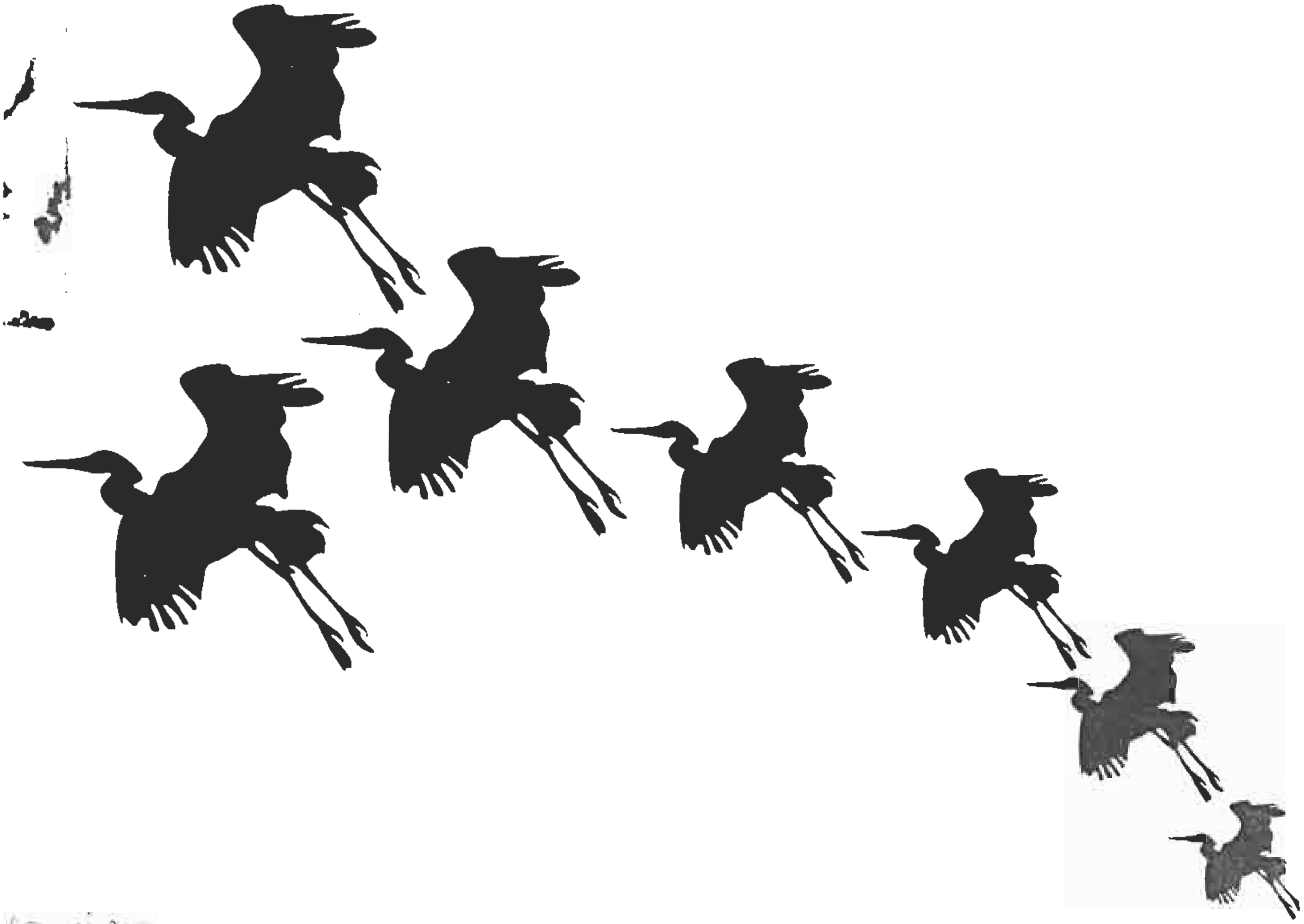
Guana Island Wildlife Sanctuary

Marine Science Month Report

August, 1995



Guana Island Marine Science Month Report

29 June, 1995

Dear Henry and Gloria,

Here is the 1995 report and proposal for Marine Science Month on Guana. Though marine scientists on Guana are a small group, a diversity of activities, including research, internships, short courses, and idea exchange, make Marine Science Month a rewarding and productive experience for all. Your generosity as benefactors (not to mention organizers) of this program is recognized and appreciated by all, and I say again that it is a rare privilege for any of us to conduct research on Guana. Your continued support has furthered scientific careers, both new and established, and has encouraged significant contributions to science.

This report includes research findings from the 94' program and intended activities in August '95 from each principle investigator. This report is also being sent to Dr. James Lazell (The Conservation Agency) and John and Catherine Morely-Dickens. A shortened version is being sent to Mr. Charles Wheatley (President, HLSCC), Honorable Oliver Cills (Minister of Natural Resources), and Mr. Ed Towle (Island Resources Foundation). If any one else is interested in a copy, please pass it on, or have them contact me.

All the best,

Lianna

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Marine Science Month 1995
Budget Request

Used Scuba Tanks (10 additional, necessary to accommodate multiple dives by more than four people. I got these tanks free, but spent $800 getting them inspected, then scrubbed, then hydrostatically tested and visually inspected)	$800
Visual Inspection of existing Guana tanks (11 tanks, $16 each)	$176
Regulator annual servicing (three reg's at $30 each)	$90
Oxygen tank fill	$20
First-aid kit replenishing	$50
Inventory of BVI hypersaline ponds:	
Plane charter for aerial photography, two hours	$250
Film and developing kits	$334
Nikonos strobe	$600
Velcro for museum pictures	$75
Communications (including phone, fax, mail, and photocopying)	$400
Contingency funds (incidentals, local transportation, air fills, emergencies)	$700
Stipend for program coordinator	
during program: $12.50/hour, 40/hrs/wk, 5 weeks	$2,500
program development (January-July:, 40 hours)	$500
Stipend for assistant ($5.00/hour, 40 hrs/wk, 5 weeks)	$1,000
<u>Logistics:</u>	
Boat use: whaler needed full time. Sovereign as necessary, estimate 10 to 14 days, 4 hours/day	
Mario ordered new compressor parts. The compressor needs to be overhauled and have new parts added.	
We need the use of a pick-up to transport tanks to and from the dock after 5 pm and before 7:30	
Breakfast at 7:00 a.m. if possible	
Other logistics will be worked out on site	
Subtotal:	*$7,495*
<u>Ornithology course:</u>	
Air fare for three instructors (ca. $600 each, totaling $1,800, of which I plan to raise half in student fees)	$900
Transportation to field sites and light refreshments at lecture breaks	$300
Course fees for GIWS interns Ian Greenspan and Franz Gerster	$200
Other: Lunch for students (10 to 15) on Guana after hike (one day only) Transportation for students to and from Guana for field trip (one day)	
Subtotal:	*$1,400*
<u>Hypersaline Pond funding renewal: July 1995 - January, 1996:</u>	
Equipment/chemicals	$700
Transportation (plane/car rental) ($400/mo.)	$2,400
Shipping bacterial mat samples by Fed X to Nova Scotia:	$300
Communications and incidentals:	$100
Assistant wages ($20/pond, $5/hr for lab work)	$1,500
Subtotal:	*$5,000*
TOTAL	$13,895

Schedule of participants, August, 1995

Dr. Graham Forrester: August 11 - September 4
Amy (assistant) August 11 - September 4
•contact: Dr. Graham Forrester, Department of Biological Science, University of California, Santa Barbara, CA. 93106. (805) 893-8798

Dr. David Carlon August 6 - 31, but away from 16 - 19
Darin MacGillivary (assistant) August 6 - 31
•contact Dr. David Carlon, Box 25445, Christiansted, St. Croix, USVI 00824-1445; (809) 773-9902

Lianna Jarecki August 1 - September 4
Darryl Sookram August 1 - August 26
•contact Lianna Jarecki, HLS Community College, Box 3097, Road Town, Tortola, BVI (809) 494-4994

Dr. Alan Harvey✍ August 20 - 30???
•contact Dr. Alan Harvey; Curator of Invertebrates, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024. (212) 769-5638

Christina Leahy August 15 - 28
AE #5434; arrives 1:17 p.m., Beef Is.
•contact Christina L. Leahy, 2049 Main Street, Glastonbury, Connecticut 06033. (203) 657-2409;

Dr. David Bird August 19 - 26
AE#5420; arrives 3:47 p.m., Beef Is.
Dr. Rodger Titman August 18 - 26
AE #5432; arrives 6:17, Beef Is.
•contact Dr. David Bird, Department of Renewable Resources, McGill University., Macdonald Raptor Research Center; 21,111 Lakeshore Road; Sainte-Anne-De-Bellevue; Quebec, Canada H9X 3V9. (514) 398-7983

Dr. Jim Battey August 24 - 27
Judy Muse August 24 - 27
•contact Dr. James F. Battey, Acting Director, MacLean Marine Science Center, University of the Virgin Islands. 2 John Brewer's Bay, St. Thomas, USVI 00802-9990. (809) 693-1381

Dr. Vance Vicente✍
•contact Dr. Vance P. Vicente; Caribbean Fishery Management Council; Suite 1108 Banco De Ponce Building; Hato Rey, Puerto Rico 00918

Ian Greenspan (intern) August 12 - 26??
Pamela Greenspan August 12 - 26??
•contact Pamela Greenspan (212) 772-2547
Franz Gerster (intern) August 6 - 2

✍ participation unconfirmed

Guana Island Marine Science Month Report

New Publications

Forrester, G.E. 1995. Strong density-dependent survival and recruitment regulate the abundance of a coral reef fish. Oecologia, in press.

Spotte, S., Bubucis, P.M., and Overstreet, R.M. 1995. Carridean shrimps associated with the slimy sea plume (*Pseudopterogorgia americana*) in midsummer at Guana Island, British Virgin Islands, West Indies. Vol. 15, Journal of Crustacean Biology.

Jarecki. L. in preparation. Seasonal changes in hypersaline pond fauna in the British Virgin Islands. Proceedings of the 27th scientific meeting of the Association of Marine Laboratories of the Caribbean. Presented orally on June 6th, 1995

1995 Marine Science Month Participants

Again, we have a combination of regulars and newcomers. Among the regulars, Dr. Graham Forrester and Dr. David Carlon will be returning as principle investigators. Dr. Stephen Spotte was invited but is unable to participate. Newcomers include Dr. Jim Battey, acting director of the MacLean Marine Science Center at the University of the Virgin Islands, St. Thomas, and Dr. Alan Harvey, of the American Museum of Natural History. Alan is interested in soldier crabs, but I have not yet received a letter of proposed research from him. Dr. Vance Vicente of the Caribbean Fisheries Office, Puerto Rico, expressed interest in participating but has not confirmed. Lastly, I invited Jorge Garcia of the Department of Natural Resources, Puerto Rico, because of his interest in estuarine copepods and in the white-cheeked pintails, but I have not heard back from him either.

Christina Leahy is returning to continue her kestrel work, and also to offer an intensive short-course with Dr. David Bird and Dr. Roger Titman, from McGill University, both of whom are new to Guana. The course is being offered to anyone in the BVI and will run the last full week of August.

Proposals and/or letters from all confirmed participants follows.

Principle Investigator Reports

GUANA ISLAND MARINE SCIENCE MONTH PROPOSAL AND REPORT

Population regulation in coral reef fishes: a long term study

Introduction and methods

This part of the project is a continuation of the monitoring study initiated in 1992. Its aim is to provide a long term analysis of patterns in the abundance of reef fishes and how they relate to characteristics of the reef habitat. The proposal for July 1995 is to continue censuses initiated during 1992. The censuses during July 1994 would be done at the sites established in 1992 using the same methodology as in previous years (see previous proposals). The censuses will be done during the middle 2 weeks of August; and prior experience suggests that this is sufficient time to complete them.

Preliminary results of monitoring from 1992-4

Relationships between habitat characteristics and the density of some common fishes identified during the first two years of the survey continued to be apparent in 1994. For example, adult density of 3-spot damsels was highly correlated with the cover of live coral on the reef (this feature explained 74% of the variation in fish density). Juveniles still show a weaker, but significant relationship with live corals (explaining 52% of juvenile density). Densities of some other species, most wrasses for example, continue to show little relationship to habitat features. With the third years information available, some preliminary temporal patterns in community structure are beginning to appear in the survey data (**Figs. 1** and **2**). It is too early to detect any meaningful patterns, or relationships, in community structure at this point, because many of the organisms on the reef live for a decade or more. The value of the monitoring information increases dramatically with each year's new data

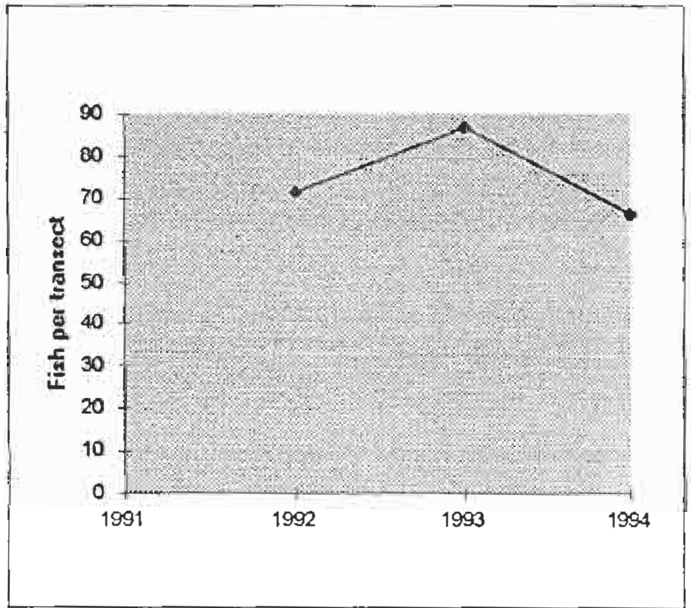

Fig. 1. Changes over time in the total density of fish (averaged across all sites). Fish abundance was slightly higher in 193, than in 1992 or 1994, but has remained relatively stable to date.

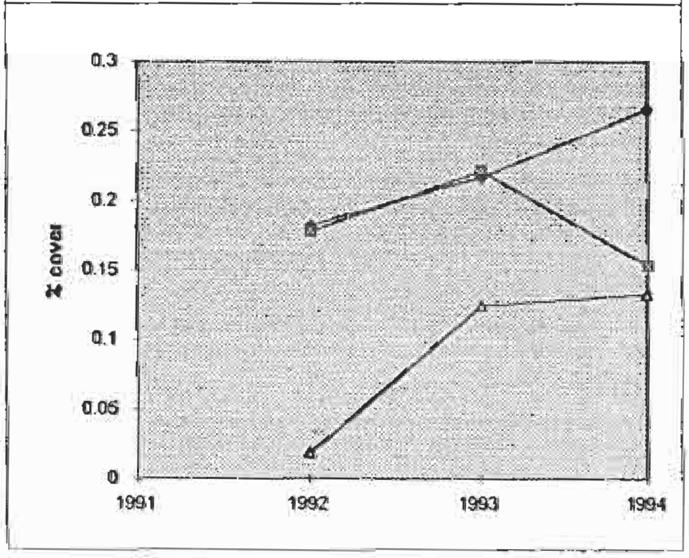

Fig. 2. Habitat structure has shown some changes over the initial 3 years of the study. For example, the % cover of live coral (diamonds) and feather soft corals (triangles) has increased each year so far. Branching soft corals (squares) have remained fairly constant, and show a similar pattern to that for fish density.

Detailed population studies of selected species

Introduction

As an extension of the monitoring project, I initiated more detailed studies of the population dynamics of the three species listed below in 1994.

Study species	**Scientific name**
Bridled goby	*Coryphopterus glaucofraenum*
Colon goby	*Coryphopterus dicrus*
Goldspot goby	*Gnatholepis thompsoni*

These species were chosen as common, representative, members of the fish community occupying thereefs around Guana Island. The goal is to test hypotheses about the factors controlling population density of these species.

Marking individual fishes

To estimate population processes I need to be able to recognize individual fishes in their natural habitat, and follow their fates over time. The three study species have very little skin pigmentation and so are translucent. In 1992 and 1993 I tested a method involving the injection of small spots of coloured ink under the fishes skin, to give them distinct markings.In 1994 I tested a new technique for marking these species. The technique involves injecting tiny (1*2 mm) pieces of plastic film under the fish's skin (called VI tags). The film has a 3 digit number printed on it which is visible to an observer if the skin and tissues are unpigmented. The growth and survival of 100 VI tagged fishes was compared to that of 250 fish marked with spots of coloured ink, and 150 unmarked fish. Survival of unmarked fish was not different from fish marked with both ink and VI tags. Ink marked fish grew slower than VI tagged fish, however, suggesting that ink marks reduce the growth of fish and VI tags are preferable. A manuscript describing these data is being prepared for publication.

Effects of local population density on growth and survival

In 1994 I conducted a combined experimental and descriptive study testing for effects of the local density of adult bridled gobies on their growth and survival, and on the colonization of reefs by juveniles. This study has been accepted for publication in the international ecological journal Oecologia, and a copy of the manuscript is enclosed with this report.

Effects of predatory fishes on the population density of bridled gobies

One of the striking features of the aforementioned study was that goby survival was severely reduced at high density. This result is very important because it indicates that this population is regulated primarily by adult survival, which is counter to currently favoured ideas about reef fish populations. In 1995 I propose to test the hypothesis that the cause of this pattern of survival is predation by piscivorous fishes (primarily lizardfishes, *Synodus* spp.). The experimental design will be to establish a gradient of densities of bridled gobies on a series of replicate patch reefs. Predators will be excluded from half of these reefs by placing temporary fences around them (the fences will be removed after the experiment and will cause no detriment to the habitat). The pattern of goby survival will be compared on reefs with and without predators to test if predation results in reduced survival of gobies at high density. I will also monitor the predatory behaviour of lizardfishes and other fishes preying on the gobies (hamlets and small groupers) to determine the behavioural mechanisms by which predators cause density-dependent survival.

The importance of larval processes in vertical patterns of reef coral distribution
Guana Island Marine Science Month, July 1994

Participants

Project leader: Dave Carlon, Department of Zoology, University of New Hampshire
Diving Assistant: Richard Nemeth, Department of Zoology, University of New Hampshire

Progress to date

Overall recruitment patterns

In the first week of July, 1994, Rick Nemeth and I retrieved one set of settlement plates deployed the previous summer at the Iguana Head and Muskmelon sites on Guana Island. A total of 96 plates were retrieved. Plates were then inspected for coral recruits in a temporary "laboratory" which consisted of the White Beach bath house set up with a light source and Lianna's dissecting microscope. This worked out very nicely and bathers did not seem to mind my presence as I sorted through the plates. The 10 x 10 cm ceramic bathroom tiles made excellent settlement surfaces for coral recruits. As many as 19 coral recruits were counted on a single shallow water (6 m depth) plate. All coral recruits were found on the bottom or sides of the ceramic plates, no coral recruit were found on the tops. All coral recruits were identified to genus if possible and colony diameter was measured with vernier calipers. Sizes of coral recruits at different depths are given in Table I. Small coral recruits (< 1.0 mm) that could not be identified are listed as "unknown".

Table I. Mean diameters (mm) of coral recruits on settlement plates at three depths. Data from Iguana head and Muskmelon Bay are combined. Ranges are in parenthesis and sample sizes are in brackets. nr= no recruitment.

Species	6 m	15 m	24 m
Agaricia spp.	3.9 (0.9-13.3) [98]	5.5 (3.1-8.6) [4]	8.9 (3.5-14.9) [3]
Porites spp.	1.6 (0.7-6.7) [30]	nr	nr
Cup corals	1.3 (0.7-2.3) [42]	1.8 (0.9-3.4) [12]	1.5 (1.0-2.2) [10]
Millepora spp.	nr	1.7 (0.4-3.2) [21]	nr
Diploria spp.	2.3 (1.1-3.7) [9]	2.2 [1]	nr
Cladocora debilis	nr	nr	7.48 (1.8-21.7) [9]
unknown	1.23 (0.6-1.9) [8]	0.841 (0.7-3.1) [27]	

Recruitment at Guana Island is dominated by corals from the genus *Agaricia* and *Porites*. Small cup corals (solitary polyps) also recruited in high numbers. These corals are most likely of the genera *Balanophyllia*, *Rhizosmilia*, and *Caryophyllia*. Hydrozoans (*Millepora* e.g. "fire corals") recruited to the plates at 15 m depth only. Some (10) *Diploria* recruits were found at the 6 m and 15 m stations. The maximum sizes of recruits give an estimate of potential growth rates over the 1 year period. *Agaricia spp.* appear to have the highest potential growth rates. The largest recruit was 14.9 mm in diameter which gives a monthly rate of 1.24 mm month^{-1}. Other colonial species appear to have much lower growth rates in the first year: *Porites spp.* = 0.56 mm month^{-1} and *Millepora spp.* = 0.26 mm month^{-1}. These estimates of potential growth assume that recruitment is continuous during the summer months. This appears to be the case for *Agaricia* and *Porites* (Van Moorsel, 1983; Chornesky and Peters, 1987), however, the reproductive cycles of *Millepora spp.* remain unknown.

Corals of the genus *Agaricia* and *Porites* were the most common recruits in studies conducted in Curacao (Bak and Engel, 1979) and St. Croix (Rogers et al. 1984). On Bermuda, Smith (1992) found brooding species such as *Porites* to recruit rapidly to denuded substrata cleared by a ship grounding. From this previous work in the Caribbean and the present study on Guana it is apparent the corals that brood larvae dominate recruitment patterns even though their adult cover is typically much lower than species that release gametes into the water column (e.g. *Montastrea* and *Acropora*). Larval recruitment by broadcasting species most likely occurs episodically at time scales greater than average ecological study (a few years at best). The maximum growth rate estimated for *Agaricia spp.* here is similar to that found by Rogers et al. (1984) who estimated a rate of 1.2 mm month^{-1} in St. Croix.

Coral recruitment on Guana Island appears to be higher than at Salt River Canyon, St. Croix. A total of 253 coral recruits were found on 96 plates on Guana over a one year sampling interval. This translates to a frequency of 2.64 recruits plate^{-1} year^{-1} on Guana Island. By comparison, Rogers et al. (1984) found a total of 271 coral recruits on 342 plates during a 26 month sampling interval. This makes an overall frequency of 0.40 recruits plate^{-1} year^{-1} in St. Croix. Rogers et al.'s study varied from this one in that it extended to a deeper depth (37 m) and settlement plates were cut from dead *Acropora* branches. However, Roger et al.'s plates had a similar surface area (120 cm^2) to the ceramic tiles of this study. Thus, the sampling efforts in terms of plate area, are comparable between the two studies. Two important points emerge from the Guana data. The first is that the recruitment rate on Guana Island 5 times higher than Salt River Canyon, a site that also has a diverse coral community. Second, the ceramic tiles and fencing mesh racks used on Guana are effective estimators of coral recruitment on Caribbean reefs as in Australia (Harriott and Fisk, 1987).

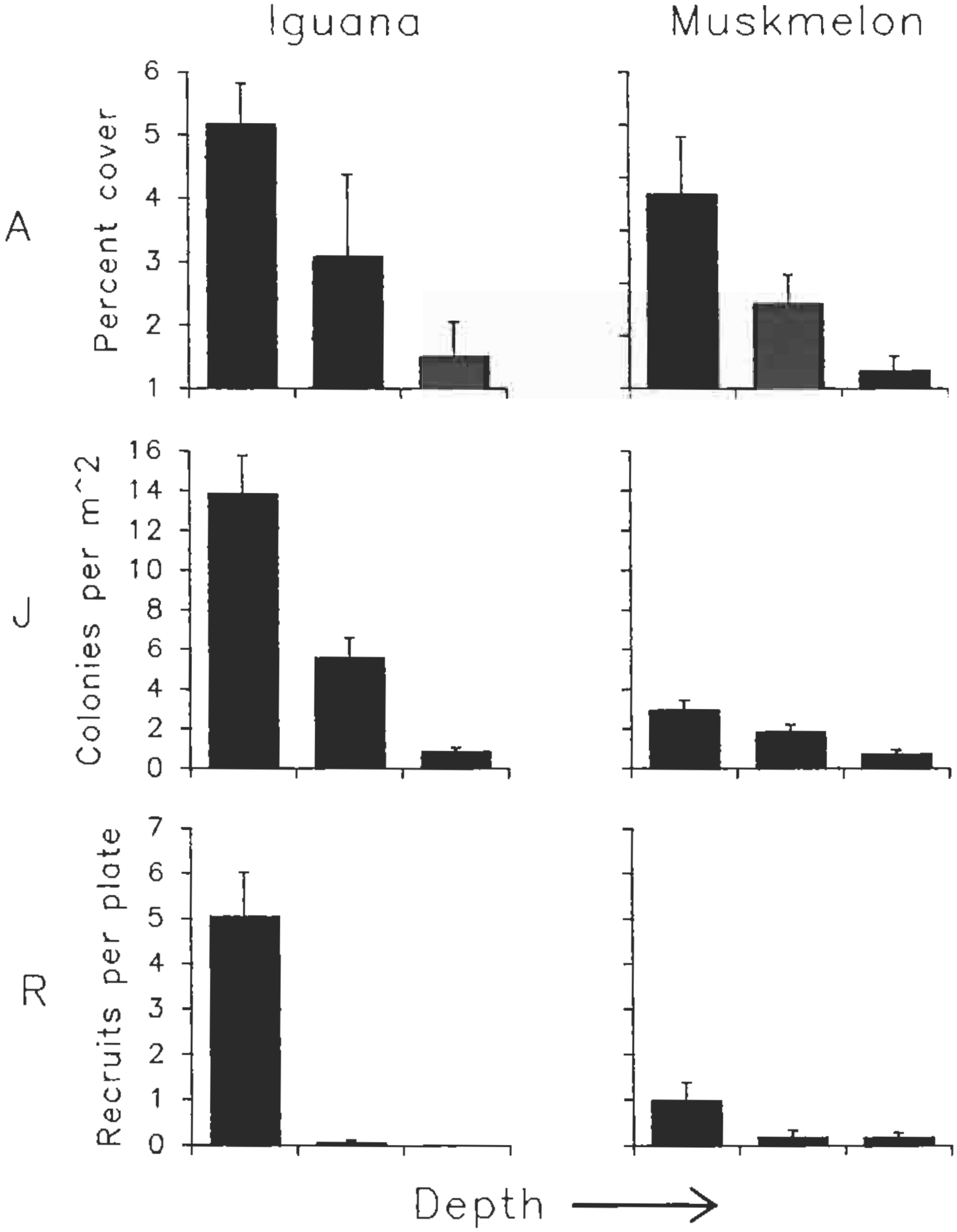

Figure 1. The abundance of *Agaricia* adult, juvenile, and larval recruits at three depths (6, 15, and 24 meters) and two sites on Guana Island. Vertical bars are 1 standard error.

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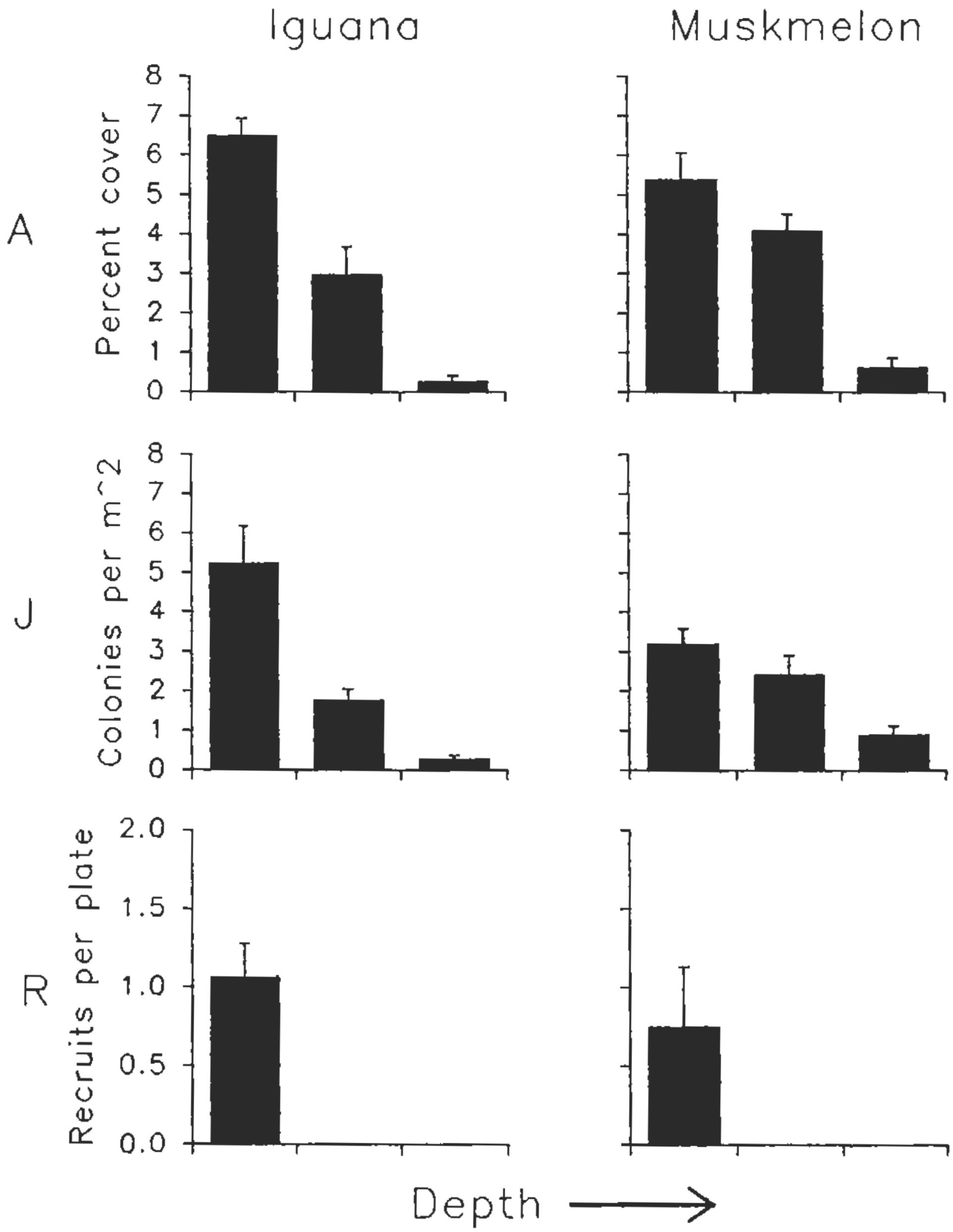

Figure 2. The abundance of *Porites* adults, juveniles, and larval recruits at three depths (6, 15, and 24 meters) and two sites on Guana Island. Vertical bars are 1 standard error.

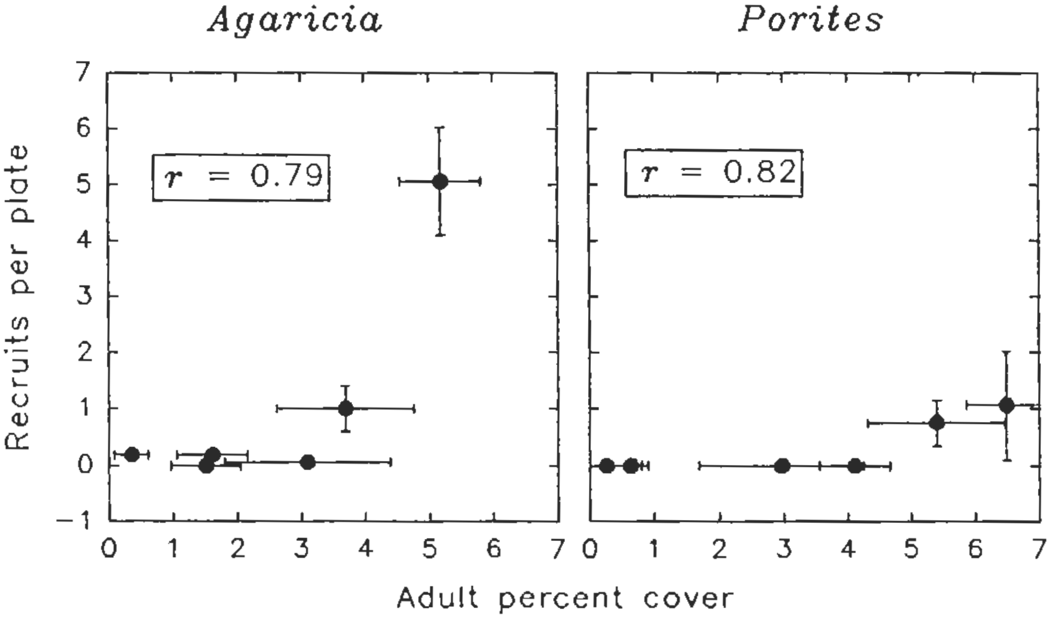

Figure 3. Adult abundance verses recruit abundance for *Agaricia* and *Porites* corals on Guana Island. Data from three depths and two sites (n= 6). Vertical and horizontal bars are 1 standard error.

Vertical recruitment patterns and adult distribution

An objective of this project was to compare vertical patterns of coral recruits with vertical distribution of juveniles and adults in order to determine at what point in coral life-histories population structure is established. To this end I have analyzed the *Agaricia* and *Porites* recruitment data and compared it to vertical patterns of juveniles and adults determined from the first year of this study (1993).

Comparison of vertical patterns of recruits, juveniles, and adults reveals increasing abundance in all these stages with decreasing depth. *Agaricia spp.* corals had highest adult and juvenile abundance at 6 and 15 m depth (Figure 1). Recruits on plates were most abundant at 6 m depth and recruitment dropped rapidly at the 15 and 24 m depth. There was some variation in adult and juvenile abundance between sites. For example, Adults and juveniles were more abundant at all depths at the Iguana Head site compared to Muskmelon Bay. This difference in abundance was also found in recruits: recruitment at 6 m depth was five times as higher at the Iguana Head compared to Muskmelon Bay. A similar relationship between recruits and adults was found for *Porites spp.* corals (Figure 2). All recruitment was at the 6 m depth at both sites and adult and juvenile abundance also peaked at the 6 m depth. Unlike *Agaricia*, there was no difference in adult, juvenile, or recruit abundances between sites.

I pooled the mean adult abundance and recruitment data among sites and depths for both genera (Figure 3). A correlation analysis shows is there is a relatively strong relationship between adult percent cover and recruits per plate regardless of site or depth. It therefore appears that vertical patterns of adults are determined early in the life-history of these corals, either at, or shortly after settlement. From these data I am unable to determine the roles of post-settlement mortality in recruitment patterns. However the study has indicated that ecological processes that control distributions of recruits (both larval and benthic) are important to adult populations on Guana Island.

Three species were included in each of the two genera for the adult and juvenile data. The genus *Agaricia* consisted of *A. agaricites*, *A. fragilis*, and *A. humilis*. The genus *Porites* consisted of *P. astreoides*, *P. colonensis*, and *P. porites*. Larval recruits could not be identified to species but are likely to originate from these species.

Publication plans

I have presented this data at the American Society of Zoologist meetings in St. Louis and have included the published abstract (*American Zoologist* 34(5): abstract # 52). I am currently completing data analysis and writing up this data for submission to the journal *Oecologia*. This data will also be included in a chapter of my dissertation at the University of New Hampshire, which I will defend in September of 1995.

Future plans for Marine Science Month

This largely concludes this recruitment study on Guana. Of the plates that remain in the field, I plan to transplant coral recruits on plates from shallow water to deeper depths in order to determine the role of post-settlement mortality in vertical recruitment pattern during the Summer of 1995. I also plan to initiate a long term photo-quadrat study of coral community dynamics along a depth gradient. I will use the Iguana Head and Muskmelon sites and establish 0.5 m^2 permanent quadrats at 6, 15, and 24 m depth. Quadrats will be photographed with a nikonos camera mounted on an aluminum quadrapod. The objective of this project is to photograph quadrats over a 5 - 10 year period in order to determine how coral community dynamics vary between depths. A similar study has been successfully used in Australia to study long term coral dynamics on reef flats (Tanner et al., 1994). However, there is little data on the dynamics of deeper reef communities for Pacific or Caribbean reefs.

Literature Cited

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Harriott, V. J., and D. A. Fisk. 1987. A comparison of settlement plate types for experiments on the recruitment of scleractinian corals. Marine Ecological Progress Series 37: 201-208.

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Tanner, J. E., T. P. Hughes, and J. H. Connell. 1994. Species coexistence, keystone species, and succession: a sensitivity analysis. Ecology 75(8): 2204-2219.

Van Moorsel, G. W. N. M. 1983. Reproductive strategies in two closely related stony corals (*Agaricia*, Scleractinia). Marine Ecology Progress Series 13(August 30): 273-283.

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British Virgin Islands (B.V.I.) 1994 Project Report on the Natural History of the American Kestrel, Caribbean subspecies *Falco sparverius caribaearum* , local name killy hawk, funded by the Guana Island Wildlife Sanctuary (G.I.W.S.).

The life history of the resident kestrel population found in the Caribbean is not well known. The falcon is the highest predator in the B.V.I. (top of the food chain), therefore an important indicator species of environmental conditions or habitat disturbances. To define the natural history of the resident B.V.I. kestrel population, we need to gather the following data: population estimates, inter-island movements, habitat requirements, territory size, nest site and prey availability, genetic viability and general health of the population. To achieve quality data requires the collection of observational and behavioral material over a long period of time, especially in consideration that our current duration of study in the B.V.I. for the kestrel research project is no more than one month out of a year.

The ability to further describe this species is dependent upon identifying and collecting information on individual birds. This necessitates capturing and handling the birds, as well as utilizing identifying markers or bands. A special complication that we have as raptor biologists and as citizens of the United States and Canada, is that we work under strict international laws governing birds of prey. These laws are dictated by the Migratory Bird Convention Act (formulated in 1916) and the laws that govern working in a foreign country are described in the North American Bird Banding manual, Volume 1, Part 7. Permits are species specific, and a special permit is required for auxiliary marking (i.e., color banding) and for each trapping method to be utilized (i.e. mist nets, bal-chatri traps). International law requires us to have permits or licenses from the government of the foreign country in which we request to trap and band birds. Presently there is no existing legislation in the B.V.I. government that protects birds, and also there is no existing B.V.I. permits or licenses to obtain that would grant permission to proceed with raptor research in the B.V.I., more specifically trapping and banding.

Trapping and banding is an integral part of avian research. It is a well established and proven safe and effective method of studying individual behaviors, it does not inhibit any natural behaviors, and it does not cause the birds to permanently relocate. Data from recovered bands provide information on the distribution and movements (i.e., inter-island, migration) of species, relative population size, annual production, life span and cause of death. This information is consequential in forming conservation and management plans. The Migratory Bird Convention Act outlines a uniform system of protection for migratory birds. The government agencies which administer the Convention (The Canadian Wildlife Service, Department of the Environment, and the U.S. Fish and Wildlife Service) also coordinate banding efforts in North America by issuing permits, supplying bands and keeping records of banding activities. Close coordination is maintained between the two offices and identical bands (U.S. Fish and Wildlife), except for numbers, are used in both countries. Information on banding and recoveries of birds is ultimately sent to the American Bird Banding Laboratory, where the information is kept in a computer data base file and is available upon request. In North America raptors are protected by legislation and all persons wishing to band raptors (in any country) require authorization from their respective bird banding offices. Furthermore, authorization must also be obtained to use mist nets and color markers. This authorization must be listed on the banding permit from the originating country.

The U.S. Fish and Wildlife bands are highly recommended because of the established means of obtaining data on recovered bands through the bird banding authorities in Washington, D.C., a valuable resource of information. An actual B.V.I. band would have to be designed and manufactured, and it would be highly recommended that the format of the North American Bird Banding directions be followed. A color coded marker would aid in specifically identifying an individual bird in the field. The B.V.I. band could serve as an auxiliary marker or color code band, used in conjunction with the U.S. Fish and Wildlife bands. A specific color could represent a particular island on which the individual bird was trapped and banded.

We have yet to gain the support of the Government of the British Virgin Islands to successfully accomplish the kestrel project. In 1993, and again in 1994, I requested permission from the B.V.I. government to trap and band the kestrel in the B.V.I., as required by international law regarding raptor permits. The first year I applied for a permit, I was verbally refused permission to trap and band kestrels by the Conservation and Fisheries Department. The 1994 project proposal was submitted as a package with all other G.I.W.S. project proposals. We did not receive any written response concerning our request to trap and band birds. Despite the lack of a written consent from the B.V.I. government, the Canadian Wildlife Service gave us the permission to trap and color band kestrels in the B.V.I., permission granted to Heather Cunningham sub-permit #10309-AG, under the Macdonald College permits held by Dr. David Bird, director of the Macdonald Raptor Research Center at McGill University.

I have recorded observational and behavioral data on the resident kestrel population, over a two to three week period of time for the last three years (October 1991, July 1992, June/July 1993), and have discovered various behavioral differences between the B.V.I. subspecies as compared with its North American counterpart, as well as other tropical kestrel subspecies (referenced information, Cruz, A., 1976, and Palmer, R.S., 1988). The most notable behavioral difference is that the resident kestrel hunts most often from a perch site and rarely will hover in the air while hunting for prey. The hover hunting technique is a behavior often utilized by the North American bird. Further research is necessary to fully understand these apparent behavioral differences as potential adaptation. Dr. David Bird, considered a leading expert in the research and study of the American kestrel, provided an assistant, Ms. Heather Cunningham (Masters degree candidate studying genetic variability in captive kestrels) to help with the 1994 kestrel research project. The behavioral differences that I have noted among kestrels observed on Guana Island were verified by Ms. Cunningham. These are exciting findings, and well worth the effort to be patient in obtaining the necessary permits, and to put in the time required to find the answers to our questions concerning this subspecies of kestrel.

Guana Island Resident Kestrel Records:

In addition to recording behavioral data, we tested various trapping techniques on the Guana Island kestrels (utilizing only G.I. kestrels as the test group) to determine the preferred method of trapping for these resident birds. The hunting activities of the kestrels on the Flat were noted during various times of the day, though most often observed in the early mornings and late afternoons. Most of our field work testing trapping methods was accomplished when the kestrels were most active on the Flat. In the beginning of July (1994) one adult pair of kestrels and two possibly three fledglings (two males and one female) were considered G.I. residents and were observed utilizing the Flat. A few days after initial observations, only the adult pair were regularly observed hunting the Flat. Occasionally a second male, probably a fledgling, was observed being passively chased away from the Flat by the dominant adult pair. Sometimes there were more aggressive displays by the adult male with actual interaction between the two birds. On July 16, 1994 and for a few days thereafter, a male and female pair were regularly observed hunting and mating in the immediate area surrounding the club. The female was identified by an incorrectly positioned left wing while perched (possibly an injury), and the male by a lighter breast coloration than the adult male and heavy chest barring. At this point there were at least two pairs of kestrels hunting daily on G.I., which might suggest the presence of two resident pairs. Presently there is no data on fledgling dispersal from the natal area in the Caribbean kestrel. The pair hunting the club area were probably fledglings (i.e., siblings) from the adult pair that typically hunted the Flat. Two methods to determine relatedness would be to a) band fledglings prior to their departure from the natal area, and/or b) blood sample individuals in order to extract DNA for the purpose of obtaining a DNA fingerprint. The importance of determining the relatedness within the kestrel population could indicate possible inbreeding and genetic drift. These genetic phenomena could eventually cause deleterious effects on the B.V.I. kestrel population.

One adult female kestrel was successfully trapped and banded on July 5, 1994 with a black color code band marked #50, the approximate time in hand was 20 minutes. The pertinent data will need to be collected from a number of resident kestrels before any comparisons with North American kestrels can be made. The data collected was as follows:

1. Body measurements - tarsus 4.5 cm, tail 13.1 cm, wing 17.6 cm
2. Beak measurements - base of feathers to tip 1.7 cm,
   cere to tip 1.3 cm, nostril to tip 1.5 cm
3. Total body length - 23.8 cm
4. Body weight - 110 grams, measured by a portable OHaus Scale

This individual female was in good weight, the feathers were healthy, and there were no signs of ectoparasites. The eyes were dark almost black, indicative of an adult bird. The lower mandible was chipped. The black band #50 (provided by the Canadian Wildlife Service) was placed on the right tarsus. She was identified as the individual that hunted the Flat often from a favored perch site marked #27. We often worked in close proximity to this female's perched location, though she exhibited no apparent fear of us prior to or after her capture. She appeared highly tractable not flushing immediately upon our approach and tolerating our presence. She continued to be observed almost daily throughout the month of July (1994), usually on the Flat, and appeared to show no deleterious effects, for example, pair bonding, mating, flying and hunting continued unaffected. The successful trapping technique utilized to capture this female kestrel was a small bal-chatri trap (24 cm x 36 cm x 19 cm) live baited with two small anoles and one active ameiva (small specimen with body length approximately 16 cm). She was captured at 2:45 PM on the Flat in the area closest to the salt pond where the highest hunting activity is observed on G.I.

The female was perched as we approached with the bal-chatri trap. She watched our activity with apparent interest, more specifically at the movement of the prey within the trap. She made a quick pass hitting the trap as I still had it in my hand and then returned to the same perch site. I had no sooner placed the trap in front of her on the ground then she was upon the trap before we could even move to another position. The female kestrel made a few attempts to fly off but was secured in the nylon nooses attached to the top of the trap and eventually remained stationary even as I approached the trap to free her from the nooses. She was unharmed by this trapping method. On the same day (July 5, 1994) a male kestrel, presumably her mate, made one hit on the same trap at 4:39 PM though the nooses did not hold him. As a note, the nylon nooses may not have been opened enough to secure the male after the female had been captured. The same individual made a second fly over the trap soon after this initial failed attempt.

The small bal-chatri trap as well as a larger bal-chatri trap (42 cm x 45.5 cm x 18.5 cm) were utilized over the duration of the study month using a variety of animals as live bait. Two mats of hard cloth (61.5 cm x 45.5 cm) with nylon nooses surrounding the perimeter were also utilized with tethered live prey items. During one observation day, the small bal-chatri trap with two anoles and a small ameiva as live bait was used when an adult male and female and one immature kestrel were present. The adult male made four passing flights over the trap, two direct hits and one hover over the trap, all within approximately 18 minutes. The same individual then perched on the ground beside the trap as two pearl-eyed thrashers flew at the trap and/or at the kestrel. The kestrel flew off and did not return.

We also set up a mist net from various marked perch sites on the Flat. During one field observation period the mist net was stretched from perch site marker #17 across to perch site marker #26. Responding to kestrel vocalization play-backs, one male kestrel flew in to the location of the mist net and made a few passing flights then perched on site marker #17. This male also vocalized as it flew in to the area. A female was observed perched at site marker #32. At a later observation period a mist net was set up between two trees where the pair typically hunted. One adult male kestrel responded to the play-backs and moved closer to the net where the recorder was located. This male appeared to fly towards the source of the vocalizations and hit the net at the bottom corner. The bird was temporarily held but upon struggling the kestrel easily ripped the net and flew off before we reached the net to attempt a capture. In its struggle to free itself the kestrel left two large holes in the mist net. The same male later made a high pass over the net and flew off to the North. Female #50 was also present at this time in the vicinity but she did not come close to the location of the net. Later on the same observation day Female #50 and her mate were present on the Flat and we set up the mist net in the same location with the small bal-chatri trap placed on one side of the net, baited with a large anole. The female briefly moved in to the trap location apparently responding to the play-backs, then she joined the male at perch site marker #3. The pair continued to hunt the Flat but paid little attention to the baited bal-chatri trap and avoided the mist net.

After the initial experiences with the mist net, the kestrels observed on the Flat appeared to avoid the net no matter where or when it was set up. They would often watch us set up the net, sometimes flying in closer to our location, and perch just above the net as if observing the activity for a short time then flying off. Two Zenaida doves were inadvertently captured in the mist net on two different days. One of the Zenaida doves captured was tested as a live bait prey item placed in the large bal-chatri trap and also tethered to a hard cloth mat with nylon nooses surrounding the bait bird. The dove proved too skittish especially in the bal-chatri trap and we aborted use of the dove as a possible live bait prey item. The kestrels displayed only mild interest in the dove making a few high passing flights over both trapping devices but made no attempts at taking the prey. To date, no kestrel has been observed with a bird as a prey item although we sometimes observed kestrels diving into a flock of doves feeding on the ground causing the doves to fly off.

In the late morning on July 15, 1994, an exterminator applied a boric acid spray bait to dispose of unwanted pests. The following days around the club, a male and female kestrel were repeatedly observed picking up dying cockroaches that littered the pathways around the buildings. There was a huge die off of cockroaches and the kestrels were opportunistically preying upon the dying insects. It was noted that they did not take any dead insects, but would take a cockroach as long as there was some movement. This pair of kestrels were probably fledglings, the female was not banded with heavily barred chest, and the male had bright legs and cream colored chest with heavy barring. This female was also identified by the way her left wing was positioned incorrectly while perched. She was highly tractable, allowing me to approach her almost close enough to capture her by hand. We also considered that the large die off of the cockroaches provided an over stimulus to the hunting kestrels and was probably a sufficient distraction for them not to be highly concerned with our presence. We took advantage of this unusual opportunity and attempted to trap the birds as they were preoccupied with the sudden tremendous availability of a preferred prey item. We utilized the small bal-chatri trap baited with anoles, placing the trap near the kitchen pathway. The female hit the trap, pulled some nooses but was not captured. We fixed the nooses then baited the top of the trap with dying cockroaches. The female flew to the trap and landed on the ground, then proceeded to take the bait off the top of the trap but did not get caught in the nooses. We also attempted to net the male twice by hand holding the mist net and approaching the kestrel from behind while it was busy on the ground capturing cockroaches. Each time the kestrel easily and quickly moved up the stone wall in front of the net and flew off. Both birds continued to come back to the same location despite our persistent attempts to capture them. Twice we observed a large blue ameiva moving down the pathway in the presence of these two hunting kestrels, though neither showed any interest even when it passed right below the female along the path. The two continued to hunt in the vicinity of the club house until early evening.

At this point in time I have yet to obtain a Material Data Safety Sheet on the compound used as bait to kill the cockroaches and other spiders and insects. Therefore we cannot at this time extrapolate the possible side effects or toxicity that these kestrels might experience as a result of ingesting these poisoned insects in great quantities over a short period of time.

On the next observation day the male kestrel was on the dining room terrace eating a cockroach seemingly oblivious to the human activity around him. The female with the wing problem was also present near the dining area. Upon close scrutiny of the female's left wing we became concerned that it was an injury to the wing. These two continued to feed on cockroaches around the club house most of the morning. At one point the female with the wing problem was perched on the kitchen roof, and an adult male and female were soaring with aerial displays and vocalizations along the slope of the Pyramid, to perch below the staff house. We set up the two mat traps along the pathway near the kitchen with an anole tethered to each mat, and used leaf debris and dead cockroaches as cover. Also the small bal-chatri trap with four anoles as live bait was placed near the mat traps. On two occasions we observed mating of these two individuals on the kitchen roof and on the roof of Upper Camanoe. Each time there was considerable 'chittering' vocalizations heard and mating was followed by extensive preening activity by both birds. The birds continued to hunt the club house area most of the day. At one point there were two males and one female present with many vocalizations heard. I picked up a small rounded pellet consisting of cockroach parts and mucous, egested on the stone wall below the kitchen. As a note, pearly-eyed thrashers were also observed eating cockroaches. A male kestrel flew to the mat with a large anole tethered to it. The kestrel flew up at my approach holding onto the anole and the whole mat lifted off the ground a few inches. The kestrel relinquished its hold on the anole and flew to the outer stone wall along the pathway. This individual made two more attempts to take the anole but did not get caught in the nooses. This male then flew off. Another mating occurred in the late afternoon on the roof corner of Upper Camanoe accompanied by 'chittering' vocalizations. Another male kestrel was present at the same time in close proximity to the mating pair. This second male flew off and the mated pair spent approximately 15 minutes preening and fluffing feathers before departing. At one point there were four birds observed, a pair below the staff house flying out over the Flat with a third bird in close pursuit, and a male perched on the kitchen roof corner.

On another observation day, a male and female kestrel were present on the rooftops hunting the dining area. At this time the presence of dying cockroaches had dwindled, though these two appeared to continue to check this area for an easy meal. The female was again identified by the position of her wing on the perch. Considerable 'chittering' vocalizations were heard at this time between these two individuals. We set up the two mats with a tethered anole and the small bal-chatri trap with two small anoles as live bait. There was no apparent interest from the kestrels and both flew off soon after they had appeared to check the area for cockroaches. Play-backs did not attract any kestrels. An adult male kestrel was later perched on the kitchen roof and in response to play-backs he made a dive at the source of the vocalizations (the recorder), flew off and then circled back to perch briefly in the same spot on the roof corner then flew off down the slope.

On a few occasions kestrels have been noted with rats as prey items. The question remains as to whether they are common prey items in the diet of kestrels, or if they are opportunistic prey items as the rats become easier to capture due to the slow death resulting from the rat poison (Talon G) used on the island. This of course remains a concern as the kestrel will acquire secondary poisoning by digesting a poisoned rat and due to the accumulation of the poison in the tissue and the highly toxic nature of the compound, very little is needed in the system to eventually kill the kestrel. The species of rat found on these islands is a descendent of the European rat *Rattus rattus*. The island rat has a brown upper body, with white underparts (not light gray like its European counterparts), large round head with large rounded ears, and a long tail in respect to its body length. Two rats, one small male and one larger female, were inadvertently entangled in the nylon nooses on the mats that were stored in the beach shed overnight. The rats were utilized as live bait in the large bal-chatri trap and tethered to the mats. Another poisoned female rat (bleeding from nose and right ear) was captured in the museum and placed in the small bal-chatri trap as live bait. The kestrels showed little interest in the rats, possibly more wary of the traps at this point in time no matter what prey item was utilized.

A large ameiva (approximately 38 cm) was utilized as live bait in the large bal-chatri trap and aroused no apparent interest from the kestrels present on the Flat at the time this bait item was used. The size of the ameiva may have been too large of a possible prey item for the kestrel to promote any interest from the birds.

One very major and discouraging aspect of utilizing live bait in traps was that the fire ants present on the Flat very quickly located the struggling prey items and quickly descended upon the victims, in one instance killing a few anoles before the ants were noticed. Even upon continually moving the traps the fire ants would eventually show up, this phenomenon occurred throughout the day hours with aggravating consistency.

1995 B.V.I. (G.I.W.S.) Project Proposal:

To promote and stimulate interest in the B.V.I. community regarding Caribbean avifauna, our August 1995 B.V.I. (G.I.W.S.) project contribution is the presentation of a week long seminar on avian biology, including bird identification, habitat requirements, bird behavior, trapping and banding techniques, bird surveys, and field research methods. The bird biology course will be coordinated with the H.L. Stoutt Community College. Guest lecturers assisting me in the presentation of the bird biology course will be Dr. David Bird, director of the Macdonald Raptor Research Center at McGill University in Quebec, and Dr. Rodger Titman, ornithology professor at McGill University, both experts in the field of avian science. Ultimately this course can provide the foundation for a field of study in avian biology taught as part of the regular curriculum of the H.L. Stoutt Community College. Positive outcome of such a program can provide the local community with trained individuals qualified to conduct research on the B.V.I. avifauna that will be beneficial to both the local community and the international scientific community (i.e., publishable material). Local individuals trained in identification of avian species can provide reliable bird census throughout the year. An active bird banding program can be established and maintained during organized bird census. Avian research in the B.V.I. can provide an understanding of the role that various bird species play in the Caribbean ecosystem, more specifically the importance of raptors as predators at the top of the food chain. Avian studies in the B.V.I. can also provide critical information on the many species that move through the B.V.I. during migrations. The knowledge gained from studying avian biology can help in identifying bird species and critical habitat that need to be maintained and/or protected.

As time allows outside of class time hours, for the duration of our visit observational data will continue to be collected on the Guana Island resident kestrels. When possible, bird surveys will also be maintained.

The abbreviated kestrel project goal outline is as follows:

1. Record behavioral data, i.e., hunting methods, prey preferences, mating behaviors.
2. Trap utilizing well documented methods and safe procedures - including bal-chatri traps and mist nets.
3. Place an auxiliary or numbered color code band on right tarsus.
4. Place an aluminum U.S. Fish and Wildlife band on left tarsus.
5. Record individual data - body measurements, general heath, gender, estimated age, presence of ectoparasites.
6. Blood sample (maximum 500 ul) from the brachial vein for DNA analysis and a blood smear for determining the presence of hemoprotozoal infection.

Christina Leahy

Guana Island Bird Survey

On Guana Island one can see twenty-five common and resident species of bird on a daily basis. These species are listed below according to habitat type. Thirty-three species of bird are listed as transient or occasional sightings. Eight migrants have been recorded on Guana Island, and may best be seen during the Fall migrations. Two accidentals have also been recorded on Guana Island following a storm. Field Observation Dates: October 20 to November 2, 1991; July 12 - 29, 1992; June 23 to July 19, 1993; June 30 to July 26, 1994.

Salt Pond Birds

Resident: Black-necked Stilt - *Himantopus mexicanus*
Wilson's (Thick-billed) Plover - *Charadrius wilsonia*
White-cheeked Pintail - *Anas bahamensis*
Greater Flamingo - *Phoenicopterus ruber*
Transient: Little Blue Heron - *Egretta caerulea*
Cattle Egret - *Bubulcus ibis*
Snowy Egret - *Egretta thula*
Great Blue Heron, also white phase - *Ardea herodias*
Long-billed Dowitcher - *Limnodromus scolopaceus*
Green-backed Heron - *Butorides striatus*
Yellow-crowned Night Heron - *Nycticorax violaceus*
Clapper Rail - *Rallus longirostris*
Common Moorhen - *Gallinula chloropus*
Black-bellied Plover - *Pluvialis squatarola*
Lesser Golden Plover - *Pluvialis dominica*
Semipalmated Plover - *Charadruis semipalmatus*
Killdeer - *Charadrius vociferus*
Greater Yellowlegs -*Tringa melanoleuca*
Lesser Yellowlegs - *Tringa flavipes*
Willet - *Catoptrophorus semipalmatus*
Spotted Sandpiper - *Actitis macularia*
Whimbrel - *Numenius phaeopus*
Ruddy Turnstone - *Arenaria interpres*
Least Sandpiper - *Calidris minutilla*

Shore and Sea Birds

Common: Brown Booby - *Sula leucogaster*
Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
Roseate Tern - *Sterna dougallii*
Royal Tern - *Sterna maxima*
Laughing Gull (seasonal) - *Larus atricilla*
Occasional: White-tailed Tropicbird - *Phaethon lepturus*
Gull-billed Tern - *Sterna nilotica*
Cayenne Tern - *Sterna s. eurygnatha*
Common Tern - *Sterna hirundo*
Least Tern - *Sterna antillarum*
Sooty Tern - *Sterna fuscata*
Sandwich Tern - *Sterna sandvicensis*
Brown Noody - *Anous stolidus*
American Oystercatcher - *Haematopus palliatus*
Belted Kingfisher - *Ceryle alcyon*

Guana Island Bird Survey

Birds of Prey - Raptors

Resident: American Kestrel, Caribbean subspecies -
Falco sparverius caribaearum
Red-tailed Hawk - *Buteo jamaicensis*

Migrant: Short-eared Owl - *Asio flammeus*
Northern Harrier - *Circus cyaneus*
Osprey - *Pandion haliaetus*
Peregrin Falcon - *Falco peregrinus*

The Birds of The Flat - Open Field

Resident: *Scaly-naped Pigeon - *Columba squamosa*
*Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
*Bananaquit - *Coereba flaveola*
*Green-throated Carib - *Eulampis holosericeus*
Gray Kingbird - *Tyrannus dominicensis*
*Pearly-eyed Thrasher - *Margarops fuscatus*

* Also seen in the Forest

Occassional: Northern Mockingbird - *Mimus polyglottos*
Antillean Mango - *Anthracothorax dominicus*

Migrant: Barn Swallow - *Hirundo rustica*

Forest Birds

Resident: Bridled Quail Dove - *Geotrygon mystacea*
Mangrove Cuckoo - *Coccyzus minor*
Smooth-billed Ani - *Crotophaga ani*
Antillean Crested Hummingbird - *Orthorhyncus cristatus*
Black-faced Grassquit - *Tiaris bicolor*
Caribbean Elaenia - *Elaenia martinica*

Occassional: Caribbean Martin (at Summit) - *Progne dominicensis*

Migrant: Yellow-bellied Sapsucker - *Sphyrapicus varius*
Black-and-White Warbler (at Summit) - *Mniotilta varia*
Black-throated Green Warbler - *Dendroica virens*

Accidentals: Northern Oriole - *Icterus galbula*
Rock Dove - *Columba livia*

Tortola Island Bird Survey

On Tortola Island various sites visited for bird surveys included Josias Bay Salt Pond 7/14/93, Fat Hog Bay Pond 7/3/94, Belmont Pond 7/14/93 and 7/24/94, and Sage Mountain 7/24/94. Birds observed in the settlement areas of the East and West Ends and around the H.L. Stoutt Community College were also recorded. Twenty-nine species of birds were listed. These species are presented below described as salt pond birds, shore and sea birds, land birds, or birds of prey.

Salt Pond Birds

Black-necked Stilt - *Himantopus mexicanus*
  7/24/94 six individuals at Belmont Pond
  7/14/93 adults with young observed at both Josias Bay and Belmont Ponds
Wilson's (Thick-billed) Plover - *Charadrius wilsonia*
  7/14/93 four adults with one young at Belmont Pond,
  7/24/94 observed at Belmont Pond
White-cheeked Pintail - *Anas bahamensis*
  7/14/93 approximately sixty individuals at Josias Bay Pond
Little Blue Heron - *Egretta caerulea*,.7/14/93
  one adult and four immature at Josias Bay Pond, 7/3/94 at Fat Hog Bay
Cattle Egret - *Bubulcus ibis*
Yellow-crowned Night Heron - *Nycticorax violaceus*
  7/14/93 at Belmont Pond, 7/3/94 immature at Fat Hog Bay

Shore and Sea Birds

Brown Booby - *Sula leucogaster*
Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*, 7/15/93
  four to six individuals diving low to water near dock at B.I. bridge,
  approx. twenty-five at Tortola point on 7/16/93, and twenty on 7/17/93
Roseate Tern - *Sterna dougallii*
Laughing Gull - *Larus atricilla*
White-tailed Tropicbird - *Phaethon lepturus*, 7/12/94,
  four to five individuals observed in channel between Tortola and G. I.
Brown Noody - *Anous stolidus*, observed in channel between Tortola and G.I.

Birds of Prey - Raptors

American Kestrel, Caribbean subspecies - *Falco sparverius caribaearum*
  individuals sighted often in settlement areas of both the East and West End;
  one male observed in flight at Sage Mt.
Red-tailed Hawk - *Buteo jamaicensis*
  7/12/93 two dark phase individuals; 7/24/94 light underside, dark above,
  dark belly band, two observations at Belmont Pond

Tortola Island Bird Survey

Land Birds

- Scaly-naped Pigeon - *Columba squamosa*
- Zenaida Dove - *Zenaida aurita*
- Common Ground Dove - *Columbina passerina*
- Bananaquit - *Coereba flaveola*
- Green-throated Carib - *Eulampis holosericeus*, 7/24/94 Sage Mt.
- Gray Kingbird - *Tyrannus dominicensis*
- Pearly-eyed Thrasher - *Margarops fuscatus*
- Northern Mockingbird - *Mimus polyglottos*
- Tropical Mockingbird - *Mimus gilvus*, 7/14/93 several individuals observed near beach at Josias Bay Pond
- Mangrove Cuckoo - *Coccyzus minor*
- Smooth-billed Ani - *Crotophaga ani*
- Antillean Crested Hummingbird - *Orthorhyncus cristatus*
- Black-faced Grassquit - *Tiaris bicolor*
- Caribbean Martin - *Progne dominicensis*, 7/24/94 Sage Mt. three to four individuals flying and diving at summit

Beef Island Bird Survey

On Beef Island various bird recording sites were visited for this survey including the southern shoreline following the existing roadway 6/28/93, Trellis Bay 7/8/93, the middle flat salt ponds (mostly dry area) 7/8/93, and Sprat Point Salt Pond 7/8/93 and 7/24/94. Twenty-six species of birds are listed. These species are presented below described as salt pond birds, shore and sea birds, land birds or birds of prey.

Salt Pond Birds

Black-necked Stilt - *Himantopus mexicanus*
    6/28/93 vocals only, 7/8/93 one pair at Sprat Point and one damaged egg
    also six vocalizing loudly and circling small wet area at middle flats,
    7/24/94 six at Sprat Point
Wilson's (Thick-billed) Plover - *Charadrius wilsonia*
White-cheeked Pintail - *Anas bahamensis*
    7/8/93 one at Sprat Point, 7/24/94 nine at Sprat Point
Short-billed Dowitcher - *Limnodromus griseus*, 7/24/94 nine at Sprat Point

Shore and Sea Birds

Brown Booby - *Sula leucogaster*
Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
    7/12/94 in channel between Tortola and B.I.
Roseate Tern - *Sterna dougallii*
Laughing Gull - *Larus atricilla*
White-tailed Tropicbird - *Phaethon lepturus*
    7/12/94 four to five in channel between Tortola and B.I.
Brown Noody - *Anous stolidus*, 7/8/93 three in channel between Tortola and B.I.,
    7/12/94 several in channel

Land Birds

Scaly-naped Pigeon - *Columba squamosa*
Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
Bananaquit - *Coereba flaveola*
Gray Kingbird - *Tyrannus dominicensis*
Pearly-eyed Thrasher - *Margarops fuscatus*
Northern Mockingbird - *Mimus polyglottos*, 6/28/93 on power lines near airport;
    7/24/94 Sprat Point
Antillean Mango - *Anthracothorax dominicus*, 6/28/93
    observed territorial displays in response to kestrel vocalization playbacks
Mangrove Cuckoo - *Coccyzus minor*, 6/28/93 vocalizations only
    two different locations near airport, 7/8/93 Trellis Bay beach
Smooth-billed Ani - *Crotophaga ani*
Antillean Crested Hummingbird - *Orthorhyncus cristatus*, 6/28/93
    observed territorial displays in response to kestrel vocalization playbacks
Caribbean Elaenia - *Elaenia martinica*
Yellow Warbler - *Dendroica petechia*, 7/8/93 one male at Trellis Bay

Beef Island Bird Survey

Birds of Prey - Raptors

American Kestrel, Caribbean subspecies - *Falco sparverius caribaearum*
    6/28/93 two sightings and vocals once (possibly same bird),
    7/17/93 at bridge flying across water toward B.I. vocalizing
Red-tailed Hawk - *Buteo jamaicensis*

Peter Island Bird Survey

The following is a compilation of two summer bird surveys accomplished in consecutive years. On July 15, 1994 assisted by Heather Cunningham, graduate student from McGill University, we spent several hours recording American Kestrel, Caribbean subspecies *Falco sparverius caribaearum,* local name killy hawk, observations for population estimates, also maintaining a bird list of all species observed or vocalizations heard. We utilized a vehicle and traveled existing roadways for the survey, stopping often for observations. On July 17, 1993 accompanied by assistant Jane Coffey we walked the roadway to the southern point and back to the club recording killy hawk observations and maintaining a bird list. Many sightings of both male, female and immature killy hawk and vocalizations heard were made in both years, an estimated 6 to 10 individuals counted in 1993 and 10 individuals counted in 1994. The presence of immature killy hawk indicates that breeding pairs reside on Peter Island. It is important to note that in 1993 a female killy hawk was flying with jesses attached to her legs, indicating that she was a falconers bird.

On Peter Island we listed nineteen species of bird. These species are presented below according to either shore and sea birds, land birds, or birds of prey. Other common birds of the B.V.I. islands often seen at salt ponds were not recorded on these two surveys but are noted below. Most of the surveys were done in the higher elevations of the island not along the beaches. Two salt ponds were noted on the island, one at the southern point with water (no birds were noted present at time of observation), and one dry salt pond at the southern end of the eastern beaches. The western land areas were not visited and is covered by dense vegetation, but it would be an important goal of future surveys because it is an uninhabited part of the island. The habitat of Peter Island is a combination of dense low vegetation, and open fields (upper elevation at southern point). A few free ranging goats were noted at the higher elevations though understory vegetation remained healthy.

It is important to note that in both years of recording killy hawk observations, Peter Island had the most number of observations of all B.V.I. islands surveyed. Islands included in the surveys were Guana Island, Tortola, Anegada Island, Beef Island, *Virgin Gorda, *Great Camanoe, and *Jost Van Dyke (* surveyed only in 1993, no killy hawk noted on Jost Van Dyke). It is also important to note that the red-tailed hawk observations were consistent between the two annual surveys, and that the behaviors observed might be indicative of territorial defense. Peter Island may be a candidate for a nesting site of the red-tailed hawk.

Peter Island Bird Survey

Shore and Sea Birds

Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
Roseate Tern - *Sterna dougallii*
Laughing Gull (seasonal) - *Larus atricilla*

*Note: Brown Booby *Sula leucogaster* and Royal Tern *Sterna maxima* were not observed on surveys but common to area.

Land Birds

Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
Bananaquit - *Coereba flaveola*
Green-throated Carib - *Eulampis holosericeus*
Antillean Crested Hummingbird - *Orthorhyncus cristatus*
Gray Kingbird - *Tyrannus dominicensis*, fledglings noted at this time in 1993
Caribbean Elaenia - *Elaenia martinica*
Pearly-eyed Thrasher - *Margarops fuscatus*
Mangrove Cuckoo - *Coccyzus minor*, one noted near the club in 1993
Smooth-billed Ani - *Crotophaga ani*
    groups of 10 - 20 individuals noted both years especially at southern point
Black-faced Grassquit - *Tiaris bicolor*
Yellow warbler - *Dendroica petechia*, noted in 1993 near club, vocals only
Caribbean Martin - *Progne dominicensis*
    4 - 5 noted in 1994 at the summit and flying around coastal rock cliffs

* Important to note that no Scaly-naped Pigeon *Columba squamosa* or Northern Mockingbird *Mimus polyglottos* were noted though common on other islands.

Birds of Prey - Raptors: considered residents

American Kestrel, Caribbean subspecies - *Falco sparverius caribaearum*
Red-tailed Hawk - *Buteo jamaicensis*
    two individuals observed in 1993 both dark phase
    one individual observed in 1994 also dark phase

*Common Salt Pond Birds

Black-necked Stilt - *Himantopus mexicanus*
Wilson's (Thick-billed) Plover - *Charadrius wilsonia*
Black-bellied Plover - *Pluvialis squatarola*
Killdeer - *Charadrius vociferus*
Little Blue Heron - *Egretta caerulea*
Cattle Egret - *Bubulcus ibis*
Greater Yellowlegs -*Tringa melanoleuca*
Lesser Yellowlegs - *Tringa flavipes*
Spotted Sandpiper - *Actitis macularia*
Ruddy Turnstone - *Arenaria interpres*

*Note: These species were not recorded yet could be seen on Peter Island.

Anegada Island Bird Survey

The following is a compilation of two summer bird surveys accomplished in consecutive years. On July 22 and 23, 1994 my assistant Heather Cunningham, a McGill University graduate student, and I traversed most of the island recording bird observations both on foot and by vehicle. On July 15, 1993 accompanied by assistant Jane Coffey we spent several hours on foot bird listing west of the airport. The main objectives of our visits to Anegada Island were to observe the American Kestrel, Caribbean subspecies *Falco sparverius caribaearum,* local name killy hawk, for a population estimate, and to check the status of the reintroduced group of Greater or Caribbean Flamingo *Phoenicopterus ruber*. In our search for killy hawk we recorded all bird species observed including vocalizations heard. On Anegada Island we listed thirty-two species of birds. These species are presented below described either as shore and sea birds, land birds, or birds of prey. Killy hawk sightings were numerous, especially in 1994 nearest to the settlement. No flamingo were observed by air in 1993, but in 1994 four individuals were sighted near the east end of the salt ponds, all four birds were banded (Bermuda Zoo) and appeared in good health. The habitat type is low scrub with isolated groups of taller vegetation; the highest upper canopy approximately 15 to 25 feet. Undergrowth is sparse; island has free-roaming domestic herbivores consuming lower canopy vegetation.

It is important to note that no Pearly-eyed Thrasher *Margarops fuscatus*, Scaly-naped Pigeon *Columba squamosa*, or Bridled Quail Dove *Geotrygon mystacea* were observed on Anegada in either year. The Bridled Quail Dove is an uncommon species found on Guana Island, and the Scaly-naped Pigeon is common on both Guana Island and Tortola. It is especially interesting that the pearly-eyed thrasher is not present on Anegada Island though numerous on other B.V.I. islands and a highly successful species, it has become a nuisance bird competing with smaller avian species. An important question to answer would be why has the pearly-eyed thrasher not migrated to and/or taken up residence on Anegada Island? The answer could shed some light on inter-island movements of various bird species. Also, two species of birds noted, the Black Skimmer *Rynchops niger* and the Black Swift *Cypseloides niger* were not found listed on past Anegada Bird Surveys.

Anegada Island Bird Survey

Shore and Sea Birds

Black-necked Stilt - *Himantopus mexicanus*
Wilson's (Thick-billed) Plover - *Charadrius wilsonia*
White-cheeked Pintail - *Anas bahamensis*
Greater Flamingo - *Phoenicopterus ruber*, 4 noted at east end salt pond in 1994
Little Blue Heron - *Egretta caerulea*
Cattle Egret - *Bubulcus ibis*
Long-billed Dowitcher - *Limnodromus scolopaceus*
Willet - *Catoptrophorus semipalmatus*
Ruddy Turnstone - *Arenaria interpres*
Brown Booby - *Sula leucogaster*
Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
Roseate Tern - *Sterna dougallii*
Royal Tern - *Sterna maxima*
Laughing Gull - *Larus atricilla* , juveniles observed 7/22/94
Brown Noody - *Anous stolidus*
*Black Skimmer - *Rynchops niger*, flock of 9 juveniles observed 7/15/93

Land Birds

Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
Bananaquit - *Coereba flaveola*
Green-throated Carib - *Eulampis holosericeus*
Gray Kingbird - *Tyrannus dominicensis*
Yellow Warbler - *Dendroica petechia*
Northern Mockingbird - *Mimus polyglottos*
Tropical Mockingbird - *Mimus gilvus*
Mangrove Cuckoo - *Coccyzus minor*
Smooth-billed Ani - *Crotophaga ani*
Antillean Crested Hummingbird - *Orthorhyncus cristatus*
Black-faced Grassquit - *Tiaris bicolor*
Caribbean Elaenia - *Elaenia martinica*
*Black Swift - *Cypseloides niger*

Birds of Prey - Raptors

American Kestrel, Caribbean subspecies - killy hawk
Falco sparverius caribaearum
many sightings close to settlement,one partial leucism with white head observed near settlement on 7/23/94

1993 Jost Van Dyke Bird Survey

On 7/12/1993 my assistant Jane Coffey and I walked the southern roadway from Little Harbor to White Harbor recording bird species observed and vocalizations heard. We listed sixteen species of birds. These species are presented below described as shore and sea birds or land birds. Most important to note is that no American Kestrels, Caribbean subspecies *Falco sparverius caribaearum* , local name killy hawk, were either heard or seen. Locals interviewed stated that it had been a long time since they had seen a killy hawk on Jost Van Dyke. It would be interesting to verify whether or not killy hawk reside on Jost Van Dyke, or are frequent or infrequent visitors to Jost Van Dyke. Also another common B.V.I. island species noted absent on this survey was the Smooth-billed Ani *Crotophaga ani.*

Shore and Sea Birds

Black-necked Stilt - *Himantopus mexicanus*
Brown Booby - *Sula leucogaster*
Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
Roseate Tern - *Sterna dougallii*
Laughing Gull - *Larus atricilla*

Land Birds

Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
Bananaquit - *Coereba flaveola*
Gray Kingbird - *Tyrannus dominicensis*
Pearly-eyed Thrasher - *Margarops fuscatus*
Yellow Warbler - *Dendroica petechia,* vocalizations only
Tropical Mockingbird - *Mimus gilvus*, many sightings
Mangrove Cuckoo - *Coccyzus minor*, vocalizations only
Antillean Crested Hummingbird - *Orthorhyncus cristatus*
Black-faced Grassquit - *Tiaris bicolor*

1993 Great Camanoe Island Bird Survey

On 7/11/1993 my assistant Jane Coffey and I were dropped off by boat at Lee Bay on the West side of Great Camanoe to record bird species observed and vocalizations heard. We also wanted to note the presence of the American Kestrel, Caribbean subspecies *Falco sparverius caribaearum,* local name killy hawk. We walked the narrow low land area between the West and East beaches, then proceeded North along the Western beach to its end point, turned back and walked to the Southern end of the beach continuing up the slope of the Southern part of the island. We walked along a road which curved up to the highest elevation of the Southern part of the island amidst a residential area. Bird activity appeared low in this area. It would be important in the future to gain access to the more impenetrable North side of the island for the bird survey, where little disturbance occurs. We listed fourteen species of birds, including the killy hawk. These species are presented below described as either shore and sea birds, land birds, or birds of prey. There were no salt ponds (an important island habitat) noted along this survey route.

Shore and Sea Birds

Brown Pelican - *Pelecanus occidentalis*
Magnificent Frigatebird - *Fregata magnificens*
Laughing Gull - *Larus atricilla*
American Oystercatcher - *Haematopus palliatus*
Wilson's (Thick-billed) Plover - *Charadrius wilsonia,* observed on the Eastern beach, one female with two young and another female with one young

Land Birds

Scaly-naped Pigeon - *Columba squamosa*
Zenaida Dove - *Zenaida aurita*
Common Ground Dove - *Columbina passerina*
Bananaquit - *Coereba flaveola,* vocals only
Gray Kingbird - *Tyrannus dominicensis*
Pearly-eyed Thrasher - *Margarops fuscatus*
Smooth-billed Ani - *Crotophaga ani,* group of 4 -5 individuals at the flat beach area between the North and South elevations

Birds of Prey - Raptors

American Kestrel, Caribbean subspecies - *Falco sparverius caribaearum* observed at Eastern beach perched in a palm vocalizing, flew South up slope
Red-tailed Hawk - *Buteo jamaicensis,* vocals only

1993 Virgin Gorda Island Bird Survey

On 7/13/1993 my assistant Jane Coffey and I were driven to Virgin Peak, the highest elevation on Virgin Gorda. We visited the park at the summit and then walked down the roadway to Savana Bay recording bird species observed and vocalizations heard. We also were looking to verify the presence of the American Kestrel, Caribbean subspecies *Falco sparverius caribaearum*, local name killy hawk, on Virgin Gorda. We listed nine species of birds, including the killy hawk. These species are presented below described as shore and sea birds, land birds, or birds of prey.

An important observation concerning the salt pond at Savana Bay was that although the salt pond ecosystem appeared healthy its integrity was being compromised by human disturbance due to its easily accessible location and proximity to a very busy beach. Future surveys on Virgin Gorda should concentrate on the elevated North portion of the island where there is less disturbance.

Shore and Sea Birds

- Brown Pelican - *Pelecanus occidentalis*
- Laughing Gull - *Larus atricilla*
- Black-necked Stilt - *Himantopus mexicanus*
    - two adults with two adult-sized young at salt pond near Savana Bay

Land Birds

- Zenaida Dove - *Zenaida aurita*
- Bananaquit - *Coereba flaveola*
- Gray Kingbird - *Tyrannus dominicensis*
- Pearly-eyed Thrasher - *Margarops fuscatus*
- Northern Mockingbird - *Mimus polyglottos*
    - observed in settled area of the Southern part of the island

Birds of Prey - Raptors

- American Kestrel, Caribbean subspecies - *Falco sparverius caribaearum*
    - two males observed, one at the summit and one on the power lines along the quarry, on the West side of the land bridge between the elevated side of the island with the flat side

Marine Science Month Report and Proposal, 1995

Lianna Jarecki

Although I was quite busy with the organization of the Natural Resources Management Program at the College last July, I was able to continue monitoring hypersaline ponds around the BVI, and I was able to continue monitoring the sponge fauna on Guana's reefs, work that is now in its third year.

SPONGE POPULATIONS ON GUANA'S CORAL REEFS

Sponge populations were counted at the ten permanent transects around Guana's reef perimeter. At each site, the permanent transect and two thirty-meter transects running in random directions from one permanent marker were counted. These transects are all at about 30' depth and are 30 meters long. Sponges were identified to genus or species where possible, and individuals were counted at points of 10cm intervals along the transect line. Forty common species were recognizable in the field, while a few others were counted as unidentified. Darryl Sookram, an A' level Biology student at H. Lavity Stoutt Community College, assisted in this project and became proficient at recognizing coral species. At each transect, he identified corals at points with 20cm intervals. Coral counts are used to characterize reef type at each transect.

This year, transect counts will be repeated using the same methods. The data will be used to compare sponge faunas at different reef sites around Guana.

HYPERSALINE POND ECOLOGY IN THE BVI

A number of hypersaline ponds were visited and sampled during July 1994. The growing patterns evident in the sporadic sampling I have done on hypersaline ponds since 1988 led me to embark on a much more intensive study, beginning in January of 1985. Darryl has assisted me with all data collection. Since January, we have sampled a set of 10 hypersaline ponds on five islands each month. Sampling includes a twenty-meter plankton tow, bird count, water chemistry analysis, depth and temperature monitoring, fiddler crab counts, and vegetation descriptions. This work has accumulated much data, some of which I presented at the 27th meeting of the Association of Marine Laboratories of the Caribbean in early June. Patterns emerging from my statistical analysis indicate the need for more sampling to achieve significant results. An abstract of the talk given follows this report.

This hypersaline pond study became even more exciting and important with the success of the Anegada flamingos' reproductive attempts in May. With continued monitoring, we can better understand the role of flamingos in the BVI hypersaline pond ecosystems. In fact, this project is now in the rare position to propose a before-and-after comparison of a species reintroduction to a confined ecosystem.

Intensive monitoring, as described above, will continue through at least December, 1995, and for another year beyond that if resources allow. During marine science month, I also plan to flesh out certain aspects of the BVI hypersaline pond study. Specifically, Darryl and I will undertake an in-depth characterization of shore vegetation at each study site; aerial photographs of all BVI ponds will be taken to calculate area and map locations; samples of fiddler crabs and copepods will be taken preserved for expert identification; temperature and salinity profiles will be measured in some ponds; and cyanobacterial mat regrowth studies will be initiated. The latter is a peripheral project being conducted in collaboration with Dr. David Garbary, a phycologist at St. Francis Xavier University in Nova Scotia.

In addition to these projects, I will coordinate the activities of marine science month participants and will assist in the coordination of the Ornithology course scheduled for the last week of August.

Correspondence

UNIVERSITY of the VIRGIN ISLANDS
MacLean Marine Science Center

MEMORANDUM

26 May, 1995

To: Ms. Lianna Jarecki
H. Lavity Stout Community College
FAX: 809-494-4996
email: ljarecki@igc.apc.org

From: James F. Battey, Ph.D. Jas F. Battey
President
Association of Marine Laboratories of the Caribbean
Acting Director
MacLean Marine Science Center
phone: 693-1381
FAX: 693-1385
email: jbattey@uvi.edu

Re: Application to Conduct Research at Guana Island

I am interested in visiting Guana Island in August, 1995 to initiate a research project on genetic relatedness within the *Montastrea annularis* species complex. I would collect 1cm diameter cores from 10 colonies of each of the 3 putative species in the complex. DNA will be extracted from the cnidarian tissue and analyzed by random amplified polymorphic DNA analysis (RAPD). The core holes will be filled with plasticine, and will grow over within one year.

I would arrive by boat with my wife, Judy Muse, on the afternoon of 24 August, and depart on the afternoon of 27 August. I am most interested in conducting much more extensive research at Guana Island in August of 1996. My participation in a Molecular Ecology of Marine Symbioses course from 1-19 August, 1995 at the Bermuda Biological Station, precludes my conducting extensive research at Guana Island during the 1995 coral research program

I look forward to meeting the scientists working at Guana Island and hope to include Guana as a site in my Caribbean-wide study of *Montastrea* population structure.

Tel: (809) 776-9885, 2 John Brewer's Bay, St. Thomas, V.I. 00802-9990

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

November 23, 1994

Lianna Jarecki
H.L. Stoutt Community College
Box 3097
Road Town, Tortola
British Virgin Islands

Dear Lianna:

First, I strongly regret not being able to participate during this summer (1994) research activities at Guana Island (BVI). This year was truly demanding. Just to give you an idea, 1994 commenced with a major oil spill and everything that such event implies.

If we plan now, I will solicit permission from my superiors to participate during next summer activities. I am particularly interested in the National Park Trust interest in monitoring recolonization of damaged reefs. Furthermore, I would enjoy receiving information on the new findings concerning associations of reef fish. I am including within this letter a paper by Dr. McGehee with respect to reef fish assemblages.

I know it has been two research summers that I have missed. Notice that I am now working with NOAA. At present I have no assistants, so I must take care of matters myself. However, lets plan next summer now.

Hope to hear from you and from your long term monitoring of reef sponge populations.

Sincerely yours,

Vance P. Vicente

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

February 7, 1995

Lianna Jarecki
H.L. Stoutt Community College
Box 3097
Road Town, Tortola
British Virgin Islands

Dear Lianna:

Thanks for your letter and for sending the article on coral recruitment. It was very useful during one of my presentations on eddies and larval transport.

I still would like to receive information from the National Park Trust monitoring recolonization studies of damaged reefs.

I would like to offer lectures at Guana between July 24-29, 1995. I could include one or several of the following topics: seagrass beds structure and function, coral reef benthic community structure, green turtle and hawksbill turtle foraging behavior, non-point source pollution and their impact on coral reefs and seagrass beds: problems and solutions for tropical islands, sponge taxonomy and ecology, and related topics. Take your choice.

Sincerely yours,

Vance P. Vicente

H. Lavity Stoutt Community College
Paraquita Bay Campus

P.O. Box 3097
Road Town, Tortola
British Virgin Islands

Tel: (809) 494-4994
Tel: (809) 494-4902
Fax: (809) 494-4996

Jorge R. Garcia
Department of Marine Sciences
University of Puerto Rico
P.O. Box 908
Lajas, Puerto Rico, 00667

12 May, 1995

Dear Dr. Garcia,

I am writing to invite you to a marine research program on Guana Island, BVI. This is an annual event, begun in 1992, that arose as an offshoot of Dr. Skip Lazell's research program in terrestrial biology on Guana. In both of these research programs, the Guana Island Resort offers its excellent hotel services to visiting scientists, who are invited from a variety of international institutions to conduct their own research on Guana Island. This year, Skip's terrestrial program will run during October and the marine program I organise will run during August. During these months, scientists either already conducting a research project or wishing to establish ongoing research on Guana Island are invited for one month to Guana Island Resort.

I am particularly desirous of your participation this year for two reasons. Firstly, I have seen your published research on zooplankton, and I would very much like your thoughts on a long-term ecological study I am presently conducting on BVI hypersaline ponds. Secondly, Skip told me that you have research interests in the white-cheeked pintail duck population here in the BVI. Please consider joining the marine research group on Guana for the month of August, 1995. Your expertise would be quite valuable to our ongoing research projects, and I would encourage you to use Guana's annual summer field station as a base to establish some of your own research. If you do wish to study the ducks, I could help with logistics as I am monitoring bird populations of hypersaline ponds.

Other biologists involved in the August program on Guana include: Dr. Graham Forrester (fish/reef associations), of the University of California, Santa Barbara, Dr. David Carlon (coral larvae recruitment), of the University of New Hampshire, Dr. David Bird and Dr. Rodger Titman (ornithology), of McGill University, Canada, Dr. Jim Battey(coral biochemistry), of the University of the Virgin Islands, and Dr. Vance Vicente (sponge ecology), of the NOAA Caribbean Fishery Management Council, Puerto Rico. I do hope that you are interested and available to join us this August. Please contact me as soon as possible.

Sincerely,

Lianna Jarecki

Lianna Jarecki

CONNECTICUT

MARINE SCIENCES INSTITUTE

12 May 1995

Ms. Lianna Jarecki
10 Timber Trail
Ry NY 10580

Transmitted by fax: [809] 494-4996

Dear Lianna

I just arrived home from a week of work at the Marine Biological Laboratory in Woods Hole. While sifting through the journals in the library I noticed that our report of the Guana Island gorgonian shrimps had just been published in *Journal of Crustacean Biology*. So I was already thinking of you when you called! I'll get reprints off as soon as they get here.

Pat and I apologize that the project took so long, but examining more than 1000 shrimps all about the size of a pencil point took some time. We also made more than 300 histological sections of 35 male *Neopontonides chacei*, the predominant shrimp appearing in the collections. This also was time consuming. At one time I worked on dolphins and whales, and it was easier: a microscope wasn't required to find them.

Your message made mention of Guana Island. What's on the program for this year? I see that you're still living in the BVIs, no doubt sailing around in the sun and having a good time.

I'll be here for the next few weeks except for a trip sometime in June to visit my son in Virginia Beach. Give a call or drop a fax. My laboratory fax is [203] 572-7700; the laboratory telephone is [203] 572-0202.

An Equal Opportunity Employer

1084 Shennecossett Road, Groton, Connecticut 06340-6097 (203) 445-3436 Fax (203) 449-8085

Good to get your message!

Yours truly

Stephen Spotte

SS/ss

UNIVERSITY OF
CONNECTICUT

MARINE SCIENCES INSTITUTE

26 May 1995

Ms. Lianna Jarecki
HLS Community College
P. O. Box 3097
Road Town, Tortola
BRITISH VIRGIN ISLANDS

Transmitted by fax: [809] 494-4996

Dear Lianna

After much thought I must regretfully decline your generous offer to participate in Marine Month at Guana Island in August. The work I had planned to submit can't be done without trained personnel.

My principal interests at the moment involve physiological aspects of ecology. The methods are more convoluted than performing a fish census or establishing a sampling station. My wife possesses the necessary expertise, but our last son has been accepted into the College of Architecture at Syracuse University, and her presence here will be required for much of August. Roy Manstan, my former graduate student, would like to go but has previous commitments.

Thanks again for considering me, and I hope that my declining this year won't jeopardize a future offer to return to Guana Island.

Yours truly

Stephen Spotte

SSlss

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Guana Island Marine Science Month Report

Short Courses

Last year we began the first cooperative dealings in education with the BVI community by offering a course in coral reef management taught by the primary researchers in Guana's Marine Program. This course was very successful. Though it kept us intensely busy, we all enjoyed putting the course together and teaching it, and students gave rave reviews. The summary report of this short course, which you should have already received last Fall, is also included here. I would like to make the teaching of one intensive short-course by Guana's researchers an annual tradition.

In the last week of August, we are planning for a short course in Ornithology. The course title is "Birds of the BVI: their habits, diversity, and protection." It will be taught by two visiting professors from McGill University in Canada, Dr. David Bird and Dr. Rodger Titman, and by our long-time Marine Science Month participant, Christina Leahy. There will be special lectures by myself and Rowan Roy. I submitted a proposal for funding to the OUS/USAID training office in Barbados, which was rejected on the grounds of being too specialized and unrelated to other regional projects. Unfortunately, this funding request was also in the wake of another, more expensive seminar in marine park development that was approved (Nick Drayton and I will be co-teaching a course in Marine Parks Development in Montserrat in July). I am presently seeking alternative funding, partially from you and partially from student fees. I have also asked the Rotary Club for a grant to sponsor a few of our College students.

Participants in this course would include members of the BVI adult community, College students, who, hopefully, will be sponsored by Rotary, and our two young Marine Science Month interns.

H. Lavity Stoutt Community College
Short Course Announcement:

"Birds of the BVI their habits, diversity, and protection."

August 21 to 25, 1995

Venue:

- Five-day intensive course.
- Each day will be split into two 1/2-day segments.
- Lectures will be given each day for 3 or more hours, with short breaks.
- The remainder of each day (4 to 5 hours) will be spent in the field observing and identifying birds in various habitats (e.g. Sage Mountain National Park, Fat Hogs Bay mangrove swamps, which is National Parks Trust land, Beef Island flats and salt ponds, and Guana Island dry forest)

Instructors:

- Dr. David Bird, Instruction, McGill University, Canada
- Dr. Roger Titman, Instruction, McGill University, Canada
- Christina Leahy, Course Design and Instruction, Raptor Rehabilitation Center, Connecticut, USA
- Lianna Jarecki, Coordination and Instruction, H. Lavity Stoutt Community College

Remarks:

This course is open to anyone interested in local birds. It is designed to give a basic understanding in all aspects of bird biology while more specifically addressing certain topics such as behavior, physiology, ecology, and conservation of BVI birds. Although some advanced topics will be discussed, no prior training is required for enrollment. Topics to be covered include: Caribbean bird identification, classification, biogeography, physiology, plumage, feather identification, habitat requirements, courtship and mating systems, territoriality, vocalizations, avian research in the Caribbean, bird banding, rehabilitation of injured wild birds, endangered species, conservation, re-introduction, and ecological indicators.

Enrollment:

Enrollment is limited to fifteen students. Fees are $120 for the week, which includes light refreshments at coffee breaks and lunch on Guana Island.

For registration information, please phone Nicole Donovan or Lianna Jarecki at HLS Community College, 44994.

THE BIRD BIOLOGY COURSE

Schedule of Activities - August 21 - 25, 1995
H.L. Stoutt Community College, Tortola, B.V.I.
Classes to be held in the College Lecture Rooms and Biology Laboratory

MONDAY - August 21

8:30 - 10:00 AM	Class: Introduction (Bird & Titman) What is a bird? How do birds differ from other animals
10:00 - 10:15 AM	Break
10:15 - 11:30 AM	Class: Bird Identification, Bird Classification, Topography, World Distribution (Bird & Titman)
11:30 AM - 12:00 PM	Lab: Caribbean Feather Identification (Leahy)
12:00 - 1:30 PM	Lunch Break
1:30 - 2:45 PM	Class: Feathers and Plumage (Titman)
2:45 - 4:15 PM	Class: Flight (Titman)
4:15 - 4:30 PM	Break
4:30 - 6:00 PM	Class: The Senses (Bird)

TUESDAY - August 22

8:00 - 8:30 AM	Travel to Sage Mountain - SemiTropical Wet Forest
8:30 -11:30 AM	Sage Mountain Bird watching
11:30 AM - 12:00 PM	Return to H.L. Stoutt Community College
12:00 - 1:30 PM	Lunch Break
1:30 - 3:00 PM	Class: Habitat Requirements (Bird, Titman, & Leahy)
3:00 - 4:30 PM	Class: Breeding Behavior (Titman) Courtship, Mating Systems, Territoriality
4:30 - 4:45 PM	Break
4:45 - 6:15 PM	Class: Vocalizations and Bird Song (Bird, Titman, & Leahy)

THE BIRD BIOLOGY COURSE

WEDNESDAY - August 23

7:30 - 11:30 AM	Field Trip to Guana Island: Hike to Long Point Bird watching
11:30 AM - 12:00 PM	Back to College
12:00 - 1:30 PM	Lunch Break
1:30 - 3:00 PM	Class : Avian Research (Bird, Titman, & Leahy) Bird Trapping and Banding, Counts, Listing, Field Studies, Rehabilitation, Museum Specimens
3:00 - 4:00 PM	Guest Speaker Lianna Jarecki Salt Pond Ecology - Bird Data
4:00 - 4:15 PM	Break
4:15 - 5:45 PM	Class: Endangered Species, Conservation, Re-introduction, Ecological Indicators (Bird, Titman, & Leahy)

THURSDAY - August 24

8:00 - 11:30 AM	Field Trip Pond Ecosystem and Bird Life Fat Hogs Bay Pond, Tortola; Beef Island Flats
11:30 AM - 12:00 PM	Back to College
12:00 - 1:30 PM	Lunch Break
1:30 - 3:00 PM	Class: Avian Anatomy and Physiology (Bird)
3:00 - 4:30 PM	Class: Nests, Clutch Size and Parasitism (Titman)
4:30 - 4:45 PM	Break
4:45 - 6:15 PM	Class: Feeding and Digestion (Bird)

THE BIRD BIOLOGY COURSE

FRIDAY - August 25

7:30 - 9:45 AM	Day Field Trip to Guana Island Birds of the Salt Pond, the Flat, the Ghut, and the Shoreline
9:45 - 10:00 AM	Break
10:00 - 11:30 AM	Class - Club House Living Room: (Titman) Migration and Navigation, Island Movements
11:30 AM- 1:00 PM	Lunch Break
1:00 - 1:30 PM	Back to College
1:30 - 3:00 PM	Class: Specialized Physiological Adaptations (Bird)
3:00 - 4:00 PM	Class: Slides on Local Bird Species (Leahy) B.V.I Christmas Bird Counts - Rowan Roy
4:00 - 4:45 PM	Summary, Student Bird Lists Test
4:45 PM	Farewell Reception - @ Loose Mongoose

Guana Island Marine Science Month Report

Internships

For the fourth year, Ian Greenspan, will be participating in the Marine Science Month activities. He is 13 years old now and is as serious about science as ever. He started a certification course with Liz Kintzing on Guana last year, and I have asked him to finish the course at a dive operation in New York before August. Once certified, he can join us underwater. He will also be able to help with labeling photographs in the museum, count birds at the salt pond, and perhaps enroll in the Ornithology course.

Franz Gerster will be joining us for three weeks. This is his first time, and he will undoubtedly be a great help. I am assigning him the duties of air compressor technician. In addition, we will train him in data collection and coral identification. Wayne is arranging for his scuba certification in New York.

Darryl Sookram will also join us again. He has been accepted to the University of the West Indies Faculty of Natural Science and will begin attending in early September. Darryl has become skilled in collecting data from salt ponds and coral reefs. He attended the Coral Reef Management Course last summer and learned to identify all of the common coral species. In my hypersaline pond study, Darryl collects all of the bird data and does much of the chemical analysis of water samples at the ten ponds we visit each month. He has also initiated his own study on the behavior of wading birds at salt ponds, and I hope that he will have enough data to publish a short article by the end of the summer. He will again assist me in taking data from the reef transects around Guana and from my 10 salt pond study sites.

Additionally, I have extended an invitation to my six A' level Biology students who will be entering their second year at HLSCC this Fall, to visit and participate in research activities. I was encouraging Liz to offer a certification course to interested locals, but it is not yet clear whether her schedule will permit it.

Guana Island Marine Science Month Report

Idea Exchange

I have invited Dr. Jim Battey from the Maclean Marine Science Center to visit for a few days. I believe he will be a valuable connection to Caribbean marine research and there may be opportunities for joint projects in the future. He may even come in the MacLean Center's research vessel! He plans collect some small coral samples for his own research at UVI, which focuses on the biochemical physiology of Caribbean corals.

Dr. Vance Vicente from the Caribbean Fisheries Office in San Juan has been invited repeatedly and I hope he will visit this year. He is also a valuable connection and intellectual resource. In fact, he is probably the most skilled person in field-identifying rare sponges and corals in Puerto Rico and the Virgin Islands. He visited for two days in 1993 and I learned more about identifying sponges in the field than in all the years prior or since using various publications and illustrated identification guides. I keep hoping that he will develop a research undertaking on Guana, but he is extremely busy with his work in Puerto Rico.

APPENDIX I

Request for continued support of hypersaline pond monitoring.

Lianna Jarecki

In 1994, $5,000 was granted by TTC/GIWS to cover expenses of my hypersaline pond monitoring project. As you know, this is an intensive monitoring study in which I, with the help of a student assistant, visit ten ponds on five different islands each month. Each pond is sampled as follows:

1. An 80um plankton net is towed over a permanently marked twenty-meter transect line. The plankton sample is observed in the field, preserved, and taken back to the lab, where microscopic analysis provides species/density information for planktonic organisms.

2. Water samples are collected and analysed in the field using a dissolved oxygen sampler, portable spectrophotometer, chemical analysis kits, and a refractometer. Parameters measured are nitrate concentration, dissolved oxygen concentration, salinity, temperature, and depth. Initially, turbidity was also measured, but was discontinued after finding constant and very low turbidity in all ponds. I would like to expand chemical analyses to include measurements of nitrite concentration, ammonia concentration, and high-level nitrate concentration. The relative concentrations of different nitrogen-based compounds will give an indication of animal activity versus nitrifying and denitrifying bacteria. The importance of bacteria in hypersaline ecosystems is becoming evident as this study progresses.

3. Bird counts are taken at each pond. The number of individuals of each species is recorded, and notes are taken on feeding and breeding behaviors.

4. Qualitative observations such as pond color, estimated thickness of cyanobacterial mat, dominant vegetation types, shore characteristics, and weather are noted.

5. Four times per year, samples of the cyanobacterial mat at all ponds are collected and shipped by express mail to Dr. David Garbary at St. Francis Xavier University, Nova Scotia. He receives these samples alive and analyses bacterial composition and chlorophyll content in the mats. We are collaborating on this project to determine the species composition of these bacterial mats, to compare mats from different ponds, and to compare bacterial mat samples taken at different salinities and depths within the same ponds.

6. Further studies will also include mapping of all hypersaline ponds in the BVI by locating and photographing them from the air; quantitative mapping of vegetation around the ten study ponds; and continued monitoring of the BVI flamingos.

As in the past six months, it is crucial to have a trained assistant in this work. Darryl Sookram was exceptionally helpful and even developed his own small study observing behavior of common birds during the peak nesting season of April through

July. He will continue to assist through the end of August but will then leave the BVI to attend the University of the West Indies in Trinidad. Thus, I will select a promising student in one of my A'level Biology classes who can assist with data collection at least through December. I plan to pay the assistant $20 per pond, plus $5.00 per hour for lab work.

Other expenses include transportation to and from sites (we fly to Anegada and rent a car; on other islands we either use my car or my boat), overnight shipping of bacterial mat samples to Nova Scotia, replacement plankton nets (they wear out every two months), replacement chemical analysis kits, new analysis kits for measuring nitrite and ammonia concentrations, and a small amount for logistical expenses such as communications and incidentals. I will need another $5,000, as listed in the "Budget" section earlier in this report, to continue this project through the end of December, which would complete a full year of continuous monthly sampling.

APPENDIX II

Preprints and Reprints
of
New Papers

Oecologia, in press (accepted Jan 1995)

Strong density-dependent survival and recruitment regulate the abundance of a coral reef fish

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Abstract Debate on the control of population dynamics in reef fishes has centred on whether patterns in abundance are determined by the supply of planktonic recruits, or by post-recruitment processes. Recruitment limitation implies little or no regulation of the reef-associated population, and is supported by several experimental studies failing to detect density dependence. Previous manipulations of population density have, however, focused on juveniles, and there have been no tests for density-dependent interactions among adult reef fishes. I tested for population regulation in Coryphopterus glaucofraenum, a small, short-lived, goby that is common in the Caribbean. Adult density was manipulated on artificial reefs and adults were also monitored on reefs where they varied in density naturally. Survival of adult gobies showed a strong inverse relationship to their initial density across a realistic range of densities. Individually marked gobies, however, grew at similar rates across all densities, suggesting that density-dependent survival was not associated with depressed growth, and so may result from predation or parasitism rather than from a food shortage. Like adult survival, the accumulation of new recruits on reefs was also much lower at high adult densities that at low densities. Suppression of recruitment by adults may occur because adults cause either reduced larval settlement or reduced early post-settlement survival. In summary, this study has documented a previously unrecorded regulatory mechanism for reef fish populations (density-dependent adult mortality) and provided a particularly strong example of a well established mechanism (density-dependent recruitment). In combination, these two compensatory mechanisms have the potential to strongly regulate the abundance of this species, and rule out the control of abundance by the supply of recruits.

Key words Density dependence . Population dynamics . Recruitment . Reef fishes

Introduction

Understanding the causes of fluctuations in population abundance is an important goal for ecologists (Andrewartha and Birch 1954). Recently, marine ecologists studying species that have dispersing larval stages have proposed an important role for the supply of larvae as a cause of variation in the abundance of adult populations (e.g. Underwood and Denley 1984, Connell 1985, Gaines and Roughgarden 1985, Keough 1986, Raimondi 1990, Hughes 1990, Karlson and Levitan 1990). These species, that include many intertidal and subtidal invertebrates and most reef fishes, tend to show relatively limited movements as adults. Their larvae, however, spend a variable period of time in the plankton, where they have the potential to disperse large distances. An assumed consequence of this life cycle is that local adult populations are open, meaning that they may be replenished by larvae from distant sites in addition to, or instead of, by locally produced young. Local adult abundance will, therefore, reflect the input of new individuals by larval settlement, and their subsequent loss by mortality, in addition to any migration of settled individuals.

Several recent studies of reef fishes have suggested that patterns in local density of these species are driven by the supply of settlers from the plankton (Doherty 1981, Victor 1983, 1986, Doherty and Fowler 1994a, 1994b). This is one of the models encompassed by the broader concept of recruitment limitation (Doherty 1981) and was referred to as recruitment determination by Forrester (1990). Since variation in mortality, migration, and settlement will all affect patterns in abundance to some extent (unless absolutely constant) this verbal model implies that rates of larval supply predict virtually all of the variance in adult density. For this to be true, all other processes influencing the size of local populations, namely mortality and migration of adults, must be relatively invariant (Warner and Hughes 1988). An additional proposed feature of recruitment determined populations is that larval settlement and adult mortality should not be related to the density of the reef-based population (Doherty 1982, 1983, Doherty and Williams 1988, Mapstone and Fowler 1988). In fact, slight density dependence in these processes is compatible with control of patterns in abundance by recruitment (Victor 1986). Strong density dependence, however, would almost certainly break down any relationships between larval supply and population density, or age structure, and would suggest control of variation in density by processes other than recruitment.

Because of the difficulties in detecting density dependence from observational and correlative studies (e.g. Hassell 1986, Gaston and Lawton 1987), experimental manipulation of density provides the most reliable test for density-dependence or -independence of demographic rates. Several such tests have been conducted on reef fishes, and virtually all have focused on larval recruitment (where recruitment means the survival of individuals that settle from the plankton to an arbitrarily defined point thereafter), or on the growth and mortality of juvenile fishes up to the point when they reach sexual maturity. A general finding of these studies is that juvenile mortality is rarely affected by density (Doherty 1982, 1983), or if so only weakly (Jones 1984b, 1987a, 1987b, 1988, Behrents 1987, Forrester 1990) but juvenile growth rates are often suppressed at high densities (Doherty 1982, 1983, Victor 1986, Jones 1984b, 1987a, 1987b, 1988, Forrester 1990, Anderson 1993). The consequences of these juvenile interactions for patterns in adult abundance are difficult to assess, particularly since these studies lasted for two years at most, and the majority were done on damselfish species that can live for a decade or more as adults (Mapstone 1988, Jones 1990, Doherty and Fowler 1994a, 1994b). In summary, although some forms of density dependence do sometimes occur in reef fish populations, whether or not they have the potential to strongly influence patterns in adult abundance remains uncertain.

The aim of this study was to test for the operation of density-dependent mechanisms that have the potential to strongly influence patterns in the abundance of a coral reef fish. I conducted the first experimental test for density dependent mortality and growth of adult reef fishes, in addition to testing for suppression of larval recruitment by adults. I chose a goby with a life span of less than one year as the study species, to provide the maximum opportunity to detect regulatory interactions that would directly influence patterns in the size of adult fish populations.

Methods

Study species and background information

The study species was the bridled goby, Coryphopterus glaucofraenum Gill. Bridled gobies range from North Carolina and Bermuda to Brazil, and are common throughout most of the Caribbean (Böhlke and Robins 1960). They occur across a broad range of depths in reef and rubble areas with sand present, where they feed by picking or winnowing small invertebrates from the sand (G. Forrester, unpublished data). Individuals first appear on the reef at 10-13 mm total length (hereafter TL) following a planktonic larval phase averaging 27 days (Sponaugle and Cowen 1994). Larger individuals occupy small home ranges (< 2.5 m^2) and can be aggressive to conspecifics and other ecologically similar goby species. Bridled gobies are protogynous hermaphrodites in which males defend nests burrowed in the sand (Cole and Shapiro 1992). Cole and Shapiro (1992) found considerable variation in the size of sexually mature and immature individuals in Puerto Rico (minimum mature size = 16 mm SL, maximum immature size = 30 mm SL) indicating that reproductive status is not strictly related to size. For the purposes of this study, gobies > 25 mm TL were defined as adults and gobies < 25 mm TL considered juveniles.

This classification was intended only to separate established individuals from recent recruits, and not as an accurate indicator of reproductive status.

A survey of natural variation in density of bridled gobies was conducted during July 1993 in order to determine an appropriate range of densities for the experiment. Gobies were counted along 40 transects (length = 8 m, width = 0.5 m), divided among 4 sites around Guana Island. Transects were run through areas of suitable habitat, comprising a mixture of sand, rubble, and patch reef at depths from 3-15 m. The counts of adult gobies may be slight underestimates because they sometimes shelter out of sight in crevices. Newly settled gobies tend to stay on the sand, but are very cryptic when not moving. To help me detect the recruits, I caused them to move by skimming my slate over the surface of the sand while swimming the transect. Each goby counted was assigned to a size class (greater or less than 25 mm TL) based on visual estimation of its total length. Practice sessions prior to the survey, when I guessed the size of fish and then caught and measured them, verified that this method was accurate to within ±3 mm. The transect counts were used to construct a frequency distribution of goby densities, and thereby quantify the number of patches within which gobies experienced different levels of density.

Effects of adult density on goby demography

An experiment was done in 1994 to test the effects of local density on the growth and survival of adult gobies, and effects of adult gobies on recruitment from the plankton. I tested for density dependence both by manipulating goby density experimentally on artificial reefs, and by monitoring natural patches of reef where gobies varied in density naturally (Table 1).

The reefs were all located at a site adjacent to the southern side of Guana Island, British Virgin Islands. Eight artificial reefs were constructed in a large sandy area from 8-11 July 1994. The reefs were isolated by at least 10 m from other reefs, and any natural reef. Each reef consisted of four piles of coral rubble (0.65 * 0.65 m square) placed on the sand over a square of mesh, which helped prevent the rubble from sinking. Three of the piles formed an equilateral triangle around the fourth pile, which was in the centre of the triangle. The outer piles of rubble were 0.5 m from the central one, creating roughly 8.5 m^2 of useable area for the gobies, assuming they will travel no further than 0.4 m from the rubble (G. Forrester, unpublished data). The 8 natural reefs contained rubble, or reef, and sand in roughly similar ratios to the artificial patches and were all between 8.1-8.5 m^2 in area, excepting one patch which was 5.2 m^2. Two patches were part of a large area of continuous reef, but the others were all isolated from other reefs by at least 7 m.

My goal in setting up the experiment was to establish a different density of gobies on each of the reefs, spanning the natural range of variation (a regression approach), rather than establishing just two or three levels of density, with several replicate reefs at each level (an analysis of variance approach). I did this because I wanted to estimate relationships between density and demographic rates across a range of densities, rather than test for significant differences between a few levels of density. To this end, each of the 8 artificial reefs was randomly assigned a different number of adult gobies (> 25 mm TL) to establish densities ranging from 0.71 to 10.7 per m^2, and I chose natural reefs with different adult densities, ranging from 1.0 to 8.2 adult gobies per m^2 (Table 1). When choosing densities, I used more reefs at the lower end of the density range than at the high end because lower density reefs had fewer fish, and so mortality and growth measures from these reefs would be stochastically sensitive (the "low numbers" effect). Conversely, high density reefs contained many more fish and so should produce more robust measures of demographic rates.

All gobies stocked on the artificial reefs, and all adult gobies resident on 3 of the natural reefs, were marked to allow recognition of individuals. The gobies were captured with hand nets and anaesthetic (quinaldine) between 12-18 July and brought to the laboratory. They were then marked and their total length measured. After marking, they were held in running sea water for 48 hours before being released on their reef to ensure that they did not rapidly lose their marks, or show adverse effects from handling. Two marking methods were used; the first technique involved injecting a fragment (1 * 2.5 mm) of plastic, called a Visual Implant Tag (NorthWest Marine Technology Inc., Shaw Island, Washington, U. S. A.), under the fishes' skin to the left side of the dorsal fin. Each fragment was printed with a unique 3 digit code which could be viewed in the field without capturing the fish. The second method was to inject coloured acrylic paint under the gobies' skin to create spots of colour that were also visible to divers (Lotrich and Meredith 1974). Fish on each patch were marked with a different colour, so that I could detect migration among patches. I also marked gobies in 6 different locations on their bodies to facilitate recognition of individuals and ,where possible, each goby was given a unique mark. When duplication of marks was necessary, fish of similar size were given the same mark to permit rough estimates of growth rates. The adult gobies occupying the 5 remaining natural reefs were not marked, so that potential effects of marking on loss rates from the reefs could be assessed. Neither method appeared to have adverse effects on bridled gobies, with the exception that fish marked with paint grew slightly more slowly than gobies marked with Visual Implant tags (Forrester, unpublished manuscript).

All juvenile gobies (< 25 mm TL) were removed from the reefs between 14-18 July to avoid the possibility of confusing them with slow growing adult gobies when the experiment was monitored, and also because I wanted to measure how many new recruits accumulated on the reefs during the experiment.

The experiment ran for roughly 2.5 months, and was ended between 5-9 October. At this time all adult bridled gobies on the reefs were captured, measured and checked for marks. At this time I also searched reefs within 25 m of any of the experimental reefs for any marked adult gobies that might have emigrated from their original patch. Growth of adult gobies that survived to the end of the experiment was measured in two ways, depending on whether or not the fish had a unique mark. Growth of gobies that could be recognized as individuals was simply the increase in total length over the experiment. Some adults marked with paint in July shared the same mark with 1-4 other gobies, so that survivors at the end of the experiment could only be identified as being one of 2-5 fish originally present. For each of these fish I estimated a maximum possible growth rate (assuming it was the smallest fish of the group bearing the same mark in July) and a minimum possible growth rate (assuming it was the largest fish with the same mark in July). Recruitment of gobies to the reefs was estimated by collecting and removing all individuals too small to have been adults in July (based on the minimum observed growth of the smallest adults that were marked in July). Collecting was stopped on a reef after 10 minutes had passed without finding a recruit. Recruits were not collected on the 5 natural reefs occupied by unmarked fish because these reefs were part of a longer term monitoring program.

Results

Most transects censused during the initial population survey in July 1993 were occupied by adult gobies at densities of between 2 and 6 fish per m^2 (Fig. 1). Densities recorded in some patches were, however, considerably higher (Fig. 1) and the highest density observed (12 adults per m^2) was above the highest density used in the experiment (Table 1). These densities are within the range of other published density estimates for bridled gobies. Cole and Shapiro (1992) reported mean total densities (including juveniles) of 16.5 and 11.6 per m^2 at two sites near Puerto Rico, and Shulman (1985) reported densities ranging from 1-32 per m^2 on small (1 m^2) artificial reefs at St. Croix.

Recapture of the marked gobies transplanted in July 1994, and searches of the surrounding area, revealed only 4 instances where marked gobies emigrated from their reef during the experiment. Two gobies moved from their artificial reef to a neighbouring artificial reef, and 2 gobies moved from natural reefs to nearby areas (< 8 m distant). I found 5 unmarked adult gobies in October on reefs that had been occupied only by marked adults at the beginning of the experiment. These unmarked fish were too large to have recruited from the plankton during the experiment, and so must have been be either immigrants from surrounding reefs, or resident fishes that lost their marks. The rarity of confirmed movements, and the low number of unmarked fish on the reefs in October, reefs suggests that gobies did not frequently migrate, nor lose their marks. In addition, migrations and tag losses occurred on several reefs, suggesting that there were not one or two unusual reefs that might confound the results. Since rates of confirmed migration were low, I assumed that gobies that disappeared from the reefs occupied by marked fish in July had died. I also assumed that the 5 unmarked adult gobies found on these reefs at the end of the experiment were resident fish that had lost their marks. For the 5 reefs where I simply monitored unmarked adult gobies, I assumed that all loss of adults was due to mortality. These assumptions mean that, if there were instances of migration that I did not detect, survival will have been overestimated and migration underestimated.

The estimated survival of adult gobies stocked on the artificial reefs showed a strong, and apparently linear negative relationship with their initial density (regression, $n = 8$, $p = 0.03$, $r^2 = 0.50$), such that the proportion of fish surviving at the highest density was close to half that at the lowest densities (Fig. 2). Estimates of survival on the natural reefs showed a similar relationship with density to that for the artificial reefs, and the regression for all reefs pooled was almost identical to that for the artificial reefs alone (regression, $n = 16$, $p = 0.001$, $r^2 = 0.50$) (Fig. 2). Survival at very low densities (< 2 adults / m^2) appeared to be more variable than survival at higher density. This may simply have been because lower density reefs were occupied by relatively few gobies (< 16), and so a small change in the number of fish surviving would cause a big change in proportional survival. Density-dependent survival had a strong numerical impact on the goby population; the final number of adults on each reef showed little relation to the numbers initially present (Table 1).

Larger individually marked gobies tended to grow more slowly than smaller gobies (regression, $n = 48$, $p < 0.0004$, $r^2 = 0.36$) (Fig. 3a) but, despite the fact that survival was strongly density dependent, individual growth rates were not related to the initial number of fish on the reef (regression, $n = 48$, $p = 0.55$, $r^2 = 0.00$) (Fig. 3b). This lack of density-dependent growth was still apparent when individual growth was regressed against both goby size and density in a multiple regression ($n = 48$, $p > 0.24$). For fish that I could not recognize as individuals, I performed separate analyses on both their maximum and minimum possible growth. Maximum and minimum growth estimates showed similar relationships to goby size and density, and so only relationships with maximum growth are presented graphically (Fig. 4). Results of regression analyses corroborate those for individually marked gobies in that there were negative, though weak, relationships between initial size and growth for both the maximum possible (regression, $n = 30$, $p = 0.05$, $r^2 = 0.10$) (Fig. 4a) and minimum possible growth estimates (regression, $n = 30$, $p = 0.10$, $r^2 = 0.06$). Both maximum, and minimum possible growth rates were, however, unrelated to goby density in simple regressions ($n = 30$, $p > 0.18$, $r^2 < 0.04$) and multiple regressions including goby size as a second independent variable (n = 30, $p > 0.24$) (Fig. 4b).

The number of recruits that accumulated on the reefs during the experiment was related negatively to the number of adult gobies initially present (regression, n = 11, p = 0.02, $r^2 = 0.41$) (Fig. 5a) suggesting that adults inhibit the successful recruitment of juveniles. I cannot distinguish whether this relationship was caused by reduced larval settlement to reefs with high adult density, or to reduced survival of recruits that settle to densely populated reefs. If adults are causing increased juvenile mortality, the effect must occur fairly soon after settlement, because 108 of the 152 recruits on the reefs were less than 16 mm TL, which is close to the size at which bridled gobies appear to settle from the plankton (roughly 10-13 mm TL, Sponaugle and Cowen 1994, G. Forrester, unpublished data). Although recruitment was related to adult density in the 1994 experiment, the initial population survey in 1993 did not reveal a significant correlation between adult density and recruit density at the spatial scale of the transects (n = 42, p = 0.65, r = 0.07) (Fig. 5b).

Discussion

Density dependence in bridled gobies and other species

Recent population studies in marine systems have tended to focus on the process of larval settlement, or events occurring shortly thereafter (e.g. Raimondi 1990, Reed 1990, Stoner 1990). This emphasis has been particularly strong in studies on reef fishes (e.g. Shulman and Ogden 1987, Robertson 1988), for which there is almost no information on the mortality and growth of adults (for exceptions see Aldenhoven 1986, Eckert 1987, Gladstone and Westoby 1988). Experimental studies on juvenile reef fishes have not generally detected strong compensatory mortality during the period from settlement to maturation (Doherty 1982, 1983, Thresher 1983b, Behrents 1987, Jones 1987a, 1988, Robertson 1988a, Forrester 1990). This study was the first test for density-dependent mortality among adult reef fishes, and revealed a strong effect of density. Establishing many treatment levels with little or no replication at each level (a regression approach) allowed me to estimate the functional relationship between survival and density across the range of natural densities observed at the site. Adult survival showed a steep and apparently linear decline with increasing density, with the result that adult survival on densely populated reefs was almost half that observed on the reefs occupied by fewest fishes. The intensity of the effect was particularly striking, given that densities used in the experiment were not unnaturally high and were, in fact, less than densities of this species at other islands (Shulman 1985, Cole and Shapiro 1992, G. Forrester, unpublished data). There have been no published tests for density dependence of growth in adult reef fishes, but the consistent finding among studies of juveniles is that their average growth is inversely related to the density of other juveniles (Doherty 1982, 1983, Victor 1986, Jones 1987a, 1987b, 1988, Forrester 1990) and to the density of conspecific adults (Jones 1987a, 1987b, Forrester 1990). My results deviate from this pattern, in that even though adult mortality was strongly density dependent, the growth of adult gobies showed no relationship to their density.

More attention has been paid to the influence of adults on the recruitment of juveniles, and the presence of resident fishes has resulted in increases (Sweatman 1985, Jones 1987b), decreases (Stephens et al. 1970, Sale 1976, Shulman et al. 1983, Sweatman 1985, Behrents 1987, Stimson 1990) or no detectable effects (Williams 1980, Doherty 1983, Jones 1984a, 1987b) on the recruitment of conspecifics. These studies all measured recruitment at just a few levels of resident density, and thus could not determine the functional relationship between these variables over their complete range. Recruitment in this experiment showed a strong, continuous decline with increasing resident density, adding bridled gobies to the list of species whose adults can suppress recruitment of juveniles in their vicinity. It would be interesting to conduct experiments using a wide range of densities on other species, especially those whose recruitment was either unaffected, or enhanced by resident density in previous studies. Perhaps recruitment of these species is also suppressed once adult densities reach levels close to the maximum observed naturally? Surprisingly, there was no correlation between recruit and adult density in the initial population survey. The experiment and survey were, however, done at different spatial scales (8.5 m^2 versus 4 m^2) and detecting recruit-adult interactions will obviously be dependent on the scale of observation.

Potential mechanisms for density dependence

In most marine species studied experimentally, density dependence of post-settlement processes has been attributed to competition for food or space. Density-dependent growth and maturation of juvenile reef fishes has been shown, in some species, to be due to food shortage (Forrester 1990, 1991) and/or social inhibition of growth by conspecifics (Jones 1987a). Typically, reduced average growth at high fish densities is associated with an increase in the variance of growth rates, a phenomenon known as growth depensation (Magnuson 1962) that is similar to the pattern of growth in competing plant and algal populations (e.g. Turner and Rabinowitz 1983, Schmitt et al. 1986, Weiner and Thomas 1986, Reed 1990). In this experiment, the fact that survival of adult gobies was density dependent while their growth was not, suggests that the mechanism for density dependence was not food shortage - because limited food seems likely to result in depressed growth prior to mortality.

Resources more likely to be limiting the density of bridled gobies, and therefore contribute to density dependent recruitment and mortality, are suitable shelter sites. Newly settled bridled gobies (less than about 15 mm TL) stay on the sand, but above this size all individuals use crevices at the sand/reef interface for shelter (G. Forrester, personal observation). The availability of shelter sites can limit recruit and adult density of other crevice-dwelling gobies and blennies (Behrents 1987, Buchheim and Hixon 1992). Shulman (1984) showed that colonization of juvenile bridled gobies was higher on small reefs made of low relief corals (*Porites porites* and *Acropora prolifera*) and conch patches than on identically sized reefs made of either high relief corals (*Acropora cervicornis*) or concrete blocks. The interpretation was that the former materials provide more sand-level crevices than the latter, and so supported more gobies. More direct evidence for shelter limitation in bridled gobies was that colonization of reefs with shelter holes was greater than colonization of otherwise similar reefs lacking shelter (Shulman 1984).

Perhaps the most likely direct agent of goby mortality during my experiment was predation. Bridled gobies, by virtue of their small size, are vulnerable to many piscivorous fishes and losses to several species were observed at the study site. Most losses occurred to lizardfishes (*Synodus* spp.), which also prey heavily on gobies in other areas (Sweatman 1984). Shortage of shelter sites at high density, with a resultant increase in vulnerability to predators is a feasible mechanism for reduced goby survival on densely populated reefs (Possingham et al. 1994). There are other possibilities though because, in general terms, both certain types of predator functional response (Hassell and May 1974) and any behavioural tendency of predators to aggregate to dense prey patches (e. g. Boulding and Hay 1984, Robles et al. 1995) can result in decreased prey survival at higher density. Finally, I note that parasitism or disease, both of which also cause compensatory mortality in host populations, represent potential additional mechanisms (Murdoch and Walde 1988).

Consequences of density dependence for population dynamics

The final relevant issue to be considered is how important these density-dependent mechanisms are in shaping the dynamics of goby populations, and potentially of populations of other species. I define importance in this context to mean the quantitative contribution to explaining variance in the phenomenon of interest, which in this case is variation in the abundance of adult fishes. Density dependence in mortality or recruitment of the sort that I observed may have a variety of effects on local dynamics, producing either stable equilibria, limit cycles or chaotic fluctuations (Warner and Hughes 1988). The dynamical consequences of the effects revealed by the density manipulation are, therefore, not obvious. It is safe to conclude, though, that the strong compensatory mechanisms I observed will overwhelm the influence of larval supply and so are inconsistent with recruitment determination for bridled gobies.

Many researchers have made the case that the processes influencing population dynamics will vary among situations, and taxa. The short life span of bridled gobies, relative to many other reef fishes, allowed me to capture events that encompassed a significant fraction of their generation time in less than 3 months. It is also quite possible that a short life span, or some other life history feature may be the reason why density dependence was so pronounced in bridled gobies. A challenge now is to determine whether features like adult longevity, the duration of the larval phase, spawning patterns, or patterns of resource use can be used to predict differences in population dynamics among taxa. Careful comparative (e.g. Sponaugle and Cowen 1994) will be the key to this endeavour.

The results of this study, and other small scale experimental studies demonstrating density dependence, are also in contrast to larger scale studies that support recruitment determination based on correlations between measures of recruitment and subsequent adult density (Doherty

1981, Victor 1983, Doherty and Fowler 1994a, 1994b). Reconciliation of these differences may perhaps come by acknowledging, that processes important on the small patches of reef examined in experimental studies may not be important, or observable, at the scale of whole islands or archipelagos (Doherty and Williams 1988). Research on insects has shown that "spatial" density dependence, occurring in small patches within a larger site, is not apparent from examination of the entire site (Hassell 1986). One hypothesis perhaps worth testing is that density dependence in reef fishes tends to occur at the small scales, over which individual fishes interact with their immediate neighbours, but not at large scales such as among whole islands where oceanographic factors may dominate.

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Table 1. Experimental design and description of the experimental reefs.

Reef type	Reef no.	Reef area (m^2)	Initial adult density (no. / m^2)	Final adult density (no. / m^2)	Gobies marked
Artificial reefs	1	8.5	0.7	0.5	yes
	2	8.5	1.2	0.5	yes
	3	8.5	1.4	0.5	yes
	4	8.5	2.4	0.8	yes
	5	8.5	3.4	1.1	yes
	6	8.5	5.1	0.9	yes
	7	8.5	6.9	2.1	yes
	8	8.5	10.7	1.3	yes
Natural reefs	9	5.3	1.5	0.8	yes
	10	8.4	2.6	1.1	yes
	11	8	3.1	1.0	yes
	12	8.1	1.0	0.4	no
	13	8.2	1.5	0.9	no
	14	8.3	1.8	0.6	no
	15	8.8	4.8	1.9	no
	16	8.3	8.2	1.9	no

Figure captions

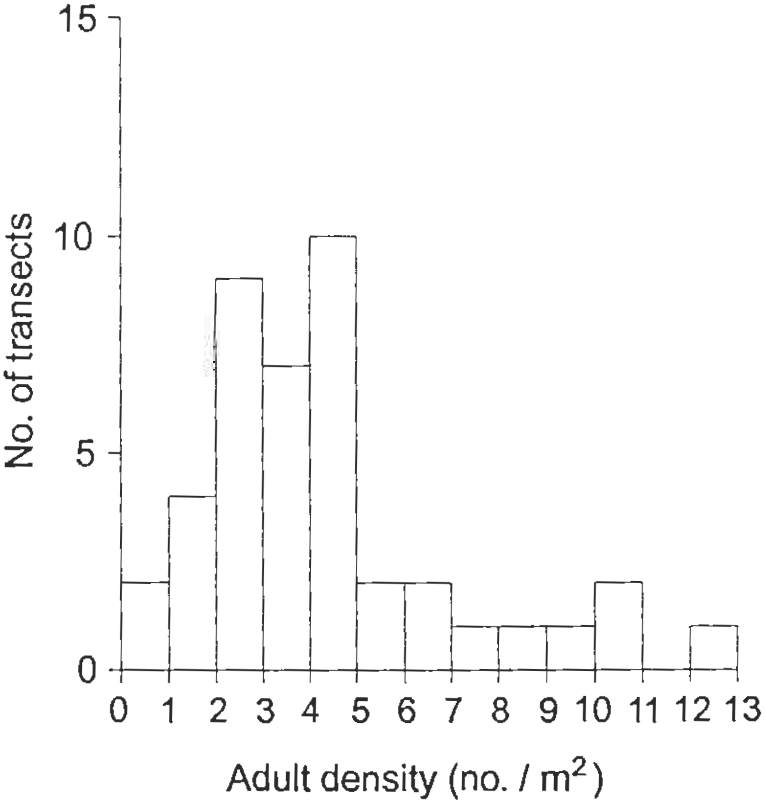
Figure 1. Frequency distribution of adult density for bridled gobies. The plot shows the number of transects where gobies were present at different densities.

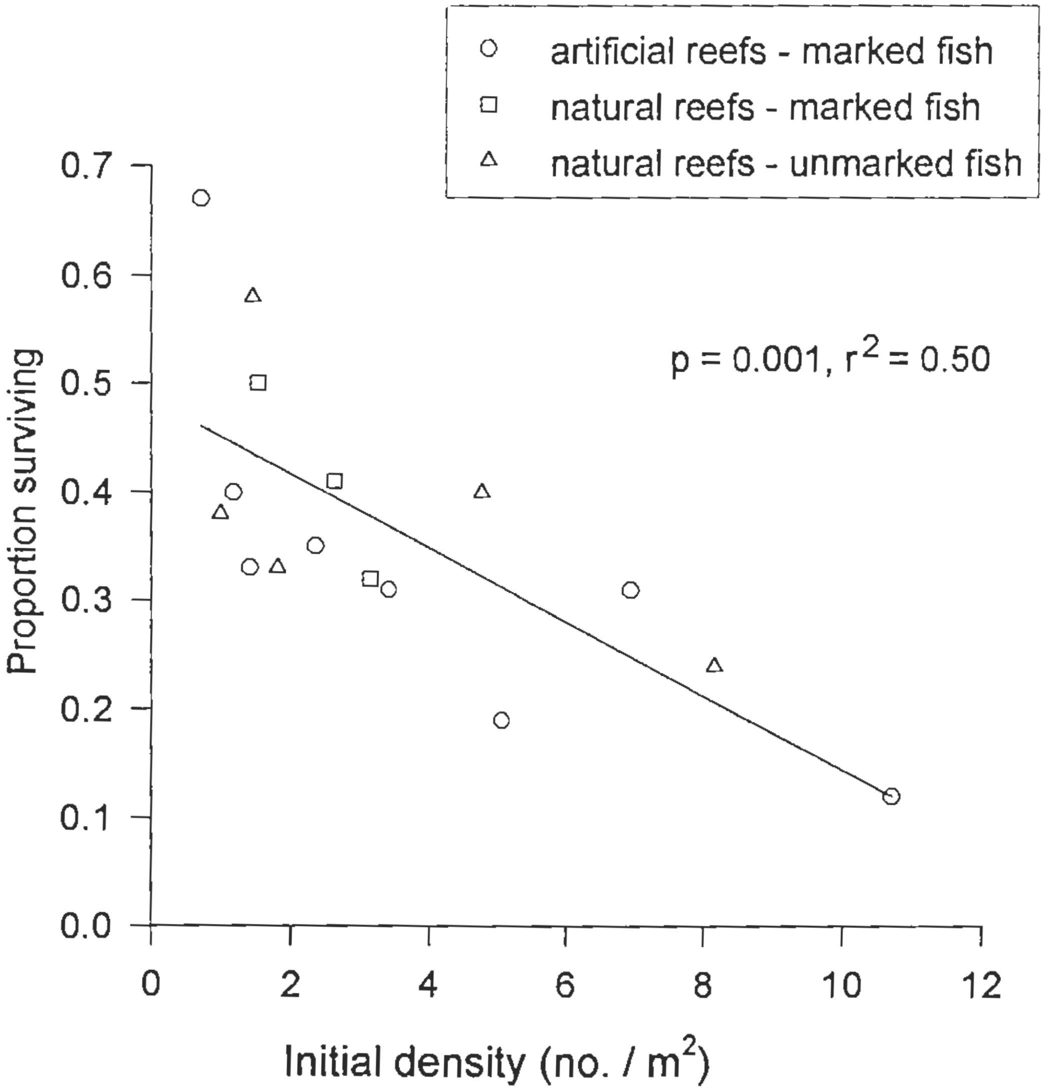
Figure 2. The relationship between the initial density and subsequent survival of adult bridled gobies on natural and artificial reefs. Gobies on different reefs were either marked (with implant tags or acrylic paint) or unmarked.

Figure 3. Relationships of (a) initial body size and (b) initial density with the individual growth of adult gobies.

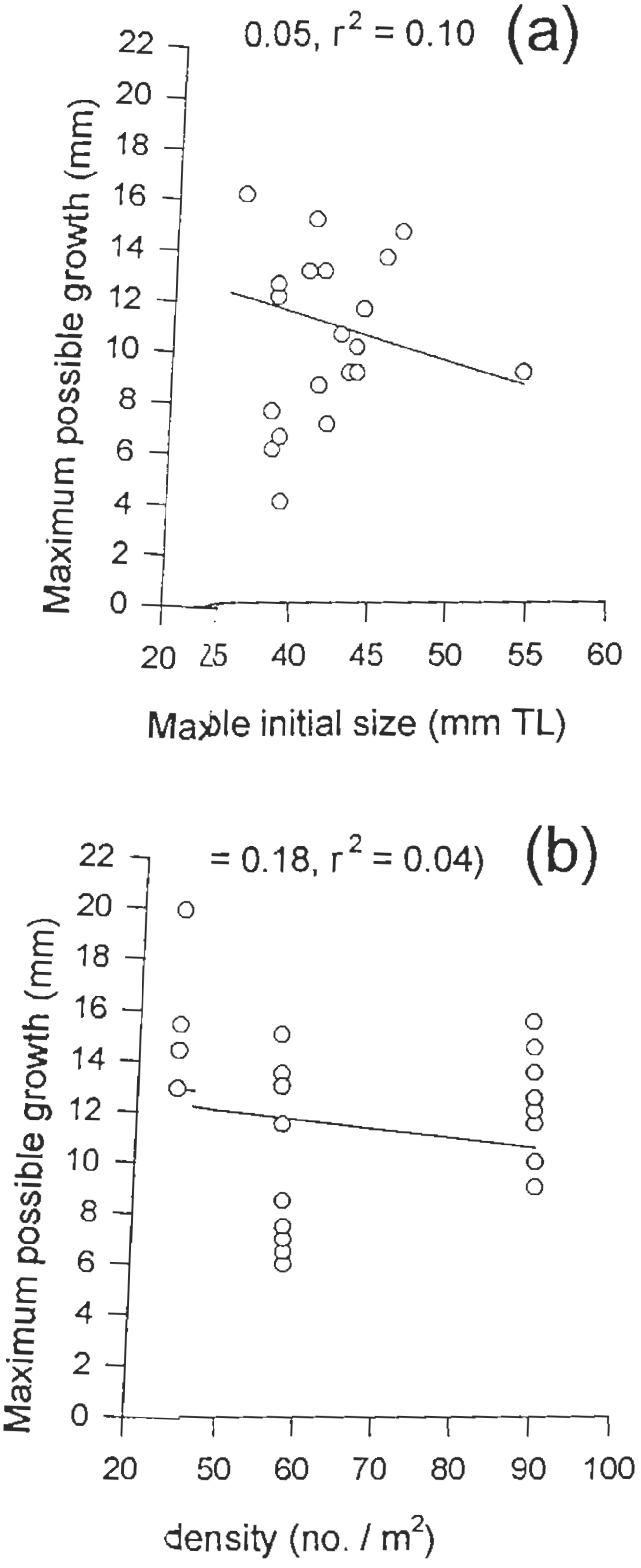
Figure 4. Relationships of (a) initial body size and (b) initial density with the growth of adult gobies. Growth rates and initial size are the maximum values possible for individuals that could not be recognized as individuals (see text for further details of growth estimation).

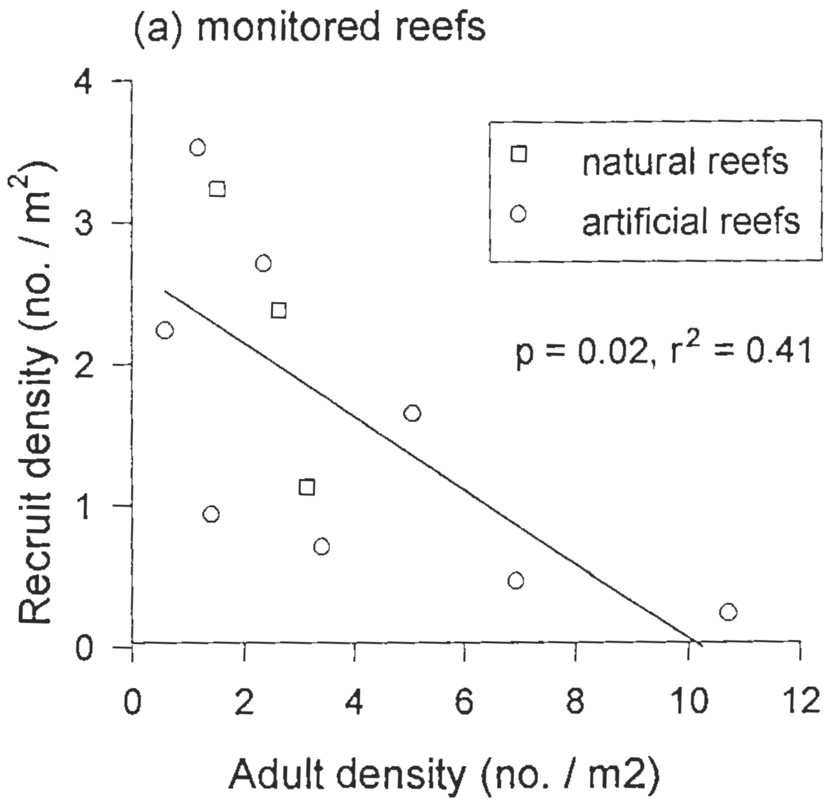
Figure 5. Relationships between recruitment and adult density. (a) The relationship between initial adult density and the number of recruits that accumulated on natural and artificial reefs in 1994. (b) Recruit and adult densities recorded using 4 m^2 transects during the initial population survey in 1993.

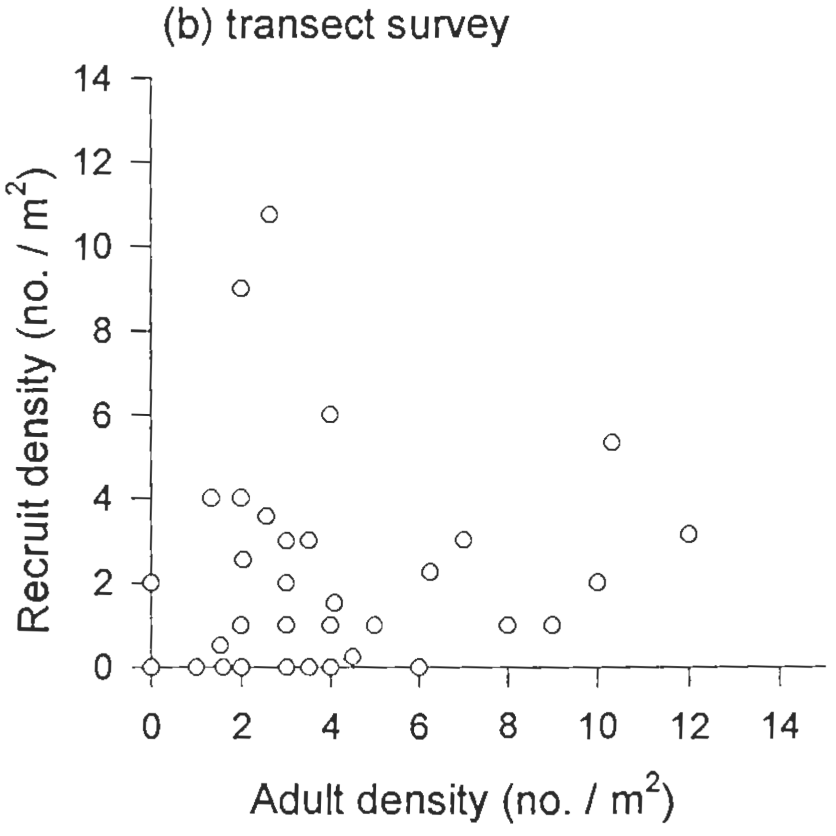

15
10
5
0
No. of transects
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Adult density (no. / m²)


○ artificial reefs - marked fish
□ natural reefs - marked fish
△ natural reefs - unmarked fish
p = 0.001, r^2 = 0.50
Proportion surviving
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
Initial density (no. / m^2)

G Forester Fig 4




(a) monitored reefs


(b) transect survey

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CARIDEAN SHRIMPS ASSOCIATED WITH THE SLIMY SEA PLUME (*PSEUDOPTEROGORGIA AMERICANA*) IN MIDSUMMER AT GUANA ISLAND, BRITISH VIRGIN ISLANDS, WEST INDIES

Stephen Spotte, Patricia M. Bubucis, and Robin M. Overstreet

ABSTRACT

Fifty-one slimy sea plumes (*Pseudopterogorgia americana* Gmelin, 1791) were sampled for caridean shrimps at Guana Island, British Virgin Islands, during one week in July 1992. Sampling depth ranged from 3–22 m. Nine species were collected: *Hippolyte nicholsoni* Chace, 1972; *Latreutes* sp.; *Neopontonides chacei* Heard, 1986; *Periclimenes* cf. *patae* Heard and Spotte, 1991; *Periclimenes* cf. *pauper* Holthuis, 1951; *Periclimenes* sp.; *Pseudocoutierea antillensis* Chace, 1972; *Tozeuma* cf. *cornutum* Milne Edwards, 1881; and *Trachycaris rugosa* (Bate, 1888). A total of 1,418 specimens (including fragments) was obtained. The number of shrimp species per gorgonian ranged from 1–5; one gorgonian harbored 156 shrimps. The 2 predominant species, *N. chacei* and *H. nicholsoni*, occupy different mean depths (12.6 and 8.2 m, respectively). Sexual dimorphism assessed with Mann-Whitney *U*-tests was not apparent in the specimens of *N. chacei* ($P > 0.05$), but females of *H. nicholsoni* were significantly larger than males ($P < 0.001$). Minimum carapace length (CL, the tip of the rostrum to the posterior dorsal margin of the carapace) at which male *N. chacei* acquire a single appendix masculina spine is 1.25 mm; male *H. nicholsoni* can acquire a single spine at 0.9 mm CL. Histological sections of male *N. chacei* showed that shrimp with 0 or 1 spine are least likely to be mature. Female *N. chacei* can become ovigerous at 1.9 mm CL and female *H. nicholsoni* at 1.2 mm CL. The taxonomic status of 5 of the 9 species collected is uncertain.

Gorgonians (octocorallians) indigenous to the West Indies are intrincate habitats that harbor a diverse array of caridean shrimps. Several authors have mentioned gorgonians as sources of holotypes or paratypes of new shrimp species (e.g., Chace, 1972; Heard, 1986; Heard and Spotte, 1991); others have noted the shrimp-gorgonian association but left its nuances unquantified (e.g., Borradaile, 1920; Patton, 1963, 1972; Criales, 1980, 1984; Cantera *et al.*, 1987). Here we describe aspects of the biology of caridean shrimps collected in midsummer from colonies of the slimy sea plume (*Pseudopterogorgia americana* Gmelin, 1791) at Guana Island, British Virgin Islands.

MATERIALS AND METHODS

Collection of Samples.—Gorgonians often are difficult to identify in the field, but *P. americana* can be recognized easily, is numerous throughout the West Indies, and inhabits a wide range of depths. Our collections were therefore limited to this species. Collections were made during daylight hours between 21 and 26 July 1992 in White Bay at Guana Island, British Virgin Islands, within ~200 m of a point of land known as Iguana Head. At this location the bottom slopes steeply from shore, terminating at 22 m in a level expanse of sand. The site has little wave action, although strong subsurface currents are sometimes encountered. Gorgonians grow in profusion along the slope, and *P. americana* is especially abundant. Because of time constraints, sample collection was completed in 6 days.

We follow convention in treating individual gorgonians as sampling units and restricting use of the term samples to collections from all sampling units obtained during a single dive (Ludwig and Reynolds, 1988; Waters and Erman, 1990). Gorgonian colonies were selected haphazardly by diving to the predetermined depth (see below), swimming perpendicular to the slope, and sampling the first colony of *P. americana* encountered.

A numbered plastic bag (45.7 × 91 cm, 0.08-mm thickness) was placed over the gorgonian, cinched by hand at the base, and shaken vigorously to dislodge any shrimps. The bag was then pulled away while still cinched tightly, and its mouth was sealed with a rubber band. Afterward, a yellow plastic tie-wrap was fastened to the base of the colony to prevent repeat sampling. Bags were used only once. Shrimps were recovered by pouring the contents of the bags through a 355-μm sieve; afterward, they were fixed for several days in 10% Formalin-sea water, then preserved in 70% ethanol. The collection procedure introduces minimal sampling bias, as assessed in a previous study (Spotte and Bubucis, unpublished data). In this other work, shrimps ($N = 0$–29) from 16 colonies of *P. americana* were collected by the method described. Immediately afterward the entire colonies were collected in separate bags and examined for any remaining shrimps. None could be found.

Random numbers corresponding to sampling depths between 3 and 22 m were generated with a hand calculator before every dive in an effort to avoid bias introduced by replicate sampling at arbitrarily selected depth ranges. Excess random numbers were generated in case a bag broke. We arranged the numbers from deepest to shallowest to facilitate planning of the dives. The sampling sequence within samples was therefore nonrandom. After completion of field work, calibration of the depth gauge was checked in a pressure chamber against known simulated depths using a gauge accurate to within 0.025%. The test was conducted 3 times at 1.5-m intervals (rate of ascent and descent = 0.3 m/s) within a simulated depth range of 0 to 45.7 m. The paired values showed significant correlation, as determined by linear least-squares regression analysis: $N = 126$, $t_{(n-2)} = -3.834$, multiple $R^2 = 0.99$, $P < 0.001$. Depth adjustments in the data therefore were not required.

Collection of Data.—Shrimps were identified from keys of Chace (1972) and Heard (1986). Morphologic and reproductive data recorded were size (measured as carapace length, CL, see below), sex, number of dorsal and ventral rostral teeth (RTD and RTV), whether females were ovigerous or nonovigerous, whether ova were eyed or uneyed, and, where appropriate, number and type of appendix masculina spines (apical and lateral) of males. As defined here, carapace length is the distance between the tip of the rostrum and posterior dorsal margin of the carapace (Heard and Spotte, 1991). The males of some species (e.g., *Hippolyte nicholsoni* Chace, 1972) do not have lateral appendix masculina spines. In one species that has such spines (*Neopontonides chacei* Heard, 1986), the distal lateral spines appear to change into apical spines. The designations apical and lateral are therefore arbitrary, and we chose to express results for *N. chacei* as total appendix masculina spines. Some of the smaller shrimps had rounded nubs where an appendix masculina spine ought to be. We recorded them as males with zero spines. Nonovigerous specimens were sexed by placing one of the second pleopods in a wet mount and examining it with light microscopy for an appendix masculina. Since the sex of some immature specimens could not be determined, this factor was recorded as unknown. For *N. chacei*, chelae of pereiopods 2 were recorded as symmetrical or asymmetrical because of discrepancies in available taxonomic keys (see Discussion).

Because *N. chacei* was the predominant species recovered at Guana Island, a series of males ($N = 35$) was sectioned to determine whether the spination of the appendix masculina relates directly to the state of maturity. These specimens were selected from the collections haphazardly, postfixed in Davidson's fixative, embedded in paraffin, sectioned at 4 μm, and stained with hematoxylin and eosin.

Damaged and Fragmented Specimens.—A few specimens removed from the sieve were badly damaged; others were fragmented. Fragments were recovered either as heads (with carapace) or abdomens. We recorded these fragments as individual shrimps for the following reason. If a gorgonian yielded several heads and abdomens of the same species, we could not know whether the fragments belonged together (and if so, which fragments) or matched parts of other individuals perhaps lost during sample collection. In any case, the numbers of detached heads and abdomens were occasionally unequal. True N is therefore unknown.

Fragmented specimens yielded incomplete information. A detached head with carapace could be measured and the rostral teeth counted, but sex was indeterminate; a detached abdomen allowed the specimen to be sexed but not measured. Rostrums without tips yielded indeterminate rostral tooth counts and precluded carapace measurement. When both second pleopods were missing from a damaged or fragmented specimen and the shrimp was not ovigerous, sex could not be assessed from external characters.

Table 1. Partial frequency table and mean depth of shrimps recovered from the gorgonian *Pseudopterogorgia americana.*

Species	Frequency (N)	Percentage	Mean depth, m
Hippolyte nicholsoni	383	27.01	8.2
Latreutes sp.	13	0.92	14.5
Neopontonides chacei	967	68.19	12.6
Periclimenes cf. *patae*	36	2.54	11.9
Periclimenes cf. *pauper*	2	0.14	10.0
Periclimenes sp.	2	0.14	21.3
Pseudocoutierea antillensis	9	0.63	13.6
Tozeuma cf. *cornutum*	4	0.28	10.2
Trachycaris rugosa	2	0.14	13.7

Analysis of Data.—Data were analyzed first for ecological patterns. We assessed depth distributions by species, by numbers of species, and by numbers of shrimps (all species combined). Possible size (as carapace length) and sex effects on depth distribution were analyzed for the two predominant species. We examined the data for species associations by depth, number of species per gorgonian, numbers of each species per gorgonian, and population intensity (total numbers of shrimps per gorgonian; see Discussion).

Assessed next were biological attributes of the two predominant species based on morphologic and reproductive data. We tested for the effects of sex on size and on numbers of dorsal rostral teeth. In addition, we measured the extent of sexual dimorphism, assessed the relationship between size and numbers of appendix masculina spines (or whether females were ovigerous), and estimated minimum size for possession of one appendix masculina spine or the presence of ova. Absent characters from damaged and fragmented specimens were treated statistically as missing data. Shrimps of indeterminate sex and size were omitted from data analyses involving these factors.

Only the pressure-gauge variables were distributed normally. Transformation did not relieve heteroscedasticity in the other variables, and they were assessed mainly by nonparametric methods.

RESULTS

Over six days we collected nine samples comprising 51 gorgonians, recovering 1,418 specimens (including fragments) of nine species (Table 1). Of the total number, 1,364 (96%) were whole, undamaged shrimps yielding complete data. *Neopontonides chacei* and *Hippolyte nicholsoni* were present in the greatest numbers (Table 1). The number of species per gorgonian ranged from

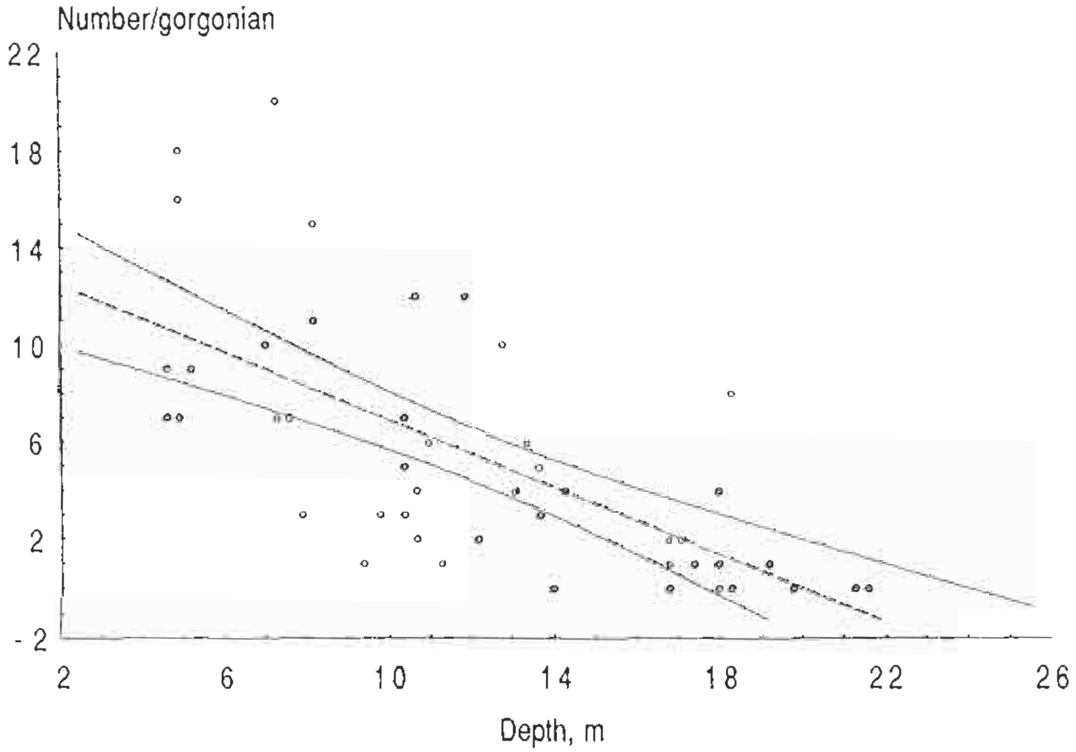

Fig. 1. *Hippolyte nicholsoni*, scatterplot of numbers per gorgonian against depth. Curve fit is linear, confidence intervals are 95%, $N = 51$. Casewise plots of the regression residuals revealed three outliers that exceeded ±2.5 times the standard deviations of the residuals. These were removed prior to plotting. Regression results: $R^2 = 0.46$, $a = 13.84$, $b = -0.69$, $F_{(1,46)} = 39.86$, $P = 0.00$.

1–5 ($\bar{x} = 2.4$). The range in total population intensity was 1–156 with a mean of 27.71 (±32.71 SD). The large standard deviation (relative to the mean) is indicative of a clumped distribution (Ludwig and Reynolds, 1988).

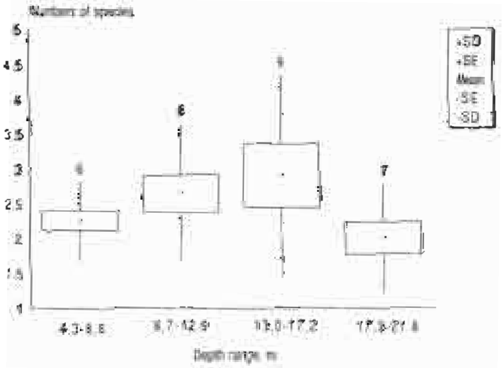

Fig. 2. Numbers of shrimp species (range = 1–9), box and whisker plots against four artibrarily selected depth ranges; $N = 51$. Maximum numbers of species are shown above the whiskers.

Mean depth distributions by species are summarized in Table 1. The predominant species, *N. chacei* and *H. nicholsoni*, occupy different mean depths. A casewise scatterplot of the numbers of *N. chacei* per gorgonian against depth yielded a horizontal regression line, suggesting little variation. The negative regression line in a similar plot of the data for *H. nicholsoni* (Fig. 1) indicates that the numbers of *H. nicholsoni* per gorgonian diminish with depth.

We converted raw depth data into four octaves of arbitrarily selected ranges. The greatest mean number of species occurred between 13.0 and 17.2 m (Fig. 2), although the greatest mean number of shrimps was found between 8.7 and 12.9 m (Fig. 3). Depth distributions of *N. chacei* and *H. nicholsoni* by size (i.e., by CL) were tested independently with Spearman's rank correlation test. The slope of the curve was slightly negative in each analysis, and the paired variables in both instances showed significant correlation. For *N. chacei* $N =$

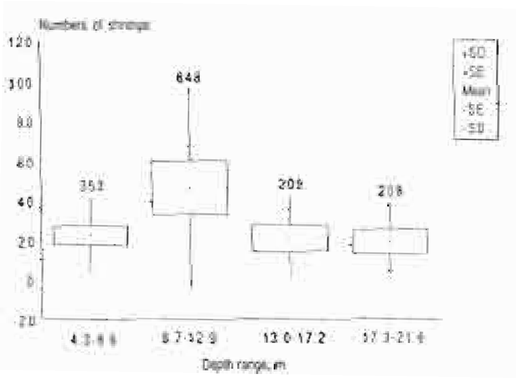

Fig. 3. Numbers of shrimps (all species combined), box and whisker plots against four arbitrarily selected depth ranges; $N = 51$. Total numbers of shrimps are shown above the whiskers.

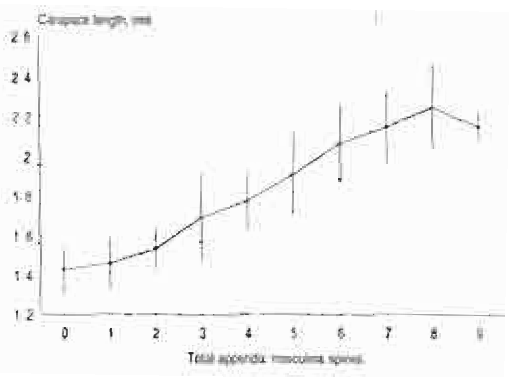

Fig. 4. *Neopontonides chacei* males, standard deviation plots of carapace length against total numbers of appendix masculina spines.

960, $\rho = -0.07$, $t_{(n-2)} = -2.24$, and $P = 0.03$; for *H. nicholsoni* $N = 371$, $\rho = -0.15$, $t_{(n-2)} = -2.92$, and $P = 0.004$.

Depth distributions of *N. chacei* and *H. nicholsoni* by sex were tested independently with Mann-Whitney *U*-tests; the relationship was not significant for either species. For *N. chacei* (males, females) $U = 110{,}255$, $N = 493$ (M) and 460 (F), and $P = 0.46$. For *H. nicholsoni* (unknown, males, females in multiple paired comparisons) $U = 2{,}507.50$–$11{,}491.50$; $N = 48$ (unknown), 123 (M), and 190 (F); $P = 0.13$–0.80. Significant differences were seen in several between-species comparisons by depth (Table 2). Entries of greatest divergence (i.e., $P < 0.001$) included *H. nicholsoni* as a pair member.

Sexual dimorphism in *N. chacei* and *H. nicholsoni* was assessed using Mann-Whitney *U*-tests with CL as the dependent variable. Significance was not detected for *N. chacei* ($P > 0.05$). However, females of *H. nicholsoni* were significantly larger than males (mean CL = 1.84 mm versus 1.26 mm); $U = 3{,}249.0$, $N = 121$ (M) and 182 (F), and $P = 0.00$.

Hippolyte nicholsoni rarely has dorsal rostral teeth. The effect of sex on the number of RTD in *N. chacei* was not significant (Mann-Whitney *U*-test): $N = 489$ (M) and 458 (F), $U = 11{,}129$, and $P = 0.86$.

Appendix masculina spination plotted against carapace length is depicted in Figs. 4, 5. Correlation between these variables was assessed using Spearman's rank correlation test and found to be strong for *N. chacei* ($N = 489$, $\rho = 0.85$, $t_{(n-2)} = 36.10$, $P = 0.00$) and weaker for *H. nicholsoni* ($N = 121$, $\rho = 0.70$, $t_{(n-2)} = 10.71$, $P = 0.00$); the paired variables in both analyses showed significant correlation. Male *N. chacei* can acquire a single spine at 1.25 mm CL ($\bar{x} = 1.5$ mm, range = 1.25–2.0 mm). Mean number of spines was 3.8 (range 0–9, $N = 494$). Male *H. nicholsoni* can acquire a single spine at 0.9 mm CL ($\bar{x} = 1.1$ mm, range = 0.9–1.3 mm). Mean number of spines was 2.9 (range = 0–6, $N = 123$).

Table 2. Paired comparisons (Mann-Whitney *U*-tests) of between-species distribution by depth. Levels of significance: n.s. = not significant, * = <0.05, ** = <0.01, *** = <0.001.

Species	1	2	3	4	5	6	7	8	9
1 *Hippolyte nicholsoni*		***	***	***	*	n.s.	**	n.s.	*
2 *Latreutes* sp.			**	**	*	*	n.s.	**	n.s.
3 *Neopontonides chacei*				n.s.	*	n.s.	n.s.	n.s.	n.s.
4 *Periclimenes* cf. *patae*					*	n.s.	n.s.	n.s.	n.s.
5 *Periclimenes* cf. *pauper*						n.s.	*	n.s.	n.s.
6 *Periclimenes* sp.							n.s.	n.s.	n.s.
7 *Pseudocoutierea antillensis*								n.s.	n.s.
8 *Tozeuma* cf. *cornutum*									n.s.
9 *Trachycaris rugosa*									

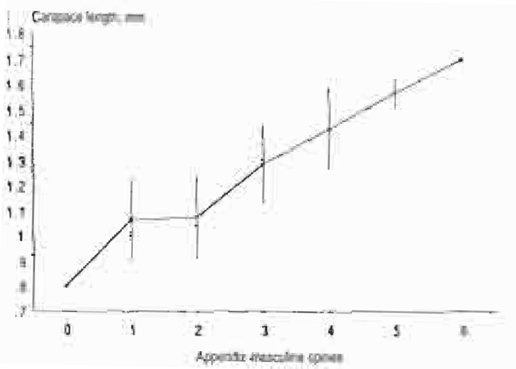

Fig. 5. *Hippolyte nicholsoni* males, standard deviation plots of carapace length against total numbers of appendix masculina spines.

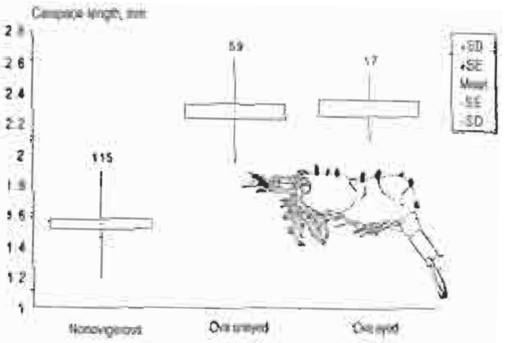

Fig. 7. *Hippolyte nicholsoni* females, box and whisker plots of reproductive status with N shown above the whiskers.

Figures 6, 7 summarize relative egg-bearing status of the two predominant species. Female *N. chacei* can become ovigerous at 1.9 mm CL ($\bar{x}$ = 2.4 mm, range = 1.9–2.8 mm). For female *H. nicholsoni*, minimum carapace length of ovigerous specimens is 1.2 mm ($\bar{x}$ = 2.3 mm, range = 1.2–2.9 mm). In both species, carapace lengths of females with uneyed versus eyed ova were statistically indistinguishable, as tested with Mann-Whitney U-tests using CL as the dependent variable: for *N. chacei*, U = 1,331.50, P = 0.74; for *H. nicholsoni*, U = 437.50, P = 0.77.

In his species description of *Neopontonides chacei*, Heard (1986) reported that the chelae of pereiopods 2 are symmetrical (see Discussion). In our material, 11% (101 of 903 specimens) had asymmetrical chelae. We recorded these data in dichotomous form (specimens missing a chela were excluded) and performed a 2 × 2 contingency analysis to test the null hypothesis of independence between sex and chelae symmetry. The null was rejected ($N = 892$, $\chi^2 = 78.74$, $P = 0.00$; $\phi^2 = 0.09$). At Guana Island, female *N. chacei* are more likely than males to have asymmetrical chelae (Fig. 8).

The reproductive status of males of *N. chacei* was readily apparent histologically in most of the 35 sectioned specimens. Figures 9, 10 illustrate the testis and associated vasa deferentia of immature (Fig. 9A–C) and mature specimens (Figs. 9D–F, 10A–D). Shrimp without appendix masculina spines or with a single spine are least likely to be mature.

DISCUSSION

To summarize some of the salient results, individual colonies of *Pseudopterogorgia americana* harbored up to 156 caridean shrimps of as many as five species. *Neo-*

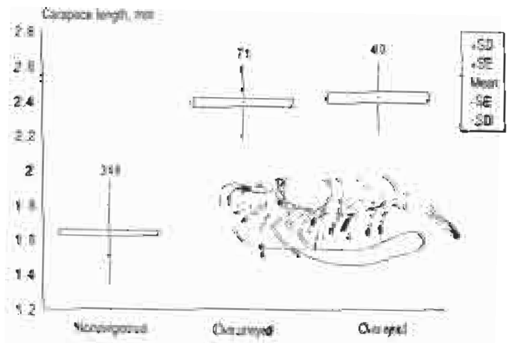

Fig. 6. *Neopontonides chacei* females, box and whisker plots of reproductive status with N shown above the whiskers.

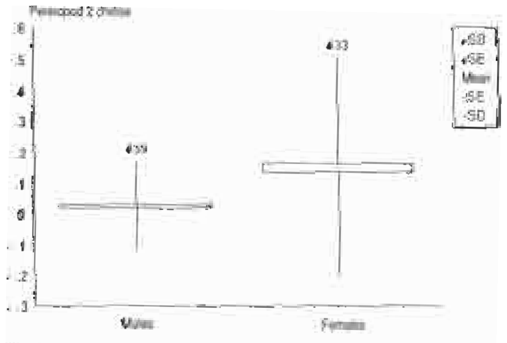

Fig. 8. *Neopontonides chacei*, box and whisker plots of the relative incidence of pereiopod 2 symmetry by sex with N shown above the whiskers. Scale of the ordinate: 0 = symmetrical, 1 = asymmetrical.

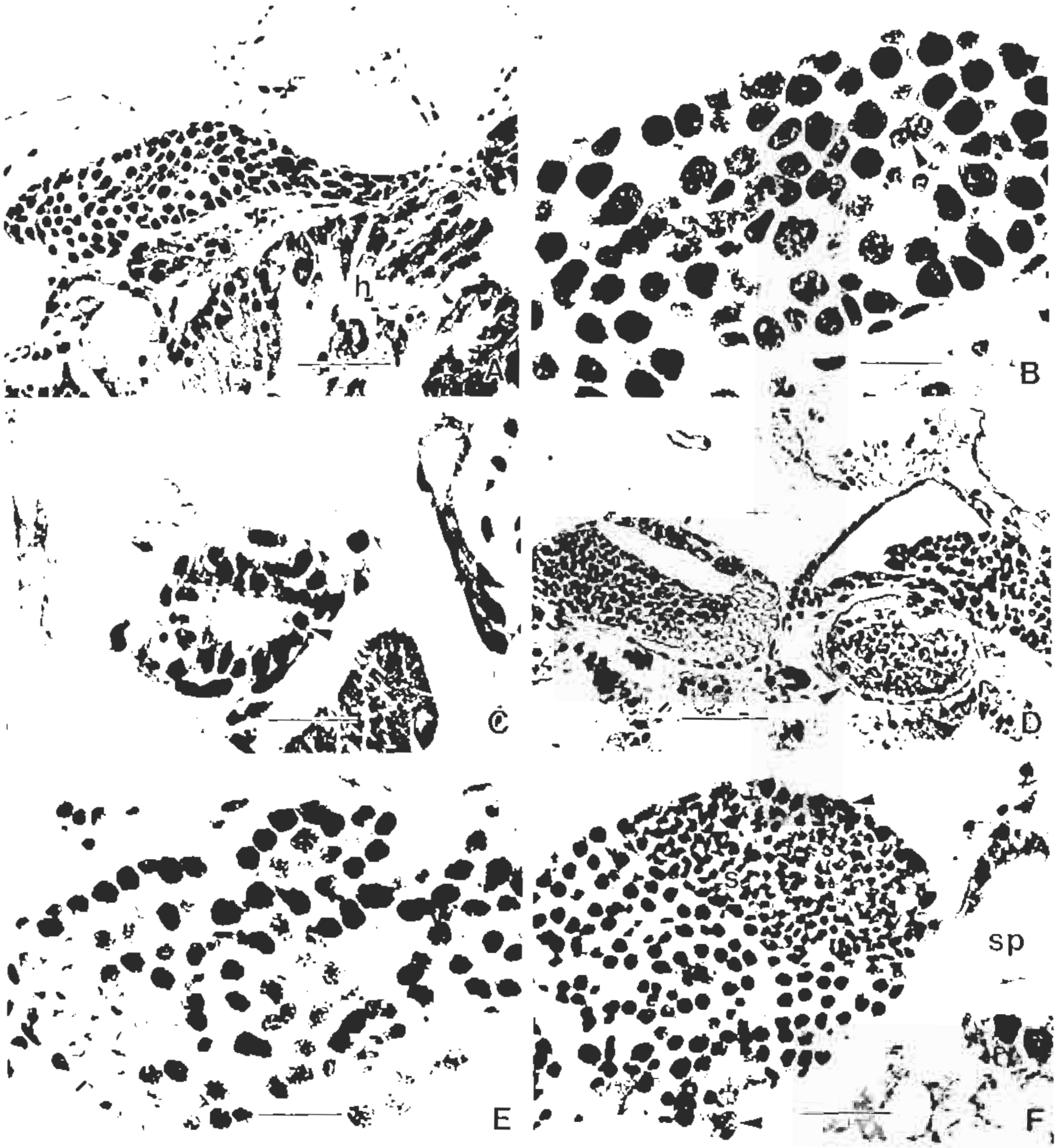

Fig. 9. *Neopontonides chacei*, histological sections of male reproductive system, hematoxylin and eosin. A–C, Immature specimens. A, Testis overlying hepatopancreas (h), sagittal section, anterior end of shrimp to left of photograph, 1 spine on pleopod 2, CL = 1.4 mm, scale bar = 50 μm. B, Close-up of (A) showing spermatogonia (e.g., arrowhead), scale bar = 15 μm. C, Vas deferens showing relatively thick columnar epithelial lining (arrowhead), transverse section with median of shrimp to left, 1 spine, CL = 1.3 mm, scale bar = 20 μm. D–F, Mature specimens, sagittal sections. D, Testis showing proximal secretory portion of vas deferens (arrowhead) with anterior end of shrimp to right of photograph, 7 spines, CL = 2.1 mm, scale bar = 60 μm. E, F, Poorly defined germinal cysts showing relatively small spermatids (s), 3 and 7 spines, CL = 1.6 and 2.0 mm, scale bars = 20 and 30 μm. Note nurse cells (arrowheads) in periphery of testis and spermatozoa (sp) in proximal vas deferens of F.

pontonides chacei and *Hippolyte nicholsoni*, the predominant species, occupy different mean depths. The depth distribution of *H. nicholsoni* shows the stronger trend, with numbers of shrimp per gorgonian declining as depth increases. Most of the nine species collected occurred near the shallow end of the sampled depth range. The depth at which the greatest mean number of shrimps was found (Fig. 3) bracketed the mean depth

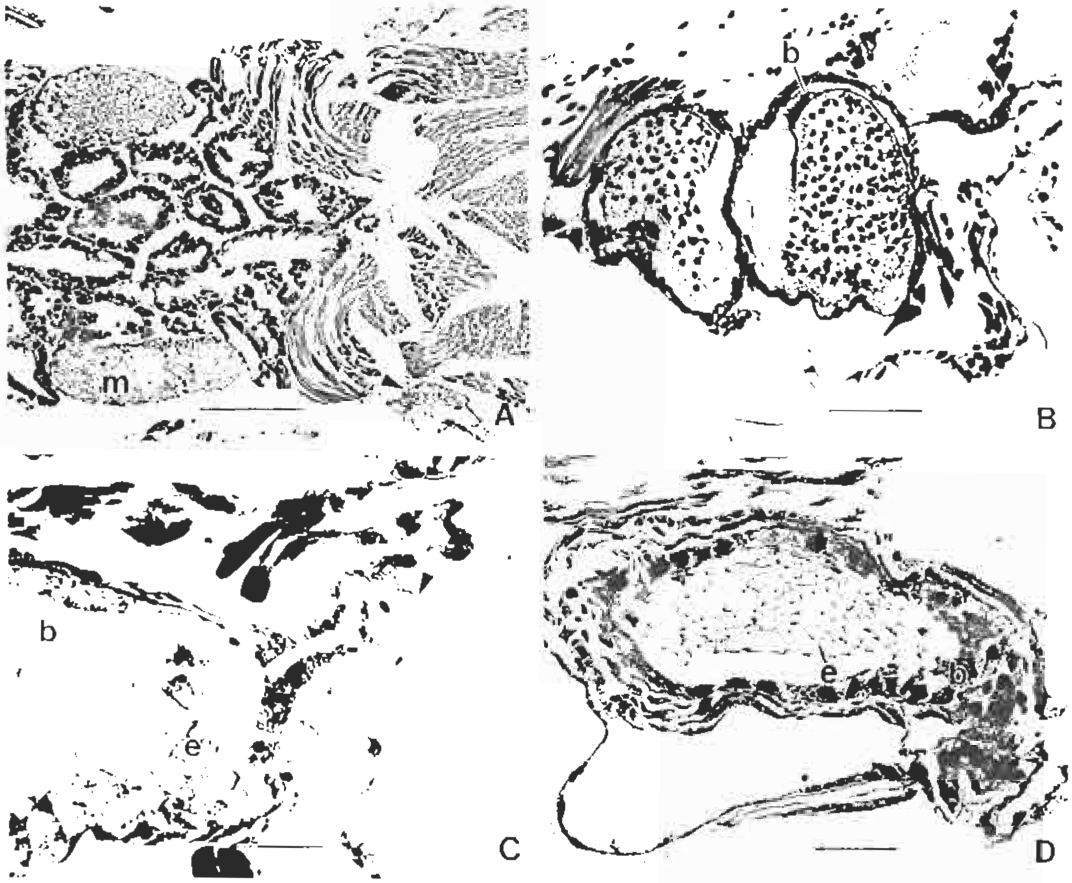

Fig. 10. *Neopontonides chacei*, histological sections of male reproductive system showing vasa deferentia of mature specimens, hematoxylin and eosin. A, Frontal section showing pair, with anterior distended medial vasa deferentia (m) on both sides of hepatopancreas and posterior distal vasa deferentia (arrowhead) associated with pair of pereiopods 5 lateral to abdominal muscles, 8 spines on pleopod 2, CL = 2.3 mm, scale bar = 150 µm. B, Sagittal section of distal vas deferens with basophilic matrix (b), dorsum of shrimp on top and anterior of shrimp toward right of photograph, 4 spines, CL = 1.5 mm, scale bar = 50 µm. C, Transverse section showing basophilic (b) and eosinophilic (e) matrices in addition to constricted ejaculatory duct leading to gonopore (arrowhead) that opens at exterior of coxa of pereiopods 5, lateral margin of shrimp on top, 6 spines, CL = 1.8, scale bar = 30 µm. D, Sagittal section showing gonopore and basophilic (b) and eosinophilic (e) matrices, 7 spines, CL = 2.4 mm, scale bar = 30 µm, dorsum of shrimp toward top of photograph.

occupied by *N. chacei*, which outnumbered all other species combined. Depth distributions of *N. chacei* and *H. nicholsoni* were independent of sex and weakly dependent on size.

Significant differences in between-species associations as a function of depth were apparent mainly when *H. nicholsoni* was included as a pair member, emphasizing the comparatively limited vertical range of this species. Sexual dimorphism was apparent in *H. nicholsoni*, with females significantly larger than males. Relatively more *H. nicholsoni* than *N. chacei* were ovigerous, which raises the possibility of offset timing of reproduction. In both species, females with eyed versus uneyed ova were of similar size. If female reproduction is size dependent, those with uneyed ova might have been younger. Intraspecific differences in mean carapace length were not significant between the two groups. However, specimens with uneyed ova were slightly smaller (2.39 versus 2.41 mm for *N. chacei*; 2.27 versus 2.30 mm for *H. nicholsoni*).

According to data obtained from sectioned specimens, the state of maturity of males of *N. chacei* relates positively to both size and the number of appendix masculina spines. Histological aspects of the male reproductive system of palaemonids and other decapod crustaceans vary considerably (Krol *et al.*, 1992). Our Figs. 9, 10 depict the weakly delineated germinal cysts containing distinct stages of spermatogenesis in mature individuals that were not apparent in immature specimens. At least two types of epithelial secretions consolidate the spermatophore. A mucoid substance, presumably the eosinophilic matrix illustrated in Fig. 9C, D, if analogous to the adhesive matrix of *Macrobrachium rosenbergii* described by Chow *et al.* (1982), surrounds and adheres the mass to the female. The adhesive matrix hardens within a few hours of mating; the basophilic matrix (Fig. 9B–D) swells, becomes softer, and serves as a protective substance (Chow *et al.*, 1982). As in other crustaceans, the appendix masculina, the spinous process on the endopod of pleopod 2, and the special setation on pleopod 1 apparently function in transfer of the spermatophoric mass to the ventral surface of the female's first abdominal sternite (e.g., Bauer, 1986).

Our overall results are clouded by the uncertain taxonomic status of the shrimps collected. Of nine species, only *H. nicholsoni*, *Pseudocoutierea antillensis* Chace, 1972, and *Trachycaris rugosa* (Bate, 1888) could be identified with confidence using morphologic characters and existing keys. *Neopontonides chacei* was described by Heard (1986) based on 31 specimens from St. Lucia (West Indies), Antigua (British West Indies), Carrie Bow Cay (Belize), and the Florida Keys (U.S.A.). Some had been collected from *Pseudopterogorgia americana*. Heard listed the principal diagnostic characters as: (1) rostrum with 0–4 dorsal teeth but no ventral teeth, (2) chelae of pereiopods 2 symmetrical, and (3) merus of pereiopods 3–5 lacking a well-developed tubercle or keellike swelling on the distal flexor margin. These characters distinguish *N. chacei* from *N. beaufortensis* Borradaile, 1920, and *N. dentiger* Holthuis, 1951, the only other described members of the genus. Heard considered *N. chacei* to be most closely related to *N. beaufortensis*, differing in the symmetry of its pereiopod 2 chelae, in the comparative slenderness of its pereiopods 3–5, in the absence of a tubercle on the merus of pereiopods 3–5, in the shape of the rostrum and eyelobe, and in the setation and spination of pleopods 1 and 2 and the propodus of pereiopod 5.

The Guana Island specimens agree with Heard's species diagnosis in having 0–4 dorsal rostral teeth (three specimens have a single ventral tooth). However, many of the Guana Island shrimp have asymmetrical pereiopod 2 chelae; still others have a prominent tubercle on the distal flexor margin of the merus of pereiopods 3–5. These last two characters are diagnostic of *N. beaufortensis*. Heard (1986) was aware of overlapping characters and suggested that all specimens of *N. beaufortensis* in reference collections be compared with *N. chacei*.

Deviation from diagnostic species characters might not be unusual in a large series of specimens such as ours; alternatively, regional variation should not be discounted. Heard (1986) mentioned examining several shrimp collected from species of gorgonians other than *P. americana* and finding them similar to *N. beaufortensis* in some characters but distinct in others. He concluded: "These forms may represent new taxa or they may be ecophenotypic variants of *N. beaufortensis*."

Neopontonides dentiger, the remaining described species, is generally thought to be restricted to the northeastern Pacific (Wicksten, 1983; Rios, 1986; Cantera *et al.*, 1987). An apparent exception is a male labeled *Neopontonides* nr. *dentiger* from collections of the National Museum of Natural History. The shrimp (USNM 249877), which has 9 dorsal rostral teeth, was captured at Ubatuba, Brazil, on 16 January 1963. Another shrimp (USNM 143356, ovigerous) labeled *Neopontonides* sp., collected 5 July 1970 from the Pacific side of Panamá (off Taboga), has a pronounced rostral shelf. It could represent an undescribed genus (R. W. Heard, personal communication).

We have not compared the Guana Island shrimps with type material of *N. chacei*. They bear little resemblance to descriptions of *N. dentiger* and differ noticeably from the specimens of *N. beaufortensis* supplied to us by R. W. Heard. Based on the evidence available, we conclude that the Guana Island shrimps are *N. chacei* and not an undescribed species of *Neopontonides*.

Criales (1992) recently clarified the taxonomic status of *Trachycaris rugosa*. She was able to examine only nine males in existing reference collections. Two had been collected at 25 m off Isla de Aguja (Colombia) and the remaining seven between 33 and 68 m off South Carolina (U.S.A.). Females available for examination were far more numerous and came from depths of 8–20 m. Known substrata from which both sexes had been collected included coral, coral sand, and calcareous algae. Criales speculated that male *T. rugosa* are more cryptic than females and live at greater depths.

Both Guana Island specimens of *T. rugosa* in our collections are small males (CL = 2.5 mm) obtained from the same gorgonian at 13.7 m. Males examined by Criales (1992) were larger (CL = 3.03–5.65 mm). Our findings extend the habitable depth of male *T. rugosa* into the known range of females, but add little to knowledge of substratum occupancy. Although we were careful to sample only gorgonian colonies, small bits of substratum might have entered the sample bags inadvertently.

The Guana Island specimens of *Latreutes* sp. are juveniles of an apparently undescribed species (R. W. Heard, personal communication). The species of *Tozeuma* is represented by developed juvenile specimens and appears to be closest to *T. cornutum* Milne Edwards, 1881. The rostrum is unarmed dorsally, and the margins of pereiopods 3–5 lack accessory spines.

Any small shrimps collected from the western North Atlantic and identified as species of *Periclimenes* require careful examination. This applies especially to those of the "iridescens" complex (Heard and Spotte, 1991; Spotte *et al.*, 1994), an unknown number of species conforming with *P. iridescens* Lebour, 1949, in Chace's key (Chace, 1972). Most of the *Periclimenes* spp. that we collected at Guana Island are juveniles, which makes their identities even more uncertain. Those labeled *P.* cf. *pauper* Holthuis, 1951, deviate from *P. iridescens* in Chace's key by having lateral branches of the antennular flagella that are less than half as long as the fused portion.

Shrimps labeled *Periclimenes* cf. *patae* Heard and Spotte, 1991, have the requisite single row of comb setae on the distal end of the pereiopod 5 propodus, but the setae are slender and fewer in number (see fig. 3f, p. 44, of Heard and Spotte, 1991). In addition, the dactyl of pereiopod 5 is much longer and narrower than comparable dactyls of *P. patae* that we have seen. Two juvenile shrimps labeled *Periclimenes* sp. bear a superficial resemblance to *P. pauper* until compared directly with the holotype of *P. pauper*. These specimens, unlike the holotype, have bifid dactyls.

Counts of total numbers of shrimps per gorgonian are a measure of "population intensity," defined by Waters and Erman (1990) as an estimate of a population expressed as the number of organisms per habitat unit (i.e., sampling unit). This is to be distinguished from "population density," which is the number of organisms per surface area or volume of the sampling unit (Waters and Erman, 1990). We were unable to calculate population densities because we knew neither the surface area nor the volume of the individual gorgonians. *Pseudopterogorgia americana* grows in protean forms. Branches are often partly or completely dead, and overall shape varies from gnarled and bent to fully upright and bushy. As in other cnidarians, the percentage of polyps expanded and contracted, and the extent of expansion and contraction, substantially affect both the surface area and volume of a colony. Newly collected colonies retract their polyps and shed mucus copiously. The result of this trauma is colony deformation within minutes. The common name "slimy sea plume" has not been bestowed loosely, and separating shrimps from mucus retained in the sample bags became the most tedious aspect of our collection procedure. The prospect of obtaining useful information about the surface area or volume of gorgonian colonies is bleak. Any future method of determining population densities of gorgonian shrimps should probably be applied in the field under conditions of minimal disturbance. Our sampling technique appears to stress colonies of *P. americana* severely, but does not kill them (Spotte and Bubucis, unpublished data). Full recovery, however, might take weeks or months. The alternative is to devise collection procedures that are less stressful to the host.

ACKNOWLEDGEMENTS

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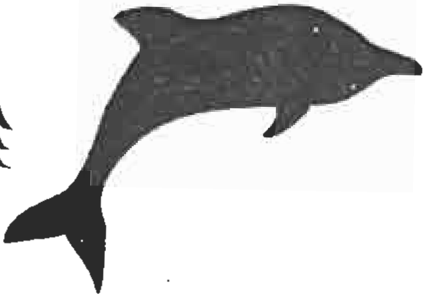
APPENDIX III



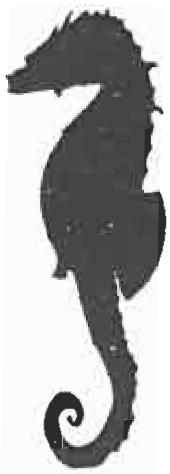
Report on the

Coral Reef Management Training Course

June 27th to July 2nd

H. Lavity Stoutt Community College
and
Guana Island

by
Lianna Jarecki
Course Coordinator



Coral Reef Management Course Report

August, 1994

An intensive six-day course in coral reef management was conducted from June 27th to July 2nd. This course was jointly run by the H. Lavity Stoutt Community College and Guana Island. Thirteen students, of varying backgrounds, attended the course. Course instructors came both from the BVI (Lianna Jarecki, course coordinator, HLSCC, and Julie Overing, marine biologist, Conservation and Fisheries Department), and from U.S.-based universities (Dr. Graham Forrester, fish ecologist at the University of California, Santa Barbara, and Dave Carlon, coral ecologist at the University of New Hampshire). Elizabeth Kintzing, from the University of New Hampshire, acted as SCUBA diving safety officer throughout the course. Guest lecturers included Clive Petrovic and Alan Baskin.

The course was funded by student fees of $200 each. The Rotary Club sponsored four students in this course with a donation of $800, and Guana Island Wildlife Sanctuary donated funds for research equipment and provided boat transportation to field sites.

The course consisted of morning lectures and afternoon field activities. Lectures at the H. Lavity Stoutt Community College covered topics ranging from mangrove and seagrass ecology to statistical data analysis for coral reef monitoring programs. Students gained an understanding of marine systems ecology, methods for monitoring marine habitats (particularly coral reefs), identification of marine organisms, developing management plans and identifying environmentally critical areas for protection. Field exercises trained students in data collection methods including water chemistry analysis, shore bird censuses, fish censuses, and monitoring methods for mangroves, seagrass areas, and coral reefs.

The course was considered a great success by students and instructors alike, and we hope to offer it again next summer. Many of the participants in this course will use their training in their regular jobs, and they will use their new awareness to educate and influence others. We expect the benefits of this course to spread through the community as the participants teach and inspire others.

All students successfully completing the course, including passing a final exam, were awarded a certificate of completion. Thirteen students attended all or part of the course and eight students sat the final exam and received a certificate.

ANNOUNCEMENT

H. Lavity Stoutt Community College and **Guana Island Wildlife Sanctuary**
will be offering a

Coral Reef Resource Management Training Seminar

from June 27th until July 2nd, 1994
Lectures will be given in the mornings and field work will continue all afternoon during the course.
Subjects to be taught will include:

Ecology of Coral Reefs, Mangroves, and Seagrasses
Ecological threats to our marine environment
Conservation practices
Methods for monitoring marine habitats

Instructors will include:
Dr. Graham Forrester, tropical fish ecologist from the University of California, Santa Barbara
Mr. Dave Carlon, specialist in coral reproduction and growth, from the University of New Hampshire
Ms. Lianna Jarecki, marine ecologist and Biology instructor at HLSCC
Ms. Julie Overing, marine conservation biologist at the Department of Conservation and Fisheries
Ms. Elizabeth Kintzing, SCUBA instructor and emergency medical technician, will provide safety and technical support throughout the course.

Certified SCUBA divers will have the opportunity to dive during some field exercises, while uncertified students will snorkel. All field sites will be shallower than thirty feet.
A certificate of completion will be awarded to finishing participants.
Please fill out a seminar registration form and pay the $200 course fee at the HLSCC, Paraquita Bay

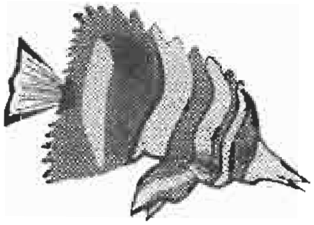
Registration deadline: June 24th.

Enrollment is limited to 15 students, selected on a first-come basis.
For more information please contact the college at 44994 or fax 44996.
(Course coordinator, Lianna Jarecki will be available after June 16th.)

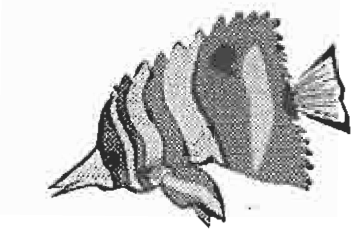
Class List

Anne Walker
Trish Baily
Tom Baily
Mike Adamson
Curtis Smith
Joy Seal
Deryn Edinboro
Ashton Frett
Lauralee Mercer
Darryl Sookram
Andre Roberts
Bob Carney
Deji Ajose-Adeogun

Certificate of Completion



Awarded to



Participant's name

for successful completion of the
Coral Reef Management Course
June twenty-sixth through July second, Nineteen hundred and ninety-four
sponsored by
H. Lavity Stoutt Community College
and
Guana Island Hotel

Charles H. Wheatley
President, H.L.S.C.C.

Lianna Jarecki
Course coordinator and
G.I.H. representative

Coral Reef Management Training Course
June 27th - July 2nd

Monday, June 27th:
Instructor: Julie Overing,
Conservation and Fisheries Department

- Mangrove and seagrass ecology, methods for ecological monitoring of these systems.
- Conservation programs in the BVI.
- Field trip: Hodges Creek, mangrove monitoring site and seagrass monitoring site.

Tuesday, June 28th

Instructors:	Lianna Jarecki	Dave Carlon
	HLS Community College	University of New Hampshire

- Hypersaline pond ecology
- Introduction to coral reefs
- Field trip: Harris pond, east end, Tortola

Wednesday, June 29th

Instructors:	Dave Carlon	Graham Forrester
	UNH	University of California

- Biology of corals
- Biology of fish
- Field trip: Guana Island reefs
  activities: in-water skills assessment
  identifying reef creatures
  using a wet lab (sea table)

Thursday, June 30th
Instructor: Graham Forrester

- Ecological monitoring: necessity, methods for data collection, limitations, and interpretation.
- Field trip: Guana Island
  activities: taking data from transects
  comparison of linear and chain transects

Friday:

Instructors:	Lianna Jarecki	Clive Petrovic
	HLSCC	HLSCC
	Dave Carlon	
	UNH	

- Introduction to conservation biology
- Threats to the marine environment
- Management plans

- Community education
- Importance of the marine environment to local economy
- Field trip: Guana Island
  activities: analysing data
  underwater practical exam

Saturday

Instructors: Lianna Jarecki Alan Baskin

- Reef conservation practices in the BVI
- private initiatives in conservation
- written exam
- afternoon: end-of-course party

Reef Identification checklist

Fishes

1) bluehead wrasse (*Thalassoma bifasciatum*)
2) yellow head wrasse (*Halichoeres garnoti*)
3) stoplight parrotfish (*Sparisoma viride*)
4) 3-spot damselfish (*Stegastes planifrons*)
5) blue tang (*Acanthurus coeruleus*)

Corals

1) Elkhorn coral (*Acropora palmata*)
2) Great star coral (*Montastrea cavernosa*)
3) Boulder star coral (*Montastrea annularis*)
4) Lettuce coral (*Agaricia agarictes*)
5) Symmerical brain coral (*Diploria strigosa*)

Other invertebrates

1) Sea rod (Soft coral)
2) Sea fan (*Gorgonai ventalina*)
3) Donkey dung sea cucumber (*Holothuria mexicana*)
4) Fire coral (*Millepora* sp.)
5) Sponge growth forms:
    a) finger sponges (e.g. *Aplysina cauliformes*)
    b) tube sponges
    c) vase sponges (e.g. *Ircinia campana*)
    d) massive (loggerhead) sponges (e.g. *Ircinia strobilina*)
    e) encrusting sponges (e.g. chicken-liver sponge, *Chondrila nucula*)
6) Green colonial anemone (*Zoanthus sociatus*)
7) Molluscs
    a) snails
    b) chitons
    c) limpets
    d) bivalves

Name ....

Coral Reef Management Exam

1. Dredging a seagrass bed would have a MAJOR ecological impact on which of the following habitats?

   a) mangrove

   b) sand bed

   c) coral reef

   d) all of the above

2. Which of he following is NOT a type of sea grass?

   a) Manatee grass

   b) turtle grass

   c) blue grass

   d) shoal grass

3. The LARVAE of virtually all coral reef fish ....

   a) stay with their parents on the reef?

   b) spend between a week and 3 months in the open ocean?

   c) live in seagrass beds?

4. Name 3 methods that could be used to monitor coral communities on a reef

   1)

   2)

   3)

5. To monitor the growth of seagrass you could punch a small hole just above the sheath and after a week....

   a) measure from the hole to the top of the leaf?

   b) measure the height of the plant?

   c) measure from the hole to the top of the sheath

   d) measure the width of the hole

Imagine a species of reef fish where all the juveniles mature into females, and only a few larger fish can change sex to become males. What would happen to this species if people started catching it to eat and preferred to catch the biggest fish.

a) only smaller fish will be left in the population

b) a shortage of males will develop and the population will reproduce less

c) the population would get larger

d) both a) and b)

7. The mangrove most likely to be found growing at the edge of the sea is?

a) black mangrove

b) red mangrove

c) white mangrove

d) buttonwood mangrove

8. Hypersaline ponds are....

a) saltier than seawater?

b) the only habitat in the BVI for stilts, flamingos and other wading birds?

c) sometimes destroyed by dredging?

d) teaming with planktonic life

e) all of the above

9. Reef-building corals obtain energy from:

a) the sun

b) zooplankton

c) Exxon corporation

d) a and b

10. Name three characteristics that would help you identify an unknown coral species.

1)

2)

3)

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)? 9.

2. What was the best part of this course?

The actual on site work - the most fun was the 30 m transect work

3. In the event of our offering this course again next year, what would you recommend to improve it?

The sections on seagrass & mangroves could be compacted and more time spent on coral & fish identification - coral formation, processes of life etc.

4. How will you use the information you have learned?

With Julies help, set up monitoring sites in areas where we have placed moorings to see if they are in fact achieving the goal of preserving the reefs and their habitats. I will also be much better equiped to answer questions when I give lectures about <u>why</u> we need a moorings programme. I can now (if I study a bit more) blind them with science !!!

5. Other comments

Personally I would have liked more on actually forming management plans for marine areas and more on actually techniques in monitoring (maybe that was covered when I wasn't here that morning!).

- Overall a wonderful course - I got more out of it than I thought I would - I learnt abt although you might not think it from my results!! My interest and drive to protect our reefs has been jolted back up to being of my Job and my determination to fight the government over 'grey' areas with fee collection of the scheme and law changes will start in ernest again.

If I get fired can I help you
next year?

Thanks everyone

Joy.

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)? 9

2. What was the best part of this course?

Field Trips

3. In the event of our offering this course again next year, what would you recommend to improve it?

4. How will you use the information you have learned?

motivation to Learn more.

5. Other comments

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)? 9/10.

2. What was the best part of this course?

The practical area. Getting out into the fields really aids you in remembering what you did in the class room.

3. In the event of our offering this course again next year, what would you recommend to improve it?

Maybe it could be long and more indepth on the political side (coming up with proposal in accordance with you data collected (over a period of yrs of course))

4. How will you use the information you have learned?

This information will help in the Monitoring side of my job. I can now have a say in how programs are set up and the relevance.

5. Other comments

See you Next Yr.

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)?

10

2. What was the best part of this course?

Going into the water and identifying different fauna & flora.

3. In the event of our offering this course again next year, what would you recommend to improve it?

make it longer.

4. How will you use the information you have learned?

I would use the information (if any) to properly manage a reef.

5. Other comments

The boat drivers that carry Student back + forth should have a little more patience.

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)? 9

2. What was the best part of this course? Liked it all - especially 2nd day of diving.

3. In the event of our offering this course again next year, what would you recommend to improve it?
Going to more or different dive spots - & skipping to beach dive -

4. How will you use the information you have learned? To keep trying to understand how we can all help preserve the environment.

5. Other comments GOOD JOB! - Next year teach a part B - that goes more into the Biology of fish & coral.

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)?

7

2. What was the best part of this course?

1) EXPOSURE TO MONITORING TECHNIQUES

2) ~~A~~ SPECIES I.D. IN THE FIELD

3. In the event of our offering this course again next year, what would you recommend to improve it?

I WOULD EXCLUDE THE SALT POND SESSION, NOT THAT IT ISN'T PERTINENT BUT I FEEL I WOULD HAVE BENEFITTED FROM MORE ~~REEF~~ STUDY, A LITTLE TIME ON SPONGES.

4. How will you use the information you have learned?

APPLY IT TO FURTHER STUDY TO ULTIMATELY INITIATE A REEF RESTORATION PROJECT & TO HELP RUN MOORING PROGRAM.

5. Other comments

I WOULD BE INTERESTED IN SPONSORING SIMILAR PROGRAMS IN USVI

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)?

9 because I cannot swim.

2. What was the best part of this course?

The best part of this course for me was the lecturing; I really enjoyed it although I didn't really know enough about coral reef + mangroves but the course made aware of them.

3. In the event of our offering this course again next year, what would you recommend to improve it?

1) Make sure that the participants can swim or snorkel.

2) Make the lectures a little longer.

4. How will you use the information you have learned?

1) Well, I might have a lecture at my church speaking mainly to the youths of my church

2) Maybe at my work

5. Other comments

1) The environment was very good.

2) The lecturers were great also the students.

Coral Reef Management Course

Evaluation

1. How would you rate this course on a scale of one to ten (ten being the highest)?

9.99

2. What was the best part of this course?

Lectures

3. In the event of our offering this course again next year, what would you recommend to improve it?

Better organized Field Trips.
Last 2 on Guana were good

4. How will you use the information you have learned?

For personal studies
To give information on reef enviroments to charter guests.

5. Other comments

- The course has been great. The lectures were extremely informative.
- Would like some study sites set up at next course that the participants can continue with throughout year
- Perhaps next year a 1 evening lecture on reef management could be designed for Charter yacht operators + Charter yacht companies, + government Officials?

APPENDIX IV

Acknowledgments

I wish to thank Henry and Gloria Jarecki for funding and generally supporting this program.

The Conservation Agency is acknowledged for administering funds to cover program costs.

I warmly thank John and Catherine Morely-Dickens for being most encouraging and supportive, not only in attending to our various and often unpredictable needs with concern and efficiency, but also by being generally interested and involved.

Mario Mondo provided technical support during the '94 season and maintained the compressor and other equipment through the year.

I thank staff of Guana Island, particularly S. Everton Henry, for daily assistance in various capacities.

The H. Lavity Stoutt Community College provided classroom space and use of laboratories in the Coral Reef Management short course.

The Rotary Club of Tortola generously granted $800 to the College so help sponsor this same course.