along as it digs in coarse sand

Tube-dwelling suspension feeders

F Sabellidae: with tubes of organic secretion and embedded sediment

Sabellastarte magnifica: the large, common featherduster worm

Sabella melanostigma: small in small "colonies

F Serpulidae: with tubes of secreted CaCO3

Spirobranchus: the common Christmas-tree worm with a double spiral of colorful feeding tentacles

Filograna: tiny colonial form producing a tangled mass of fine CaCO3 tubes < 1 mm diameter

Pomatostegus: with orange horseshoe-shaped tentacle crown

F Spionidae: tube-dwellers of generally tiny size with two long waving tentacles; often commensal with red encrusting sponges on reef

Holoplanktonic forms

F Tomopteridae

F Alciopidae

Ectoparasites

F Myzostomidae

Myzostoma: a small flat form crawling on the surface of the crinoid Nemaster; with only a few pairs of appendages each with a single hook- shaped chaeta for crawling about on host

Ph Tardigrada (water bears): microscopic forms resembling tiny bears; (6 spp. found in beach sand of Yacht Club)

Ph Arthropoda: "joint-legged" forms, with rigid external cuticle and segmented body and appendages with numerous bristles or setae

[SubPh Trilobita: EXTINCT; the most primitive of arthropods; common in Paleozoic fossil assemblages]

SubPh Chelicerata

[Cl Merostomata (icludes "horseshoe crabs" of eastern U.S.)]

Cl Pycnogonida (sea "spiders"): small generally overlookled forms with reduced bodies and greatly elongated legs

Cl Arachnida (group of primarily terrestrial forms including spiders, scorpions and their relatives; marine forms include some mites)

SubPh (or Cl) Crustacea: includes nearly all marine arthropods

[SubCl Cephalocarida]

[SubCl Mystacocarida]

SubCl Branchiopoda: forms with numerous feathery swimming appendages; primarily freshwater

O Cladocera: planktonic

SubCl Ostracoda: very small; greatly shortened forms with only two pairs of thoracic appendages; fully enclosed by carapace; rarely to 1 mm; benthic and planktonic

SubCl Branchiura: ectoparasites that scuttle around on the skin of fishes

SubCl Copepoda: abundant forms in both planktonic and benthic environments; to about 1 mm

O Calanoida: most abundant of planktonic metazoa

O Harpactacoida: mainly benthic, but also planktonic

O Cyclopoida: planktonic and benthic, with a number of parasitic forms as well

Sapphrina: common oceanic form; iridesces as bright blue flashes in bright light

F Corallivexidae: parasitic forms in the guts of stony corals

SubCl Cirripedia (barnacles)

O Thoracica (free-living barnacles): sessile as adults, usually protected by $CaCO_3$ plates; feed with feather-like thoracic legs

SubO Lepadomorpha (stalked or gooseneck barnacles)

Lepas: common on objects floating at sea (and washed onto beaches

Conchoderma: with plates reduced or absent

Octolasmis: occur in gill chambers of lobsters and other large crustacea

SubO Balanomorpha (acorn barnacles): small to medium- sized (usually up to 1 or 2 cm) volcano-shaped forms

Balanus

Tetraclita

"diogenes barnacle": occurs on underside of conch shell carried by hermit crab P diogenes

O Acrothoracica (boring barnacles): forms that bore into $CaCO_3$ substrates including mollusc shells and reef substratum

O Rhizocephala: highly specialized parasites of other crustacea; recognizable as barnacles only in larval stages

Peltogaster: parasite of hermit crabs

SubCl Malacostraca: includes most of the larger crustacea; usually "shrimplike" or "crablike" forms with 8 thoracic and 6 abdominal segments

SuperO Phyllocarida
O Nebaliacea
SuperO Hoplocarida
O Stomatopoda (mantis "shrimps"): highly alert raptorial forms that attack prey from "home" cavities in reef or soft substrates
Gonodactylus
Pseudosquilla
Lysiosquilla: large burrowing form (in sand)
SuperO Peracarida: smallish forms in which female carries embryos in ventral thoracic brood pouch
O Mysidacea: shrimp-like forms that swim continuously, often in schools
Heteromysis: very small red forms that school near the sea anemone Bartholomea
Mysidium: small transparent forms that school near Diadema and disperse at night
O Cumacea: shallow-burrowers of the sediment surface; males sometimes taken in nocturnal plankton tows
O Tanaidacea: small elongated forms common in bottom vegetation
O Isopoda: generally flattened oval forms with strong grasping legs
Anilocra: large ectoparasite of some reef fishes
O Amphipoda
SubO Gammaridea: includes beachhoppers and other forms
SubO Hyperiidea: oceanic planktonic forms with greatly enlarged eyes
SuperO Eucarida
O Euphausiacea: planktonic (the "krill" of southern oceans)
O Decapoda: largest and best known crustaceans; with 5 pairs of thoracic "legs"; carapace covers whole thorax to form large lateral gill chambers
InfraO Peneidea (prawns)
Peneus: nocturnally active over reefs and sediment bottoms; readily swim or burrow for defense; occasionally large aggregations enter shallow mangrove lagoons
F Sergestidae: oceanic planktonic forms
InfraO Stenopodidea: true shrimps with third (of 5) walking leg greatly enlarged as claw (used in intraspecific combat)
Stenopus
S hispidus: (barberpole shrimp)
S scutellatus: smaller red and yellow-banded form
InfraO Caridea (broken-back shrimps: with conspicuous abdominal flex where second pleurite overlaps those in front and behind); includes most species of true shrimps; many are associates of larger coral reef invertebrates
Alpheus (snapping shrimp): a common symbiont of the the anemone Bartholomea, which it defends
Synalpheus: yellow with red-tipped claw, in sponge passages especially Spheciospongia
Beteus: a smaller snapping shrimp
Rhynchocinetes: a large, large-eyed red nocturnal shrimp common on reefs
Periclimenes
P pedersoni: a common symbiont of sea anemones; performs grooming services for reef fishes

P yucatanicus: also found with anemones
Thor: a small brown and white-saddled shrimp found with sea anemones
Gnathophyllum americanum (bee shrimp)
Lysmata
L grabhami
L wurdemanni
Pontonia: symbionts of various bivalves, found in male/female pairs in the mantle cavity
P mexicana ("penshell pontonia")
"fileshell pontonia"
"Spondylus pontonia"
Stegapontonia: narrow elongated shrimps found clinging to urchin spines or other narrow objects; colored like "host"
"Diadema shrimp"
"Tripneustes shrimp"
"Syringodium shrimp"
Microprosthema: small distinctive form with X pattern of antennae
Axiopsis: sand burrowing shrimp often visible near rim of burrow
InfraO Palinura (spiny lobsters and relatives)
Panulirus (spiny lobsters)
P argus
P guttatus
P brasiliensis
Justitia (long-handed lobster): a smaller, large-eyed deeper water form sometimes taken by scuba divers
Scyllarides (trunk, slipper or shovel-nosed lobster)
Palinurellus (copper lobster)
InfraO Anomura
SuperF Thalassinoidea: shrimp-like forms that excavate deep and often elaborate tunnel systems in sediments
Callianassa
SuperF Paguroidea (hermit crabs): with abdomen modified for inhabiting vacated snail shells
Paguristes cadenati: small red hermit crab
Dardanus: blue-eyed hermit crab that may house sea anemone Calliactis
Petrocheirus: the largest Caribbean hermit crab, often inhabiting shells of the queen conch
Coenobita: land hermit crab
SuperF Galatheoidea: flattened, very crab-like forms but reduced abdomen capable of locomotory movements
galatheids
Petrolisthes: in reef rubble
Porcellana: living with Petrocheirus
SuperF Hippoidea (mole "crabs"): oval streamlined forms that dig rapidly into the wave zone of sand beaches
Hippa
InfraO Brachyura (true crabs): abdomen greatly reduced and permanently flexed under laterally expanded cephalothorax
F Dromidiidae
Dromidia: carries hunk of sponge or other object over dorsum with upward-flexed last legs

F Calappidae

Calappa: several spp of sand-burrowing forms with massive claws

C flammea

C sulcata

F Portunidae

Portunus: swimming crab, nocturnal on reefs; with 2 large "ocelli" on carapace

Callinectes (blue crab) common inshore or in mangrove lagoons

Arenaeus (speckled crab) small speckled form in coarse sand

F Ocypodidae

Ocypode (ghost crab) digs burrows on sandy beaches

Uca (fiddler crab) in extensive "colonies" on mud flats

F Grapsidae

Grapsus (Sally-light-foot crab) common on rocky shores and docks; very fast and nimble; tolerant of long exposure to air

Percnon: very flat crab often found under Diadema

Aratus: mangrove crab, often abundant among the prop roots of the red mangrove

Goniopsis (red mangrove crab) fierce; reddish; also common among the prop roots of the red mangrove; generally closer to base of tree than the former

F Gecarcinidae

Cardiosoma (Kalaloo crab) large inhabitant of deep burrows dug near the waters edge; often venture onto highways on rainy nights

Gecarcinus (land crab)

G lateralis: small dark purple

G ruicola: large dark purple

F Majidae

Stenorhynchus: very slender and elongated crab that often "dances" in front of Diadema

Mithrax: includes several species of spiny crabs

M spinosissimus: very large, spiny,long-legged

M sculptus: common green form to several cm

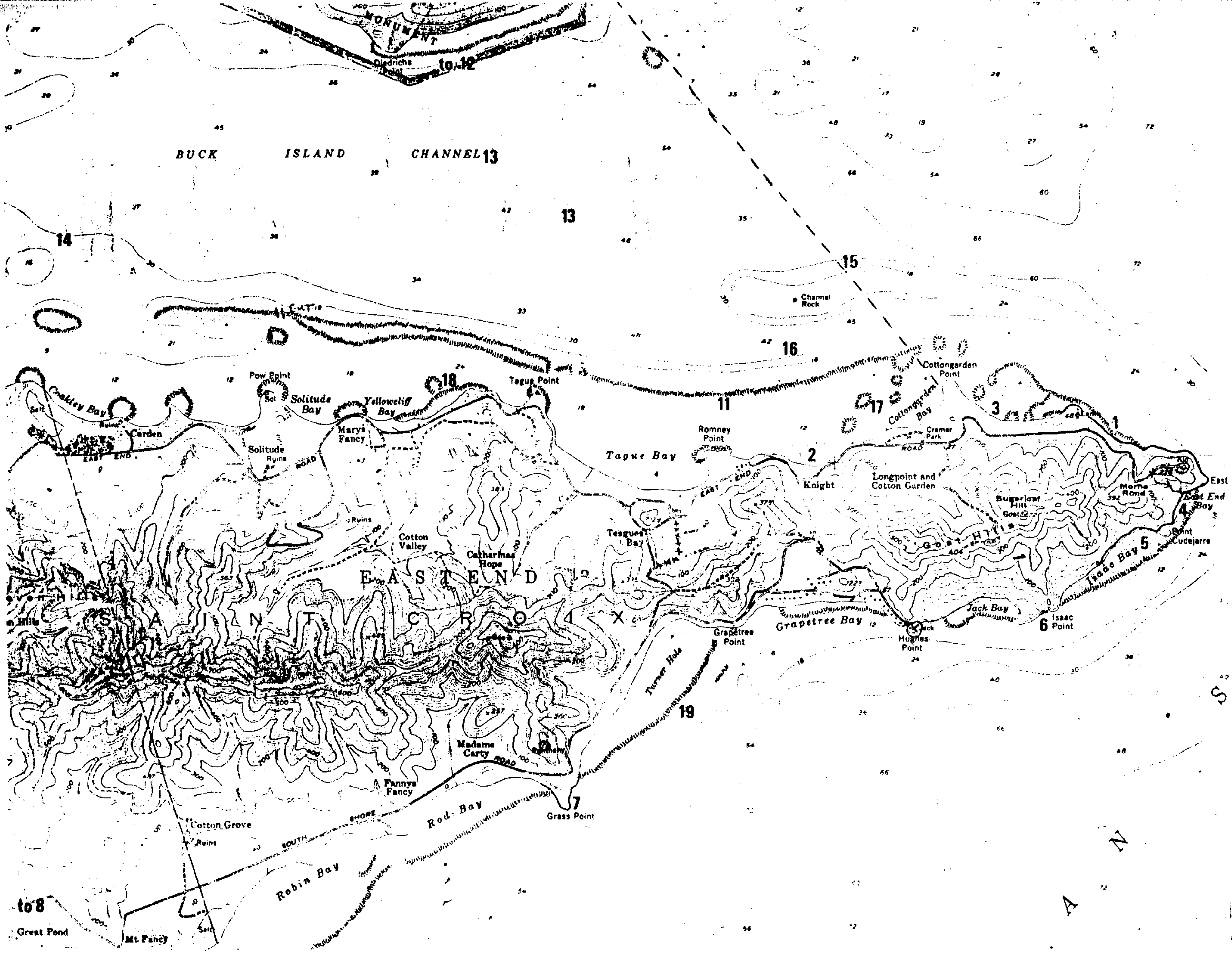
F Pinnotheridae

Carpilius (coral crab): large smooth crab of reefs

Paraliomera longimana: small dark brown crab abundant in coral cavities

SubPh (or Cl) Insecta

Halobates (marine water strider) found in the shade of mangrove trees


MONUMENT
Diedrichs Point
to 12
BUCK ISLAND CHANNEL
13
13
14
15
Channel Rock
16
CUT
Coakley Bay
Garden
Pow Point
Solitude Bay
Solitude
Ruins
Yellowcliff Bay
Marys Fancy
18
Tague Point
11
Cottongarden Point
Cottongarden Bay
17
3
1
Romney Point
Tague Bay
2
Knight
Cramer Park
Longpoint and Cotton Garden
EAST END ROAD
Sugarloaf Hill
Goat Hill
Morne Rond
East
East End Bay
4
Point Cudejarre
5
Isaac Bay
Isaac Point
6
Jack Bay
Hughes Point
Grapetree Bay
Grapetree Point
Tesgues Bay
Cotton Valley
Catharinas Hope
EAST END
SAINT CROIX
Turner Hole
19
Madame Carty
Fannys Fancy
7
Grass Point
Rod Bay
SOUTH SHORE ROAD
Cotton Grove
Ruins
Robin Bay
to 8
Great Pond
Mt Fancy

Shallow-water Marine Field Sites of St. Croix
(* detailed account given below in manual)

[the first 12 sites all have SHORE access
and are suitable for self-led groups]

1* Lamb Bay (Shallow; SHORE access)
Good INTRODUCTORY snorkelling site with shore access
Good diversity of anthozoans
Illustrates lagoonal morphology on a small scale (and can be seen from overlook above the bay)

2* WIL Dock and Vicinity (Shallow; SHORE access)
Variety of fouling communities on pilings and boat bottoms
Complex benthic algal community with some interesting cnidarian species
Shoaling fishes

3* Smuggler's Cove (Shallow; SHORE access)
Easy shore ACCESS from WIL
Diversity of near-shore environments including beach, beachrock, fringing _A palmata_ reef, grassbed

4* Tague Bay Patch Reefs and Grassbed (Depth = surface to 20'; snorkel OR Scuba; BOAT access, but can be reached from shore by snorkellers)
Natural carbonate platforms from a few 100 m2 to a few 1000 m2
Good for study of lagoonal reef dynamics and reef/grassbed interface
Good collecting for echinoderms
Good for studies of replicate reef communities
Good for studies of fish community dynamics

5* Boiler Bay: Beachrock and nearshore algal reefs (Shallow; SHORE access)
Diversity of macroALGAE
Well-developed E lucunter communities in several microhabitats
Good cryptofauna in algal reefs

6* East End Bay (Intertidal; SHORE access)
Rich DEACHROCK COMMUNITY with good invertebrate diversity
(CAUTION: not a good site when surf's up and tide's in)

7 Isaac's Bay (Shallow; SHORE access)
Shallow clear bay in scenic location
Variety of habitats
Formation of _A palmata_ reeflets

8 Isaac's Point (Shallow; SHORE access;can be reached from east or west)
Well-developed high-energy ALGAL RIDGES near shore with some cave development; interesting spot

9 Grass Point (Intertidal; SHORE access)
Good collecting ground for invertebrates amidst rubble on western side of point

10* Great Pond/Great Pond Bay (Intertidal; SHORE access)
Shallow tidal pond with entrance/exit channel lined by mangroves
Rich and diverse crab fauna
Interface of mangrove and grassbed
Shallow, nearshore grassbeds with invertebrate infauna

11 Analy Bay (Intertidal and snorkel; SHORE access [1/2 h hike]
Spectacular north coast site with rugged uplifted fringing carbonate platforms and giant tide pools and caves
Rich intertidal gastropod community
In calm weather, shallow-water community characteristic of exposed rocky bluffs

12 The "Baths" (Estate Northside) (Depth 10' to 25'; scuba OR snorkel; SHORE access)
Rich community of CORALS, other anthozoans, SPONGES and fishes
Numerous ASSOCIATIONS between small invertebrates and fishes and larger invertebrates

[THE FOLLOWING SITES REQUIRE THE USE OF BOATS]

13* Tague Bay Reef: Research Platform Site (Depth = surface to 45'; snorkel OR Scuba; BOAT access)
Zonation of a bank barrier reef
Huge <u>P</u> <u>porites</u> colonies
Good general INTRODUCTORY site with good diversity of reef cnidarians and fishes
Good site for DAY/NIGHT comparison
Swim access to forereef

14* Buck Island: UW Trail, Windward forereef, Scuba cut, Haystacks (Depth = Surface to 30'; Snorkel OR Scuba; BOAT access)
Well-developed <u>A</u> <u>palmata</u> reef
REEF STRUCTURE
Coral Formations
Coral and anthozoan diversity

15 Buck Island Channel Patch Reefs (Depth = 40'; SCUBA ONLY; Boat access)
Coral and anthozoan DIVERSITY
Diversity of small sessile invertebrates (hydroids, bryozoans, ascidians, bivalves)
SPONGE diversity
Well-developed gorgonian gardens
Interface of deeper water reef/sand halo/grassbed

16* Horseshoe Patch (Depth = 35'; SCUBA ONLY; BOAT access)
Deeper water sand flat/grassbed community
Large echinoderms and molluscs
Specialized fishes

17 Channel Rock and Porpoise Patch (Depth = 10' to 60'; primarily SCUBA; BOAT access)
Well-developed <u>A</u> <u>palmata</u> reef (shallow)
Diversity of anthozoans, sponges and small invertebrates (deep)
Diversity of fishes

18 Channel Block Reefs (Depth = 40'; SCUBA ONLY; BOAT access)
Replicate, isolated small communities (on 40 block pyramids)
Good for comparative community structure (of fishes, corals and other invertebrates
Good for crustacea and other mobile invertebrates

19* Holt's Reef (Depth = Surface to 20'; snorkel OR Scuba; BOAT access)
Diversity of SUSPENSION and DEPOSIT feeders
Best lagoonal sponge fauna at East End
Diversity of small crustacea and annelids

20 Turner Hole (Beach Hotel) Algal Ridge (Depth 25'; SCUBA; BOAT access)
Most extensive underwater CAVE system on St. Croix

21* Salt River Bay (shallow; SHORE and small Boat access)
Best developed RED MANGROVE forest on ST. Croix
Can drive small boat under well-developed red mangrove canopy; snorkel among prop roots

22 Salt River Canyon (Depth 20' to 100+'; SCUBA ; BOAT access)
Spectacular vertical TOPOGRAPHY
Rich shelf-edge fauna with some specialized forms

23* Cane Bay / Northstar / Davis Bay (Depth 30' to 100+'; SCUBA; BOAT or SHORE access)
Rich and well-developed buttress reefs
Rich and diverse CORAL and ANTHOZOAN communities
Rich and diverse SPONGE community
Clear zonation from shore beyond shelf edge
Rich and diverse FISH community
DEEPER REEF organisms not found at east end sites
Accessibility to oceanic plankton

24* Fredericksted Pier (Depth 0' to 40'; scuba OR snorkel)
A unique and rich environment
Many UNIQUE FISHES and other organisms, found only here
Rich SPONGE community
Diverse small sessile invertebrates such as HYDROIDS, tube worms, etc.
Rubble below pier rich in annelids and crustaceans
Access to oceanic plankton

Additional Field Trips (Terrestrial) of Special Interest

I. Terrestrial Vegetation and Plant Communities

1. Jack's Bay: Rich and diverse littoral vegetation

2. Smuggler's Cove and road to Cramer Park: Rich and diverse example of dry forest vegetation; ALSO good terrestrial litter fauna

3. Buck Island nature trail: Dry forest and scrub vegetation ALSO (in winter) Nesting of Brown Pelicans

4. Green Cay (U.S. Fish and Wildlife Refuge): Only remaining habitat of the endemic and endangered lizard *Ameiva polops*; ALSO good roosting and nesting sites of local water birds; ALSO Pre-Columbian conch midden

5. Creque Dam Road: Good example of moist forest (= St. Croix "rain forest")

6. Caledonia Valley: Good example of moist forest; semi-permanent stream with pool fauna (shrimps and FW fishes); bridled quail doves

7. St. George Botanical Gardens.

8. Christiansted and Fredericksted towns: good examples of trees and other West Indian vegetation

Birding Locations

9. Great Pond: the southeast and northern ends of this permanent pond are good habitat for migrant shorebirds and various herons in particular

10. Southgate Pond: a temporary pond usually full from mid-Fall to late Spring; good for groups of waterbirds rsident and migrant (shorebirds, herons, ducks, raptors)

11. Salt River Dike: best location for migrant and wintering wood warblers

Other

12. Southwest Cape (= Sandy Point): Sea turtle nesting (at night in spring and summer

13. Rock Outcrops / Geological Sections: Villa LaReine; Hess; Airport; F'sted

FIELD SITE: Buck Island Reef

The bank barrier type reef characteristic of the eastern end of St. Croix is well-represented at Buck Is. Reef National Monument. In general this type of reef rises from the St. Croix shelf at a general depth of 10-15 m to the water surface with occasional topographic lows navigable by swimmers or even boats. Landward of the reef is a semi-protected lagoon of approximately 5-7 m depth. The morphology of the reef differs strikingly from the northern to the eastern to the southern exposures and these differ from other reefs in the area. The control of this variation is only partially understood.

THE LAGOON extends from shore to the reef and is generally 3-5 m deep and 100 m wide, with a more or less uniform bottom. The inner portion of the lagoon has a highly bioturbated sand bottom (due to callianassid shrimps) with little evident epifauna or flora; the outer portion is a flat carbonate pavement with scattered small to medium-sized coral heads and gorgonians over much of its area, and extensive dense thickets of Acropora prolifera covering the remainder (which largely died out a few years ago, but are starting to recover).

THE BACKREEF is characterized by dense stands of Acropora palmata, large heads of Montastrea annularis and Diploria strigosa and "boilers" (algal ridges) probably composed of the former coral species consolidated by crustose coralline algae. In the lower more shaded portions of the grottos and stands of A palmata are dense growths of the zoanthid Z sociatus, flattened growths of P astreoides and Agaricia sp. and numerous Isophyllia sinuosa. Large gorgonians (Pseudoplexaura spp.) are numerous here.

THE REEF CREST reaches the surface in many places but is 1 m deep in some parts. This shallow high energy zone is dominated by Millepora complanata and the zoanthid P caribbea. In places an algal ridge has developed, especially toward the west.

THE FOREREEF was until recently composed primarily of dense stands of A palmata on a shallow slope in the east. Toward the west coralline algal consolidation is pronounced, the forereef slope nearly vertical in places and has numerous small caves and grottos which shelter nocturnally active fishes and urchins. Ready access is provided to the forereef from the Underwater Trail (follow the large arrow to the outside); a swim of about 100 m to the east leads to the once-rich A palmata dominated eastern forereef. Though badly damaged by a combination of "white-band disease" and storm waves during the past decade, it now shows signs of recovery.

THE ISLAND SHELF or BANK begins at the base of the forereef at a depth of about 10 m. This zone is characterized by scattered large coral heads, cylindrical columns of M annularis, numerous gorgonians, patches of pavement and sand. Numerous conical "haystacks" covered with A palmata lie on the bank bottom to the north of the bank barrier reef, and extend nearly to the surface. These structures as well as the eastern forereef particularly good examples illustrating the recent history and mechanism of reef construction.

Abundant or noteworthy organisms

A. CORALS:

Acropora palmata Occurs in dense stands and dominates much of the backreef and reeftop zones and most of the forereef. The colonies that still stand are some of the finest examples of the stature that can be achieved by this species

A prolifera formerly abundant in the lagoon, forming extensive dense growths in many areas; now only traces remain

A cervicornis common; forms thickets on the bank bottom just off the base of the forereef, especially in southeast.

Montastrea annularis forms large heads on the backreef, especially to the northwest, and large columns just off the base of the forereef.

Diploria strigosa common on the backreef, forming large heads; abundant towards the northwest

Porites astreoides numerous on the pavement area of the lagoon; bright green heads about 0.3m across; on the forereef side of the Underwater Trail are flattened examples growing in the shade

Siderastrea siderea forms large heads at the base of the forereef on the bank bottom, common

Agaricia agaricites abundant on vertical surfaces on the backreef and forereef especially the sides of M annularis columns just off the forereef.

Isophyllia sinuosa colonies numerous in the deeper areas of the backreef and lagoon.

Mycetophyllia ferox common on the steeper parts of the forereef toward the northwest

Mussa angulosa common on the bank bottom

Colpophyllia sp. common on the bank bottom and base of the forereef

B. ZOANTHIDS:

Palythoa caribbea most abundant on the shallow reef top and shallow forereef where colonies coalesce to form extensive mats

Zoanthus sociatus abundant in shady areas, common in the lagoon especially on backreef

C. GORGONIANS

Pseudoplexaura the largest and most numerous gorgonian in the lagoon and backreef areas.

Briareum asbestinum numerous in the lagoon and backreef

Erythropodium forms pinkish mats in shady areas especially on the backreef

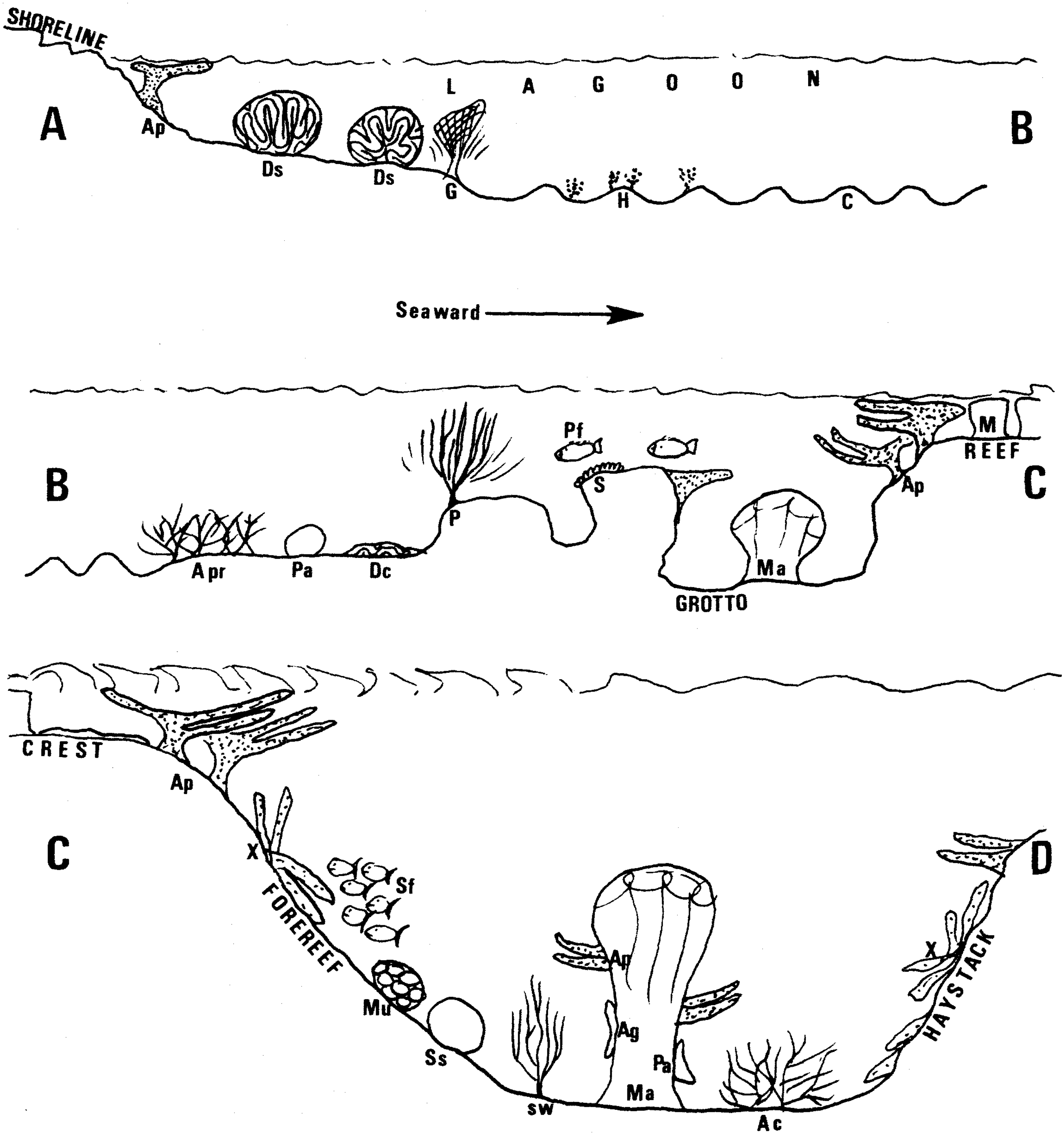
Plexaura homomalla second commonest "seawhip" on the backreef

Gorgonia sp. common on the forereef in certain areas

D. HYDROZOANS

Millepora complanata dominates the shallowest portions of the reeftop

PROFILE AT BUCK ISLAND FROM SHORELINE ACROSS LAGOON AND REEF TO HAYSTACKS



E. FISHES

Scaridae (parrotfishes): abundant at this site especially lagoon and backreef; seen singly or in groups feeding on algal turfs or occasionally live coral

Acanthuridae (surgeon fishes):abundant, seen principally on backreef and lagoon as large schools of roving herbivores

Pomacentridae (damselfishes): abundant all zones. Most are highly territorial and defend small areas of reef

Labridae (wrasses): abundant, especially backreef and lagoon

Lutjanidae (snappers): this family is particularly well represented at this site, especially lagoon, backreef and forereef.

Kyphosidae (chubs):common around the Underwater Trail, boat moorings and shallow forereef

Malacanthidae (sand tilefish):common in the sandy portions of the lagoon where they construct caves of coral rubble

KEY TO BUCK ISLAND REEF PROFILE (left to right = inshore to offshore)

Ap	Acropora palmata (elkhorn coral)
Ds	Diploria strigosa (large brain coral)
G	Gorgonia (sae fan)
H	Halimeda (segmented calcareous green alga)
C	Callianassa (=burrowing shrimp) mounds; bioturbated sand
Apr	Acropora prolifera (small staghorn coral)
Pa	Porites astreoides
Dc	Diploria clivosa
P	Pseudoplexaura (large slimy sea whip)
Pf	Parrotfish
S	Stoichactis (sea anemone)
Ma	Montastrea annularis
M	Millepora (fire coral)
X	Dead and toppled Acropora palmata
Sf	Surgeonfish
Mu	Mussa
Ss	Siderastrea siderea
sw	sea whips of various spp
Ag	Agaricia agaricites
Ac	Acropora cervicornis (large staghorn coral)

FIELD TRIP: The Shoreline near WIL

A. The WIL Dock, yacht basin and vicinity

The closest field site to WIL includes the diverse composite of environments in the low-energy lee of Romney Point: the WIL and Yacht Club docks, the fouling communities on moored boats, the rich silty bottom community and the rocky shore community near Romney Pt. itself. You may find the water a bit turbid compared to other local environments but the abundance of interesting organisms should compensate for this; many of the animals found here are excellent for laboratory material.

THE DOCKS AND BOAT BOTTOMS support a rich but specialized fouling community with a wide taxonomic representation; there is seasonal variation, with the richest growth present from spring to late fall when the water temperature is warmest.

A. SPONGES:
- a variety of soft encrusting demosponges often dominates these environments but more interesting are:
- Leucosolenia this small delicate white calcareous sponge demonstrates the simplest body form of any adult sponge; excellent lab material
- Clathrina similar to previous but yellow and structurally a bit more complex Because of their adaptation to inshore waters, both of these spp live well in the seatables where a number of simple experiments can be performed on their growth

B. CNIDARIANS:
- Aiptasia this small brownish long-tentacled sea anemone may form extensive mat-like clones in these areas; once expanded in a dish it provides excellent material for observation. Larvae entering through the seawater pipes have established a permanent population in the seatables.
- hydroids of several types, often very small are locally common

C. ASCIDIANS:
- botryllids: gelatinous, mat-like forms with distinctive geometry of mouth openings in colonies
- didemnids: similar to above but generally tougher and with less distinctive surface patterns
- Perophora small green forms in loosely connected colonies which make excellent lab material (mounted gently beneath propped up cover slip on microscope slide)
- Herdmannia large, solitary orangish form, tough and often in clumps

D. BRYOZOANS:
- Zoobotryon forms long stringy branched masses; good lab material for basic bryozoan structure and function
- crustose forms: with a minutely "cellular" appearance

E. ALGAE:
- a variety of forms is present; collect the different types and return to the lab to identify it

F. CRUSTACEANS:

Stenopus the barberpole shrimp, often occurs in male/female pairs on the shaded dock pilings

Panulirus juvenile spiny lobsters (to a few cm long) occur seasonally in this environment, especially when algal growth is dense for concealment

Grapsus the Sally-Lightfoot crab, has a permanent resident population on each of the docks. Generally they hang out above the water surface but will submerge to escape threats

THE SILTY BOTTOM OF THE YACHT BASIN supports a somewhat specialized and interesting flora and fauna

A. PLANTS:

seagrasses: all four local spp of seagrasses can be found in this basin

Thalassia

Syringodium

Halodule

Halophila normally a deeper water species, this delicate form occurs just off the WIL dock, perhaps because of the consistent high turbidity

Penicillus this shaving-brush-shaped green alga is common and is an important producer of carbonate silt

Halimeda several spp with crunchy green segments, this sp is an important local producer of sand other spp of a variety of types occur as well

B. CNIDARIANS:

Aiptasia common on the bottom

Bunodeopsis this small anemone appears as flat, enlarged warty patches on turtle grass blades; pluck a few blades to collect them

Myrionema is a hydroid which appears like a tiny brown daisy; it is commonest near shore in the shallow grassbeds

Cassiopeia this medium to large rhizostome jellyfish forms a resident population on the quiet lagoon floor

cerianthids are common here but can be seen emergent from tubes only at night

C. CRUSTACEANS:

a variety of burrow-dwelling crustaceans live here but are rarely seen: shrimps, stomatopods, callianassids, and crabs, as well as other, smaller forms

D. FISHES:

a variety of specialized inshore fishes occur here as well as the juveniles of a number of typical reef fishes; in particular look for:

gold-spotted eel

mojarra (several spp)

The shallow grassbeds near shore (which may be exposed during a very low tide) harbor a representative infauna which can be sampled by use of a shovel or coring device. Because of the limited size of these beds please do VERY LIMITED SAMPLING HERE.

ROMNEY POINT and the surrounding shoreline support some of the more typical and resistant reef organisms as well as a few specialized ones that do not occur on the reef.

You will find a variety of corals, sea anemones, gorgonians and other cnidarians; annelids crustaceans and molluscs (be on the lookout for Octopus burrows and their telltale shell middens: the leftover shells of mollusc and crustacean meals); and fishes, including some unique types found only along shorelines (e.g. night sergeant, various blennies). On the intertidal rocks along this stretch of shore you can find a variety of molluscs.

B. Smuggler's Cove

This site can be most easily reached on foot or by vehicle by walking east on the road from the WIL gate for about 1 km. Take the left fork then shortly take the path that goes to the beach between two stone pillars. The environment here is higher energy than the previous and several environments are represented beach, beachrock, fringing reef and grassbed.

The BEACH is composed of medium-grained sand and has the typical inhabitants of this environment:

Ocypode the ghost crab digs numerous burrows in the mid to upper beach zone; this is an ideal site to carry out a 24 h study of the behavioral ecology of an interesting organism

amphipods these small beachhoppers are common, especially among clumps of drift seagrass

Hippa this small scavenging mole crab can sometimes be found in the wash zone

The BEACHROCK forms a seaward barrier for much of the beach but is best developed at either side of the old dock; urchin beds are fairly well developed in this area and serve as rich microhabitat for a variety of small invertebrates and fishes. On a reasonably calm day it is possible to snorkel along the outer edge of this beachrock and see many of these organisms. In addition, at the seaward base of the beachrock there is an overhang; beneath it is a wealth of small fishes, lobsters and other mobile forms. A row of old pilings just to the west of the dock often has a wealth of small fishes, anemones and other organisms. In the urchin bed look particularly for:

Bunodosoma the small brown sea anemone

Echinometra lucunter the numerous rock urchin

limpets, keyhole limpets and other gastropods

gobies: especially the Nine-banded and the Green-banded

a variety of algae is also present

By chipping a chunk of rock off the seaward edge of the beachrock, numerous types of nestling worms (including sipunculids and scale worms) and bivalves can be found

The RUBBLE ZONE is particularly well-developed off the eastern end of the beach; look for a variety of sea anemones, and by turning rocks, echinoderms and crustaceans, including stomatopods and porcellain crabs

The GRASSBED can be investigated by swimming a wide arc across the front of the beach; collect any unusual plants or large invertebrates; note any fishes. How does this habitat differ from the soft community in front of the WIL dock? The differences observed probably arise ultimately from differences in wave energy, leading to differences in the nature of the deposited sediment and subsequently to floral and faunal differences.

A FRINGING REEF composed primarily of Acropora palmata lies about 100 m to the west of the beach. The small rock outcrops and grassbed encountered enroute have an interesting assortment of organisms. The fringing reef harbors a very rich fish fauna (more than 50 spp can be censused in a half hour by a good observer). What do these fishes do at night?

C. Smuggler's Cove at Night

This is an interesting area to snorkel at night, particularly after a daytime trip. In addition to the perceptual differences a variety of organisms should be in evidence that were not seen by day. Be sure to cover ALL major habitats here. The comparison of this area between day and night makes a very rewarding activity if done conscientiously. Among the numerous forms evident that were not seen by day are: Octopus, squids, spiny lobsters, cerianthids, snake eels, etc.

FIELD SITE: Tague Bay Patch Reefs

The eastern end of Tague Bay (Knight Bay, Cottongarden Bay) has a series of nearly 20 carbonate patch reefs in 3 - 5 m water depth with an average size of about 1500 m2. These are relatively uniform in general structure with a flattened top about 1 m deep with scattered stands of A palmata and Millepora and have sloping sides with a variety of head corals on the lower portion. The reefs are surrounded by seagrass meadow, with or without a sand halo in between. These are interesting small ecosystems in their own right, but additionally have provided natural replicate reefs which have served as the basis of a number of ecological studies since the early 1970's (e.g. see Ogden et al. 1973; Gladfelter et al. 1979; McFarland et al. 1979.). A numbering system has been applied to these reefs and has been used consistently in the published literature (ranging from No. 1 off Smuggler's Cove in the west to No. 18 off Cottongarden Point in the east; see accompanying Fig.). The dimensions and other physical parameters of these reefs are given in Gladfelter and Gladfelter, 1978. Although these are most conveniently reached by boat from the WIL Dock some of them can be reached from shore by snorkelling out from Cramer Park Beach (especially nos. 6 and 7).

Characteristic Organisms

A. Algae

Large browns predominate: Sargassum, Turbinaria and Padina

B. Sponges

Simple calcareous sponges, Clathrina and Leucosolenia can be found in the cryptic environments on the steep west ends of a number of these reefs

C. Cnidarians

The large anemone Condylactis is common around the base

Sea fans, Gorgonia are common on the tops and exhibit a high degree of orientation to wave movement (see Wainwright, 1969)

Other gorgonians including Briareum are common on the flanks

The typical suite of backreef corals occurs here:

Acropora palmata
Porites porites
P astreoides
Montastrea annularis
Diploria strigosa
Agaricia agaricites
and others

Millepora

Zoanthids

D. Echinoderms

The large white sea urchin Tripneustes is common both on the reefs and in the surrounding grassbeds; look for the small well-camouflaged shrimps on the spines; dead tests of this urchin (which have been bored by the predaceous gastropod Cassis often harbor small conchfish).

Other urchins (Diadema, Echinometra lucunter, E viridis and Eucidaris are all common, mostly in crevices or under rubble
Brittlestars, particularly the large Ophiocoma are numerous
Holothurians of several types occur but are most commonly seen in rubble or at night

E. Mollusca

A variety of predatory gastropods can be found around these reefs, particularly the large urchin-eating Cassis
While queen conchs (Strombus) used to be common in the bay heavy fishing prevents their numbers from increasing

F. Crustaceans

These can be most readily found at night though smaller forms such as commensal shrimps (Periclimenes and Alpheus, living with anemones, as well as stomatopods occur by day)

G. Fishes

Most conspicuous are the large heterotypic resting schools of young grunts, including as many as 8 species; well over a hundred species of reef fishes have been censused from these reefs (see Gladfelter and Gladfelter, 1978).

FIELD SITE: Lamb Bay

This is the easternmost reef lagoon on the north shore of St Croix. It is small and shallow and has a diversity of common coral reef organisms; it's a good place to start.

Vehicles can be parked above both the western and eastern ends of the bay. It is worth a walk (or drive) past the end of the bay to the first hairpin turn in the rough rocky road, overlooking Lamb Bay. Here the morphology of the bay can be seen. A surface-reaching barrier-type bank reef (or bank-barrier reef) bounds the bay on its seaward side. This is primarily an Acropora palmata reef with Millepora and a few other important species. On a calm day one or two channels across the reef provide access to the forereef [NOT RECOMMENDED AT ANY TIME FOR BEGINNERS, OR FOR ANYONE ON ROUGH DAYS]. The backreef zone has a variety of corals and other reef organisms. The lagoon has a sand floor with sparse grassbeds, primarily of Halodule and Syringodium (see key to marine algae). Shoreward is a shelf of submerged beachrock. What other features can be identified from this vantage-point.

Enter the lagoon from the eastern end and disperse. By swimming around and looking carefully you should be able to locate nearly all of the following: be sure to check the variety of microhabitats available, such as shore zone, reef crest, grassbed, etc.

A. Coelenterates:

Stoichactis this large, stubby-tentacled anemone is abundant on the rock and corals near shore

Bunodosoma small brown anemone common on beachrock

other anemones such as Condylactis, Bartholomea occur here

Zoanthus The colonial zoanthid usually occurs in shaded areas under large rubble or under ledges; comes in various colors

Palythoa In tan leathery mats on the reef crest

Ricordea Forms clusters of individuals like greenish warty silver dollars Similar to a tiny Stoichactis

sea whips of a number of species are present; in addition to looking at colony growth form you should try to see the bipinnate tentacles characteristic of the small polyps; pinch the tip of a branch, what happens?

Gorgonia these sea fans occur on the reef crest; note their orientation

Briareum Purple fingers whose surface looks furry and brown when the polyps are extended

Millepora Smooth, tan and hard in upright colonies; not a true coral, this fire coral is a hydrozoan and can give a bad sting if touched; if you look carefully you may see the tiny white thread-like polyps

corals: a number of common species are present, including the following:

Acropora palmata
A. prolifera
Porites porites
P. astreoides
Diploria clivosa
D. strigosa

Siderastrea radians forms small patches on the beachrock
Montastrea annularis
Agaricia agaricites
Isophyllia and Isophyllastrea "fleshy" gray and green forms that look more like fungi than corals
other species are also present

B. Other invertebrates
Echinometra The common beachrock urchin; abundant in the intertidal
Diadema Abundant around coral heads and underledges
Tripneustes Large white urchin that occurs in the lagoon on grass

If you look in among piles of rubble you will see such things as brittlestars, fireworms (DON't touch), shrimps, etc. On the intertidal beachrock occur chitons, snails, and other molluscs. The lagoonal squid, Sepioteuthis can usually be seen in the lagoon.

FIELD TRIP: Holt's Reef

This near-shore reef is a unique site among the various reef sites of eastern St Croix. It is a small outcrop of bedrock which rises above high tide line. On its shoreward side it is surrounded by shallow grassbed with low diversity; on its seaward side the silty sand bottom slopes gradually into the lagoon to a depth of 8 - 10 m. On this slope are a few rock outcrops in the upper regions and a variety of live and dead coral formations farther out. Turbidity is generally high and there is often a current, sometimes quite strong. The most outstanding feature of this small reef however is the wealth of invertebrates of a great many types not common elsewhere on this part of the island. It also is the richest lagoonal site for sponges and other filter- feeders on eastern St. Croix.

Because of its uniqueness, its small size and the need to manipulate the environment to find some of the mobile organisms, it is very easy to cause permanent or long-term damage. Therefore, while searching for organisms here, PLEASE BE AS GENTLE AS POSSIBLE WITH THE ENVIRONMENT; if you move a boulder, please replace it as it was, do not go stepping on sponges, etc,

Abundant and noteworthy invertebrates

A. Sponges:

- Ircinia strobilina: large gray rubbery sponge with cluster of small oscules
- Amphimedon compressa: long maroon finger-like colonial sponges; abundant
- Aplysina fistularis: large yellow tubular sponge
- Spinosella vaginalis: purplish-gray flat upright sheets or "vases"
- Niphates digitalis: similar to above but more grayish and porous; often with commensal zoanthids
- Mycale laevis: orangish sponge common under hanging ledges of Montastrea
- Desmapsamma: soft pink sponge with whitish tinge to surface
- Ircinia felix: small soft brown sponge with reticular surface; common

B. Hydrozoans:

- Millepora: is present here in all its forms; complanata, alcicornis, squarrosa and the gorgonian-encrusting form; look in particular for the latter and for extended polyps
- Halocordyle: the most conspicuous of our local hydroids is common here; tufts and clusters of small white polyps well-separated; other hydroids may be common

C. Other Coelenterates:

- Bartholomea: with its pinkish tentacles with white rings is abundant here along with its typical menage of associated crustaceans: Alpheus, Periclimenes and Heteromysis
- Condylactis: the large finger-tentacled anemone is common
- a variety of corals occur here; among those not necessarily common elsewhere; Dichocoenia, Siderastrea siderea

D. Ascidians:

Ascidia nigra: common on rocks

Herdmannia momus: common on rocks, often in clusters; squirt if touched

E. Polychaetes:

Sabellastarte: the large featherduster is common, its tubes extending down into Porites heads

Spirobranchus: the Christmas-tree worm

Eupolymnia: the spaghetti worm is common under coral rocks, masses of its spaghetti-like feeding tentacles extending out from beneath

Hermodice: the fireworm is common under rocks as well; DO NOT TOUCH! various other polychaetes can be found in crevices and under rocks

F. Mollusca:

Lima: the file shell is common under rocks and in crevices; will swim when disturbed

Scaphopods: can be found in the sand by running your spread fingers along several inches deep and inspecting the track left

G. Crustacea:

Stenopus: the barberpole shrimp is found in small caves, often in pairs do not grab this or other crustaceans by a limb or you will end up with just a limb in your hand

Alpheus: the snapping shrimp is a commensal with Bartholomea; its antennae banded red and white can readily be seen and if the anemone is disturbed the shrimp emerges; often in pairs

Periclimenes: small clear blue-banded shrimp that occurs with anemones especially Bartholomea 2 spp are common:

P pedersoni slender with fine bright blue lines, and

P yucatanicus thicker-bodied with pale lavender saddles

Panulirus: juveniles of the spiny lobster are common under ledges here

Stenorhynchus: the arrow crab; in front of Diadema

FIELD SITE: East End Bay, Intertidal Zone

This trip should be planned for a time when the tide is as low as possible, and preferably when seas are not too strong. Sneakers should be worn and clothing that you don't mind getting wet. Access is via the East End Road, past Cramer Park, past Lamb Bay and up the long, generally rough hill to the saddle where a jeep track cuts off to the right (south). Park at the top and walk down the right fork to the beach. The rich beachrock zone occupies the western half of the beach, meeting bedrock bluffs at the west end. Despite, or perhaps, because of, the generally high wave energy here, there is a wealth of marine life to be found by the careful observer.

A number of these are restricted to certain microhabitats such as beneath rocks, among the urchins, in larger pools, etc. You might want to characterize all the organisms found in this way. Another worthy exercise would be to compare the biota of this beachrock site with that of other such sites in different physical settings (e.g. Isaac's Bay, Boiler Bay, Smuggler's Cove)

Characteristic Organisms

A. Algae

A variety of intertidal forms including _Padina_, _Laurencia_, _Sargassum_, _Acanthophora_, _Centroceras_, and others

B. Sponges

Chondrilla forms small brownish lumps in the rough outer zone near the west end

C. Cnidarians

Anemones:

Bunodosoma moderately common in small pockets and crevices but often difficult to see because of its tan color (has banded tentacles)

Anemonia dark maroon in color and usually confined to the underside of overhanging ledges

Stoichactis this large flat anemone with its disc covered with stubby tentacles occurs here

Corals:

Siderastrea radians occurs as small patches in outer zones

Porites astreoides same

Hydrozoans:

Millepora forms quite extensive crusts in outer areas

D. Echinoderms

Urchins:

Echinometra lucunter Abundant, in dense beds in outer zones; forms important microhabitat for many other organisms

Tripneustes sometimes young individuals occur in large tidepool at west end

Diadema same
Sea Cucumbers:
Thyone occurs in urchin beds towards west end of beachrock
Brittlestars:
Ophiocoma under larger rocks in large tidepool at west end
other spp also may occur

E. Mollusca

Chitons:

several spp can be found in the open and under rocks along the entire stretch of beachrock; how are they zoned by microhabitat?

Gastropods:

Diadora this large keyhole limpet is well-camouflaged covered with algae; occurs on the upper beachrock

Fissurella fascicularis this small, flattened keyhole lives in the burrows occupied by E lucunter

Acmaea limpet, especially in E lucunter zone

Cittarium the West Indian topshell occurs low, especially on the bed rock

Nerita at least 3 spp, N tesselata, N versicolor and N peloronta occur on upper beachrock and adjacent bedrock

several spp of littorinids occur high up on the bedrock: Littorina ziczac, Nodilittorina, Tectarius

Thais this predatory snail can often be found preying upon N tesselata

Purpura may leave a pungent odor on fingers when handled

Stilifer this tiny parastic snail occurs on the underside of E lucunter in about 5 - 10% of the population

the sea hares Aplysia and Dolabrifera occur in upper beachrock zone, also well camouflaged

vermetids

Cephalopods:

Spirula the spirally coiled, chambered shell of this pelagic relative of the squids can be found washed ashore

F. Arthropods

Grapsus the Sally Lightfoot crab occurs in all zones but is quick and often seeks shelter

Ocypode the ghost crab digs tunnels in the sand beach

hermit crabs: marine forms occur in all zones; the terrestrial Coenobita can be found on the beach occasionally by day, frequently by night

stomatopods mantis "shrimps" occur in the large tidepool and the outer zones but they are wary and quick and difficult to spot

Lepas this gooseneck barnacle frequently occurs on debris that has washed ashore, and often the individuals are still alive

a variety of small amphipods, isopods and other crustacea occur among clumps of algae and elsewhere

G. Fishes, etc.

several spp occur permanently in the tidepools and among the sea urhcins:

Sergeant Major: juveniles of this species always occur in the alrge tidepool at the west end

Frillfin goby: common in all zones with standing water

Nine-lined goby: this tiny black form with bright blue bands occurs in the urchin beds, as does:

Green-banded goby: same

Clingfish: this small form clings to rock substrates in the lower zones

a variety of other forms, particularly blennies and the juveniles of some reef fishes can also be found here

Chain moray: this typically shallow-water moray preys largely on the Sally Lightfoot crab and can be seen in pursuit by day or night (students in one class actually watched the moray catch a crab)

Sea turtles: come ashore to lay eggs on this beach, watch for tracks

FIELD SITE: Tague Bay Backreef: Day / Night Comparison

In addition to providing you with an opportunity to see a few new organisms the main purpose of this field trip is to familiarize you with a site that you will return to at night. The backreef here is a fairly wide sandy shelf extending landward from the dense reef crest Acropora palmata stands to the lagoon proper where the shelf abruptly drops from 2 m to about 4 or 5 m depth. On this sandy shelf are areas of A palmata stands and rubble, large P porites colonies, a few large Monstastrea annularis heads and a lot of smaller coral heads and dead coral heads. By day the area resembles the backreef zone at Lamb Bay but is somewhat richer in species. It will give you a good opportunity to review the reef organisms you have already learned as well as apply your newly developed skills as an underwater naturalist and observer. In the list below only forms many of you have not seen or identified before are given:

A. Coelenterates:

Gorgonians: there is a good variety here; anyone wishing to identify more than the few required forms can find all common genera here: check polyp structure and reactions if you have not already done so.

Zoanthids: Zoanthus in the shade; Palythoa in the open

Ricordea This small, stubby-tentacled corallimorph occurs in clusters

Rhodactis A flat, frilly corallimorph that occurs commonly in piles of A palmata rubble.

Phymanthus a medium sized anemone occurring in sand pockets on the reef

Lebrunea Both spp. occur here, the larger L danae looking like clumps of the brown alga Dictyota: the smaller occurring in tiny cavities so that only the tips of its little pseudotentacles are visible

Siderastrea siderea moderate to large heads occur on the backreef shelf or at the base of the shelf in the lagoon

Isophyllia and Isophyllastrea are both common in among the branches of dead A palmata

Helioseris is common tucked back in among the shaded branches of A palmata

B. Echinoderms:

Brittlestars The three common forms Ophiocoma, Ophioderma and Ophiothrix all occur among the coral rubble, as does the small starfish Linckia, and the pencil-spined urchin Eucidaris

C. Crustacea:

Other than arrow crabs, and the numerous swarms of small clear mysids, Neomysis few crustaceans are in evidence

Anilocra a large isopod can be seen on the head and gill covers of a number of species of reef fishes.

D. Fishes:

A typical assemblage of daytime lagoonal reef species is present especially damselfishes, parrotfishes, surgeonfishes, and wrasses.

E. Plankton:

Because of the filtering action of the reef and the bank little is generally in evidence by day.

COMMONLY SEEN NOCTURNALLY ACTIVE ANIMALS OF THE BACKREEF:

A. Coelenterates:

Corals are generally expanded at night as opposed to daytime; see if you can still identify all the species with their tentacles greatly extended; forms like Isophyllia, Meandrina and other brain corals look particularly different. By shining a moderate light on the coral you will attract swimming plankton into the light beam and into the waiting tentacles of these corals: it is a spectacular demonstration of coral feeding. Try this with several different species of corals; do you notice any difference in the voracity with which they feed?

Other coelenterates that may have been seen by day are also active feeders at night; one of the most spectacular is the corallimorph Rhodactis which occurs among piles of Acropora rubble. When a moderate light is shown upon it attracting plankton as before notice the dramatic feeding response.

cerianthids are tube-dwelling anthozoans that generally emerge only at night around here; they are common at the base of the slope; when disturbed they withdraw rapidly into their tubes, somewhat reminiscent of a feather- duster; when illuminated with a moderate light they will feed as before.

other anthozoans such as zoanthids appear generally similar to the way they look by day but their tentacles may be greatly elongated; why?

B. Echinodermata:

What is the main difference between daytime and nighttime distribution of echinoderms in this area? Consider both urchins and brittlestars.

Astropecten is a sand-dwelling starfish that emerges from the sand just below the slope at night; if you find one collect it so that other students might see it

Euapta this long soft wormlike sea cucumber emerges from reef crevices at night and may be seen near large coral heads

C. Mollusca

Sepioteuthis though this large lagoonal squid can be seen by day it is more obvious at night; if you are lucky enough to see one note its behavior, how it swims, reacts, etc.

Octopus these are often out stalking crustacean prey at night; again if you are lucky enough to see one observe its behavior for a while, including crawling, swimming and color change

D. Crustacea:

These generally come out in force at night. Why?

Rhynchocinetes A medium-sized shrimp with very large eyes is abundant in the stands of A palmata; by shining your light into the stands you will see dozens of pairs of little red eyes reflecting the light; these are Rhynchocinetes

peneids A number of these small prawns will be sitting on the sand surface and will dart into the water column as you disturb them

lobsters of several kinds occur and are out foraging at night:

Panulirus guttatus the spotted or rock lobster is the commonest

P argus will also be found; notice how both of these respond to your presence or your approach; observe particularly their walking, swimming escape response and their use of their large antennae defensively.

Scyllarides the slipper lobster, which looks like a giant isopod also is out foraging at night; it is readily approached and grabbed but has a powerful tail-flipping escape response that often enables it to escape

crabs a variety may be found but in no great abundance, among them:

Portunus The ocellated swimming crab; notice how it swims to escape

Carpilius the coral crab a large smooth shelled form with large strong claws

Plankton

There is often an abundance and variety of nocturnal plankton here and it is attracted to light; by shining your light against your slate for example you should be able to see a great variety of planktonic crustacea, worms and perhaps cephalochordates.

Fishes:

A characteristic fish assemblage is active on the reef at night; by and and large it differs from that of the daytime; wrasses, damselfishes, parrot fishes and surgeonfishes are tucked away in crevices, where they can occasionally be seen (notice particularly parrotfishes in the mucus cocoons they secrete presumably to protect them from predation at night). The groups you are most likely to see active at night that were inactive by day are:

squirrelfishes medium-sized reddish forms with large eyes and near the bottom

cardinalfishes much smaller reddish or pale forms on the bottom or in the water column

glasseye medium-large red and silver form with huge reflective eyes

copper sweeper like a hatchetfish in general appearance with deep chest and large eyes, silvery in color

reef croaker elongate grayish lurking form

blackbar soldierfish reddish with large eyes, usually up in the water column

morays are likely to be seen and may even be out in the open

FIELD TRIP: Horseshoe Patch

This site lies due north of Sand Cay about 500 m; the bottom depth is about 14 m. This is a more or less U-shaped sand patch surrounded by Syringodium grassbed. It is a good site for its variety of large echinoderms and molluscs as well as other interesting soft bottom forms. The field trip plan includes a search of the sand flat as well as the surrounding grass for the following forms; the sand should be kept in sight at all times, as there may be strong currents here and disorientation, even with a compass, is easy.

Abundant or noteworhty invertebrates and fish

A. Coelenterates:

<u>Manicina areolata</u> This coral is typical of soft bottoms and here is common in the grass; note the conical peduncle used to "anchor" the coral. What problems are faced by a coral in this habitat as opposed to living on hard substrate?

sea anemones <u>Bartholomea</u> and <u>Condylactis</u> are common in the dead conch shells in this area

<u>Calliactis</u> Though not common, this anemone, commensal on the hermit crab <u>Dardanus</u>, should be looked for and if found, collected for the whole class to see

B. Echinoderms:

<u>Astropyga</u> This very large relative of <u>Diadema</u> is sometimes present in this area in groups of up to dozens of individuals; its brightly red-and-white-banded young may be found here singly

<u>Meoma ventricosus</u> This large brown shallow-burrowing heart urchin is common here; carefully observe how it locomotes, and if possible, how it feeds. Note all the dead <u>Meoma</u> tests; examine the tests and determine how they were killed (if possible); look for the small white commensal crab, how is it distributed on the urchin? Why?

<u>Holothuria mexicana</u> This large, tough dark brown sea cucumber should be found here

<u>Astichopus</u> This large, soft, papillate sea cucumber is less common than the previous but does occur here

<u>Oreaster</u> The large starfish is abundant here; most specimens are 5-rayed but some have a few as 4 or as many as 7 rays; turn a few specimens over to see that they are eating (note the everted stomach); watch a couple right themselves after being turned over.

C. Mollusca:

<u>Strombus gigas</u> The queen conch occurs here in small numbers, usually on grass; observe how they move and how they feed, also how they react to your movements (note the well-developed eyes); turn a conch over and watch it right itself; many of these conchs harbor small conchfish (cardinalfish) in their mantle cavities; sometimes the fish will leave when the conch is disturbed; queen conchs develop the wide lip only when sexually mature; the young have a very sharp edge .

other conchs As many as 4 other species of Strombus can be seen here:
S costatus (milk conch)
S gallus (rooster-tail conch)
S pugilis (fighting conch)
S raninus (hawk-wing conch)
All of these are a good deal smaller than the queen conch

Cassis spp. Helmet snails occur here, though uncommon; they are predators on urchins; if you see one in the process of feeding, by all means watch it for a while.

Pinna (etc) A large bivalve partly anchored in the grassbed is common here; if you look down the opened valves you can frequently observe the commensal shrimp, Pontonia, that lives inside.

Crustacea:

hermit crabs several species can be found here, including Dardanus, which carries Calliactis on its snail shell, and Petrocheirus the largest Caribbean hermit crab, often in a conch shell

Vertebrates:

garden eels: Often occur in groups on the sand; they extend out of sand burrrows and catch plankton, but retreat as the diver approaches

yellow-headed jawfish: Also live in burrows, generally hover over them and also retreat on approach

razorfish; swim over the grass or sand and if approached too closely dive into camouflaged burrows

large rays: both southern sting rays and spotted eagle rays frequent this area and should be looked for; both disturb the bottom to forage for invertebrates; though not dangerous, care should be taken to avoid the long sharp spine on the tail of the former

sea turtles: are occasionally seen in the area

bottle-nosed dolphins: May be seen here or on the surface enroute to this site; they are curious and may spend several minutes swimming close to you before moving on

Dead Conch Shells provide an interesting microhabitat in this environment, be sure to examine them inside and out for a variety of interesting small invertebrates in fishes, particularly shrimps.

FIELD SITE: Mangrove forest: Great Pond / Salt River

In certain parts of the tropics this is the principal type of littoral community. Mangroves are usually best developed where wave energy is very low and the sediment shore has a very shallow slope. On this field trip we visit two mangrove sites, one of which is marginally developed, the other being the best St Croix has to offer. In addition to looking at the morphology of the plants and their organization into communities we will look at their animal associates.

Mangroves are generally zoned along the seaward gradient, having different optimal tolerances to soil salinity and immersion. The most seaward is the red mangrove (Rhizophora which actually grows in seawater to over 1 m deep and which is characteristically supported by numerous prop roots which grow out of the trunk and branches. Below the water surface these prop roots generally are heavily encrusted by a characteristic community of invertebrates that are tolerant of brackish water (see below). In addition a variety of mobile forms such as crustaceans and fishes shelter and/or breed among these proproots. At certain times of the year the germinating young plants (seeds) hang abundantly from the branches of the red mangrove, drop into the water and some of them take root eventually. The tangle of proproots tends to impede water movement causing suspended sediment to drop out thus building the soil deposit; it is also known that this trend is reversible.

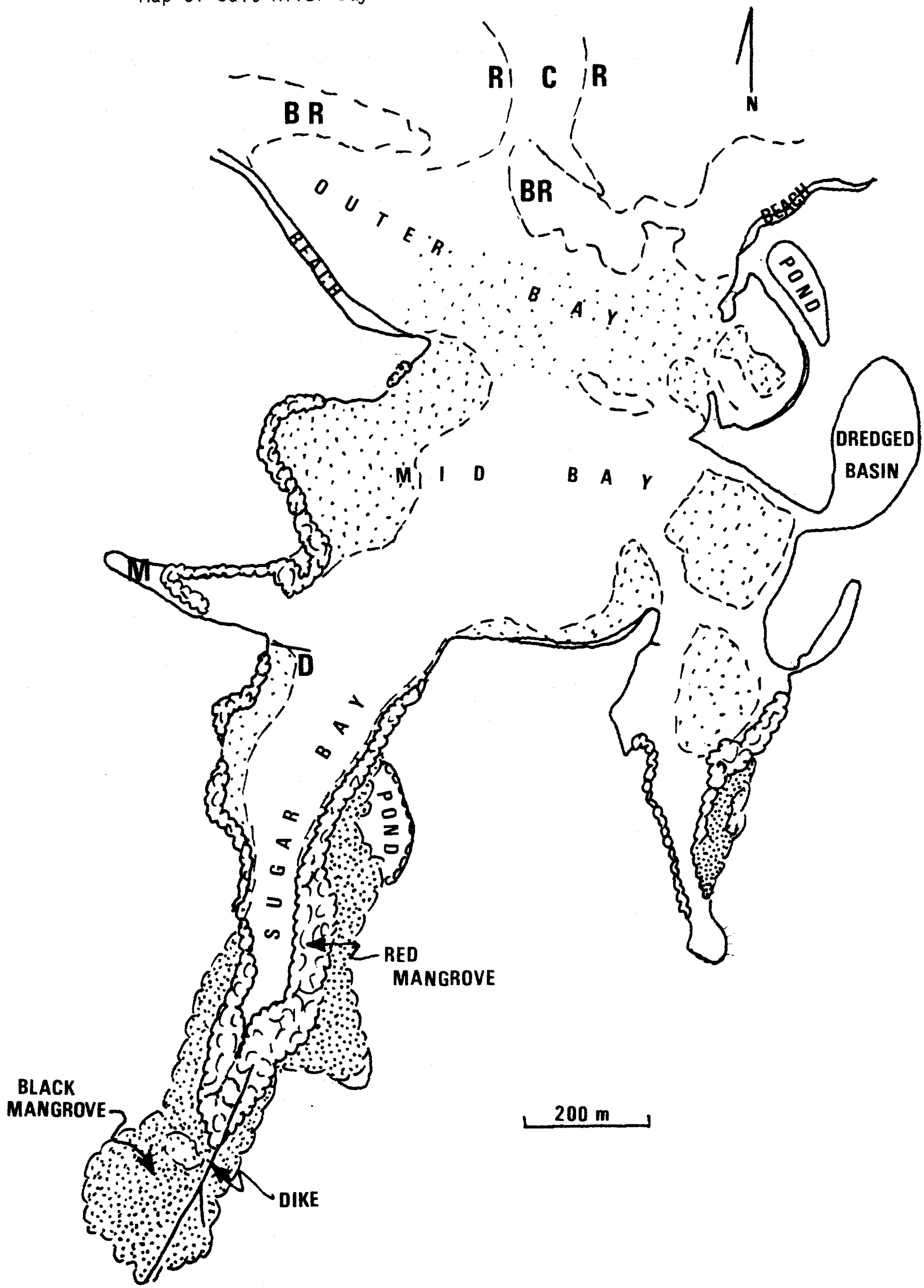
The white mangrove (Laguncularia) is next in the sequence toward shore, and frequently lines closed lagoons or temporary salt ponds (eg. Southgate).

The black mangrove is yet more shoreward (and salt tolerant) and is characterised by extensive systems of pneumatophores which project upward into the air from the extensive root systems in the soil.

A fourth species, buttonwood, is found still further shoreward. The characteristic shared by all these mangroves is that they are tolerant of salty soil and are thereby largely free of competition from typical land plants.

At Great Pond it is the black mangrove that is most in evidence in the southeast corner of the pond and along most of the fringes. An entrance/exit channel to the lagoon near the southeast corner is lined along its outer, deeper end with red mangroves. Depending on the state of the tide it is possible to swim the length of this channel; at maximum flow a current of 1-2 knots flows through here and it makes an entertaining ride. While drifting or paddling past the prop roots of the red mangroves look past the first few rows of prop roots and notice the dense populations of the red mangrove crab Goniopsis (beware, this is a fierce opponent). From the inner end of the channel walk southwest across the forested barrier bar to the outer beach. There are numerous holes of the land crab Cecarcinus in these woods. Along the outer "beach" there are usually numerous seedlings of the red mangrove. It is interesting that these seedlings are much more tolerant of physical conditions than are the adults, and most do not survive

Map of Salt River Bay



to maturity. Also present in the vicinity of the southeastern corner of the pond are other types of crabs:

Cardiosoma, the large land crab, which lives in deep burrows just above the high tide line, so that the lower part of its burrow is submerged;
Callinectes the blue crab in the shallow lagoon surrounding and mangroves
Uca, the fiddler crab on mud flats between the black mangroves
Grapsus, the dock crab
Ocypode, the ghost or beach crab
others may be present as well; look for the small triangular Aratus, on the red mangrove prop roots, is the most specialized of the prop root denizens, not relinquishing their grasp for anything

In addition, during the fall, winter and spring months this corner of Great Pond and the northern end of the pond are good habitats for migrant shorebirds, as well as herons and sometimes ducks.

At Salt River it is possible to take a small boat, such as a Boston Whaler, to the upper reaches of Sugar Bay to see a well-developed stand of red mangroves. Here beneath the closed canpopy of these large trees one can look in all directions and not see the limits of the red mangrove forest. The deep channel can be followed until it becomes too narrow to navigate. One is surrounded by extensive prop roots which support a rich community of mainly suspension feeding invertebrates:

Mangrove oysters, Isognomon
4-6 spp of demosponges, one of which, the firesponge, stings
Featherduster worms
Solitary and compound ascidians
Aiptasia, the sea anemone
various other organisms

Other good sites for snorkelling and observing this prop root assemblage are across from the Hydrolab base, or more seaward near Columbus' Landing. In the case of the latter, how does the composition of this community differ from that in the upper end of the bay.

Other Interesting Mangrove Sites

The border and entrance channel to Altona Lagoon at the edge of Christiansted is an interesting site. The lagoon floor is rich in quiet water algae and a variety of invertebrates as well.

The Manning Bay area directly south of the Airport terminal, reached by several dirt tracks is another interesting habitat.

FIELD SITE: Cane Bay Reef

This portion of the shelf-edge reef along the northwest coast of St Croix is readily accessible from shore at Cane Bay Beach (or by large boat from WIL). By swimming out from the west end of the beach, somewhat obliquely to the west, 5 or 6 zones are crossed. The innermost zones (ending about 125 m from shore) are rather barren with relatively few corals, gorgonians and fishes, and with usually high turbidity. Seaward of this (Seaward Pavement) is a carbonate pavement relatively rich in coral, gorgonian and sponge species extending out to about 175 m from shore. Beyond this is a 30 - 40 m wide band of sand and mixed coral heads or Acropora cervicornis. Beyond this zone begins the extremely rich and complex buttress reef zone, as shallow as 6 - 8 m at its inner end and extending seaward to about 300 m from shore at a depth of over 20 m. The buttresses in this zone are spectacular ridgelike parallel formations of Montastrea annularis, Porites porites and numerous other species which run perpendicular to shore with a relief of 3 - 4 m above the 3 - 5 m wide sandy channels that separate them. Because of the relatively unique and spectacular nature of this outer reef as well as its richness in species of many taxa, the field trip will be carried out primarily n this zone.

Swim out as a group from shore, obliquely to the west (or alternatively anchor boat in center of buttress zone). Because of inherent dangers in this type of shelf-edge ("bottomless") diving, the maximum allowable depth will be 60' but may be less than this depending on the wishes of the instructor or diving supervisor. When your pressure gauge reaches some pre-determined value (ca. 500 - 600 psi) begin to work your way shoreward along the bottom, following the orientation of the buttresses, sand channels and gorgonians. This will permit a little "sight-seeing" enroute to shore.

Abundant and NOTEWORTHY organisms and fish of the buttress zone

A. Sponges:

These are an important and diverse component of the bottom fauna in this zone. 20 to 30 of the species in the SPONGE KEY can be readily identified here. A few of the more conspicuous ones are:

Xestospongia: large, brown basket sponge with huge opening at top; common and unmistakable

Aplysina spp: both tubular and enlongated "colonial" types are common

Agelas spp: includes both the "pipe-organ" sponge and the large orange "elephant-ear" sponge

Spinosella: two species of purple sponges: S plicifera the luminous lavender vase sponge and S vaginalis more elongated grayish fanlike vases.

Amphimedon: maroon "colonial" fingers

Cliona: includes several spp. of excavating sponges usually revealed only by their colorful intake or exit apertures which may be yellow, red or brown; the masses of sponge tissue lie within the $CaCO_3$ substrate

B. Sea anemones:

Heteractis: with long pinkish tentacles and white knobs of stinging capsules

Lebrunea danae: with brown "leafy" masses of pseudotentacles and a few white nematocyst knobs

C. Zoanthids:

A great variety can be found here but notice particularly: those living symbiotically with a variety of sponges, several species of both are involved; using color as a key, record the distribution of different zoanthids in different sponges

Palythoa grandis: occurs in small groups of brown polyps at the bases of coral heads

D. Gorgonians:

Gorgonia: the sea fans here are large and spectacular and oriented perpendicular to the water movement

Pseudopterogorgia: the sea plume is also large and spectacular here and especially in the outer pavement zone

Iciligorgia: occurs in the lower part of this zone but is not common [it is more common at Salt River]

E. Corals:

Nearly all common coral species on St Croix can be found here, however, the ones to concentrate on are those that you have probably not seen yet or have only seen rarely:

Mussa
Eusmilia
Dichocoenia
Montastrea cavernosa
Stephanocoenia
Madracis decactus
M. mirabilis
Mycetophyllia
Meandrina
Colpophyllia
Diploria labyrinthiformis
and nearly all the others

F. Echinodermata:

Nemaster: this spectacular orange or yellow-armed crinoid is quite common here; its feathery arms will be emerging from a crevice

Astrophyton: the large and spectacular basketstar is common here at night and could be found curled up by day, but is usually overlooked in the daytime.

Eucidaris: the pencil urchin can be commonly found in small crevices if looked for

G. Plankton:

Because this site is at the shelf edge and abuts deep oceanic water, oceanic plankton here is often rich and diverse and may include a wide variety of ctenophores, siphonophores, small medusae, pteropods, salps and other observable forms.

H. Fishes:

This is an excellent site for fishes; perhaps most noticeable the assemblage of plankton-feeding fishes that swarm above the reef by day including:

creole wrasse: often in loose aggretations of 100's to 1000s
brown chromis
blue chromis
black durgon
boga which swim with the creole wrasses, but are more slender

Other unusual or spectacular fishes that can regularly be seen here are:

spadefish in tame school that may circle the diver
barracuda
mackerel
In the reef itself are:
graysby
longspine squirrelfish
spotted drum or highhat
Spanish hogfish
royal gramma
moray eels
Swissguard basslet abundant in crevices or under ledges

I. Other vertebrates

Hawksbill turtle commonly seen; moderately tame (but be careful not to follow them into the deep)

Deeper Zones

A dramatic faunal change occurs occurs below 20 m with a corresponding decrease in abundance and diversity. This deeper reef environment is dominated by Agaricia lamarcki and antipatharians (black corals: Stichopathes, Antipathes). Other noteworthy organisms include:

Ceratoporella: the sclerosponge that can reach quite large size in cryptic environments below 40 m
Ellisella: and other deeper water gorgonians
Justinia: the deep-water lobster
Analciometra: the swimming crinoid, on gorgonians
and a variety of small deeper water fishes such as the ridgeback basslet and sunshine fish

Cane Bay at night

The buttress reefs are marvelous at night. Access is best from shore as during the day. The most striking difference in the fauna from that present by day is the presence of nocturnal fishes in the water column, replacing the daytime community.

In addition a number of cnidarians, overlooked or contracted by day can be seen:

Telmatactis
Pseudocorynactis
cerianthararians

A variety of echinoderms and crustaceans not generally seen by day can also be found [see section on Tague Bay Backreef, Day-Night Comparison].

FIELD SITE: Fredericksted Pier: Pilings and adjacent bottom

The outer, widened section of the pier is the site of our field trip. The basic itinerary is to enter the water (by jumping) near the large ladders and to gradually swim seaward to the end of this widened section, then to return by an alternate route. Be sure to inspect the pilings at all depths as well as to investigate the debris on the bottom. BECAUSE OF POTENTIAL HAZARDS OF BOAT TRAFFIC AND MATERIALS BEING DROPPED FROM ABOVE IT IS ADVISABLE TO REMAIN WITHIN THE CONFINES OF THE PIER. The pilings are heavily encrusted from near the water surface to near the bottom at a depth of about 10-14 m. primarily with demosponges; A FEW OF THESE CAN CAUSE SEVERE IRRITATION SO AVOID TOUCHING THEM. Why do you think these pilings are so dominated by sponges? Of interest on the sand bottom adjacent to the piling can usually be found garden eels, Meoma and other interesting organisms mentioned below. The fish fauna around the pilings is one of the most unique around St Croix, including batfishes, flying gurnards, seahorses, frogfishes, scorpionfishes and others.

Because of the wealth of sponges and the general calmness of the water here, this is a good site to demonstrate the pumping activities of some of the large sponges. Use concentrated fluorescein dye (mixed in seawater beforehand) in a small syringe and apply on the surface of the sponge away from the prominent oscule (the big excurrent hole(s) at the top). This can also be done quantitatively with the addition of a ruler and stopwatch.

Abundant or noteworthy invertebrates and fish

A. Sponges:

<u>Aplysina</u> spp: tubular sponges, the large white or lavender ones are good for measuring pumping rates

<u>Neofibularia</u>: a large brown sponge BADLY IRRITATING TO THE TOUCH; it is occupied by thousands of small white polychaetes, Syllis spongicola which emerge if the surface is slightly cut with a knife; the relationship between these and the sponge is unknown

<u>Ircinia</u> <u>strobilina</u>: large gray rubbery sponge with numerous small oscules in a cluster at the top; also good for pumping rate measurements

Dozens of other spp comprise the remainder of the fauna in a bewildering diversity of colors, forms and sizes; use your key to identify some of them.

B. CORALS:

These are relatively scarce here but a few forms such as the following can be found:

<u>Tubastrea</u>: dark orange when contracted and bright orange with the polyps out occurs in small fist-like colonies

<u>Madracis</u> sp: forms encrusting layers

What other spp. can you identify?

Other coelenterates:

Anemones such as Condylactis and Bartholomea are common especially among the rubble at the base of the pilings; if you see them, also look for their characteristic symbiotic crustaceans, especially the small blue shrimp Periclimenes

Parazoanthus: some of the sponges have these symbiotic zoanthids; how many kinds of sponges can you find that have them?

Hydroids: there is a wealth of hydroids on the shaded pilings though many are small and easily overlooked;

Millepora: occurs also

D. Echinoderms:

Ophiothrix: This spiny-armed brittlestar is abundant on the surface of many sponges; can you figure out why it lives out in the open like this?

Large cucumbers may be present on the sand at the base of the pilings

E. Mollusca:

Spondylus: the spiny oyster is abundant but is overgrown by sponges, etc. and is well-camouflaged; they can be detected by their rapid closure when they perceive you with their numerous marginal eyespots or the lower valve is cemented to the piling.

Lima: the file shell, with its bright red interior can be seen nestled in crevices of various sorts on the pilings; it can swim in response to disturbance

F. Polychaetes

Syllis spongicola (see above)

Hermodice: these fireworms are very common, especially on sponges, which they feed on; observe their feeding if possible; touch their head to see their defensive reaction; AVOID TOUCHING THEIR NUMEROUS WHITE BRISTLES AT ALL COSTS.

Spirobranchus: as well as other tubeworms are common on the pilings; inspect the structure of their tentacle crown carefully; what is their tube made of?

Eupolymnia: the spaghetti worm is found among the rubble at the base of the pilings; it lives in a tube under rubble from which emerge the numerous spaghetti-like tentacles various other polychaetes are present; interesting ones may be collected

G. Crustacea

Stenorhynchus: the slender arrow crab is most conspicuous but other more interesting forms are present:

Dromidia: which carries a sponge or clump of algae on its back

various decorator crabs which affix algae, hydroids and other living materials to their exoskeletons where it grows

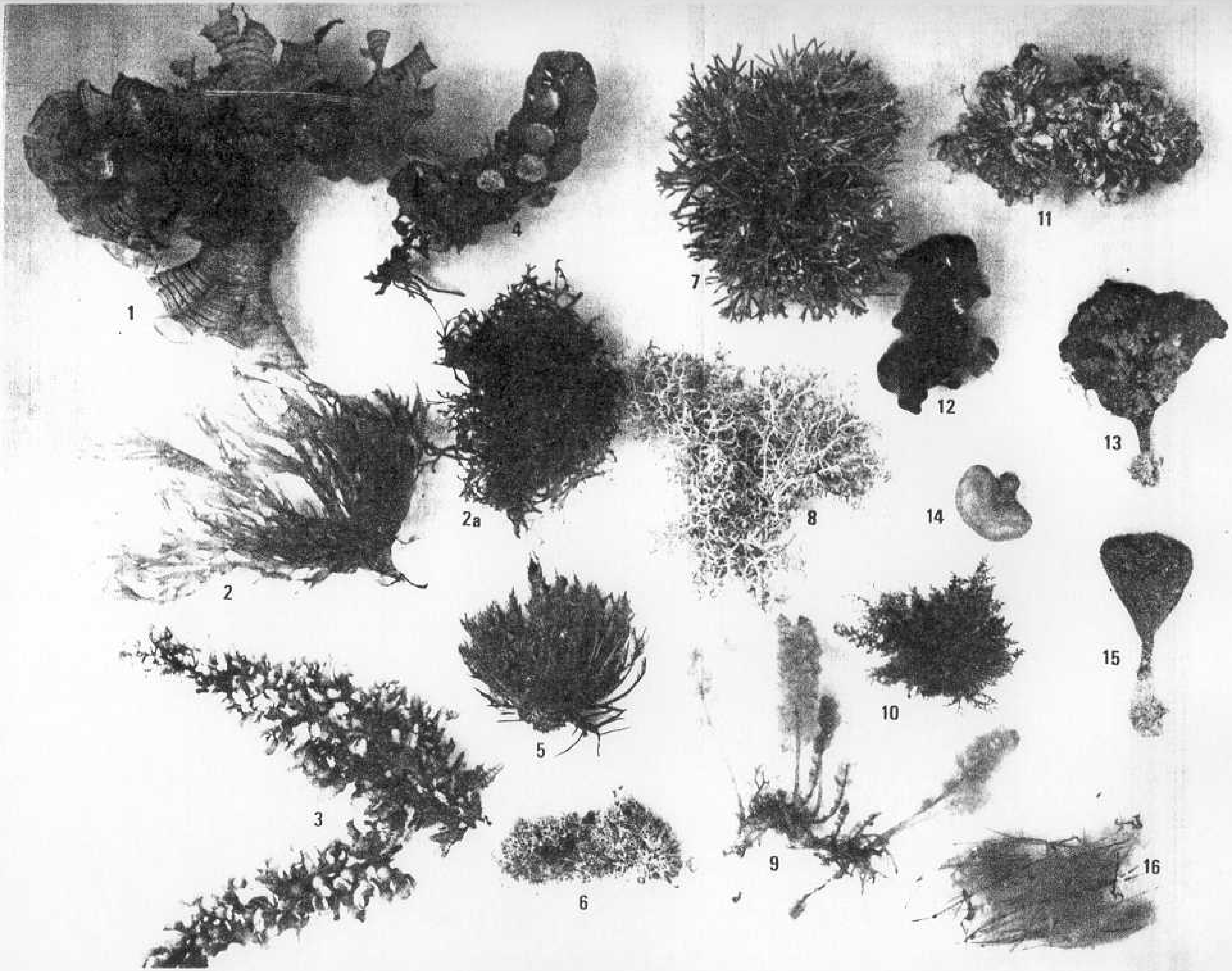
H. Plankton

Because the pier is near the shelf-edge dropoff, there is sometimes an abundance and diversity of oceanic plankton in the water around the pilings including such forms as ctenophores, siphonophores, pteropods, salps, and other forms that can be observed underwater with the unaided eye. Check it out.

I. Fishes

In addition to many of the forms common elsewhere around St. Croix, there are many unique or unusual forms here

Seahorse: around pilings
Frogfish: around pilings often well camouflaged, colored like sponge
Batfish: on sand
Flying gurnard: on sand; note display by enlarged pectoral fins
Garden eels: often in colonies near base of pilings in sand
Scorpionfishes: on pilings or in rubble piles; DANGEROUS DORSAL FIN SPINE
Soapfish: lying on side as if drugged; has irritating mucus
Lizardfish: common on sand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EXERCISE: Identification of Common Marine Plants

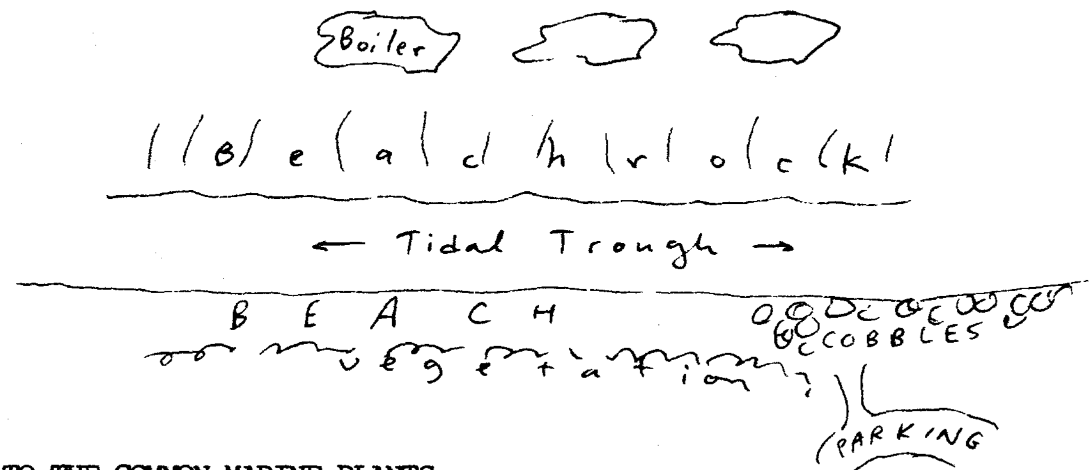
This exercise is intended to introduce you to the diversity of tropical marine plants. The shallow, near-shore waters of Boiler Bay, east end, St Croix, provide a readily accessible diversity of benthic algae and seagrasses in wading and snorkelling depths.

Today the class will make a brief excursion to the middle landing at Boiler Bay (snorkelling gear; collecting bags; buckets). Each buddy pair will attempt to collect representatives of as many different algae as possible: a small thumb-sized tuft will suffice for each species. A good sample should include 25-30 species. Be sure to collect in all the available zones from the shore seaward to outside the boilers (see diagram below). Be sure to spread yourselves out along the beach (about 100 m) from the landing.

After collecting for about 30 to 45 minutes, return with your collection and drain nearly all the water off. On return to WIL, change into dry clothing then meet in the lab.

Spread your collection (each buddy pair) in a pan with a few cm. of seawater. Using the following key, identify the specimens in your collection, In addition, classify them to Phylum and Order and indicate which are adapted to soft substrates, and whatever other adaptations you can determine for any of the species.

Collecting Site at Boiler Bay



KEY TO THE COMMON MARINE PLANTS

I. Thallus green (mostly Chlorophyta and Tracheophyta)
   A. Grass-like, with frim, separate blades, wide or narrow, rising from root system below sediment surface; seagrasses
      1. Blades wide and flat
         a. Blades large, of equal width throughout, tip generally not rounded; no midrib <u>Thalassia</u>
         b. Blades small (few cm long) with rounded ends and midrib <u>Halophila</u>

2. Blades narrow
a. Blades round in cross-section — Syringodium
b. Blades flattened in cross-section, finer — Halodule

B. Plants with tubular stolons with feather-like or pea like projections: — Caulerpa
1. Projections blade-like with rounded tips; firm no midrib — C prolifera
2. Projections feather-like
a. Lateral branches slender and separate — C sertularioides
b. Lateral branches wide and sometimes overlapping — C mexicana
c. Lateral branches short, tooth-like — C cupressoides
3. Projections pea-like
a. Larger — C racemosa
b. Spheres smaller, in tufts — C microphysa

C. Plants individual, upright, usually anchored in sediment (with holdfast)
1. Like an old-fashioned shaving brush — Penicillus * 15
2. Blade broad and flat, fan-like
a. Soft and felt-like — Avrainvillea *
b. Stiff — Udotea * 13
3. Goblet-shaped — Udotea cyathiformis *
4. Branches segmented, composed of rigid small plates or rods of $CaCO_3$ — Halimeda * 11

D. Thallus spherical or subspherical
1. Shiny, turgid sphere resembling a flashbulb; bursts when squeezed — Valonia
2. Subspherical hollow lump with granular surface — Dictyosphaeria 14
3. Very dark green lumps, felt-like texture — Codium 12

E. With thick dark green branches, felt-like in texture — Codium

F. Soft and filamentous
1. Filaments extremely fine, dark green,slimy,in tufts — [blue-green]
2. Masses of long hair-like filaments — Chaetomorpha 16
3. Small moss-like clumps — Cladophora
4. Filaments are hollow tubes; more rigid and branched — Ernodesmis
5. Filaments with lateral branches, delicately feather-like — Bryopsis
6. Soft hollow tubular thalli to 1mm or so in diameter — Enteromorpha

G. Soft, delicate, translucent blades to many cm across — Ulva

H. Thalli as small upright projections of various shapes
1. Umbrella-shaped — Acetabularia
2. Rod- or club-shaped less than 1 cm; often whitish — Neomeris
3. Very small dark green delicately branched spherical forms — Batophora

J. Highly branched, like miniature trees, often tinged with reddish: (all Rhodophyta)
1. Firm, with rounded branch tips — Laurencia 10
2. Soft and feathery
a. Larger, 3-5 cm long — Asparagopsis 9
b. Smaller, ca. 1 cm long — Wrangellia

II. Thallus brown or tan (mostly Pheophyta)

A. Finely filamentous (filaments cross-banded under hand lens) tan — Centroceros

B. Stiff, brush-like or feather-like
1. Brush-like with short thick forked lateral branches
a. Lateral branches sparsely arranged; light tan — Acanthophora

b. Lateral branches more dense; darker brownish red — Bryothamnion
2. Comb-like, lateral branches slender and pointed — Gelidiella 5
C. Highly branched with hooks at ends of some branches — Hypnea
D. With flat branches, dichotomously branched
1. With midrib — Dictyopteris
2. Without midrib
a. Branches taper at tips — Dilophus
b. Branches do not taper at tips — Dictyota 2
E. With flat, wide blades
1. With concentric bands; relatively delicate
a. Tan, curled more or less circular blades; common in very shallow water — Padina 1
b. Longer, forked or branched flat blades may have greenish tinge; deeper water — Stypopodium
F. Hollow, subspherical lumps — Colpomenia
G. With long, tough central stem and lateral blades
1. Triangular floats about 1 cm across — Turbinaria 4
2. Without such floats; linear leaves and sometimes with small round floats — Sargassum 3
H. Dark brown crust on small rocks — Ralfsia
J. Dark brown slimy masses of very fine filaments — [blue-green]

III. Pink, lavender or reddish in color (Rhodophyta);
A. Very soft and slimy; pale pink; branched — Liagora * 8
B. Branches somewhat stiff, calcareous
1. Firmly calcareous
a. Branches tubular (indented tips) — Galaxaura * 7
b. Branches not tubular, brittle — Amphiroa * 6
c. Branches delicate and generally flexible — Jania *
d. Branched in intricate symmetrical pattern — Corallina *
2. Not calcareous
a. Branches with rounded ends — Laurencia
b. Branches pointed — Ceramium
C. Bushy, with rounded branch tips, often suffused with other colors — Laurencia
D. Openly branched forms with relatively robust branches — Gracilaria
E. Tufts of delicate, feathery finely branched filaments — Dasya
F. Delicately lacy; locally abundant — Martensia
G. Crustose
1. Surface smooth
a. Small thin forms on seagrass blades — Melobesia
b. Thicker and rocklike (includes a number of genera) — Lithophyllum, etc.
2. Surface papillate — Neogoniolithon

IV. Other colors
A. Stubby branches (ca. 1 cm long) with bright iridescent blue sheen — Coelothrix
B. Bright orange, crustose — Peyssonelia

* Indicates those genera which are calcareous

EXERCISE (Field and Lab): Sponges

The West Indian sponge fauna is rich and diverse in most marine habitats; it is not uncommon to encounter more than 50 species during a single reef excursion. [Note that nearly all these are Demosponges].

The principal evident activity performed by sponges is the pumping of water through their porous bodies. This activity can be most strikingly demonstrated by performing a simple experiment underwater. Before going into the field prepare a concentrated solution of Fluorescein Dye and place a few cm3 in a syringe or a fraction of a cm3 in a small baggie. Once underwater locate a sponge whose pumping action you wish to demonstrate and give a small squirt from the syringe or tear the baggie NEAR THE BASE OF THE SPONGE. This is best performed when there is little wave surge or current. The dye will be drawn in and shortly expelled from the oscule. The rate of flow can be measured using a stopwatch (function on most digital UW watches) and an object of known length (ruler, knife blade, etc). Also measure the diameter of the oscule. From these simple measurements the volume of flow per unit time (sec, h, da, etc.) can be readily calculated.

At the right time of year, mass spawnings of some species can be observed at night.

LAB

If you wish to maintain sponges alive in the seawater tanks at the lab it is necessary to keep them fully submerged. That is, transfer them from collecting bag to large bucket UNDERWATER, then transfer them from the bucket to the aquarium UNDERWATER. Some species do very well in the aquaria, others do not. <u>Plakortis</u>, <u>Niphates</u>, <u>Amphimedon</u> and others generally do well.

I. Spicule Prep and I.D.

In order to examine the variety of skeletal organization found in local sponges your instructor will collect a variety of specimens. The following provide a good selection spicule types: any calcareous species, <u>Geodia</u>, <u>Chondrilla</u>, <u>Tethya</u>, <u>Spirastrella</u>, <u>Cliona</u>, or other members of the more primitive orders (see Tax. list).

On return to the lab make a thin radial slice of each sponge species with a razor blade and place each in a watch glass, Petri dish, etc. and cover with Chlorox. All the organic material should dissolve within 15 min. With a pipette draw up a drop or two from the pile of disassociated spicules, place on clean slide, cover with cover slip and examine with 10x objective of compound microscope. Identify the various kinds of large spicules (=megascleres). Switch to higher power and examine the tiny microscleres (e.g. with 40x objective). [See accompanying Figure].

II. Collar cells.

These are the flagellated cells responsible for driving water through all sponges. They are largest and most readily observed in some of the simple calcareous sponges, especially <u>Leucosolenia</u> (obtained under rocks, Yacht Club dock, etc.). These must be handled as gently as possible, including not exposing them to air. Once in a small dish in the lab, gently tease off a few mm of one tubule of Leucosolenia, tease gently apart and place in large drop of seawater on slide and cover with cover slip. If you are lucky you will be able to observe the flagellated collar cells will proper illumination; often the collars are withdrawn when the specimen has been handled roughly.

III. Eggs and larvae.

These can often be found by making razor blade sections through various sponges

IV. Organic skeletons.

Examine the various dried organic skeletons available in the lab to gain an awareness of the variety of development and organization of these fibers. In particular compare forms whose consistency while alive or at least fresh you are familiar with (e.g. soft forms, spongy forms, hard forms, etc.)

V. Budding.

The small Tethya sp common under coral rubble on the backreef produces conspicuous buds during much of the year; obtain one of the budding adults and follow the fate of a few of the buds in the aquaria.

VI. Growth experiments with small calcareous sponges.

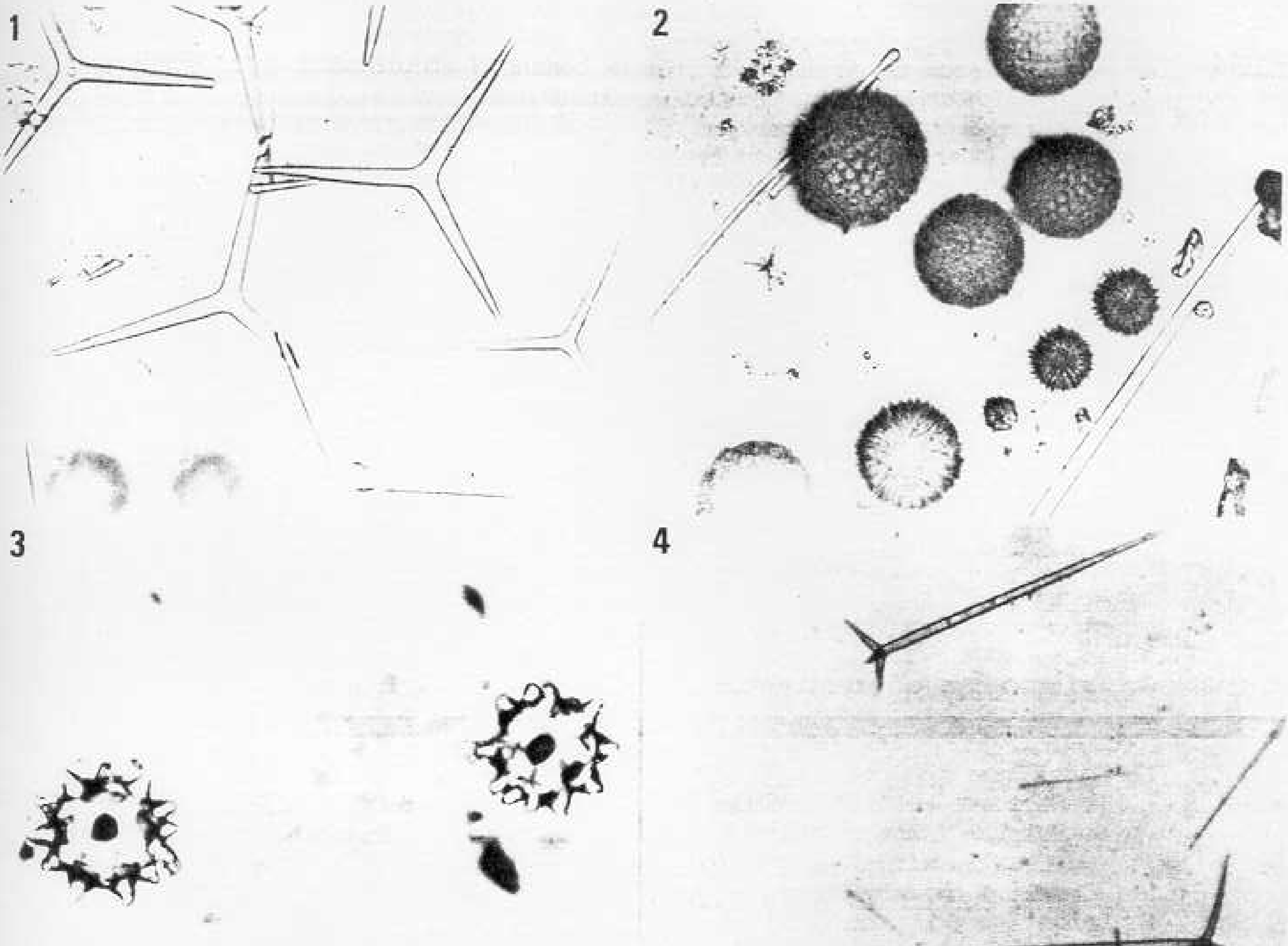
At certain times of the year, a population of small vase-shaped calcareous sponge develops in the lab seatables. Note their orientation. Experiments can be done on these and Leucosolenia on the effects of water current in the development of morphology. See WG for details.

VII. Excavating sponges.

Collect pieces of coral rubble from the reef. They will usually be occupied by excaving sponges, Cliona. The red C lampa is best to work with. Remove all the sponge from the excavated cavity. Place in a small dish of Chlorox. Also chlorox the cavity to remove excess tissue. Examine the details of the cavity under the highest power of the dissecting scope using the best illumination. After dissociation of the spicules, examine under the compound scope as before but also look for the characteristic small calcareous ships etched out of the coral by the sponge.

Key to Fig: Representative Sponge Spicules

1. Triaxon (calcareous sponge)
2. Sterraster (Geodia)
3. Oxyspherasters (Chondrilla)
4. Triaenes (unidentified)
5. Spirasters and one tylostyle (Spirastrella)
6. Anisochelae and subtylostyle (unidentified)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EXERCISE (FIELD): Field Identification of Sponges

The following key is a includes a moderately complete coverage of the more conspicuous shallow-water (to 15 m) sponges of reef habitats of the northeastern Caribbean [see Taxonomic checklist for the systematic positions of these spp; also refer to accompanying Figure].

On St. Croix a number of field sites are particularly rich in diversity and biomass of sponges. Among these, some of the best are: Channel Patch Reefs, Porpoise Patch, Cane Bay, the "Baths" and F'sted Pier. Of these, the last two are suitable for snorkellers. In addition, Holt's Reef, is a fairly good site close to WIL and accessible to snorkellers.

For use underwater, the following key can be reduced and xeroxed onto underwater paper or onto regular paper then covered with a transparent plastic sheet.

[Many of the identifications of sponges herein were kindly provided by Dr. K. Ruetzler of the U.S. National Museum]

KEY TO THE FIELD IDENTIFICATION OF SPONGES OF ST CROIX

I. WHITE
- A. Small clumps of anastomosed tubules to a few cm; cryptic Leucosolenia

II. YELLOW
- A. Small
  1. Delicate reticular masses to several cm; cryptic — Clathrina
  2. Pointed fingers emerging from sand several cm high usually with "fuzzy" layer (of entoprocts) — Leiodermatium
  3. Yellow chimneys emerging from carbonate rock — Siphonodictyon
- B. Large
  1. Thick-walled tubes 6-8 cm across, to 50 cm long sometimes with a slender elongate processes; firm — Aplysina fistularis
  2. Subspherical to irregular; surface honeycomb-like often tinged with dark blue coating; tough — Pseudoceratina crassa

III. ORANGE
- A. Spherical or subspherical, slightly encrusted; firm; to 15 cm — Cinachyra **8**
- B. More ridge-like with grooves instead of pits, somewhat slimy — Topsentia
- C. Soft clumps or sheets with papillate surface — Ulosa ruetzleri
- D. Masses found beneath overhanging coral plates (often Montastrea annularis) with emergent clear chimneys — Mycale laevis
- E. Large, flattened, firm with irregular surface channels; shelf edge; to 50 cm or more — Agelas clathrodes
- F. Rock-hard masses up to 15 or more cm, generally cryptic at depths > 30 m — Ceratoporella nicholsoni
- G. Soft very smooth, "cerebral" (F'sted Pier) — Halisarca dujardini

IV. RED or RED-ORANGE
- A. Forming thin encrusting sheets or boring into carbonate substrates
  1. Thin encrusting sheets with raised, whitish major excurrent canals — Monanchora barbadensis **9**

2. Boring, small oscules visible at surface each 1-2 mm across
Cliona lampa 7

3. Larger oscules, (1 cm); raised pads with incurrent pores
C delatrix

B. With more "body"

1. Very firm, smooth surfaced "cushions" to 10 cm with scattered low conical oscules — Spirastrella coccinea

2. Rather firm, upright with reticular surface
Pseudaxinella lunaecharta

3. Similar to 2 but surface papillate — Ptilocaulis rudis

4. Long slender irregular branches to 50 cm — Thalysias juniperinus

5. Firm, spongy, nestled; with numerous holes in surface
Agelas clathrodes (?)

6. Encrusting on gorgonian axes; firm and finely porous — Clathria calla

V. PINK

A. Elongate cylindrical branches or irregular spongy masses with scattered oscules ca 1-2 mm diameter; red interior
Desmapsamma anchorata 14

B. "Frosted" appearance; elongated chimneys ca 5 mm diameter; somewhat soft — Ulosa arenosa

C. Delicate small tubular form to several cm long with conspicuous mass of the coralline alga Jania sp growing throughout — Dysidea janiae

D. Hard, cryptic calcareous — Leucetta imberbis

VI. LAVENDER or PURPLE (see also X, below)

A. Very slimy; soft with radiating papillae — Mycale angulosa (?)

B. Elongate tube sponge; thickness of wall about equal to diameter of spongocoel; to > .5 m — Aplysina

C. Spectacular iridescent vase-shaped with deeply sculptured maze-like outer surface — Spinosella plicifera 12

D. Greatly elongate fingers, very firm with scattered small oscules; to 1 m (sometimes yellowish) — Aplysina cauliformis 5

E. Smooth-surfaced encrusting form to several cm across with distinctive aster shaped "oscules" — Halisarca

F. Spongy lavender cushion to 10 cm across — Haliclona

G. Upright, shiny bright pinkish lavender — Igernella notabilis

VII. MAROON or DARK PURPLE

A. Upright spongy maroon or reddish fingers with small oscules along sides — Amphimedon compressa

B. Stalked and upright, dark purple papillate surface, slimy, purplish slime rubs off — Pandaros acanthifolium

C. Dark purple cup with deeply pitted surface, slimy dark red when illuminated — Mycale laxissima

VIII. DARK BROWN or BLACK

A. Nearly black, "woody" in consistency, upright lumps or ridges, often with prominent oscules — Pellina carbonaria

B. Nearly black, heavily encrusted with sand, hemispherical to 20 cm — Tethya crypta

C. Large subspherical, heavily encrusted, firm woodlike consistency — Geodia gibberosa

D. Upright, spongy fingers with small oscules scattered
along length, slightly sticky surface Amphimedon complanata

E. Rather soft (but tough) with reticular brown lumpy surface,
lumps ca several cm across Ircinia felix 13

F. Soft dark brown with numerous sand-grain inclusions
often living on sand Oligoceras hemorrhages

G. Soft thin encrusting, dark charcoal gray; small with
regularly spaced equal-sized small oscules Chelonaplysilla erecta

H. Large, firm hemispherical; in grassbeds; cluster
of oscules in shallow depression at top Spheciospongia vesparium
[see X below]

IX. TAN or BROWN

A. Rich brown, chestnut; firm woody consistency, granular surface;
massive to .5 m or more [TOXIC!! DO NOT TOUCH]; with abundant small
white polychaetes just below surface Neofibularia nolitangere

B. Very large, funnelshaped spongocoel; outer surfaces ribbed with
prominent longitudinal ridges and grooves; firm woody consistency;
to >1m Xestospongia muta 1

C. Forming tan, sometimes extensive mats on carbonate substrates,
sometimes in high-energy areas; with raised oscules
Anthosigmella varians

D. Orangish-brown with numerous (often contiguous)
elevatd oscules Ectyoplasia ferox

E. Forming rubbery encrusting layers on dead corals;
with small regularly spaced oscules Chondrilla nucula

F. Bores extensively in carbonate substrates; visible as large patches
of brown substrate with evenly spaced tiny oscules Cliona caribbea 6

G. Rich chestnut brown forming flat or curved plates;
firm to woody consistency Cribrochalina vasculum

H. Tan, rather stiff, forming upright hollow fingers
to 20 cm high Spheciospongia cuspidifera

I. Brown with numerous large (several mm) incurrent pores; larger
colonies may form curved branches with oscules on prominent
elevated chimneys; spongy Agelas confera 10

J. Large tube sponge with deep cylindrical spongocoel; wall
of varying thickness from 1-2 cm up to 10 cm or more; outer
surface with deep pits very firm Aplysina lacunosa 11

K. With almost honeycomb-like reticular surface;
with more or less pearshaped and sized body units; rigid
Verongula rigida

L. Very similar to above but honeycomb pattern less
pronounced; body less rigid V reiswigi

M. More or less spherical; to 5-10 cm with prominent
oscule; firm Plakortis 3

X. GRAY

A. Reticular, honeycomb-like surface tough and spongy;
with cluster of oscules; to.5 m or more Ircinia strobilina 4

B. Firm, spongy forming upright cup or partial cup Niphates digitalis 2

C. Ramose or not, linear colonies N erecta

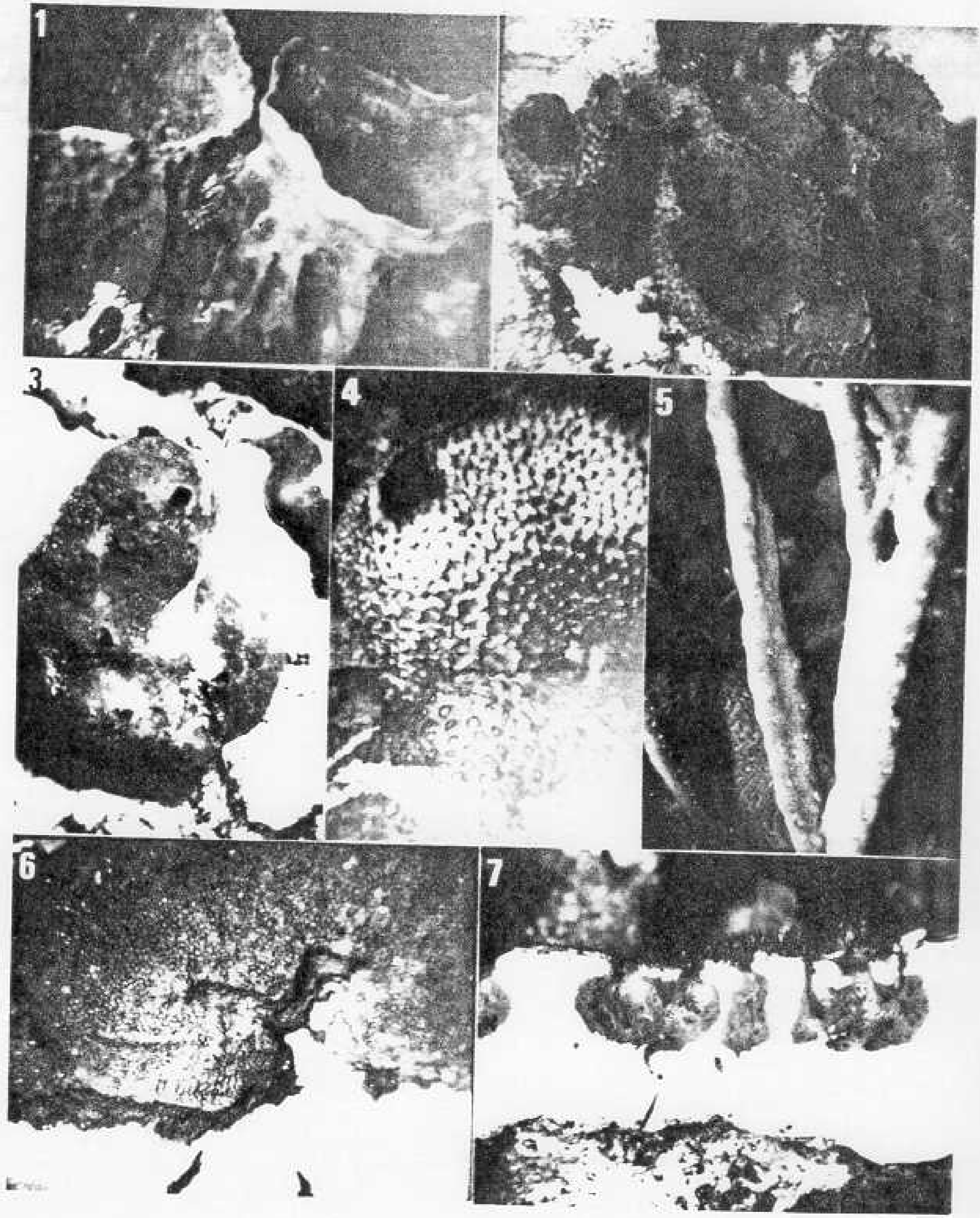
D. Forming tubes, flattened erect funnels, flat erect sheets or
linear branches with incurrent surface having distinctive
system of conical projections (not to be confused with
I strobilina above); may be purplish Spinosella vaginalis

XI. BLUE

A. Bright, pale blue; very soft; to several cm — *Dysidea etherea*

XII. GREEN

A. Small cushions — *Haliclona viridis*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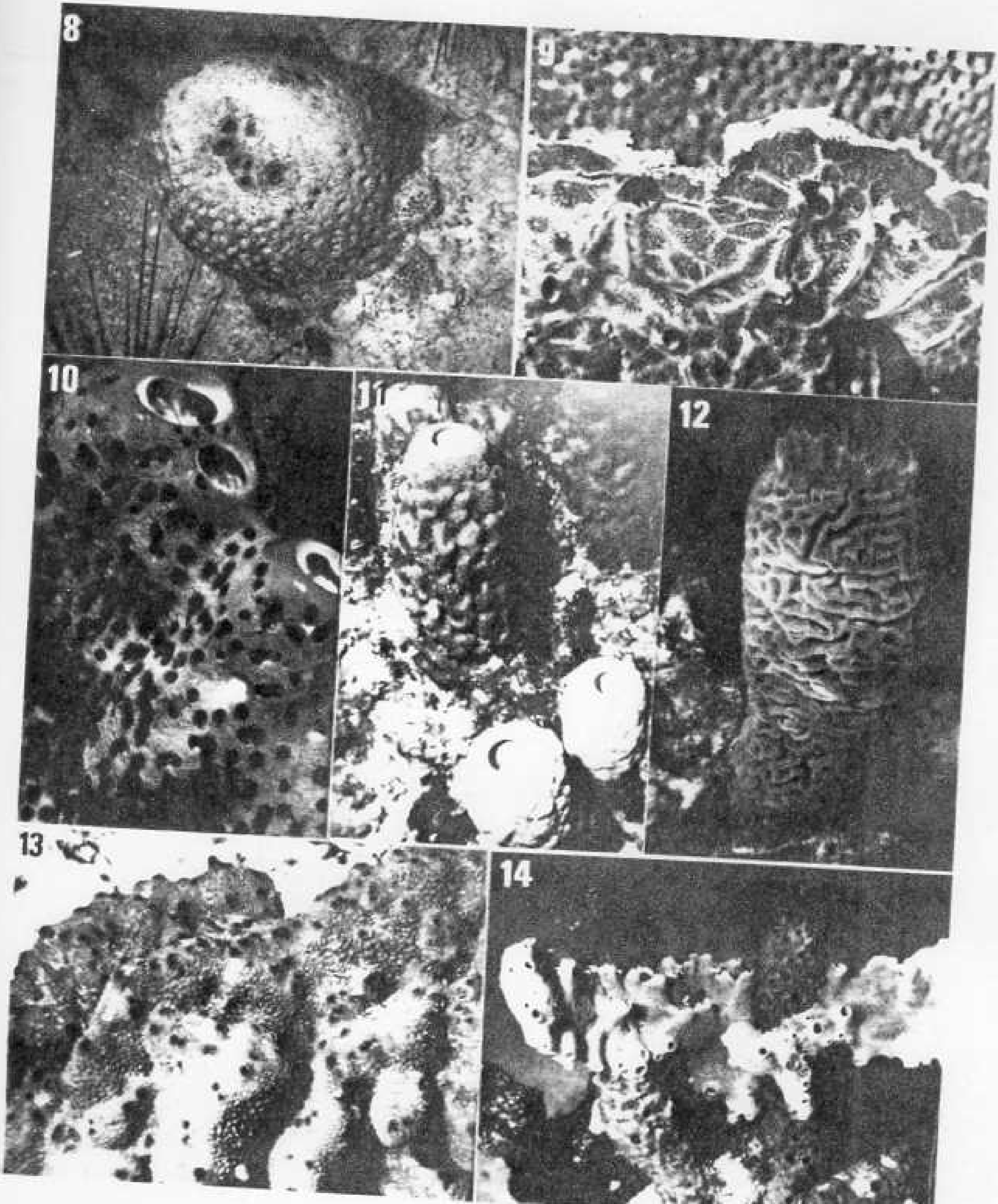
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EXERCISE (LAB): Cnidaria

Cl Anthozoa
SubCl Hexacorallia (=Zoantharia)
O Actiniaria (sea anemones)

This group is well represented with a diversity of forms in local waters.

a. Morphology

The smaller transparent or translucent forms are best for this: Aiptasia, Lebrunea coralligens, or Bunodeopsis. Using one or all these species set up beforehand in small glass dishes, examine under the dissecting scope and identify: tentacle crown, column, basal disc, mouth, pharynx, gastrovascular cavity (g.v.c.), mesenteries (septa), and any specialized structures such as pseudotentacles (Lebrunea). The internal mesenteries, very important in the Anthozoa, can best be seen with transmitted light, particularly at their junction with the column, oral disc or basal disc. At this time also try to note the circulation of fluid in the gastrovascular cavity (there are generally small particles present, and sometimes larvae which are being brooded, as well).

b. Locomotion

Most anemones can slowly crawl about using tiny muscular waves of the basal disc. Though usually too slow to watch in the lab, the result of their movement can be seen the next day, especially if one is placed in an unfavorable location. Others use a variety of means to get around, such as tentacles (Bunodeopsis): special nematocysts called spirocysts are used for this. This can be demonstrated by smearing egg albumin on a microscope slide then allowing a Bunodeopsis to crawl across it. Afterwards, examine the slide under high power of the microscope.

c. Light responses

Many anemones and other anthozoans respond by contracting or expanding or bending toward or away from light. What are the responses of L coralligens and other anemones to a beam of bright light. Note how different parts of the body respond. Try using a photographic flash if one is available.

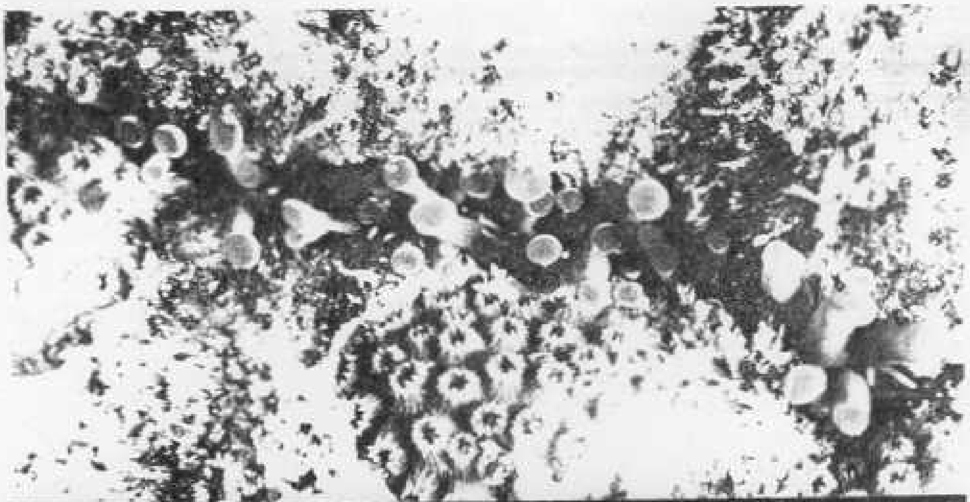
d. Feeding

Using a small anemone such as Aiptasia or Bunodosoma in a small dish of seawater under the dissecting scope, observe the details of feeding on the following: individual brine shrimp larvae (hatched in the lab) or plankton (caught just before time of use); tiny bits of hard-boiled egg yolk; large bit of the same; a swarm of plankton. After each trial the dish should be dipped in the seatable for fresh seawater. Follow the whole sequence in each case from initial capture of the particle until it has been swallowed. Also note the circulation of small particles in the g.v.c. Feed some of the larger sea anemones in the sea table, such as Condylactis or Stoichactis chunks of animal or plant matter; how do they differ from the smaller anemones in this behavior?

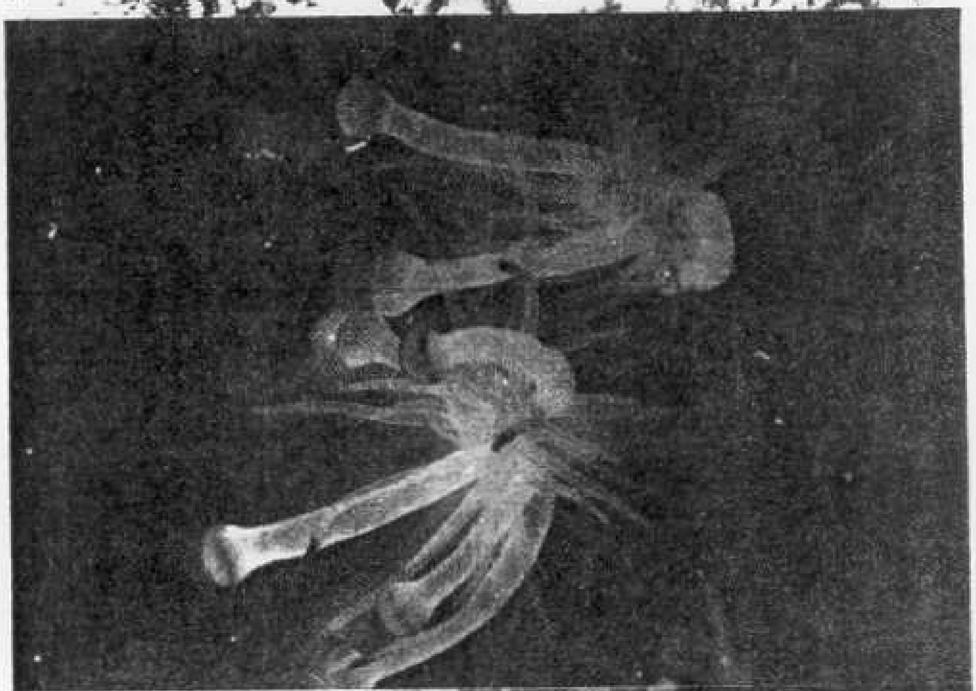
e. Nematocysts and Zooxanthellae

Cut off a tip (a couple of mm) from the tentacle of a Bartholomea

Lebrunea coralligens



Pseudotentacles emergent from crevice in dead coral by day



Pseudotentacle response to bright flash from left; note lack of response of slender tentacles

Planula larvae brooded to large size, circulating in gut cavity of tentacles, etc.

or an Aiptasia. Make a slide preparation (with seawater and a cover slip of course). Examine at 400x for n'cysts and zoox. Add a drop of acetic acid to the edge of the cover slip nearest the tentacle and draw in with paper. Watch the discharge of the n'cysts. Sometimes this can be done by moving a brine shrimp larva into contact with the tentacle while in the field of view.

f. Larvae and direct development

Some of these anemones (such as Lebrunea) brood their developing planulae. Examine a few specimens of a couple different species for brooded larvae. Those of L coralligens are not released until they are ready to turn into small anemones. This can sometimes be demonstrated by leaving the animals overnight (see instructor). If you can get the release of planulae of this species, by morning they will have sprouted the first 6 tentacles and will be small functional polyps.

g. Defenses

Most anemones respond to a disturbance by contracting into a lump or by stinging the source of disturbance. A few forms such as Aiptasia and Bartholomea also "eject" long strands laden with nematocysts. Jab one of these anemones to see how it responds. Examine one of the ejected strands (called "acontia") under the high power. As the animal expands later, the strands are pulled back into the g.v.c.

A few spp possess specialized n'cyst-laden structures called acrorhagi; these are found at the top of the column below the tentacles. They are used for spatial defense against other members of the same species. Locally Anemonia is an example; place a few together and observe the results (as with other cnidarian activities, this may not occur instantly or rapidly.

h. Complex behavior

In response to the proper stimuli, some anemones exhibit quite complex behavior; e.g. Calliactis lives on snail shells occupied by the hermit crab Dardanus. When the crab changes shells it elicits a complex transfer behavior in the anemone. Keep your eyes out for this anemone on field trips.

O Corallimorpharia

These forms resemble sea anemones but cannot move around. The commonest local forms, Rhodactis and Ricordea occur on shallow reefs in clones. Identify thhese if available in the lab. In the dark Rhodactis has a spectacular feeding response; try it.

What other behavior can you elicit from these forms?

O Zoanthidea (zoanthids)

These small colonial anemone-like forms are quite different from anemones internally. If available in lab identify Zoanthus, Palythoa and Parazoanthus. The last is commensal in a number of the local sponges, particularly Niphates and Agelas. By carefully picking away sponge tissue see if you can trace the connections between the polyps. What advantages do you think are conferred to the zoanthids by this association? Might the sponge also benefit?

O Antipatharia (black corals)

Examine the dried colonial skeleton of a black coral, or if available examine a piece of black coral jewelry (polished parts of the organic dried skeleton).

O Scleractinia (=Madreporaria) (true or stony corals)

This is the largest and most diverse cnidarian order and includes many of the forms responsible for the construction of coral reefs.

a. Response to light

Place several specimens in the dark for a while (either the darkroom, a large cabinet or covering with opaque black plastic will do). What happens? Because these animals are normally nocturnally active many of their more interesting behavioral attributes must be observed in the dark or after exposure to the dark:

i. Feeding

Feed these animals just as you fed the anemones. Note what happens.

ii. Currents in the gastrovascular canals

While the corals are expanded in the dark, use a solution of fluorescein dye to determine circulation within the colony of a few different forms.

iii. Defensive response

Many corals display a strong defensive reaction to contact with other corals. Place several combinations of corals close together in a large dish of seawater or in the seatable and place in the dark (or wait until dark in the latter case). If enough combinations are used a dominance heirarchy can be determined (as a hint, include in the species you use the following: <u>Porites</u>, <u>Montastrea</u> and <u>Isophyllia</u>.

b. Morphology and diversity of coral skeletons

Examine the surface structure and a vertical section through a "typical" coral such as <u>Montastrea</u> and using a hand lens or the dissecting scope identify : corallite, calyx, scleroseptum, columella, dissepiments, coenosteum.

Now examine a brain coral in the same way and identify the same parts. Make sure you understand how both types of coral grow. If this is not yet clear take a look at <u>Dichocoenia</u> which is somewhat intermediate in form. Do you understand the terms intra- and extra-tentacular budding and can you relate them to the skeletons you are looking at?

Check out cross sections of <u>Acropora</u> <u>cervicornis</u>. How does it differ from some of the others? Also check out a section of pillar coral, <u>Dendrogyra</u> if available; compare both these with sections of <u>P porites</u> or <u>Montastrea</u> or <u>Diploria</u>.

Look at the coral skeleton collection. Begin to learn the names of all the corals listed.

SubCl Octocorallia (=Alcyonaria)

O Gorgonacea (sea whips, sea fans, etc.)

a. Polyp structure

Prepare a relaxed specimen for examination the next day: cut a section of gorgonian branch about 5 cm long and place upright in a small beaker in the seatable (the larger, firmer seawhips are best for this). After the polyps have emerged, carefully remove the dish, with the gorgonian section fully immersed, and add some $MgCl_2$ carefully. After a

Morphology of scleractinian skeletons reflects budding pattern of tissue

1 Scolymia: solitary; no budding

2 Eusmilia: phacelloid; intratentacular budding of polyps but lack of coenosarc connecting polpys results in calyces at end of dichotomous branches (also in Mussa) in various stages of division

3 Dichocoenia: intratentacular budding, but with coenosarc connecting polyps results in solid head with calyces in various stages of division

4 Isophyllia: intratentacular budding, with several polyps (hence calyces) remaining connected

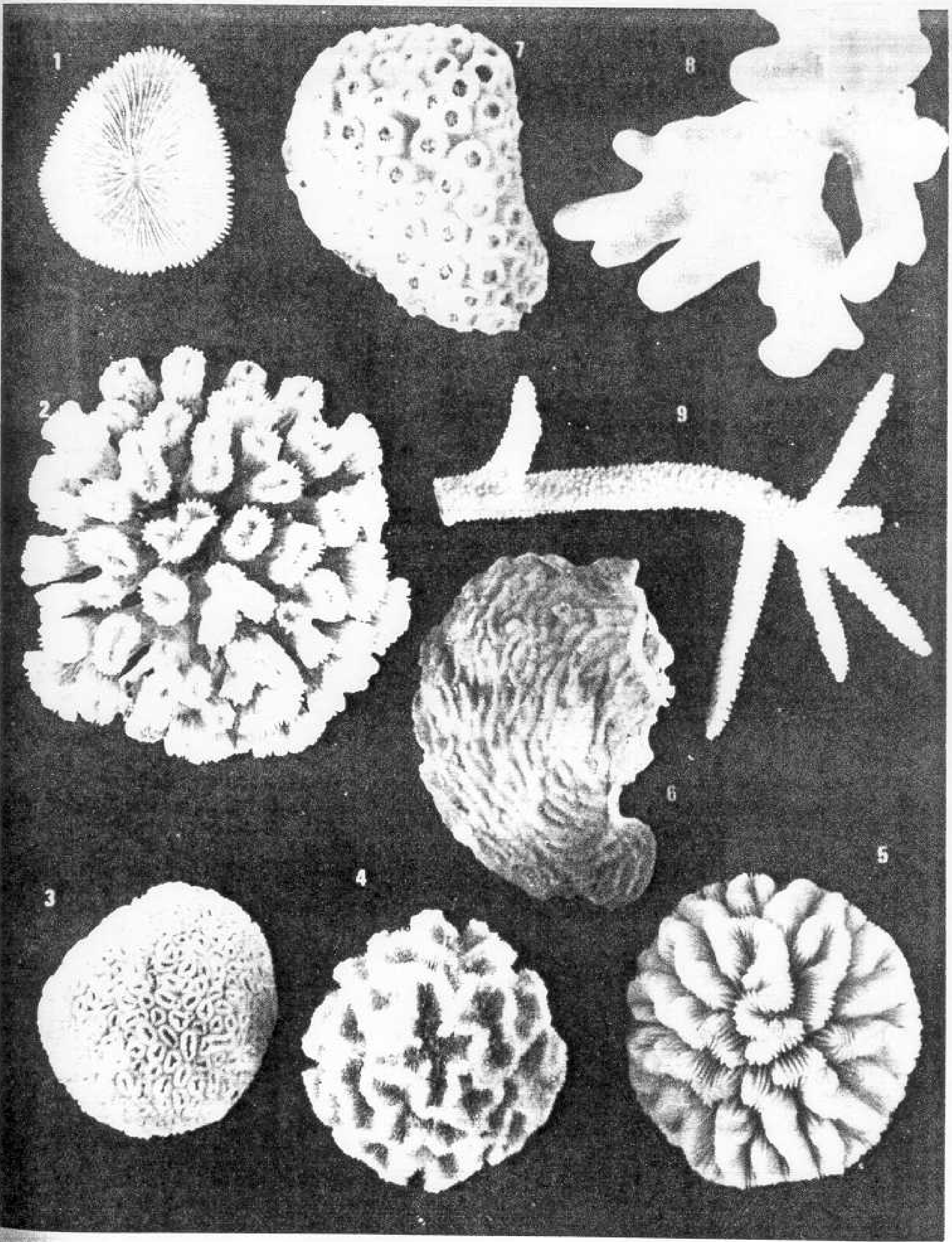
5 Meandrina: same but with much more extensive polyp systems connected as long meandering rows of sclerosepta with evenly mouths (brain corals: Manicina, Diploria, Colpophyllia, etc.)

6 Agaricia: similar but systems shallow, calyx details more distinct and and whole skeleton generally flattened

7 Montastrea: extratentacular budding (i.e. between existing polyps); (also in Siderastrea, Tubastrea, etc.)

8 Porites: same, but "head" secondarily formed into branches (each of which is basically comparable to a Montastrea); (also in Madracis, etc.)

9 Acropora: similar, but growth axis of branch specialized and terminating in one (or several, e.g. A palmata) large axial calyces; growth rate along this axis is particularly high)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while add some more. When fully relaxed, add a little formalin to preserve. After this has been prepared, cut x-sections one half to 1 cm long and observe polyp structure under the dissecting scope: 8 bipinnate tentacles, 8 mesenteries in the g.v.c., eggs, the tubes connecting polyps in the colony (= solenia).

b. Colony structure

This can be done on the above preparation or simply on a cross section through any fat-branched seawhip (using a razor blade). Examine the x-section, noting the calyces with polyps (may all be retracted), the large eggs, the solenia, the longitudinal canals, the spicule skeleton, the axial skeleton (absent in Briareum)

Shave off a lttle of the spicule skeleton, place on a slide and add some chlorox; after a minute or two add a little water, a cover slip and observe the spicules.

c. Diversity

Examine the collection of dried gorgonian specimens and begin to learn some of the names.

O Coenothecalia (blue coral)
O Stolonifera (pipe-organ coral)
[Both these groups occur in the tropical Indo-Pacific but not in the Caribbean. Examine the dried skeletons composed of fused spicules]

Cl Hydrozoa

Examine some of the hydroid or hydrocoral colonies that may be available. Small colonies or bits of colonies of freshly collected material should be set aside in small dishes, undisturbed for a few minutes so that the polyps will expand. This material must be fresh, it will not keep overnight. Note diversity of polyp form, polymorphism (e.g. many forms have structurally different feeding, reproductive and even defensive polyps; note that medusa buds may be present on some polyps: these may or may not develop to free-swimming medusae), and colony form. Feed with brine shrimp larvae and follow the entire sequence from food capture to swallowing. On rare occasion it is possible to get Millepora polyps to expand in the lab; it's worth a try. Set up a small piece in a dish and let go overnight if necessary (in the seatable). If the polyps emerge transfer the dish very gently to the dissecting scope and observe reactions to touch and to food.

Squash a tiny hydroid polyp on a slide using a cover slip. Place under high power and check different body regions for the different types of n'cysts. Get them to fire as before. Check out any demonstration material.

If anyone is interested in observing planktonic hydromedusae they are best caught while diving (generally outside the reef is best) and capturing the generally tiny forms in a jar.

Cl Scyphozoa

a. Cassiopeia, behavior

Work with a small specimen (ca. 5 cm) if possible. Place in a large dish, etc. and observe swimming and turning behavior. Think about how these are achieved: how does the bell contract? how does it re-expand? what does the animal do if you turn the umbrella upward? After you have observed normal swimming and turning activities remove all the rhopalia except one and note the effect. Remove the last one; what is the effect?

How does the nervous system of Cassiopeia differ in its fundamental organization from that of a sea anemone?

With the animal lying motionless on its umbrella feed one of the small suctorial mouths a brine shrimp larva or tiny bit of egg yolk; follow the sequence as far as possible.

b. Cassiopeia, morphology

Examine the oral arms, suctorial mouths, small feeding tentacles and arm canals. Remove sections of the oral armns to develop an understanding of the 3-dimensional structure of the animal. Identify the stomach, umbrellar g.v.c. canals and gonads. Identify the swimming muscle and the rhopalia (marginal sense organs). Cut tangential and radial sections through the umbrella to understand its structure. What do you think the function of the large "appendages" on the oral arms is?

Does this animal have zooxanthellae and n'cysts? Where are they distributed?

c. Aurelia

This pale bluish jellyfish is seasonally common in tropical as well as more northern waters. These are suspension feeders catching tiny organisms in the mucus on the outer and inner surfaces and tentacles and then moving these via well- defined tracts toward the oral arms and mouth. If these animals are available they can be observed readily in the lab.

PH Ctenophora (comb jellies)

Again, seasonally and locally common these delicate forms can best be collected by carefully and very gently moving them into a plastic bag while underwater. In the lab their delicate movements using elaborate comb rows of enlarged cilia can be observed, as can their general structure.

APPENDIX: Where to find cnidarians.

Any shallow-water reef site will have a wealth of anthozoans including gorgonians, corals, zoanthids, anemones and corallimorphs. The hydrozoan Millepora is also nearly ubiquitous; Myrionema is often common at such sites; other hydrozoans are more common at deeper sites (10 m depth or more), such as the base of Tague Bay forereef, Buck I. Channel patch reefs, Cane Bay, etc. F'sted Pier is also a good site for hydroid diversity. The scyphozoan Cassiopeia is particularly abundant between the WIL dock and Romney Point; this area is also rich in the small anemone Bunodeopsis and also Aiptasia and small thecate hydroids The deeper shelf-edge reefs (e.g. Cane Bay, Salt River) are particularly rich in coral species and below 15 m black corals can be found.

EXERCISE (FIELD): Field Identification of Cnidarians

The following key is primarily intended for use in the field (i.e. underwater). It can be reduced and xeroxed onto good bond or underwater paper for that purpose. Nearly all local reef environments have a rich variety of cnidarians (particularly anthozoans). Some of the best introductory sites include Tague Bay backreef (e.g. off Romney Point), Lamb Bay and Buck Is. lagoon; all these sites are good for snorkelling.

(FIELD) KEY TO ANTHOZOANS

I. Forming upright, flexible, branched (usually) whiplike, fanlike or featherlike colonies, to over 1 m high
  A. Polyps with (8) bipinnately branched tentacles; retractile into pits (calyces): Gorgonacea.
    1. With protein axis (determined by breaking end of branch)
      a. Branches upright; "seawhips"
        i. Branches very flat; polyps in grooves along edges — _Pterogorgia_
        ii. Colony pale gray; calyces sharp or prickly — _Muricea_
        iii. Calyces protruding and tubular; colonies generally brown or gray — _Eunicea_
        iv. Colonies pinkish; closed calyces slit-like; surface like very fine sandpaper — _Plexaurella_
        v. Long slender grayish or lavender branches, often slimy; calcyces pore-like; may reach 2 m — _Pseudoplexaura_
        vi. Colony surface dark brown, pigment rubs off easily — _Plexaura homomalla_
        vii. Colony whitish,moderately rough surface; highly branched — _Plexaura flexuosa_
      b. One or a few vertical branches with numerous horizontal lateral branches; plumelike; to 2 m. high — _Pseudopterogorgia_
      c. Sea fans; reticulum of fine anastomosing branches in a plane — _Gorgonia_
    2. Without protein axis
      a. Purple with brown "furry" polyps; encrusting or upright branches to 1/2 m — _Briareum_
      b. Pinkish; encrusting only — _Erythropodium_
      c. Dark brown "maze-like" fan on dropoff reefs only — _Iciligorgia_
  B. Polyps tiny with simple tentacles, not retractile into pits; on dropoffs: Antipatharia
    1. Unbranched, long slender whiplike colonies to 3m high — _Stichopathes_
    2. Highly branched with terminal branches very delicate — _Antipathes_

II. Large "fleshy" solitary polyps growing singly or in small groups; tentacles very long body generally in a crevice
    1. Tentacles pinkish with numerous white rings — _Bartholomea_
    2. Tentacles pinkish with numerous small white bulbs — _Heteractis_
    3. Tentacles thick, fingerlike, often greenish with purple tips — _Condylactis_
    4. Tentacles hidden by day; instead there is a "leafy" mass of highly branched pseudotentacles with white areas — _Lebrunea danae_

5. Very large, long pointed transparent tentacles; generally seen only at night on grass or sand bottoms — Alicia

6. Emergent only at night; polyp with long slender marginal tentacles and short oral tentacles; retracts instantly into tube when disturbed — Ceriantharia

III. Medium to large polyps generally solitary or in small groups with short tentacles

A. Flattened; disc covered with short tentacles

a. Large, with sticky tentacles — Stoichactis

b. Large, whitish, with deeply crenulated margin; in grass or sand; retracts out of sight — Homostichanthus

c. Medium-sized; not sticky to touch; usually in groups — Ricordea

2. Short, forked tentacles scattered on disc; usually in groups — Rhodactis

B. Marginal tentacles only

1. "Typical" anemones of medium size

a. Occur only on shoreline rocks

i. Dark maroon — Anemonia

ii. Light brown with banded tentacles — Bunodosoma

b.Occur only on hermit crab shells — Calliactis

2. Otherwise

a. Short, pointed marginal tentacles

i. Tentacles numerous; in sand pockets on reef — Phymanthus

ii. Tentacles few — Palythoa grandis

b. Tentacles tipped with round red orange knob — Pseudocorynactis

c. Tentacles blunt tipped of alternating length; often under rocks — Telmatactis

C. No tentacles — Paradiscosoma

IV. Polyps small (1 cm diameter or less); often in colonies or clones.

A. Form dense colonies of polyps ca. 1 cm diameter

1. Tan — Palythoa caribbea

2. Dark green and other colors — Zoanthus

B. Symbiotic in sponges — Parazoanthus

C. Occur in clones on docks, boats and mangroves; long slender (banded) tentacles — Aiptasia

D. Form flat "warty" patches by day; at night with long transparent tentacles — Bunodeopsis

E. In small reef cavities; only tips of blunt pseudotentacles visible — Lebrunea coralligens

V. Stony corals; living tissue covers $CaCO_3$ skeleton beneath; skeleton characterized by cups or pores with radial sclerosepta

A. Branched corals

1. Each branch terminating in a single calyx (cup) or polyp

a. Terminal calyx large (over 1 cm) — Eusmilia

b. Terminal calyx up to only a few mm across

i. No lateral calyces; colonies only a few mm across — #Cladocora

ii. Branches with scattered widely spaced lateral calyces — #Oculina

iii. Branches covered with lateral calyces; colonies to 1 m or more

aa. Branching sparse, interval 15 cm or more — Acropora cervicornis

bb. Branching much more frequent — A prolifera

2. Branches clothed in polyps; no single terminal calyx

a. Branches armlike, forming huge colonies — Acropora palmata

b. Branches fingerlike or pencil-like in thickness

i. Fingerlike
aa. Tapering near end, with open branching — Porites furcata
bb. Not tapering near end (i.e. before hemispherical end); closer branching; can form huge colonies — P porites
ii. Pencil-like
aa. With dichotomous branching; small colonies in grassbeds — P divaricata
bb. Forming dense colonies on deeper reefs (over 10 m depth) — Madracis mirabilis

B. Solid corals with separate calyces (small lumps to hugh spheres)
1. Calyces very large (ca. 5 cm or more); "fleshy"
a. Solitary — Scolymia
b. Colonial — Mussa
2. Bright orange polyps (when expanded) ; lives in shaded or wave surge areas — Tubastrea
3. Calyces ca. 1 cm across
a. Fleshy; calyces with jagged edges; often gray with pale green centers (see Isophyllia, below) — Isophyllastrea
b. Calyces volcano-like with fine external radial ridges — Montastrea cavernosa
c. Calyces tend to be oblong with very prominent sclerosepta — Dichocoenia
4. Smaller calyces
a. Calyces volcano-like with prominent external ridges — Montastrea annularis
b. Calyces tiny simple pits; colony usually lime green (sometimes light tan) — Porites astreoides
c. Colonies generally "golfball" like, on shallow reef crests; color pale, whitish — Favia
d. Colonies generally small flat patches to 5 cm across often growing in turbid conditions — Siderastrea radians
e. Colonies often forming small olive-colored nubbins 2 - 3 cm across at depths greater than 10 m — Madracis decactus
f. Colony turns white when touched (tan polyps retract leaving bare white surface) — Stephanocoenia
g. Small funnel-like calyces; colonies to 1 m — Siderastrea siderea

C. Brain corals; coalesced calyces forming long meandrine systems
1. Pillar coral; colonies consist of rigid vertical pillars to 1 m high rising from flattened base; tan "furry" appearance due to expanded polyps — Dendrogyra
2. With relatively simple valley systems (6-10 calyces); "fleshy"; colonies less than 15 cm usually
a. Gray with wide green valleys usually — Isophyllia
b. Brown — Mycetophyllia lamarckiana
3. "Typical" brain corals; colonies sometimes reaching 1 m
a. Generally found in grassbeds or sandflats only; to 10 cm — Manicina
b. With prominent and smooth sclerosepta — Meandrina
c. Ridges with secondary depressions — Diploria labyrinthiformis
d. Not like the above
i. Valley systems wide — Colpophyllia
ii. Valley systems intermediate — Diploria strigosa
iii. Valley systems narrow — D clivosa

e. Colonies generally flattened with "unusual" pattern of ridges
   i. Pattern maze-like; colonies generally gray — *Mycetophyllia ferox*
   ii. Ridges discontinuous; colony often green — *M aliciae*

D. Generally flat and platelike corals with sharp edges; with distinct calyces partly interconnected
1. Large spiral plates on dropoff reefs deeper than 15 m — *Agaricia lamarcki*
2. Flattened plates or crinkly lumps in shallow water — *A agaricites*
3. Calyces tiited toward edge of colony; generally under ledges; with lustrous sheen — *Helioseris cucullata*

Good living material representing all 5 extant echinoderm classes is available locally. In this lab you have the opportunity to examine live representatives of at least 4 of these classes as well as additional demonstration material.

C1 Echinoidea (sea urchins, sand dollars)
SubC1 Regularia (regular sea urchins)
a. External morphology and behavior

Place a small Echinometra in a finger bowl with seawater and examine under the dissecting microscope. Identify the following: mouth, teeth, peristome, madreporite, anus, periproct, tube feet (=podia), suckers, pedicellariae, "gills", movable spines (and parasitic snails [Stilifer], if present if so do they have broods of young larvae in their pseudopallium?) Note the mode of action of individual spines, tubefeet, pedicellariae and teeth. Do you understand how each of them works (i.e. how it can move the way it does?) To what extent do these movable organs show coordination? Turn the urchin upside-down (mouth upward) and describe how it rights itself. What are possible functions of the pedicellariae? How does the urchin respond to a beam of light? to a probe on its surface or on a spine? to extract of Cassis? to a piece of Cassis or other predatory snail?

b. Internal anatomy

Place a large Echinometra in a finger bowl with seawater. Carefully cut around the equator and separate the two halves in the seawater. Identify the following: Aristotle's lantern, teeth, dental sacs (where new tooth material is formed), gut, gonads, ambulacral areas (with tube foot ampules and pores for shaft of tube foot), axial organ and stone canal, madreporite, perivisceral coelom.

If available, Tripneustes, which is much larger, can be used for internal anatomy. The gonads, if ripe, are nutritious and delicious and should be sampled; your instructor will set the example.

c. Morphological diversity

Look at any other available regular urchins; how do they differ most strikingly from Echinometra? What functional significance might these differences have? Usually available are Diadema and Eucidaris.

d. Skeleton

Using the dissected specimen of Echinometra make the following preparations: whole test, A's lantern, spine, pedicellaria, tube foot. After examining each, use dilute chlorox to remove excess tissue to permit a better look. The pedicellariae and tube feet should be mounted on a microscope slie with coverslip for examination. When examining these parts note particularly the porous structure of each ossicle; also note how they fit together into a functional whole.

SubCl Irregularia (heart urchins, sand dollars, etc).

a. Examine live Meoma (and Cassidulus and Clypeaster if available; if not, use dried skeletal tests) Note particularly how they differ from the regular urchins in the following respects: spine morphology and arrangement; location of mouth (and anus); locomotion (place them on sand of sufficient depth to see if they will burrow); righting. Identify tube feet and pedicellariae (a hand lens should suffice for this). A demonstration Meoma should be dissected for all the class to observe; what is the most striking feature of the internal anatomy? in what other ways does it differ from the regular urchin in internal anatomy?

Spatangoids such as Meoma show a great degree of specialization of tube feet and other structures; check out tube feet from different regions and compare their morphology; does it correlate with function? (e.g. mouth area, petals, etc.)

b. Representative tests

Examine the collection of tests representing the 4 orders of extant irregular urchins. Note the main characteristics by which the orders can be distinguished (because they are fragile, they are kept behind glass in the outside display cabinet.

Cl Holothuroidea (sea cucumbers)

a. A few hours before the dissection is to begin, place Thyone in a 50:50 mixture of isotonic MgCl2 (7.5% by wt) and seawater. Place the Thyone in a wax-bottomed pan with about 1/2 - 1" of seawater-MgCl2. Cut a long incision down the body and pin out the edges; continue the incision to both ends of the body. Identify the following (refer to figure) CaCO3 ring, ring canal, polian vesicle, buccal podia, ampules of buccal podia, stone canal, gut, mesenteries, hemal vessels, cloaca, cloacal dilator muscles, Cuvierian tubules (not always present), respiratory trees, gonad, longitudinal retractor muscles, tube feet ampules, coelomic cavity. What has the cucumber been eating? To what group of cucumbers does Thyone belong? Knowing this, what can you say about its life style? How does this compare with Holothuria? Chlorox a small piece of body wall and examine ossicles.

If available, place a live Synaptula in a petri dish with a little seawater and a sprig of Galaxaura. Watch its locomotion. Place a specimen in seawater on a microscope slide; using props add a cover slip and SLIGHTLY flatten the beast to slow it down and render its internal anatomy more visible. Note particularly the specialized ossicles in the body wall, and young that may be in the coelom. If Synaptula is not available, perhaps a specimen of the long Euapta is; examine the spicules of its body wall.

Compare the large Holothuria mexicana in the seatable with the Thyone you just dissected; how do these two differ in general life habit and external morphology?

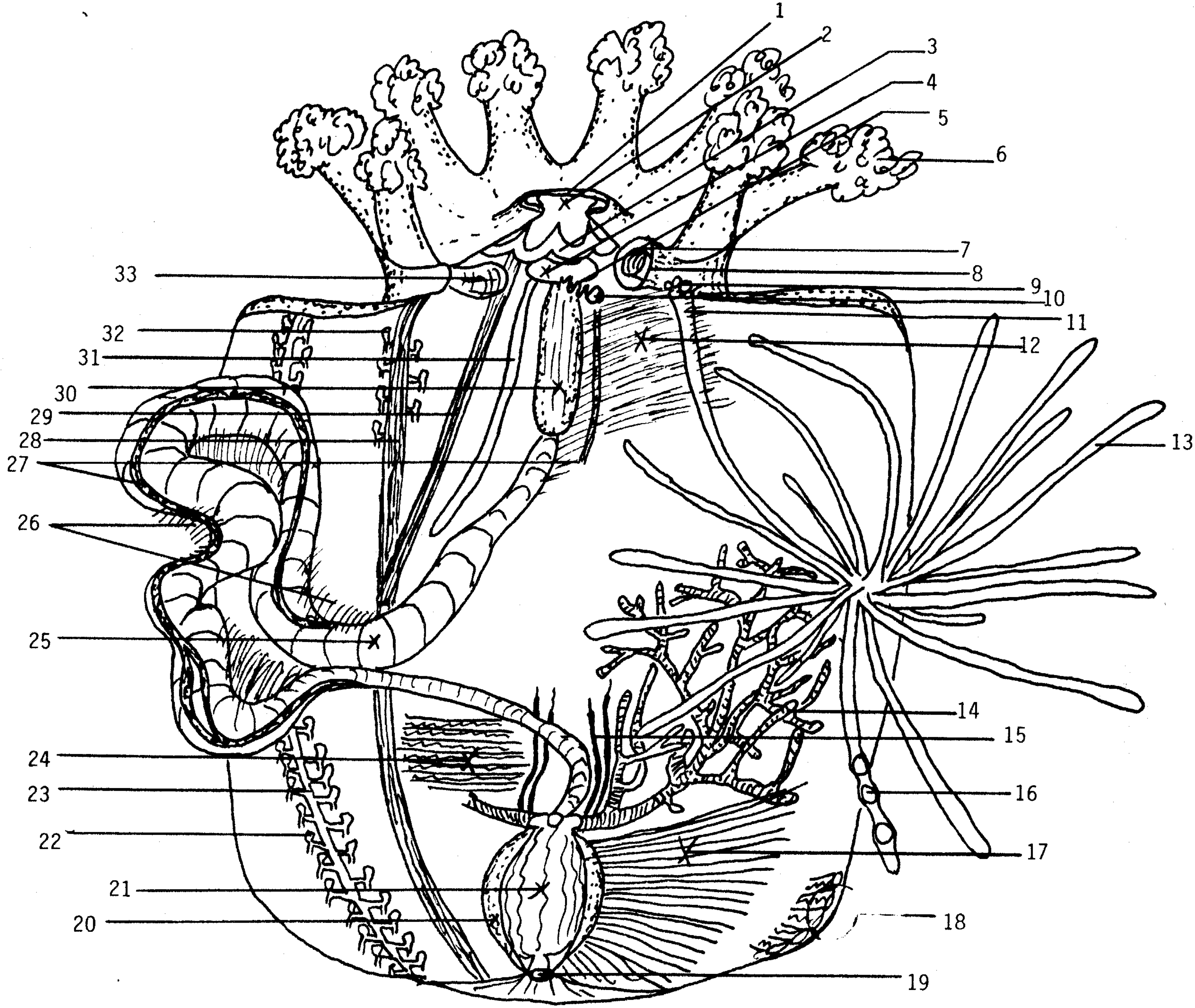
Cl Asteroidea (starfishes)

Observe the starfish Oreaster in a large glass aquarium. Set the animal's oral surface against the vertical glass side and observe the action of the tube feet in walking; what degree of coordination (or lack thereof) do you observe? Lay an animal on the bottom of the tank on its aboral surface and observe righting (patience, it takes a few minutes). Examine the external surfaces of Oreaster, underwater; identify the papules ("dermal gills"). Identify the following: mouth, anus, arms, madreporite, fixed spines, movable spines, ambulacral grooves, tube feet.

How does a starfish such as Oreaster feed? In the field or lab it can often be found with its cardiac stomach everted through the mouth. The diet of Oreaster includes a variety of animals, plants and detritus.

Key to the Dissection of a Dendrochirote Sea Cucumber

1. nerve ring
2. mouth
3. calcareous ring, to which pharyngeal retractors attach
4. water ring (ring canal)
5. stone canal
6. buccal tentacles
7. modified tube foot in tentacle
8. edge of severed tentacle
9. genital papilla
10. madreporite
11. gonoduct
12. mesentery (portion only shown)
13. gonad branch
14. respiratory tree (transparent and secured by mesenteries)
15. Cuvierian tubule (white, may not be present; defensive)
16. egg
17. extensor muscles of cloaca
18. section of body wall, 3 layers: epidermis, connective tissue, circular muscle
19. cloacal opening
20. cloacal wall (opened)
21. cloacal chamber
22. ampule of tube foot
23. radial canal (overlying muscle band removed)
24. circular muscle in body wall (portion only shown)
25. intestine
26. mesenteries
27. hemal vessels (portion only shown)
28. longitudinal retractor muscle overlying radial canal
29. pharyngeal retractor muscle
30. muscular stomach or pharynx
31. Polian vesicle (may be numerous; larger than tube foot ampules)
32. tube foot ampule
33. ampule of buccal podium (tentacle); may be long and thin



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If anyone is interested, one _Oreaster_ can be dissected for the class. Cut laterally with strong shears. Identify: gonads, stomach retractors, cardiac stomach, pyloric stomach, tube foot ampules, skeletal holes for papules, hepatic caeca, stone canal. Examine a piece of the aboral arm skeleton; chlorox it What happens?

Examine dried specimens of _Acanthaster_, _Linckia_ (and "comet"), etc.

Cl Ophiuroidea (brittlestars and basketstars)

Place a live _Ophiocoma_ in dish with seawater and make observations on how it locomotes and rights itself. Compare these movements with what you observed for the starfish? How are they similar or different? Identify disc, arms, arm spines, tube feet, mouth, jaws, gonopores. With a razor blade sever one arm about a third of the way from disk to arm tip and remove one arm segment. Examine it under dissection scope then chlorox it to determine the arrangement of ossicles in the arm segment.

What are the principal structural differences between starfish and brittlestar? Set aside a few brittlestars with freshly cut arms to observe regeneration over the next few days.

Look at other ophiuroids that may be available, e.g _Ophiothrix_.

Cl Crinoidea (featherstars)

These can be readily obtained on some of the slightly deeper reefs (e.g. Cane Bay). If a specimen of _Nemaster_ is available, examine it carefully and compare its structure with that of a brittlestar, which it may superficially resemble. What are the similarities and differences? Frequently, an ectoparasitic, highly modified annelid, _Myzostoma_, can be found crawling on the crinoid; if you see one (a few mm long) let the class know: this is a real treat! _Nemaster_ can crawl about using its cirri; place one in the seatable and return after dinner to see where it has gone.

Another, smaller crinoid, _Analcidometra_ found in deeper water on can sometimes be found; it SWIMS.

Echinoderm Development

Obtain 6 - 10 large urchins. Obtain fresh gametes (_Tripneustes_ is best, or use _Echinometra_ or even _Diadema_) by injecting the peristome with a few cc of 0.5 N KCl. If the urchins are ripe within a minute or two gametes will be extruded from the aboral gonopores: eggs are orange and sperm white. Place eggs into a Petri dish with a few mm of sea water. In a separate dish do the same with sperm. Then take a few drops of the sperm suspension and add to the egg dish; stir; cover. Eggs can be pipetted out for observation at any time. Try to observe all the stages below and ecord time intervals at which they occur:

Unfertilized egg
Fertilized egg (recognized by clear fertilization membrane surrounding egg)
2-cell stage
4-cell stage
8-cell stage
etc.
blastula
gastrula
prism
early pluteus (usually this is the last stage that will be reached

unless the cultures are provided with food and ample volume of seawater).

APPENDIX: Where to obtain echinoderms

The best habitats to visit to collect a variety of echinoderms are: beachrock, along most of the east end beaches, for *Echinometra* reef rubble for a variety of brittlestars, *Eucidaris*, and *Linckia*; mixed grass and sand bottoms such as at Horseshoe Patch for *Meoma*, *Oreaster*, large holothurians and *Astropyga*; deeper reefs such as Cane Bay for crinoids; intertidal and subtidal boulders for *Thyone*; intertidal tufts of *Galaxaura* for *Synaptula*.

Cl Polyplacophora (chitons)

a. External morphology, locomotion, righting, radula action:

Underwater place the ventral surface of a chiton flat against a large glass slide till it adheres. Examine the undersurface and identify: girdle (=mantle), mantle cavity, head, mouth, foot, ctenidia, anus, (renal and genital pores if possible). Observe the chiton as it glides along the glass plate; do you understand how locomotion is achieved by the small muscular waves of the foot? Watch the mouth for action of the radula. Remove the chiton from the glass and place it on its back (underwater, of course). Observe righting. Compare this with the kind of action seen in Oreaster.

If chunks of coralline algal ridge have been returned to the lab look into the small tunnels for the Acanthochitona that dwell therein; gently crack open these tunnels and watch the chitons move; note the grooves in the coralline algae (caused by radular action of the grazing chitons).

b. Internal anatomy

Tape or tie a chiton flat to a glass slide or other flat surface (e.g. tongue depressor). Immerse briefly in boiling water to kill it. Remove, pin into dissection pan and carefully dissect either from below through the foot or from above by removing the plates. Identify the internal organs. Be sure to note the prominent radula with its iron-tipped teeth.

Cl Gastropoda (snails and slugs)

a. Morphology of the queen conch

Observe a live conch in the seatable (one of the smaller species such as milk conch will do fine for this). Note particularly how locomotion and righting are achieved. Over a period of several days it might be possible to observe a conch using its eversible proboscis and radula for feeding (especially good if observed rasping algae from sides of glass tank).

Remove a conch from its shell; there are two ways to do this: one is to crack a hole near the site of muscle attachment of the body to the shell and sever this attachment (this is generally located in about the middle of the second whorl as the conch lies flat on its opening); if done carefully and properly, the heart of the conch may still be beating when the animal is removed. The other way is to freeze a conch overnight then thaw it before dissection. It can then generally be removed with a tug on the operculum. Neither method is foolproof and sometimes mutilated conchs are the result. Do your best. If there is a shortage of conchs, the instructor will do the dissection for the whole class. All the structures present in the diagram of HAM can usually be identified (see Figs. of HAM and conch dissection).

The queen conch is a species of economic importance in the West Indies. It can be further prepared for eating by removing all the viscera and then by carefully skinning. Conch can be prepared in a number of way for eating, raw or cooked; a few common ones are: marinated, sauteed, deep-fried, or in chowder.

The structure of the mantle cavity and coelomic structures can be seen in their primitive condition in the keyhole limpet. Carefully cut between the body and shell to detach the animal. Pin it in a small wax-bottomed dish and carefully cut open the mantle cavity. (This must be done under the dissecting scope). Note the two well-developed aspidobranch ctenidia. Note the openings of the anus, gonad and kidneys. Carefully remove the tissue just posterior to the mantle cavity; it should reveal the heart (perhaps still beating), with ventricle and two auricles, two kidneys, and gonad.

b. Gastropod diversity.

Examine the diversity of gastropods available (keyhole limpet, periwinkle, vermetid, flamingo tongue, Conus, Stilifer, sea hare, sacoglossan, and others). Relate external morphology to mode of life in these forms (i.e. habitat, feeding, locomotion, defenses, etc.).

Examine the collection of shells available. These can be identified and classified (to family) using one of the books available (e.g. Caribbean Seashells) or a number can be found in the plate included here.

c. Predation

The majority of higher gastropods are predators. In the intertidal zone Thais and Purpura are common predators on other intertidal snails such as the nerites. Place these forms together in a shallow dish of water and see if you can get a response. Other predatory acts can be seen with Cassis (preys on Tripneustes or Meoma).

d. Radulae

Compare the radulae of the chiton and the conch dissected above. Then, if one is available, dissect out the radula sac of a Conus. How is this remarkable apparatus used?

Cl Bivalvia (bivalves)

a. Morphology of Spondylus

If specimens of this bivalve have been collected (e.g. from F'sted Pier) they make an excellent demonstration of bivalve anatomy (refer to the plate for aid in identifying structures). Open the bivalve by inserting a strong fairly sharp device such as a knife blade between the shells and slide along the upper valve to slit the attachment of the adductor muscle (instructor will demonstrate this technique). Once open, look for specimens of the commensal shrimp Pontonia which often live in pairs in the mantle cavity of this as well as other spp of bivalves; many of these are species specific associations between shrimp and host. Carefully free the mantle from the upper valve and remove the valve. Place lower valve with animal in it in a dish of seawater. Identify the structures successively, starting with upper mantle, removing it, ctenidium, etc. Examine part of the ciliated ctenidium under the microscope. Using small pigmented particles such as graphite or carmine red see if you can trace the course of particles trapped on the surface of the ctenidium.

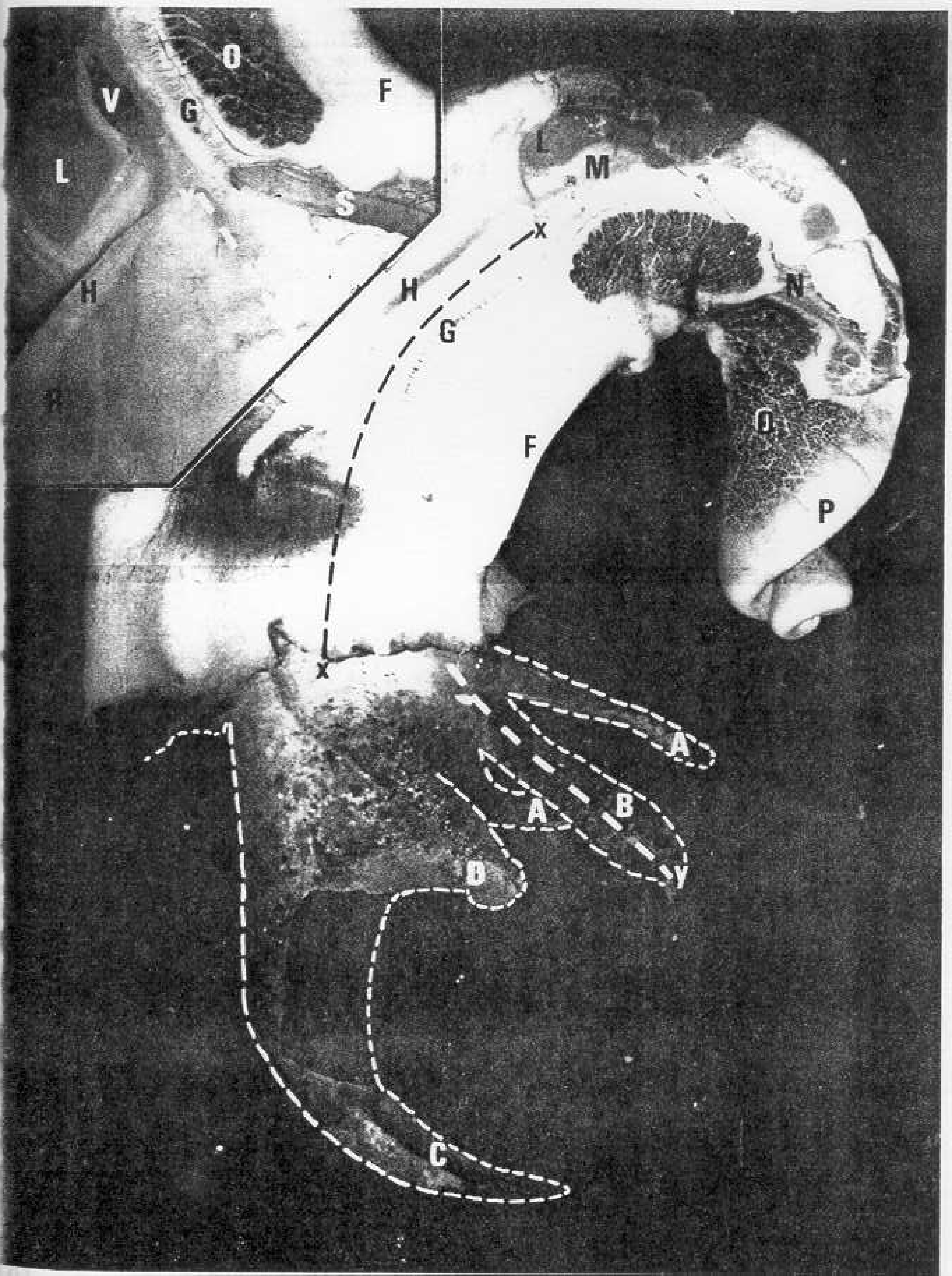
In the absence of Spondylus, almost any medium to large-sized bivalve will do well. Most sediment-dwelling forms have a differently arranged ctenidium in which the filaments are fused.

Guide to Anatomy and Dissection of the Queen Conch

[Insert: dorsal view of mid region with mantle cavity, pericardium and part of style sac removed

A Eye stalk (with eye and sensory antenna; see back cover)
B Eversible proboscis (with radula and odontophore near tip)
C Operculum (attached to posterior of foot; used in locomotion
D Anterior end of foot
E Edge of mantle
F Shell muscle (continuous with foot muscle)
G Style sac
H Afferent ctenidial vessel
I,J and K (Obscured from view: rectum, oviduct and mucus gland: lie in roof of mantle cavity to anatomical right of ctenidium)
L Kidney (reddish in color)
M Pericardium (surrounding heart)
N Stomach (thin-walled, with end of crystalline style protruding into it)
O Digestive gland
P Gonad
R Ctenidial filaments
S Crystalline style with portion of sac removed
V Ventricle of heart

xx Incision to make through roof of mantle cavity to expose structures within
yy Incision to make through esophageal canal to expose radula, odontophore, esophagus and portions of nervous system



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b. Diversity

If there are other living bivalves available, take a look at them. Common are Pinna, Lima, and a number of other filibranchs. Young Spondylus, Lima and mussels will readily secrete a few byssus threads for temporary attachment to the substrate. The first two of these will also swim if disturbed; can you describe this action in detail? If there are any sand-burrowing forms available, watch them dig into sand. Bringing chunks of reef substrate back to the lab will often reveal the presence of the boring bivalve Lithophaga.

Take a look at the collection of bivalve shells. Some of these are burrowers in sediment; some are attached to rocks (by byssus or cementation) some bore holes in carbonate substrates, etc. Which ones do which? A good place to look for a variety of bivalve shells is by the entrance of octopus burrows.

Cl Cephalopoda

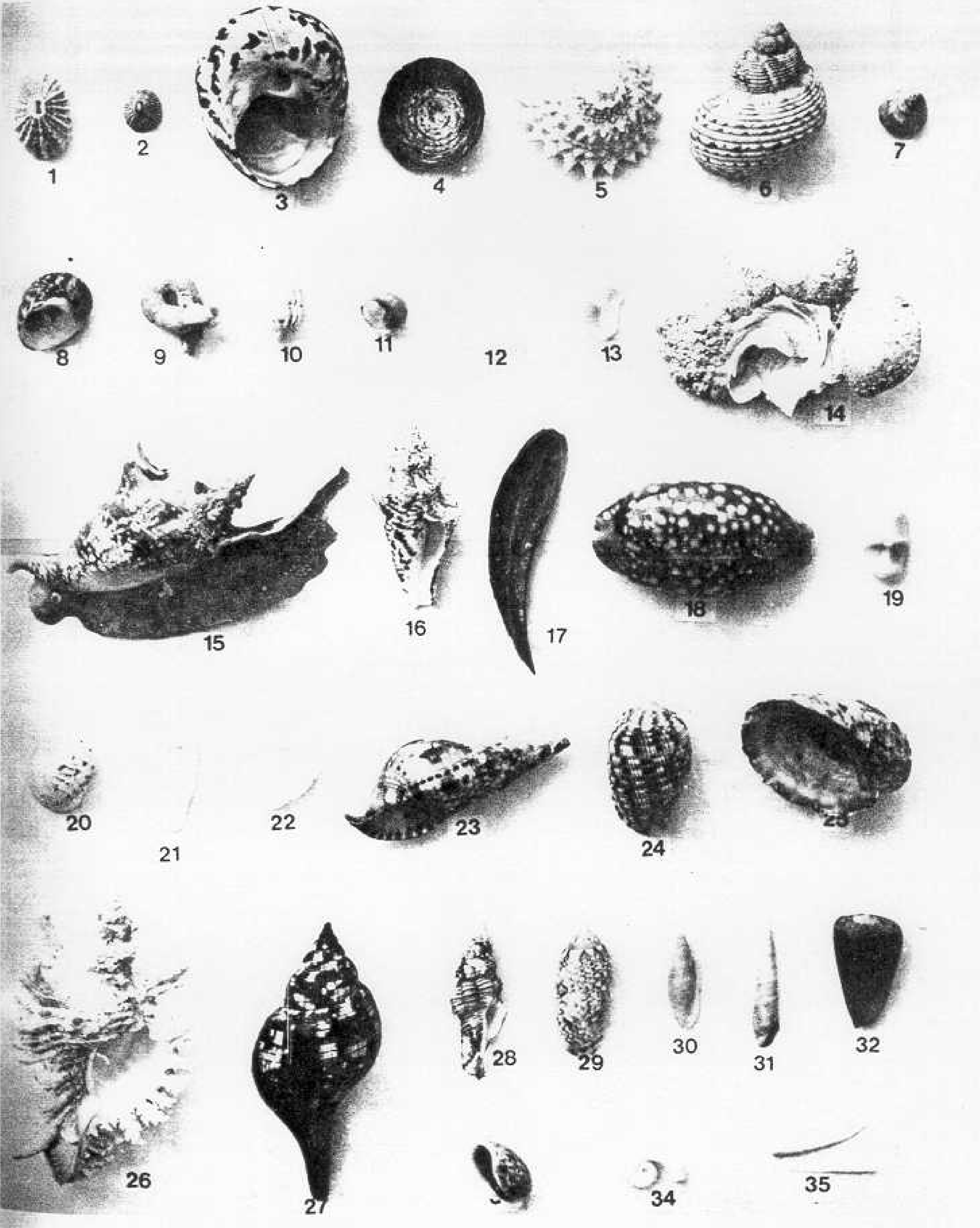
If an octopus is available watch its behavior, color change, etc. Look at the cephalopod skeletons representing an evolutionary series from the primitive large chambered shell of the Nautilus, to the partially chambered shell of the cuttlefish, the small chambered shell of Spirula, to the thin transparent "pen" of the squid. All these occur locally except for the Nautilus.

Cl Scaphopoda

These small forms occur locally in sand. If there are any available for lab observe how they dig into sediments. Using transmitted light in a small glass dish identify the captacula, radula, "gill". Are there forams in the buccal cavity (remember, these are predators on forams)?

APPENDIX: Where to collect molluscs

Although not uncommon, it usually takes a little searching to find a variety of molluscs in local waters. The large gastropods (conchs, helmets, tritons, tulips) can often be found in the open on sand or grass or patch reefs. Keyhole limpets and a variety of primitive gastropods as well as chitons can be found on most rocky shores or beachrock, especially sites with higher wave energy. The numerous filibranch bivalves can be found in a variety of reef habitats, in crevices, cemented to old gorgonians, and their shells around the mouths of Octopus burrows. Other good sites for bivalves are F'sted Pier (especially Spondylus) and good red mangrove stands such as at Salt River (Isognomon). Pinna are not uncommon in grassbeds. Scaphopods can be turned up by running fingers through loose sand in a variety of sand bottom environments: it usually takes a minute or two to turn one up.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Representative West Indian Gastropods

1. *Fissurella* (keyhole limpet)
2. *Acmaea* (limpet)
3. *Cittarium* (topshell, welk)
4. operculum of *Cittarium*
5. *Astraea* (starshell)
6. *Turbo* (turban)
7. *Calliostoma*
8. *Nerita* (nerite)
9. *Serpulorbis* (vermetid)
10. *Epitonium*
11. *Janthina* (purple snail)
12. *Cheilea* (false slipper)
13. *Crepidula* (slipper shell)
14. *Xenophora* (carrier shell)
15. *Strombus gallus* (rooster tail conch)
16. same, young specimen
17. operculum of *S gigas*
18. *Cypraea* (cowrie)
19. *Cyphoma* (flamingo tongue)
20. *Natica* (moon snail)
21. operculum of same
22. *Sinum* (ear shell)
23. *Charonia* (triton)
24. *Cypraecassis* (helmet cowrie)
25. *Purpura*
26. *Murex*
27. *Fasciolaria* (tulip shell)
28. *Latirus*
29. *Oliva* (olive)
30. *Mitra* (miter)
31. *Terebra* (auger)
32. *Conus* (cone)
33. *Bulla* (bubble shell)

34. *Spirula* (Cl Cephalopoda)
35. scaphopods (Cl Scaphopoda)

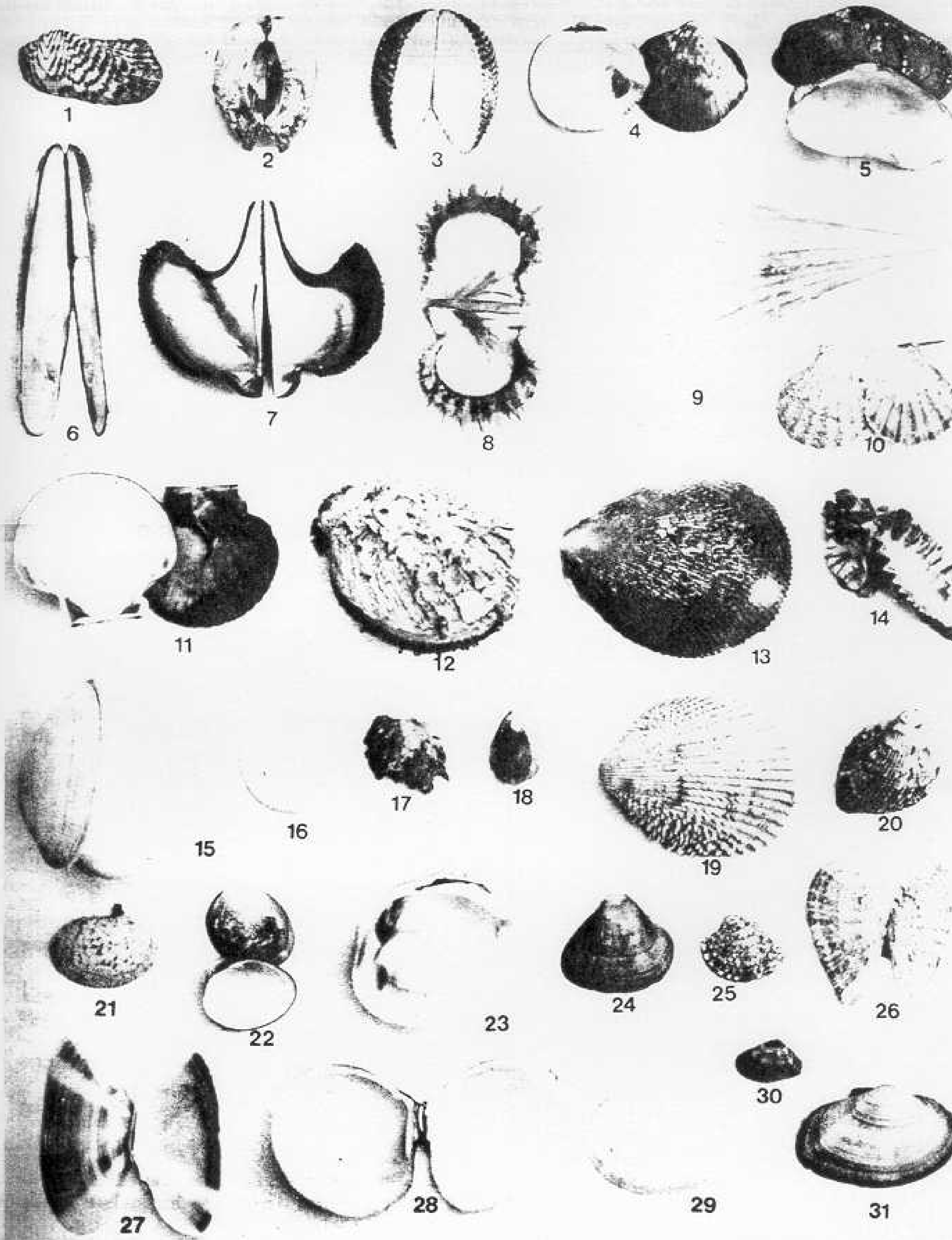
Common West Indian Bivalves

O Filibranchia

1. *Arca zebra*
2. *A imbricata*
3. *Anadara notabilis*
4. *Glycimeris decussata*
5. *Modiolus americanus*
6. *Lithophaga antillarum*
7. *Pteria colymbus*
8. *Pinctada radiata*
9. *Atrina (Pinna) seminuda*
10. *Chlamys imbricata*
11. *Pecten ziczac*
12. *Spondylus*
13. *Lima scabra*
14. *Lopho frons*

O Eulamellibranchia

15. *Codackia orbicularis*
16. *Linga pensylvanica*
17. *Chama macerophylla*
18. *C sarda*
19. *Trachycardium isocardia*
20. *Americardia media*
21. *Papyridea soleniformis*
22. *Laevicardium laevigatum*
23. *Antigona listeria*
24. *Tivela mactroides*
25. *Chione paphia*
26. *Tellina listeri*
27. *T radiata*
28. *T fausta*
29. *Apolymetis intastriata*
30. *Donax striatus*
31. *Asaphis deflorata*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EXERCISE (Lab): Annelids and other Worms

PH ANNELIDA

Cl Polychaeta (bristle worms)

a. Comparative external morphology related to lifestyle.

Examine in sequence specimens of the three or four representative modes of life:

Free-crawling predator: forms with well developed parapodia and chaetal bundles, head sense organs and usually an eversible proboscis

- Hermodice (fire-worm): large form particularly common aggregations of sponges on which they feed; protected by bundles of STINGING white calcareous chaetae
- Syllis spongicola: a tiny white commensal or micropredator found particularly in the large brown STINGING sponge Neofibularia
- Marphysa and other large eunicids found in coral rubble Porites heads

Sediment burrower: typically with reduced head and sense organs and reduced parapodia and chaetae; with or without well-developed eversible proboscis; typically found in grassbed core samples or other soft bottoms

- Glycera: with small pointed head and enormous eversible proboscis with biting jaws at end

Tube-dwelling deposit-feeder: body in self-constructed tube of cemented sand grains or other materials; with extensile tentacles or other mechanisms for gathering deposited organic detritus.

- Eupolymnia (spaghetti worm): in sand grain tube beneath coral rubble; extends long extensile tentacles radially to gather detritus
- Pectinaria: in conical tube which is a mosaic of precisely fitted sandgrains; mobile in coarse sand which it ingests

Tube-dwelling suspension-feeder: in self-constucted tubes of organic, sand grain or secreted $CaCO_3$ construction (or boring into carbonate rock); head end with elaborate tentacles for feeding and respiration; parapodia reduced.

- sabellids: with parchment-like tubes: featherduster worms
  - Sabellastarte: the large featherduster worm
- serpulids: with white tubes of secreted $CaCO_3$
  - Spirobranchus: the Christmastree worm sabellariids: with sand-grain tubes
- cirratulids: boring into coral rock
  - Dodecaceria: e.g. in dead A palmata in Tague Bay

Ectoparasite: with various modifications for clinging and feeding on larger Invertebrates

- Myzostoma: highly modified ectoparasite of crinoids (e.g. Nemaster) with parapodia modified as little "legs" each with a single large hook-shaped chaeta

Planktonic: represented by several families with different modifications for planktonic existence

- Tomopteris: flattened and transparent with elongated swimming parapodia without chaetae.

Other forms representing these or other modes of life may be available. Compare the following in terms of form and function in these animals: head, tentacles, sensory strucutres, parapodia, chaetae, gills, proboscis, locomotion, tube and tube construction, defensive reactions, feeding, etc. Prepare a large chart for ease of comparison.

OTHER WORM PHYLA

At least a dozen phyla of marine organisms fall into the loose category of "worms", united only by their soft elongated bodies. Representatives of some of these phyla may be available and should be examined, at least superficially. Locally common are members of the following "worm" phyla (see Taxonomic Synopsis):

Ph Platyhelminthes (flatworms)
Ph Nemertea (ribbonworms)
Ph Hemichordata (acorn worms)
Ph Sipuncula (peanut worms)
Ph Echiura (proboscis worms)

APPENDIX : Where to collect worms

The best sites for collecting a variety of polychaete worms are in piles of coral rubble, near shore or on the back reef. Particularly good field sites for collecting the above-mentioned and other polychaetes as well as other worms are: Holt's Reef, F'sted Pier, the rubble build-up on the west side of Grass Point and the grassbeds in shallow water such as at Great Pond Bay (a shovel and sieving screens are useful in this case).

EXERCISE (Lab): Arthropods

SubPh Crustacea

a. Shrimps and Crabs

The great majority of large and conspicuous crustaceans in local waters fall into the general categories of "shrimps" and "crabs". These are not strictly taxonomic categories (see Taxonomic Synopsis). Usually, but not always, the term "shrimps" refers to members of several taxonomic groups of the order Decapoda which are of relatively small size and have relatively large abdomens (="tails"). Other "shrimps" (mantis-shrimps, brine shrimps, bean shrimps, etc.) belong to very different crustacean groups. "Crabs" refers to short- and heavy-bodied decapods with reduced abdomens.

Members of the Decapoda have the body divided into two main regions: the head-thorax and the abdomen. The former bears 2 pairs of antennae, 3 pairs of basic mouthparts, 3 pairs of "leg-mouthparts" (derived from the thorax), and 5 pairs of larger "legs" (which may be specialized for a variety of functions from food-catching and walking to swimming and gill-cleaning.

Shrimps (including larger forms, called lobsters) have a large muscle-filled abdomen (="tail") whose main function is to provide for rapid escape from danger by flexing powerfully and directed a jet of water forward, thereby driving the animal backwards. "Crabs" include a variety of forms with reduced abdomens in which this function is reduced or absent; in this miscellaneous group we find a gradation in the reduction of the "tail" culminating in the true crabs (Brachyura):

Examine the following representatives of the "shrimps" and "crabs" and try to understand the functional significance of the gradual reduction of the abdomen:

Callianassid (ghost) shrimp
Spiny lobster (shrimp-sized specimens are best)
Barberpole shrimp
Galatheid shrimp or crab
Hermit crab
Mole crab
Porcellain crab
True (Brachyuran) crab

In making your comparison consider the following points:

reduction of the size of the abdomen
use of the abdomen in the tail-flex, and ability to escape thereby
other uses of the abdomen
other changes in locomotion (e.g. changes in walking)
development of telson and uropods

b. Specialization of Appendages

Primitively, crustaceans are believed to have a great number of very similar appendages (like a trilobite or a centipede, for example). However, most crustaceans show a great degree of specialization of appendages along the body for a variety of functions: walking, swimming, escape, food-catching, eating, sensory detection, digging, mating, respiration, egg-carrying, grooming, etc.

Look at the following forms and try to figure out what all the appendages are used for:

Juvenile lobster
Hermit crab
True crab (examine a swimming crab also)
[a number of crabs that live on sand are capable of rapid digging, portunids, Calappa, etc. do this; if possible examine a few of these and how they dig]
Stomatopod (if available)
others (e.g. some of the near microscopic forms such as copepods and ostracods)

c. Anatomy

Dissect a crab underwater by first removing the carapace to expose the gill chambers, then working downward, identifying structures as you proceed.

d. Commensal Shrimps

A great diversity of commensal shrimps can be found living on and with a variety of larger, more sedentary reef organisms. If some of these are available in the lab observe their behavior in relation to their "host". Such commensals often occur with anemones (Alpheus, Thor, Periclimenes), bivalves (Pontonia spp), sea urchin spines (Stegapontonia spp on Diadema and Tripneustes), etc.

APPENDIX: Where to find crustaceans

The larger reef crustaceans are active primarily at night (lobsters, larger crabs) though they can sometimes be found in caves during the day. Juvenile lobsters can be found in fouling vegetation on boat bottoms when very small or later around appropriate-sized rubble or sea urchins. Many of the smaller shrimp species are commensal with larger invertebrates: anemones, urchins, etc. In particular Bartholomea and other long-tentacled anemones are choice habitats. Barberpole shrimps are most common on man made structures such as docks but also occur on reefs. Stomatopods are numerous anywhere that there are cavities for refuge; they can best be collected by bringing large chunks of dead coral rubble to the boat or ashore. Ghost shrimps can be excavated in grassbeds by using a coring device. Hermit crabs can usually be encountered in good numbers in intertidal pools or the terrestrial Coenobita can be found nearly everywhere. The more esoteric anomurans such as mole crabs, galatheids and porcellanids are not common but can be encountered on sand beaches or under coral rubble (as appropriate). A great variety of smaller crustacea turn up in collections of benthic algae, plankton tows, etc.

EXERCISE: Tropical Zooplankton

Plankton includes those small aquatic organisms that spend all or part of their life cycle drifting in the water column more or less at the mercy of water currents; zooplankton is the animal fraction. Nearly all zooplankton have locomotory ability but this is mainly used only in very small-scale movements (such as in the capture of prey or the escape from predation) or in vertical migrations in the water column. Tropical waters are very rich in the variety of zooplankton, but overall abundance is generally low. Many forms are restricted to, or most often found in, one of the major plankton habitats: (1) lagoonal, e.g. Tague Bay; (2) shelf, e.g. Buck I. Channel; (3) oceanic, e.g. offshore, at Cane Bay dropoff or at F'sted Pier. The richest of these regions in terms of plankton diversity is offshore, where representatives of as many as 10 or 12 phyla and 20 or more Classes may be taken in a single 10 minute plankton tow. Usually, however, a tow in the Channel will yield a good 8 - 10 phyla with rich representation of species and larval forms.

FIELD

In order to obtain a diverse sample of plankton in the brief time available a tow will be taken about .5 km outside the reef cut to Buck I. channel. We use a net with a 0.5 m diameter opening and a mesh size of 350 microns (or smaller if we wish to obtain more small invertebrate larvae or plant cells). The net bridle should be weighted with at least 15 lbs. of lead (diving weights do just fine). With the towing boat moving into the wind (and waves) at very slow speed, and with the towing rope secured to the boat about 50 ft. from the bridle, lower the net. If the net appears to sink rapidly, shorten the towing line (the channel is less than 40 ft deep and you do not want to hang the net up on a coral head!) A tow of 5 - 10 min is generally sufficient to obtain a rich sample. The finer the net mesh, the slower the towing boat should move (with a mesh less than 75 microns, drifting with the wind may be fast enough). At the end of the tow, with the boat in neutral, pull in the net and remove the "bucket"; place the contents into a few inches of fresh seawater in the bottom of a clean bucket and head immediately back to the lab. Most of the animals will die within a few hours so it is important to look at them as soon after collection as possible. For comparative purposes rich plankton samples can also be taken: (1) in Tague Bay lagoon, at NIGHT; or (2) off the shelf edge very early in the morning; e.g., pass just to the west of the western boundary buoy of Buck I. National Monument and continue seaward at least 1 km (the water depth here is many 100's of ft. deep) tow as deep as convenient.

LAB

Most of the plankton will settle to the bottom of thebucket. To take a small sample for observation under the dissecting scope use a turkey baster or similar device and suck up enough material to cover the bottom of a Petri Dish or small finger bowl to a depth of a few mm. The great majority of forms are either copepod crustaceans or larval forms of decapod crustaceans. Since the purpose of the lab is to observe as great a phyletic diversity as possible you should not confine your observations to one or two dishes with a bunch of crustaceans; look for other phyla and classes as well. Keep a list of the taxonomic groups you identify along with a brief description (phrase or sentence) of each.

Illumination is very important when observing transparent and delicate forms such as these. Generally the BEST results can be obtained using transmitted light reflected from the white, rather than the mirrored side of the substage mirror: try both sides to find which is better for you.

The following outline is a synopsis of the forms that are regularly taken in these tows (numbers refer to accompanying Figure)

Ph Cyanophyta: Trichodesmium, fine, straight brownish strands often in clumps; off shelf

Ph Chrysophyta: diatoms: ornate, generally symmetrical forms sometimes round and flat (centric) sometimes long, uncommon except seasonally in lagoon

Ph Pyrrhophyta: dinoflagellates: uncommon often represented by the asymmetrical 3-horned Ceratium

Ph Sarcodina

Cl Foraminifera: Globigerina, central cluster of assorted sized spheres, with radially projecting processes oceanic

Cl Radiolaria: radiolarians: similar to above but center radially symmetrical

Ph Cnidaria

Cl Anthozoa: cerianthid larvae: like tiny elongate anemone

Cl Scyphozoa: small coronate medusae: with distinct coronal groove on exumbrella, oceanic

1 Cl Hydrozoa: medusae of various orders shelf or oceanic (hydromedusae)

O Siphonophora: siphonophore colonies, often in fragments e.g. swimming bells and bracts: these are highly transparent angular objects most often cube-like or projectile-like, oceanic

2 Ph Ctenophora: comb jellies; often as fragments of comb rows usually a few (rows of) large beating cilia attached to a band, shelf or oceanic

6 Ph Chaetognatha: arrow worms; always present in good numbers on shelf or offshore; elongate, large transparent rod-like forms with distinct head tiny eyes and bristle jaws; sometimes deformed or contorted

Ph Echinodermata:

Cl Echinoidea: pluteus larvae: tiny 6- or 8- armed angular ciliated forms; not common

Cl Ophiuroidea: pluteus larvae

4 Cl Asteroidea: bipinnaria and brachiolaria larvae: rather ear-shaped or derived therefrom with long flexible processes; tiny, uncommon

5 Ph Hemichordata: tornaria larvae: large globular form with pronounced, convoluted ciliated band; oceanic

Ph Chordata

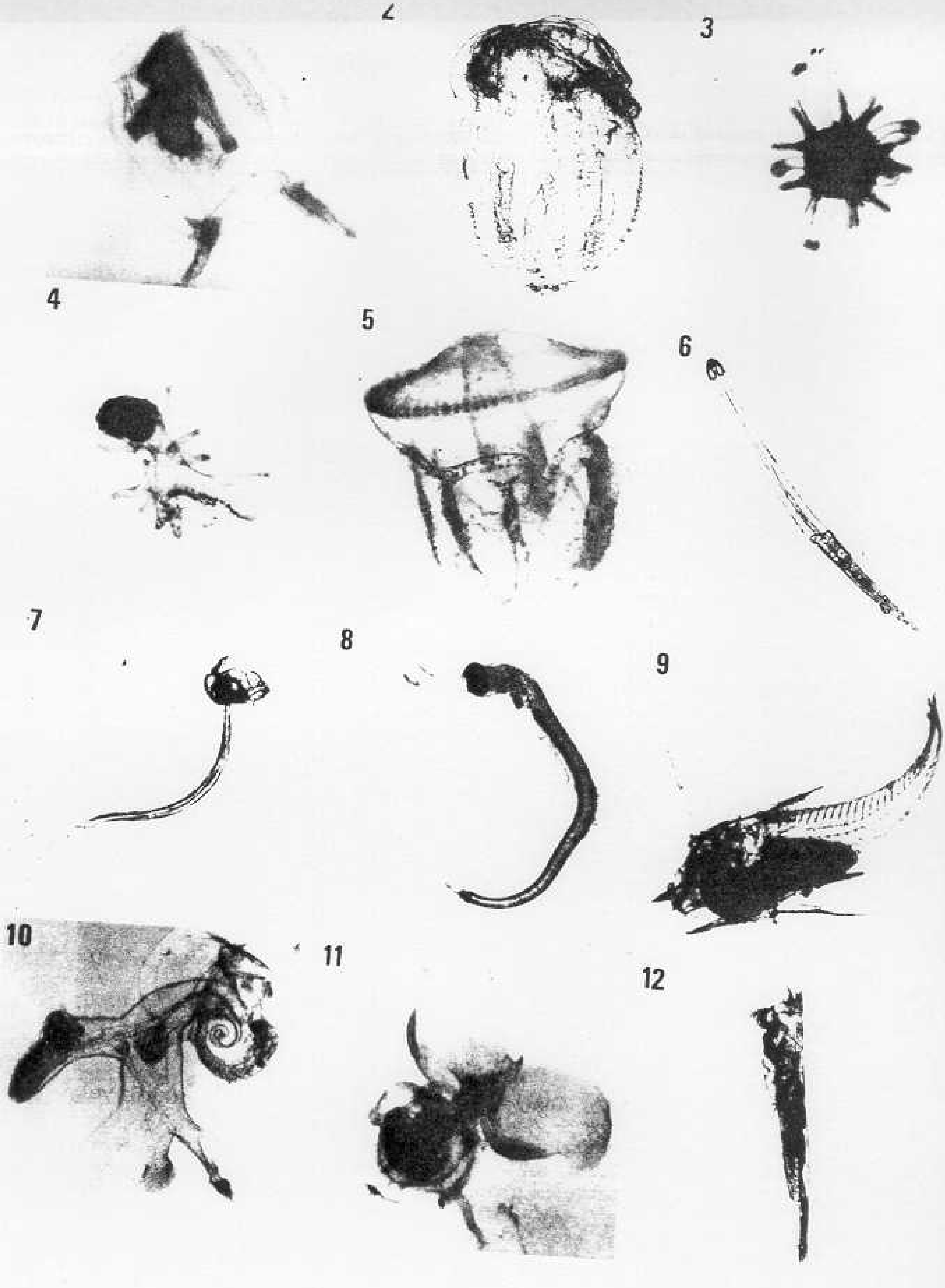
SubPh Urochordata

7 Cl Larvacea: larvaceans: tiny forms with small body and relatively large beating tail; normally live in mucus "house"

Cl Thaliacea: doliolids: symmetrical barrel-like forms salps: asymmetrical barrel-like forms

SubPh Cephalochordata: lancets: tiny transparent fish-like forms; no eyes, pointed at both ends

8,9 SubPh Vertebrata: fish larvae and eggs of numerous types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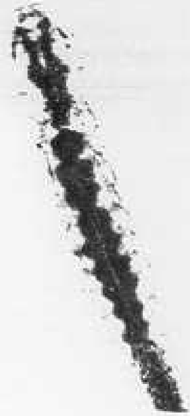

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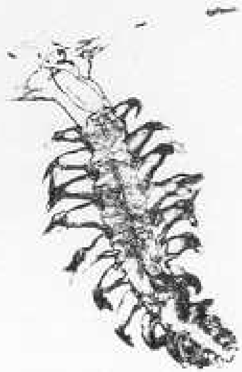

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O Apodiformes (eels): leptocephalus larvae: superficially like lancets (above), but with eyes and generally much larger; uncommon

Ph Bryozoa: cyphonautes larvae: like tiny flat ciliated triangular hat

Ph Mollusca

Cl Gastropoda: veliger larvae: tiny snails with large ciliated lobes

10 heteropods: large-eyed predators with either coiled or cap-shaped shell

11,12 pteropods: with variously shaped shells ranging from elongate cone to coiled; swim by flapping large muscular lobes

Cl Cephalopoda: juvenile squid: look just like adults; notice operation of chromatophores under scope

13 Ph Sipuncula: larvae: chunky worm-like forms capable inverting one end

Ph Annelida: polychaete larvae of various types: normally of

14 (early) only a few segments, sometimes beginning to develop

15,16 (later) tentacles of adult form

17 Tomopteris, flat and transparent with about a dozen pronounced lateral appendages without chaetae

alciopids: elongate segmented worms with enormous eyes

syllids: short forms with abundant lateral bristles

18 other adult forms: often with egg masses

Ph Arthropoda

Cl Crustacea

SubCl Branchiopoda

O Cladocera: tiny forms with shortened body, large sessile eyes and pronounced swimming antennae; uncommon

SubCl Ostracoda: bean shrimps: tiny forms completely enclosed in bean shaped, bivalved carapace

SubCl Copepoda: ABUNDANT IN ALL TOWS; tear-drop to slightly elongated forms with pronounced antennae and short segmented "tail" region

19 O Calanoida: as above, with simple median eye

O Harpactacoida: generally more elongate form

20 O Cyclopoida: various, with generally shorter antennae

Sapphrina wide, flattened form which flashes blue due to iridescence

SubCl Cirripedia: barnacle larvae: similar to ostracods (see above) but with pointed posterior; seasonal

SubCl Malacostraca

21 O Stomatopoda: larvae; large transparent forms with enormous raptorial lateral claws and large eyes

O Amphipoda: hyperiids: shortened banana-shaped forms with enoumous sessile eyes; shelf and offshore gammarids: sometimes taken in nocturnal tows, like previous but smaller eyes and longer

O Isopoda: in nocturnal plankton, "sowbugs"

O Cumacea: in nocturnal plankton, less commonly; with chunky body and elongate tail and jerky swimming

O Mysidacea: shrimp-like but with all similar thoracic appendages; no abdominal appendages

O Euphausiacea: euphausids: similar to previous but with photophores at bases of some legs; abdominal appendages

O Decapoda: numerous larval stages of shrimps, crabs, lobsters, etc. at various stages of development

22,23 zoea larvae: with elongate projections from carapace particularly elongate in anomuran larvae (zoeas of hermit crabs and their relatives

24 mysis larvae of shrimps: shrimplike forms

phyllosoma larvae of spiny lobsters: long-lived, long-legged spider-like forms with large flattened carapace, to quite large size

SubO Peneidea: sergestids (the only decapods truly planktonic as adults)

EXERCISE (FIELD): Identification and behavior of coral reef fishes

More than 300 species of fishes have been recorded from the shallow waters surrounding St. Croix. The majority of these are associated with reefs and most can be observed by the diver. In an hour an experienced fishwatcher can observe and identify more than 50 spp in many environments and up to 100 in the best. Members of about 60 families of bony fishes can be found in a few dives. Most of the species observed by the beginner however belong to about 30 families; the overwhelming majority of individuals (and species) belong to about a dozen families. Most of the species of most of the 30 or so families seen by the beginner have characteristics in common with other members of the family, both physical and behavioral. Thus it is possible to generalize about most of the species of most of these reef fish families.

The most useful tool for the beginning fishwatcher is an immersible copy of the Fishwatcher's Guide by Chaplin and Scott. With this tool in hand while in the water one can identify nearly all shallow-water species observed (including many that come in several color varieties).

The best approach is to learn the common names of these 30 families and some of their characteristics, both descriptive and and biological, before going into the field. Be familiar with the general appearance of squirrelfishes, grunts, damselfishes, wrasses, parrotfishes, and others. Then, when setting out for the first time to actually identify species in the field, it will be much easier. After a very few dives you will will be amazed how many species you will have identified

Identification is merely the first step in the study of a group of organisms. The behavioral and ecological diversity of reef fishes is as great as their morphological diversity. Many aspects of the biology of reef fishes cannot be studied by simple observation; however, many can. Particular areas that are ripe for observational study are:

(1) Position, posture and locomotion.

Where in the complex structure of the reef and its surface structures does the fish spend its time? (does it rest on the bottom? on sand? on a coral head? in a hole? does it swim above the reef? low or high? What is its posture? What is its mechanism of locomotion? (i.e. does it use its pectoral fins alone? its body and tail? does it use different methods at different times?) Characterize each species according to its position and movement. Why do various species do as they do?

(2) Feeding activity, movements and migrations.

The representatives of many families of reef fishes feed in characteristic ways and on characteristic foods. In many of these groups useful information about the feeding biology can be obtained by observation alone; for example, what do most parrotfishes do? the brown damselfishes? squirrelfishes? How continuously do the members of these groups feed? when? where? on what? how much do they move about while feeding? do they migrate between feeding and resting sites? etc.

Summary of Important Families of Reef Fishes of Tague Bay Lagoon:

FAMILY	NO. COMMON Spp.	GENERAL HABITS
Herring	2	Shoaling by day near shore or reef; plankton-feeding at night offshore
Lizardfish	1	Sedentary predator on other fishes
Moray	6	Crevice and cavity dwelling predator mostly on fishes; may emerge night
Trumpetfish	1	Predator of small fishes; relies on camouflage
Squirrelfish	6	Nocturnal foragers on crustacea
Barracuda	1	Large resident fish eater
Grouper	14	Diverse in size and form; predators mainly on fish; often secretive
Cardinalfish	5	Small, cavity-dwelling; forage at night on small crustacea mainly
Jack	2	Silvery, fast-swimming, often schooling predators of fishes,etc.
Snapper	4	Mainly predators on other fishes (Yellowtail on plankton largely)
Grunt	9	Often in mixed schools by day; forage in grassbeds at night
Drum, Croaker	4	Mostly with striking black & white pattern; feed at night crustacea
Goatfish	2	Disturb sediment with muscular barbels; eat small invertebrates
Butterflyfish, Angelfish	7	Colorful, often paired; former nip cnidarians latter eat sponges
Damselfish	12	Diverse group including territorial herbivores, planktivores, etc.
Wrasse	9	Usually slender quick-moving opportunists; feed on inverts.
Parrotfish	10	Large herbivores which often bite chunks of reef to obtain algae
Goby	7	Diverse group of very small forms of diverse habits
Surgeonfish	3	Herbivores that often move in large schools
Triggerfish,	5	Diverse in habits planktivores to Filefish urchin eaters
Scorpionfish	3	Well-camouflaged sedentary predators of fishes
Trunkfish	4	Armored forms; feed on small inverts
Porcupinefish	2	Strong-jawed forms that eat hard-shelled inverts; inflate

QUANTITATIVE ECOLOGICAL EXERCISES:
Analyis of tropical marine populations and communities

The following section provides a number of quantitative exercises that deal primarily with the analysis of the structure and function of tropical marine communities. These are intended for the more advanced student who has a familiarity with the identification and basic autecology of the common Caribbean marine organisms (e.g. a student who has had at least a week-long intensive field course). The exercises cover a variety of problem areas in community structure and function and include a variety of methods of sampling and obtaining and analyzing ecological data. Some of the problems (i.e. exercises) are of very general applicability, whereas others are highly specific but locally or regionally important. Likewise, some are quite involved with a number of intricate analyses and others are quite simple with only one analysis. Many of these exercises can be more fully developed as group or class projects of much greater extent.

The team approach is used throughout this section; this requires proper coordination to work but has its rewards in providing a large data base and in having input from a number of sources (i.e. student minds). A very important part of the educational process here is a group discussion of the project afterwards. This can be led by the instructor or by individual students with editorial input from the instructor.

ECOLOGY EXERCISE: Environmental influences on population parameters of the sea urchin Echinometra lucunter

[This exercise is best carried out in calm weather and/or at low tide]

INTRODUCTION.

Long-lived and seemingly stable populations of E lucunter inhabit exposed shoreline substrates along many east end beaches. These populations live under a variety of conditions particularly in terms of wave action, food availability and crowding. We will compare populations from several environments to try to determine

(1) if these populations ARE different in terms of parameters of morphology, growth and reproduction, and, if they are, to try to determine:

(2) which of several environmental variables measured may account for this.

FIELD WORK.

One team (__ persons) will go to each of several beachrock sites (East End Bay, Boiler Bay beachrock, B.B. rocks at west end, and Smugglers Cove).

A. Measure wave action.

Since this is to determine relative values at the different sites it is important that this be done at each site in the same way. The simplest method is probably by placing a meter stick vertically in the middle of each sampling area while another observer records the heights of 30 successive crests and troughs. For direct comparison of all sites the measurement should be made halfway along the urchin-occupied beachrock gradient. The persons responsible for this measurement in each group should get together beforehand to make sure the measurements are made uniformly.

B. Drift algae.

This has been claimed to be the major source of food for these urchins (Abbott et al. 1974. WIL Special Publication). Drift algal traps can be set in the center of the study plot and left to collect algae for 15 min. intervals (to be repeated if possible). The algae from each collection should be bagged separately for return to the lab. The drift algal traps can be like those used by Roberts (1983; WIL Student Research Project) or can be simple devices such as dip nets held in place to catch algae; use your ingenuity to come up with something; again, persons from each group should be involved here so that there is consistency in method among sites.

C. Urchin quadrats.

25 x 25 cm quadrats should be placed without bias* in the middle of the urchin bed (not near the upper or lower limits). Every urchin within the quad, OR MORE THAN HALF WAY IN should be pried loose and the long diameter measured with urchin calipers. Enough quads should be taken so that a minimum of 50 urchins are taken from each site, and no fewer than 5 quads are to be taken. Urchin lengths from the different quads must be kept SEPARATE. Be careful when prying not to destroy the animals; if one is broken or crushed, still try to get a measurement.

Haphazardly collect 5 urchins with a length of 4 cm from each site and place in a plastic bag for return to the lab.

* The validity of the whole experiment depends upon unbiased sampling. In the case of urchins sampled among the boulders, choose an appropriate boulder, roll it then place the quad. Carefully replace the rock when you are done.

D. Field Equipment (per site)

meter stick
25 x 25 cm quadrat (1 or more depending on team size)
prying tool such as diving knife or screwdriver (as above)
plastic bags
algal trap
urchin calipers (as for quads)
slate and pencil

LAB WORK

From each site you have measured about 50 urchins from the quads. For each site you want to determine a mean and standard deviation for each of the following:
(1) urchin density (2) greatest test length.

Now, from each field site take the 5 urchins of 4 cm greatest test length and record greatest length, test height (along oral/ aboral axis) gonad wet weight, weight of test and spines.
Obtain wet weights of the drift algal samples and obtain means and standard deviations if more than one sample was obtained.

DATA ANALYSIS

The data taken above should be compiled by each team and should include the following means for each site:
(1) wave height
(2) weight of drift algae/h
(3) urchin density (no./sq. meter)
(4) urchin length
(5) urchin height
(6) gonad weight
(7) test and spine weight
Nos. 1 - 3 can be considered environmental parameters; nos. 3 - 7 population parameters.

Remembering back to the introduction we are interested in answering two questions about the urchin populations in this exercise; to answer the first look at the means and standard deviations: do any of the values for the 7 parameters measured seem to be "significantly" different between sites? If so one of several simple statistical tests of significance of difference can be performed. The simplest tests, which require the fewest conditions be met, but which are less sensitive (i.e. they may not detect differences where they really occur) are the non- parametric tests such as the Mann-Whitney U test or the Wilcoxon signed rank test (for method see Sokal and Rohlf,1981). More sensitive is a parametric test such as Student's t-test, which requires means, standard deviations and sample size. If there do SEEM to be differences in any of the population parameters between sites we are interested in whether any of the environmental variables may be responsible for the morphological differences. Plot the morphological parameters as a function of the environmental parameters in those cases. Now, if any of these plots indicate a definite trend, we can do a CORRELATION ANALYSIS to determine how good the trend is (see Sokal and Rohlf).

DISCUSSION.

1. Are any of the morphological parameters significantly different between sites? What do we mean by significant?
2. Is there a good correlation between any of the morphological parameters and environmental parameters? Why?

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ECOLOGY EXERCISE: Population Ecology of a Reef Coral: Status and Recovery of a Devastated *Acropora* Reef

INTRODUCTION

Unexpected "catastrophic" events can play a major role in determining the structure of ecological communities. It has only been relatively recently that the importance of such events in determining long-term community structure has been appreciated (e.g. Connell, 1978). Major storms or outbreaks of the crown-of-thorns starfish are examples of agents that have had major effects on reefs. We are now beginning to understand that such events are probably cyclic and natural functional events in the operation of these systems. Another such phenomenon is the white-band "disease" of *Acropora palmata* (Gladfelter, 1982). Once dense and healthy stands of this coral on shallow windward reefs such as Tague Bay forereef, Buck Island reef and others throughout the Caribbean have within the last decade been reduced to rubble piles by the combined action of this disease, borers, and storm waves. Now that this "disease" has largely run its course on these reefs (at least locally), there seem to be some signs of recovery in the form of small regenerating patches of coral tissue and newly developing colonies (recruits).

[See Antonius (1977) and Peters et al. (1983) for discussions of the possible nature of this disease.]

It is clear that although in the course of this "epidemic" the reef has suffered in terms of aesthetics and carbonate deposition, it is evident that advantages have also been brought about such as the consolidation of the reef surface by crustose coralline algae growing on the fallen branches and in terms of improved grazing grounds for herbivorous fishes.

Without data it is not possible to assess recovery on these reefs. In this exercise our goal is to gather data on the status of the *A palmata* population and from this to predict what the future course of development of this important reef-builder is.

FIELD WORK

We will work at one or more sites: Buck Island forereef, Tague Bay forereef, Channel Rock, etc. where *A palmata* is or was the dominant reef builder. At each site a long nylon transect line (e.g. 30 m) marked off at 5 m intervals with leaders at each end, will be laid along depth contours at 3 m depth intervals starting as shallow as possible and extending to the base of the A p zone. A team of 2 divers will work along the line, each with a weighted meter stick and record each of the following categories of *A palmata* within or partly within the transect:

1. Live healthy colonies
2. Live colonies with white band disease
3. Largely dead skeletons with recovering or regenerating patches of *A palmata* tissue
4. New recruits (recognized usually as generally circular patches or healthy coral with clear white growing border; at later stages, an arm starts to grow upward from the center of the patch)
5. Erect, but totally dead skeletons
6. Dead and toppled skeletons

Be sure that you can recognize each of these categories borfore going into the field. Also, obtain a rough measure of the greatest linear dimension of each of the above categories, especially the new recruits. Record the number of 5 m intervals covered by each survey. If necessary the work can be divided up so that along each side of the line one student censuses the large categories and one censuses the small (i.e. recruits and regenerating patches).

DATA ANALYSIS

What is the density per 100 m2 of each of the categories of A palamata at each depth at each site? Graph your values. Do there appear to be significant differences among either depths or sites? If so, perform a simple nonparametric test or do a correlation analysis (see previous Exercise).

DISCUSSION

Based on your data alone, what do you think is happening in terms of reef degradation or recovery?

If available, compare your results with the results of previous classes. Is there a trend noticeable?

Give a scenario for the cyclic development of an A palamata reef including the components dealt with in this exercise.

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ECOLOGY EXERCISE: Microhabitat Specificity in Coral Reef Environments: "Symbiotic" Relationships

INTRODUCTION

In an ecosystem as rich in species as that of the coral reef and its associated environments and one that has probably been relatively stable over geological time it is not surprising that a large number of species have evolved rather specific microhabitat relationships with other generally larger organisms. For convenience we can refer to these organisms as "guests" and the larger forms with which they are associated "hosts".

These relationships vary both in trophic nature, in the degree of specificity and obligation and the degree of saturation of the microhabitat (i.e.to what degree available hosts are occupied by the guest species. In the first case the relationships can be mutualistic (of benefit to both species); commensal (sensu lato, of benefit to the smaller and neutral to the larger; frequently shelter or protection is the benefit to the smaller form here); parasitic (of benefit to the smaller and detrimental to the larger); or predatory (very similar to the previous but generally creating more clearcut damage).

In terms of degree of specificity, some small organisms seem to be highly specific with regard to their choice of host (e.g. the spine shrimps of various sea urchins, which seem to occur nowhere else). In other cases specificity is broader, e.g. shrimps that occur with several species of sea anemones. In terms of obligation this is closely related to specificity but reflects the ability of the guest to exist without a host.

The degree of saturation of the microhabitat (i.e. the host species) is the most likely to vary over the short term and with geographic location.

In the shallow waters of the Caribbean there are perhaps hundreds of examples of such relationships or microhabitat specialization. Many can be readily observed by a careful observer (remember, the guest organism is often very small and perhaps camouflaged as well). Relatively little is known about those aspects of these relationships mentioned above (trophic nature, specificity, etc.). By recording simple data a class can shed light on some of these parameters. Others require more detailed observation or experimentation.

FIELD WORK

We will go to a site where we can expect to find a number of such associations. Particularly good are the Baths, Holt's Reef, and the Channel patch reefs. Following is a summary list of the commoner associations that can be found at these sites (not all at one site, of course). Remember that in nearly all these cases, there is probably some degree of obligation of the guest to the host, but the reverse is generally not so.

GUEST SPECIES	HOST SPECIES OR GROUP	Probable nature of Association
HYDROZOA		
corynid sp.	*Monanchora* (red sponge)	
corynid sp.?	*Trematooecia* (bryozoan)	
corymorphid sp.	tips of gorgonians	
"clavid" sp.	underside of queen conch shell	
ANTHOZOA		
Calliactis (anemone)	*Dardanus* (hermit crab: on shell)	
ENTOPROCTA		
Loxosoma (several spp)	various sponge spp.	
ECHINODERMATA		
brittlestars	with sponges; probalby nonspecific	
FISHES		
sponge cardinalfish	sponges	
Nes longus (goby)	in shrimp burrows	
nine-lined goby	*Echinometra lucunter* beds	
green-banded goby	*E lucunter* beds	
MOLLUSCA		
Fissurella punctata	*Echinometra lucunter* burrows	
Stilifer	*Echinometra lucunter*	parasitic
Cyphoma	gorgonians	predatory
ANNELIDA		
Syllis spongicola	*Neofibularia* (sponge)	
spionid sp.	in red sponge	
Myzostoma	*Nemaster* (crinoid)	
CRUSTACEA		
corallivexid copepods	coral guts	parasitic
Octolasmis (barnacle)	gill chambers of lobsters, crabs	
"diogenes barnacle"	*Petrocheirus* (hermit crab)	
Peltogaster	hermit crabs	parasitic
Heteromysis	*Bartholomea*	
Anilocra (isopod)	fishes	ectoparasite
Alpheus	*Bartholomea*	
Synalpheus	*Spheciospongia*	
Periclimenes spp	sea anemones	
Thor	sea anemones	
Pontonia sp	*Spondylus*	
Pontonia sp	*Lima*	
Pontonia sp	*Atrina* (=*Pinna*)	
Stegapontonia sp	*Diadema* spines	
Stegapontonia sp	*Tripneustes* spines	
Porcellana	*Petrocheirus* (hermit crab)	
Percnon	under *Diadema*	

In this particular exercise we will take data that will enable us to make statements about both the specificity and the degree of saturation of a variety of associations; the latter is a bit more difficult. We will go to a suitable site carefully check all potential hosts for the presence of guests. In particular check gorgonians for hydroids, Cyphoma, etc.; anemones for shrimps; sea urchins for shrimps, crabs, snails; sponges for hydroids, entoprocts etc. Record every species of host inspected and the number of guest found on each host: 0, 1, 2, etc. In addition it would not hurt to observe any behavioral interactions that might indicate the precise nature of the relationship.

DATA ANALYSIS

Tabulate the results for the whole class and discuss the results.

DISCUSSION

1. Which relationships seem to be the most specific? the least specific?

2. Were any of the hosts saturated (i.e. every host occupied) with guests?

3. Did you make any interesting biological or behavioral observations?

4. What are the potential advantages or disadvantages of high host specificity?

5. What is indicated by the saturation or lack thereof of the hosts?

ECOLOGY EXERCISE: Coral reef community structure at intermediate scale: a comparison of methods.

INTRODUCTION

This exercise can be carried out at nearly any reef site, however Acropora palmata reefs pose particular geometric problems. We have chosen Cane Bay on the northwest coast of St. Croix as the site for this because of its diverse and complete surface cover by living reef organisms.

The buttress reef zone at Cane Bay is spatially heterogeneous, biologically rich and diverse. To minimally characterize such a reef community we want to know: (1) all the species present and (2) their absolute and/or relative abundances. The next step would be to know the spatial and functional relationships of these organisms. Even to specify (1) and (2) above may be cumbersome when comparing different communties, hence ecologists have long been fond of reducing (1) and (2) to one or several simple numerical indices that characterize the community. Generally these are only of any use when comparing communities. Today we will be making a two-fold comparison of reef structure at Cane Bay: first along the seaward/depth gradient (a la Porter, 1972) and second by using different methods to measure community structure. If the class is sufficiently large a comparison of structure along different buttresses can be carried out. From our data we will derive two indices to characterize the reef (or segments thereof): (1) diversity and (2) dominance. These will be explained more fully under Data Analysis.

Cane Bay reef is a big place, and to accurately determine all the species present and their abundances would require quite an extensive operation. Thus in this as in most cases of community sampling we can get an approximation of the relative abundances of the quantitatively more important (i.e., larger and/or more numerous) organisms by applying unbiased sampling or measuring methods. The three methods that we will employ differ in that they give more or less accurate portrayals of community structure depending on the scale to which they are applied and the time available for sampling.

FIELD WORK

Before the day of the exercise REVIEW CORAL IDENTIFICATIONS so that you know all the species in the display cabinet. Also go over other colonial anthozoans and important sponges (see appendix to this exercise).

We will be trying to characterize the reef community along the tops of the buttresses along the seaward/depth gradient (i.e., from the inshore end of the buttresses at about 6 - 7 m deep to the seaward end ot the buttresses at about 25 m deep). A transect line is to be laid along this gradient, beginning at the seaward, deep end and extending shoreward. This may be done either by members of the class or by your fearless leaders. In either case the 80 m (or more or less depending on class size) long transect line should be conspicuously marked at 5 m intervals (e.g., with colored plastic ribbon) and wrapped on a spool (broomstick, etc.). A buoy with about 10 m of line should be anchored at at the inner end of the transect. The 80 m line should be anchored at the outer end first then swum in a straight line up the buttress toward its landward end. Make sure the line runs straight and free of obstructions; secure it at its landward end. Avoid laying the line over large patches of bare sand; if necessary bend the line or start over. The three methods to be used are as follows; in all cases be sure to include ALL substrate in your counts etc. (i.e. sand, turfs, crustose corallines, sponge, etc): if they are not used in the analysis they can be discarded.

(1) Line transect: 1 buddy pair per 5 transect intervals (4 at deeper end to 6 at inner end

The method is a modification of Porter's (1972), using cm units on a weighted meter stick instead of chain links. The first team starts at the seaward end of the transect (marked by a surface buoy, remember) and work shoreward for four 5 m intervals; the next team will start there and work five 5 m intervals shoreward; the third team, etc.; the most shoreward team will do five intervals. Each team will lay the meter stick along the transect line and record the number of cm units overlying every organism or other surface cover; this will be done for a total of 500 cm (i.e., 5 m). The data for each 5 mm interval should be kept separate. In addition record the depth at each ribbon.

(2) Quadrat method: buddy pair assignments as above

The first team begins at the lower end of the transect line; lay the 1 m2 quadrat adjacent to the first meter of the line and record every species of coral and other substrate categories therein and estimate its proportional area within the quad (to the nearest percent; it helps if the quad is divided beforehand into 25 equal squares with string). Move up to the next ribbon and do the same, and so on for a total of 4 quads (0,5,10,15, and 20 m) . The second team begin at 25 m and do 5 quads; etc. as above. The last team do the last 6 quads, ending at the end of the transect line. Rewmember to record the position on the line and the depth of each quad.

(3) Belt transect or semiquantitative eyeball method: 1 or 2 buddy pairs

Beginning at the lower end of the transect line as before, estimate the proportional abundance of all benthic sedentary organisms present in a swath 1 m wide from the 0 to the 5 m mark. Do this again for a 1 m wide swath from the 5 m to the 10 m mark and so on. Apportion the work as above, depending on whether there are 3 or 4 buddy pairs.

IN ALL CASES ABOVE, MAKE SURE THE DATE ARE KEPT SEPARATE FOR EACH INTERVAL MEASURED OR CENSUSED.

FOR ALL THREE METHODS BE SURE YOU BUDGET YOUR TIME SO THAT YOU DO ALL YOUR SECTIONS OF THE TRANSECT, SLOWLY ENOUGH TO BE THOROUGH BUT FAST ENOUGH TO GET IT ALL DONE WITH AT LEAST 300 PSI LEFT.

Field Equipment:

80 m (or more or less) long nylon line marked at 5 m intervals and numbered (leave a 2 m long leader at each end so the line be a total of 84 m long with ribbons 2 m from each end)

weighted meter stick
1 m2 quads
underwater slates and pencils
1 gallon chlorox bottle with 10 m nylon string

DATA ANALYSIS

We can now use our data to determine changes in reef community structure along the seaward/depth gradient. We can also compare the results determined by each method and evaluate the methods themselves.

(1) Diversity.

This is a community parameter which in its simplest form is simply the number of species present.
(A) Make a graph of species number as a function of sampling interval (beginning at shoreward end) for each of the three methods employed. Do all three graphs on the same set of axes. How do they compare?
(B) Do the same but plot species number as a function of depth. How do they compare? (Remember, in each case, the independent variable, distance or depth, is plotted on the horizontal axis).

More complex formulae have been devised which take into account not only the number of species but their relative abundances as well (i.e., their evenness or equitability). The most commonly used of these is the Shannon-Wiener function, which is a measure of the uncertainty of obtaining a particular species when randomly sampling from a community. The function is:

$$H' = -3.32 \sum p_i \log_{10} p_i$$

where p_i = the proportion of all individuals sampled belonging to species i. Other diversity indices (such as Simpson's) weigh rare species more or less heavily (e.g., if we use simple species number as our measure of diversity, then rare species carry weight equal to abundant ones. The use of different indices is obviously subjective and the polemics of this topic can be found scattered through the ecological literature. Now, calculate H' for each sampling interval and graph these values as done above for simple species number. Compare these graphs by sampling method used, by whether they were plotted as a function of distance or depth, and compare them with the graphs obtained using species number alone. What are your conclusions?

(2) Percent live coral cover

Determine the percent live coral for each sampling interval and plot vs. interval and also depth as above.

(3) Dominant species.

In addition to calculating simplified measures such as those above it can be useful to compare the relative abundances of dominant species such as along our gradient. Graph the changes in relative abundance of: M annularis and A lamacki (and others if you like) as functions of distance and depth, as above.

IV. Discussion Questions.

1. Which of the three sampling methods gives the most accurate portrayal of the reef community on the tops of the buttresses? Why? What are the advantages and disadvvantages of each method?

2. Are there any major trends in diversity or dominance along the reef gradient? Do you feel these are real or artifacts of the sampling method? If the latter, what might be done to obtain more accurate results? If they are real, explain them.

3. What is the difference between accuracy and precision? How is this distinction relevant in the present study? Which of these is most important in a study such as this? Why? When is the other important?

4. How is the matter of scale related to the effectiveness of the various sampling methods used herein to approximate reef community structure? Under what circumstances might the method deemed least effective here become the most effective? and vice versa?

5. If you were interested in determining reef community structure across a reef such as Tague Bay reef (from base of backreef to base of forereef) in a limited time (e.g., say two dives) and wished to maximize both accuracy and precision, what sampling procedure would you use (not necessarily being limited to the precise methods used here)?

6. Why were all transects begun at the outer end instead of the inshore end?

REFERENCES

1. Ogden and Gladfelter. 1980. An ecological survey of Cane Bay Reef. WIL Special Publication.

2. Porter. 1972. Patterns of species diversity in Caribbean coral reefs.

APPENDIX

In addition to reviewing the stony corals be sure that you can identify the following:

Zoanthids / encrusting gorgonians / Millepora / compound ascidians (especially *T solidum*) / crustose coralline algae / algal turfs / sand / sponges

ECOLOGY EXERCISE: Comparison of community structure in grassbeds of different densities

INTRODUCTION

Sediment substrata predominate under many of the world's shallow coastal waters, including those of tropical regions. In the West Indies these substrata range in plant cover from a virtual absence of macrophytes to dense seagrass meadows and algal plains. A single suite of techniques can be used to quantitatively sample any of these level bottom communities, though procedures are greatly simplified when vegetation is absent.

Some of these areas, particularly those supporting rich seagrass meadows serve a variety of important functions: (1) stabilization of shallow coastal environments (2) nurseries for a variety of postlarval fishes and invertebrates (some of them of great economic importance) (3) principal feeding grounds of important herbivores such as the green turtle and the queen conch.

Seagrass meadows are highly productive systems which have the potential to support dense populations of the species adapted to their utilization (e.g. green turtles, queen conch, other herbivores such as sea urchins, and a great variety of infaunal and predatory species). By applying the variety of techniques discussed below it is possible to quantitatively characterize this rich and complex ecosystem.

In this exercise we will sample the following components of this ecosystem:

1. The seagrasses
2. Macro-algae
3. Fishes and epifaunal large invertebrates
4. Infauna
5. Demersal plankton

Additionally it is possible to get a measure of primary productivity of the system quite simply as long as it is possible to make 2 trips to the site several days apart.

FIELD WORK

This exercise is most instructive if samples are taken from grassbeds of 3 different densities: sparse, intermediate and rich or from grassbeds of different depths (e.g shoreline, mid-bay, Buck I. Channel).

A. Sediment Cores

This is a difficult procedure involving the use of physical strength. A cylindrical coring device with a sharpened "cutting edge", handles, a top with a pluggable hole, and a cap to fit over the open lower end is essential. Ideally the device should be leakproof. It should be 25 - 30 cm in diameter and about a half m long. The diver using the device should be WELL OVER-WEIGHTED. Shove the device with twisting movement, vertically into the substrate to the handles, plug the top and extract, then cap and return to the boat at the surface. Grassbeds in shallow water can be cored without the use of SCUBA. Non- or quasi-quantitative samples can be taken in shallow water with a shovel. Slide the core into a bucket on the boat for later analysis.

B. Small quads for surface vegetation

Small wire quads of roughly 15 cm x 15 cm can be used to quantify surface vegetation, including grass bundles and algae.

C. Swim transects for fishes and macro-invertebrates

Swim slowly along the bottom from a designated point and visually census all animals observed: one observer look for small stuff in a band about 0.5 m wide; the other look farther afield for fishes and larger invertebrates such as starfishes, urchins and conchs. Both move at the same speed. Measure the distance covered and estimate the area covered by each observer.

D. Demersal plankton

As Alldredge and King (1977) demonstrated, the substrates of all reef environments harbor a rich assemblage of small animals that emerge into the water column at night. These can be sampled quantitatively by the of "traps" such as they used. These can be made quite simply; mainly what is needed is a funnel-shaped device to place snuggly against the substratum (without "leaks") topped by a floating bottle or into which the vertically migrating organisms swim but cannot escape. These can be placed out at dusk and recovered in an hour or two or early next morning

E. Primary production

Net production can be readily measured by measuring the growth in seagrass blades per unit area per unit time. Since the blades grow from the base a marker such as a staple (Zieman,) can be used as a reference point. Staple a few blades of <u>Thalassia</u> and measure from the base of the leaf bundle to the staple. Return in a few days and measure the difference.

LAB WORK

Some of this can be carried out on the vessel or on the dock, particularly the sieving of sediments from the core samples. Place a portion of one core into a sieving screen and flood with water or dip into the ocean and agitate; this should be carried out gently until all sediment has been removed. Inspect what remains for small animals, particularly annelids, crustaceans, molluscs, sipunculans and others. All animals from a single core should be placed into a small vial of alcohol. Separate plant components into individual seagrass species, including both leaves and root systems, and macroalgae. Repeat the procedure for each core taken and keep all samples separate and label every one.

Return to lab and obtain wet biomass for each of the components of EACH CORE (i.e weights to 3 significant figures, so use appropriate balances)

(1) animals
(2) leaf bundles for each species of seagrass
(3) root systems for each species of seagrass
(4) algae

Also weigh a few measured segments of <u>Thalassia</u> blades and determine a mean blade weight for a 1 cm length segment (to be used in productivity determinations).

If demersal plankton collections have been made, be sure to record the area of substratum covered and weigh the drained samples.

Identify and count all taxa of macroalgae, infauna and demersal plankton.

CALCULATIONS

With the above raw data you should be able to determine the following values for each area (mean and s.d.):

I. Seagrasses:
   (1) blades and leaf bundles per m2 from cores and quads
   (2) wet weights of leaf bundles and root systems for each species per m2

II. Macroalgae:
   (1) no. plants per m2
   (2) total biomass per m2
   (3) list of taxa and numbers per unit area

III. Infauna and Demersal plankton (separately, of course)
   (1) biomass per m2
   (2) list of taxa and numbers per unit area

IV. Macroinvertebrates and fishes (separately)
   (1) list of taxa and numbers per unit area

Make a table listing the above for all the types of environments sampled (e.g. grass density, water depth, etc.). On visual inspection do there appear to be any correlations? If so these can be graphed or a correlation coefficient calculated as in the earlier exercise on Echinometra.

DISCUSSION QUESTIONS

1. What correlations exist between grassbed density and abundances of any of the aninmal components of the system? Why?

ECOLOGY EXERCISE: Spatial and temporal similarity in fish community structure on small artificial reefs.

INTRODUCTION

For the last 20 years, and especially the last 10, a great deal has been written on what factors are responsible for the structure of fish communities, i.e., what determines what species are present and in what abundances. Many of these have been based on censuses of replicate reefs and most of these have involved small or very small structures (Sale and Dybdahl, 1975; Gladfelter and Gladfelter, 1978; Talbot et al., 1978; Ogden and Ebersole, 1981; and many others). The theory is essentially that if fish assemblages are spatially and/or temporally more consistent than expected by chance alone then such assemblages are controlled in part by deterministic factors such as feeding patterns, competition or species-specific predation. On the other hand if such assemblages are not more similar than expected by chance, then such deterministic factors are probably not of importance.

In the mid-1970's Ogden and Gladfelter oversaw the construction of a series of cinderblock "reefs" in Buck Island Channel at about 12 m depth and arrayed parallel to Tague Bay reef, with the intention of monitoring the development and changes of replicate fish communities; until that time most such work had been done in the south Pacific with different conclusions than were expected by workers in the Atlantic. Ten of the structures consisted of a single pyramid of 40 large (25 kg) blocks; three of the reefs consisted of 4 such pyramids; and one consisted of 10 such pyramids. Regular monitoring stopped after a few years but sporadic monitoring has continued. Thus, by censusing these reefs we can make both spatial and temporal comparisons of their fish communities in an effort to understand what kind of factors are responsible for community structure.

This exercise can be carried out on any set of replicate reefs, for example: (1) the patch reefs in eastern Tague Bay (2) small isolated coral heads, etc.

FIELD WORK

The reefs are arranged as follows:

```
WEST 8 7 11 (6) 9 10 5 (4) 12 3 A (2) 1 B EAST
            med        med    lg med
```

The four-unit and ten-unit reefs are designated as med and lg. The easternmost reefs have been tumbled by storm swells and are thus less desirable to use for these censuses because of reduced fish faunas (probably due to decreased available refuge space) and because of greater difficulty of censusing internal spaces. (It is advisable for someone to locate these reefs in advance and mark one or more with a float; otherwise, the easiest way to locate them is to anchor about 150 m outside the WIL research platform opposite Romney Point; the nearest small reef is no. 11. The others lie more or less in a straight line parallel to the reef and spaced at about 35 m).

Underwater slates should be prepared in advance with the census form given in the appendix (this can be inserted directly on your slate beneath the drafting film). It is also helpful if you review these fishes in advance of the exercise using Chaplin and Scott (the Fishwatchers Guide) or Stokes, or slides, if available; in addition one member of each buddy pair should take a copy of the guide underwater. Each small reef can be censused by onew buddy pair. Each individual should do a complete census trying to determine as accurately as possible exactly how many individuals of each species are present. Since many fishes remain within the confines of the reef be sure to look in all the cracks and holes (repetitively). At the end of the census each buddy pair should return to the boat and go through the complete species list making sure they agree on all entries.

(Optional)

After the censuse we may poison one of the reefs with rotenone, a respiratory poison that does in the fishes but is harmless to divers. A few minutes after the application of the poison, a team of at least 4 students with net bags and plastic bags (for tiny fishes) should work around the reef and collect ALL individuals. A few students should work the water column above and slightly downstream for fishes which drift away from the site. Ideally ALL fish individuals can be collected, thus allowing for accurate identification, counts and even determinations of biomasses. Those of you who are queasy about this operation do not have to participate. It should be remembered that (1) these are artificial habitats and if we had not constructed them in the first place these fishes would probably not exist and (2) these reefs will be completely repopulated in a few months time.

DATA ANALYSIS

(1) Similarity indices.

We can calculate an index of similarity between the fish communities of every pair of reefs. The simplest such index simply involves comparing the presence or absence of species on both reefs being compared (this has been referred to as the coefficient of community). This index weighs rare and abundant species equally:

$$S1 = 1 - \frac{\Sigma|x-y|}{\Sigma x+y}$$

where x and y represent the presence or absence (1 or 0) of each species i on each pair of reefs.

At the other extreme, the similarity index can be based on similarities in numbers of individuals of every species present (S3). Such an index weighs a species in direct proportion to the number of individuals present; in this case x and y represent the number of individuals of each species i on each pair of reefs.

A third, intermediate, index (S2) is based on logarithmic or approximately logarithmic abundance categories of individuals in each species, thus not overemphasizing the importance of either species or individuals. For simplicity we will use the following abundance categories: 1 (1 individual), 2 (2 - 4 individuals), 3 (5 - 16 individuals), 4 (17 - 64 individuals), and 5 (64 -256 individuals). Each of these categories is based on logarithms of the actual abundances; use the formula as before.

Depending on the number of students in the class and the number of reefs censused the calculation of similarity indices should be divided up more or less equally: everyone should calculate S1, S2, and S3 for as many pairs of reefs as necessary.

Similar comparisons can be made between today's censuses and previous censuses made on the same reefs (see appendix). How does the similarity for fish communities made on the same reef over a period of years compare with similarities made at the same time on different reefs?

(2) Comparison with randomly generated communities (optional)

The following calculation (from Sale, 1974) is laborious and timeconsuming. Construct a summary table of all species and individuals, i.e. the total of individuals of every species on the reefs censused. Convert these into proportions (i.e. divide each by the total number of individuals of all species). Now convert these into intervals between 0 and 1.00 (unclear? ok, if species "a" represents .32 of all the censused individuals it covers the range 01 to 32; if species "b" represnts .17 of all the censused individuals it covers the range 33 to 49 and so forth to species z with .09 of all censused individuals which covers the range 92 to 00. Now enter a Random Number Table such as that found in Rohlf and Sokal (1969; p. 153). Follow instructions for the table; each 2-digit number represents an individual of the species whose range (determined as above) it falls in. Repeat for as many 2-digit numbers as approximate the mean number of individuals per reef. Go through the procedure again to simulate the fish community of a second reef and so on for several reefs. Now determine S2 for all pairs of randomly generated communities. Then determine the mean and standard deviation of the similarity values for these simulated reefs. Perform a simple comparative statistical test (t-test or one of the non-parametric tests) to see if the mean similarity between reefs is significantly different from the mean similarity between randomly generated reefs. What do you conclude?

(3) Trophic structure of the community (optional)

In the event that a poison station was done, spread out all the fishes in pans in the lab, separate them into species, count individuals and determine a similarity index between this and the census value for the same reef. Group the fishes into major trophic (feeding) categories and weigh each category. Use the following trophic categories: Herbivores: parrotfish; surgeonfish; most damselfish Planktivores: Chromis, blackbar soldierfish, postlarval grunts Invertivores: wrasse; angelfish; butterflyfish;grunt;squirrelfish Piscivores: moray; grouper

DISCUSSION QUESTIONS

1. What conclusions can be made about the determinants of fish community structure based on similarities of:
   a. simultaneous censuses on different reefs?
   b. sequential censuses on the same reefs after a few years?

2. Discuss the merits of the various indices of similarity.

REFERENCES

1. Gladfelter and Gladfelter. 1978. Fish community structure as a function of habitat structure on West Indian patch reefs.

2. Ogden and Ebersole. 1981. Scale and community structure of coral reef fishes: a long term study of a large artificial reef.

6. Rohlf and Sokal. 1969. Statistical Tables.

3. Sale, P. 1974. Overlap in resource use and interspecific competition.

4. Sale and Dybdahl. 1975. Determinants of community structure coral reef fishes in an experimental habitat.

5. Talbot et al. 1978. Coral reef fish communities: unstable, high diversity systems?

Appendix: Summary of artificial reef censuses (1982; by WBG)

	#4 May	#4 Oct	#6 May	#9 May	#10 May	#12 May
P.m.moray				1	1	
Sp.moray			1			
Com.squirrelf.	2	2		2		
Longjaw sq.f.	5	4	2	3	5	1
Longspine sq.f.			1			
Dusky sq.f.			2	1		
Bl.b.soldierf.	100	50	100	100	6	
Red hind			2		1	
Graysby	2	2	2		1	
Belted card.f.	10	5	15			1
Flamefish	2	2	2			
Sawchk.card.f.				2		
Longtooth.card.f.		2	3			
Hawkf.			1			
Black grunt	1	2				
Blue str.grunt	1	1				
White grunt		3			32	
Tomtate	22	200+	100	1		2
Cottonwick						
French grunt	15	200+	40	10	15	
postlarval grunts			500			2
Y.t.snapper		1		2		
Highhat			1			
Spot.goat.f.	8	4	20			

Queen angelf.			3	1	3	
4 eyed butt.flyf.						1
Cocoa dams.f.	5	9				
Bicol.dams.f.	2	1	2			
Blue chromis	11	9	7	2		
Brown chromis	14	1			1	
Sh.n. puffer	3		3		1	2
Bluehead	11	2				2
Y.hd.wrasse	6	2	10	1		3
Puddingwife	2					
Creole wrasse			1			
Slip.dick	10	7	20	15	16	
Span hogf.	1		3	1	1	1
Rd.t. & Rd.bd.p.f.	12	12	5			3
Brid.goby	10	+	30	5+		5+
Goldspot goby	10	+	40	5+		
Cleaning goby	10	+				
Sadd.blenny	1					
Blue tang	11	10	8		3	4
O.surg.f.	5	1	11		1	1
Doctorf.	4			1		1
Poison Station (6/82)		9	10			

Herbivores		3.6 kg	2.4 kg
Planktivores	(day)	0.01	-
	(night)	1.2	0.5
Invertevores		0.4	1.0
Crustaceavores		0.6	1.1
Spongivore		-	0.2
Cleaner		tr	0.01
Piscivore		3.0	2.0
Total Wt.		8.8 kg	7.2 kg

ECOLOGY EXERCISE: Primary production in the reef ecosystem
(by E. H. Gladfelter and R. C. Carpenter)

INTRODUCTION

Coral reef ecosystems are among the most productive ecosystems known (Odum and Odum, 1955; Lewis, 1977; Kinsey, 1985). The most common method of measuring "whole reef" productivity is the "upstream-downstream" measurement of dissolved oxygen in water passing over the reef. Any increase in O2 from the upcurrent site to the downcurrent site (after correction for physical factors) must be the result of primary production by the reef community. An alternative approach is to measure component productivity (Rogers and Salesky, 1981). If productivity rates of specific reef components are known, as well the the amount of surface area covered by individual components, a whole reef production figure can be calculated.

Photosynthesis is the physiochemical process by which light energy is converted into chemical energy in the form of organic molecules (cf. App. I, the equation for photosynthesis). When carbohydrates are produced, O2 is evolved as a by-product. With certain assumptions, the rate of photosynthesis can reliably be determined by measuring the rate of O2 production. Since several methods exist for measuring oxygen concentration in water, this is a common approach for assessing aquatic plant metabolism. Photosynthesis measured by this method is called apparent photosynthesis because of the indirect nature of the measurement.

Respiration is the oxidation of organic molecules to yield energy. All organisms (including algae) are usually respiring continually (thus consuming O2), so that any change in the oxygen concentration surrounding an alga will be the difference between the rate of oxygen production (by photosynthesis) and oxygen consumption (by respiration). In the dark photosynthesis cannot occur, so any change in oxygen concentration will be the result of respiration.

By determining the changes in O2 concentration caused by an alga in the light and in the dark, we can determine the rates of respiration, net primary production and gross primary production:

(1) Respiration is the rate of oxidation of organic matter, and can be determined by measuring rate of decrease of O2 in the dark;

(2) Net primary production is the difference between the total amount of organic material produced and that consumed in a given time period, and can be determined by measuring the change in O2 concentration in the light; and

(3) Gross primary production is the total amount of organic material produced by photosynthesis, i.e. the sum of NPP + R. This forms the conceptual basis on which our determinations will be conducted.

The purpose of this exercise is to compare the rates of carbon fixation by primary producers in two reef zones, e.g the backreef and forereef of Tague Bay reef, two patch reefs in the bay, or between shallow and deep sites on the forereef. Productivity will be measured as grams of carbon fixed per meter square projected surface area. Primary producers will be divided into 3 functional groups: (1) macroalgae, (2) turf algae, and (3) the zooxanthellae contained in the tissues of cnidarians.

Field work will consist of determing the amount of surface area covered by each of these functional groups of producers in each of the reef zones. In an area with complex topography, there can be 2 or more m2 of surface covered by primary producers in 1 m2 of projected surface. Representative samples of the functional groups of primary producers will be collected and returned to the laboratory for determination of production rates.

FIELD AND LAB WORK

Part I. One half Day:

Determine surface area of component producers, relative to projected surface area of section of the BR and of the FR at a depth of ca. 2m. Use of a 1 m quadrat is probably the best way: Surface areas of turfs and corals should be expressed as ACTUAL (not projected) surface areas (so that it is common to have more than one m2 of producer surface per m2 quad. A number of quads should be sampled from the whole area being considered.

Collect representative samples of producers from each of the 3 functional groups (from each of the areas being compared), i.e. 3 specimens of each species (of coral, macroalga or turf) per pair of students [these specimens should fit into the incubation jars but should fairly well fill them up] If the group of students is large, several spp from each functional group can be used. Return samples to seawater tanks (at the dock or the lab) [It is best to do this part in the afternoon so that samples can partially recover from the stress of collection overnight].

Part II. One half Day

1. INCUBATIONS

a. Begin incubations by gently placing specimens in chambers (jars), two to be exposed to sunlight and one darkened bottle. These can be done by suspending from boards in shallow water at the dock (this should allow for a sufficient light level for maximum rate of productivity, as well as allowing for gentle agitation to prevent boundary layer buildup which would inhibit rate of gas diffusion) or in one of the seatables in the sun at the lab. Each incubation should take 30 minutes. YOU MUST BE SURE TO LABEL EACH SAMPLE, Each group will need 3 incubation jars,12 B.O.D. bottles and labelling tape and pen.

b. At the beginning of each set of incubations, take a sample of seawater in a B.O.D. bottle, fix (see e below) to serve as your t = 0 ambient O2 concentration. DO NOT TRAP ANY BUBBLES IN ANY B.O.D. BOTTLE.

c. You are going to do 3 sets of incubations, each for 0.5 h in duration. Each set will consist of 2 light bottles and 1 dark bottle. DO NOT MIX UP YOUR SPECIMENS; they should be identified as L1, L2, and D. You will need to determine their respective surface areas later in the laboratory!

d. After 0.5 h, carefully siphon the water from the incubation jar into a B.O.D. bottle and fix (see e below). Refill the incubation jars with new seawater and begin another incubation.

e. To "fix" the O_2 in a B.O.D. bottle:

1. Add 1 ml $MnSO_4$ with the automatic pipette provided; DON'T MIX UP THE 2 PIPETTES. Let fluid drain down the side of the B.O.D. bottle neck about 1 cm above the fluid surface; DO NOT submerge the pipette!

2. Next, add 1 ml alkaline iodide, using the same careful technique as you used above.

3. Replace the glass stopper; Make sure you do not trap bubbles!

4. Invert the bottle 5-10 times until the precipitate is well mixed.

5. Let stand in a cool dark place, remix and bring it to the laboratory for titration (within the next 6 h).

2. TITRATIONS

a. To titrate samples:

1. Acidify by adding 1 ml conc. H_2SO_4, restopper and mix until the precipitate is well dissolved. No air should be trapped in the bottle.

2. Titrate two 50 ml subsamples with 0.01 N sodium thiosulfate; when the solution becomes light yellow,add a drop of starch solution, so the endpoint of the titration is very clear.

3.Record ml of thiosulfate; repet for second subsample and average the two values.

3.CALCULATIONS

a. CONCENTRATION OF OXYGEN

to calculate $[O_2]$ from titration:

f = F factor: posted on board

$$\text{mg-at } O_2/l = .1006 \times f \times \text{ml (thiosulfate)};$$

$$\text{mg-at } O_2/l \times 16 = \text{mg } O_2/l$$

b. CHANGE IN ABSOLUTE AMOUNT OF OXYGEN IN INCUBATION CHAMBER

We can determine the change in concentration of oxygen caused by the metabolic processes of the sample by subtracting $[O_2]$, t = 0.5 h from $[O_2]$, t = 0.

To determine the absolute amount of O_2 consumed or produced we must multiply the change in concentration by the total volume in which the sample was incubated:

mg $O_2/l \times V$, where V = total volume of chamber minus displacement volume of sample

c. Finally, when we know the absolute amount of O_2 consumed or produced per sample and we divide this by the surface area of the sample causing this change, we can determine:

mg O2/cm2 per 0.5 h

Surface area can be determined either by tracing the surface area on graph paper, or by the aluminim foil method. Cover the metabollically active surface with 1 layer of foil. Weigh the foil. Compare this weight with a standard conversion that you construct by weighing known surface areas of foil.

d. Convert component productivities to:

g O2/m2/h

e. Multiply component productivity times the surface area of the reef zone covered by that component in a projected square meter of reef zone.

f. At last: Add the three components and compare zone productivity.

DISCUSSION QUESTIONS

1.Calculate the 24 h P/R ratio for the Backreef and the Forereef. What do these figures imply?

2. Total organic productivity of an ecosystem is dependent on its rate of primary production. On a coral reef the cnidarian-zooxanthella symbioses not only "fix" carbon but also supply spatial heterogeneity on a reef. Knowing this what would you predict would happen to primary productivity and to productivity at higher levels of the trophic pyramid if:

(1) the important grazer Diadema disappeared?
(2) white-band disease wiped out all of the Acropora palmata?
(3) the reef were hit by a hurricane?
(4) a sewage outfall, releasing high concentrations of nutrients, discharged onto the reef?

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ECOLOGY EXERCISE: Effects of herbivory on the algal community
(by R.C. Carpenter)

INTRODUCTION

Herbivores are important in most marine ecosystems and are especially so in tropical marine communities. The process of herbivory is dynamic (varying over time and space) and has a structuring influence on plant distribution and abundance. The purpose of this exercise is to determine the effects of herbivores in the coral reef community by quantifying their effects on algal abundance and species composition.

There are 4 basic questions we will address:
(1) What are the abundances of different herbivores over 4 reef zones (backreef, shallow forereef, deep forereef and sandy plain)?
(2) What is the grazing intensity within each zone?
(3) What is the relative algal standing crop within each zone?
(4) What is the algal species composition?

FIELD WORK

Divide the class into 4 gorups, each of which will be responsible for obtaining data to answer one of the above questions. The methods for obtaining such data are given below. Although each group will only be required to use those methods appropriate to its given task, everyone should be familiar with all the methods to facilitate group discussion.

(1) Herbivore abundance

Materials: 1 m2 quadrat per buddy pair
10 m lines
1 slate per person
1 caliper, 1 plastic ruler per buddy pair

One group will work together with the quads and will count and measure urchins (mostly Diadema, but others also, if present) in at least 4 quadrats in EACH of the 4 zones. Do more quads if time permits. Measure maximum test diameter with the long-jawed calipers (try to keep urchin mortality to a minimum!). Make sure you look in crevices, especially for Echinometra and Eucidaris.

Another group should have a 10 m line (per buddy pair). Within each of the 4 zones place the line along a depth contour (i.e. all parts of line at same depth). Each pair swim slowly along the line counting the number of different fish herbivores occurring 2 m on either side of the line. Identify to species where possible (probably impossible for juvenile parrotfishes). Try to swim at a consistent slow speed. Repeat at least twice for each transect. Members of this group should review the fish slides beforehand so they can quickly identify species within the following families: parrotfishes, surgeonfishes, blennies, damselfishes, chubs. Prepare your slates for censusing beforehand.

(2) Grazing intensity

Materials needed: clothespin assemblies

standard Thalassia pieces
standard Acanthophora pieces
plastic rulers
slates

Members of this group should read Hay (1981) to familiarize themselves with the method. You will use 3 different methods to quantify grazing intensity. Clothespins having known sizes of plants (both Thalassia and Acanthophora) will be presented to herbivores in each zone. These will be put out on the reef at 0630 in the morning. In the afternoon these will be relocated (you will have marked the general area with flagging) and you will measure the lenght of the piece left in the clothespin. Each piece will be 5 cm long to begin with so if 2 cm remains, 60% will have been removed. Score each of the plant pieces in each of the zones. Also note whether removal was by fish (crescent-shaped scar) or urchins (ragged scar). The assay samples must be prepared the afternoon or evening before the exercise is to be carried out.

The third method will involve censusing the number of fish bites per unit time per area. Remain motionless at a distance of 2 - 3 m and count the number of bites taken by herbivorous fish on a portion of the bottom or dead coral branch for 5 - 10 min. Record number of bites, time then measure the area of substrate observed. Also note whether the area was on the bottom or on a dead coral branch. Make sure you are not observing a damselfish territory (WHY?). Repeat 3 times in each reef zone.

(3) Algal biomass

Materials needed: plastic rulers
slates
1 m2 quads

Within each reef zone estimate the percent cover of algal communities with different canopy heights. You will notice that much of the area is covered with a very thin (ca. 1 mm) layer of filaments and crustose corallines. However, there are scattered areas that have stands of algae that are much higher. Establish several categories to which areas can be assigned (e.g . < 2 mm, 2 - 5 mm, 6 - 15 mmm etc.). Damselfish territories can be considered a special case. Repeat the above within such territories.

From each of the components, collect 2 representative pieces that can be brought back to the lab and weighed. We will use these as rough estimates of biomeass to convert the height categories to weight estimatews. What should result from the above is the percent area within each zone that is covered by algal communities in each of the categories.

(4) Algal species composition

materials needed: slates
quadrats
plastic bags

Persons in this group should work with those doing the algal biomass estimates and also collect representative samples of substrate that will be returned to the lab for gross identification. Within the quadrats in each zone estimate the % cover by the following algal components: crustose corallines, sparse algal turf (< 2 mm high), thick algal turf (5 - 10 mm high) and macroalgae (identify to species; collect if you are unsure of identity). Estimate abundance using the following scheme:

1 = 0 - 10 %
2 = 10 - 20 %
3 = 20 - 50 %
4 = 50 - 70 %
5 = > 50 %

Upon return to the lab examine the turf collections under a dissecting scope and scrape a few areas to place on a microscope slide for identification. You should end up with a rough list of taxa and their relative abundances in each zone.

DATA ANALYSIS

Data should be tabulated in the following units:

1. No. urchins/ m2 for each zone
2. Mean urchin diameter +/- s.d. for each zone
3. mean no. fishes/ 40 m2 +/- s.d. for each species for each zone and a mean total +/- s.d. for each zone
4. Mean % *Thalassia* and *Acanthophora* removed / h for each zone
5. Mean no. bites / m2 / h for each zone
6. % cover of each biomass category for each zone
7. Weighted mean biomass for each zone (= wt. of each category x % cover within a zone)
8. List of taxa for each component and relative abundances (1-5)

DISCUSSION

Answer each of the 4 questions posed in the Introduction.

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ECOLOGY EXERCISE: Twilight changeover in the reef fish community: does predation result in a "quiet period" on St. Croix?

INTRODUCTION

Most groups of reef fishes are active (i.e. searching for food) either by day or night. The twilight periods of dusk (sunset to darkness) and dawn are characterized by the orderly disappearance of daytime fishes and emergence of nocturnal fishes in the first case and the reverse of this in the second (Hobson, 1972; Domm and Domm, 1972). In both cases certain species (and even, to a certain extent, families) characteristically disappear or appear ahead of others. According to Hobson (1972) between the disappearance of diurnal fishes and the emergence of nocturnal fishes there is a "quiet period" of little activity of either group (determined from studies in the Pacific Ocean) ; there is a similar period in the morning. Presumably both the sequential activity and the quiet period are evolutionary responses to an increased vulnerability to predation (by other fishes; Major, 1977) during the middle of the quiet period: some fish eyes are better adapted to bright light than others, and during the period of maximum vulnerability to predatory attacks it is clearly of advantage to be tucked away in the reef (see McFarland et al, 1979). Our main purpose in the present exercise is to quantitatively document the sequence of disappearance and emergence of fishes during dusk to determine if there is a quiet period locally and if so, does it correspond to a period of increased predatory activity by pioscivores.

In addition to this pattern which can be documented at any reef site, a few species undergo regular migrations to and from foraging sites during dusk and dawn. In the case of juvenile grunts (e.g. on Tague Bay patch reefs) or copper sweepers (at certain sites on Tague Bay reef and elsewhere, these migrations are preceeded by assembly of individuals at consistent sites at the edge of the reef. The whole sequence for each species is consistently cued to diminishing (or increasing) light levels. the migratory patterns of either of these species can be observed, timed and mapped by being at the appropriate site a little before sunset. For further details see Ogden and Ehrlich (1977) or Gladfelter (1979). Predatory activity can generally be observed at these sites

FIELD WORK

This exercise can be carried out at any reef site; Tague Bay backreef is best for snorkellers; the south forereef of Buck I. is good for both snorkellers and SCUBA divers if sea conditions are ok; the buttresses at Cane Bay are good. Before starting out it is imperative that all watches be synchronized; the exact time can be obtained from the Alexander Hamilton Airport tower. Sunset times can be obtained from the Nautical Almanac for any day of the year (subtract 6 min from the San Juan times for Tague Bay). It is important that everyone be on site 10 min before sunset.

Set up your slates with rows and columns beforehand; the first column should be designated the time at 9 min before sunset then number every successive column 3 min later; provide about 30 rows to allow for diurnal, nocturnal and predatory fishes. Be sure to review your nocturnal fishes beforehand (squirrelfishes, cardinalfishes, drums, glasseyes, reef croakers, sweepers).

Once at the reef site spread out in buddy pairs. Set Pick a visual field that you can convenient census in a minute or so (e.g. 10' wide by 5' deep and indefinitely high). Every 3 min BEGINNING AT 9 MIN BEFORE SUNSET make a quick census of your area, recording for EACH SPECIES the number of individuals. Continue to do this till 40 min after sunset (or if your air supply reaches 300 psi beforehand). It is best to use a small dive light such as a Q-lite for this work so as to disturb the fishes as little as possible; try to census as long as possible without using the light and when you do try to mask the beam with your hand.

During your sojourn, record any bona fide predatory attacks that occur (by trumpetfish, groupers, snappers, etc.)
[If you prefer to characterize the details of the migrations of the species mentioned, use the cited references as a guide]

DATA ANALYSIS

These data should be worked up collectively by the whole class. First make a summary table (on a big chart or the blackboard) listing all species vertically and time intervals horizontally. Fill in the table with everyone's observations. Now graph the number of individuals of the major species present (i.e. those which were common during part of the period) as well as predatory attacks. Also plot the total number of individuals of all species for each time interval.

DISCUSSION

1. Is there a quiet period, based on your data? Does it coincide with a peak of predatory activity?
2. Do some species go into the reef before others or emerge before others? Why?

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ECOLOGY EXERCISE: Niche Breadth and Overlap in Habitat Utilization in a Community of Tropical Marine Organisms

INTRODUCTION

Ecologists are interested in how large numbers of species manage to co-exist in tropical communities. One of the longer-standing hypotheses is that groups of species with similar requirements actually subdivide or partition them along one or more environmental resource axes (Schoener, 1974). There is evidence of the operation of this mechanism in coral reef communities (Kohn, 1959: gastropods of the genus Conus; Gladfelter and Johnson, 1983: Caribbean squirrelfishes). On the other hand it is claimed that the mere existence of differences in resource utilization among species does not necessarily answer the initial question, for more proximate causes may play equal or larger roles (e.g. predation or larval wastage at such a level that competition for resources never really comes into play). In any case the concept is an interesting one and worthy of investigating for some groups of coral reef organisms.

Nearly any group of ostensibly similar organisms can be used for this exercise though it is most relevant to carry it out on groups that seem to be using the same resources in the same way (i.e. a GUILD, Root, 1967). The resources most useful to consider are food and space: those resources most frequently shown to be the basis of competition. However, we must remember that the UTILIZATION OF SIMILAR RESOURCES DOES NOT NECESSARILY IMPLY COMPETITION FOR THOSE RESOURCES. A good model to use for space partitioning is the work of Clarke (1977) on Caribbean damselfishes and chaetodontids. The model provided by Clarke as well as others, or even this exercise, can be extended to a variety of other groups: plant or animal.

One of the assumptions of this "niche diversification" theory is that guilds with more members utilizing resource bases of similar width tend to divide up their resources more finely, that is tend to specialize more or have narrower niches (i.e. niche widths). The idea is that at certain times, when a resource DOES become limiting, greater specialization tends to reduce competition (either exploitative or interference). There are clearly flaws in this thinking (what are they?) but there may be some truth as well. Likewise, on a given resource axis a given number of species will have smaller niche overlaps if their niche widths are smaller.

The simplest useful measure of niche width is that for resource diversity, i.e. application of H' (see Reef Community Exercise):

$$H' = -3.32 \sum p_i \log_{10} p_i$$

where p_i is the proportional contribution of each resource variate to the whole resource spectrum.

Niche overlap between two species is most simply expressed as:

$$O = 1 - 0.5 \sum | p_{xi} - p_{yi} |$$

where p_{xi} and p_{yi} are proportional utilization of each resource variate (see similarity indices used in Fish Community Structure Exercise).

In this exercise we will look at habitat utilization by the territorial damselfishes:
(1) yellowtail (2) bicolored (3) three-spot (4) dusky (5) beaugregory (6) cocoa (7) honey. The sergeants and chromis are less tied to the substrate and will not be included in this analysis.

[Remember this exercise could be carried out on any group of similar species utilizing a resource spectrum]

FIELD WORK

Choose a site with some sort of habitat gradient (shoreward/seaward; depth; substrate complexity; etc.); Tague Bay Reef or Cane Bay might be best for the first two of these. For example, Tague Bay Reef can be divided into a number of zones roughly parallel to the reef axis (E/W). Beginning from lagoon these might be (or modify them):

1. Base of slope into lagoon
2. Shallow rubble zone
3. Backreef coral stands
4. Shallow forereef coral stands
5. Deep forereef with scattered corals
6. Forereef base

You might also want to include a lagoonal patch reef with its 2 - 3 zones and the shore zone.

Divide up into the appropriate number of teams to census the above 7 species of damselfishes in each recognized habitat type. It is probably worth distinguishing between colorful juveniles and the duller adults for the 5 species that show such a difference.

To carry out a census, each buddy pair work a non-overlapping pattern and record every damselfish in a certain width strip: absolute numbers are not as important here as proportions.

DATA ANALYSIS

Make a summary table of the class census data for the 12 damselfish forms (i.e. adults and juveniles) in x number of habitats. Convert the absolute values into proportions (i.e. for each species calculate proportional occurrence of individuals in each habitat; these then become the p (see Introduction) for determining H'; they also become p and p for determining O.

[To illustrate: if species A, B and C are found in habitats 1,2 and 3 in the following numbers (censuses):

	1	2	3	
A	12	3	5	20
B	3	8	7	18
C	6	4	1	11

converting to proportions:

	1	2	3
A	.60	.15	.25
B	.17	.44	.39
C	.55	.36	.09

then the p 's for species A to calculate H' are .60, .15 and .25. The p 's and p 's for calculation of O between species A and B are .60 and .17, etc.

Calculate niche widths for all species (including juveniles as separate forms ; calculate niche overlaps for all pairs of species (forms).

Species diversity can also be calculated for each habitat by calculating proportional occurrence of all species in each habitat, i.e. sum census values for each habitat (columns in examples above) and express census values as proportions of the column sum.

DISCUSSION

1. Which species have particularly broad or narrow niche widths? Why?

2. Which species pairs have greatest or least habitat overlaps? WHy?

3. Which habitats support the greatest and least diversities of damselfish species? Why?

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II. RELEVANT SCIENTIFIC JOURNALS

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Atoll Research Bulletin
Bulletin of Marine Science
Caribbean Journal of Science
Coral Reefs
Environmental Biology of Fishes
Journal of Experimental Marine Biology and Ecology
Marine Biology
Marine Ecology Progress Series
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