Smithsonian Tropical Research Institute

Bocas del Toro Research Station

FY06-FY07

Biennial Report

Inaugurated in 2003, the laboratory building was designed to be environmentally friendly. The 10,000 square feet of lab and office space features natural lighting through skylights in a building-integrated photovoltaic roof that doubles as a rainwater collector. Pillars and beams made of local, sustainably harvested hardwood, canafistula, support the roof and give the building an airy feel.

bocas del toro research station

The Bocas del Toro Research Station (BRS), a field station of the Smithsonian Tropical Research Institute (STRI) on Panama's Western Caribbean coast, is an ideal platform for both marine and terrestrial research. The station hosts a diverse group of Smithsonian scientists, their colleagues and students.

Activities at the station contribute to the Smithsonian Institution's primary mission: the increase and diffusion of knowledge. BRS visitors are engaged in research on the biodiversity, ecology, paleontology and archaeology of the Bocas del Toro region. Educational and outreach activities range from hosting K-12 school groups, to specialized training for international graduate students.

Founded in 1998, the BRS campus has provided field accommodation since 2002 and a fully operational research laboratory since 2003. Subsequent development of a running seawater system, a new dock, boat ramp, and additional support facilities, as well as two houses to accommodate visiting researchers, soon followed. The BRS now boasts the most up-to-date research facilities among the preeminent field stations in the Caribbean.

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1970/1980's

Charles Handley (1924-2000), curator of mammals at the Smithsonian's National Museum of Natural History, mounted expeditions to survey the mammal fauna of the Bocas del Toro region.

1990's

Anthony Coates then STRI's deputy director, coordinated the Panama Paleontology Project's work in Bocas to document the rise of the Isthmus of Panama.

1998 STRI purchased a six-hectare plot on Isla Colon for the development of a Caribbean marine station.

1999 STRI joined CARICOMP (the Caribbean Coastal Marine Productivity Program) to monitor sites for coral, mangrove, and seagrass productivity near the BRS.

2001 A dormitory building to house 16 people was completed. The station began to host a number of visiting scientists including Davey Kline, then a graduate student at the University of California, and Mark and Dianne Littler from the Smithsonian's National Museum of Natural History.

2002 STRI appointed Rachel Collin, staff scientist, as BRS director. The station hosted 'Tropical Marine Ecology," a Florida International University undergraduate course, for the first time.

2003

The state-of-the-art laboratory building was inaugurated in October. The Mellon Foundation funded an Organization for Tropical Studies course in Tropical Marine Ecology at the station. The first invertebrate biodiversity workshop, supported by the Smithsonian Institution's (SI) Marine Science Network and SI's Women's Committee, documented the exceptional sponge and tunicate diversity in the Bocas del Toro region. STRI appointed Gabriel Jacome as BRS station manager.

2004

A running seawater system was completed. A second invertebrate biodiversity workshop further catalogued local marine biodiversity, focusing on crustaceans and bryozoans.

2005

An issue of the Caribbean Journal of Science edited by Rachel Collin was dedicated to the fauna and environment of Bocas del Toro. The first Training in Tropical Taxonomy course instructed 14 international students in taxonomy and systematics of sponges.

2006

Casa Hoch and Casa Cofrin were completed, increasing the station capacity to 24 researchers. Two new 18-foot boats were added to the BRS fleet, bringing the total to 8. The SI Board of Regents and SI's Women's Committee visited the BRS. The Bocas del Toro biodiversity database reached 3,000 entries. DNA barcoding of the marine invertebrates of Bocas del Toro began.

2007

Donations from the Cofrin and Hoch families enabled the design and imminent construction of a new, larger dormitory. The SI National Board visited the BRS. The original sawmill building was demolished and the reception area was remodeled. BRS publications topped 200.

Located on the “little isthmus” on Isla Colon, the BRS site faces a small sandy beach and the open ocean beyond (the beach is seen on the right side of photo). The 6-hectare site backs onto Bahía Almirante. The lush growth of red mangroves along this side of the property includes a CARICOMP long-term monitoring site for mangroves. Encroachment of development on both sides of the property currently threatens the idyllic setting of the station.

Biologically rich marine and terrestrial habitats in the province of Bocas del Toro, on the Western Caribbean coast of Panama, provide BRS visitors with a wealth of field opportunities. The complex geography of the region contributes to its unique biodiversity and easy access to many habitat types.

Mangrove-fringed mainland peninsulas and islands, seagrass beds, and patch reefs delimit two distinct bays: the Bahía Almirante and the Laguna de Chiriquí. Reefs are best-developed in the Bahía Almirante. The Laguna de Chiriquí, which receives most of the terrestrial run-off, is dominated by seagrass and mangrove ecosystems.

The Bocas del Toro mainland is covered by montane and lowland humid tropical forest and banana plantations. There are large expanses of peat-swamp forest along the coast of the Bahía Almirante. Deforestation is common on the islands of the archipelago, which are primarily covered by secondary forest, pasture, and teak plantations. Despite this, some old-growth forest still remains on Islas Colon and Bastimentos.

Bocas del Toro holds vast fossil deposits. Fossil reefs and other outcrops from the last 18 million years are common throughout the area. Fossil molluscs, forams, bryozoans and corals from the region are well studied.

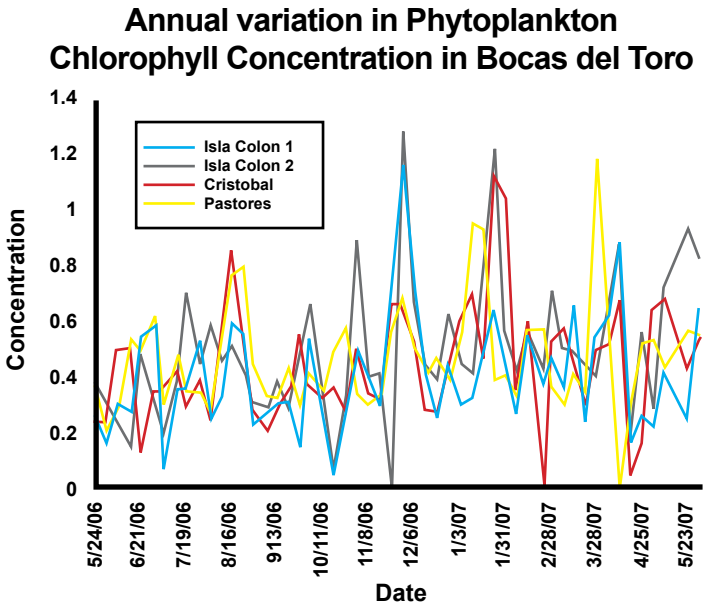
Easy access from the BRS to these numerous habitats and rich outcrops has enabled a diversity of studies aimed at understanding the environmental changes associated with the rise of the Isthmus of Panama, subsequent environmental changes, and the resulting evolutionary divergences between the Pacific and Caribbean biotas.

The Bocas del Toro Archipelago is composed of seven islands that separate two main bodies of water: Bahía Almirante and the Laguna de Chiriquí. A complex network of small islands and mainland peninsulas fringed by mangroves delimits the two bays. This complexity makes the archipelago a biologist's paradise.

An automated data station records hourly values of oceanographic and meteorological data, including water level, rainfall, and solar and quantum radiation. Hourly sea temperature is also recorded at seven remote sites in the surrounding area.

The region around the BRS receives about 3-5 meters of rainfall annually. Temperature and rainfall do not show the pronounced seasonal patterns of the Pacific Coast of Panama. To allow comparisons with other STRI sites around Panama, Bocas del Toro is the focus of considerable environmental monitoring. Weekly and daily measurements of rainfall and air and sea temperature are taken at the research station. Seventy-one coral sites, 52 seagrass sites, and 5 mangrove sites have been surveyed and there are several permanent monitoring sites in each habitat. The BRS is also part of CARICOMP, a Caribbean-wide program to monitor the productivity of coral reefs, mangroves and seagrass. Standardized CARICOMP monitoring protocols are followed in all three habitats.

Real-time information on the physical conditions at the Bocas Research Station can be viewed at www.stri.org/Bocas.



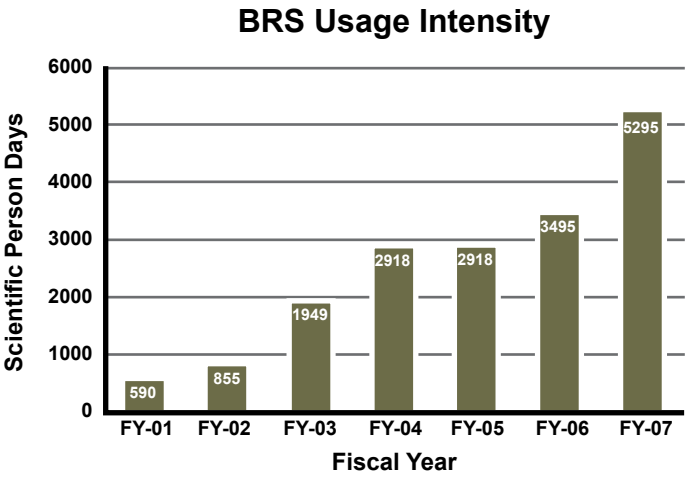
Marine systems productivity is a fundamental feature that structures ecosystems and habitats much as rainfall shapes terrestrial habitats. In 2006 the BRS initiated a weekly chlorophyll monitoring program. These four direct measurements of phytoplankton productivity at sites around the Bocas del Toro archipelago will allow important comparisons to be drawn between Bocas del Toro and other sites in the Caribbean, and between Bocas del Toro and the Pacific coast of Panama.

As part of the CARICOMP protocol, Arcadio Castillo monitors standing crop, biomass, growth rate and leaf-area index for two sites within a *Thalassia* seagrass bed on the south side of Isla Colon.

The explosive success of the BRS and the rapidly increasing number of scientific visitors is reflected in the statistics on station usage (see graph). Accommodations offered by the station have kept pace with this growth aided by the January 2006 inauguration of Casa Hoch and Casa Cofrin. With their completion, BRS housing capacity increased from 16 to 24 people and now includes more appropriate housing for long-term visitors and senior researchers.

Continued growth has prompted plans for additional housing at the station. With generous donations from the Cofrin and Hoch families, plans are in place for the design and construction of an additional dormitory and dining hall complex. We anticipate that ground will be broken for construction in 2009. With the completion of the new dormitory, the station's capacity to house visitors will increase by nearly 50%. The 2007 update of STRI's master plan calls for the construction of conference and office facilities, expansion of the dock, and increased laboratory space as priority projects for future development.

An architect's concept for the new housing complex at the BRS ties in design elements from the laboratory building and the existing dormitory. Although the design is still being finalized, it is clear that the new facilities will include a building for cooking and socializing and at least one other building for sleeping.



Station usage has increased by 400% over the last 6 years.

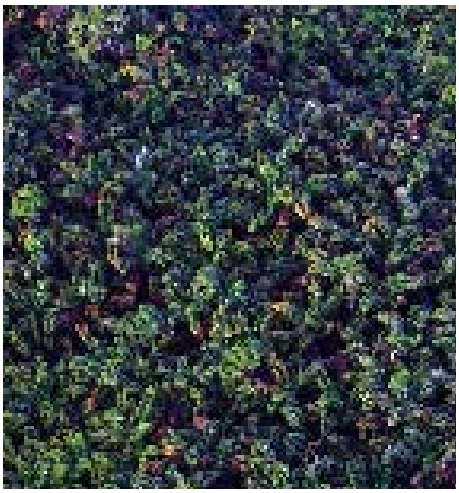
Existing kitchen and dining facilities make it possible for staff and students to do their own cooking. Local chefs who prepare Caribbean cuisine are often hired to cook for larger groups or courses.

Oscar Puebla, a graduate student in the STRI-McGill program, collects fish for his genetics studies. Scuba diving is a valuable tool for almost all aspects of marine research. More than 1,000 dives (more than 60% of all STRI dives) are logged every year at the BRS.

research highlights

Research at the BRS ranges from deep time to real time, from the tree-tops to the ocean's depth, and from ephemeral microbes to ancient corals.

The rise and fall of animal species is tracked through the origins of the newest coral species in the Caribbean back to the geological extinctions of ancient marine animals.



In the local peat swamp forest San San Pond Sak, a UN World Heritage Site, studies reveal the role of soil nutrients on tree-species composition in this rare habitat type.

A wide range of projects address human impacts on fragile ecosystems. Increases in sugars associated with pollution have detrimental effects on members of reef communities like these sick corals.

Most projects at the BRS are conducted in a comparative framework and center on the goals of the Smithsonian Marine Science Network: Understanding spatial and temporal patterns of marine biological diversity and the effects of human activities on them. A minority of studies focus on physiology, development, or behavior of a single species, or on applied topics like sustainable approaches to drug discovery.

Many of the projects at the BRS are linked by a few common themes. The relative importance of geographic and ecological or behavioral separation in the origin of species underlies the work of Oscar Puebla, Tim Billo and Dave Carlon, as well as the work on poison dart frogs by Corrine Richards.

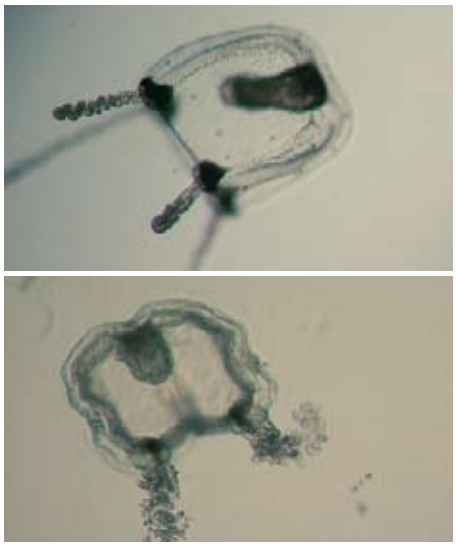
The impacts of local development and global anthropogenic change, such as global warming, are examined through coral disease and coral bleaching experiments by Davey Kline, Steve Vollmer, Mary Alice Coffroth and colleagues; dolphin behavioral observations by Laura May-Collado and colleagues, and reef community composition by Katie Cramer.

Major efforts are being made to document biodiversity in the southern Caribbean with current emphasis on algae (Brian Wyson, Wilson Freshwater, Suzanne Fredericq, and Jim Norris), mieofauna (Rich Hochberg), shrimps (Arthur Anker), hydrozoans (Maria Pia Miglietta), and gastropods (Marta deMaintenon).

In FY06-FY07 the BRS hosted 436 scientific visitors. They and their projects, and their publications are listed at the end of this report. Because the more than 100 ongoing projects at the BRS are too numerous and diverse to describe in full here, this section highlights the work of students who received fellowships from the Smithsonian Institution and STRI, and projects of visiting researchers in two important thematic areas: 1) the role of color in mate choice and in the evolution of new species and 2) mechanisms of the origin and extinction of marine invertebrates in the Caribbean.

SI/STRI fellows

Maria Pia Miglietta grows jellyfish species from different geographical regions in similar environments to see if transitions between life stages vary.



Like corals and sea anemones, medusae (jellyfish) belong to the phylum Cnidaria. Hydromedusae - like the ones in these pictures - are small and delicate predators. Despite being inconspicuous, they are extremely abundant, and have undeniable, but often overlooked effects on marine food webs.

MARIA PIA MIGLIETTA

Smithsonian Marine Science Network Postdoctoral Fellow (2005-2007)

Life cycle evolution, morphological traits, and ecological correlates in Hydrozoa (phylum Cnidaria)

Maria Pia Miglietta takes advantage of the fact that the rise of the Isthmus of Panama split jellyfish species when it separated the Pacific Ocean from the Caribbean, about 3 million years ago. She compares the evolution and ecology of the resulting "sister species" to understand better how their life cycles reflect the environment.

The group she studies, the hydromedusae, are small, delicate predators that eat tiny marine organisms. They have a benthic polyp stage and a pelagic medusa stage. Though inconspicuous, they are extremely abundant, and play a significant, often overlooked, role in marine food webs.

Today, Panama's Pacific side is a very high nutrient (high marine productivity) environment with distinct seasonal temperature changes. The Atlantic side has low productivity and fairly constant temperatures. Miglietta also studies jellyfish from Florida, another high productivity marine environment, for comparison.

Miglietta's preliminary results show that production of the sexual, medusa stage of the hydrozoan life cycle is highly seasonal in many species and that the duration and complexity of the medusa stage is tightly linked to the productivity of its marine environment. She is conducting experiments in aquaria to identify the environmental triggers and the mechanisms behind transitions between the benthic polyp stage and the free-swimming medusa stage in order to make comparisons with other taxonomic groups.

EVA TOTH

Smithsonian Institution Postdoctoral Fellow (2004), Smithsonian Marine Science Network Postdoctoral Fellow (2005-2007)

Comparing the importance of colony relatedness and environmental factors in the evolution of eusociality in snapping shrimp

The fact that social insects such as ants, honeybees, and termites give up their own chance to reproduce in order to help rear the offspring of one or a few individuals did not make much sense to Darwin, who thought that individuals maximize their own survival and reproduction. However, by helping their relatives, truly social (eusocial) animals may propagate their own genes indirectly.

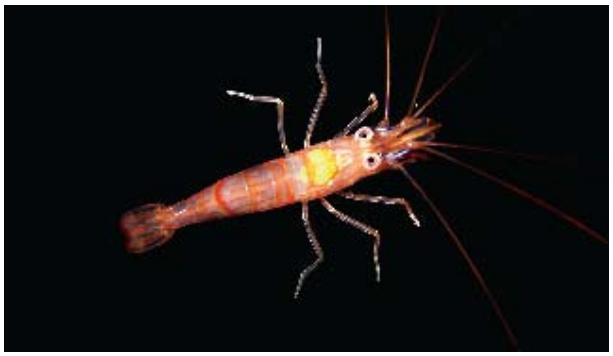
Social shrimp live in the internal canals of sponges and probably eat sponge tissue or detritus. Colony size ranges from tens to hundreds of individuals, depending on the species, colony age and sponge size. One or a few large queens produce all of the offspring from the colony. Once their eggs are fertilized, queens carry them in their abdominal pouch until they hatch. The rest of the colony consists of juveniles of different sizes and larger animals without developed gonads. Most are the queen's offspring. The larger animals defend the sponge, and thus the colony, against intruders.

Because social shrimp were discovered fairly recently and because they live underwater, they are one of the least-studied groups of social animals.

Toth has been working to fill in the basic information that will help us to understand how these societies evolved. She has been developing and using genetic tools to see how closely related the animals are in each colony. She has also used behavioral experiments to examine interactions between colony members.

Eva Toth studies the little-known social systems of snapping shrimp. To do so she snorkels or uses scuba to collect entire sponges with their resident colonies of shrimp.

Social *Synalpheus* shrimp (left) are tiny, from a few to 15 mm in length. The queen, above, is carrying eggs (indicated) under her abdomen, the green area that is missing in the worker, below. The shrimps live within the walls of this *Xestospongia rosariensis* sponge (right).



These marine shrimp (from top to bottom: *Lysmata ankeri, L. bogessi, and L. wurdemanni*) are born as males and change into simultaneous hermaphrodites at some point during their lives. The timing of the transition from male to hermaphrodite depends upon the male's mating opportunities, which, in turn, depend upon the proportion of males and hermaphrodites in the shrimp population. Sophisticated models have been developed to predict when such changes should occur, but they are seldom tested.

ANTONIO BAEZA

STRI Hoch Postdoctoral Fellow and Smithsonian Marine Station in Fort Pierce Fellow (2006-2010)

Testing the effect of mating group size in simultaneous hermaphrodites: Marine shrimp, *Lysmata,* as a model system

Animals split their time and energy between reproduction and other activities. They partition resources for reproduction between males and females. The theory of sex allocation seeks to explain how resources are partitioned.

Antonio Baeza uses a model system for testing theories about sex allocation: shrimp that modify their sexual allocation of resources during their lifetimes. These shrimp of the genus *Lysmata*, reproduce first as males and then as simultaneous hermaphrodites, capable both of producing eggs and fertilizing eggs from other individuals. His experiments are the first to test recent models explaining the evolution of protandric simultaneous hermaphroditism or PSH. The results of his experiments indicate that two proposed models—sex-dependent time commitments and size-dependent mortality rates—go far to explain the evolution of PSH.

Baeza also wants to know if social interactions determine sex allocation. Preliminary data indicate that sex allocation shifts according to theoretical expectations. When male shrimp were kept in groups in which most individuals were hermaphrodites, it took longer for them to mature as hermaphrodites than when kept in mostly male groups. This is the first evidence that "sex change" in shrimp is socially mediated.

Baeza is currently extending his work to cover other species of the genus *Lysmata*. Understanding their relationships will give Baeza some ideas about the way this novel sexual system evolved.

MARY K. HART

STRI Predoctoral Fellow (2007-2008)
Doctoral candidate, University of Kentucky

Sex allocation and egg-trading strategy: examining sexual conflicts in ecological context

Mary Hart studies how conflicts over mating vary across environments. Conflicts arise because a single mating is often much more costly for an egg-producing female than for a sperm-producing male. This can result in adaptations in males to increase their number of matings or to be more effective in sperm competition, which can be detrimental to females. Females evolve adaptations to counter the detrimental effects. What are the trade-offs?

Hart chose chalk bass, *Serranus tortugarum* (Serranidae) a simultaneously hermaphroditic coral reef fish, as a model to test sex allocation, the energy invested in male vs. female function. In this species, a balance must be struck between male and female sex roles according to available mating opportunities, which may shift across environments.

Two mating behaviors, "egg parceling" and "streaking" provided Hart with a chance to test her hypotheses. Hermaphrodites alternate roles as males and females several times during a spawning period. They subdivide the egg clutch into packages, a behavior called "parceling." Parceling may have evolved to protect the female-role investment in egg production. But parceling may also be used as a form of cheating if individuals divide their egg clutches into more parcels to gain extra matings in the male-role with other mating partners.

Streakers intrude on other spawning pairs, releasing sperm to gain extra paternity. Hart has found that streaking is more common in high-density populations. When distracted, couples may not divide their clutches into as many parcels. Habitat complexity influences both fish density and predation risk which can affect mating behavior and reproductive success.

To discover the rules in the mating games of coral reef fish, Hart and her assistants spend hours underwater observing and videotaping chalk bass behavior.

To avoid partners who cheat on them, these tiny chalk bass mate repeatedly every day at dusk. By dividing their eggs into parcels and mating several times they reduce the risk that their partners will cheat.

Theme 1: How color affects evolution

Dendrobates pumilio color morphs in the Bocas del Toro Archipelago. Isla Pastores (above); mainland near Almirante (below, left); Isla Solarte (below, right). Blue and spotted morphs are not shown.

MARTINE MAAN, MOLLY CUMMINGS AND COLLABORATORS

University of Texas at Austin

Poison or passion: warning and attraction in a color-polymorphic frog

Poison frogs are among the most colorful animals known. Their colors make it easy for predators to remember that they are toxic and should be avoided. To enhance this message, toxic animals often use the same set of colors: black, red and yellow.

The strawberry poison frog, *Dendrobates pumilio*, is a spectacular exception to this rule: in the Bocas del Toro archipelago, these frogs show extreme color variations, ranging from red to orange to yellow to blue or green, sometimes with stripes or spots.

Martine Maan and Molly Cummings investigate the role of sexual selection in the evolution and maintenance of this paradoxical polymorphism. If frogs choose mates based on their color, polymorphism may eventually lead to speciation. Previous work in Bocas showed that different color morphs mate and produce viable offspring. However, females preferred to mate with males from their own population.

Mann tests female preferences in several populations, to see how widespread these color-assortative preferences are. She also asks if females not only prefer males of particular colors, but also select for color-pattern brightness and contrast.

Female color preferences may differ between islands because of microhabitat differences: vegetation affects the light spectrum that the frogs are exposed to, and this may affect both color perception and color preferences. Alternatively, color divergence may have happened in a random fashion. To distinguish these possibilities, Maan analyzes the ambient light spectra, vegetation and frog visual properties of each population.

OSCAR PUEBLA, FREDERIC GUICHARD AND ELDREDGE BERMINGHAM

McGill University and STRI

Color pattern as a "magic trait" driving ecological speciation of *Hypoplectrus* coral reef fishes

A well-documented mechanism for the formation of new species, referred to as allopatric speciation, hypothesizes that new species are established when a geographic barrier such as a mountain range emerges. Animal populations separated by a barrier follow distinct evolutionary trajectories due to chance and to different environmental conditions. Ultimately, they may become reproductively isolated and a new species is formed.

Geographical barriers are not obvious in marine systems except at the scale of entire ocean basins, e.g., the separation of the Atlantic and Pacific Oceans by the Isthmus of Panama. It is therefore not clear to what extent allopatric speciation can account for the high diversity of marine ecosystems.

Another, more controversial, mechanism of speciation posits that a new species is established when one population splits through ecological processes, without geographical separation. Puebla and colleagues' work on Caribbean coral reef fishes of the genus *Hypoplectrus* presents one of the few potential cases of ecological speciation documented in the marine realm.

They have shown that sympatric *Hypoplectrus* color morphs mate assortatively and are genetically distinct, and can therefore be considered incipient species. Furthermore, they have identified ecological conditions conducive to speciation by presenting behavioral evidence of aggressive mimicry, whereby predatory color morphs mimic the color patterns of non-predatory reef fish species to increase their success as they approach and attack prey.

Can ecological processes drive speciation? *Hypoplectrus* coral reef fish mimic the colors of other fish on the reef. This mimicry prevents their prey from recognizing them as predators.

By censusing fish along the reef, researchers begin to understand the evolutionary dynamics of coloration and mate choice.

Billo and his local assistant, Elving Castillo capture manakins in mist nets. Here, 4 newly captured birds wait to be measured.

Morphological features like wing-length and color pattern are recorded before birds are released. On the basis of this study, Billo may elevate the island form of this manakin to a newly described species or subspecies, rather than simply a yellow "White Collared" manakin as it has been treated in the past.

TIM BILLO

University of Washington, Seattle

Speciation in *Manacus* manakins

Tim Billo studies the origin, maintenance and future of three separate forms of *Manacus* manakins, providing a glimpse of evolution in progress and insight into the maintenance of this species group.

Previous studies showed three phenotypically distinctive populations of these birds along the mainland Caribbean coast of Bocas del Toro: pure Golden Collared Manakins (*Manacus vitellinus*), pure White Collared Manakins (*Manacus candei*), and a form located geographically between the other two that is genetically and behaviorally similar to the White Collared, but has plumage traits of the Golden Collared. Yellow plumage is found up to 50 km into the range of the White Collared Manakin, and not vice versa.

The intermediate form is considered to result from uni-directional gene flow from the Golden Collared into the White Collared through a single hybrid zone, as White Collared females select yellow hybrids as mates. By sampling isolated populations on the Archipelago, offshore from the hybrid zone, Billo developed a new hypothesis, with Storrs Olson of the Smithsonian, explaining the origin of the "hybrid" phenotype on the mainland.

Evidence from islands isolated sequentially through time from 1,000 to 8,900 years ago, suggests that a dwindling ancient "island" phenotype (previously described as a hybrid receiving uni-directional geneflow from Golden Collared Manakins) is present on the mainland and hybridizing with pure Golden and White Collared populations on either side. Billo is able to estimate the age of hybrid zones on the mainland, and the speed and timing of range movement and geneflow into "island" populations from White Collared and Golden Collared Manakins.

Theme 2: Origin & extinction of marine invertebrates

AARON O'DEA AND JEREMY JACKSON

STRI

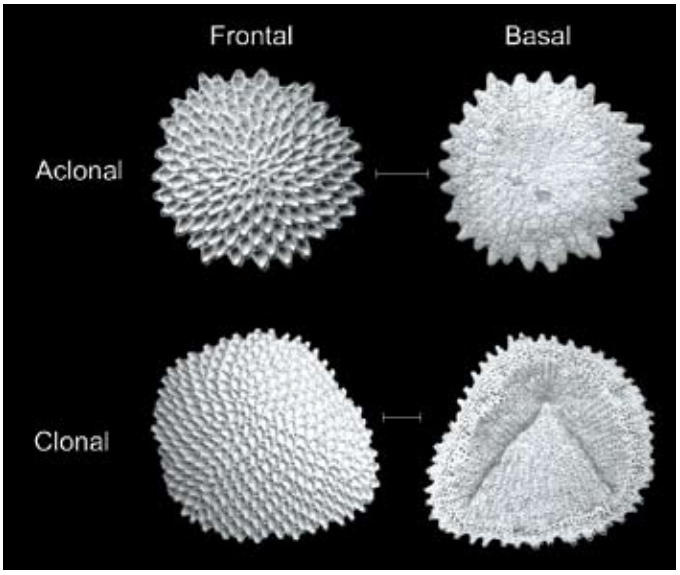
How life history affects probability of extinction

Does sexuality aid speciation? Does asexuality lead to extinction during times of stress? With the support of the U.S. National Science Foundation Aaron O'Dea, Jeremy Jackson and more than 30 collaborators discovered that evolutionary changes associated with major environmental events might take much longer than expected. Fossils from tremendous deposits in Bocas del Toro provided key evidence.

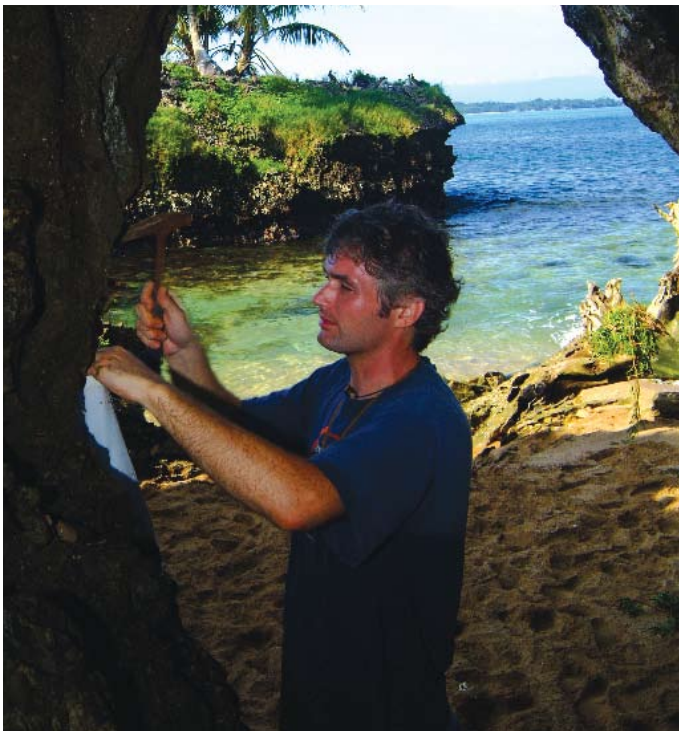
Roughly 3 million years ago, the Isthmus of Panama rose to divide the seaway that once connected the Caribbean with the Pacific Ocean, resulting in major environmental change and a regional mass extinction of marine animals. O'Dea and colleagues found that, in some animal groups, it took a surprising 2 million years for extinction to occur. Such a long time lag challenges the conventional wisdom that cause and effect coincide in geological time.

Now, O'Dea plans to test whether extinction and speciation rates are tied to ecological factors and reproductive strategies. Studies of cupuladriid bryozoans are underway to determine how sexuality/asexuality responded to the closure of the Isthmus. Results demonstrate that when the Isthmus closed, asexuality became increasingly rare in the Caribbean, probably due to lowered planktonic productivity, which selects for asexual propagation. Future work will increase the taxonomic breadth of the study by examining diet and reproduction in gastropods and bivalves.

Their results may help us to predict how different species might respond to modern day environmental change.



Scanning Electron Microscope photos of these minutely sculptured cupuladriid bryozoan fossils help paleontologists to identify the species and determine the mode of reproduction.



Not all fossil beds in Bocas del Toro are as easily accessible as these cliffs on Swan's Cay where O'Dea collected key samples for this study. They are often overgrown by lush tropical vegetation or occur on wave-swept promontories.

Jon Coloma and Narissa Bax, two undergraduate students from the University of Hawaii, count and sort larvae released from different populations around Bocas del Toro. Preserved larvae are analyzed at highly variable genetic markers to determine whether they are crosses between populations, or the result of mating within populations.

Adaptation to unique habitats in Bocas is quantified with reciprocal transplant experiments and a "common garden" where corals are grown in their natural habitats and in habitats where they don't normally occur. Results from these studies suggest factors (predation, low growth, physiological stress) limit species distributions.

DAVID CARLON AND ANN F. BUDD

University of Hawaii and University of Iowa

A multidisciplinary approach to species boundaries in tropical reef corals

There is considerable debate as to how new species form in tropical reef corals, and whether coral species regularly hybridize long after differences in ecology and morphology originate. Funded by the U.S. National Science Foundation, Dave Carlon and Ann Budd study the ecological, morphological, and reproductive nature of species boundaries in corals. This effort combines data from three lines of inquiry: (i) ecological and reproductive field work at the BRS, (ii) morphological analyses at the University of Iowa and (iii) molecular genetic analyses at the University of Hawaii.

Field work takes advantage of diverse environments and high species richness in offshore and lagoonal sites. Carlon and Budd build morphological and DNA collections of hard (sclearactinian) corals of the genera: *Colpophyllia*, *Diploria*, *Favia*, *Manicina*, and *Mycetophyllia* in order to retrospectively recreate a history of gene flow among all species within each genus. DNA sequence analyses, along with an excellent fossil record, shed light on the timing of morphological diversification and reproductive isolation among all species in each of these genera. At finer temporal and spatial scales, an endemic radiation of two very young *Favia* species is used to understand how adaptation to different habitats correlates with reproductive isolation. This species pair reproduces every month on a lunar cycle but larvae are retained and brooded within the parent. Genetic techniques developed in forsenic sciences measure the relative rates of mating within and between these young species.

This research reveals how habitat complexity contributes to new biological diversity, and perhaps to the formation of new species without requiring complete geographic isolation.

RACHEL COLLIN

STRI, Director of the BRS

The role of geographic variation in egg size in diversification of marine gastropods

Closely related, morphologically similar species of marine gastropods often occur in the same places. Observed differences in reproduction and development may explain their ability to coexist.

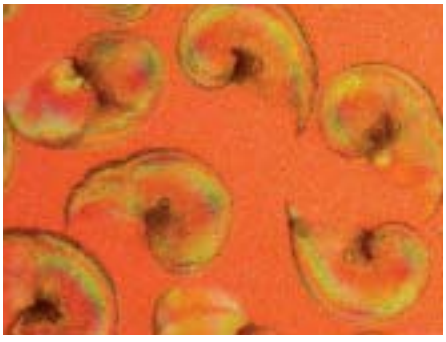
Collin's previous work with slipper snails showed that changes in development are evolutionarily common. Collin's current research considers how differences in development come about and what role they play in the formation and maintenance of species.

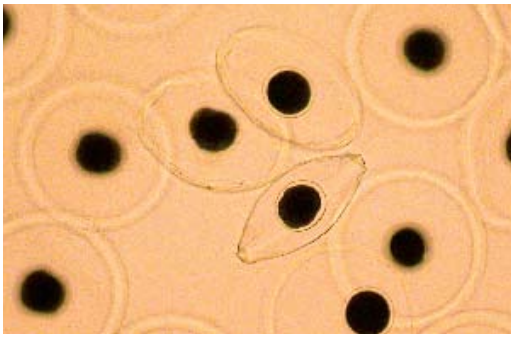
She compares egg size and hatching size of gastropods that range throughout the Caribbean to see how these fundamental features of development vary with changes in environment and with genetic divergence. Laboratory experiments quantify how much variation in egg size within a species is due to genetic factors versus environmental factors. By growing snails under different conditions she can also determine if genetically distinct lineages have different egg sizes.

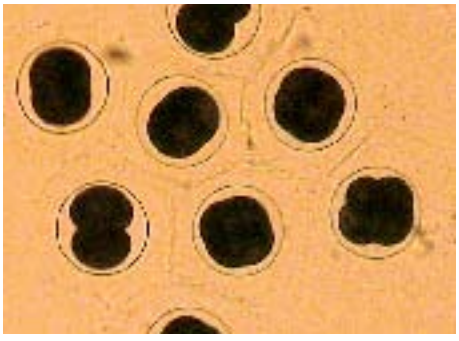
Preliminary results show that there is significant egg size variation between females, and less variation among locations suggesting that, contrary to other evidence, evolutionary change in egg size should be slow to evolve.

Rachel Collin injects potassium chloride into a sand dollar to induce spawning. The eggs she collects will be photographed and measured digitally to ensure a minimum of measurement error.

Variation in the size at hatching and egg size of marine gastropods can be measured in photographs such as these of littorinid eggs and hatchlings. Egg size is thought to be constant within a species, but Collin's results show that this is not always the case.







Dr. Cristina Diaz, USNM Research Associate, describes the reproductive strategies of sponges to graduate students enrolled in the Training in Tropical Taxonomy course on Taxonomy and Ecology of Caribbean Sponges. More than 150 sponge species have been reported for Bocas del Toro. Each year students in the course add to the list.

outreach, education, training

Outreach and education at the Bocas del Toro Research Station spans a range of programs targeting K-12 students, university undergraduates, graduate students and young professionals. K-12 education includes visits to local schools, some of which are in remote mountainous locations, and student visits to the BRS. The station also offers a training workshop for local K-12 teachers once every two years.

More than 190 university undergraduates visited the station as participants in courses hosted by the Bocas Research Station (see page 42), and more than 100 participated as research assistants and interns in numerous research projects. Our outreach specialists also reached local undergraduates by visiting the University of Panama in Changuinola. Finally, graduate students and young professionals obtain advanced training at the BRS where they learn specialized skills for studying biodiversity from the Training in Tropical Taxonomy program.

Activities at the station also touch the general public from around the world. Bi-weekly station open houses received 700 visitors from 20 countries in FY07. The BRS also has an active web presence. The BRS Biodiveristy database received 10,000 unique hits during this two year period. The virtual mangrove walkway and real-time biological monitoring data are also popular sites.

Plans for future development of the public programs include design and construction of an interpretive walk. The walk will include pond, forest, and mangrove ecosystems that are present on the BRS property.

These colorful sponge samples form the backbone of the data that supports the Bocas Biodiversity web page and the Training in Tropical Taxonomy program.

Lidia Valencia works with school children from Isla Colon to convey the importance of coral reef ecosystems. BRS outreach also includes local teacher training.

Local school outreach

A visit to the BRS, hosted by Marlon Smith, may be the first time that local students, who live on islands or near the coast, begin to match names to marine species and understand their function in marine ecosystems.

The BRS local school outreach program began 4 years ago and currently works closely with 10 educational centers in the area. Outreach staff organize approximately three visits to the station per month, and travel to schools that do not have easy access to the station. Over 670 students participated in this program in FY07.

The program consists of activities tailored to the educational level and prior knowledge of each group. Students compare ecosystems, use laminated photo sheets and keys to identify organisms, test water quality and make connections between land use and coral reef health.

BRS researchers often participate, sharing their expertise and enthusiasm with the students.

In 2006 the station hosted a second workshop for local teachers, organized in conjunction with Panama's Ministry of Education (MEDUCA). 42 local teachers spent time in the field with outreach staff, listened to scientists present their work and developed effective classroom exercises to incorporate biological information into the standard curriculum.

These students from the local San Jose High School are making a movie called "Science in Progress" that features work at the BRS.

Biodiversity database

Coordinated by BRS director, Rachel Collin, the Bocas biodiversity database aims to provide a list of plants and animals that are known to occur in the Bocas del Toro Archipelago, the Bahía Almirante, Laguna de Chiriquí, and the surrounding mainland. Users can search for a particular term or browse the database by group.

Descriptions and photographs, as available, are included to aid in species identification. Work continues to add more information for the 3,200 species as well as increase the number of species included.

The database is useful for scientists planning work at the Bocas del Toro Research Station, field workers trying to identify organisms they have seen in the field, and students working in this part of Panama. The page receives an average of 400 unique visitors per month--5,000 unique hits per year--10,000 visitors over this 2-year period.

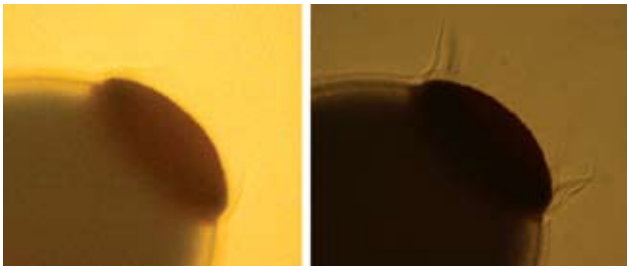
Goals for 2008 include the migration of the database to the relational STRI-wide database system, the addition of another 300 species and of photographs for another 200 species.

The BRS biodiversity database is an essential tool for researchers and also benefits students and area residents who can identify a wide range of organisms based on photos and written descriptions of more than 3,000 organisms.

Sponges like *Callyspongia vaginalis* (left) and the 156 other sponge species reported for Bocas del Toro can each provide habitat for as many as 15,000 other organisms. Grazing by sea urchins, like these *Diadema antillarum* (center), can radically alter Caribbean reef habitats, and protect corals from overgrowth by algae. Only half of the 100 tunicate (right) species from the region have been formally described and named.

Training in Tropical Taxonomy

Paco Cardenas, student in the TTT course, Taxonomy and Ecology of Caribbean Sponges, explains the characteristics of the Astrophorida. The wide diversity of experience and interests of the students in these courses makes learning from each other as important as learning from the instructors.



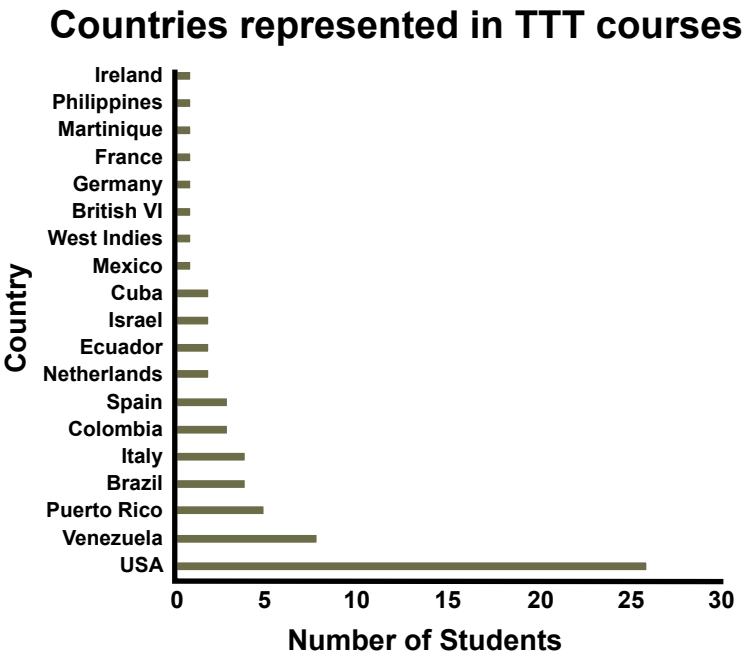
Results of several student projects have been published or presented at scientific conferences. Here, students examined the mechanism by which a sponge larva swims away from the light. These simple ciliated balls of cells that lack a nervous system extend and beat the long cilia on their posterior when light is reduced (right). The cilia stop beating and fold into the body when light increases (left).

One of the major impediments to the documentation and conservation of global biodiversity is the shortage of scientists trained in taxonomy (finding, describing and naming organisms). The BRS's Training in Tropical Taxonomy (TTT) program, founded and coordinated by Rachel Collin, is one of less than a handful of programs worldwide aimed at addressing this shortage.

The TTT runs a series of courses to train students and biologists interested in biodiversity and taxonomy of tropical marine animals. This training enables them to (1) efficiently collect and preserve material for subsequent taxonomic work, (2) roughly sort the material correctly to the level of family or genus (depending on the group), (3) have the tools to use existing keys or monographs to identify material to species, and (4) learn basic techniques important for research on the biology of each group.

During the course each student becomes familiar with Caribbean species. These courses also promote development of personal connections between taxonomists in different countries or regions and foster collaborations between scientists in developed and developing countries (see graph for breakdown of participants by country). These courses focus on groups of organisms that are of particular interest to biologists or that are in urgent need of taxonomic expertise.

With the support of SENACYT, Panama's governmental office of science and technology, the SI's Marine Science Network and the SI's Women's Committee, two "Taxonomy and Ecology of Caribbean Sponges," one "Taxonomy and Biology of Tunicates" and one "Taxonomy and Ecology of Caribbean Gorgonians and Black Corals" course were offered in FY06-07. Courses focusing on tropical marine algae and the taxonomy of shrimps are planned for FY08.



TTT courses are truly international, with fewer than 50% of the students coming from North America.

Peter Etnoyer, a graduate student at Texas A&M University, uses identification guides to help him identify local gorgonian species in the field.

Students practice using characters like surface texture, compressibility or the copious mucus discharged by this *Haliclona mucifibrosa* sponge to ID species in the field. These kinds of features make it possible to ID many, but not all, species in the field.

The BRS fleet, vital to all aspects of research at the station, includes 9 boats ranging from 15-25 feet. The most recent addition to the fleet is a 25' glass-bottom Eduardoño which will be used for K-12 education and outreach activities for the public.

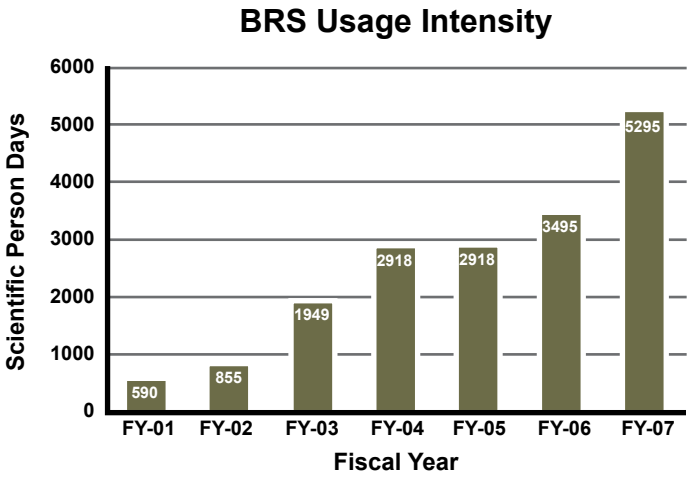
BRS visitors and usage

Since its inauguration in 2003, the number of BRS scientific visitors has increased five-fold from 75 in FY02 to almost 300 in FY07 (see below).

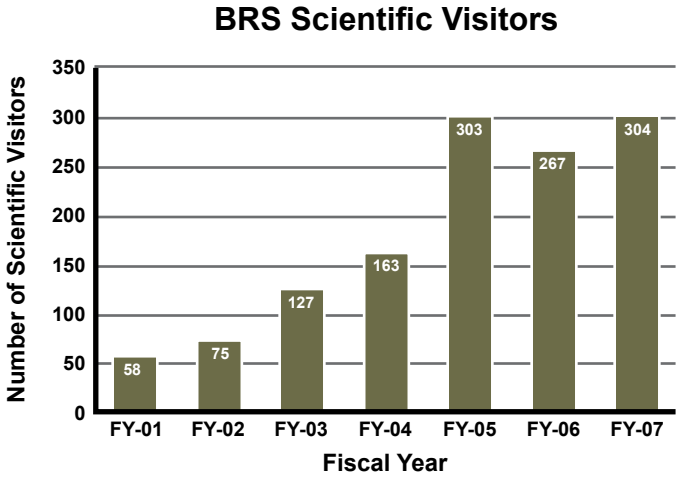
The total number of visitors in FY06-07 was 436. Of these, 43% were students in courses, whereas 30% were graduate students, undergrads and interns. BRS scientific visitors came from over 34 countries.

The intensity of usage as measured by person days has likewise increased from 855 person days in FY02 to 5,000 in FY07, in part because many researchers make multiple visits to the station every year.

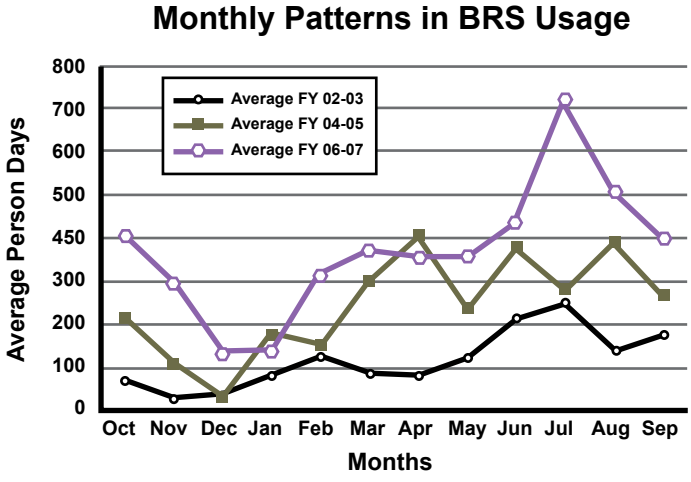
A comparison of the number of visitors at the BRS with other facilities at STRI shows that the BRS has a similar demand to Barro Colorado Island. Over 30% of STRI visitors do some work in Bocas del Toro.



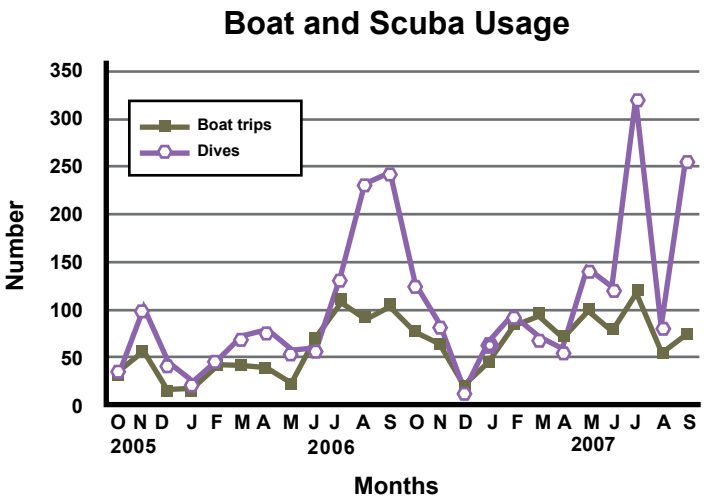
The number of person days spent at the station has increased steadily since its inauguration.



Recent increases in the number of person days with only a moderate increase in the number of visitors shows that visitors are now staying longer at the station.

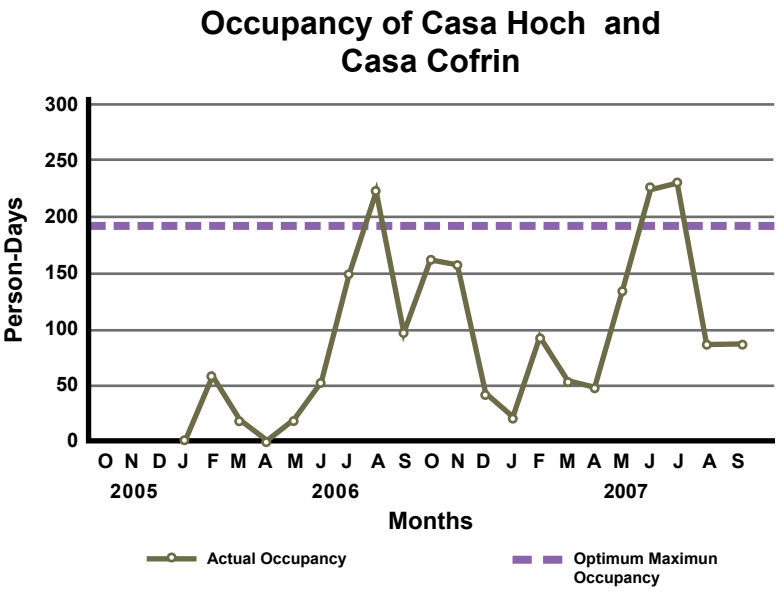


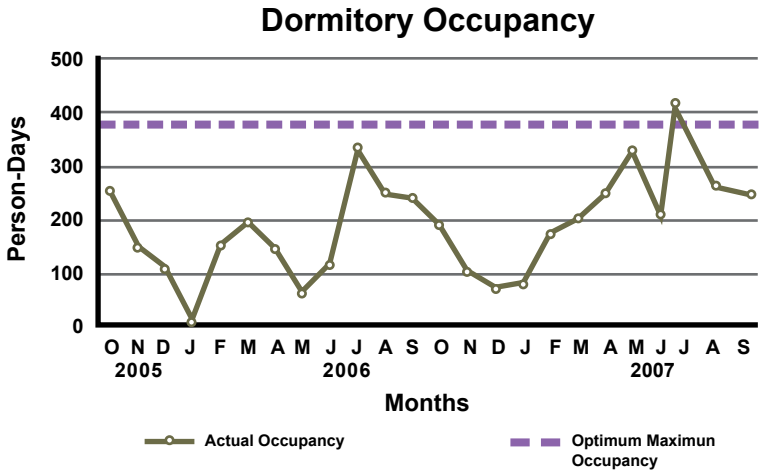
There is a distinct seasonal pattern in the number of visitors with peaks in July and August and a slow season in December and January.



Boats and scuba facilities are vital to the success of any marine laboratory. The usage of both is seasonal, reflecting the monthly variation in the number of visitors.

Accommodations





Occupancy of both houses and dormitories is increasing steadily, but monthly occupancy rates reflect the seasonal variation in station usage. An optimal occupancy rate of 80% would represent 192 person days for the houses and 384 person days for the dormitories.

Accommodation at the Bocas del Toro Research Station includes a dormitory with a common kitchen area that houses 16 people and two 2-bedroom houses (Casa Hoch and Casa Cofrin) that can each house 4 visitors.

Occupancy of the houses (Fig. above left) in FY06-07 reached a monthly average of 94-96% in June and July, 2007. The average annual occupancy was 32% in FY06 and 46% in FY07. A continued increase is expected for FY08.

The dormitories consist of 4 rooms, each with 4 beds. Occupancy (Fig. lower left) was slightly lower that in the houses, with a maximum monthly average of 80% in July, 2007. The average annual occupancy was 35% in FY06 and 44% in FY07. Overall, the dormitories are very crowded during the busy season and pleasantly quiet in the off-season. 21% of the station visitors live off-campus in remote locations or in the town of Bocas del Toro.

Scientific visitors

STRI Scientists

George Angehr
Work on the book: "Where to Find Birds in Panama: A Site Guide for Birders"

Eldredge Bermingham
Behavioral evaluation of aggressive mimicry in the genus *Hypoplectrus*

John H. Christy
Comparison of the circatidal swimming behavior of fiddler crab larvae from different tidal regimes

Anthony Coates
Geologic mapping of the Bocas del Toro Archipielago

Rachel Collin
The role of geographic divergence in egg size in diversification of marine gastropods

Richard Condit
Evaluating the importance of resource heterogeneity in species richness patterns of the San San Pond Sak coastal freshwater swamp utilizing comparative analyses along an altitudinal gradient in upland forest

Aydee Cornejo
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Nefertaris Daguerre
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Luis D'Croz
Phytoplankton community responses to nutrient enrichment

Juan Del Rosario
Phytoplankton community responses to nutrient enrichment

Carlos Guevara
Survey of Bocas del Toro coral diversity

Javier Jara
Coral spawning in *Montastraea annularis* complex

Harilaos Lessios
Adaptive values of sea urchin covering behavior

Juan Mate
Development of an integrated coastal management plan for Bocas del Toro province

Marta Moreno
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Steve Paton
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Rolando Perez
Evaluating the importance of resource heterogeneity in species richness patterns of the San San Pond Sak coastal freshwater swamp utilizing comparative analyses along an altitudinal gradient in upland forest

Ruth Reina
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Ricardo Thompson
Monitoring of mangrove ecosystems in Bocas del Toro

Mark Torchin
Bocas del Toro marine parasite diversity

Benjamin Turner
Biogeochemistry of a tropical wetland

Christian Ziegler
Documentation of STRI research

STRI Fellows

Alexandra Amat, STRI Post-doc Fellow
Response of reef growth and calcification to elevated CO_2 and temperature: comparison between low and high latitude reefs

Juan Antonio Baeza, Hoch Post-doc Fellow
Testing the effect of mating-group size in simultaneous hermaphrodites: marine shrimp, *Lysmata,* as a model system

Ivania Ceron Souza, STRI Pre-doc Fellow, Universidad de Puerto Rico
Dispersal limitations and genetic structure of two mangrove species.

Andia Chaves-Fonnegra, STRI Pre-doc Fellow, Universidad Nacional de Colombia
Mechanisms of cellular death in competitive interactions between the encrusting excavating sponge *Cliona delitrix* and reef corals

Katie Cramer, STRI Pre-doc Fellow, Scripps
Historical and current impacts of land use on the Southern Meso-American Coral Reef

Aldo Croquer, STRI Post-doc Fellow, University of Puerto Rico
Environmental Science Program-monitoring coral reef diseases

Michael DeSalvo, STRI Pre-doc Fellow, University of California
The functional genomics of coral bleaching in the *Montastraea annularis* complex

Alana Domingo, STRI Short-term Fellow, Louisiana University
The missing link in the population biology of reef fishes: molecular ecology of larval dispersal in gobies

Mary Hart, STRI Pre-doc Fellow, University of Kentucky
Sex allocation and egg-trading strategy: examining sexual conflicts in ecological context

Margareta Kalka, STRI Pre-doc Fellow, Free University of Berlin
Impact of insectivorous bats on herbivore abundance on shade-grown cacao in Panama

Maria Pia Miglietta, STRI Post-doc Fellow
Life cycle evolution, morphological traits, and ecological correlates in Hydrozoa (phylum Cnidaria)

Matthew Miller, STRI Pre-doc Fellow, University of Alaska
Phylogeography of Central American birds

Osamu Miura, STRI Post-doc Fellow
Diversification of snails and trematode parasites separated by the Isthmus of Panama

Oscar Puebla, STRI Pre-doc Fellow, McGill University
Behavioral evaluation of aggressive mimicry in the genus *Hypoplectrus*

Corinne Richards, STRI Short-term Fellow, University of Michigan
Selection and the rapid evolution of morphological variation among strawberry poison-dart frogs of the Bocas del Toro archipelago

Sharlene Santana, STRI Pre-doc Fellow, University of Massachusetts
The evolution of cranial morphology and diet in phyllostomid bats (Chiroptera: Phyllostomidae)

Adam Smith, STRI Post-doc Fellow
Impact of insectivorous bats on herbivore abundance on shade-grown cacao in Panama

Eva Toth, STRI Post-doc Fellow
Behavioral and genetic analysis of the principle of sociality in sponge-dwelling shrimp

Steve V. Vollmer, STRI Post-doc Fellow
Coral disease transmission: hybridization, introgression and a genetic view of coral species.

Scientific Researchers

Ingi Agnarsson, University of Akron
Boat traffic and potential negative effects on the behavior and acoustics of a resident bottlenose dolphin population (*Turpsius truncates*)

Marie-Pierre Aubry, Rutgers University
Geologic mapping of Bocas del Toro Archipielago

Marylin Ball, Australian National University
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Uta Berger, Center for Tropical Marine Ecology
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Patrick Biber, University of Southern Mississippi
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Luz Boyero, James Cook University
The Gavilán Project (Inventory of flora and fauna in the areas affected by the Chan-75 and Chan-140 hydroelectric projects)

Catherine Caballero, International Cooperative Biodiversity Groups
Survey of Bocas del Toro sponge diversity

David Carlon, University of Hawaii
A multidisciplinary approach to species boundaries in tropical reef corals

Paulyn Cartwright, University of Kansas
Assembling the tree of life- an integrative approach to investigating cnidarian phylogeny

Mary-Alice Coffroth, University of Buffalo
Coral Reef Genomics: A genome-wide approach to the study of cnidarian symbiosis

Laurel Collins, Florida International University
Geologic mapping of Bocas del Toro Archipielago

Molly Cummings, University of Texas
Poison or passion: warning and attraction in a color-polymorphic frog

Stephen E. Davis, Texas A&M University
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Marta DeMaintenon, University of Hawaii
Intoxicating connections: bridging the gap between the lab bench and informal science education using venomous mollusks

William Dennison, University of Maryland
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Donna Devlin, Florida Atlantic University
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Maureen A. Donnelly, Florida International University
Geographic and temporal variation in chemical defense of the dendrobatid frog, *Dendrobates pumilio*, and its relationship to diet, color pattern, and forest structure

Amy Driskell, Smithsonian National Museum of Natural History (SI-NMNH)
All Bocas Barcode Alliance project to DNA barcode the marine invertebrates of Bocas del Toro

Norman Duke, University of Queensland
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Candy Feller, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Suzanne Fredericq, University of Louisiana at Lafayette
Bocas del Toro biodiversity of marine algae

D. Wilson Freshwater, University of North Carolina Wilmington
Marine algal diversity of southern Central America

Leonidas Fusani, University of California
Understanding the origin of *Manacus* phenotypes in Bocas del Toro

Raymond L. Gabriel, University of Oxford
Theraphosid taxonomy and biology

Charles Gallegos, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Deborah Gochfeld, University of Mississippi
Biogeographic comparison of defenses against predation and disease in Caribbean sponges.

Gretchen Goodbody, Harvard University
Reproductive Ecology and Phylogeography of the western Atlantic Corals *Montratraea cavernosa* and *Favia fragum*

Harald Gross, ICBG
Tropical disease drug discovery from marine and plant sources in Panama (as part of the exisiting ICBG project)

Jeffrey Hunt Smithsonian National Museum of Natural History (SI-NMNH)
All Bocas Barcode Alliance project to DNA barcode the marine invertebrates of Bocas del Toro

Richard Hochberg, University of Massachusetts
Bocas del Toro biodiversity

Terry Lynn Jordan, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

W. Judson Kenworthy, NOAA, NCCOS, Beaufort, NC
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Michel Kirby, University of Florida
Southern Caribbean Neogene gastropods: systematics, ecobiostratigraphy and biogeography

James Klaus, Miami University
Geology of Isla Colon - Chronostratigraphy of fossil Coral bearing units

Andrew Kratter, University of Florida
Neotropical Fish and Bird Collections / Effect of density and risk on the mating behavior of an egg-trading simultaneous hermaphrodite, *Serranus tortugarum*

Bernard Landau, Universidad de Lisboa
Southern Caribbean Neogene gastropods: systematics, ecobiostratigraphy and biogeography

Don Levitan, Florida State University
Coral spawning in the *Montastraea annularis* complex

Roger Linington, Oregon State University, ICBG
Marine cyanobacteria as a potential source of antiparasitic and anticancer drugs

Benjamin Longstaff, University of Maryland
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Catherine Lovelock, University of Queensland
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Ivan Marin, Institute of Ecology and Evolution, Moscow
Taxonomy molecular and morphological phylogeny of the shrimp genus *Alpheus* and molecular phylogeny of the family Alpheidae

Carlos Marques de Silva, Universidad de Lisboa
Southern Caribbean Neogene gastropods: systematics, ecobiostratigraphy and biogeography

Catherine McFadden, Harvey Mudd College
Assembling the tree of life: an integrative approach to investigating cnidarian phylogeny

Karen L. McKee, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Donald McNeill, Miami University
Geology of Isla Colon - Chronostratigraphy of fossil coral-bearing units

Kerry McPhail, Oregon State University, ICBG
Marine cyanobacteria as a potential source of antiparasitic and anticancer drugs

Monica Medina, University of California Merced
Coral Reef Genomics: A genome wide approach to the study of cnidarian symbiosis

Anne Meylan, Florida Fish and Wildlife Conservation Commission
The ecology and migrations of marine turtles of Bocas del Toro Province, Panama

Peter Meylan, Eckerd College
The ecology and migrations of marine turtles of Bocas del Toro Province, Panama.

James Norris, Smithsonian National Museum of Natural History (SI-NMNH)
Bocas del Toro biodiversity of marine algae

Julie Beth Olson, University of Alabama
Biogeographic comparison of defenses against predation and disease in Caribbean sponges

Edward Proffit, Florida Atlantic University
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Carlos Ramirez, Southern Connecticut State University
Palm diversity in Bocas del Toro

Wilfrid Rodriguez, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Sofie Sjogersten, University of Nottingham
Nutrient controls on carbon dynamics in tropical wetlands

Daniel Suman, University of Miami
Development of an integrated coastal management plan for Bocas del Toro

Richard Tankersley, Principal investigator, Florida Institute of Technology
Comparison of the circatidal swimming behavior of fiddler crab larvae from different tidal regimes

John Taylor, The Natural History Museum of London
Biology and evolution of lucinid bivalves

Maurice Thomas, Palm Beach Atlantic University
Reproductive patterns, community structure and population fluctuations of bats in cave roosts on Bocas

Robert Thacker, University of Alabama
Ecology and evolution of sponge-cyanobacteria symbioses

Elizabeth Torres, California State University
Phylogenetic reconstruction of the ostracod family Cypidinidae, and the evolution of bioluminescence

Angel Valdez, NHMLAC
Morphological and molecular study of the geminate species of opisthobranch mollusks from the Central American isthmus

John P. Wares, University of Georgia
Global phylogeny of *Chthamalus*

James Watling, Florida International University
Geographic and temporal variation in chemical defense of the dendrobatid frog, *Dendrobates pumilio*, and its relationship to diet, color/pattern and forest structure.

Lee Alan Weigt, Smithsonian National Museum of Natural History (SI-NMNH)
All Bocas Barcode Alliance project to DNA barcode the marine invertebrates of Bocas del Toro

Bret Wolfe, University of Virginia
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Janie Wulff, Florida State University
Influence of competition, mutualism, and environment on patterns of sponge diversity and co-occurrence in Caribbean coral reefs and mangroves

Brian Wysor, Roger Williams University
Preliminary investigations for the NSF proposal RUI: Collaborative Research: Marine algal diversity of southern Central America

Post-doctoral Researchers

Arthur Anker, University of Alberta
Taxonomy, molecular and morphological phylogeny of the shrimp genus *Alpheus* and molecular phylogeny of the family Alpheidae

Marcy Balunas, Oregon State University
The Panama ICBG project—collection of marine cyanobacteria as a potential source of antiparasitic and anticancer drugs

David Ferrel, Florida State University
Coral spawning in the *Montastraea annularis* complex

Mande Holford, University of Utah
Intoxicating connections: bridging the gap between the lab bench and informal science education using venomous mollusks

David Kline, STRI
The effect of anthropogenic stress on white band disease transmission

Martine Maan, University of Texas
Poison or passion: warning and attraction in a color-polymorphic frog

Aaron O'Dea, University of Bristol
Dissection of an extinction: Evolution and environment in tropical American cupuladriids

Tiffany Troxler, Florida International University
Quantifying relationships between resource heterogeneity and plant community structure in a coastal freshwater swamp in Panama

Graduate students

Fernando Alda, Museo Nacional de Ciencia, Madrid, Spain
Dispersal limitations and genetic structure of two mangrove species

Jeffrey Barnes, McGill University
Do ecological principles or physiological properties explain the patterns of colonization of exotic species by parasites?

Stephen Barnes, University of Hawaii
The ecology of speciation in neotropical corals

Timothy James Billo, University of Washington
Speciation in *Manacus* Manakins

Yolanda Camacho Garcia, Universidad de Costa Rica
Morphological and molecular study of the geminate species of opisthobranch mollusks from the Central American Isthmus.

Argelis Centeno, ICBG
ICBG Project: Tropical disease drug discovery from marine and plant sources in Panama

Alexander Cheesman, University of Florida
Soil nutrient dynamics

Liza Comita, University of Georgia
Evaluating the importance of resource heterogeneity in species richness patterns of the San-San Pond Sak coastal freshwater swamp utilizing comparative analyses along an altitudinal gradient in upland forest

Giuseppe DiCarlo, Smithsonian Environmental Research Center
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Nathaniel Evans, University of Kansas
Assembling the tree of life: an integrative approach to investigating cnidarian phylogeny

Nathalia Giraldo, Universidad de los Andes
Dispersal limitations and genetic structure of two mangrove species

Vanessa Liz Gonzalez, California State University
Phylogenetic reconstruction of the ostracod family Cypidinidae, and the evolution of bioluminescence

Jodie Hartill, University of Nottingham
Nutrient controls on carbon dynamics in tropical wetlands

Ayana Johnson, Scripps
Coral spawning in *Montastraea annularis* complex

Samantha Joye, University of Georgia
Effects of nutrient over-enrichment on structure and function of seagrass and mangrove ecosystems

Stacie Knight, University of Georgia
Effect of density and risk on the mating behavior of an egg-trading simultaneous hermaphrodite, *Serranus tortugarum*

Stephanie Knowles, Natural History Museum of Los Angeles County
Morphological and molecular study of the geminate species of opisthobranch mollusks from the Central American Isthmus

Justin Lawrence, University of Texas
Poison or passion: warning and attraction in a color-polymorphic frog

Nicolas LeDantec, Scripps
Coral disease transmission

Silvia Libro, Universidad di Padlova
Life cycle evolution, morphological traits and ecological correlates in Hydrozoa (phylum Cnidaria)

Stacey Littlefield, College of Charleston
The impact of non-equilibrium processes on benthic bacterial community structure: using molecular techniques to assess the effects of deposit feeding by *Holuthuria mexicana*

Jose del Rosario Loaiza, McGill University
Ecology of malaria vectors

James Maley, University of Alaska Museum
Phylogeography of Central American birds

Kristen Marhaver, Scripps
Hybridization, introgression and a genetic view of coral species

Christopher Martell, University of Texas
Poison or passion: warning and attraction in a color-polymorphic frog

Benjamin Mason, University of Miami
Coral reef genomics: A genome-wide approach to the study of cnidarian symbiosis

Laura May-Collado, Florida International University
Boat traffic and potential negative effects on the behavior and acoustics on a resident bottlenose dolphin population (*Tursiops truncatus*)

James McDonald, Rutgers University
Effect of costal development on animal communities in mangrove root and seagrass beds

Irene Mendoza, University of Florida
Evaluating the importance of resource heterogeneity in species richness patterns of the San-San Pond Sak coastal freshwater swamp utilizing comparative analyses along an altitudinal gradient in upland forest

Francois Michonneau, Florida Museum of Natural History and University of Florida
Biodiversity of Aspidochirotida (Sea cucumbers)

Peggy Miller, ICBG
Phylogeography of Central American birds

Felipa Navarro
Evolutionary ecology and seed predation in tropical rainforests

Marah Newman, Scripps
Hybridization, introgression and a genetic view of coral species

Flavia Nunes, Scripps
Coral disease transmission

Felipe Lamus Ochoa, Universidad Nacionál de Colombia
Geological study of coral fossils

Jill Leonard Pingel, SCRIPPS
Evolution and environment of tropical American Cupuladriids

Sara Pinzon, Imperial College of London and Natural History Museum of London
Evolutionary ecology and seed predation in tropical rainforests

Christina Auline Riehl, Princeton University
Diversity of tropical terrestrial sloth

Dominique Roche, McGill University
Do ecological principles or physiological properties explain the patterns of colonization of exotic species by parasites?

Sebastian Rodriguez, Universidad Simon Bolivar
Effect of *Halofolliculina* sp. (Ciliophora) on scleratinian corals, a possible pathogen in the Caribbean

Eva Salas, Universidad de Costa Rica
Genetic structure and gene flow of bicolor damselfish populations in Costa Rica and Panama

Iveth Santos, STRI
Phylogeography of Central American birds

Ralph Saporito, Florida International University
Geographic and temporal variation in chemical defense of the dendrobatid frog, *Dendrobates pumilio*, and its relationship to diet, color pattern and forest structure.

Carmen Schloeder, University of Kaiserslautern
Population ecology and genetics of *Porites furcata*

Emmanuel Irrizary Soto, Universidad de Puerto Rico
Coral reef genomics: A genome wide approach to the study of cnidarian symbiosis

Adam Stein, Syracuse University.
Signal evolution and speciation in the Bearded Manakin (*Manacus* spp.)

Milla Suutari, University of Helsinki
Diversity of tropical terrestrial algae

Anne-Marie Svoboda, Vrije Universiteit Amsterdam
Effect of density and risk on the mating behavior of an egg-trading simultaneous hermaphrodite, *Serranus tortugarum*

Evelin Taubitz, University of Rostock
Boat traffic and potential negative effects on the behavior and acoustics on a resident bottlenose dolphin population (*Tursiops truncatus*), Bocas del Toro, Panama

Christopher Thornburg, Oregon State University
Panama ICBG project: collect marine cyanobacteria as a potential source of antiparasitic and anticancer drugs

Erin Trimble, ICBG
Panama ICBG project: Tropical disease drug discovery from marine and plant sources

William Vervaeke, Smithsonian Environmental Research Center
Effects of Nutrient Over-Enrichment on Structure and Function of Seagrass, and Mangrove, Ecosystems: Bocas del Toro Marine Laboratory in Panama

James Bryson Voirin, New College of Florida
Biology of *Bradypus variegates* and *Choloepus hoffmanni* in Bocas del Toro

Ian Jen Wang, University of California
Evolution of color polymorphism in poison-dart frogs

Carmen Zinssmeister, J.W. Goethe-Universität
Biodiversity of the Opistobranchia (Mollusca, Gastropoda) of the interstitial sand

Volunteers, Undergraduates, Assistants and Interns

Rafael Aizprua, STRI
Jessie Alden, Roger Williams University
Dalal Al-Abdulrazzak, Middlebury College
Kora Andersson, University of Kansas
Christopher Angioletti, SCRIPPS
Elizabeth Arnold, California State University
Andrew Baker, Syracuse University
Narissa Bax, University of Hawaii.
Maude Beaumier, McGill University
Moises Bernal, Universidad de Panamá
Irving Bethancourt, Universidad de Panamá
Jenny Calvo, Universidad de Panamá
Alison Cawood, College of Charleston
Darlenis Cedeño, University of Panamá
Chip Clark, Smithsonian National Museum of Natural History
Jon Coloma, University of Hawaii
Miles Collins, Smithsonian National Museum of Natural History
Ricardo Cossio, Universidad de Panamá
Jack Cramer, Eckerd College
Ryan Crim, Huxley College
Jennifer Davison, University of Hawaii
Natalia DeCastro Gonzalez, Universidad de Medellin
Kimberly Diver, unafilliated
Currie S. Dugas, Brown University
Angie Estrada, Universidad de Panamá
Sergio Estrada, Universidad de los Andes
Christopher Evans, Balliol College of Oxford University
Jolyon Faria, University of Bristol
Myla Jean Frankel, Greater Victoria School District
Steve Leonard Frankel, Greater Victoria School District
Dumas Galvez, Universidad de Panamá
George Gann, unafilliated
Fernando Garcia, Universidad de Panamá
Liza Maria Garcia, Universidad Jorge Tadeo Lozano
Hannah Giddens, College of Charleston
Laura Gillespie, Miami University
Tiffany Harvey, University of Texas
Sarah Herbst, State University of New York
Lindsey Holland, SUNY Buffalo
Sarah Susanne Holloway, University of Texas
Robert Horan, University of Georgia
Jennifer Kelly, University of North Carolina--Wilmington
Allison Kreutzer, University of Kentucky
Ashley Lamb, University of Texas
Michael Lelevier, University of Alaska Museum
Dioxelis Lopez, ICBG--STRI
Anne Arnold Madden, Wellesly College
Daniel Mancilla Cortez, College of Atlanta
Digna Matias, Universidad de Panamá
Jorge May-Barquero, Florida International University
Beatriz Medina, Universidad de Panamá
Stephan Meylan, unafilliated
Selena Moss, University of Miami
Karen Nuñez, unafilliated
Maria Cristina Ordoñez Espinosa, Caribbean Conservation Corporation
Jose David Palacios, Fundación Keto
Luis Ignacio Quiroz, Universidad Nacional de Colombia
Jennifer Reitz, University of Washington
Nicolas Roche, University of Montreal
Jose Ricardo Rovira, Gorgas Institute
Victor Schmidt, St. Lawrence University
Letzy Serrano, Universidad Autonoma de Chiriqui
Byron Shoemaker, University of California -Davis
Emilia Sogin, Brown University
Justin Suraci, University of Virginia
Ryan Tisdale, Princeton University
Rolando Torres Cosme, Instituto Conmemorativo Gorgas
Orlando Vargas, Organization for Tropical Studies
Sandra Vargas, STRI
Marilyn Waite, Princeton University
Scott Walls, University of Hawaii
Lesley Wilson, ICBG--STRI
Lachlan Wilmott, University of Wollongong
Vera Yonathan, Universidad de Oriente
Maren Ziegler, STRI

Course participants-- Visiting courses

Harvard University
Biology and Evolution of Invertebrate Animals
March 24 – April 1, 2006
Instructor: Gonzalo Giribet
Students: Geoffrey Dilly, Sarah Elwell, Kristina Fontanez, Harry Gilliam, Ryan Kerney, Paul McGuinness, Lachezar Nikolov, Michael Pakes, Benjamin Pazin, Prashant Sharma, Melinda Snitow
March 24 – 31, 2007
Instructor: Gonzalo Giribet
Teaching Assistants: Stephanie Aktipis, Jessica Baker
Students: Emily Boehm, Jennifer Cai, Jessica Chao, Rebecca Compton, Ifunanya Ejebe, Alejandra Guzman, Matthew Kan, Allison Kessler, Stephanie Madden, Maureen Moen, Jamie Sodikoff, Ying Soh, Kelly Stecker, Amy Tao, Jesus Souza Troncoso, Jessica Worl

Princeton University
Tropical Marine Coral Ecology
February 4 – May 3, 2007
Instructor: Stephen Pacala
Teaching assistant: Chen Ampin
Students: Rebecca Allen, Karen Bailey, Amadea Britton, Anthony Cortez, Nathan Geller, Jessica Harrop, An Qi Hu, Jean Hwang, Lisa Kelly, Eric Knoh, Sarah Maguire, Daniel Medina, Eduardo Medina, Laura Morales, Jerry Moxley, Aneth Sarmiento, Zoe Shapleigh, Max Winston

Radford University
Environmental Biology
May 13 – 21, 2007
Instructor: Judy Guinan
Students: Elizabeth Cummingham, Carolina Duggan, Eileen Hudson, Beth Meyer, Susanne Picklett, Ashley Shiraishi

School for International Training
Tropical Marine Ecology
October 17 – 21, 2005
Instructor: Juan Mate, Julie Payne, Luis Dominguez
Students: Katherine Asselin, Allison Covey, Logan Egan, Lisa Filak, Erin Gaines, Maisie Ganz, , Rebecca Kayes, Lisa Maas, Bebecca Monti, Maria Tranguch, Liana Twardosz, Lowell Walker, Aubrey Weeks, Melanie Ziff.
April 16 – 21, 2006
Instructor: Juan Maté, Julie Payne, Luis Dominguez
Students: Kristin Foss, Lindsey Franklin, Morala Griffith, Amanda Gurgul, Lauren Hart, Norah Kates, Kelsey Moore, Jared Oubre, Carey Pulverman, Jamey Redding, Danica Taber, Nicolas Turner, Leah Witus.
October 11 – 15, 2006
Instructor: Juan Maté, Alyson Dagang
Students: Hallie Bare, Jeffrey Beem-Miller, Joanna Bove, Eleanor Cowley, Emily Dangremont, Jennifer Grablander, Bonnie Hemphill, David Kerns, Alison Lay
May 7 – 12, 2007
Instructor: Juan Maté, Julie Payne
Students: Maritza Mallek, Daniel Margoles, Liza McEloroy, David Miller, Ariadne Prior-Grosch, Rachel Sanders, Jeffrey Stein, Sage Trombulak
July 2 – 7, 2007
Instructors: Juan Maté, Julie Payne
Students: Chuck Franklin, Cooper Morton, Rayl Steffrey Smith, Dorothy Van Oppen

St. Edward University
Summer Program in Tropical Ecology
May 21 – 27, 2007
Instructors: Catherine MacDermott, Mary Katherine O'Brien, William Quinn
Students: Lena Assaf, Morgan Baima, Libby Bicack, Megan Borland, Ross Fife, Adrienne Francis, Afton Kolbe, Stephanie Mercado, Julien Nguyen, Madeline Orf, Kyle Overby, Chris Redmond, Lauren Smitherman, Maria Taylor

Universidad de Los Andes, Bogota, Colombia
Marine Ecology
September 26– October 1, 2007
Instructors: Juan Armando Sánchez and Victor Piñeros
Students: Victoria Ortegón, Néstor Beltrán, Wendy Gómez, Carlos Ferre, Maria del Pilar Restrepo, Sebastián Gonzáles, Juliana López, Dairo Escobar, Michelle Guevara, Camilo Díaz

University of Toronto
Tropical Ecology and Evolution
February 21 – 26, 2006
Instructors: Christopher Darling, James Rising, James Eckenwalder, Douglas Currie, Jacqueline Miller
Students: Tamara Adams, Katherine Burgess, Brandon Campitelli, Justin Carroll, Anna Darvin, Isabella DeBarbaro, Laura Gilbert, Monica Granados, Catherine Grzesiowski, Gina Montesano, Raman Rai, Grace Ellen Rawnsley, Janet Seo, Lauren Shorser, Nisha Srivastava, Natalie Trent, Deanna Trinh, Crystal Vincent, Neil White
February 20 – 24, 2007
Instructors: Christopher Darling, Spencer Barret, Claire Healy, Jacqueline Miller

Students: Ekaterina Alchits, Kayla Baistrocchi, Christianna Facey-Crowther, Sjavash Ganjbakhsh, Frederick Hayes, Daniel Kukla, Anna Majclak, Chikako Matsuda, Karleen Murrain, Erika Nardone, Annabel Por, Sarah Rice, Daniel Rios, Bethany Rommel, Ryan Schott, Nathaniel Sharp, Kum Shim, Laura Southcott, Ginni Yeung, Taige Zhang

University of Stuttgart
Sedimentology and Ecology of a Mixed Carbonatic/clastic Setting
March 11 – 15, 2006
Instructors: Boris Saric, Hartmut Seyfried
Students: Alessandra Balz, Anita Bayer, Nicolas Joachin Deinerth, Nicole Gehres, David Gilbert, Kilian Gruhbaum, Ralf Kopp, Tatjana Morash, Klaus Pelz, Svenja Rausch, Sabrina Rothmund, Silvia Sailer, Annette Sontheimer, Marcel Strasser, Brita Zaretzki, Tibor Zold

Course participants-- STRI-TTT courses

Taxonomy and Ecology of Caribbean Sponges
July 17 – 29, 2006
Instructors: Maria Cristina Diaz, Robert Thacker
Students: Lorenzo Alvarez, Maria Amaro, Elisabeth Becking, Christina Elmore, Matthew Forrest, Christopher Freeman, Renata Goodridge, Liana Jarecki, Steven Kimble, Gisele Lobo-Hajdu, Alex Mercado, Ivan Ramirez, Estrella Villamizar

August 18 – September 1, 2007
Instructors: Robert Thacker, Sally Leys, Cristina Diaz
Students: Paco Cardenas, Sophie Carteron, Edlin Guerra, Tse-Lynn Loh, Belinda Longakit, Caterina Longo, Linnet Busutil Lopez, Andrew Mobley, Sara Rivero, Ronan Roche, Alice Rodriguez Perez P., Erick Sperling, Gideon Tirosh, Paula Young

Taxonomy and Biology of Tunicates
August 13 – 27, 2006
Instructors: Charles Lambert, Gretchen Lambert, Rosana Rocha
Students: Safra Altman, Cintia Monteiro Barros, Federico Brown, Maritza Cardenas Calle, Flavia De Olivera Marins, Adriana Gittenberger, Erin Grey, Kristen Larson, Silvia Libro, Tanya McKitrick, Noa Shenker, Lauren Stefaniak, Maria de las Mercedes Varela, Erica Westerman, Giuliana Zaga

Taxonomy and Ecology of Caribbean Gorgonians and Black Corals
July 23 – August 2, 2007
Instructor: Mary Alice Coffroth, Howie Lasker, Dennis Opresko, Juan Sanchez
Students: Mercer Brugler, Isabel Chacon Gomez, Peter Etnoyer, Federica Fava, Silvia Patricia Gonzalez, Nelson Manrique Rodriguez, Maia Mukherjee, Carlos A . Prada Montoya, Raphael Williams, Jana Thoma, Daniel Wagner, Branwen Williams, Herman Wirshing, Anabella Zuluaga Montero

5-year bibliography

In Press

Anker, A, C. Hurt and N. Knowlton. Three transisthmian snapping shrimps (Crustacea: Decapoda: Alpheidae) associated with innkeeper worms (Echiura: Thalassematidae) in Panama. Zootaxa.

Baeza, J.A. and A. Anker. *Lysmata hochi* n. sp., a new hermaphroditic shrimp from the southwestern Caribbean Sea (Crustacea: Caridea: Hippolytidae). Journal of Crustacean Biology.

Browne, W. E., S.H.D. Haddock and M.Q. Martindale. Phylogenetic analysis of lineage relationships among hyperiid amphipods as revealed by examination of the mitochondrial gene, *cytochrome oxidase I* (COI). Integrative and Comparative Biology.

Diaz, M. C., R. W. Thacker, and K. Rützler. *Haliclona (Soestella) walentinae* (Chalinidae, Haplosclerida) and *Xestospongia bocatorensis* (Petrosiidae, Haplosclerida), two new sponge species from Caribbean Panama with filamentous cyanobacterial symbionts. In: Hajdu, E. and G. Muricy (eds.). Porifera Research: Biodiversity, Innovation, and Sustainability.

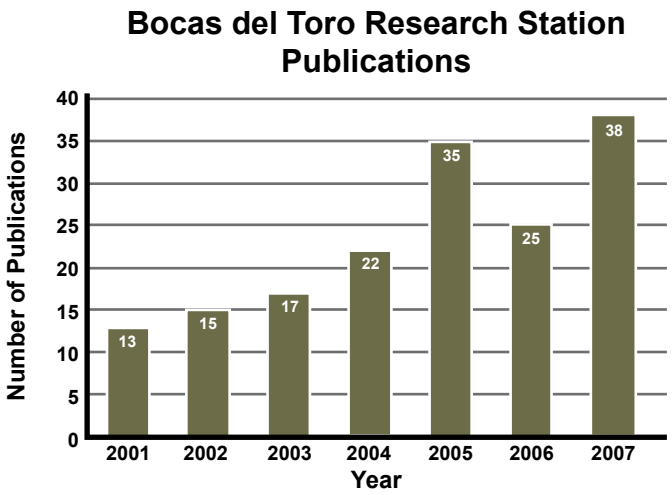
Erwin, P. M. and R. W. Thacker. Incidence and identity of photosynthetic symbionts in Caribbean coral reef sponge communities. Journal of the Marine Biological Association of the United Kingdom.

O'Dea, A., J.B.C. Jackson, P.D. Taylor and F. Rodriguez. Modes of reproduction in Recent and fossil cupuladriid bryozoans. Palaeontology.

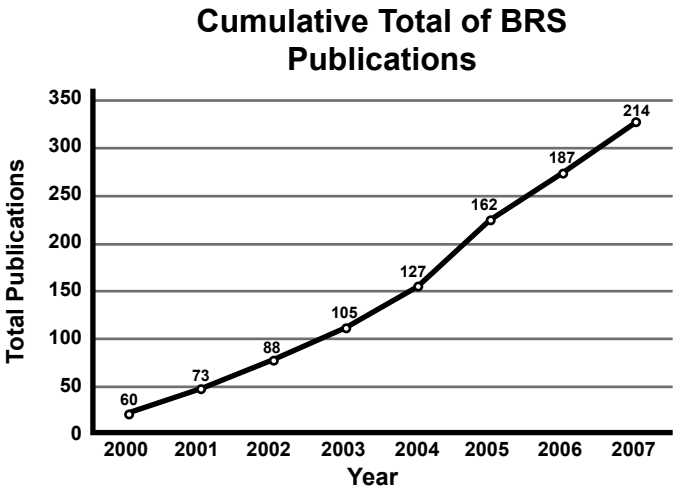
Puebla O, E. Bermingham and F. Guichard. Population genetic analyses of *Hypoplectrus* coral reef fishes provide evidence that local processes are operating during the early stages of marine adaptive radiations. Molecular Ecology.

Saporito, R.A., M.A. Donnelly, P. Jain, H.M. Garraffo, T.F. Spande and J.W. Daly. Spatial and temporal patterns of alkaloid variation in the poison frog *Oophaga pumilio* in Costa Rica and Panama over 30 years. Toxicon.

Thacker, R. W., M. C. Diaz, K. Rützler, P. M. Erwin, S. J. A. Kimble, M. J. Pierce and S. L. Dillard. Phylogenetic relationships among the filamentous cyanobacterial symbionts of Caribbean sponges and a comparison of photosynthetic production between sponges hosting filamentous and unicellular cyanobacteria. In: Hajdu, E., and G. Muricy (eds.). Porifera Research: Biodiversity, Innovation, and Sustainability.



Research at the BRS results in the publication of an average of 25-35 peer-reviewed papers per year. The number of yearly publications has nearly tripled over the last 6 years and continues to rise.



The total BRS bibliography has now reached over 200 publications. These papers include the descriptions of new species of shrimp, sponges and kinorynchs discovered in Bocas del Toro.

Tomaiuolo, M., T.F. Hansen and D.R. Levitan. A theoretical investigation of sympatric evolution of temporal reproductive isolation as illustrated by marine broadcast spawners. Evolution.

Troxler, T. G.. Patterns of phosphorus, nitrogen and 15N along a peat development gradient in a coastal mire, Panama. Journal of Tropical Ecology.

2007

Anker, A., C. Hurt and N. Knowlton. 2007. Revision of the *Alpheus nuttingi* (Schmitt) species complex, with description of a new species from the tropical eastern Pacific (Crustacea: Decapoda: Alpheidae). Zootaxa 1577: 41-60.

Baeza, J.A. 2007. Sex allocation in a simultaneously hermaphoditic marine shrimp. Evolution 61: 2360-2373.

Baeza, J.A.. 2007. Male mating opportunities affect sex allocation in a protrandric-simultaneous hermaphroditic shrimp. Behavioral Ecology and Sociobiology 61: 365-370.

Crowley, P.H. and M. K. Hart. 2007. Evolutionary stability of egg trading and parceling in simultaneous hermaphrodites: The chalk bass revisited. Journal of Theoretical Biology 246: 420–429.

De Grave, S. 2007. A new species of *Pseudocoutierea* Holthuis from the Caribbean coast of Panama (Crustacea, Decapoda, Palaemonidae), with a key to the genus. Zootaxa 1397: 29-37.

Granek, E.F. and K. Frasier. 2007. The impacts of Red Mangrove (*Rhizophora mangle*) deforestation on zooplankton communities in Bocas del Toro, Panama. Bulletin of Marine Science 80: 905-914.

Hooge, M., A. Wallberg, C. Todt, A. Maloy, U. Jondelius and S. Tyler. 2007. A revision of the systematics of panther worms (*Hofstenia* spp., Acoela), with notes on color variation and genetic variation within the genus. Hydrobiologia 592: 439–454.

Johnson K.G, J.A. Todd and J.B.C. Jackson. 2007. Coral reef development drives molluscan diversity increase at local and regional scales in the late Neogene and Quaternary of the southwestern Caribbean. Paleobiology 33: 24.

Kicklighter, C.E. and M.E. Hay. 2007. To avoid or deter: interactions among defensive and escape strategies in sabellid worms. Oecologia 151: 161–173.

McKee, K.L, D. Cahoon and I.C. Feller. 2007. Caribbean mangroves adjust to rising sea-level through biotic controls on soil elevation change. Global Ecology and Biogeography 16: 545-556.

McPhail K.L, J. Correa, R.G. Linington, J. Gonzalez, E. Ortega-Barrıa, T.L.Capson and W.H. Gerwick. 2007. antimalarial linear lipopeptides from a Panamanian strain of the marine cyanobacterium *Lyngbya majuscula*. Journal of Natural Products 70: 984-988.

Neigel, J., A. Domingo and J. Stake. 2007. DNA barcoding as a tool for coral reef conservation. Coral Reefs 26: 487-499.

O'Dea, A., J.B.C. Jackson, H. Fortunato, J.T. Smith, L. D'Croz, K.G. Johnson and J.A. Todd. 2007. Environmental change preceded Caribbean extinction by 2 million years. Proceedings of the National Academy of Sciences 104: 5501–5506.

O'Dea, A., F. Rodriguez, C. DeGracia and A.G. Coates. 2007. La paleontología marina en el Istmo de Panamá. Canto Rodado 2: 149-179.

O'Dea, A., F. Rodriguez and T. Romero. 2007. Response of zooid size in *Cupuladria exfragminis* (Bryozoa) to simulated upwelling temperature. Marine Ecology 28: 1-9.

Ordoñez, C., S.Troëng, A. Meylan, P. Meylan and A.Ruiz. 2007. Chiriqui Beach, Panama, the most important leatherback nesting beach in Central America. Chelonian Conservation and Biology 6: 122-126.

Pearse, V.B. and O.Voigt. 2007. Field biology of placozoans (*Trichoplax*): distribution, diversity, biotic interactions. Integrative and Comparative Biology: 1-16.

Puebla, O., E. Bermingham, F. Guichard and E. Whiteman. 2007. Colour pattern as a single trait driving speciation in *Hypoplectrus* coral reef fishes? Proceedings of the Royal Society 274: 1265-1271.

Reynolds, R.G. and B.M. Fitzpatrick. 2007. Assortative mating in poison-dart frogs based on an ecologically important trait. Evolution 61: 2253-2259.

Rudh, A., B. Rogell and J. Hoglund. 2007. Non-gradual variation in colour morphs of the strawberry poison frog *Dendrobates pumilio*: genetic and geographical isolation suggest a role for selection in maintaining polymorphism. Molecular Ecology Online.

Saporito, R.A., M.A. Donnelly, R.A. Norton, H.M. Garraffo, T.F. Spande and J.W. Daly. 2007. Oribatid mites as a major dietary source for alkaloids in poison frogs. Proceedings of the National Academy of Sciences 104: 8885-8890.

Smith, M., K.S. Zigler and R.A. Raff. 2007. Evolution of direct-developing larvae: Selection vs loss. BioEssays 29: 566–571.

Uy, J.A.C. and A.C. Stein. 2007. Variable visual habitats may influence the spread of colourful plumage across an avian hybrid zone. Journal of Evolutionary Biology 20: 1847-1858.

Van Bael, S.A., P. Bichier, I. Ochoa and R. Greenberg. 2007. Bird diversity in cacao farms and forest fragments of western Panama. Biodiversity and Conservation 16: 2245-2256.

Vollmer, S.V. and S.R. Palumbi. 2007. Restricted gene flow in the Caribbean staghorn coral *Acropora cervicornis*: Implications for the recovery of endangered reefs. Journal of Heredity 98: 40-50.

Zamzow, J.P. 2007. Ultraviolet-absorbing compounds in the mucus of shallow-dwelling tropical reef fishes correlate with environmental water clarity. Marine Ecology Progress Series 343: 263-271.

2006

Anker A, S.T. Ahyong, A.R. Palmer and P.Y. Noël. 2006. Morphological phylogeny of alpheid shrimps: parallel preadaptation and the origin of a key morphological innovation, the snapping claw. Evolution 60: 2507-2528.

Baums, I. B., M. W. Miller and M. E. Hellberg. 2006. Geographic variation in clonal structure in a reef building Caribbean coral, *Acropora palmata*. Ecological Society of America 76: 503-519.

Collin, R., M. Wonham and K. R. Barr. 2006. *Crepidula convexa* Say 1822 (Caenogastropoda: Calyptraeidae) in Washington State, USA. American Malacological Bulletin 21: 113-116.

Collin, R. 2006. Sex ratio, life history invariants, and patterns of sex change in a family of protandrous gastropods. Evolution 60: 735-745.

Collins, A. G., P. Schuchert, A. C. Marques, T. Jankowski, M. Medina and B. Schierwater. 2006. Medusozoan phylogeny and character evolution clarified by new large and small subunit rDNA data and as assessment of the utility of phylogenetic mixture models. Systematic Biology 55: 97-115.

Croquer, A., C. Bastidas, D. Lipscomp, R.E. Rodriguez-Martinez, E. Jordan-Dahlgren and H.M. Guzman. 2006. First report of folliculinid ciliates affecting Caribbean scleractinian corals. Coral Reefs 25: 187-191.

Dominici Arosemena, A. 2006. Community structure and patterns of diversity in reef fish communities in the tropical Western Atlantic and tropical Eastern Pacific. Ph.D. dissertation, Universitat Bremen, Bremen, Germany.

Ellingson, R.A. and P.J. Krug. 2006. Evolution of poecilogony from planktotrophy: Cryptic speciation, phylogeography and larval development in the gastropod genus *Alderia*. Evolution 60: 2293–2310.

Garren, M., S. Walsh, A. Caccone and N. Knowlton. 2006. Patterns of association between Symbiodinium and members of the *Montastraea annularis* species complex on spatial scales ranging from within colonies to between geographic regions. Coral Reefs 25: 503-512.

Herrera-Cubilla, A., M. H. Dick, J. Sanner and J. B. C. Jackson. 2006. Neogene Cupuladriidae of tropical America. I: Taxonomy of recent *Cupuladria* from opposite sides of the Isthmus of Panama. Journal of Paleontology 80: 245-263.

Kline, D.I., J. Bryant, G. Rohwer, E. Kisflaudy, F. Nostropaur, J. Grayson, N. Knowlton and F. Rohwer. 2006. The Aquatic Automated Dosing and Maintenance System (AADAMS). Limnology and Oceanography: Methods 4: 184-192.

Kline, D.I., N.M. Kuntz, M. Breitbart, N. Knowlton and F. Rohwer. 2006. Role of elevated organic carbon and microbial activity in coral mortality. Marine Ecology Progress Series 314: 119-125.

Newman, M. J. H., G.A. Paredes, E. Sala and J.B.C. Jackson. 2006. Structure of Caribbean coral reef communities across a large gradient of fish biomass. Ecology Letters 9: 1216-1227.

MacIntyre, I.G. and R.B. Aronson. 2006. Lithified and Unlithified Mg-Calcite Precipitates in Tropical Reef Environments. Journal of Sedimentary Research 76: 81-90.

O'Dea, A. 2006. Asexual propagation in the marine bryozoan *Cupuladria exfragminis*. Journal of Experimental Marine Biology and Ecology 335: 312-322.

Ritger, R. K. and J. L. Norenburg. 2006. *Tubulanus riceae* new species (Nemertea: Anopla: Palaeonemertea: Tubulanidae), from South Florida, Belize and Panama. Journal of Natural History 40: 931-942.

Saporito, R.A., M.A. Donnelly, H.M. Garraffo, T.F. Spande and J.W. Daly. 2006. Geographic and seasonal variation in alkaloid-based chemical defenses of *Dendrobates pumilio* from Bocas del Toro, Panama. Journal of Chemical Ecology 32: 795-814.

Schulze, A. 2006. Phylogeny and genetic diversity of palolo worms (Palola, Eunicidae) from the tropical north Pacific and the Caribbean. Biological Bulletin 210: 25-37.

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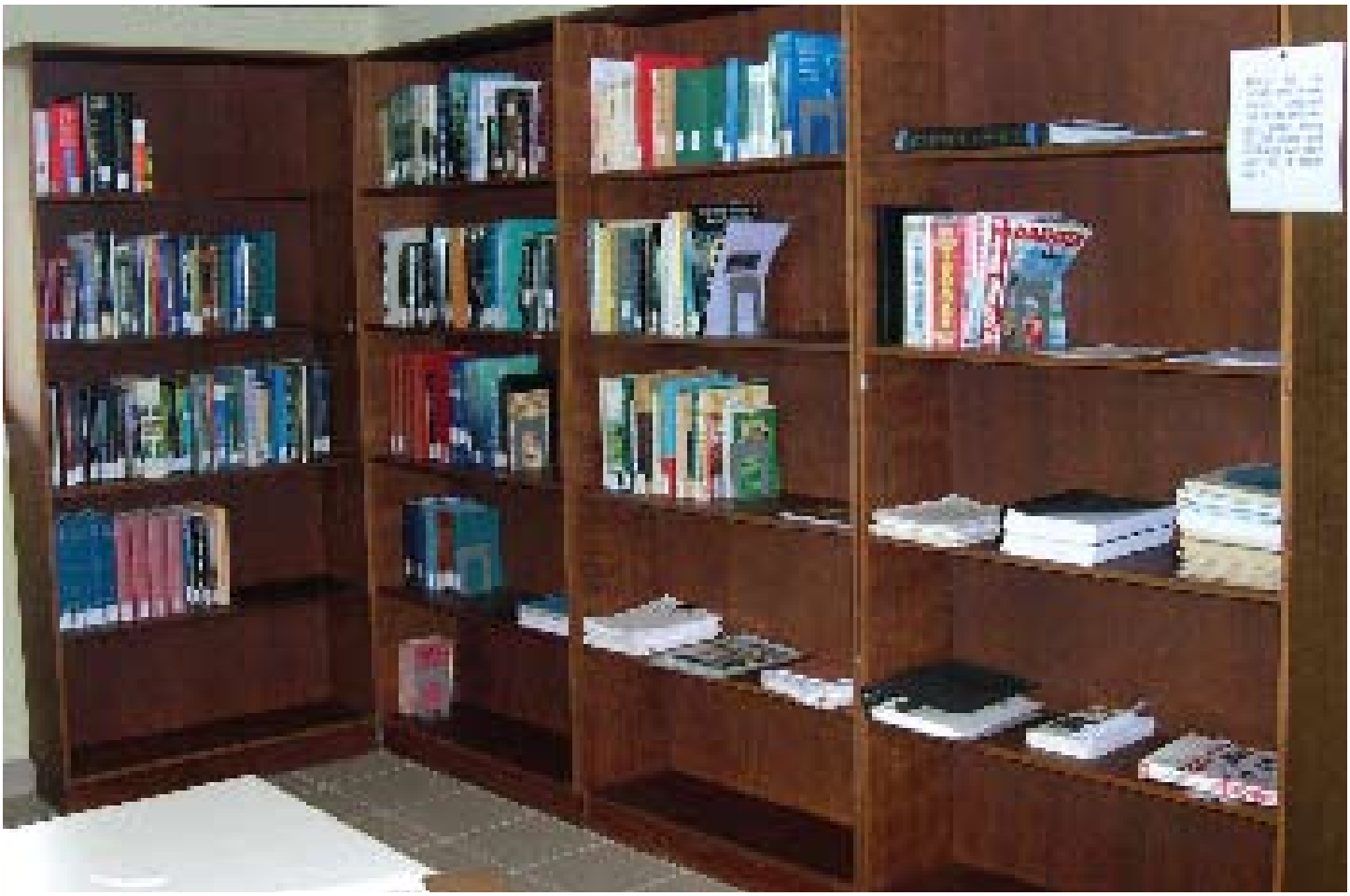

equipment

Microscopes:

Compound Microscopes:
5 Nikon E600 & E200, with camera
2 Eagle scopes
Wild scope

Dissecting microscopes:
Nikon SMZ 1500 w/ camera
2 Nikon SMZ 645
Leika MS5
3 Leika Z45V
2 Wild M3B
25 Eagle SMR1

Lamps:
11 Fiber optics lamps, Fiber optics lamp with O ring

Scuba:

Bauer compressor, Thunnus compressor, Filtering system, Oxygen Kit, Diving flags, First aid kid, 40 Diving tanks

Laboratory Equipment:

Autoclave, Analytical balance, Bench balance, Portable balance, Micro centrifuge, Centrifuge, Ultrasonic cleaner, Liquid nitrogen container, Dessicator, Flowmeter, Freezer -20 C, Fume Hood, Furnace Oven, Fridge, Heater & Stirrer, Incubator, Light meter, Microwave, Oxygen probe, pH meter, Multiparameter meter, Shaker, Water bath, E-pure water filtering system, Drying oven, Vaccum pump, Spectophotometer, Roto mix, Ice machine, Colorimeter hatch

Computers and AV equipment:

4 Dell Pentium 4, Core Duo
2 Mac G5's
3 Hp printers
High speed broad-band internet connection
2 Nikon coolpix cameras
TV, VHS, DVD, multimedia projector, screen

Vehicles:

Electric Car
Kawasaki Mule
2 Toyota Pickup trucks

Boats:

22 ft Mako
25 ft Eduardoño
25 ft Glass bottom Eduardoño
17 ft Coiba
2, 17 ft Caribe Pro
2, 15 ft Boston Whalers
12 ft Kayak

Aquaria, pumps and filters:

Running seawater system with raw and bubble bead filter with associated air and electrical outlets
Glass tanks - 40, 10-gallon capacity
2, 50-gallon capacity aquaria
Fiberglass tanks - 8, 80-gallon capacity
4, 50-gallon capacity
Plastic tanks - 10, 30-gallon capacity

staff

Gabriel Jacome

Arcadio Castillo and Plinio Gondola

Urania Gonzalez

Like researchers at remote field stations around the world, scientific visitors to the BRS rely on the station's staff (listed here). Their jobs include creative problem solving as they work long hours to welcome visitors and keep the station running smoothly. Additional support for the BRS comes from STRI's headquarters in Panama City. Boat mechanics Reynaldo Tapia and Pierre Fuentes and STRI's Dive Safety Officer, Edgardo Ochoa provided daily support and visit the station monthly. Mercedes Dennis works closely with the station visitors to assist their applications for collection and export permits.

During FY06-07, the Smithsonian Institution's Office of Facilities, Engineering and Operations (OFEO) has worked closely with station staff to design and build new facilities keep existing facilities operating smoothly. Staff from STRI's Office of Information Technology have kept the BRS online and in communication with the rest of the world. The Visitors Office in Panama City helps process the visitors applications and Nelida Gomez coordinates visits from university classes. Procurement and Accounting Offices keep supplies coming. The Human Resources office has worked to understand the needs of the staff. The Director's Office, the Development Office and the Special Events Office have worked to find supporters and to bring them to Bocas where they can experience our research efforts first hand.

Rachel Collin	Director
Gabriel Jacome	Scientific Coordinator
Plinio Gondola	Research Assistant
Dennis Allen	Maintenance Supervisor
Urania Gonzalez	Secretary
Arcadio Castillo	Research Technician
Doroteo Machado	Maintenance
Gilberto Murray	Mechanic small craft
Marlon Smith	Janitor/Public Program
Deselvia Mercado	Janitor
Keyla Serrano	Janitor
Mauricio Pineda	Gardener/Grounds Keeper

financial contributions

The Cofrin Family

Mr. Paul Peck

The Smithsonian Institution Women's Committee

THE BRS GRATEFULLY ACKNOWLEDGES DONATIONS TO BOCAS DEL TORO MARINE STATION DURING FY2006-FY2007

Dr. and Mrs. David A. Cofrin have been deeply involved over the past several years in Bocas del Toro's expansion, contributing to the construction of both the photovoltaic roof of the laboratory and to the new dormitory, which will be built beginning in 2009.

They also provided funding for Bocas del Toro's glass-bottom boat, which will allow students and visitors to explore marine life from the water's surface.

The **Hoch Family (Hoch Charitable Trust)** has generously supported Bocas del Toro for almost a decade, contributing to the construction of the laboratory, senior scientist residences and both the original dormitory and the new dormitory. In addition, the Hochs have funded postdoctoral two-year fellowships for research at the BRS.

The **Hunterdon Fund** and the **Johnson Fund** through the Smithsonian Marine Science Network, have provided funding for the operational costs and salaries needed to maintain Bocas del Toro.

Mr. Paul Peck's gift to Bocas del Toro has made it possible to extend the Training in Tropical Taxonomy Program into FY08.

SENACYT , the Republic of Panama's office of science and technology, has provided grants to support the Training in Tropical Taxonomy Program.

The Smithsonian Institution Women's Committee has generously contributed over the past 5 years to the documentation of biodiversity in Bocas del Toro as well as to the Training in Tropical Taxonomy Program.

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