

## Abstracts of Masters Theses in Biology at the University of Guam, 1968–1991

**Editorial Note.**— The University of Guam has had a Master of Science program in Biology since 1967. Over seventy theses have been written, many on coral reef organisms. Some have been published, or parts published, others have not. Publications are listed below each abstract. A booklet listing all papers from the Marine Laboratory is available from that unit. Copies of all the theses are filed in the R. F. Kennedy Library at University of Guam.

Abstracts are given in chronological order, as listed in the University's booklet of Masters Theses.

### ALPHABETICAL LISTING

Belk, M.S.	1971	Lassuy, D.R.	1979
Best, B.R.	1981	Meyer, K.D.	1991
Bowden-Kerby, A.	1984	Molina, M.E.	1983
Braley, R.D.	1981	Muniappan, S.	1976
Branch, J.B.	1969	Myers, R.F.	1983
Bryan, P.G.	1974	Neill, J.B.	1985
Carlson, M.R.	1968	Neubauer, C.P.	1983
Chandran, R.	1987	Neudecker, S.	1978
Chernin, M.I.	1979	Pendleton, D.E.	1983
Chase, J.A.	1975	Peterson, R.D.	1972
Clayshulte, R.N.	1981	Plucer-Rosario, G.	1983
Colgan, M.W.	1981	Potter, T.S.	1986
Davis, G.W.	1985	Randall, R.H.	1971
Day, J.E.	1977	Rideout, R.S.	1975
Dickinson, R.E.	1977	Rogers, S.D.	1989
Donaldson, T.J.	1981	Romeo, C.J.	1982
Doty, J.E.	1977	Rosenberg, D.L.	1972
Edward, A.E.	1986	Ross, R.M.	1976
Eastlick, P.	1991	Rowley, D.M.	1980
Ellis-Neill, L.	1987	Rupp, J.J.	1973
Fitzgerald, W.J., Jr.	1976	Sanger, H.R.	1989
Gates, P.D.	1986	Sherwood, T.S.	1985
Gawel, M.J.	1977	Smalley, T.L.	1981
Gordon, G.D.	1975	Smith, B.D.	1979
Grimm, G.R.	1983	Stojkovich, J.O.	1979
Grosenbaugh, D.A.	1979	Strong, R.D.	1975
Hillman-Kitalong, A.	1984	Tobias, W.J.	1976
Hohman, T.C.	1972	Tseng, W.Y.	1972
Hopper, D.R.	1990	Wilder, M.J.	1977
James, S.	1982	Wilkins, S.deC.	1986
Jameson, S.C.	1975	Wooster, D.S.	1979
Kami, H.T.	1972	Wortman, C.G.	1976
Katnik, S.E.	1982	Wray, F.O.	1975
Kock, R.L.	1980	Wylie, C.R.	1988
Kropp, R.K.	1981	Zahner, S.	1974
Larson, H.K.	1974	Zolan, W.J.	1980

## ABSTRACTS

THE ECOLOGICAL INTERACTION OF THE POMACENTRID *DASCYLLUS ARUANUS* (LINNAEUS) WITH THE CORAL *ACROPORA ARBUSCULA* (DANA). Martin R. **Carlson**, 1968.

This study is an autecological survey investigating the relationship of the pomacentrid fish *Dascyllus aruanus* with the coral *Acropora arbuscula*. Factors considered in the investigation were the behavior and population composition of *Dascyllus aruanus* in regard to its use of the coral and the life history of the fish. The morphology of the digestive tract and the digestive tract contents were investigated in studying the food habits of *D. aruanus*. The flora and fauna of *Acropora arbuscula* were collected and catalogued to locate sources of food items and to determine possible competitors. Repopulation experiments furnished some information concerning movements of the fish population.

Results of the study indicate that *Dascyllus aruanus* depends on *Acropora arbuscula* for cover rather than for food. Although the digestive system is adapted primarily for the life of a carnivore, *Dascyllus aruanus* is omnivorous. The fish is not inclined to migrate to depopulated corals. *Adudefduf leucozona*, another pomacentrid, apparently occupies a niche very close to *D. aruanus*.

OBSERVATIONS ON THE ECOLOGY AND BEHAVIOR OF GUAM PEARLFISHES (CARAPIDAE). James B. **Branch**, 1969.

From April, 1968, to January, 1969, specimens of pearlfishes and 1,776 host specimens were collected on the fringing reefs of Guam. Five species of pearlfishes are represented and their distinguishing characteristics discussed. These specimens were taken from five holothurian species and from the cushion starfish, *Culcita novaeguineae*. The percentage of infestation of the pearlfishes varied with the host species and the reef zone occupied by the hosts.

*Carapus homei* tenuis larvae were collected in May, September and October. Observations on the tenuis larvae indicate that metamorphosis into the juvenile stage probably occurs within a host. The total length of the adults appears to be dependent upon the size of the host species. *C. homei* may have an annual reproductive cycle, with spawning in the late summer, and an in-

crease of infestation by the tenuis and juvenile forms during the winter months.

The form called *Carapus murlani* is structurally similar to *C. homei* but differs in its behavior (host preference), superficial melanophores, size of the pectoral fins, and possibly in the seasonality of the life form. Experimental results suggest that the anatomical differences of the two forms are not due to the effects of the hosts.

It was found that adult specimens of *Encheliophis gracilis* form male and female pairs, each pair infesting a single host. This paired infestation is dependent upon the gonadal development of the pearlfishes and only specimens in a spawning condition were found paired. Two egg rafts from these *E. gracilis* pairs were spawned in aquaria, and the embryonic and larval development of the fertile eggs was observed. Developing vexillifer larvae reached a length of 2.5 mm.

The majority of the pearlfishes were found in the coelom or respiratory trees of their hosts. Radiographs indicate that the fishes move tail first up the respiratory trees of the holothurians upon entry, and the area of breakthrough into the coelom of the hosts may be the cloaca.

Stomach contents indicate that *Encheliophis gracilis* specimens feed exclusively on the gonads of *Holothuria argus*. The other pearlfish species appear to be predators, feeding upon fishes and shrimps.

The behavior of the Guam pearlfishes was observed and filmed in the laboratory. Location of the hosts, pearlfish entry, and host reaction were noted.

TANGUISSON-TUMON, GUAM, REEF CORALS BEFORE, DURING, AND AFTER THE CROWN-OF-THORNS STARFISH (*ACANTHASTER PLANCI*) PREDATION. Richard H. **Randall**, 1971.

The first part of the study is a distributional analysis of living corals at Tumon Bay, Guam, before *Acanthaster planci* (Linnaeus) predation of the fringing reefs there greatly altered the distribution of corals. The coral community there is composed of 150 species representing 36 genera. A zonal analysis of the corals is given which includes the inner reef flat, outer reef flat, reef margin, reef front, submarine terrace, and seaward slope zones.

The second part of the study deals with observations of *A. planci* in the Tumon Bay area of

Guam, where their first population increases were noted. Included in these observations are notes on feeding habits, distribution by reef zones, and coral predation during various phases of the population explosion.

The third part of the report describes the distribution of reef corals at Tanguisson Point, Guam, after the fringing reef corals had been subjected to intensive *Acanthaster* predation. A zonal analysis of the reef corals is given for the same zones that occur at Tumon Bay. The reef community at Tanguisson Point is composed of 96 species represented by 33 genera.

Four hundred twenty nine coral specimens were collected representing 113 species and 31 genera, most of which were collected before the starfish predation at Tumon Bay. An additional 48 specimens representing 12 genera and 18 species were collected from the Tanguisson Point reefs after the starfish predation of reef corals there. A comparison is made of all reef zones between both study sites. Included in the studies at Tumon Bay and Tanguisson Point are distribution studies by reef zones of coral growth forms, coral diameter, and percentage of reef surface covered by living corals.

- Randall, R. H. 1973. *Micronesica* 9:119-158.  
 ———. 1973. *Micronesica* 9:212-222.  
 ———. 1973. *Publ. Seto Mar. Biol. Lab.* 20:469-489.

A CONTRIBUTION TO THE COMPARATIVE ECOLOGY OF *POMACENTRUS LIVIDUS* AND *POMACENTRUS ALBOFASCIATUS* (PISCES: POMACENTRIDAE) TUMON BAY, GUAM. Mary Schug Belk, 1971.

Two species of *Pomacentrus*, *P. lividus* and *P. albofasciatus*, from Tumon Bay, Guam, were investigated for factors that might provide potential ecological separation of the species. Specific factors investigated were habitat and community structure, behavior, size differences, feeding habits, and reproduction.

The fishes are sympatric in the coral zone of the inner reef flat where each lives in a different habitat: *P. lividus* is usually found in *Acropora* colonies and *P. albofasciatus* in the spaces between these coral colonies. Both pomacentrids are browsing herbivores that generally eat the same algal species but the proportions vary. This variance appears to be a function of the differences in habitat. *Pomacentrus lividus* is a highly territorial species. The slightly larger size of *P.*

*lividus* appears to aid it in excluding *P. albofasciatus* from the coral colonies.

- Belk, M. S. 1975. *Copeia* 1975:603-607.

EFFECTS OF LIGHT INTENSITY ON THE MORPHOLOGY AND PRODUCTIVITY OF *CAULERPA RACEMOSA* (FORSSKAL) J. AGARDH Russel D. Peterson, 1971.

Six varieties and three additional growth forms of *Caulerpa racemosa* were found in Guam's fringing reef flat. Variation in length and number of both assimilators and rhizoids and in the spacing of ramuli with light intensity was demonstrated for the varieties *uvifera* and *lamourouxii*. Characteristics of other varieties developed on specimens collected in the field after they were placed under altered laboratory light intensities. Seasonality of *C. racemosa* was correlated with the number of midday minus tides.

Productivity data suggested the adaptation of var. *uvifera* and var. *lamourouxii* f. *requienii* to habitats of high and low light intensity, respectively. Variety *lamourouxii* f. *requienii* had a lower compensation point, larger P/R (gross photosynthesis/respiration) value, and higher net photosynthetic rate than var. *uvifera* at low light intensities. When exposed to full sunlight the P/R value and net photosynthetic rate of var. *uvifera* exceeded those of var. *lamourouxii* f. *requienii*, which dropped at that intensity. Chlorophyll a and carotenoid concentrations of field-collected var. *lamourouxii* specimens were approximately twice those of var. *uvifera*. Chlorophyll a, but not carotenoid content, was found to decrease with exposure to increasing light intensity for specimens originally classified as var. *lamourouxii*.

The relationships of morphologic and productivity factors to light intensity provide evidence for their environmental rather than genetic control. Reference to *C. racemosa* growth forms as ecophenes is suggested.

- Peterson, R. D. 1972. *Micronesica* 8:63-86.

DIURNAL PERIODICITY IN THE PHOTOSYNTHETIC ACTIVITY OF *CAULERPA RACEMOSA* (FORSSKAL) J. AGARDH. Thomas C. Hohman, 1972.

Oxygen evolution of the green alga *Caulerpa racemosa* was measured at two-hour intervals for 24- and 48-hours under constant temperature and light conditions. Plants exhibited a unimodal periodicity in photosynthetic activity similar to that

previously reported in phytoplankton. Holding the plants under high-light intensity erased the photosynthetic rhythm.

THE PRISTIPOMOIDES (PISCES: LUTJANIDAE) OF GUAM WITH NOTES ON THEIR BIOLOGY AND FISHERY ASPECTS. Harry T. Kami, 1972.

Taxonomic data as well as information on the biology and fishery aspects of four species of deep water snappers, genus *Pristipomoides*, are presented. The genus is represented in Guam by the following species, *P. auricilla* (Jordan, Evermann, and Tanaka), *P. sieboldii* (Bleeker), *P. filamentosus* (Cuvier and Valenciennes), and *P. flavipinnis* Shinohara.

Close affinities are found between *P. auricilla* and *P. sieboldii* and between *P. filamentosus* and *P. flavipinnis*. Sexual dichromatism of *P. auricilla* and *P. filamentosus* is described. *P. sieboldii* and *P. flavipinnis* displayed no sexual dichromatism.

Limited information on the feeding habits of these snappers indicates that pelagic tunicates are important food items.

Differences in number between the males and females taken of *P. auricilla* and *P. filamentosus* were significant, but *P. sieboldii* and *P. flavipinnis* showed no such differences.

Catch rates indicate that the northeastern region of the island is a better fishing area than the northwestern or southwestern regions. However, due to weather exposure, more fishing was done in the two latter regions resulting in larger total catches. Depths from which these snappers were taken ranged from 90 to 360 m, but best catches occurred at depths of 181 to 270 m.

*P. auricilla* is the most important species of the *Pristipomoides* fishery in Guam.

Kami, H. T. 1972. *Micronesica* 9:97-117.

DEVELOPMENT OF THE PELAGIC OSTRACOD, EUCONCHOECIA ELONGATA MÜLLER. Wen Young Tseng, 1972.

A general zooplankton survey conducted from October 1971 to July 1972 revealed that *Euconchoecia elongata* Müller was one of the predominant species occurring in Apra Harbor, Guam.

Continuous breeding was apparent for this species throughout the study period and larval liberation took place nocturnally. Mean sex ratio for the species was 1:4 (male to female). One-third of the mature females were found to be gravid. Embryonic development occurred inside the brood chamber of the female. Individual larvae

of *E. elongata* hatched asynchronously in the same brood chamber which differs from other crustaceans, such as cladocerans.

A new classification of larval and juvenile stages of *E. elongata* is proposed. This classification is based on each molt, on growth of the shells, and on the addition of claws to the furca. There are seven developmental stages: metanauplius, first through fifth ostracodite, and adult.

BEHAVIORAL ASPECTS OF PHOTOSENSITIVITY AND SPECTRAL SENSITIVITY IN ACANTHASTER PLANCI (L.) Daniel Lee Rosenberg, 1972.

The photosensitivity and spectral sensitivity of *Acanthaster planci* was investigated. Specimens were found to display negative phototaxis, tube foot retraction, respiratory papillae retraction, and radial flexure in response to non-filtered light and light in the spectral region between 460 and 620  $\mu\text{m}$ .

Other photosensitive responses were investigated. Excised radii and transverse sections of these radii were found to be photoresponsive. Individuals in the field were found to be sensitive to shadows. In the laboratory, intermittent light was found to be a more effective stimulus for respiratory papillae retraction than constant light.

EFFECTS OF TEMPERATURE ON FERTILIZATION AND EARLY CLEAVAGE OF SOME TROPICAL ECHINODERMS WITH EMPHASIS ON ECHINOMETRA MATHAEI (DE BLAINVILLE) John H. Rupp, 1972.

Select temperatures above normal are shown to reduce success of fertilization and normal early cleavage, in the laboratory, for the echinoderms *Acanthaster planci* (L.), *Culcita novaeguineae* Muller and Troschel, *Linckia laevigata* (L.), *Echinometra mathaei* (de Blainville), and *Diadema savignyi* Michelin. The data indicate that cleavage is more sensitive to increased temperature than fertilization. Upper tolerance limits for early cleavage in most of the species is near 34.0 °C. The early development stages of *Acanthaster planci* were the most sensitive to elevated temperature, and those of *Echinometra mathaei*, the least.

Further experiments with *E. mathaei* showed that unfertilized ova were still viable, dividing normally when fertilized, after two hours of exposure at 36.0 °C. The ova were significantly less viable after three hours. Early cleavage stages of *E. mathaei* were resistant to 36.0 °C for exposure



times of up to 40 minutes but were inhibited beyond this period.

It is suggested that the ability of *E. mathaei* to develop normally at 34.0 °C (6 °C above ambient) and to withstand limited exposure to 36.0 °C may account for the wide distribution of this species in habitats which are often subjected to frequent broad temperature fluctuations, such as reef flats.

Rupp, J. H. 1973. Mar. Biol. 23:183-189.

FOOD HABITS, FUNCTIONAL DIGESTIVE MORPHOLOGY, AND ASSIMILATION EFFICIENCY OF THE RABBITFISH *SIGANUS SPINUS* (PISCES: SIGANIDAE) ON GUAM. Patrick G. Bryan, 1974.

Analyses of stomach contents of *Siganus spinus* showed that algal availability, and size and behavior characteristics of the fish determine what kinds of algae are ingested in the field. Sixty-two algal species were tested during multiple choice food preference trials in the laboratory. Elimination trials and observation tests showed a ranked order of algal preference; 1. *Enteromorpha compressa*, 2. *Murrayella pericladus*, 3. *Chondria repens*, 4. *Boodlea composita*, 5. *Cladophoropsis membranacea*, 6. *Acanthophora spicifera*, and 7. *Centroceras clavulatum*. An examination of the morphology of the digestive system showed that the fish are well adapted herbivores, especially toward the filamentous algae. The assimilation values for the adults ranged from 6 to 39%; those for the juveniles ranged from 9 to 60%.

Bryan, P. G. 1975. Pac. Sci. 29:269-277.

NOTES ON THE BIOLOGY AND COMPARATIVE BEHAVIOR OF *EVIOTA ZONURA* AND *EVIOTA SMARAGDUS* (PISCES: GOBIIDAE). Helen K. Larson, 1974.

*Eviota zonura* and *Eviota smaragdus* are sympatric gobies inhabiting the fringing reef platform of Guam. They are ecologically separated by habitat preference. *Eviota zonura* prefers the cut benches and rimmed terraced pools of the windward reef margins. *Eviota smaragdus* is abundant on both windward and leeward sides of the island. Its preferred habitats are elevated outer reef flats that are usually protected by an algal ridge, and parts of the inner reef flat.

Both species are carnivorous and feed on essentially the same items. *Eviota* are probably not, themselves, important prey species for reef flat dwelling predators. Reproduction may occur year

round for both species. There is possibly a peak in breeding from June to August for *Eviota zonura* and from November to January for *Eviota smaragdus*.

Observations on behavior as an isolating mechanism were made in the field and laboratory. Both species are aggressive and display ritualized fighting behavior with several species-specific action patterns. Only breeding males show territoriality in the field.

TWO BACTERIAL DISEASES OF SOLANACEOUS CROPS ON GUAM: *PSEUDOMONAS SOLANACEARUM* AND *XANTHOMONAS VESICATORIA*. Sharon Zahner, 1974.

Two bacterial plant pathogens of Solanaceae were shown to be *Pseudomonas solanacearum* and *Xanthomonas vesicatoria*. Comparative studies of N11, Saturn and Venus varieties of tomato indicated that Saturn and Venus were resistant to *P. solanacearum*, but they were less resistant to *X. vesicatoria* and nematodes and were less productive than N11.

DISTRIBUTION OF BUTTERFLYFISHES (PISCES: CHAETODONTIDAE) ON THREE CONTRASTING GUAM REEFS. Jennifer A. Chase, 1975.

Abundance and diversity of chaetodontids on three contrasting coral reefs seem to be linked directly to the abundance of live coral. A total of sixty, 20-minute chaetodontid counts was made on the reef fronts and submarine terraces of the three reefs. Live coral cover was estimated at each of the six sites studied. Values ranged from 426 individuals in 16 species of Chaetodontidae seen at a site of approximately 14 percent coral cover, to 909 individuals in 21 species counted at a site of approximately 54 percent coral cover. Previous work, substantiated by further stomach analysis, established six species of the genus *Chaetodon* as strict coral polyp feeders. These are submitted as potential indicator species: *Chaetodon ornatissimus*, *C. punctato-fasciatus*, *C. quadrimaculatus*, *C. reticulatus*, *C. strigangulus*, and *C. trifasciatus*.

FLORISTIC AND DISTRIBUTIONAL ACCOUNT OF THE COMMON CRUSTOSE CORALLINE ALGAE ON GUAM. Gregory D. Gordon, 1974.

The common crustose coralline algae on Guam were collected from the reef flats and to depths of 40 meters. Specimens were decalcified, embedded in paraffin, microtomed, stained, and examined under a microscope. Twenty seven spe-

cies are described. *Porolithon onkodes* Foslie and *Hydrolithon reinboldii* (Weber van Bosse and Foslie) Foslie are the two species found in greatest abundance over the widest range of habitats. The two dominant genera, *Lithophyllum* and *Neogoniolithon*, have five and six species, respectively.

Gordon, G. D., T. Masaki & H. Akioka.  
1976. *Micronesica* 12:247-277.

ASEXUAL REPRODUCTION AS A MEANS OF  
POPULATION MAINTENANCE OF THE CORAL  
REEF ASTEROID LINCKIA MULTIFORA  
(LAMARCK). Randolph S. Rideout, 1975.

The asteroid *Linckia multifora* reproduces by autotomy of arms. Seven phases are recognized in its asexual reproductive cycle (automized arms; comets; counter-comets; post counter-comet I, II and III; and disc-parents). Individuals of the comet phase represent the highest percentage for population samples collected throughout the year at Asan reef flat, Guam. Cocos Lagoon and GabGab Beach population samples also demonstrated comet predominance. This indicates a continuous asexual reproduction through which populations of *L. multifora* are being maintained on the reefs of Guam.

Rideout, R. S. 1978. *Mar. Biol.* 47:287-295.

EARLY LIFE HISTORY OF THE GIANT CLAMS  
TRIDACNA CROCEA LAMARCK, TRIDACNA  
MAXIMA (RODING), AND HIPPOPUS HIPPOPUS  
(LINNAEUS). Stephen C. Jameson, 1975.

Giant clams may be stimulated to spawn by the addition of excised gonad to the water. *Tridacna maxima* collected at Anae Island, Guam were spawned during November to March. *Hippopus hippopus* spawned in June and *Tridacna crocea* in July on Palau.

*T. crocea*, *T. maxima*, and *H. hippopus* displayed a stereotyped development pattern in morphogenesis and rate of development. Fertilized eggs of *T. crocea*, *T. maxima*, and *H. hippopus* had a mean diameter of 93.1, 104.5, and 130.0  $\mu\text{m}$ , respectively. The day 2 straight-hinge veligers of *T. crocea*, *T. maxima*, and *H. hippopus* had mean shell lengths of 155.0, 168.0, and 174.4  $\mu\text{m}$ , respectively. Settlement occurred 12, 11, and 9 days after fertilization at a mean shell length of 168.0, 195.0, and 202.0  $\mu\text{m}$  for *T. crocea*, *T. maxima*, and *H. hippopus*, respectively. Metamorphosis was basically complete about one day after

settlement. Juveniles first acquire zooxanthellae for *T. crocea*, *T. maxima*, and *H. hippopus* after 19, 21, and 25 days, respectively. Growth rates increase sharply after the acquisition of zooxanthellae. Calcification of juvenile shells begins after 47 days for *T. maxima* and after 50 days for *H. hippopus*.

The short pelagic larval period of the giant clams studied makes the outlook for mass aquaculture favorable. At this stage, the development of a suitable substrate for spat collection is the crucial problem.

Jameson, S. C. 1976. *Pac. Sci.* 30:219-233.

DISTRIBUTION, MORPHOMETRY, AND THERMAL  
STRESS STUDIES ON TWO FORMS OF LINCKIA  
(ASTEROIDEA), ON GUAM. Ronald D. Strong,  
1975.

Two similar forms of the asteroid genus *Linckia* were surveyed by a timed swimming count at eight locations around Guam. *Linckia laevigata*, cobalt blue in color, was found mainly on the reef flats but larger specimens occurred as deep as ten meters, whereas *Linckia* species, brown in color, usually occurred between depths of ten and 20 meters. *Linckia* species tends to have longer, more slender arms than *L. laevigata*. The rate of oxygen uptake increased between 25 ° and 34 °C in *Linckia* species. It also increased between 25 ° and 31 °C, but leveled off between 31 ° and 34 °C in *L. laevigata*. At 36 °C, the rate of oxygen consumption in both forms of starfish decreased, indicating a disturbance in metabolic activity because of increased temperature. *Linckia laevigata* was more tolerant to short exposures at 36 °C and survived for longer periods of time when maintained at 34 ° and 36 °C than did *Linckia* species. Thus, *L. laevigata* seems better adapted for living in a reef flat environment than does *Linckia* species. Phylogenetic relationships between the two forms remain unclear.

Strong, R. D. 1975. *Micronesica* 11:167-183.

AN ELECTROPHORETIC STUDY OF THE EYE  
LENS NUCLEAR PROTEINS OF ABUDEFDUF  
AMABILIS (DE VIS) AND ABUDEFDUF  
LEUCOPOMUS (LESSON) (POMACENTRIDAE).  
Frieda Osborne Wray, 1975.

Variation in color patterns within a single species has caused many taxonomic problems. It was thought that *Abudefduf amabilis* (De Vis) and

*Abudefduf leucopomus* (Lesson) were perhaps also color variants of the same species. Hybrids have been found on Guam and elsewhere in relatively small numbers and although it is indicative of interbreeding between these two species of *Abudefduf* it does not imply that they are the same species.

It was decided to use the technique of cellulose acetate electrophoresis to study the eye lens nuclear proteins. The eye lens nuclei have been used in many taxonomic studies because of their very stable character and have been found to be reliable indicators of species as well as breeding populations. *Abudefduf glaucus* (Cuvier and Valenciennes) and *Abudefduf biocellatus* (Quoy and Gaimard) which belong to the same subgenus, *Chrysiptera*, as *Abudefduf amabilis* and *Abudefduf leucopomus* were used as controls since they were readily distinguishable. Although all four species have the same protein band pattern, that is they all exhibit seven bands with the same migration distances, it was found by using the Kruskal-Wallis and Wilcoxon statistical tests that there is a significant difference ( $P = .05$ ) between the four species in protein concentration of these bands. Thus four separate breeding populations are present and probably four difference species.

ENVIRONMENTAL PARAMETERS INFLUENCING THE GROWTH OF *ENTEROMORPHA CLATHRATA* (ROTH) J. AG. IN THE INTERTIDAL ZONE ON GUAM. William J. FitzGerald, Jr., 1976.

Laboratory studies were conducted to determine the light intensity, salinity, temperature, and nutrient levels that would provide optimum growth for *Enteromorpha clathrata*. The criteria for determining growth were the ratio of net productivity to respiration and mass volume change over a defined incubation period. Environmental conditions providing optimum growth were found to be a light intensity of 2600 ft-c or higher; 30 °/∞; 25 °C; and 150 µg-at/l of N, where the N:P ratio was maintained at 4:1.

Seasonality, zonation, and the influence of substratum were examined in the field. *E. clathrata* at Tumon Bay occurred year-round, and seasonal variations were correlated to wave height. Additional factors influencing the presence of this alga were wind-generated surge and grazing by herbivorous fish. The zone of *E. clathrata* growth in Tumon Bay occurred between mean tide level and mean lower low water. Adequate-sized substratum, which varied with the degree of water

movement, was necessary to maintain a population of *Enteromorpha*.

FitzGerald, W. J., Jr. 1978. Bot. Mar. 21:207-220.

REPRODUCTIVE AND TERRITORIAL BEHAVIOR OF THE ANEMONEFISH AMPHIPRION MELANOPUS BLEEKER. Robert M. Ross, 1976.

Populations of the anemonefish *Amphiprion melanopus* were observed on Guam from November 1974 through March 1976 in order to determine their ecology, display repertoire, reproductive behavior, and territorial behavior. Individuals colonize the anemone *Physobranchia* sp. extensively and almost exclusively. The number and size of fish (measured in terms of total standard length) in each population is closely related to the areal coverage of resident anemones, suggesting that some critical resource (such as food, shelter, or protection) is directly related to the quantity of anemone present. Breeding populations require proportionally more anemone area than non-breeding populations. The mean population size is 3.51 individuals per anemone aggregation ( $n = 37$ ). Individuals of stable breeding populations have a calculated mean turnover period of approximately 4 years. Both larval recruitment and interpopulation migration may contribute to optimum population size.

The display repertoire (excluding reproductive behavior) consists of some 11 behavior patterns, most of which are either directly or indirectly related to the defense of territory. Other displays, functioning as appeasement or submissive postures, may be related to dominance within the populations.

Nest preparation probably consists of behavior causing anemones to contract (anemone biting) followed by substrate biting. Spawning occurs 2-2.5 hours after sunrise and lasts for approximately 1.5 hours. Egg fanning occurs only during daylight hours and increases in frequency as the eggs mature. Hatching occurs 1-2 hours after sunset on the seventh or eighth day of incubation. Spawning is related to moon phase, with peak activity at -5 and +6 days from the full moon. Hatching peaks correlate strongly with high water heights (high tides) and currents, suggesting that hatchling predation may have been the selective force resulting in the observed rhythmicity. There is no seasonal periodicity in spawning activity.

The experimental introduction of conspecific "intruding" fish shows that both juveniles (as

small as 20 mm SL) and adults defend territory. The mated adult female and male defend essentially the same territory, which is considerably larger than the area covered by resident anemones. The mated adult female fish defends territorial peripheries to a significantly greater extent than does the male. Juveniles and subadults, however, defend mutually exclusive areas (sub-territories) within the confines of the anemone aggregation defended by the mated adult pair. Consequently, adult-juvenile agonistic encounters are frequent. Large conspecific intruders are attacked more heavily and at greater distances than are small ones. Territorial fluctuations in size, emphasis, and location are related to loss of individuals, changes in nest location, and immigration. Reduced agonistic behavior (resulting in increased immigration and growth of juveniles) in adult fish whose mates are lost may reflect a feedback mechanism whose effect is to stabilize populations at their optimum size. Interspecific territorial behavior is sporadic and appears to be directly related to defense of the nest or eggs rather than defense of feeding areas. Territorial behavior in *Amphiprion melanopus* probably functions to protect some vital resource related to the actinarian host as well as to increase reproductive success.

Ross, R. M. 1978. *Copeia* 1978:103-107.

THE DETERMINATION OF PLANT COMMUNITIES ALONG A COMPLEX ENVIRONMENTAL GRADIENT AT HILAAN BEACH, GUAM. Sheila Muniappan, 1976.

A belt transects 5 m  $\times$  290 m was established at Hilaan Beach. The transect extended from the beach, through a fresh water cenote and terminated at the base of the cliff which rises to the plateau of northern Guam. All vascular plants within each 5 m<sup>2</sup> subplot were identified and measured. From these data a profile diagram was drawn and species importance values computed, graphed and analyzed by statistical clustering.

Six distinct vegetational communities were distinguished and named according to computed dominance: *Scaevola/Messerschmidia*, *Cocos*, *Aglaia/Guamia*, *Pandanus dubius*/marsh ferns, and *Merrilliodendron*. Each community was described by species composition and physiognomy. Soil samples were mechanically and chemically analyzed. A strong correlation exists between the number of species present and exchangeable soil potassium, sodium and calcium.

Muniappan, S. 1976. *Micronesica* 12:283-302.

ECOLOGY OF *SIGANUS ARGENTUS* (PISCES: SIGANIDAE) IN RELATION TO ITS MARICULTURE POTENTIAL ON GUAM. William James Tobias, 1976.

To assess the mariculture potential of *Siganus argenteus* on Guam, a study was conducted to integrate the known information on *S. argenteus*, to provide relevant information of the general biology (i.e., habitat preference, feeding habits, behavior, growth rate, and diseases) of sub-adult and adult fish and to determine their tolerance to environmental parameters (i.e., temperature, salinity, and oxygen), as encountered on Guam's fringing reefs.

Field observations have shown that *S. argenteus* juveniles migrate from the reef flat to spend their sub-adult and adult lives feeding diurnally on the algal turf of the submarine terrace and seaward slope (3-40 m in depth).

Analysis of stomach contents from 20 sub-adult/adult specimens has shown *Tolypocladia glomerulata* (Importance Value = 47.8), *Hali-medea discoidea* (IV = 24.1), *Dictyota* sp. (IV = 19.3), and *Galaxaura marginata* (IV = 10.4) to be the most important algae consumed in the field. Comparison of stomach content analysis with quantitative field analysis of the dominant macro-algae present indicates that the algal species ingested directly reflect the algal availability of that specific area. *S. argenteus* exhibits no active food selection, with the exception of possible avoidance of the blue-green alga *Schizothrix calcicola*.

The growth rate of *S. argenteus* is faster than *S. canaliculatus* and *S. spinus*. Fork length and weight measurements of similar initial size and weight *S. argenteus*, *S. spinus*, and *S. canaliculatus* grown under similar laboratory conditions after seven months were 187 mm/114 g, 124 mm/29 g, and 158 mm/59 g, respectively. Length-weight regression line slopes for *S. argenteus*, *S. canaliculatus*, and *S. spinus* were not significantly different. *S. argenteus* was sexually mature in 11 months at 201 mm fork length and approximately 150 g.

Some laboratory reared *S. argenteus* developed symptoms similar to those caused by deficiencies of B-complex vitamins. *S. argenteus* juveniles develop exophthalmia in water with a mean temperature of 33.2  $\pm$  1.3  $^{\circ}$ C and 6.68 ppm dissolved oxygen concentration.

The survival rates of fish subjected to water temperatures of 28, 30, and 32 °C were 100, 94, and 79%, respectively, over 14 days. Fish in 34 °C water had 50% mortality in 2.7 days, 96% mortality in 5 days, and 100% mortality in 8 days. *S. argenteus* juveniles are tolerant to reduced salinities and oxygen concentrations. The lower lethal salinity limit range was 4–7‰. The survival of *S. argenteus* is reduced to 50% after two days at 4‰ salinity. The growth rate of *S. argenteus* was not significantly different at salinities of 10, 20, and 30‰ over a 1-month period.

The 24-hour lower dissolved oxygen concentration limit for *S. argenteus* held in 48-liter aquaria was 1.0–2.0 ppm. The average fish survival time was 1.5 and 4.6 hours, respectively, for the 0.5 and 1.0 ppm oxygen experiments; 100% survival was recorded for fish maintained in 2.0 and 3.0 ppm dissolved oxygen concentrations. An oxygen consumption rate of 0.1 mg l<sup>-1</sup> hr<sup>-1</sup> was recorded for fish maintained in 2.0 and 3.0 ppm dissolved oxygen concentrations.

TOXICITY OF FIVE PESTICIDES TO THE TROPICAL HERMIT CRAB *CLIBANARIUS HUMILIS* DANA. Claudia Jean Galbraith Wortman, 1976.

Acute toxicities of five pesticides were determined at 24, 48, 72, and 96 hours for the tropical hermit crab, *Clibanarius humilis* Dana. Diazinon was found to be the most toxic pesticide tested, followed by chlordane, malathion, dicofol, and carbaryl, which was considerably less toxic than the others. Comparisons with values in the literature for temperate crustaceans indicated that *C. humilis* was not as sensitive to these pesticides as its temperate counterparts. Two assay procedures showed degradation within 24–48 hours for carbaryl and malathion, while dicofol degraded gradually; and no degradation was observed for chlordane or diazinon. In general, increased temperature and increased salinity resulted in increased toxicity. Carbaryl, however, was more toxic at lower temperatures.

THE COMMON SHALLOW-WATER SOFT CORALS (ALCYONACEA) OF GUAM. Michael John James Gawel, 1977.

The common alcyonaceans of Guam were collected to depths of 40 meters. Specimens were preserved and their sclerites were extracted and mounted on permanent slides for microscopic examination. Keys to the alcyonacean genera of the shallow-water tropical Pacific and to the species

of Guam are provided, based on observations, measurements of specimens, and literature review. Twenty-eight species are described and illustrated, all of which are new records for Guam. Their abundance, distribution, and habitats are discussed.

Gawel, M. J. J. 1976. *Micronesica* 12:303–307.

THE OCCURRENCE AND NATURAL HABITAT OF THE MANGROVE CRAB, *SCYLLA SERRATA* (FORSKAL), ON PONAPE AND GUAM. Richard E. Dickinson, 1977.

The natural habitat of the mangrove crab, *Scylla serrata* (Forsk.) is described, and various physical data from habitats where mangrove crabs occur are presented. Physical data included temperature, dissolved oxygen, and salinity. *S. serrata* tolerated low dissolved oxygen levels in the field, as low as 0.7 ppm, and often experience extended periods of aerial respiration. Crabs occurred in zones of continuously variable salinity, but evidence indicated that larger individuals, especially large males, occurred more often in water of high salinity (greater than 25 ppt).

Gut analyses were performed on crabs from Ponape and Guam. Ponape individuals fed primarily on the bivalve *Geloina papua* (Lesson). Guam individuals fed mostly on a benthic grapsid crab, *Ptychognathus ishii* Sakai. Other food items are listed. Fish were rarely eaten.

Tagging studies indicated that crabs may remain in the same channel or river for up to one month or more.

A series of morphometric measurements were made on individuals captured in the field. There is a sexual dimorphism in cheliped size; the growth rate of the male cheliped is faster than the growth rate of the female cheliped. The relationship of prey size and cheliped size as important factors regulating the distribution of mangrove crabs is discussed.

Crabs were maintained in small cubicles and in water of different salinity. Twelve individuals molted at least once and percentage increase in growth agreed well with growth data from work done elsewhere.

FISSION IN *HOLOTHURIA ATRA* AND HOLOTHURIAN POPULATION GROWTH. James Edward Doty, 1977.

Transverse fission and regeneration in *Holothuria atra* were studied to determine if fission is

a significant factor in the growth of populations of this species. *Holothuria atra* divides by a process of constriction and twisting of the body wall at a point approximately  $\frac{1}{3}$  the body length from the anterior (oral) end. Most of the individuals in which fission was observed were completely separated into posterior and anterior segments two to seven days after the time at which twisting was first noted. Posterior segments were less mobile, had a higher rate of survival and regenerated faster than anterior segments. Regeneration of anterior organs by posterior segments required approximately two months. Regeneration of posterior organs by anterior segments required two to four months.

Previous authors have reported the coincidence of high temperatures and fission. The areas of Guam where *H. atra* fission products were found are shallow areas characterized by episodes of high temperatures. Increased relative density of fission products in Pago Bay was coincident with high (37 °C) maximum temperatures. It therefore seems probable that elevated temperatures induce fission.

The average size (volume) of *H. atra* varied from place to place but was not correlated with the relative abundance of fission products. Smaller average size is not indicative of increased fission.

The overall density of holothurians on Cave Rock Transect in Pago Bay increased throughout the study period with the exception of a 75% decrease in late May 1976 caused by Typhoon Pamela. In spite of increased fission during the period of June 1976 to February 1977, *H. atra* density did not increase at a significantly greater rate than during the November 1975 to May 1976 period. *Holothuria pervicax*, which showed no indication of asexual reproduction, increased at a significantly greater rate than *H. atra*. No evidence was found in support of the hypothesis that fission is a significant reproductive process in *H. atra*.

Observations of species diversity in Piti Bay and Pago Bay indicate that diversity may vary seasonally but remains more-or-less constant from year to year.

GROWTH RATES OF, AND PREDATION ON, DIFFERENT SIZE CLASSES OF *QUIDNIPAGUS PALATUM* (BIVALVIA) ON TWO REEF FLATS OF GUAM. Jon Edward Day, 1977.

Six hundred individuals of the bivalve *Quidnipagus palatum* Iredale were notched and placed

into cages or fences on two reef-flats on Guam. After three months the growth increments were measured. Smaller size classes showed the most growth rings formed during the three-month period varied from one to nine rings. Clams inside the cages did not grow as rapidly as clams inside fences. Predation rates were significantly higher on smaller individuals of *Q. palatum*. Predation rates, bivalve diversity and predator diversity increased in a seaward direction along the transect. Low predation rates on mature *Q. palatum* suggest that commercial harvesting would have minimal effects on the reef-flat food web.

BIOLOGICAL ASPECTS AND FISHERIES POTENTIAL OF TWO DEEP WATER SHRIMPS *HETEROCARPUS ENSIFER* AND *HETEROCARPUS LAEVIGATUS* IN WATERS SURROUNDING GUAM. Michael Julian Wilder, 1977.

Two species of pandalid shrimp, *Heterocarpus ensifer* and *Heterocarpus laevigatus*, were trapped along the leeward (west) coast of Guam over a two-year period, from May 1975 to May 1977. Seven depths between 244 and 732 m were sampled to define the depth distribution of each species. Primary environmental factors of depth, area, and season along with certain physical characteristics, particularly temperature, oxygen, salinity, and sediments were evaluated for their affect on catch rates. Catch rates were evaluated to determine the feasibility of a shrimp fishery on Guam.

*Heterocarpus ensifer* was collected between 213 and 732 m with the greatest abundance between 366 and 457 m. *H. laevigatus* was found at depths ranging from 457 to 732 m with the greatest abundance between 610 and 732 m. Depth was determined to be the most significant factor in the variability of catches for both species. Area and season also affect the variability in catches of these shrimp, but these parameters account for considerably less variability than does depth.

Males outnumber females three or four to one for both species, and both species exhibit protandric hermaphroditism. The largest individuals of both species seem to congregate at the deep end of their depth distribution. The breeding and spawning is well defined for *H. laevigatus*, occurring in winter and spring. The seasonal breeding and spawning pattern for *H. ensifer* is less defined but appears to occur from late winter to summer.

The results of this study indicate an annual yield of two to three metric tons for the total



fishing grounds around Guam. It is possible that a small "cottage" fishery might support itself on these estimates.

**SPECIES DISTRIBUTION AND BIOMASS  
ACCUMULATION OF CORAL REEF FOULING  
COMMUNITIES ON TRANSLUCENT AND OPAQUE  
SETTLING PLATE SURFACES. Steve Neudecker,  
1978.**

The relative influences of orientation of translucent and opaque settling plates, available light, and sedimentation rates on coral reef fouling community structure were investigated with plexiglass plates which were simultaneously submerged but recovered after varying time periods. Several aspects of community structure were determined for fouling communities on 75 cm<sup>2</sup> horizontal surfaces left in predator exclosures at four depths. Orientation had the greatest effect on species composition, biomass accumulation, proportion of organic production, diversity, and surface cover. All sampled variables were significantly different between upper and lower surfaces. Differences were related in part to available light and to sedimentation rates. Upper surfaces had significantly more biomass ( $p < .005$ ) and surface cover ( $p < .001$ ) while lower surfaces were significantly more diverse in coverage ( $p < .001$ ) and had a greater proportion of organic biomass ( $p < .001$ ). Generally, the amount of biomass accumulation was inversely related to depth and a similar trend occurred in surface cover. Differences between translucent and opaque plates had little effect on community structure and these differences were generally not significant.

Only 58 of the 282 plates were colonized by 112 colonies of corals which belonged to four scleractinian genera. Survival was significantly greater ( $p < .005$ ) on the much smaller vertical surfaces (24 cm<sup>2</sup> per plate) than on upper or lower horizontal surfaces. Vertical surfaces exposed coral recruits to light, reduced the intensity of interference competition with algae for space, exposed the recruits to increased water movement, and did not accumulate sediments. Unlike the rest of the fouling community, corals preferred translucent plates ( $p < .005$ ). This preference was probably more directly related to physical differences between plates than to translucence or opaqueness. *Stylophora mordax* was the most abundant recruit (56 percent of all corals). It colonized plates in shallow water year-round. A

*Montipora* (?) sp. comprised 36 percent of the coral recruitment and colonized deeper water plates that were older than 308 days. A *Pocillopora* sp. accounted for seven percent of coral recruitment and also colonized plates at deeper depths that were older than 308 days.

Average mortality for all species was 10 percent, but this was probably underestimated. Recruitment by the four species was significantly partitioned both temporally and spatially ( $p < .005$ ). Such niche separation facilitates mutual survival in a space-limited environment. It appeared that coral recruits settled gregariously, since their co-efficient of dispersion was high ( $C.C. = 2.72$ ) and their distribution was significantly different from that of a Poisson distribution ( $p < .005$ ).

Neudecker, S. 1979. Ecology 60:666-672.

———. 1981. Proc. 4th Coral Reef Symp.  
2:376.

**POPULATION DYNAMICS AND REPRODUCTIVE  
STRATEGY OF BUFO MARINUS (L.) ON GUAM.  
Mitchell Irwin Chernin, 1979.**

To determine the population dynamics and reproductive strategy of *Bufo marinus* on Guam, five sampling areas were selected: (1) a spring with constant standing water; (2) a swamp with a fluctuating water table; (3) a limestone forest; (4) a savanna; and (5) an area of human habitation.

Population estimates of *B. marinus* showed the highest densities in areas of standing water (Agana Springs) and human habitation with 225 and 185 toads/ha, respectively. Toads were excluded from the savanna area probably because of thermal extremes. Density was correlated with rainfall. Increases in population densities occurred at Agana Springs and Agana Swamp during peak rain periods as females immigrated to these sites to breed, whereas density estimates decreased at the Human Habitation site as toads emigrated to preferred breeding sites.

Two population types were apparent: a feeding population associated with areas of human habitation and a reproductive population associated with areas of standing water. Feeding populations were characterized by larger and heavier toads (mean SVL, 86.2 mm at the Human Habitation site vs 82.2 mm at Agana Springs). Reproductive populations were characterized by a higher percentage of gravid females (23.3% at Agana Springs vs 9.9% at the Human Habitation site). Growth



rates of juvenile and adult toads were also 4 times greater at the feeding population site than they were at the reproductive population site (0.417 mm/day for juveniles, 0.274 mm/day for adults and 0.119 mm/day for juveniles, 0.055 mm/day for adults, respectively).

Juveniles comprised 42.0, 43.5, and 58.8 percent of the population at Agana Springs, Agana Swamp, and Human Habitation sites, respectively. Adult sex ratios showed that male toads outnumbered females 1.5:1, 1.5:1, and 1.3:1 at Agana Springs, Agana Swamp, and Human Habitation sites, respectively, except during the peak of the rainy season (October) when females outnumbered males 1.3:1 at the three sites.

Reproduction was seasonal and individuals probably bred only once a year; a major portion of males and females were at their reproductive peaks in the middle to late rainy season. *Bufo marinus* is also an opportunistic breeder in that a proportion of individuals were reproductively active during any given month.

**ROLE OF THE BLUE-GREEN ALGA NOSTOC MUSCORUM AS A POSSIBLE NITRATE SOURCE TO THE GROUNDWATERS OF GUAM. Deborah A. Grosenbaugh, 1979.**

An investigation of the nitrogen-fixing blue-green alga *Nostoc muscorum* Ag. as a possible contributor of nitrate to the groundwater of Guam was carried out from October 1977 to January 1979. Total potential nitrate contribution was determined by combining data obtained for ammonia excretion (a maximum of  $1.39 \mu\text{g}/\text{NH}_4/\text{g}$  *Nostoc*/hr), percent nitrogen (3.38%) and growth rates (40% increase/wk) with algal biomass estimates for Guam ( $2.6 \times 10^6$  kg) to obtain a value of  $1.5 \mu\text{g NO}_3\text{-N}/\text{mL}$  rainwater. Soil percolate studies were similarly extrapolated to produce a corresponding value of  $6.5 \times 10^{-4} \mu\text{g NO}_3\text{-N}/\text{mL}$  rainwater. Both values are well below those obtained from the groundwater, i.e., ca.  $2 \mu\text{g NO}_3\text{-N}/\text{mL}$ . It is concluded that *Nostoc muscorum* does not contribute significantly to the high nitrate content of Guam's groundwater.

**THE RELATION OF DIET, INTESTINAL MORPHOLOGY AND NITROGEN ASSIMILATION IN THE DAMSELFISH EUPOMACENTRUS LIVIDUS. Dennis Raymond Lassuy, 1979.**

The feeding habits, intestinal morphology and nutritional biology of juvenile and adult *Eupomacentrus lividus* were investigated on Guam.

Analysis of stomach contents revealed a shift from omnivory in juveniles to herbivory in adults. Red algae, primarily *Polysiphonia* spp., *Gelidiopsis intricata* and *Ceramium* spp., formed the bulk of the diet in all size classes. Foraminifera and small crustaceans were of particular importance in the diets of juveniles. Net nitrogen assimilation efficiency of field-fed *E. lividus* was approximately 60% and did not vary with fish size. The net assimilation efficiencies of fish fed on *Enteromorpha* in the laboratory ranged from 36–79% for nitrogen and from 29–72% for total organic material and increased from juveniles to adults. Juveniles, then, apparently compensate for a relative inability to assimilate plant food by including a higher percentage of animal material in their natural diets. The ratios of intestine length to standard length (IL/SL) and to intestine diameter (IL/ID) increased rapidly in juveniles and leveled off in adults. The retention time for ingested food items may only be about one-half as long in juveniles as in adults. The combination of observed IL/ID ratios and estimated retention times proved most valuable in the interpretation of ontogenetic changes in feeding habits and assimilation efficiency.

Lassuy, D. R. 1980. Bull. Mar. Sci. 30:304–312.

**REVISION OF THE PANTROPICAL ALGAL GENUS AVRINVILLEA DECAISNE (CODIALES, CODIACEAE). Jeanine Olsen Stojkovich, 1979.**

Eighteen species of *Avrainvillea* are recognized in this revision, a reduction from the previous number of twenty-three. Four species occur only in the tropical Atlantic, while ten species occur only in the tropical Indo-Pacific. An additional three species are common to both provinces. One species is reported from southern Australia.

A thorough morphological study of both habit and internal siphon structure was made. Biogeographic data, type material, fresh collections, and standard herbarium specimens were examined.

Habit is useful as a general guide to identification but is best utilized in conjunction with internal anatomy. Significant macroscopic characteristics include type of holdfast, stipe development, branched or nonbranched habit, gregarious or solitary flabella, and, occasionally, size and color.

Internal structure and pattern of the siphons are the most reliable set of differential criteria. Cylindrical, torulose, moniliform, tortuous, or ta-

pered siphons, combined with rounded, pointed, hooked, or clavate apices, and strongly or weakly constricted dichotomies, contribute to species characterization. Siphon diameter and pseudocortical development are definitely affected by environmental conditions and are not reliable by themselves.

Each species was analyzed for all characteristics. A synonymy, description, discussion, habit photographs, and line drawings are included for each species. A glossary accompanied by microphotographs is also provided.

Comparison of the effects of light and water motion on the morphology of *A. obscura* suggest that water motion plays a more significant role, leading to less consolidated thalli and larger average siphon diameters. Torulose characteristics were not affected in these experiments.

Author's note: a thoroughly revised and corrected version was published:

Olsen-Stojkovich, J. 1985. *Nova Hedwigia* 41:1-68.

GROWTH RATE, ABUNDANCE, AND  
DISTRIBUTION OF THE TOPSHELL *TROCHUS*  
*NILOTICUS* ON GUAM. Barry D. Smith, 1979.

Growth rates of the topshell *Trochus niloticus* Linnaeus on Guam, Mariana Islands, were studied with a mark and recapture method. A total of 598 topshells were tagged, measured, and released. Monthly measurements of the increase in diameter were made to the nearest 0.1 mm. Growth rates were determined on the basis of 322 recaptures. Although considerable variation in growth rates is evident, there is a significant negative correlation ( $r = -0.69$ ,  $p < 0.01$ ) between growth rate and initial shell diameter. A fit of the growth data to the von Bertalanffy equation has the form  $L_t = 146.5[1 - e^{-0.2462(t)}]$ , when  $t_0$  is assumed to be 0.

Spatial distribution and abundance of *T. niloticus* were surveyed at sites characterized by wide reef flats, narrow reef flats, and limestone benches. The low densities ( $<0.1/20 \text{ m}^2$ ) of topshells found on the windward (eastern) side of the island may be related to the low-relief topography of the windward reefs. Mean abundances at various sites on the leeward (western) side of the island ranged from 0.05 to 2.13/20  $\text{m}^2$ . Distinct zonation of size classes of topshells was found for the outer reef flat, reef margin, 6-m contour, and 12-m contour. The size distribution

of *T. niloticus* appears to be related to reef topography.

Smith, B. D. 1987. *Bull. Mar. Sci.* 41:466-474.

THE SHALLOW-WATER HERMIT CRABS OF THE  
MARIANA ISLANDS (DECAPODA, PAGURIDEA:  
COENOBITIDAE, DIOGENIDAE, PAGURIDAE).  
Daniel S. Wooster, 1979.

A collection of shallow-water hermit crabs from the Mariana Islands, representing thirty-three species in nine genera and three families, is described. One new species of *Aniculus* and three new species of *Calcinus* are described and illustrated.

Nearly all of the hermit crab species reported in this paper are new records for the Mariana Islands as little work has been done previously. Considerable range extensions into the tropical western Pacific are reported for the following species: *Aniculus maximus*, *Clibanarius virescens*, *Calcinus imperialis*, *Calcinus* sp. 1, *Calcinus minutus*, *Dardanus crassimanus*, *Orthopagurus harmsi*, and *Pylopaguropsis zebra*.

Wooster, D. S. 1982. *Micronesica* 18:121-162.

PERIPHYTIC DIATOM ASSEMBLAGES ON A  
WINDWARD FRINGING REEF FLAT IN GUAM.  
William J. Zolan, 1979.

Standard microscope slides were placed in tropical fringing reef waters to collect periphytic diatoms. Slides were placed in three areas: the inner reef flat, outer reef flat, and the inner reef flat adjacent to a river channel that cuts through the fringing reef. The slides were placed in the three study areas on a monthly basis from September 1974 through October 1975 (except January 1975) for a 10-day exposure period. Other exposure periods were also tested. The diatoms on the exposed slides were identified and counted until at least 8,000 individuals were sampled. Water samples were collected from the three study areas and analyzed for nitrate-nitrogen, phosphate-phosphorus, silicate-silicon, salinity and turbidity.

The resulting data were used to construct log-normal distributions of number of species versus number of individuals per species for each sample. Also, the species diversity indices, i.e., Simpson's index, Shannon-Wiener index, and the probability of interspecific encounter, were cal-

culated for all samples for comparison. In addition, other community parameters such as maximum diversity, evenness, species richness, rarefaction curves, and others, were determined.

The analyses indicate that there is essentially one diatom assemblage for the reef flat. No significant differences between the three study areas were found in any analyses. However, the outer reef flat had a different predominant diatom species from the inner reef flat study sites and the outer reef flat had the lowest species diversity.

The use of lognormal distributions and species diversity indices of diatom assemblages to monitor environmental quality is not recommended. The natural variability from month to month was such that the assemblage diversity could not be predicted by a particular lognormal distribution or species diversity index value. The quantities of some physical-chemical parameters (especially silicate) on the reef were shown to be dependent upon rainfall activity. However, no correlations between assemblage parameters and rainfall activity were observed.

**ANALYSIS OF BIOFOULING COMMUNITIES ON SETTLING PLATES AT THE PROPOSED OCEAN THERMAL ENERGY CONVERSION SITE OFF GUAM. Dana Marie Rowley, 1980.**

Concrete blocks with plexiglass and PVC settling plates were submerged off Luminao Barrier Reef, Guam. Settling plates were exposed at 6, 12, 24, and 37 m for 37-, 77-, 100-, and 180-day durations. The plates were placed in replicate groups of four in horizontal, vertical, and shaded orientations. Exposed and protected surfaces were examined.

Biomass accumulation increased as the duration of exposure changed from 37 to 180 days for each depth. There was an increased rate of biofouling from 100 to 180 days at 6 m that was not evident at the other depths. Biomass was greatest at shallower depths and decreased as depth increased. Horizontally-placed plates accumulated more biomass than did vertically-placed plates. Exposed horizontal and vertical plates accumulated more biomass than did shaded plates.

Biomass accumulation rates on small plexiglass plates oriented horizontally at 6 m were compared between Guam, the Caribbean, and the Pacific coast of Panama. Guam and the Caribbean had similar rates of fouling accumulation for the first 100 days, but at 180 days the fouling was greater off Guam. The rates of fouling off the Pa-

cific coast of Panama was seven times that off Guam after six months and was probably the result of upwelling of nutrients.

Biomass accumulation on large, vertically oriented, PVC plates submerged off Guam was less than fouling accumulations on asbestos plates set off Hawaii. This difference was presumed to be the result of the variance in faunal representatives between the two areas and the increased nutrients from terrigenous run-off around a large island chain such as Hawaii as compared to Guam.

A set of small plexiglass plates was placed at Western Shoals inside Apra Harbor for 77 days to make a comparison of biomass accumulation between a barrier reef and a lagoon. Fouling accumulated twice as fast on horizontal plates at Western Shoals than on horizontal plates at Luminao. This difference was the result of increased sedimentation and large bivalve populations at the lagoon site.

The proportion of surface coverage increased with exposure duration and decreased with increasing depth. Algae was the predominant cover on exposed surfaces. Protected surfaces had a higher proportion of animals.

Community development, as evidenced through the patterns of surface coverage and changes in diversity of fouling assemblages, was found to be influenced by the intensity of fish grazing. The intensity of grazing was greatest at 77 and 180 days. The grazing activities of herbivorous fish affected the proportions of surface coverage of filamentous and crustose coralline algae. The diversity of fouling assemblages increased with duration of exposure and increased grazing pressures.

**PATTERNS IN THE ABUNDANCE VARIATIONS OF REEF FISHES NEAR AN ARTIFICIAL REEF AT GUAM. Robert Logan Kock, 1980.**

The fish community development on a submerged LCM barge and the variation in fish abundance on permanent transects nearby were surveyed twice monthly for twenty months. During that time there was a steady increase in the abundance of certain fishes on the LCM, i.e., accumulation. Other species exhibited no pattern in abundance change, i.e., nonregular variation, and a few species exhibited a distinct annual pattern in their abundance, i.e., seasonal variation. Most of the seasonal species commenced settlement between March and May.

Some seasonal species were site selective and the study site was an area of particularly high

recruitment. This may explain why roving predators became significantly more abundant at the study area during the months of maximum prey settlement. Larval settlement of several species during the same few months was also important because juveniles were available in abundance as a food source of predators during these few months of the year. The possibility exists that periodic swamping of predators by abundant prey improves the chances for a rarer prey species to survive and to be among the mature fishes later in the year.

Kock, R. L. 1982. Environ. Biol. Fish. 7:121-136.

DISTRIBUTION AND RECRUITMENT OF FORAMINIFERA IN THE FAMILIES ACERVULINIDAE AND HOMOTREMATIDAE IN SHALLOW CORAL REEF ENVIRONMENTS ON GUAM. Russell N. Clayshulte, 1981.

Occurrence and recruitment of adherent foraminiferans were quantified for natural substratum habitats and artificial biofouling surfaces. Species occurrence and recruitment were assessed in lagoon, fringing reef, barrier reef and coral community environments.

Species from the Families Acervulinidae and Homotrematidae are a conspicuous component of epibenthic communities in the upper littoral zone of Guam's leeward coast. Foraminiferal species occurrence, surface coverages and frequencies of occurrence on natural substratum vary between reef zones and habitat types. Species readily recruit to biofouling plates, with species recruitment variable between reef environments. Foraminiferal densities on artificial and natural habitat types are generally less than 1 specimen/cm<sup>2</sup> (10,000 individuals/m<sup>2</sup>). Although adherent species are visually obvious on habitat surfaces, the average total surface coverage is about 1%.

*Planogypsina squamiformis*, *Acervulina inhaerens* and *Gypsina vesicularis* readily recruit to biofouling surfaces after short exposure periods (37-180 days), and they can successfully compete with other benthic taxa, excluding fleshy algae, for space on exposed surfaces. These early successional species, which have encrusting growth forms, are generally not as successful on exposed surfaces after longer exposure periods (>1 yr). The late successional species *Homotrema rubrum*, *Miniacina miniacea*, *Carpenteria utricularis*, *C. monticularis*, *Sporadotrema cylindricum* and possibly *S. rubrum* have a preference for

shaded or cryptic habitat surfaces. *Homotrema rubrum* is the dominant species on reef flat substrata and shows a distinct decrease in density and surface coverage seaward of the reef margin. *Miniacina miniacea* is the principal species on reef slope habitats where it can successfully compete for space with calcareous algae and other benthic encrusters. *Carpenteria utricularis* occurs on most substratum types in all reef environments. Specimens of *S. cylindricum* are usually found on cryptic surfaces, particularly in the reef margin zone, as massive "pseudo-colonies."

EFFECTS OF CHLORINE-INDUCED OXIDANTS ON SELECTED INSHORE ORGANISMS AROUND GUAM. Bruce R. Best, 1981.

Static 96-hr controlled temperature bioassay systems were developed, with NaOCl as a chlorine source, to investigate the effects of single doses of chlorine-induced oxidants (ClO) on the phytoplankters *Chaetoceros gracilis* and *Dunaliella tertiolecta*, plutei of the urchin *Echinometra mathaei*, the hermit crab *Clibanarius humilis*, and two species of fish — the mullet *Chelon engeli* and the cardinalfish *Apogon lateralalis*.

LC50- and LT50-values were interpolated by log-probit analysis. Results indicate that the phytoplankters were affected at concentrations as low as 0.09 ppm ClO (28 °C 96-hr LC50), the fish at around 0.2-0.3 ppm (30.1 °C 96-hr LC50) followed by the plutei at 0.2-1.0 ppm (for 48- and 96-hr LC50s at temperatures from 28 to 33 °C). The LC50s for the hermit crabs were above 2.4 ppm for temperatures of 27.8 and 31.6 °C. LT50 data for fish indicate a fast response (<3 hr) to the toxic effect of introduced chlorine compared to the general response by other nonvertebrate organisms of increased mortality with increased exposure time.

Best, B. R., R. Braley, J. A. Marsh, Jr. & D.B. Matlock. 1982. Proc. 4th Intl. Coral Reef Symp. 1:169-172.

REPRODUCTIVE PERIODICITY IN THE INDIGENOUS OYSTER *SACCOSTREA CUCULLATA* IN SASA BAY, APRÁ HARBOR, GUAM, WITH REFERENCE TO CULTIVATION. Richard Donald Braley, 1981.

The *Saccostrea cucullata* population in Sasa Bay underwent low-level continuous reproduction with three main peaks per annum. Spawning activity occurred in November-December, March-April, and late June. Gametogenic cycles

took 3–4 months to complete. Histological examinations revealed the general trend of gametogenesis to be similar for both sexes, although they were not always in synchrony. Partial spawning with resorption of unspawned gametes was the general rule. Neither temperature, salinity, turbidity, nor climatological parameters appeared to be exogenous clues for spawning. Evidence of lunar periodicity in spawning was not apparent from histological examinations.

Peaks in spat collection generally followed peaks in gonad ripeness by one month or less which indicates that the planktonic larval period lasts about 3–4 weeks. There were significant differences in the abundance of spatfall between sites but not between collector types. Metamorphosing larvae preferred concave surfaces over convex.

Oyster larvae were a major component of bivalve larvae taken in zooplankton tows. Main peaks of larval abundance were in May, October, and November–December. The relative abundance of oyster larvae in the vicinity of an oil spill was reduced for several months. Histological examinations of adult oysters taken near the oil spill site revealed an occurrence of 0.77% sex-reversal/hermaphroditism pre-spill and 2.78% post-spill.

Braley, R. D. 1982. Mar. Biol. 69:165–173.

THE DISTRIBUTION AND ABUNDANCE OF *NERITA Plicata* IN A TROPICAL, ROCKY INTERTIDAL HABITAT. Thomas L. Smalley, 1981.

On Guam, the herbivorous gastropod *Nerita plicata* is one of the most common and widely distributed organisms of the high rocky intertidal habitat. This species is commonly found on windward and leeward shores and occurs in the greatest abundance on semiprotected horizontal shores. Distribution patterns within and between shores, however, are patchy.

Although *N. plicata* exhibited a clumped dispersion pattern at Ylig Bay, daily distribution patterns are constantly in a state of flux in relation to the tidal cycle. At high tide individuals aggregate immediately above the water line, in the littoral fringe, whereas at low tide they occupy a relatively narrow zone above the water line in the high intertidal zone.

Furthermore, distribution and abundance of *N. plicata* varied significantly along the shore in relation to structural complexity as well as over

time in relation to daily and seasonal variation in meteorological and sea conditions.

Reproductive aspects such as structure of the egg capsule and position of capsule deposition on the shore in relation to substrate topography and physical factors are similar to those described for other members of the family. Sex ratios did not deviate from the expected 1:1 ratio for the four smallest size classes ( $\leq 5.0$ , 5.1–10.0, 10.1–15.0, 15.1–20.0 mm). The largest size class ( $\geq 20.1$  mm), however, differed significantly from the expected ratio in favor of males (3.1:1).

Growth rate of *N. plicata* varied considerably among individuals as well as within an individual over a number of months. A significant negative correlation existed, however, between growth rate and initial shell diameter.

The results of field observations and experiments (transplanting with and without predator-exclusion cages) suggest that predation may play a less significant role in setting the lower limit of high intertidal gastropods than has been previously suspected.

Smalley, T. L. 1984. Mar. Ecol. Prog. Ser. 14:138–144.

FEEDING BIOLOGY OF THREE HALALOCARCINID CRAB SPECIES. Roy K. Kropp, 1981.

The maxillipeds of three hapalocarcinid crab species — *Hapalocarcinus marsupialis*, *Pseudocryptochirus kahe*, and *Favicola rugosus* — previously thought to be filter feeders, were found to have long simple, serrate, or long spinose setae; not the plumose setae required for filter feeding. *P. kahe* was observed to obtain food by picking debris from the border zone around the pit, inside the pit itself, or from the coral surface. It also used its chelae to scoop mucus to the mouth. *F. rugosus*, by using a criss-cross chelae pattern, collected mucus and debris into a bolus which was eventually transferred to the mouth. *H. marsupialis* gathered mucus by rapid fanning of the third maxillipeds and by scratching the dactyls of its walking legs against the coral surface. Physiological studies were used to calculate O:N ratios of 121.1 for *H. marsupialis* and 62.4 for *P. kahe*. These high ratios indicate that the diet of each crab was high in carbohydrate and low in protein. The difference between the two relates to habitat-related food differences — *P. kahe* consumed mucus which was more likely to have accumulated debris. Mucus consumed by these crabs was not a metabolic drain on the coral because it is

sloughed off normally as a part of the sediment-rejection system of the coral.

AGONISTIC BEHAVIOR OF THE FRESHWATER PRAWN *MACROBRACHIUM* LAR IN RELATION TO SIZE AND SEX. Terry John **Donaldson**, 1981.

The agonistic behavior of the freshwater prawn *Macrobrachium* lar was measured to determine whether or not differences in size, weight, and sex between opponents influenced its expression. Data were collected during 10-minute dyadic encounters of male-male, male-female, and female-female pairings. Individual aggressive and submissive acts were described and their frequencies of occurrence recorded. An agonistic index, consisting of the total number of aggressive acts committed per individual per match divided by the total number of aggressive and submissive acts per individual per match, was calculated for individuals for each match as a measure of agonistic behavior. Other measures of agonistic behavior were recorded, including the number of bouts per match, the fighting response latency per match, and the accumulated attack time per match. Additionally, records of matches won by large opponents in dyadic encounters were recorded.

No significant correlations of differences in either the carapace length or weight with agonistic index, the number of bouts per match, the fighting response latency or the accumulated attack time could be determined. The relations between the accumulated attack time and weight and the fighting response latency and the number of bouts per match were correlated for male-male and female-female pairings respectively. A significant difference was found between male-male, male-female, and female-female matches in the mean values of the agonistic index. No significant difference could be determined for mean values of the number of bouts per match, the fighting response latency, or the accumulated attack time. Individual aggressive and submissive acts were quite variable within groups. Larger animals did not have significant advantage in winning success in intrasexual encounters but they did in intersexual encounters. Differences in the agonistic index were found between winners and losers, winners having a high mean agonistic index value with little variation while losers had a low mean agonistic index value with considerable variation.

THE EFFECTS OF LAND-CLEARING ON A SMALL WATERSHED IN SOUTHERN GUAM. Clifford P. **Neubauer**, 1981.

Hand-clearing of a forested ecosystem in southern Guam had significant effects on some aspects of the limnology of the river flowing through the perturbed area compared to that of the upstream control area. Significant differences in soil temperatures, maximum and minimum air temperatures, water temperatures, conductivity, pH, hardness, total phosphorus, and orthophosphate concentrations between the control and experimental area were found, with no significant differences in nitrate concentrations and turbidity between stations.

Mean maximum air and water temperatures of the experimental area were 1.4 °C less than that of the control area. The mean minimum water temperature of the experimental area was 2.0 °C greater than the control area. The mean soil temperature at 0.3 m depth of the experimental area was 0.7 °C greater than that of the control area. Mean conductivity and hardness values of the experimental area were 11.0  $\mu\text{mhos}/\text{cm}^2$  and 9.0 mg/l less than those of the control area, respectively. The pH of the water for the experimental area was 0.22 pH unit greater than that of the control area. Mean total phosphorus concentration of the experimental area was 8.15  $\mu\text{g}/\text{l}$  less than that of the control area. The mean orthophosphate concentration of the experimental area was 1.64  $\mu\text{g}/\text{l}$  less than the control area. Nitrates and phosphates appeared to be leached to the river in pulses with the onset of precipitation.

LONG-TERM RECOVERY PROCESSES OF A CORAL COMMUNITY AFTER A CATASTROPHIC DISTURBANCE. Mitchell Willard **Colgan**, 1981.

The 1968–1969 outbreak of *Acanthaster planci* at Tanguisson Reef, Guam, caused a catastrophic mortality of corals. The subsequent recovery was examined from data collected in 1970, 1971, 1974, 1980 and 1981. Four categories of survivors were found: 1) corals in turbulent shallow water habitats, 2) corals which were not the preferred food of *Acanthaster*, 3) living patches of partially eaten colonies and 4) small colonies located in cryptic interstices. Nonrandom recruitment of corals was the primary factor determining the eventual distribution of adult colonies. Zones were established through the settlement of juvenile corals and were further differentiated by the positive correlation between the abundance of



adult and juvenile conspecifics. The contagious distribution pattern developed as a result of the strong associations between adults and juveniles within localized areas. The feeding preferences of *Acanthaster* were determined and an analysis of coral community structure showed a shift from predominance of nonpreferred prey in the early years after the *Acanthaster* disturbance to a prevalence of preferred prey species as the recovery of the coral community progressed. The recovery of the coral community was facilitated by the presence of patches of surviving corals as well as the continued structural integrity of the reef.

**EFFECTS OF FISHING PRESSURE ON THE REEF FLAT FISHERIES OF GUAM.** Stephen Eugene Katnik, 1982.

To demonstrate the impacts of reef flat fishing pressure, comparisons of the fishery catch and effort data and the standing stock densities of fished species were made on three pairs of reef flats on Guam. Members of each reef flat pair were comparable physiographically but differed in the amount of fishing effort to which they were subject. Comparisons revealed lower standing stock densities, lower catch rates, generally smaller sized fish in the catch, and the reduction of certain large carnivores in the catch on the heavily fished reefs. The results suggest that overfishing has occurred on the heavily fished reefs. Schaefer surplus production curves constructed from the catch and effort data of the three reef flat pairs indicated that decreased effort on the heavily fished reefs and increased effort on the lightly fished reefs would result in increased yields. Differences in the size and shapes of the Schaefer curves among the three types of reef flats indicate that the potential yields and optimal levels of effort vary depending on the intrinsic characteristics of the reefs. Although highly preferred fishes from a variety of trophic levels were affected by the fishing pressure, it was the larger bodied carnivores that were most influenced. Certain preferred fishes, such as the siganids, seemed to be unaffected by fishing pressure, whereas the undesired species, *Scolopsis cancellatus*, exhibited higher densities on the heavily fished reefs. Heavy fishing pressure did not seem to affect recruitment rates significantly. In light of the various signs of overfishing on some of Guam's most accessible reef flats, management measures which would increase reef flat productivity are discussed.

**TAXONOMIC USE OF PHYCOBILIPROTEIN ELECTROPHORETIC BANDING PATTERNS FROM THE RHODOPHYTA OF GUAM.** Charles J. Romeo, 1982.

Twenty-one species of algae representing five orders of Rhodophyta from Guam were compared for their phycobiliprotein absorption spectra and electrophoretic banding patterns. All species contained R-phycoerythrin with absorption maxima at 565 nm greater than 498 nm. Absorption in the 540 nm region occurred as a distinct peak, a plateau, or a shoulder depending on the species examined, and this was used to define three spectral types. Polyacrylamide gel electrophoresis of phycobiliproteins resulted in approximately ten different banding types for R-phycoerythrin. Species appeared fixed for their R-phycoerythrin banding pattern, making this protein marker useful as a species characteristic. There were no consistent banding patterns within the orders of Rhodophyta and it appeared unlikely that R-phycoerythrin banding patterns were useful in higher order systematics above the species and, perhaps, genus level. Subunit molecular weight determinations by sodium dodecyl sulfate gel electrophoresis of isolated R-phycoerythrins demonstrated characteristic  $\alpha$ ,  $\beta$ , and  $\gamma$  molecular weights. Considerable variation in subunit molecular weights was evident.

Matlock, D. B. & C. Romeo. 1982. Proc. 4th Intl. Coral Reef Symp. 2:415-417.

**PHOTOSYNTHESIS AND RESPIRATION OF TWO SPECIES OF RED ALGAE, GRACILARIA ARCUATA AND GRACILARIA EDULIS, FROM GUAM.** Spensin James, 1982.

Rates of photosynthesis and respiration were determined for *G. arcuata* and *G. edulis* at temperatures of 0 °, 20 °, 30 °, and 40 °C and salinities of 10, 20, and 30‰. The photosynthetic rates changed from 1.5 to 45.5  $\mu$ l oxygen/g dry wt/min. The photosynthetic rates were not significantly affected by salinity but increased with an increase in temperature. Both species showed maximum rates of photosynthesis at 40 °C, the highest temperature tested. Rates of respiration were unaffected by salinity. Respiration rates changed from 1.3 to 25.6  $\mu$ l oxygen/g dry wt/min.

The photosynthetic rates of *G. arcuata* and *G. edulis* at 28.5 °C and 33 °C under a range of irradiances showed an increase in net oxygen production by each species above saturating irradiances as the temperature increased. The



saturation points occurred at  $230 \mu\text{E}/\text{m}^2/\text{sec}$  for both species.

The results indicate that these species could be cultivated in environments of high temperature and over a wide salinity range.

**EFFECT OF SUBSTRATE AND LIGHT ON GROWTH AND DISTRIBUTION OF TERPIOS, AN ENCRUSTING SPONGE WHICH KILLS CORALS. Gyongyi Plucer-Rosario, 1983.**

The effects of light and substrate on the growth and distribution of *Terpios* was demonstrated at three locations on Guam's reefs. *Terpios* grows fastest on clean substrates followed by live coral, reef rock and red calcareous algae. Growth on these substrates is often intermittent as *Terpios* typically exhibits periods of growth followed by long periods without growth. *Terpios* encrusts *Montipora* and *Porites* colonies less frequently than would be expected by chance. This favors the relative abundance of these corals in comparison with abundances of corals which *Terpios* encrusts more frequently. *Terpios* is sometimes overgrown by *Montipora*, *Porites*, and red calcareous algae. Reef rock may harbor organisms which inhibit *Terpios* growth.

Light does not affect *Terpios* growth or distribution except in limiting it to illuminated areas of the photic zone on reefs. The growth of *Terpios* does not vary with months between September and June. Senescence and death of *Terpios* follows a distinct succession of conditions. *Terpios* is able to form bridges of tissue from one coral branch across open water to another coral branch and is also able to generate a new colony from a small fragment.

*Terpios* is probably a fast-growing competitor of corals for space rather than a predator of corals. *Terpios* overgrows most hard stable reef substrates, and the growth rate on all sample substrates is substantial. This demonstrates that *Terpios* has a great potential for covering a reef. *Terpios* may influence more of a reef over the long run than does *Acanthaster planci*, indicating that *Terpios* may be one of the most important causes of coral reef disturbances.

Plucer-Rosario, G. 1987. Coral Reefs 5:197-200.

**POTENTIAL IMPACT OF A PROPOSED STACK GAS SULFUR SCRUBBER ON GRACILARIA ARCUATA (RHODOPHYTA). David E. Pendleton, 1983.**

*Gracilaria arcuata*, a benthic macroalga, was selected as an indicator organism prior to a pro-

posed pollution discharge. The relative abundance, distribution and productivity of this red alga in the outfall area were determined by field and laboratory studies. A bioassay was conducted to evaluate the potential impact of a proposed power plant stack gas sulfur scrubber on *Gracilaria*.

The total *Gracilaria* biomass in the proposed effluent outfall area was estimated to be 106,000 kg. Little change in abundance and distribution was observed over a 16-month period. Estimates of the energy contribution of *Gracilaria* productivity in the outfall area were 8.6 and  $8.7 \times 10^5$  kcal per day, based on respirometry and growth studies, respectively.

A bioassay showed that pilot scrubber effluent concentrations of 25% or greater resulted in significantly lower *Gracilaria* growth. Concentrations of 50% or greater resulted in significantly lower photosynthetic rates. Most of the outfall area would be subjected to at least 67% effluent if a full-scale scrubber is built. Therefore, the likelihood of complete decimation is high.

Similar results were found between field population productivity estimates made with an oxygen probe for large seaweed clumps in a large chamber, and productivity measurements made with a manometric, multiple chamber Gilson respirometer for small sprigs.

**GENETIC VARIATION IN MACROBRACHIUM LAR ON GUAM. Gretchen R. Grimm, 1983.**

Vertical polyacrylamide gel electrophoresis was used to assess protein variation in three stream subpopulations of the freshwater prawn *Macrobrachium lar*. Homogenates of tail muscle tissue were examined.

Twelve enzymes and 19 loci were determined to be under independent genetic control. Four loci exhibited genetic variation. Each stream subpopulation was polymorphic at 21.1% of the loci examined. Mean heterozygosity per locus ranged from 6.6% to 11.9%; mean heterozygosity per individual ranged from 10.1% to 13.3%. Genetic heterozygosity is evenly distributed among the subpopulations studied. Slight differences in frequency of loci could have been attributed to genetic drift. Estimates of genetic similarity and genetic distance also indicated that the subpopulations were part of a panmictic population.

SEASONAL AND ANNUAL VARIATION OF CORAL-REEF FISHES ON THE UPPER REEF SLOPE AT GUAM. Michael E. Molina, 1983.

Coral-reef fishes were monitored monthly at four upper reef-slope depths (5, 9, 18 and 30 m) at two locations at Guam between September 1979 and November 1980. Overall fish density increased markedly at all depths during the spring and summer months, corresponding to the onset of the rainy season and the diminishing of the tradewinds. Maximum abundances were recorded between May and July. A less pronounced increase in fish abundance occurred in the fall. Most of the observed seasonal variation in fish abundance resulted from juvenile recruitment and the movements of subadults and adults of a relatively small group of abundant species at each depth. Planktivores, piscivores and benthic-invertebrate feeders, primarily in deeper water, were largely responsible for the spring/summer peak, while the fall increase was significantly influenced by herbivorous fishes at shallower depths. Fluctuations of fish abundance may be related to variations in the availability of food resources. Climatological and oceanographical phenomena may have favorably influenced food resource availability as well as reproductive success during certain months. Estimates of site- and depth-related annual variation in fish abundance and species composition of 35 ubiquitous fish species indicated relative constancy over extensive areas of reef. Fish species richness was found to be greatest at 18 m. An explanation for this trend in species richness based on the "intermediate disturbance hypothesis" is offered.

THE COMPARATIVE ECOLOGY OF THE SHALLOW-WATER SPECIES OF CANTHIGASTER (FAMILY TETRAODONTIDAE) OF GUAM. Robert F. Myers, 1983.

The utilization of resources of food and space and possible mechanisms of avoiding competitive exclusion among sympatric species of *Canthigaster* were investigated. Species of *Canthigaster* were not homogeneously distributed between habitats or within habitats. One species, *Canthigaster solandri*, occurred in all habitats investigated and was the most abundant species in each habitat. Seven other species were variously encountered less frequently and in fewer habitats than *C. solandri*. For every possible species pair, one species was consistently found in one or more habitats not inhabited by the other, and many

were entirely separated spatially. Some species utilized microhabitats rarely exploited by congeners occurring in the same habitats.

The only relevant morphological difference between species is a significantly shorter gut in *Canthigaster epilampra*, the only species that fed primarily on animals.

All species fed on a wide variety of both plant and animal food. Although there were few notable qualitative dietary differences among species based on frequency of occurrence of diet categories, numerous and consistent quantitative differences were found. Each species consistently fed on one or more diet categories absent, or nearly absent, in the diets of its congeners. Diet differed significantly between most species, but not between individuals of the same species from different habitats, indicating that species-specific selectivity of certain diet items may be more important than differences in food availability between habitats. Diet differed less between individuals of different species collected in the same habitat and site than between all individuals of different species collected. The interspecific differences in niches may reduce competition between species.

TWO-YEAR STUDY OF TEMPORAL VARIATION IN ZOOPLANKTON COMMUNITIES IN AN INNER REGION OF APR A HARBOR, GUAM. Ann Hillmann-Kitalong, 1983.

A two-year survey of zooplankton was conducted in a partially enclosed region of Apra Harbor, Guam. Significant ( $p < .001$ ) temporal (annual, seasonal, lunar, diurnal) variations and cross-areal variations in the abundances of selected zooplankters (*Cresius acicula*, *Orbulina universa*, *Armandia intermedia*, *Perinereis cultrifera*, *Sagitta enflata*, *Lucifer chacei*, *Acartia clausi*, an *Acetes* sp., a *Leptocarpus* sp., fish larvae, fish eggs, a crab zoea, and a shrimp mysis) were found. Significant ( $p < .001$ ) biological and physical correlations between these zooplankters were also found.

The composition of the holoplanktonic species represents a typical coastal community, consisting of relatively few genera. The predominant holoplanktonic species in this study are well represented throughout the Indo-Pacific. However, the mean annual dry weight of zooplankton in this study was less than that of other tropical Indo-Pacific areas.

Significant seasonal variation was found for ash-free dry weight, which was strongly correlated

with *Cresius acicula*. Crab zoeae, *Sagitta enflata*, and shrimp mysis also showed significant seasonal variation. Total zooplankton abundance and biomass were highest in February and March as has been found in other Indo-Pacific studies. Most individual species or groups of zooplankton showed no consistent seasonal peaks in abundances.

*Perinereis cultrifera* was significantly more abundant at new moon, *Armandia intermedia* at full moon, crab zoeae at the third and last quarters of the moon, and *Lucifer chacei* at new moon. In four 24-hour studies, *Acartia clausi* was significantly more abundant at 0700–0900, *Sagitta enflata* at 0200–0400, fish larvae at 0200–0400, and shrimp mysis at 1800–2000.

Rainfall showed significant correlations with more zooplankters than did any of the other physical variables examined. *Acartia clausi* and *Sagitta enflata* were significantly correlated with each other. However, no exogenous factor was correlated with peaks in total biomass or abundances of the total zooplankton.

Hillman-Kitalong, A. & C. Binkeland. 1987.  
Mar. Ecol. Prog. Ser. 38:131–135.

THE FRESHWATER RED ALGAE (RHODOPHYTA) OF GUAM, PALAU, AND TRUK: A BIOGEOGRAPHICAL, ECOLOGICAL, AND DISTRIBUTIONAL ACCOUNT. W. Austin Bowden-Kerby, 1984.

Streams and springs of Guam, Palau, and Truk were extensively sampled for freshwater red algae. At least fifteen species of Rhodophyta from eight genera were found: *Audouinella* (number of species undetermined), *Batrachospermum* (six species), *Bostrychia* (one species), *Compsopogon* (one species), *Compsopogonopsis* (one species), *Hildenbrandia* (one species), *Nemalionopsis* (two species), and *Thorea* (two species). Twelve of these species are new records for Micronesia.

As many as six undescribed species of *Batrachospermum*, one undescribed species of *Compsopogon*, one undescribed species of *Thorea*, and one undescribed species of the genus *Nemalionopsis* (the second species of this genus) were found. Many of these species are thought to be endemic to the island where found.

*Thorea gaudichaudii* Agardh and *Thorea violacea* Bory (a species found outside Micronesia) are proposed as relict species because of their widespread occurrence and confinement on vol-

canic islands. These are the first freshwater algae to be proposed as relict species.

The freshwater Rhodophyta of Micronesia are limited to very restricted habitats, typically occurring along only a few meters of rocky streambed, and with the exception of *Bostrychia* (a marine intruder of freshwater), usually confined to headwaters and springs. These freshwater genera are usually found together and often intermingled in these restricted habitats. Such associations of freshwater red algae have been reported from only two other locations worldwide.

In sites where repeated collections were made over a three-to-four-year period, all Rhodophyta were perennial.

Guam has the least diverse rhodophyte flora, lacking *Compsopogon*, *Compsopogonopsis*, *Hildenbrandia*, and *Nemalionopsis*, or half of the genera of Micronesian freshwater red algae. Although the freshwater red algal habitat of Guam is roughly equal in area to that of Palau and Truk, the much lower ratio of this habitat to the total land area of Guam is proposed as a factor inhibiting the successful deposition of these algae into proper habitats by migratory aquatic birds. A biogeographic barrier to north-south transport of Rhodophyta along the Japanese-Marianan Flyway is proposed, the result of predominately unsuitable habitats of the Marianas interfering with the transport of algal dissemules.

A global biogeographical overview of the freshwater Rhodophyta is presented, and previously unpublished records from Hawaii, New Zealand, and the Philippines are also included.

Kumano, S. & W. A. Bowden-Kerby. 1986. Soru (Jpn. J. Phycol.) 34:107–128.

EFFECTS OF NITROGEN EXCRETION BY THE DAMSELFISH *DASCYLLUS ARUANUS* ON THE GROWTH RATE OF THE CORAL *ACROPORA ASPERA*. Timothy S. Sherwood, 1985.

The effects of nitrogen excretion by the humbug damselfish *Dascyllus aruanus* on the growth of the coral *Acropora aspera* were studied. Growth experiments were conducted by the placement of coral colonies in tanks with and without resident fish. Experiments were also conducted to find the effects of nitrogen, at the levels excreted by the damselfish, on the rates of respiration and photosynthesis.

It was found that the presence of resident fish increased the growth of the coral *Acropora aspera*. It was also shown that corals in seawater enriched

to 10  $\mu\text{M}$   $\text{NH}_4^+-\text{N}$  exhibited higher rates of gross photosynthesis and respiration than those in unenriched seawater. These results support the hypothesis that resident fishes stimulate coral growth by increasing the amount of regenerated nitrogen available to the coral.

**BURROW DEFENSE IN THE SEA URCHIN  
ECHINOMETRA MATHAEI (BLAINVILLE) ON AN  
INDO-WEST PACIFIC REEF FLAT. James Bruce  
Neill, 1985.**

Burrow defense of the rock-boring echinoid *Echinometra mathaei* (Blainville) was investigated in two different reef-flat habitats on Guam (Mariana Islands). Outer reef-flat inhabitants more commonly defend resident burrows than do individuals occurring in the inner reef flat. Urchins transplanted from the outer reef flat to the inner reef flat do not alter defensive tendencies. Individuals transplanted from inner reef-flat regions to the outer reef flat do not defend burrows. Recolonization rates of empty burrows in inner reef-flat regions are five times higher than in outer reef-flat regions. Burrow colonists range in maximum test diameter from 1.6 cm to 4.9 cm. Residents of the outer reef flat are unable to retain occupied burrows in the presence of larger intruders. Behavioral differences in burrow defense provides evidence supporting the splitting of *E. mathaei* into two species.

Neill, J. B. 1987. Bull. Mar. Sci. 41:92-94.

———. 1988. J. Exp. Biol. Ecol. 115:127-136.

**REPRODUCTIVE PATTERNS OF THREE  
ECONOMICALLY IMPORTANT SURGEONFISH  
SPECIES ON GUAM. Gerald W. Davis, 1985.**

The reproductive patterns of three species of surgeonfish, *Acanthurus triostegus*, *Acanthurus lineatus*, and *Naso lituratus*, were determined from collections made during 16 night spear-fishing trips over an 8-month period. No seasonal or lunar patterns of fish spawning were found during the study period. The low percentage of spent individuals and the lack of peaks in gonad weight and in number of individuals within size classes exhibited during all collection periods indicate that these species spawn throughout the year. The cumulative size-specific reproductive capacity for each species was determined. This relationship can be used to select minimum size limits for harvesting that will protect a desired level of reproductive capacity.

**EFFECTS OF DIFFERENT HABITATS ON  
MORPHOLOGICAL VARIATION WITHIN  
NATURAL POPULATIONS OF THREE REPORTED  
SPECIES OF DICTYOTA (PHAEOPHYTA). Tom S.  
Potter, 1986.**

Three species of tropical Phaeophyta in the genus *Dictyota* have been traditionally grouped taxonomically on the basis of morphology. However, the morphologies of these algae have been reported in the literature to be highly variable and on Guam they have been observed to vary considerably in different habitats. In this field study, the species *D. friabilis*, *D. cervicornis*, and *D. bartayresii* were recognized in Guam waters to be ecomorphs of a single species. The different growth morphologies and subsequent zonation of *D. friabilis*, *D. cervicornis*, and *D. bartayresii* were found to be influenced primarily by habitat, with water motion as the major environmental parameter differing in these habitats. In situ transplantation of individuals transformed one species (or growth form) into another.

Assessment of environmental parameters seemed to indicate that changes in water current were related to the generation of morphological variation between species and to the transformation of one growth form into another. Since significant taxonomic differences were not found to exist between the Guam specimens of *D. friabilis*, *D. cervicornis*, and *D. bartayresii*, and since the latter has priority, the others have been placed in synonymy under it. In addition, some aspects of the seasonality of these algae have been examined.

**BROWSING PATTERNS OF HERBIVOROUS FISHES  
IN A HALODULE UNINERVIS SEAGRASS BED OF  
A PACIFIC ISLAND CORAL REEF (GUAM,  
MICRONESIA). Paul D. Gates, 1986.**

Browsing patterns of herbivorous fishes were investigated in a seagrass bed (*Halodule uninervis*) near Guam (Micronesia). Artificial reefs of three sizes were set out to determine 1) if browsing is greater around reefs than in the open seagrass, and 2) if browsing pressure is related to reef size. Browsing levels around the two smaller reefs were similar to that recorded in the open seagrass. Fish browsing activity was greater around the largest reef, and a nearly barren sand halo was created within 80 days. Changes in hydrography due to the presence of the largest reef was not a factor in halo formation. Fishes were also demonstrated to concentrate browsing in sheared

areas which were similar to developing sand halos. Seagrass preference experiments tested whether fishes preferred epiphytized or nonepiphytized blades of *Halodule uninervis*. The results indicated that fishes overwhelmingly preferred nonepiphytized blades. When sheared-area and preference results are considered collectively, it is apparent that browsers preferred younger *Holodule* blades. These results are supported by foraging theory. Halo formation is discussed in terms of reef-size threshold and browser preferences for nonepiphytized seagrass.

EFFECTS OF POST-HARVEST HOLDING CONDITIONS ON THE QUALITY OF AGAR EXTRACTED FROM TWO SPECIES OF GRACILARIA (RHODOPHYTA) FROM GUAM. Susanne de Crinis Wilkins, 1986.

Post-harvest holding conditions significantly altered the quality of agar extracted from *Gracilaria* thalli. Thalli held in darkness produced gels with greater strengths than those exposed to light. However, in unenriched systems there was no improvement in gel strengths of agar extracts in relation to those from recently harvested thalli. The most dramatic improvements in gel strength were produced with weekly 1-h exposure to nitrogen enrichment. Post-harvest enrichment of thalli with 750  $\mu$ M nitrogen resulted in extracts with greatest gel strength. There was a significant correlation between gel strength and thallus nitrogen levels for thalli in the enriched post-harvest treatment. Additional physical characteristics of agar (agar yield, dynamic gelling temperature, relative viscosity, and ash content) were not correlated with gel strength.

DIET AND ASSIMILATION EFFICIENCY OF THE SURGEONFISH ACANTHURUS LINEATUS (PISCES, ACANTHURIDAE) ON GUAM. Ahser E. Edward, 1986.

Diets and assimilation efficiencies of 3 size classes of *Acanthurus lineatus* from Agat Bay, Guam, were investigated. Analysis of stomach contents revealed that these fish ingested a wide variety of algae. Species of Rhodophyta formed the bulk of the diet. *Hypnea* sp. had the highest relative abundance in the stomachs of all size classes. Among the algal types, filamentous algae were the most preferred, while calcified were the least preferred.

Organic assimilation efficiencies ranged from 29 to 35% and were similar between size classes.

Likewise, ash contents of algae and fecal materials were similar between size classes.

DISTRIBUTION AND PRODUCTION DYNAMICS OF BENTHIC INVERTEBRATES IN A TROPICAL STREAM ON GUAM. Leigh Ellis-Neill, 1987.

The factors influencing the distribution of benthic invertebrates in the Pigua River, Guam (Mariana Islands) were investigated. Current velocity, substrate particle size, seasonality and amount of leaf litter were found to be important parameters in the distribution of stream invertebrates. The secondary production of the dominant atyid shrimps was used as an indicator of the relationship between the shrimps and their habitat. Secondary production rates varied significantly between sampling sites. This variance was correlated with differences in secondary production in pool and riffle sites. No correlation was found between secondary production and substrate particle size.

THE DISTRIBUTION AND ABUNDANCE OF HOLOTHURIANS IN SAIPAN LAGOON, MARIANA ISLANDS. Ravi Chandran, 1988.

The distribution of holothurian species in Saipan lagoon was studied and the factors affecting their presence were analyzed. A total of eleven species of holothurians were found in the three types of habitats studied including nearshore sea grass beds, midlagoon sand flats, and outer rocky reef margins. Holothurian species show distinct habitat preferences, with species diversity and abundance of individuals being inversely proportional to distance from shore. Diversity and abundance were greatest in the nearshore sea grass beds, and lowest in the midlagoon sand flats. *Holothuria atra* occurred in near shore grass beds, midlagoon sand flats and outer rocky reefmargin zones. *Bohadschia marmorata* was found predominantly in high energy rocky reef margin areas where wave action was strong. Temperature and sediment grain size seem to play a role in the habitat selection of *Holothuria leucospilota*. *Holothuria atra*, an edible species, occurred in harvestable quantities. Large numbers of juveniles of *H. atra* were found, for the first time, in nearshore *Halodule uninervis* sea grass beds. *Stichopus chloronotus* was found in the nearshore grass beds and the rocky outer reef margin zones, and showed partial separation of habitats when present along with *Holothuria atra*. No predators of holothurians were found.

CHEMICAL DEFENSES IN THREE SPECIES OF  
 SINULARIA (COELENTERATA, ALCYONACEA):  
 EFFECTS AGAINST THE PREDATOR CHAETODON  
 UNIMACULATUS (PERCIFORMES). Chad R.  
 Wylie, 1988

The butterflyfish *Chaetodon unimaculatus* feeds selectively on the soft corals *Sinularia* sp., *S. polydactyla*, and *S. maxima* located on a Cocos Lagoon patch reef in Guam. *Sinularia* sp. is the most preferred, while *S. maxima* is the least preferred. Secondary metabolites, functioning as feeding deterrents, were hypothesized as a major determinant of *C. unimaculatus* feeding preferences. Types and concentrations of terpenoid secondary metabolites varied among the 3 species of soft corals. Organic extracts were not deterrent at whole colony concentrations (3–7% dry wt.); however, all extracts were feeding deterrents at concentrations of 20% dry weight and the *S. polydactyla* extract was deterrent at 10% dry weight. Actual extract concentrations in the tips of *Sinularia* sp. (12% dry wt.) were lower than the concentration which causes feeding deterrence, while the extract concentration in *S. maxima* tips (28% dry wt.) was higher. Chemical feeding deterrents help to explain preferences for these 2 soft corals but not for *S. polydactyla*. Comparisons between extracts of any 2 species showed no significant differences in deterrence when tested at the same concentrations. No significant differences in deterrence were found between grazed and ungrazed colony extracts. Nonpolar terpenoid hydrocarbon fractions were also not deterrent at whole colony or tip concentrations. A major cembranoid di-terpene isolated from *S. maxima* was deterrent only at the concentration found in the tips (12% dry wt.). Sclerites as structural defenses appear to be of little importance in determining the soft coral preferences of *C. unimaculatus*. *Sinularia* secondary metabolites were very effective in deterring other fish predators in the field. Thus, *C. unimaculatus* seems to have an unusual tolerance to the secondary metabolites of *Sinularia* enabling this fish to exploit a food source unavailable to most other marine organisms.

Wylie, C. R. & V. J. Paul. 1989. J. Exp. Mar. Biol. Ecol. 129:141–160.

ASSIMILATION OF EPIPHYTIZED AND  
 NONEPIPHYTIZED BLADES OF THE SEAGRASS  
 HALODULE UNINERVIS BY THE HERBIVOROUS  
 RABBITFISH SIGANUS ARGENTUS (QUOY &  
 GAIMARD). Herling R. Sanger, 1989.

The utilization of epiphytized and nonepiphytized forms of the seagrass *Halodule uninervis* as

a nutrient source by the rabbitfish *Siganus argenteus* was investigated. *Siganus argenteus* did not show a preference for either type of seagrass blades. *Siganus argenteus* assimilated proteins from epiphytized seagrass (90.7%) at a significantly higher efficiency than from nonepiphytized seagrass (50.5%). The caloric assimilation efficiencies for epiphytized blades (24.7%) was also significantly higher than nonepiphytized blades (17.1%). No difference was detected in efficiencies of assimilation of either organic matter (19.1%, nonepiphytized and 22.6%, epiphytized) or nitrogen (42.3%; 23.4%) between nonepiphytized and epiphytized blades. Seagrasses may constitute a more important direct trophic link to herbivorous reef fishes than formerly thought.

FEEDING PREFERENCES AND CHEMICAL  
 DEFENSES OF THREE GLOSSODORIS  
 NUDIBRANCHS AND THEIR DIET SPONGES.  
 Shelly D. Rogers, 1989.

Dorid nudibranchs are known to prey upon sponges, tunicates, and bryozoans with high levels of secondary metabolites many of which have proved to be feeding deterrents. Nudibranchs frequently accumulate these deterrent compounds to use for their own defense. In this study three *Glossodoris* nudibranchs fed on *Hyrtios* sponges containing potent feeding deterrent compounds; yet, the nudibranchs showed no evidence of accumulating these deterrent compounds.

On a pinnacle in Apra Harbor, Guam, *Glossodoris pallida* was found feeding exclusively on a variety of *Hyrtios erecta* containing a high concentration of scalarial. *Glossodoris hikeurensis* and *G. cincta* preyed upon another variety of *H. erecta* from Cocos Lagoon, Guam which did not contain scalarial, but had high concentrations of heteronemin. Heteronemin was not found in *H. erecta* from Apra Harbor. When these two sponges were compared in laboratory preference tests *G. pallida* strongly preferred *H. erecta* from Apra Harbor while *G. hikeurensis* and *G. cincta* preferred *H. erecta* from Cocos Lagoon.

The chemistry of *G. pallida* was similar to *H. erecta* from Apra Harbor, with some minor differences occurring, indicating that *G. pallida* receives its secondary metabolites through its diet. In laboratory preference tests *Glossodoris pallida* was not attracted to the crude extract or major metabolite of *H. erecta* from Apra Harbor. Thus, secondary metabolites did not appear to act as feeding cues for *G. pallida*. It is unknown how *G.*



*hikeurensis* and *G. cincta* receive their secondary metabolites. Both of these nudibranchs contained four major metabolites in their organic extracts, none of which have been identified; but none were similar to heteronemin, the major metabolite of their diet sponge.

Organic extracts of the *Hyrtios* sponges were deterrent in at least two of the three feeding assays while organic extracts of nudibranchs were not deterrent under identical conditions. Minor metabolites may play a key role in determining feeding deterrence. Heteronemin was the only pure metabolite which proved to be a predator deterrent. Heteronemin was apparently consumed by both *G. hikeurensis* and *G. cincta*, but not stored. Deterrent compounds from diet *Hyrtios* sponges are probably excreted or altered by the *Glossodoris* nudibranchs.

Rogers, S. D. & V. J. Paul. Mar. Ecol. Prog. Ser. (in press).

REPRODUCTIVE BIOLOGY OF ACTINOPYGA MAURITIANA (ECHINODERMATA: HOLOTHUROIDEA) ON GUAM. David R. Hopper, 1990.

*Actinopyga mauritiana* is a dioecious, aspidochirote holothurian of Indopacific reefs, typically found in high energy, intertidal areas. Females and males both show seasonal peaks in gonadal index during spring and summer months. Mature gametes could be found in some animals throughout the year, but spawning occurred in late spring and summer. Most animals reach sexual maturity at a weight of 200 g (drained weight) or greater. Fecundity, as measured by the number of eggs per unit wet weight of ovary, is high compared to other tropical sea cucumbers, the mean value being  $6.2 \times 10^5$  eggs g<sup>-1</sup>. The fecundity index (mean ovary wt/oocyte diameter<sup>3</sup>) for *A. mauritiana* was  $3.1 \times 10^4$  during periods of peak gonadal index with a mean of  $1.3 \times 10^4$  annually. Following fertilization of eggs, gastrulation is observed within 24 hr. The planktotrophic auricularia larval stage is reached by day 3 and may persist for over 20 days. Metamorphosis to the auricularia to the second larval stage, the doliolaria, may begin as soon as 6 days after fertilization, but generally was not observed until after 2 weeks following fertilization. The second metamorphosis results in shrinkage of the larvae in overall length by 41%. Recruitment of juveniles was observed, but these animals had already attained relatively large sizes, the smallest being 10

g whole wet weight, and the most being greater than 50 g.

Data suggest that to properly manage this species, harvest should be seasonal, following the completion of spawning. Reproductive populations can be maintained by taking adults larger than 400 g (whole wet weight), and by ensuring high adult densities.

INTRASPECIFIC VARIATION IN THE CONCENTRATION OF SECONDARY METABOLITES IN FOUR SPECIES OF GREEN ALGAE AND ITS EFFECTS ON FEEDING BY HERBIVOROUS FISHES. Karen D. Meyer, 1991.

Four species of green algae were examined for intraspecific variation in the concentrations of their secondary metabolites. Since variation was evident, the varying levels of the secondary metabolites were tested in feeding preference assays toward natural populations of herbivorous fishes.

Optimal defense theory predicts that plants should allocate defenses in such a way as to maximize their individual fitness. It was predicted that secondary metabolite concentration would be highest in those portions of the plant most exposed to macroherbivores. Individual plants were collected from reef areas on Guam, divided into plant portions, and extracted separately. All four species, *Neomeris annulata*, *Caulerpa sertularioides*, *Caulerpa racemosa*, and *Caulerpa cupressoides* showed higher amounts of organic extracts, as well as secondary metabolites, in the parts of the plants that were exposed to macroherbivores, the same parts which were involved in growth and reproduction. Herbivorous fishes were not deterred from feeding on lower levels (1.5% and 5%) of the *N. annulata* metabolites, but were deterred by a concentration of 15% (dry weight). The major pure compound comprising the crude extract did not deter fish feeding, while a second minor pure compound did significantly deter fish feeding, at natural concentrations found in plant tips.

Although all three *Caulerpa* spp. showed variation in the concentrations of chemical defenses, results from the feeding studies showed that the chemical defenses did not act to deter feeding by herbivorous fishes. Little work has been done with the idea of secondary metabolites being produced as antifoulants or acting to deter grazing by molluscs, urchins or mesograzers, but it was proposed here that these would be likely explanations for the different concentrations of sec-



ondary metabolites in different parts of *Caulerpa* spp.

PRODUCTION AND DEPOSITION RATES OF  
STROMATOLITES ON THE ASMAFINES RIVER IN  
SOUTHERN GUAM. Pam Eastlick, 1991.

Stromatolitic deposition has been noted in the stream beds of some of the rivers of southern Guam, one of the Mariana Islands in the western Pacific. To determine accumulation rates of this material, Plexiglas plates were attached to the stream bed with concrete nails at five sites along the upper Asmafines River. Plate sets (consisting of one plate at each site) were left in place for varying periods of time from 7 to 442 days. Some plate sets were designed to assess possible differ-

ences in accumulation rates in the rainy and dry seasons. Accumulated material was analyzed for weight, thickness, percent organic content and density as well as insoluble residue percentages. The pH and calcium content of the water were also measured. It was ascertained that stromatolitic deposition occurred at all sites but at very different rates. The amount of deposition appeared to be correlated with the presence or absence of limestone inclusions immediately upstream of the sampled site. Deposition occurred faster in the dry season. Data indicate that the water of the Asmafines River is supersaturated with calcium bicarbonate much of the time and literature references indicate this is also true for most of the sites world-wide, where stromatolites form in freshwater.