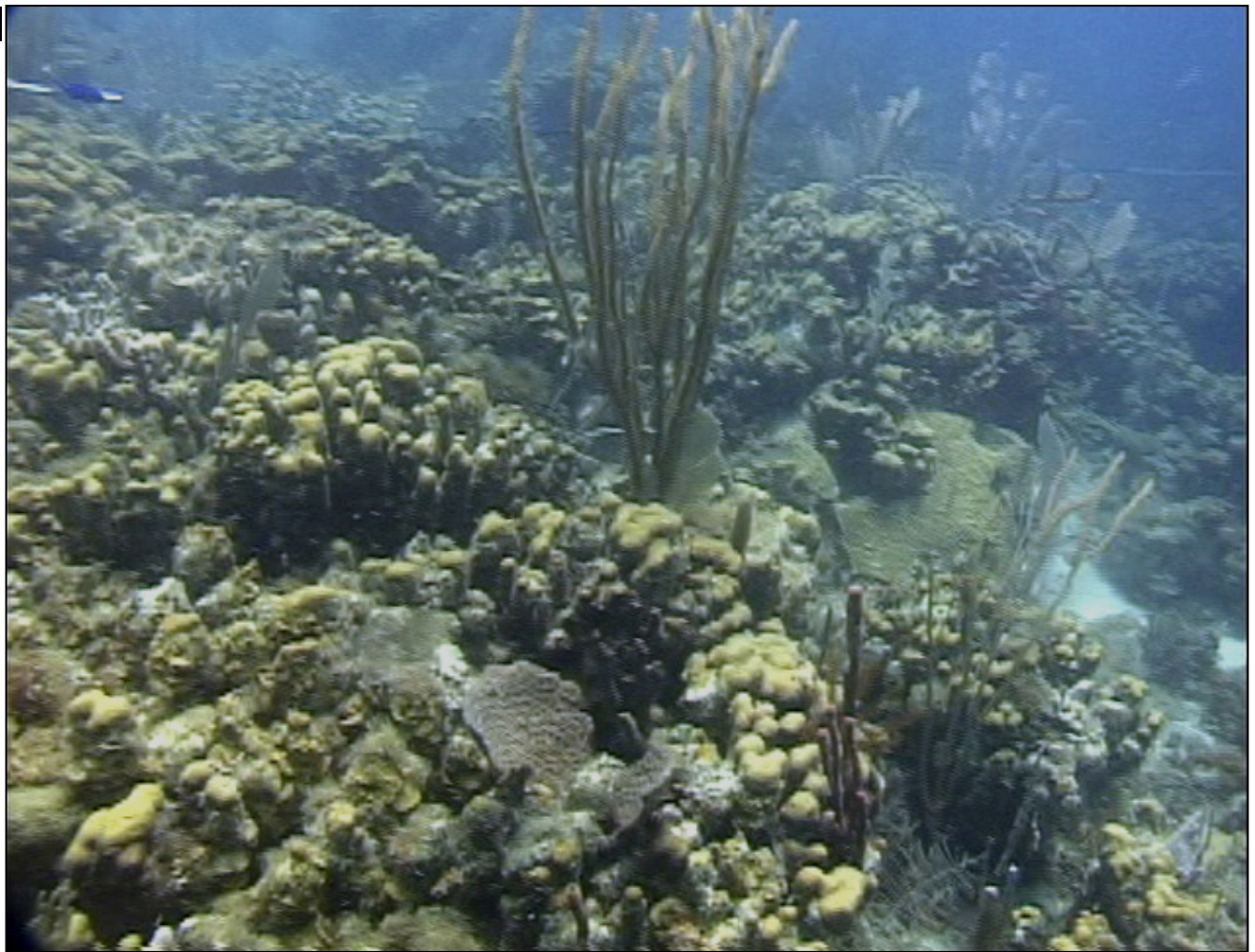




Coral Reef Monitoring Protocol

Natural Resource Report NPS/SER/SFCN/NRR—2007/XXX



ON THE COVER

Mennebeck Reef (2002) in Virgin Islands National Park

Coral Reef Monitoring Protocol

Natural Resource Report NPS/SER/SFCN/NTR—2007/XXX

By Jeff Miller¹, Caroline Rogers², Andrea Atkinson³, Erinn Muller⁴, Andy Davis¹,
Christy Loomis⁵, Matt Patterson³, Rob Waara³, Brian Witcher³, Alexandra
Wright⁶, Jim Petterson⁷

Collaborative project of

National Park Service Inventory and Monitoring Program, South Florida / Caribbean Network
Virgin Islands National Park, National Park Service
U.S. Geological Survey - Florida Integrated Science Center

¹National Park Service, South Florida/Caribbean Network
1300 Cruz Bay Creek, St. John, VI 00830

²U.S. Geological Survey – Florida Integrated Science Center
Virgin Islands National Park
1300 Cruz Bay Creek, St. John, VI 00830

³National Park Service, South Florida/Caribbean Network
18001 Old Cutler Rd. Suite 419, Village of Palmetto Bay, FL 33157

⁴Florida Institute of Technology, Department of Biological Science
150 W. University Blvd, Melbourne FL, 32901

⁵ National Park Service, Virgin Islands National Park
1300 Cruz Bay Creek, St. John, VI 00830

⁶University of Wisconsin- Milwaukee
3209 N Maryland Ave, Milwaukee WI 53211

⁷ National Park Service, Pinnacles National Monument
5000 Highway 146, Paicines, CA 95043

Draft – December 15, 2007

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

Natural Resource Reports are the designated medium for disseminating high priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability. Examples of the diverse array of reports published in this series include vital signs monitoring plans; monitoring protocols; "how to" resource management papers; proceedings of resource management workshops or conferences; annual reports of resource programs or divisions of the Natural Resource Program Center; resource action plans; fact sheets; and regularly-published newsletters.

Views, statements, findings, conclusions, recommendations and data in this report are solely those of the author(s) and do not necessarily reflect views and policies of the U.S. Department of the Interior, NPS. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the South Florida / Caribbean Network website (<http://science.nature.nps.gov/im/units/sfcn/>) on the Internet or by sending a request to the address on the back cover.

Please cite this publication as:

Miller, W.J., C. Rogers, A. Atkinson, E. Muller, A. Davis, C. Loomis, M. Patterson, R. Waara, B. Witcher, A. Wright, J. Petterson. 2007. Coral Reef Monitoring Protocol. Natural Resource Report NPS/SER/SFCN/NRTR—2007/003. National Park Service, Miami, Florida.

Acknowledgments

The creation of this protocol and attached SOPs could not have been done without the support of innumerable persons including colleagues, co-workers, friends, and spouses. Beginning with the I&M prototype protocols, listed herein as SOP 1 and SOP 2, each contain a list of people who made contributions to those protocols, thereby creating a foundation for this document. The authors wish to thank those that took part in the vital signs workshops, and took the time to participate in ranking the vital signs. Your input has provided guidance. We'd like to acknowledge the SFCN Board of Directors, and the Science and Technical committee. Your review and comments of the Monitoring Plan Phase reports are much appreciated. 2007 has seen the retirement of two NPS leaders and strong advocates of the I&M program: Mike Soukup and Gary Davis. Contributions and support by these friends and colleagues to the I&M program as well as the SFCN are sincerely appreciated. Additionally we'd like to acknowledge Amanda Bourque, Dan Clark, Blue and Jeanie Douglas, Mike Echevarria, Ian Lundgren, Shelby Moneysmith, Judd Patterson, Tony Pernas, Dave Sapio, Carrie Stengel, Eric Sudalter, Iris Wilson.

Contents

Figures	vii
Tables	viii
Executive summary	ix
Background and Objectives	1
Background and History-from prototype to operational program	1
Ecological context of USVI and Florida parks	2
Rationale for monitoring coral reefs	3
History of monitoring coral cover within SFCN parks	6
Measurable Objectives	9
Sample Design	10
Rationale for selecting this sampling design	10
Site Selection	10
Procedures for selecting and establishing transects within a site	11
Rationale for using permanent transects	11
Rationale for selecting “coral cover” as primary parameter to be monitored	11
Sample frequency and timing	12
Recommended number and location of sample sites	12
Level of change that can be detected	13
Current monitoring sites within SFCN parks.....	16
Field Methods	25
Using Videography to Monitor Coral Reefs – Overview	25
Using the AquaMap™ at a Study site – Overview	26
Using a GPS and ArcView™ at a Study Site – Overview	27
Counting <i>Diadema</i> on coral reefs	28
Measuring coral disease	28
Measuring rugosity on coral reefs	29
Data Handling, Analysis and Reporting	30
Overview of database design	30
Data entry, verification and editing	30
Recommendations for routine data	31
Reporting	32
Recommended methods for statistical analysis	36
Metadata procedures	37
Data archival procedures	37
Personnel Requirements and Training	38
Roles and responsibilities	38
Qualifications	38
Training procedures	38
Operational Requirements	40
Annual workload and field schedule	40
Facility and equipment needs	40
Startup costs and budget considerations	41
References	42
Appendix 1 –Products associated with this protocol and SOPs	47

Standard Operating Procedures

SOP 1– Using videography to monitor coral reefs	SOP 1-1
SOP 2– Using the Aquamap™ system at a study site	SOP 2-1
SOP 3– Selecting random sampling points using GPS	SOP 3-1
SOP 4– Counting <i>Diadema</i> on coral reefs	SOP 4-1
SOP 5– Measuring rugosity on coral reefs	SOP 5-1
SOP 6– Measuring coral disease	SOP 6-1
SOP 7– Coral reef monitoring database user’s guide	SOP 7-1
SOP 8– Operation and maintenance of NPS vessel, Acropora	SOP 8-1
SOP 9– Revising the protocol	SOP 9-1

Figures

Figure 1: Results of sample size calculations for SFCN park index sites with more than 20% mean coral cover as of annual 2005 sampling.

Figure 2: Results of sample size calculations for SFCN park index sites with between 10% and 20% mean coral cover as of annual 2005 sampling.

Figure 3: Results of sample size calculations for SFCN park index sites with less than 10% mean coral cover as of annual 2005 sampling.

Figure 4: Outline of Biscayne National Park boundary showing the locations of SFCN index sites, Amanda's and Ball Buoy Reefs.

Figure 5: Ball Buoy Reef perimeter showing sample transects locations.

Figure 6: Amanda's Reef perimeter showing sample transects locations.

Figure 7: Digital rendering of Buck Island showing location of SFCN index sites and portion of park boundary (green line). The east end of St. Croix, USVI is in the background.

Figure 8: Dry Tortugas National Park, the location of the SFCN index sites, and the boundaries of the Research Natural and Traditional Use areas.

Figure 9. Orientation of SFCN index sites in DRTO in relation to the RNA and traditional use area.

Figure 10. Map of St. John, boundary of VIIS and the location of SFCN index sites.

Figure 11. Location of SFCN index sites on south side of St. John, locations relative to managed areas.

Figure 12: Locations of SFCN index sites in northeast St. John with locations relative to managed areas.

Figure 13: Overview of database design.

Figure 14: Percent cover by major benthic groups at Tektite Reef.

Figure 15: Percent coral cover on transects monitored at SFCN park index sites during annual sampling, using the SOPs for videography and random site selection.

Figure 16: Mean percent coral cover (with standard error), mean percent coral cover bleached and total area of coral tissue killed by disease during episodic monitoring at selected SFCN park sites in the Virgin Islands during the 2005-06 bleaching/disease outbreak.

Tables

Table 1: SFCN index sites with size of study areas.

Table 2: Results of sample size calculations for permanent and non-permanent transects at SFCN park index sites as of 2005 annual sampling.

Table 3: Report descriptions.

Table 4: Annual monitoring schedule.

Executive Summary

The coral reef monitoring protocol guides the monitoring of this globally imperiled system within four national parks of the South Florida/Caribbean Network (SFCN): Biscayne National Park (BISC), Dry Tortugas National Park (DRTO), Virgin Islands National Park (VIIS) and Buck Island Reef National Monument (BUIS). Coral reef communities within the SFCN represent some of the best Caribbean and Western Atlantic Coral reefs within the National Park Service. The enabling legislation and/or presidential proclamations for VIIS, BUIS and DRTO specifically mention coral reefs within these park units as significant environmental communities. These reefs support incredible diversity, including conchs, lobsters, and endangered sea turtles. Reefs also play a vital role for humans by supporting fisheries, nursery areas, tourism, pharmaceutical bio-prospecting and shoreline protection to name a few. Monitoring coral reefs was identified as a national priority in President Clinton's Executive Order 13089, establishing the US coral Reef Task Force.

The objectives for this protocol include:

- Determine whether percent cover of major taxonomic groups (e.g. coral, algae [turf, calcareous, macroalgae], gorgonians, sponge, substrate), coral species diversity, coral community structure, and rugosity are changing through time within selected coral reef sites.
- Track trends and severity in reef-associated covariates such as coral bleaching, coral disease and presence of the herbivorous sea urchin, *Diadema antillarum*.
- Maintain and archive a video record of the transects to allow for quantification and future analyses of benthic components not identified in this protocol.

To achieve these objectives, coral reef monitoring involves the following components:

1) selection of the reef study site, 2) selection of twenty, 10-m transects within the mapped perimeter of that study site, 3) filming the benthic community with a digital video camera in an underwater housing, and 4) quantification of benthic organisms found under random “dots” applied to the video images. This reef monitoring is supplemented by the simultaneous collection of data on presence and size of disease lesions, presence and severity of coral bleaching, presence of *Diadema antillarum*, and rugosity along the transects. Monitoring is conducted annually and episodically, as necessary. The SFCN analyzes and archives data and videotapes. The network will also prepare an annual report detailing the status and trends of the coral cover at the selected sites, termed index sites.

Two standard operating procedures (SOP 1 and 2) attached to this protocol were developed by the US Geological Survey (USGS) under the Inventory & Monitoring Prototype program and have been in use throughout the SFCN for nearly a decade. The other SOPs were developed by the I&M program and have been used within SFCN parks for more than five years.

Background and Objectives

Background and History – from prototype to operational program

Knowing the condition of natural resources in national parks is fundamental to the National Park Service's (NPS) ability to protect and manage parks. National Park managers across the country are confronted with increasingly complex and challenging issues, and they are increasingly being asked to provide scientifically credible data to defend management actions. In the early 1990s, the NPS created the Natural Resource Inventory and Monitoring Program (I&M Program) to provide funding and technical assistance to parks with significant natural resources. The short-term goal of the I&M program is to acquire twelve natural resource inventory datasets needed by park managers to deal effectively with park planning, management, and protection. The long-term goal is to implement monitoring of critical natural resource indicators, termed vital signs, in more than 270 parks with significant natural resources.

Beginning in 1992, the NPS I&M Program established a network of experimental or “prototype” long-term ecological monitoring (LTEM) programs in an attempt to learn how to design scientifically credible and cost-effective monitoring programs in ecological settings of major importance to a number of NPS units. Parks vary greatly in ecological conditions, sizes and management capabilities, and any attempt to institutionalize ecological monitoring within the Service poses substantial challenges. To develop monitoring expertise throughout this range of ecological and managerial diversity, natural resource park units were grouped into 10 major biogeographic areas, or biomes, and one park from each major biome was then selected to serve as a prototype LTEM program for that biome.

The first four prototype monitoring programs (Channel Islands National Park, Denali National Park, Great Smokey Mountain National Park and Shenandoah National Park) were funded in 1992 and were chosen because considerable design work had already been accomplished. In 1993 NPS issued a Call for Proposals to competitively select seven additional prototype monitoring programs. To address the needs of smaller parks, three of the prototype programs were designed as "cluster" programs, i.e. a grouping of 3-6 parks, each of which lacked the full range of staff and resident expertise needed to conduct a long-range monitoring program on its own. In the same year, the 3-park cluster consisting of Virgin Islands National Park (VIIS), Buck Island Reef National Monument (BUIIS), and Dry Tortugas National Park (DRTG) was selected as the prototype for the tropical/subtropical biome. Initial funding for this Virgin Islands/South Florida (VI/SF) prototype program was provided in FY 1996. After submittal of the proposal, NPS scientists based in VIIS were transferred first to the National Biological Survey, and then to the Biological Resources Division of the U.S. Geological Survey (USGS). The prototype program was a collaborative effort between NPS and USGS, with USGS scientists responsible for the design of long-term monitoring program and development of sampling protocols. Once protocols were developed, the operational monitoring tasks (including data analysis and reporting) were assumed by NPS staff.

In FY 2000, as part of the Natural Resource Challenge, NPS implemented an expanded strategy

for natural resource monitoring in parks with significant natural resources, whereby parks were organized into 32 networks linked by geography and shared natural resource characteristics. The network approach was intended to facilitate collaboration, information sharing, and economies of scale in natural resource monitoring, and to provide parks with a minimum infrastructure for initiating natural resource monitoring that could be built upon in the future. As part of the new framework for inventory and monitoring, prototype LTEM programs were nested within the network structure, and are to provide expertise and support to other parks in their network. But, in October 2003, the prototype I&M program based in Virgin Islands National Park (VIIS) was transferred to the South Florida-Caribbean Network (SFCN). Two positions, fisheries biologist and biologist technician, remain located in VIIS, however programmatic and financial obligations for those positions are based out of the NPS southeast regional office. Offices for the remaining SFCN staff are in Palmetto Bay, Florida.

NPS has clear responsibilities for coral reef monitoring and management. On July 11, 1998 President Clinton signed Executive Order (EO) 13089 – Coral Reef Protection. This executive order mandated all federal agencies to provide for implementation of measures needed to research, monitor, manage, and restore affected ecosystems, including, but not limited to, measures reducing impacts from pollution, sedimentation, and fishing. The US Coral Reef Task Force, co-chaired by the Secretary of Interior and the Secretary of Commerce, was created and wrote a *Coral Reef Action Plan* to address the federal agencies' responses to EO 13089.

The NPS I&M Program monitoring goals include:

- Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals

This protocol primarily focuses on the first three goals, and specifically on detection of trends in tropical marine ecosystems.

Ecological context of USVI and Florida parks

It is important to consider VIIS, BUIS, BISC and DRTO within the bio-geographical and ecological context of the wider Caribbean. The Caribbean Sea is relatively small, only 1200 nautical miles (nm) by 500 nm, and marine systems can be adversely and beneficially affected by upstream events and conditions. Areas within the wider Caribbean are “connected” via transport of fish and coral larvae in currents that generally move from east to west. Roberts (1997) examined the connectivity of Caribbean coral reefs by assuming passive dispersal of larvae and mapping what he called “transport envelopes” showing potential arrival of larvae from upstream sources and export of locally produced larvae downstream over 1 and 2 month time frames.

While he acknowledges that larvae of many species exhibit some activity resulting in greater local retention, his analysis highlights the potential linkages within the Caribbean and reminds us that coral reefs far from each other are not isolated (Rogers et al., 2007). USVI reefs can receive larvae from several upstream sources, including the British Virgin Islands, St. Martin, Anguilla and Saba. Currents transport harmful pollutants as well as larvae of fishes and other reef organisms. A dramatic example occurred in 1991 when oil began showing up on British and US Virgin Island beaches two weeks after a barge sank off Eustatia island. Under certain wind and current conditions, the Orinoco plume extends to the USVI, producing visible phytoplankton blooms and bringing seeds and perhaps pollutants from South America. In another dramatic example, ash from the eruption of the volcano on Montserrat Island (200 miles south of the USVI) fell on the islands the next day.

South Florida reefs are downstream from large source areas in Central America and the Gulf of Mexico. The Caribbean current sweeps northward along the western edge of the Caribbean Sea, moving both water and larvae towards South Florida. The Caribbean current diverges as it passes the Yucatan peninsula, where it becomes the Yucatan Current feeding into both the Gulf Stream and the Loop Current of the Gulf of Mexico. The islands of the Bahamas, Cuba, Hispaniola, and Puerto Rico provide a southern and eastern boundary creating a narrow fast moving trough of water through the Straits of Florida. Water typically moves from west to east and then north as it follows the Florida reef tract. There is also an inshore countercurrent that moves from the north to the southwest close to shore along the reef platform. The Gulf of Mexico Loop Current rotates clockwise first running along the Mexico and Texas coast before shifting to the East along the northern Gulf of Mexico. At this point, it receives outflows off the Mississippi River and continues east towards the Big Bend of Florida. The Loop Current continues southward along the west coast of Florida and joins the Gulf Stream in South Florida.

Historically, it is thought more water moved through Florida Bay eastwards from the Gulf to the Atlantic, but much of this flow was blocked at the turn of the century with the construction of the Flagler Railway from Miami to Key West. Flows still transit from the Gulf of Mexico through Florida Bay and between the Upper and Middle Keys, with some flow traveling through Barnes Sound and Card Sound into Biscayne Bay. These currents hydro-dynamically connect South Florida, with Florida Bay acting as nursery habitat for some species (e.g., pink shrimp) in the Dry Tortugas. Substantial freshwater discharges can produce algae blooms brought south from the Fort Myers area southwards into Florida Bay and the lower Keys as seen in the blackwater event of 2002. It's also possible that the Loop Current could bring pollutants from the Mississippi Delta and other areas of the Gulf of Mexico although this has yet to be demonstrated. Currents tend to sweep pollutants from the Miami River northwards away from Biscayne Bay.

Rationale for monitoring coral reefs

There is enormous evidence supporting the decision to have coral reefs the primary focus of the SFCN program. All seven parks of the SFCN ranked this vital sign #1 of the 69 considered during the vital signs ranking process ("Vital signs" as defined by the NPS, are a subset of physical, chemical and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources or elements that have important human values). Dr. John Ogden Director of the Florida Institute of Oceanography, made the following

statement in a presentation in June 2002 for Capitol Hill Oceans Week: “Coral reefs are not remote, exotic systems, but rather a significant percentage of our national ocean patrimony”. He noted that about 40% of the 200 nm Exclusive Economic Zone (EEZ) of the US encompasses areas where coral reefs are the dominant ecosystem. Dr. Ogden called for a new approach to managing oceans. Furthermore, he noted that “There is no reef, indeed no coastal ecosystem, that hasn’t already been extensively changed and damaged by the activities of human beings...” and that human activities which adversely affect coral reefs fall into three general categories: 1) careless land-use practices, 2) fishing, and 3) alterations of global climate.

The declines in coral reefs over the last 20-30 years are attributable to many factors including coral bleaching (e.g., Brown 1990), coral diseases (e.g., Weil 2002), tropical storms & hurricanes (e.g., Rogers et al., 1982), overfishing (e.g., Jackson et al., 2001), and sedimentation (e.g., Rogers 1990) and nutrification (e.g., Szmant 1997), which are described in more detail below. Coral reefs within National Parks have not been immune to these stresses.

Coral Bleaching:

Severe coral bleaching due principally to elevated water temperatures has been reported on reefs in SFCN in 1987, 1997-99, and 2005-06. The severity of bleaching is linked to the level and duration of warming as record-warm water temperatures in the USVI in 2005 caused >90% of coral cover to bleach at SFCN index sites (Miller et al., 2006). This event was so severe, it produced the first observation of the bleaching of *Acropora palmata* in the territory. While coral mortality from bleaching can occur, it was not extensive in the 1998 and 1999 event in the Virgin Islands (Nemeth and Sladek-Nowlis, 2001, Nemeth et al., 2003). However, in the Florida Keys, the combination of a hurricane and bleaching caused extensive mortality (Banks et al., 2005). Bleaching was followed by a massive disease outbreak in the Virgin Island in 2005-06. Bleaching-induced coral mortality was observed, primarily on Agariciids; however, the disease outbreak that followed bleaching caused extreme mortality (see coral diseases below).

Coral Diseases:

The number and extent of coral diseases have increased dramatically in the past two decades, and are now a problem world-wide. Within the SFCN parks, coral diseases are one of the most destructive chronic stresses, and are of concern to park managers. In spite of a controversial recent paper, in which Patterson et al., (2002) claimed that bacteria in human feces caused “white pox” disease in the Florida Keys, the links between human activities and coral diseases are not well-understood. Very few coral diseases have confirmed causative agents. (For this protocol, we have limited our discussion of coral diseases to those that do not affect *Acropora* spp., as this protocol does not address *Acropora* monitoring.)

Beginning in 1997, coral diseases began to increase in severity and incidence in Florida and the Caribbean. A survey of 30 sites from Key Biscayne to Dry Tortugas conducted in August 2000 showed diseases throughout the Florida Keys reef tract (Santavy et al., 2005) with nearly 30% of corals surveyed at two Bird Key Reef (DRT0) sites showed signs of the coral disease white plague. Most regional disease surveys conducted in the Florida Keys take place annually, in either spring or summer. A connection between

disease prevalence and temperature is suggested but may be a factor of monitoring schedule and frequency.

Tektite Reef, a reef within VIIS off the south shore of St. John with initially, very high coral cover, exhibited very conspicuous white plague and in 1997 was selected for a pilot coral disease monitoring project. Because of the density and morphology of the dominant coral species *Montastraea annularis*, monitoring of individual coral colonies was not feasible. Miller et al., (2003) reported coral disease was present during every survey (conducted nearly monthly from December 1977 to May 2001), and area killed by disease was not correlated to temperature.

Episodic monitoring conducted at five index sites in the Virgin Islands during and after the coral bleaching event in 2005 showed catastrophic outbreaks of coral disease. The monitoring showed that while record-breaking seawater temperatures caused the bleaching, it was the mortality from coral disease that led to the over 50% decrease in live coral cover (Miller et al., 2006b).

Tropical storms/hurricanes:

Storms are a natural part of the SFCN parks' ecosystem and can be a major force in shaping reef communities through processes such as direct physical impact to reefs, wave action, scouring by sand; and indirect processes such as increased terrestrial runoff, sedimentation, and pollution. Hurricanes Hugo (1989) and Marilyn (1995) had the most devastating effects on USVI reefs. In 2004, four major hurricanes impacted the Florida coastline. Dry Tortugas NP had impacts from five storms in 2005 with two affecting BISC that same year. Monitoring of reefs has provided quantitative data on the effects of these storms. While these weather systems are obviously beyond the control of resource managers, one cannot ignore the significant effects they have had. The challenge is to address stresses caused by humans within the context of such natural stresses.

Overfishing:

Coral reefs provide the ecological foundation for the S. Florida tourism-based economy and fishery that combined to generate an estimated 71,000 jobs and \$6 billion of economic activity in 2001 (Johns et al., 2001). Rogers and Beets (2001) state intensive fishing may be the single most damaging stress of all to USVI coral reefs. Fishing can stress coral reefs through habitat damage, removal of non-target species (by-catch), and removal of targeted species; and stress from fishing is compounded when combined with others.

Sedimentation/nutrification/run-off:

Excessive sedimentation is a cause of reef decline worldwide. Sediments smother marine organisms and reduce the light available for photosynthesis by corals and reef algae (Rogers 1979, Rogers 1990). In the Virgin Islands, because of the island's steep terrain and accelerating rate of development, sedimentation has been of great concern on St. John. Sedimentation is not as major a factor at DRTO and BUIS, because there are no streams on these islands and no development. However, coastal development and runoff, are of concern at BISC. Sediment and other pollutants can be carried large distances by

oceanic currents to affect even the remotest of reefs (e.g. DRTO).

Linking runoff to deterioration of marine systems is not easy for many reasons. Declines are usually the result of several different stresses acting synergistically. There is no direct relationship between rainfall quantity and amount of sediment or other pollutants in runoff reaching off shore habitats.

Additionally, nonpoint sources of pollution, in the form of storm water runoff, ground water seeps and surface water runoff can negatively affect reefs. Navigational inlets and passages can be direct conduits to reefs, and the porous limestone substrate underlying Florida can allow seepage of pollutants to reefs and coastal waters (BISC).

Nutrient loading from numerous land-based (e.g., failed septic systems [VIIS], agriculture [BISC]) and boat-based source (e.g., vessel waste in all SFCN parks) can cause increases in macroalgal blooms. Nitrogen from land-based sewage has been linked to macroalgal blooms in Southeast Florida (Lapointe 1997, Lapointe and Barile 2001). An increase in nutrients can lead to a degradation of the proper water quality necessary for coral reef growth and survival and may result in physiological stress to corals and deterioration of coral reef systems.

It is difficult to disentangle the effects of sediments from the effects of other more obvious stresses such as coral diseases. Chronic input of terrigenous (land-derived) sediments and other pollutants is presumably having an adverse effect on reefs. Carbonate, reef-derived sediments can also abrade or bury reef organisms during storms. More conspicuous stresses such as coral diseases may have masked the effects of these impacts at our study sites.

In the 1980s, when coral reef monitoring began in VIIS, it was believed that reefs protected within the parks would serve as useful benchmarks for comparison with unprotected reefs. Now, after observing the combined effects of hurricanes, bleaching and coral diseases, we see that stresses affecting reefs are more complex than originally thought and less tractable to management. At international meetings in 1993 (Ginsburg 1993) and 1996 (Lessios et al., 1997) stresses such as sedimentation and nutrification were identified as the most critical. However, no one could predict the worldwide bleaching episode in 1998, the catastrophic losses from disease following the bleaching event in the NW Caribbean, the increase in incidence and severity of coral diseases since 1997, and the increase in the frequency of hurricanes, all of which gave coral reef scientists a different perspective. Clearly some of these stresses cannot be controlled by resource managers. However, park managers have the opportunity to minimize threats to already degraded reefs to allow recovery to occur.

History of monitoring coral cover within SFCN parks

The current I&M work in this region was built upon previous NPS programs and partnerships. For example, NPS provided funding to support the NPS Coral Reef Assessment Program for a 5 year period beginning in 1988. The overall goal was to establish effective long-term research and monitoring sites at the four NPS units which have coral reef ecosystems: BISC, BUIS, DRTO,

and VIIS. Seven cooperating institutions participated in this program including the University of Georgia, Florida Department of Natural Resources, and the Southeast Fisheries Center (NOAA). Described below are brief summaries of research and monitoring highlights describing the evolution of monitoring at each of the SFCN parks.

Biscayne National Park (BISC)

A great deal of research on coral reefs has occurred throughout the Florida Keys with descriptions of the reefs beginning as early as 1852 (see Jaap, 1984). However there are few monitoring projects lasting longer than 3 years. Jaap (1980) monitored 8 patch reef sites in Biscayne National Park from 1977-1980. Porter and Meyer (1992, 1995) monitored two sites within the park from 1989-1994, one at Ball Buoy reef and the other at Triumph reef, using photostations and chain transects.

Ongoing monitoring activities (other than those conducted by SFCN) included the annual coral bleaching and disease monitoring by BISC park staff in cooperation with The Nature Conservancy since 2005 and post-vessel grounding coral reef restoration monitoring by BISC staff since 2006 (A. Borque, pers. comm.). A distribution map of *Acropora cervicornis* (Staghorn coral) and *A. palmata* (Elkhorn coral) was completed in 2004 in preparation for *Acropora* spp. monitoring program development (Dickman, 2004).

Dry Tortugas National Park (DRTO)

Research and expeditions into the Dry Tortugas occurred in 1850 and 1851 by Louis and Alexander Agassiz. In 1881 A. Agassiz made one of the first attempts to quantify the marine biotopes in Dry Tortugas (Agassiz 1883). Nearly a century later, Gary Davis (NPS) conducted a mapping survey within DRTO, and published the comparison of his map with that of Agassiz's 1881 map (Davis 1982). In 1975-76, the Tortugas Reef Atoll Continuing Transect Studies (TRACTS) research program was implemented by NPS. This project coordinated numerous federal, state, and private agencies and university scientists, and published findings on geology, fish assemblage and mapping (see Jaap et al., 1989). TRACTS established monitoring transects from the fore-reef shelf edge to the back reef on Bird Key Reef. Monitoring increased in 1989 when NPS contracted Florida Marine Research Institute (FMRI) which installed five 2.5 m² quadrats for monitoring species composition and percent cover. Monitoring expanded again at this site in 1997 when FMRI installed 4 groups of 3 parallel transects (each about 22 m long). These were monitored with videography and point count similar to the SOP – “Using Videography to Monitor Coral Reefs”. This evolution in monitoring led the SFCN I&M program to use the SOP – “Using the Aquamap™ System at a Study Site” to expand the study site, installing 20 permanent transects each in two adjacent sections of Bird Key Reef, called Bird Key Reef and Bird Key North

Virgin Islands National Park (VIIS) and Buck Island Reef National Monument (BUIS)

Monitoring in the USVI parks began in the 1970s and 1980s and provides some of the Caribbean's longest coral monitoring data sets. In a 1997 review of quantitative studies of trends in coral abundance, Dr. Joseph Connell was able to find only 23 studies of four or more years in duration, and data were available for only three locations from the Eastern Caribbean: the US Virgin Islands (including data from VIIS and BUIS), the Netherlands Antilles, and Barbados

(Connell 1997). Most of these studies were conducted on a very small spatial scale.

In St. John, long-term transects were established at Yawzi Reef in Great Lameshur Bay in 1989 (Rogers 1991, Rogers 1997) and on Newfound Reef (offshore Newfound Bay) in 1990. Chain transects have been used at both sites (described in Rogers et al., 1994). The chain transect method is used by the Caribbean Coastal Marine Productivity Program (CARICOMP), a regional Caribbean monitoring program, and in many other locations throughout the Caribbean.

We compared the chain transect and video method (described in SOP – “Using Videography to Monitor Coral Reef”) and found remarkable similarity in coral cover data, but some differences in cover by macroalgae (“fleshy seaweeds”) (Rogers and Miller 2001). Although we would now set up these transects randomly to increase the area of inference (described in SOP – “Using the Aquamap™ System at a Study Site”), these monitoring projects provide useful data over a long time period and were instrumental in providing a basis for the creation of Virgin Islands Coral Reef National Monument. The chain transect data from Yawzi Reef have been highlighted in the 1998 and 2002 DOI brochures on “Protecting the Nation’s Coral Reefs”. (See also Rogers and Miller 2006.)

Additionally, from 1969-1970, Tektite Reef, on the south side of St. John was the location of the long-term submerged laboratory/habitat programs, Tektite I and Tektite II. An extensive and complete set of marine science research within VIIS was conducted at this site (Collette 1972), and included the adoption into the Tektite Aquanaut program of the then NPS scientist, Gary Davis. The area (Lameshur Bay) of this site is also the location of the Virgin Islands Environmental Research Station (VIERS) which is operated by the University of the Virgin Islands and Clean Islands (corp). This station supports a large number of undergraduate, graduate, post-doc and local school groups. For example, Dr. Pete Edmunds (California State University, Northridge) has been conducting research and monitoring on Tektite and in Lameshur bay for nearly 20 years (Edmunds 2002).

At BUIS, Dr. John Bythell, University of Newcastle upon Tyne, set up a coral colony monitoring program in 1988 which tracked approximately 480 colonies of three species for weekly and monthly monitoring (see Bythell et al., 1993). This project continued with annual monitoring and was the driver for the development of a USGS/NPS protocol on coral colony monitoring (Rogers and Catanzaro 2002, Phillips 2002). BUIS also conducts chain transect monitoring on 4 reef sites. These sites were monitored approximately annually through 2005 with simultaneous monitoring with the video method (described in SOP – “Using Videography to Monitor Coral Reef”) beginning in 2000.

This approach, using video to monitor coral cover on randomly selected transect reef sites in the SFCN, has been in use since 1999 at 13 index reefs sites during 84 separate sample events (annual and episodic), resulting in the filming and analyzing of over 1680 transects. Data have been used in numerous written documents such as annual reports, technical publications, NPS publications, professional meeting proceedings/posters and peer-reviewed scientific journals. Data and results have been used for community outreach including local newspaper articles, informative articles in trade books, local newspapers and NPS interpretative materials. Hundreds of presentations have been made at scientific, professional and NPS meetings. Presentations

have been given to government senators, state and territorial officials, as well as local schools, hotels and resorts, university and civic groups. Briefings were given to the Director of the National Park Service, Southeast Regional Director, numerous superintendents, and members of the US Coral Reef Task Force committee. Methods, results and images have been used around the world, over the internet, radio, and on national and public television networks. Workshops have been given to teach this approach to several Caribbean governments and non-governmental organizations (See Appendix 1 for list of products).

Measurable Objectives

The objectives for this protocol include:

- Determine whether percent cover of major taxonomic groups (e.g. coral, algae [turf, calcareous, macroalgae], gorgonians, sponge, substrate), coral species diversity, coral community structure, and rugosity are changing through time within selected coral reef sites.
- Track trends and severity in reef-associated covariates such as coral bleaching, coral disease and presence of the herbivorous sea urchin, *Diadema antillarum*.
- Maintain and archive a video record of the transects to allow for quantification and future analyses of benthic components not identified in this protocol.

Sampling Design

This protocol addresses the question “What is the change in the benthic community within selected coral reefs” within a particular national park or managed area. The SFCN Coral Reef Monitoring Protocol sampling design involves first selecting study areas on coral reefs based upon reef structure, coral cover, coral complexity, coral diversity, management interest or historical work. These sites have been termed, index sites. Once a site is selected and boundaries defined twenty, permanent, video transects (10-meters in length) are randomly chosen from all possible sample transects within the site. Videography is used to film the transects with additional data collected on rugosity, abundance of the herbivorous sea urchin *Diadema antillarum*, and coral bleaching and disease (See attached SOPs for each). Reef water temperature is collected under a separate protocol (Davis et al., 2007).

This overall approach and design was developed as a result of numerous workshops and meetings attended by statisticians, reef ecologists, biologists and technicians during the USGS prototype protocol development. This sample design was identified as one of only four protocols of 119 evaluated that met the requirements of random sampling and replication within habitats of a mosaic nature such as coral reefs (Lewis 2004).

Rationale for selecting this sampling design

A true coral reef is a “rigid skeletal structure in which stony corals are major framework constituents” (Hallock 1997) which are the products of primarily biological processes and that exert some amount of physical control over the nearby oceanographic processes (Hubbard 1997). Coral reefs cover a small percent of the bottom within the parks of this network, yet they are of disproportionate importance as sinks and sources of the larvae of fish, coral, and other reef organisms that replenish or draw from areas far beyond the park. They are “special places” within “special places” (i.e., National Parks) that have been set aside precisely because of their ecological significance; these coral reefs were a driving force behind the establishment of many of the SFCN parks.

Site selection

The selection of an index site is based on several factors including, but not limited to the type, size, environmental context, research history, management relevance, depth, location, and safety during sampling. It was decided to focus primarily on the lower forereef zone because this zone is found on most reefs in SFCN parks, and it is a zone of active reef-building. They usually have high substrate relief and relatively high coral cover, both of which have been correlated with higher diversity and abundance of reef fishes and other marine invertebrates. These areas are affected by the stresses of significant concern to NPS managers. During the prototype protocol development a pilot study was conducted to evaluate differences among depth zones within the forereef at one study site. Results showed it was not necessary to stratify sample (transect) allocation by depth within this zone. Although developed for forereefs, this protocol was also successfully applied on two patch reefs in BISC.

Once an area was identified as a study area of interest, investigations into historical monitoring and/or research conducted at the site were made. Field surveys to determine the type of reef, ecological structure, depth gradients, and extent of homogeneity were conducted. Park managers were consulted for relevance to management actions. Co-locating the monitoring of other vital signs and the ecological and management relevance of the vital sign was considered during the process of selecting an index site. (See Current monitoring sites within SFCN parks section for current details.)

Procedures for selecting and establishing transects within a site

Once a site has been selected, the Aquamap™ System is used to delineate the study site boundaries and then to randomly select 20, permanent, 10-meter transect within the site (refer to SOP – “Using the Aquamap™ System at a Study Site”). If the site is too shallow to use the Aquamap™ System (<2m), a hand-held GPS system is used (refer to SOP – “Selecting random sampling points using GPS”). Boundaries of the site are typically set at the natural boundaries of the reef, depth limits, and limits of the Aquamap™ system (largest site is 40,753m²). The Aquamap™ system is used to navigate to and find the permanent transects through time. In addition, the South Florida sites have been marked with copper-clad stakes to facilitate finding the transects again.

Rationale for using permanent transects

A pilot project in protocol development began in 2000 in an effort to quantify potential differences between permanent random transects and annually re-randomized transects. At three index sites, 20 newly-chosen, random samples were identified and sampled in addition to sampling the permanent transects. This dual sampling was conducted at Newfound Reef (a site with “moderate” coral cover) from 2000-2003; at Yawzi Reef (a site with “low” coral cover, <10%) in 2004-2005; and at Mennebeck Reef (a site with “high” coral cover, >20%) in 2006.

Preliminary results indicate the increased power and reduction in sample size when using permanent transects (Miller et al., 2006a; and see this protocol Section: “Level of change that can be detected” in this protocol for details). A power analysis comparing 20 permanent transects versus 20 annually re-randomized transects showed that it would take at least 7 times the number of re-randomized transects to have the same power to detect change in percent live coral cover as the permanent transects. (Both methods yielded similar coral cover estimates.)

Rationale for selecting “coral cover” as primary parameter to be monitored

Cover of coral, algae and other reef organisms are quantified with this protocol. Several parameters can be used to describe reef structure including coral cover, density of colonies, condition of colonies and size frequency distributions. It was decided to emphasize monitoring of coral cover (as well as algal cover) for several reasons. Corals are the primary architects of the reef, providing shelter and habitat for many other organisms. Most of the stresses that affect corals within this network cause loss of coral tissue. If the corals fail to recover, the affected areas will be rapidly colonized by algae. Major stresses therefore will result in a decrease in the amount of “cover” of living coral on the reef and, usually, an increase in the amount of algae.

Increasing algal cover can inhibit the recovery and growth of coral as the algae out-compete the coral for available space. Changes in the amount of living coral recorded with still photography or video are changes in the amount of living coral tissue visible in planar (2-dimensional) view. Although these techniques will under-represent colonies with a more vertical morphology (e.g., pillar coral), they are suitable for monitoring the encrusting and hemispherical morphologies of the species that dominate in the lower forereef zones that are the focus of this protocol.

Density of coral colonies can be a useful descriptor of a reef zone. However, it is often difficult to determine where one colony ends and another begins, especially in areas with *Montastraea annularis* (the dominant coral species on St. John reefs) or branching species like staghorn coral (*Acropora cervicornis*). Also, stresses to coral reefs could lead to higher densities of coral colonies but less live coral (cover), for example, if large adult colonies give rise to several smaller ones through fragmentation.

Sampling frequency and timing

Sampling is conducted throughout the year, with each site visited in the same month each year. While coral shows little inter-annual variability, cover by algae can change dramatically due to storms, swell conditions, wave action, and currents. Monitoring each site at the same month provides the best opportunity for accurate comparisons across years for all taxonomic groups. However, comparison of percent cover of algal communities across sites should be treated with caution if monitored during different time periods.

Frequent monitoring has been shown to be essential in revealing the causes of some coral declines. Most corals grow very slowly (mm/yr; see Gladfelter 1978) so detecting growth or increases in coral cover can take several years if not decades. Coral mortality occurs very fast (i.e., weeks or months). Our intention is to conduct annual monitoring, however given the rapid mortality that can occur, an incorrect interpretation for the cause of a decline in coral cover. Therefore, an increased monitoring frequency is recommended during periods of undue stress (e.g., a hurricane, elevated water temperature or disease outbreaks).

As an example, episodic monitoring of Virgin Islands index sites was triggered by elevated water temperatures detected in the summer of 2005, with an increase in sampling to bi-monthly and quarterly. This schedule continued for a year due to the coral disease outbreak that followed the bleaching event. Evaluation of the annual data collected would suggest declines in coral cover were due to bleaching. However, when including the data collected episodically during the same time, it is easily seen that coral disease was overwhelmingly the source of mortality, not bleaching. Having at least two sampling visits before and after this event greatly improved the statistical power to detect changes, allowing early reporting that the changes occurring were statistically significant and establishing a previously little-understood relationship between bleaching, disease outbreaks, and coral mortality.

Recommended number and location of sample sites

The current methodology allows assessment of trends within each site. The current name, location and size of SFCN sites (by park) are located in Table 1. Selection of additional sites can

be made after evaluating the inventory and maps of the reefs within network parks. Consideration should be given to the type of reef, extent, and ecology, along with the history of monitoring and other monitoring that may be conducted on other vital signs at that area.

Table 1: SFCN index sites with size of study area.

Park	Site	Area (m ²)
Biscayne NP	Amanda's Reef	20240
Biscayne NP	Ball Buoy Reef	14136
Buck Island Reef NM	S. Fore Reef	40753
Buck Island Reef NM	W. Spur and Groove Reef	26365
Dry Tortugas NP	Bird Key Reef	19765
Dry Tortugas NP	Bird Key North Reef	25642
Virgin Islands NP	Haulover Reef	13568
Virgin Islands NP	Mennebeck Reef	12495
Virgin Islands NP	Newfound Reef	13768
Virgin Islands NP	Tektite Reef	18711
Virgin Islands NP	Yawzi Reef	7125

Level of change that can be detected

A sampling optimization analysis was performed on existing average coral cover data obtained with this protocol at nine index sites (relatively homogenous fore reef sites) during monitoring performed annually from 1999 through 2005 (see Miller et al., 2006a).

The following equation was used to calculate the power (1-β) of the current design of 20 transects at each site to detect a proportional change in mean coral cover of 0.25 over 5 years (i.e. +/- .05 proportional change (trend) per year):

$$n = 12 * \frac{(s / \bar{x})^2}{r^2 * y} * (t_{\alpha/2, df} + t_{\beta, df})^2$$

where n= # transects; r=change/year; y= # sampling events = # years; $\bar{x}$ =avg. coral cover; s^2 = mean square error from analysis of covariance; $df=(y-2)*n$
(Equation adapted from Gerrodette as reported in Thompson et al., 1998.)

Results are presented in Table 2. Note that the averages below were calculated from transformed data and then back-transformed and thus are slightly lower than averages calculated from untransformed data. The Coefficient of Variation (CV) was calculated from transformed data.

For two years at Yawzi Reef and three years at Newfound Reef an additional 20, non-permanent, annually re-randomized transects were monitored. Sample sizes necessary to detect trends were also calculated (see Table 2).

The equation above was then used to estimate the number of transects needed to detect proportional changes of the mean of 0.20-0.50 after 5 years (i.e. 0.04-0.10 trend per year) at 80% power (1-β). Sites were grouped into low, medium, and high coral cover sites (Figs. 1, 2 and 3).

Table 2: Results of sample size calculations for permanent and non permanent transects at SFCN park index sites as of 2005 annual sampling. Site averages, coefficients of variation (CV = s / x), power of current design to detect a proportional change in mean coral cover of 0.25 over 5 years (0.05 trend per year; $\alpha = 0.05$) and # transects needed to detect a trend with 80% power. Note: Averages below were calculated from transformed data and back transformed.

Permanent transects							
State/ Territory	Park	Site	Pre-2005 Avg.	Cover Class	CV	Power	Recommended # transects
U.S. Virgin Islands	Virgin Islands NP	Newfound Reef	13.6	Medium	9.6%	92%	12
		Yawzi Reef	7.3	Low	12.4%	74%	22
		Mennebeck Reef	21.5	High	8.4%	97%	9
		Haulover Reef	20.7	High	8.6%	96%	10
	Buck Island Reef NM	W. Spur & Groove	5.0	Low	12.0%	76%	23
		S. Fore Reef	17.3	Medium	6.5%	100%	6
South Florida	Dry Tortugas NP	Bird Key Reef	12.2	Medium	9.7%	91%	13
	Biscayne NP	Ball Buoy Reef	5.7	Low	12.9%	70%	26
		Amanda's Reef	5.7	Low	15.0%	57%	34
Non-permanent, annually, re-randomized transects							
US Virgin Islands	Virgin Islands NP	Newfound Reef	13.8	Medium	27.3%	21%	92
		Yawzi Reef	6.9	Low	35.8%	14%	181

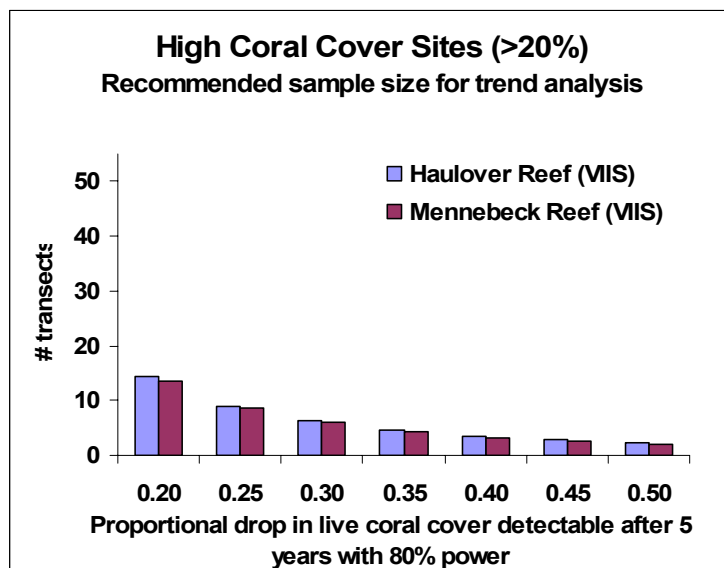


Figure 1: Results of sample size calculations for SFCN park index sites with more than 20% mean coral cover as of annual 2005 sampling.

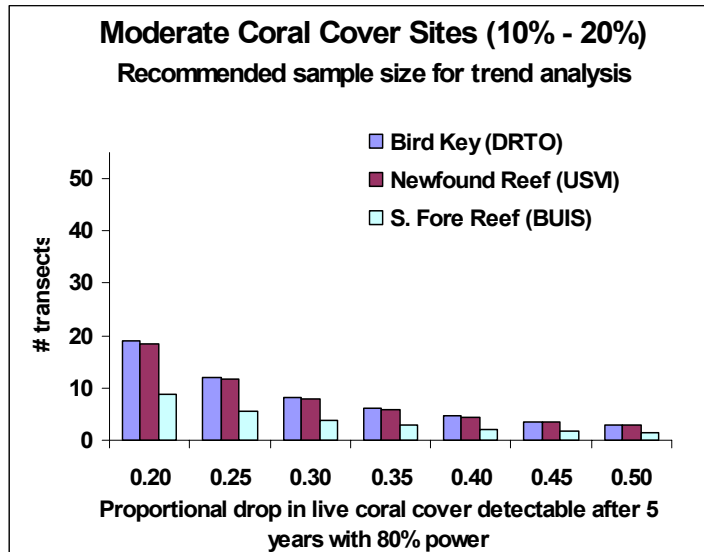


Figure 2: Results of sample size calculations for SFCN park index sites with between 10% and 20% mean coral cover as of annual 2005 sampling.

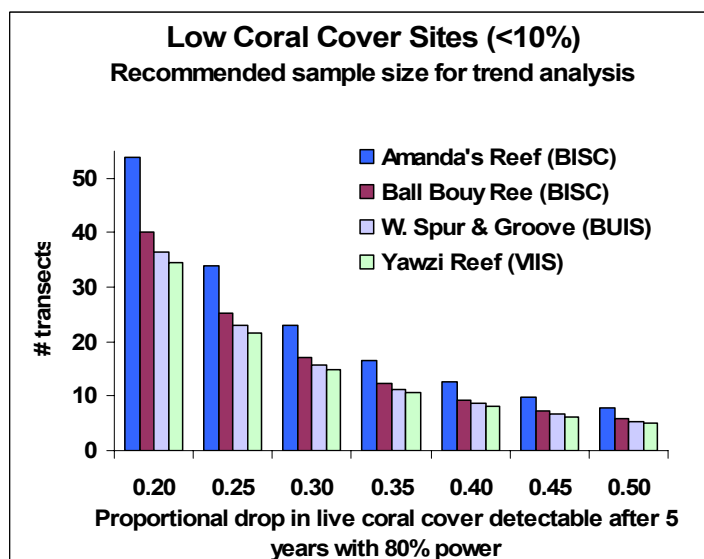


Figure 3: Results of sample size calculations for SFCN park index sites with less than 10% mean coral cover as of annual 2005 sampling.

The current sampling design at moderate to high coral cover sites has a power of over 90% to detect trends of at least 0.25 proportional change in the mean over 5 years (0.05 change per year). At low cover sites (< 10% coral cover) the current design ranged from 57-76% power to detect the same change. These calculations show that 9-10 transects for high cover sites (>20% live coral cover) were needed to detect a proportional drop of the mean of 0.25 with 80% power. Moderate cover sites (20% to 10%) ranged from 6-12 transects. Low cover sites (<10% live coral cover) ranged from 22-34 transects to detect a proportional drop of 0.25, but could detect a drop of 0.35 with 11-17 transects.

Non-permanent transects require *over 7 times* the sample size of permanent transects to detect trends with equivalent power.

It is important to note that following the 2005-06 bleaching/disease outbreak the average coral cover in the USVI SFCN sites is only 7.0 %. Episodic data from 2005 and all data from 2006 are not included in the sample size analyses. No SFCN site is currently >15% coral cover, thus no “high” coral cover sites (as defined during the analysis above) are currently monitored. Currently the protocol uses 20 permanent transects and this is recommended to continue as declines into the “Low Coral Cover” range are possible or have already occurred at all sites.

Current monitoring sites within SFCN parks

As stated previously, this approach was developed as part of the I&M prototype program and has been in use by SFCN parks since 1999. Presented below are details of the application of the sample design outlined above as currently applied within SFCN.

Biscayne National Park (BISC)

SFCN has been annually monitoring two coral reef sites at Biscayne National Park since 2004 (fig. 4), “Ball Buoy” and “Amanda’s Reef”. Selection of the study sites was made after consultation and field investigations led by the BISC resource management staff.

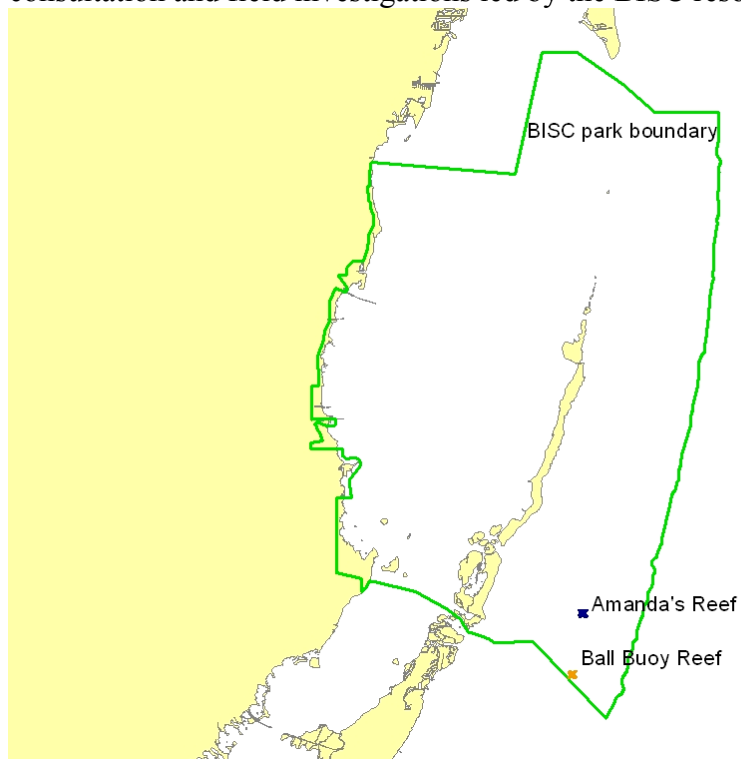


Figure 4: Outline of Biscayne National Park boundary showing the locations of SFCN index sites, Amanda’s and Ball Buoy reefs.

- Ball Buoy reef was selected due in part to the historical monitoring done at this site. Furthermore, the reef formation and coral reef habitat at this site are very similar to that of sites monitored by the state and located within the upper Florida Keys reef tract. Dr. Jim Porter (University of Georgia, Athens) has conducted photomonitoring at this site, and other similar reefs in the upper Florida Keys. The site contains a substantial population of the federally threatened Elkhorn coral (*Acropora palmata*) and while this coral is not a target of this protocol, it is an additional feature of interest to BISC resource managers.

Ball Buoy reef study site (fig. 5) is the eastern-most patch reef site toward the southern end of the park on the ocean side of the northern-most Florida Keys. The study site is 14,136 sq. meters and defined by the reef crest to the west, sand to the east, and a narrowing of the forereef habitat to the north and south. The site is shallow near the reef crest and extends to a depth of 12m on the offshore (east) side.



Figure 5: Ball buoy reef perimeter showing sample transect locations.

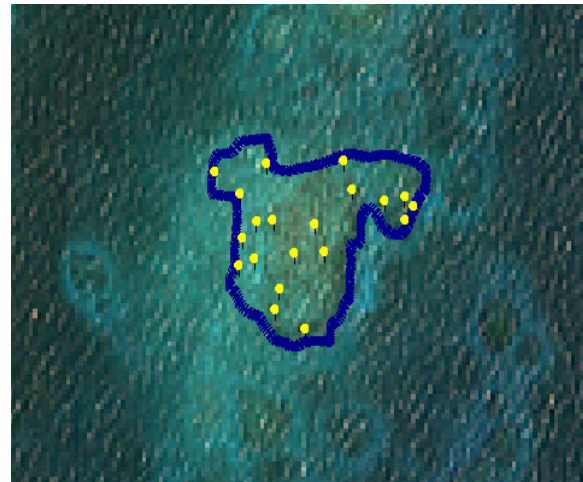


Figure 6: Amanda's Reef perimeter showing sample transect locations.

- Amanda's Reef study site (fig. 6) is one of several thousand patch reefs found in BISC and was selected to include that type of reef structure (patch). It is a shallow feature, average depth <3m, with some corals found within 0.3 meters of the surface. The edges slope to seagrass/sand community at a depth of 6m. This reef was also selected due to a boat grounding that occurred, and the population of Elkhorn coral it contains. These components are not selection criteria for an index site but are features of interest to the BISC resource management staff. The shallow depth (<2m) of this site would not allow for the use of the Aquamap™ System as the shallow coral colonies and divers conducting the monitoring would block the signal from the SONAR transducers. A modified procedure was created using a hand-held GPS device in a water proof bag, and towed by a diver/snorkeler on the surface. (See SOP 3 –Selecting random sampling points using GPS”) Communication between the divers and surface personnel aided navigation to sample points.

Buck Island Reef National Monument (BUIIS)

In June 1999, SFCN scientists collaborated with BUIS resource management to conduct preliminary investigations in five habitats (spur and groove, forereef slope, elkhorn coral “haystack” complex, lagoon, and backreef). These trials demonstrated the SOPs, “Using Videography to Monitor Coral Reefs” and “Using the Aquamap™ System at a Study Site”, could be used in any of the tested habitats. Park managers indicated that their highest priorities for long-term monitoring were the Western Spur and Groove Reef and the South Forereef (fig. 7). These habitats were selected based on the depth, size of the reef area, composition and complexity of the reef structures.

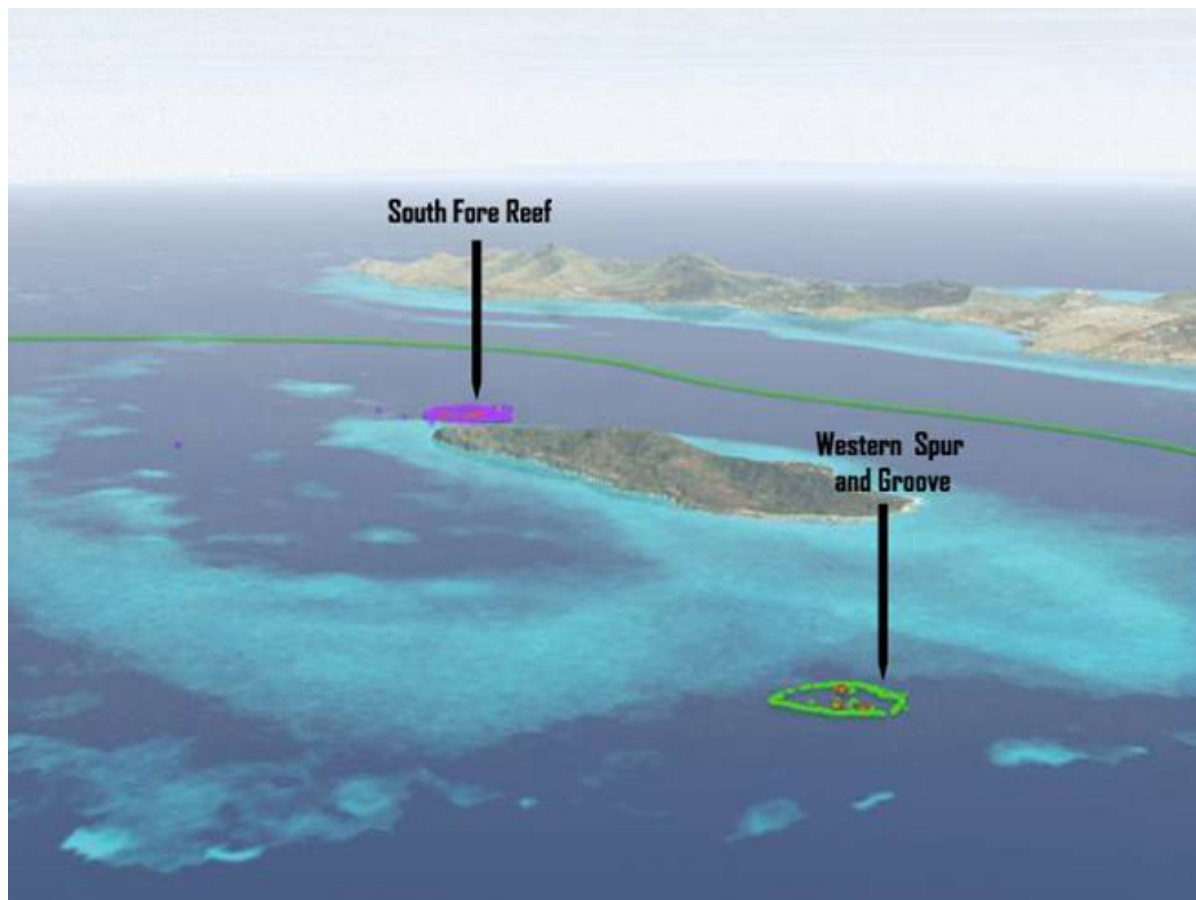


Figure 7: Digital rendering of Buck Island showing location of SFCN index sites and portion of park boundary (green line). The east end of St. Croix USVI is in the background.

- The Western Spur and Groove Reef study site is a 26,365 sq. meter area, located within this reef type that comprises a substantial portion of the park’s northwest waters. The “spurs” are low relief features with shallow sand channels between. Depths range from 9 - 13m. The area is subjected to large sea swells from the north, especially during winter “cold” fronts that approach the area. Coral cover is relatively low, and made up of low “mounded” type corals (e.g., brain and great star corals) which survive well in the high surge environment. Monitoring began in 2000 with the establishment of 20 permanent transects and has continued annually.

- The South Forereef study site is the largest of any in the SFCN parks. It encompasses over 40,000 square meters of the forereef that typifies the southern waters of BUIS. The site was selected as a representative of a highly complex, high coral cover reef, dominated by *Montastraea annularis* (complex). This type of reef is typically found extending into the forereef on the south side of Buck Island. Depths range from 11-14m. The site is bordered by sand on the west, and north; the south and east boundary is defined by the limitations of the mapping equipment as the habitat characterized by this site extends beyond the east and south boundaries. Monitoring began at this site in 2003 with the installation and sampling of 20 permanent transects and has continued annually. Additionally, episodic monitoring was conducted at this site during the bleaching/disease event in 2005-06.

Dry Tortugas National Park (DRTN)

Bird Key Reef is one of the most well-developed reefs in DRTN. Lying SE of Garden Key this linear reef extends for over 2 km and is approximately 360-400m wide. A shallow reef crest is emergent during low tide. Jaap et al., (1989) describe the reef zones: a rubble and fleshy algae zone (0-3m depth, extending approximately 100 m from the reef crest), octocoral-dominated hardgrounds (3-6 m deep, extending 100 to 150 meters from the reef crest), mixed hardgrounds and sediments (6-9m deep, extending 150 to 250 meters from the reef crest), and spur and groove zone (9-23m deep, extending 250 to 400 meters from the reef crest).

- Bird Key Reef study site (figs. 8 and 9) encompasses the locations of all the historical work mentioned above and expands the area to 19, 765 sq meters. The area is a well developed spur and groove reef with the deep buttresses in approximately 25m depth, and the shallow (west) end terminating in a gorgonian hardbottom and sand community at approximately 6m depth. Twenty, permanent 10-meter transects were established and sampled in 2004 and annually since.
- In 2005, in an effort to extend the area of knowledge around this large reef tract, Bird Key North study site (figs. 8 and 9) was added to the north of the existing SFCN Bird Key study site. The site was mapped with similar characteristics as the existing Bird Key site, and is 25,642 sq. meters in size. Twenty permanent, 10-meter transects were established and sampled beginning in 2005 with annual monitoring occurring since.

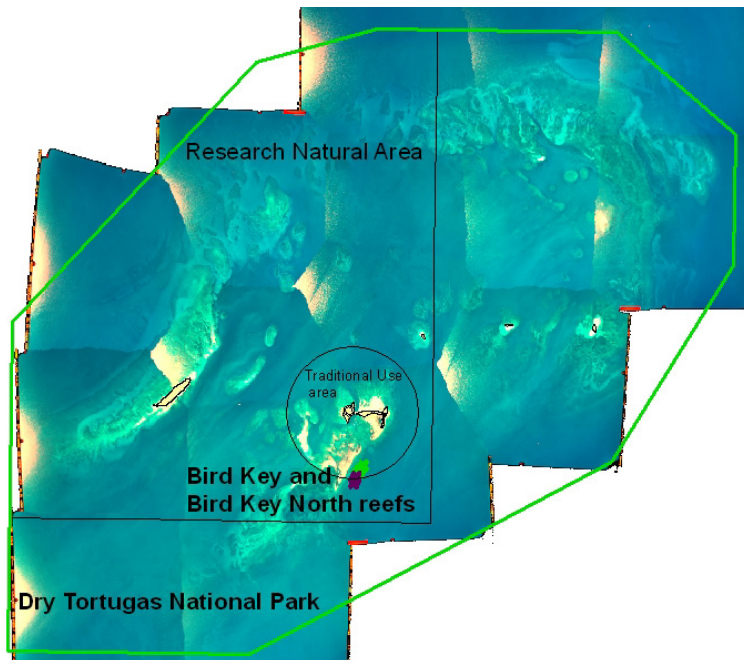


Figure 8: Dry Tortugas National Park, the location of the SFCN index sites, and the boundaries of the Research Natural and Traditional Use areas.

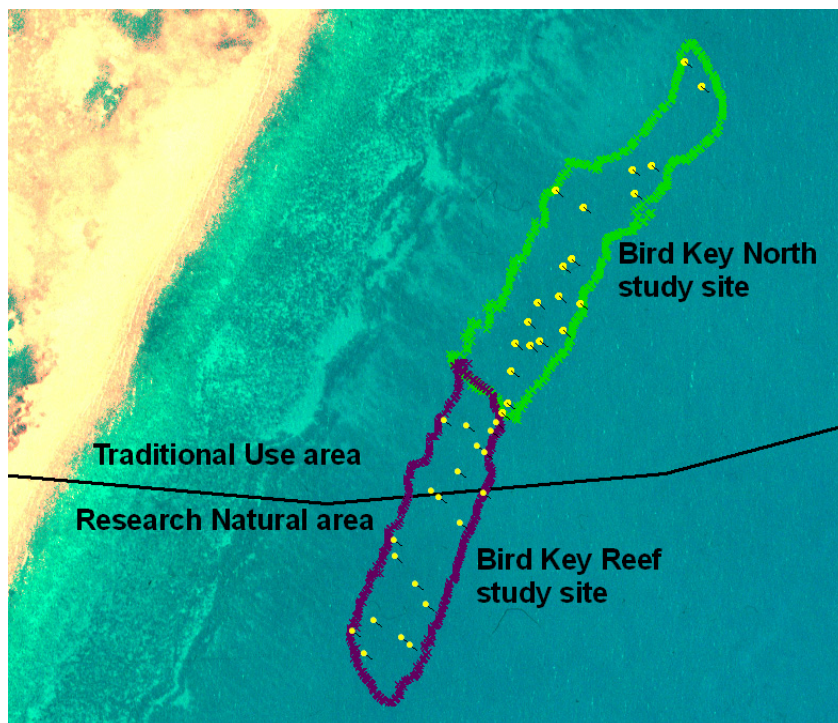


Figure 9. Orientation of SFCN index sites in DRTO in relation to the Research Natural and Traditional Use area. SFCN sample transects are shown as yellow markers with black lines.

Virgin Islands National Park (VIIS)

The National Park Service has been monitoring coral reef sites annually at Virgin Islands National Park since 1988 (fig. 10). Development of “SOP 1 – Using Videography to Monitor Coral Reefs” began in 1997 with the initiation of the I&M prototype program and was based in VIIS (Rogers 1993, 1997). Initially the linear chain transect method was used. After the development of the video SOP both techniques used concurrently on the same transects at Yawzi and Newfound Reefs. To evaluate the differences in methods, this simultaneous monitoring of the transects with both methods was conducted annually from 1998 through 2002. (See Rogers and Miller 2001 for comparison of video and chain methods.)



Figure 10. Map of St. John, boundary of VIIS and the location of SFCN index sites.

Additionally, a new approach to sampling was developed. On the advice of a USGS statistician, it was decided to invest a considerable amount of time in ensuring that transects selected for video monitoring were truly independent of each other, rather than “haphazardly” chosen as is the case in most other reef monitoring projects (see Lewis 2004). This change resulted in the development, testing, and refinement of “SOP 2 – “Using the Aquamap™ System at a Study Site”. This evolution of monitoring techniques was piloted at VIIS (Rogers and Miller 2006), therefore at this time more study sites are monitored in VIIS than other SFCN parks. The sites are detailed below in the chronological order of SFCN monitoring.

- Yawzi Reef is located near Tektite Reef on the south side of St. John (fig. 11) between Great and Little Lameshur Bays. The study site is the smallest monitored by SFCN at 7,125 sq. meters. It is defined by a sand plateau on all sides except the north, where the reef boundary is defined by a change in habitat from scattered corals to a mixed boulder and gorgonian

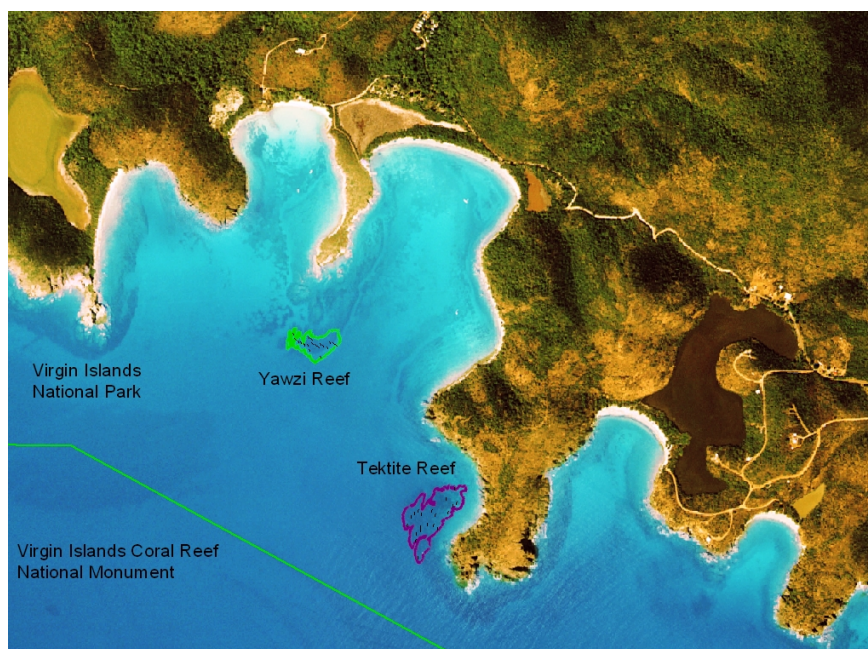


Figure 11. Location of SFCN index sites on south side of St. John, with locations relative to managed areas.

community. Following the pilot testing of the “SOP 1 – Using Videography to Monitor Coral Reef” in 1999, SFCN monitoring began with the establishment of 20, ten-meter transects with annual and episodic monitoring since that time.

- Newfound Reef study site is a 13,768 sq. meter site located on the East end of St. John (fig. 12), outside the boundary of Virgin Islands National Park. The site is within a watershed that is privately owned, but undeveloped at this time. The forereef site is defined by a 4m depth contour (west), an imaginary line offshore and perpendicular to a rocky outcropping (north), the sand channel that enters into Newfound Bay back reef (south), and the edge of the forereef slope (east). Shoreward of the study site is a backreef lagoon, which is a popular anchorage for day-charter boats bringing visitors to this reef.

Inventory and Monitoring involvement at this site began in 1997, as part of the USGS prototype protocol development program, and once pilot testing was completed, permanent monitoring began in 1999. Sampling the 20 random transects has been conducted annually since 1999 through the I&M program, now under the auspices of SFCN. Episodic monitoring was also conducted here during the 2005-06 bleaching/disease outbreak.

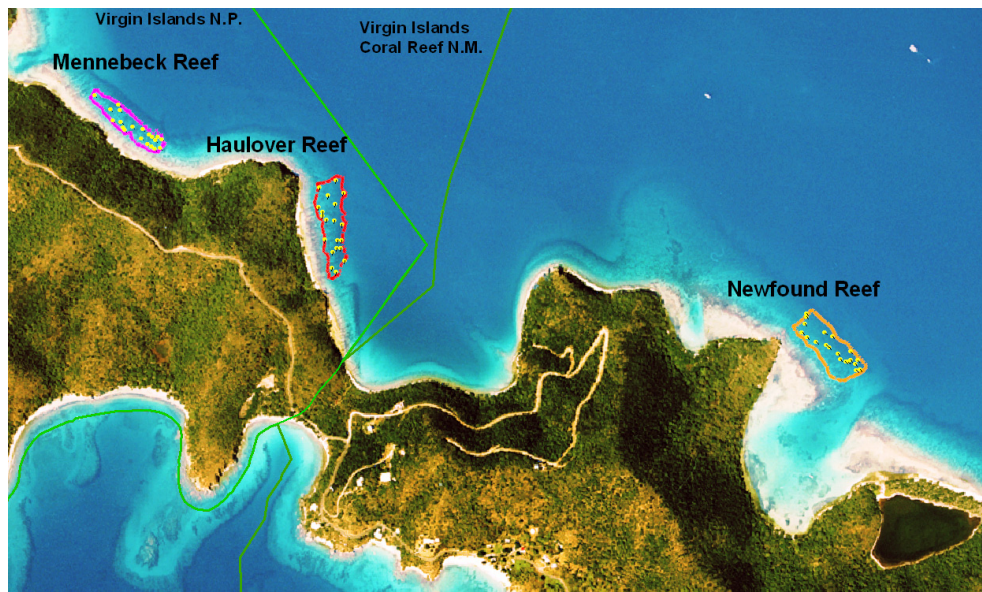


Figure 12: Locations of SFCN index sites in northeast St. John with locations relative to managed areas.

- Mennebeck Reef study site (fig. 12) is 12,495 sq. meters and is located within a completely undeveloped watershed within the VIIS boundary. There are no roads or trails to this site and it is not marked or known as a destination for divers or snorkelers, therefore it receives very little visitation (R. Boulon pers. comm.). However, it is directly “downstream” of the majority of islands that comprise the British Virgin Islands. The site is defined by a depth contour of 4m (north), fragmentation of the reef structure with increased sand channels (both in frequency and size) to the east and west, and the forereef slope to the sand base at 18m (south). The SFCN has been monitoring annually and episodically at this site since 2000.
- Haulover Reef study site is located on the north-east end of St. John, within VIIS (fig. 12). The site is on the north side of Haulover Bay, a bay that is bisected by the boundary of the park. Currently, development is progressing on the southern shore of the bay and plans have been approved for 35 home sites on a very steep slope. The proximity of this well-developed reef to the park boundary and the development pressures from adjacent non-park land makes this site of particular interest to VIIS resource managers.

The study site is an approximately rectangular fore reef site, measuring 13,568 sq. meters and located on the outer edge of the fore reef along the north side of the bay. The site is defined by a 10 m depth contour (west), rocky outcroppings (north and south), and the forereef slope (east). It is similar in size, structure, composition and proximity to Mennebeck Reef, located approximately 2 km south. However, this site receives substantial visitation, primarily from snorkelers with access from the shore. Their impacts are minimal at the depths of the monitoring transects. The SFCN began monitoring here in 2003 and monitoring has been conducted annually and episodically.

- Tektite Reef is located on the south side of St. John, in a bay to the north and west of Cabritte Horn Point. The study site is 18,711 sq. meters in size (fig. 11). Its boundary was

determined on the north, east, and south by the determination of where the linear reef gave way to a patch reef habitat. The site is bounded by deep sand to the west. The depth at this site varies from 4 -20m.

This site is in a relatively undeveloped watershed, but has two day-use dive moorings maintained by VIIS, so visitation by scuba divers is common. The reef was comprised of areas of very high coral cover by *Montastraea annularis*, which has suffered significant mortality since 1997 from the coral disease, white plague (Miller et al., 2003). Monitoring by SFCN began in September 2005 with the installation of 20 permanent transects, then continued bi-monthly during the bleaching/disease outbreak. Monitoring is conducted on an annual frequency.

Field Methods

As part of the prototype I&M program, two protocols were developed by USGS and NPS:

- Using Videography to Monitor Coral Reefs and

- Using the AquaMap™ System at a Study Site

They were peer-reviewed and finalized in April 2001. Those protocols provide the explicit details on all aspects of the methods and are attached to this Coral Monitoring Protocol as Standard Operating Procedures (SOPs). To maintain the integrity of those protocols, the original format and structure has been preserved in the SOPs. Seven additional SOPs have been added:

- Using a GPS and ArcView™ at a Study Site – Overview:

- Counting *Diadema* on coral reefs

- Measuring rugosity on coral reefs

- Measuring coral disease

- Coral reef monitoring database user's guide

- Operation and maintenance of NPS vessel, Acropora

- Revising the protocol

A brief overview of each is provided below:

Using Videography to Monitor Coral Reefs – Overview

As mentioned above, videography monitoring was selected over the chain transect method because comparisons between the methods showed that the coral data were comparable; the video monitoring method did not require touching the corals, thus minimizing risk of damaging the resource; the video tape can be archived creating a permanent visual record; videotaping requires less dive-time; because the corals are identified on the videotape in the office, the level of coral expertise required by the field crew is reduced; and error-checking of coral species identification is possible.

Given the constraints of scuba diving, photography provides the most practical means of sampling large areas underwater. A diver needs to be adept at buoyancy control to produce quality video images, but a proficient videographer can obtain large amounts of data with little or no impact to the surrounding resource.

Since the development of this method, video technology has progressed from analog video, digital video to hi-definition video. Whichever format is selected, the objectives remain the same; however, the exact details of the camera preparation, settings, and use will differ. The advent and refinement of digital still cameras in the past decade has added yet another option. The details for conducting image analyses with different formats will depend upon the type of video format used, and computer equipment available however, the objectives of the method are the same. The SOPs attached provide a step by step outline for using video equipment, underwater housings, computers, and software that are both commonly available and affordable.

For this protocol, the diver uses a digital video camera fitted with a wide-angle lens and an underwater housing. The diver videotapes while swimming slowly (~30 seconds per meter) along the transect holding the camera perpendicular to the substratum from a height of ~40 cm, producing a “swath” or belt transect that is ~ 40 cm wide.

The videotape is viewed to make sure that the clarity and resolution are satisfactory, then catalogued to archive the raw footage. A computer is connected to either the camera or a separate videotape player and the tape is played to "capture" 25-30 adjacent, non-overlapping frames as still images. In this way, each transect is depicted by a number of unique frames, or video "quadrats," which are converted to photo files and saved in a computer folder. Ten random dots are placed on each frame during a process that uses Microsoft Excel and Adobe Photoshop and is automated by WinBatch for Windows, a batch-processing program. After the images have been processed, an analyst identifies the benthic components under the random dots while viewing the frames in Adobe Photoshop. The resulting 250-300 points per transect are identified and used to calculate percent cover of substratum categories.

The video "SOP 1- Using videotape to sample coral reefs" contains details on the following sections:

- 1) Overview
- 2) Video equipment Preparation and Handling
- 3) Field Activities
- 4) Viewing and Cataloging the Videotapes
- 5) Capturing the Video Images
- 6) Using Adobe Photoshop
- 7) Random Dot Processing Setup
- 8) Automating the Dotting Process
- 9) Substrate Identification and Data Entry
- 10) Data Summaries and Analysis
- 11) Guide to Substrate Identification
- 12) Appendices
 - a. Identification codes for Benthic Components
 - b. Glossary of terms
 - c. Creating Laminated Photos for Transect Relocation

Using the AquaMap™ System at a Study Site – Overview

AquaMap™ is similar in concept to the Global Position System (GPS), except that it operates underwater, on a much smaller scale, and uses a SONAR (sound navigation and ranging) system to emit and receive high frequency sound. Although light and most radio waves travel more slowly and shorter distances in water than in air, sound propagates significantly faster and much further in water, and is therefore used in fish finders and depth sounders, as well as by marine mammals to navigate and communicate.

When using AquaMap™ to fix a position, the diver station emits a signal that is received by two or three baseline stations at established locations which then send a signal back to the diver station. The diver station uses the defined locations of the baseline stations and the time it takes to receive each return signal to calculate its own location. To use this system to navigate accurately and relocate the same points over time, each baseline station must be returned each

time, to exactly the same depth and location; and the diver station must have the correct information regarding their positions.

We use the AquaMap™ system to:

- map the perimeter of a study,
- calculate the site area in square meters,
- define the population of sample points (transect origins) within that site,
- randomly select a number of points from that population, and then
- locate those points during initial and subsequent sample events.

The SOP 2 – Using AquaMap™ at a Study Site contains the following sections:

- 1) Overview
- 2) System Preparations
- 3) AquaMap™ Basics
- 4) Using AquaMap™ in the field
- 5) Data Management and Summary Chart
- 6) Appendices
 - a. Recommended configuration file settings
 - b. Using the convert program
 - c. Using the AREA program

Using a GPS and ArcView™ at a Study Site – Overview

The situation may arise in which the AquaMap™ can't be used to meet the objectives of the sample design. For example, if an index site is shallow (<2m), the SONAR signals can't effectively propagate without blockage, thus making SONAR communication, tracking and mapping unproductive. In such cases, a handheld GPS unit in a waterproof container can be used by a snorkeler or a diver on the surface in much the same way the AquaMap™ system works underwater. (Note that even the slightest film of water over the antenna portion of the GPS unit will terminate satellite reception.) The surface person can swim the perimeter of the index site to obtain the bounds and record that track in the GPS unit. In the office, using ArcView™ or similar software, scripts can be used to meet the objectives of the random sample selection design including:

- calculate the site area in square meters,
- define the population of sample points within that site,
- randomly select a number of points from that population, and then
- create a range and bearing between selected sampling points
- locate those points during initial and subsequent sample events.

Safety is of utmost concern during the use of this method. During the site setup, a person(s) is required to be on the surface for extended periods. When mapping and tracking, caution must be taken to avoid separation of field persons as communication between those on the surface and those underwater will be limited.

Accuracy is another factor to be considered with this procedure. Fixing a location on the surface may not translate simply to an exact location even a few feet underwater. Range and bearings calculated in ArcView™ or similar software will contain error, and the precise navigation underwater is not easily accomplished. Rough sea states, current, surge, and poor visibility (above and below water) can complicate this procedure and compromise safety rapidly. However, given appropriate conditions and with user experience, an index site can be successfully sampled following this SOP.

Counting *Diadema* on coral reefs

The abundance of *Diadema antillarum* are monitored along each transect. This invertebrate is a significant marine herbivore and can have substantial effects on the algal cover on coral reefs. Algal removal is a major step in the coral recruitment process. During the 1980's, this sea urchin suffered Caribbean-wide mortality at levels approaching 90%. Within the past 5 years, some scientific and anecdotal information suggest numbers of *Diadema* are increasing. Using this method, the number of all long-spined sea urchins (adult and juvenile) found within 1m on both sides of the sample transect are counted when the transects are filmed. The data will be used to look for associations between *Diadema* recovery and cover by algae and other benthic organisms.

The number of *Diadema antillarum* along each transect are counted by having one of the divers swim slowly along the transect searching in the various reef cracks and under ledges in a “swath”, or ten by two meter belt transect bisected by the video transect. Details and example of the data form are given in the “SOP 4-Counting *Diadema* on coral reefs.”

Measuring Coral Disease

Outbreaks of coral disease were responsible for a large portion of the coral mortality in the 2005 bleaching/disease outbreak event. Pathogenesis for most coral diseases are still unknown, so field observations remain the most effective way of documenting coral diseases. Identification of the type of disease, measurements and digital photographs are taken of disease “lesions”, bright white areas of coral skeleton (recently killed = not encrusted with any algae, turf or otherwise) within 1 m on both sides of the sample transect. Taking samples of the recently dead area(s), nearby tissue, or healthy coral tissue is encouraged but not covered under this SOP.

Coral disease is monitored within on meter on either side of the video transect during each sampling event. The following are recorded:

- Type of coral disease
- Coral species affected
- Location along transect
- Approximate distance from transect
- Maximum length of recent disease lesion
- Maximum dimension perpendicular to measurement above

Details and an example of the data form are given in the “SOP 6– Measuring Coral Disease”.

Measuring rugosity on coral reefs

Coral reefs are three dimensional structures. The overall structure of the reef supports a high diversity of fishes and other organisms which depend on it for shelter, food, etc. Generally, greater reef structure equates to higher numbers of reef-associated animals. Changes in the structure can occur through long-term growth of the corals, hurricane damage and movement, visitation damage (anchors, kicking reefs), and erosion, as areas no longer covered by live coral tissue are gradually lost. (See SOP 5– “Measuring rugosity on coral reefs”).

Rugosity measures of each transect are taken once every 10 years or after a major event such as a hurricane or ship grounding. The diver takes a chain and lays it along the transect, following the bottom hard structure. The length of chain required/10 meters straight length is the measure of rugosity. Details and an example of the data form are given in the SOP.

Data Handling, Analysis and Reporting

Overview of database design

Database design is a legacy dataset that was originally designed using the Natural Resource Database Template (NRDT) Phase 2 format. Implementation of any future changes to the database will require that the overall design follow the most current version of the NRDT. Current design is shown in Figure 13.

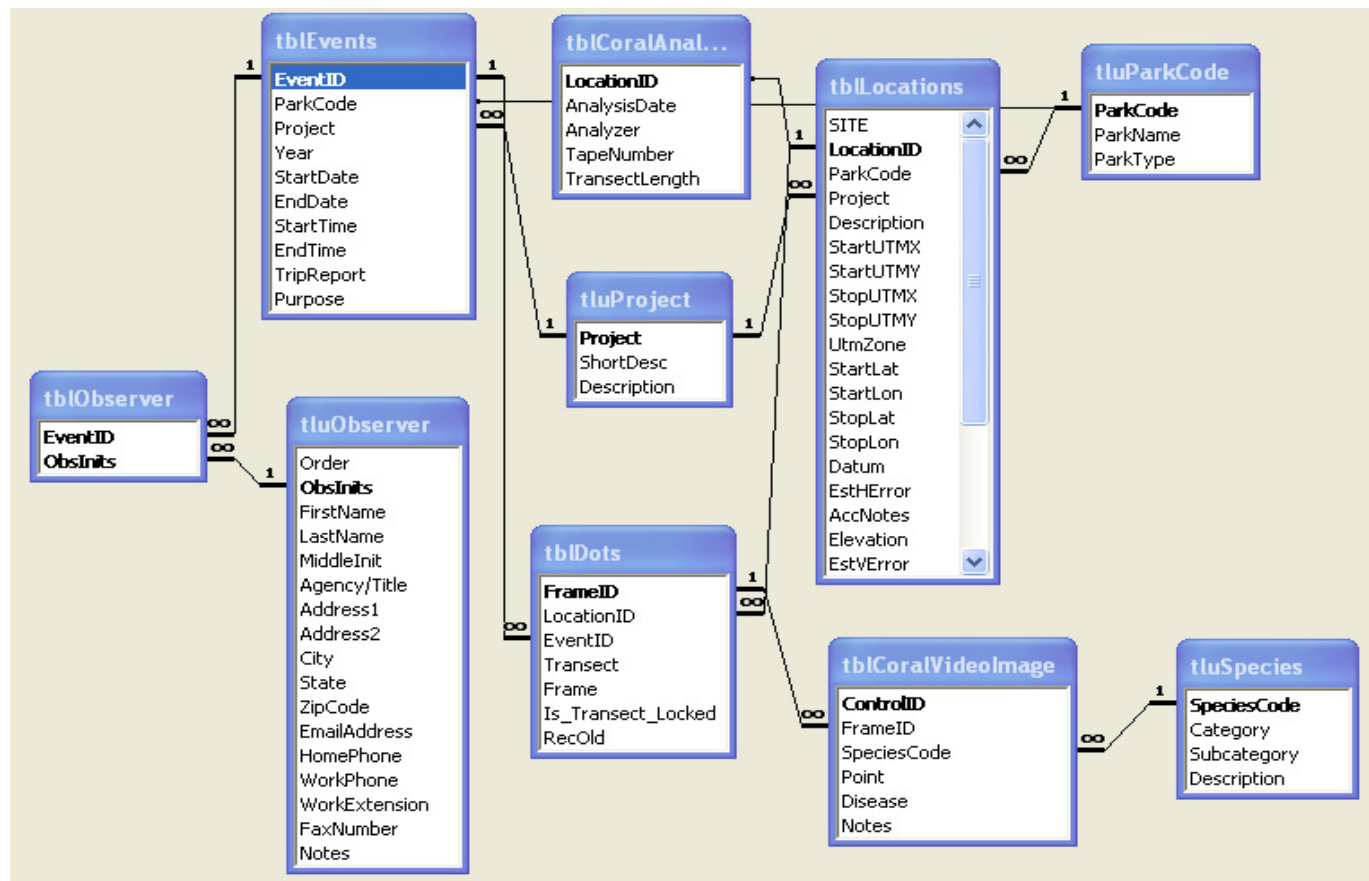


Figure 13. Overview of database design

Data entry, verification and editing

The “SOP 7 – Coral reef monitoring database user’s guide” describes the process of entering data from the coral transects image analysis into the database. Data for *Diadema* abundance, coral disease and rugosity are currently entered into MS Excel spreadsheets.

The database only allows entry of pre-determined species codes and site codes. Transect number, site names, and sampling date are double-entered both directly and as part of a unique location code and unique event code. This allows cross-verification of entries although automated error checking routines have not yet been included in the database.

Recommendations for routine data summaries

Currently, queries exist within the MS ACCESS database which is run sequentially to generate tables of summarized data. This data is then exported to an MS Excel spreadsheet for further analyses. Automated data summaries will be incorporated into the next version of the database. Additionally, MS access data are exported to a pre-defined MS Excel spreadsheet that contains an analysis template which produces automated summary tables of components *i-iv* listed below.

The number of points identified per transect ranges from 240-300 points depending on the number of non-overlapping video image captures that occur (i.e. 24-30 images). Typically there are 25 image captures and thus 250 total points. The number of points unidentifiable due to equipment (fall on the measuring tape, camera wand, or shadow) is subtracted from the total number of points for an adjusted total of points. All percent cover calculations are made by dividing the number of points by this adjusted number of total points.

Recommended annual data summary routines using benthic cover data generated with MS Access queries include:

- i. Mean percent cover (with standard error [SE]) by all coral species identified
- ii. Mean percent cover (with SE) by major benthic groups
 - a. corals
 - b. gorgonians
 - c. sponges
 - d. zoanthids
 - e. macroalgae
 - f. coralline algae
 - g. turf algae
 - h. sand, rubble, and pavement
 - i. other (live components – e.g.: fish, but not benthic)
 - j. unknown
- iii. Mean percent (with SE) of coral cover bleached
- iv. Mean percent (with SE) of coral cover diseased

The following calculations are made based on records in the database:

1. The Shannon-Weaver Diversity Index is calculated for each transect and for the entire site using: $H' = -\sum p_i \ln p_i$, where $p_i = n_i / N$, in which

$$p_i = n_i / N$$

N = total number of point (individuals) of all species, and

n_i = the number of points of species ' i '.

Dots identified as "CORAL" (but not identified to species) are *excluded* from this calculation. Therefore information on the number/percent of coral points **not** identified to species should be calculated to give relevance to the H' .

2. Percent cover and SE for abundance of major coral species or genera relative to all corals. Suggested groups for this analysis include:
 - a. *Montastraea* complex (*M. annularis*, *M. franksi*, *M. faveolata* and *M. annularis* complex)
 - b. *Colpophyllia natans*
 - c. *Diploria* genera
 - d. *Montastraea cavernosa*
 - e. *Siderastrea siderea*
 - f. *Stephanocoenia michelinii*
 - g. *Agaricia* genera
 - h. *Porites* genera
 - i. *Millepora* genera
 - j. Hard coral, unknown species

Reporting

Reports will follow the standard format required in the CBE style Manual (1994). The natural resources technical report template for NPS documents is also required. Reports should be direct and concise. The types of reports expected are listed in Table 3.

Trends in coral cover and cover by other reef organisms can be quantified in a statistically rigorous way using this protocol. This protocol has been in use since 1999 with sites added each year and examples of data reporting figures can be seen in Figures 14-16. A figure containing percent cover with SE of the major benthic groups can effectively illustrate many categories of

Table 3: Descriptions of reports.

Type	Purpose	Primary Audience	Review Process	Frequency
Annual Status Reports for Marine Benthic Communities	Summarize monitoring data collected during the year and provide an update on status of selected resources.	Park resource managers and external scientists	Internal review by SFCN staff	annual
Executive Summary of Annual Reports	Summarize key points for non-technical audiences.	Superintendents, interpreters, and the general public	Internal review by SFCN staff	Simultaneous with Annual Status Reports
Comprehensive Trends and Analysis and Synthesis Reports	Same as Annual Status Reports but summarized to highlight key points for non-technical audiences.	Park resource managers and external scientists	Internal review by SFCN staff; External review solicited as necessary	Every 5 years or after a major event; more frequently if declines occurring

monitoring data (Fig. 14). Multiple sites can be displayed showing coral cover with trend analysis (where observed) can be effective to show network or park results (fig. 15). Additionally, these objectives were adapted to accommodate episodic monitoring triggered by elevated seawater temperatures in 2005 (fig. 16) at sites in the USVI. Reporting data for *Diadema*, and rugosity can be in a narrative form; coral disease can be narrative, a stand-alone figure, or combined with coral cover (for example, see Figure 16). These data effectively showed that coral disease was the true cause of the >50% decline in coral cover at the index sites (Miller et al., 2006b). These results are meaningful to a wide audience; from superintendents, resource managers, popular press, to scientific literature. Additionally, creating a long-term photographic record (video and still images) to illustrate the measurable objectives is an invaluable communication tool. Other step-by-step instructions for reporting are found in the “SOP 1 – Using videography to monitor coral reefs”, Section X: Data summary and analysis.

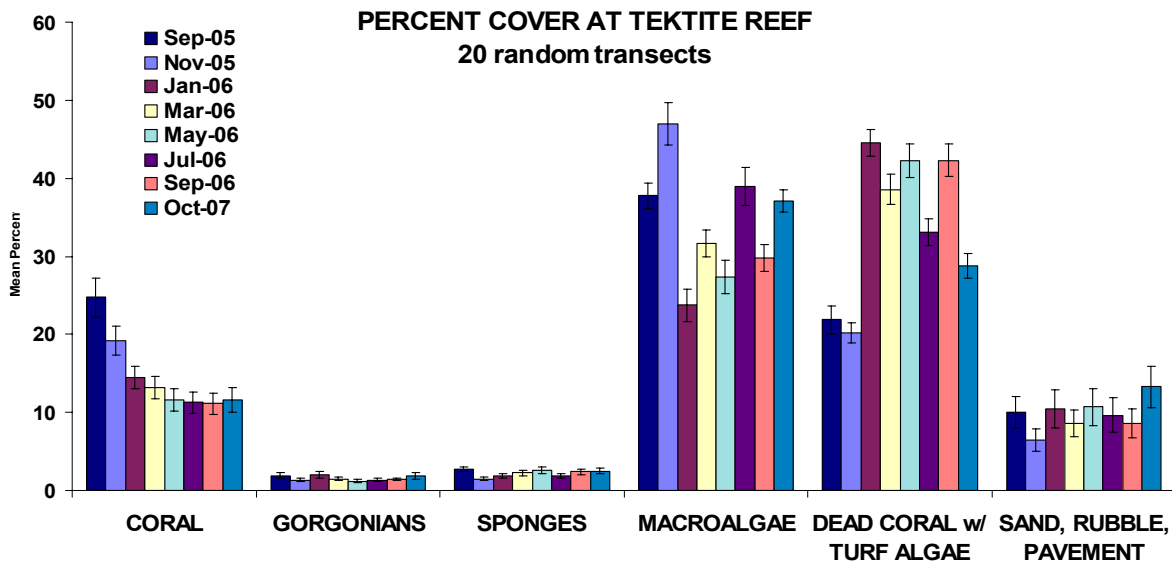


Fig. 14. Percent cover by major benthic groups during monitoring period at Tektite Reef.

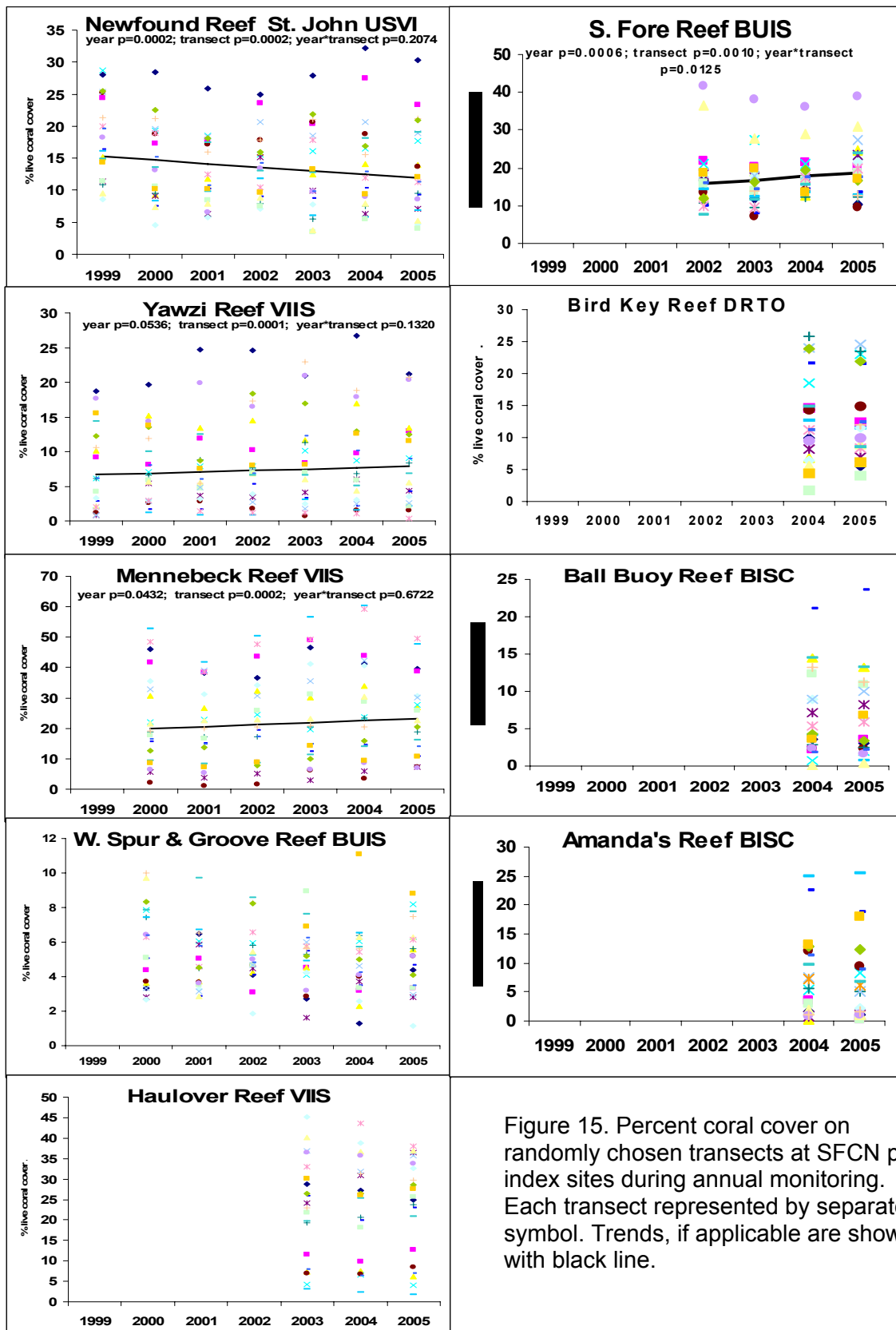


Figure 15. Percent coral cover on randomly chosen transects at SFCN park index sites during annual monitoring. Each transect represented by separate symbol. Trends, if applicable are shown with black line.

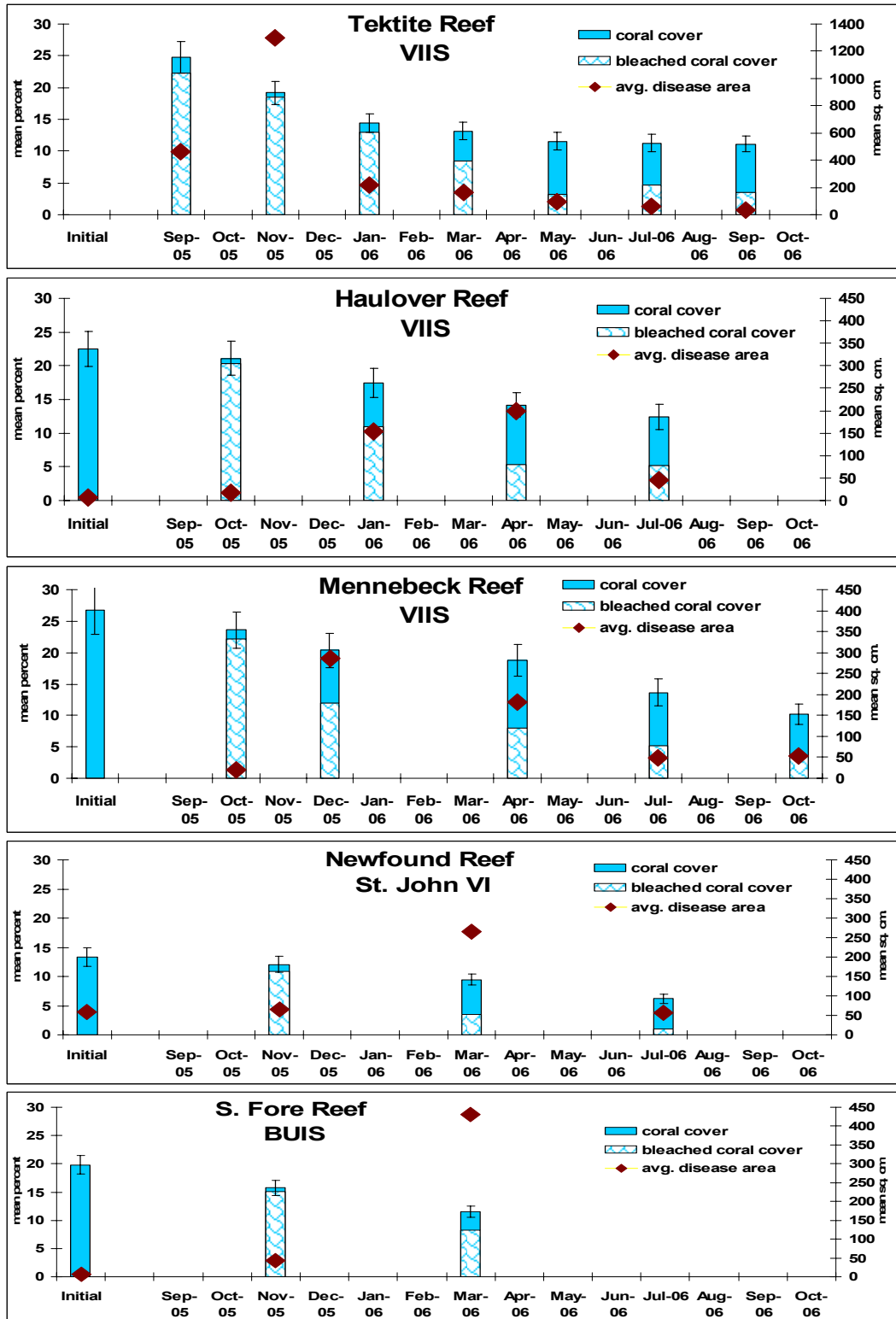


Figure 16: Mean coral cover (with standard error), mean percent coral cover bleached, and total area of coral cover killed by disease during at selected SFCN Virgin Islands park index sites obtained during episodic monitoring of the 2005-06 bleaching/disease outbreak.

Recommended methods for statistical analysis

This protocol produces a great deal of information and a lot of different analyses are possible both for detection of change and for detection of associations with covariates. Only a few of the more important analyses are discussed below.

Statistical analyses have primarily been conducted on

- % live coral cover
- Number of coral species/transect
- % live coral cover of major reef species
- % cover of macroalgae
- % cover of coralline algae
- % cover of turf algae

The types of analyses recommended are

1. Repeated Measures Analysis of Covariance to assess gradual trend increases or decreases. Time is treated as regression variable and transect as a class variable. A time*transect interaction is also included. The hypotheses being tested are:

- H: % live coral cover is changing with time
- H_{null}: % live coral cover is not changing with time

2. Repeated measures analysis of variance using a contrast analysis to assess changes before and after an event such as coral bleaching/disease events, major hurricanes, and harmful algal blooms. Time is treated as class variable and transect as a class variable. A contrast analysis compares data before versus after the event. The hypotheses being tested are:

- H: % live coral cover before the event is different from after the event
- H_{null}: % live coral cover before the event is not different from after the event

SFCN has used SAS statistical software to conduct the analyses.

Because variance in percent live coral cover increases with the mean, a square root ($X + 1$) data transformation is recommended before running the analyses.

Both for calculations of species richness and for individual species trends analysis, the species in the *Montastraea annularis* complex were combined together and considered one species as they could not be reliably differentiated when small. This included the species *Montastraea annularis* (MA), *Montastraea faveolata* (MFAV), *Montastraea franksi* (MFRA) and an undetermined *Montastraea annularis* complex category (MACX).

Analyses are typically conducted on a site by site basis. However data from multiple sites can be combined as long as it is clear during reporting that the statistical inference is only to those sites. This proved to be necessary during analyses following the 2005 bleaching/disease outbreak event as the power to detect change for some individual coral species was low unless combined across

multiple sites. Data from all transects at a site were combined into an average cover by year for analysis, eliminating a problem of zero cover for some species at some transects. Sites in this analysis became the replicate and a time, site, and site*time interaction was included in the contrast analysis described above. Combining of multiple site data for analysis of algal variables should be approached with caution as algal cover is ephemeral and sites are monitored during different months of the year.

Interpretation of changes in gorgonian cover should be made cautiously as heavy wave action can cause normally upright seafans to lie flat and thus temporarily increase their exposed surface area during filming. Thus small but statistically significant changes should be evaluated in the light of the conditions during filming.

Analysis methods for the rugosity, *Diadema antillarum*, and coral disease data are still to be developed but are likely to be similar to those mentioned above.

Metadata procedures

Metadata (such as date, location, observers...) for each event are stored within the database. Metadata for the spatial location of the sample sites are stored with the shapefile. For further discussion concerning metadata requirements please see section 8.3 of the SFCN data management plan (<http://www1.nrintra.nps.gov/im/units/sfcn/docs/phase/appq.pdf>).

Data archival procedures

Initial archiving is started once the Project manager has conducted the appropriate QA/QC procedures for a specific field season's data and has notified the Network Data Manager that the dataset is ready for archiving. At this point the Network Data Manager places a copy of the dataset into the appropriate folder within the archive directory on the network server. For example, the Coral database would be copied onto the network server under Archives/Projects/Marine_benthic_communities/Coral/Data . Once the data are archived, any changes made to the data must be documented in an edit log. From this point forward, original field forms are not altered. Field forms can be reconciled to the database through the use of the edit log. Secure data archiving is essential for protecting data files from corruption. Subsequently, an electronic version of the data set is maintained in a read-only format on the program server. Backup copies of the data are maintained at the South Florida office and at the Southeast Regional office in Atlanta, GA. For further detail of the archiving procedure please refer to the SFCN Data Management Plan (<http://www1.nrintra.nps.gov/im/units/sfcn/docs/phase/appq.pdf>).

Personnel Requirements and Training

Roles and responsibilities

A marine ecologist serves as the project manager and is based out of the Florida office. For monitoring in the Virgin Islands, the fisheries biologist acts as the on-site manager and along with the biological technician, they conduct the work. For monitoring in S. Florida parks, the ecologist and biologist conduct the work. When necessary, VI personnel can travel to S. Florida to provide assistance, and vice versa. Analysis of imagery is conducted by the four staff mentioned above. Typically the project manager oversees the image analyses, equipment maintenance and storage, as well as data summary, analyses and reporting. The data manager designs and oversees data security and archiving. The data manager is also responsible for building adequate quality assurance-quality control (QA/QC) procedures into the database management system, and for following appropriate data handling procedures. The network coordinator supervises this team.

Qualifications

Training is an essential component for the safe and accurate collection of credible data. Personnel need to not only become qualified but extremely proficient in scuba diving; diving is the means to collect the data, not the objective itself. Personnel must have a high level of comfort with multiple tasks while diving, in addition to excellence in buoyancy control. Image analysis and subsequent data collection and results can be compromised if filming was not done in a controlled manner.

For data analysis, knowledge and familiarity of marine invertebrate taxonomy is required yet as this is a “remote sensing” method, the analyst needs sufficient in-water “coral reef” experience possess the ability to interpret the video imagery and make correct identifications. Section XI in the “SOP 1 - Using Videography to Monitor Coral Reefs” contains a Guide to Substrate Identification which is recommended for review by an analyst. Image analysis can be conducted by new personnel however an evaluation period where data duplicate identification with an experienced taxonomist should be conducted.

The NPS requires anyone diving within the park service to meet requirements of the Diving Control Board and obtain an NPS “Blue card” certification (Ref RM4, 485 DM 27 ed. 2005). In addition, in order to operate a motor vessel, an NPS employee must pass the requirements established within the Motorboat Operators Certification Course (Ref 36 CFR part 3, 485 DM 22). The “SOP 8 – Operation and Maintenance of NPS Vessel, Acropora” contains details regarding the use of this NPS vessel during this protocol.

Training Procedures

Training takes place under the supervision of the project manager in the use of the Aquamap™ equipment, video equipment, video image capture, and data analysis and entry. Filming of transects in a controlled manner requires buoyancy control and practice.

Image analysis by new personnel is completely checked during an evaluation period by an experienced taxonomist using data duplicate identification until there is consistent concurrence in species identification. Continued review of literature regarding taxonomy is recommended.

As the sampling for this protocol takes place throughout the year field and office skills (data analysis and entry) are continually honed.

Personnel must complete and maintain the necessary requirements to maintain NPS Blue card and Motor Boat Operation certification (MOCC). Details on vessel operation can be found in SOP – “Operation and Maintenance of NPS Vessel, Acropora”.

Operational Requirements

Annual workload and field schedule

Monitoring is conducted throughout the year with suggested months for field activities listed (table 4) as target dates. Some flexibility is allowed, but if the scheduled month is altered, effort should be made to conduct the work within the same season (eg: Summer, Spring, Fall, Winter). Weather, sea conditions and in-water visibility are major factors in scheduling sampling as good field conditions allow for better video images which result in more accurate analyses.

Table 4: Annual monitoring schedule.

Month	Park	Site
January	VIIS	Haulover
February	BUIS	S. Forereef
March	VIIS	Newfound
May	BUIS	W. Spur & Groove
June	DRTO	Bird Key
June	DRTO	Bird Key North
June	BISC	Ball Buoy
June	BISC	Amanda's
September	VIIS	Yawzi
September	VIIS	Tektite
October	VIIS	Mennebeck

Two people minimum are required for the field work; for both boat and diving safety, and data collection. (The NPS does not require a 'top-side' person on vessels during diving operations.) Generally, a site can be sampled in two days, typically consecutive, but in all cases as close together as possible.

Videotaping requires ~5 minutes of bottom time per 10-meter transect, plus the time needed for transect location and set-up. Using AquaMap™ System to locate sample points, the divers will probably complete no more than five transects per dive. Ten 10-meter transects can be filmed during a typical dive day (two dives, 60 to 75 minutes bottom time) using one battery and videotape (digital tapes and batteries last approximately 60 minutes). The "SOP 1– Using Videography to Monitor Coral Reefs" contains more details.

Facility and equipment needs

Field and office equipment are detailed in the SOPs – Using Videography to Monitor Coral Reefs and Using the AquaMap™ System at a Study Site. Those lists are specific to the Sony DCR-VX 1000 digital camera, Light and Motion Stingray housing, and AquaMap™ SONAR system. A more generic list of suggested videography and diving equipment is as follows:

- Video Camera and accessories (batteries, tapes, lens, battery chargers)
- Camera housing and accessories (O-rings, O-ring grease, cotton swabs, distance aiming mechanism)

- Standard dive equipment and accessories
- Miscellaneous underwater equipment (slate, survey tapes, underwater paper, pencils, rubber bands)
- Laminated transect relocation photos and map for the site being sampled
- Navigation equipment and accessories (e.g., AquaMap™ system, GPS, waterproof bag, misc. lines, floats)
- Dive and boating safety equipment.

Startup costs and budget considerations

The Aquamap™ equipment costs about \$20,000. The video camera equipment and housing costs about \$10,000. Standard dive equipment costs about \$1000 per diver. 40 copper-clad stakes for marking start and end of transects at a single 20 transect site costs about \$720. Pinnacle software license is about \$200. Boat and maintenance are also required but costs and time are not included here.

Each sites of 20 transects take a team of 2 divers approximately 2 days to sample including filming, collect rugosity, urchin and disease data, and perform site maintenance. Non-video data entry can be accomplished in approximately 4 hours. Time requirements for components of the video protocol including data capture, entry, analysis, and archiving are detailed in the “SOP 1 - Using videography to monitor coral reefs.”

References

- Aggasiz A. 1883 Explorations of the surface fauna of the Gulf Stream, under the auspices of United States Coast Survey II. The Tortugas and Florida reefs. Mem. Am. Acad. Arts Sci. Centennial Vol. 2(1):107-132.
- Banks K., C. Beaver, J. Bohnsack, R. Dodge, D. Gilliam, W. Jaap, B. Keller, V. R. Leeworthy, T. Matthews, R. Ruiz-Carus, D. Santavy, R. Spieler. The State of Coral Reef Ecosystems of Florida. pp150-200. In J. Waddell (ed.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD. 522 pp.
- Brown B. (ed.), 1990. Special Issue: Coral Bleaching. Coral Reefs. 8:153-232.
- Bythell JC, Gladfelter EH, Bythell M. 1993. Chronic and catastrophic natural mortality of three common Caribbean reef corals. Coral Reefs 12: 143-152.
- CBE Style Manual Committee. 1994. Scientific style and format: The CBE manual for authors, editors, and publishers. 6th edition. Council of Biology Editors, Cambridge University Press, New York, New York.
- Clinton, W.J. 1998. Presidential Documents, Executive Order 13089 – Coral Reef Protection. Federal Register Vol 63, Number 115. (FR Doc. 98-16161) 32701-32703.
- Collette BB, Earle SA (eds.) 1972. Results of the Tektite Program: Ecology of Coral Reef Fishes. Natural History Museum, Los Angeles County, Science Bulletin 14. 180pp.
- Connell J.H. 1997. Disturbance and recovery of coral assemblages. Coral Reefs 16, Suppl.:S101-S113.
- Davis, A., C. Loomis, J. Miller, C. Rogers, R. Waara, and K.R.T. Whelan. 2007 Coral Reef Water Temperature Monitoring Protocol - Natural Resource Technical Report NPS/SER/SFCN/NRTR—2007/004. National Park Service, Miami, Florida.
- Davis G. 1982. A century of natural change in coral distribution at the Dry Tortugas: A comparison of reef maps from 1881 and 1976. Bull Mar Sci.32 (2): 608-632.
- Dickman, C. H. 2004. Mapping the distribution of *Acropora cervicornis* (Staghorn coral) and *Acropora palmata* (Elkhorn coral) for a reef monitoring program in Biscayne National Park, Florida. An internship report submitted to the faculty of the University of Miami Rosenstiel School of Marine and Atmospheric Sciences in partial fulfillment of the requirements for a the degree of Masters of Arts. Miami, Florida. December 2004.
- Dustan P. 1985. Community structure of reef building corals in the Florida Keys: Carysfort Reef, Key Largo and Long Key Reef, Dry Tortugas. Atoll Res. Bull. 288. 27pp.

- Edmunds P.J. 2002. Long term dynamics in coral reefs in St. John, US Virgin Islands. *Coral Reefs* 21:357-367.
- Ginsburg R.N. 1993. *Global Aspects of Coral Reefs: Health Hazards and History*. University of Miami. 420 pp.
- Gladfelter E. H., R. K Monahan, W.B. Gladfelter. 1978. Growth rates of five reef building corals in the northeastern Caribbean. *Bul Mar Sci* 28(4):728-734.
- Hallock P. 1997. Reefs and reef limestones in earth history. In C. Birkland (ed) *Life and Death of Coral Reefs*. International Thomson Publishing. 536pp.
- Hubbard D.K. 1997. Reefs as dynamic systems. In C. Birkland (ed) *Life and Death of Coral Reefs*. International Thomson Publishing. 536pp.
- Jaap, W. C. 1984. the ecology of the South Florida coral reefs: a community profile. US Fish and Wildlife Service Technical Report FWS/OBS-82/08. 138pp.
- Jaap, W. C. 1980. Stony coral community structure and species diversity at selected patch reefs within Biscayne National Monument. Technical report. Florida Department of natural Resources, Marine Research Laboratory, St. Petersburg, Florida. 50pp.
- Jaap, W.C., W. G. Lynos, P. Dustan, P. and G. C. Halas. 1989. Stony Coral (Scleractinia and Milleporina) community structure at Bird key Reef, Fr. Jefferson National Monument, Dry Tortugas, Florida. *Fla. Mar. Res. Publ. No. 46*. 31p.
- Jackson, J.B.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner, and R.R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293: 629-638.
- Johns, G. M., V. R. Leeworthy, F. W. Bell and M. A. Bonn. 2001. *Socioeconomic Study of Reefs I Southeast Florida, Final Report*. Broward County Environmental Protection Department, Technical Report 01-10.
- Lapointe, B. E. 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. *Limnology and Oceanography* 42(5):1119-1131.
- Lapointe, B. E. and P.J. Barile. 2001. Discrimination of Nitrogen Sources to Harmful Macroalgal Blooms on Coral Reefs off Southeast Florida. *Florida Institute of Oceanography*. 27pp.
- Lessios, H.A. and I.G. Macintyre (eds). 1997. *Proceedings of the 8th International Coral Reef Symposium*. Panama, June 24-29, 1996.

- Lewis, J. 2004. Has random sampling been neglected in coral reef faunal surveys? *Coral Reefs* 23:192-194.
- Miller J, C Rogers, Waara R. 2003. Monitoring the coral disease, plague type II, on coral reefs in St. John, US Virgin Islands. *Rev. Biol. Trop.*, 51, Supl. 4:47-55.
- Miller J., A. J. Atkinson, R. Waara, M. Patterson, A. Wright, B. Witcher, K. R. T. Whelan. 2006a. Trends Power and Sample Design. Lessons learned during 7 years of coral reef monitoring. Poster and oral presentation Ocean Sciences Meeting, Honolulu HI.
- Miller, J., E. Muller, R. Waara, C. S. Rogers. 2006b. Coral bleaching and disease combine to cause extensive mortality on reefs in US Virgin Islands. *Coral Reefs* 25:418.
- Nemeth, R. S. and J. Sladek-Nowlis. 2001. Monitoring the effects of land development on the near-shore reef environment of St. Thomas, USVI. *Bulletin of Marine Science*. 69:759-775.
- Nemeth, R. S., S. Herzlieb, M. Taylor, S. Herald and W. Toller. 2003. Coral reef monitoring in St. Croix and St. Thomas US Virgin Islands. Year 2 final report, submitted to Department of Planning and Natural Resources.
- Patterson, K.L., J.W. Porter, K.B. Ritchie, S.W. Polson, E. Mueller, E.C. Peters, D. L. Santavy, G.W. Smith. 2002. The etiology of white pox, a lethal disease of the Caribbean elkhorn coral, *Acropora palmata*. *Proceedings of the National Academy of Sciences*. 99(13):8725-8730.
- Phillips B. 2002. Coral Colony Monitoring, Buck Island Reef National Monument, USVI. Prototype protocol prepared for NPS and USGS. 21 pp.
- Porter, J. W. and O. W. Meier. 1992. Quantification of loss and change in Floridan reef coral populations. *American Zoologist* 1992 32(6):625-640.
- Porter, J. W. and O. W. Meier. 1995. Long Term Monitoring of the coral reef organisms of Biscayne National Park: Phases 2 and 3. Final report. 1993-1994 Field Seasons including Tropical Storm Gordon resurvey. Technical Report. Cooperative Agreement CA-5000-9-8020, University of Georgia, Athens, Georgia. 234 pages.
- Roberts, C.M. 1997. Connectivity and management of Caribbean coral reefs. *Science* 278: 1454-1457.
- Rogers, C.S. 1979. The effect of shading on coral reef structure and function. *J. Exp. Mar. Biol. Ecol.* 41:269-288.

- Rogers C.S., Suchanek T., Pecora F. 1982. Effects of Hurricanes David and Frederic (1979) on shallow *Acropora palmata* reef communities: St. Croix, USVI. Bull Mar Sci 32: 532-548.
- Rogers, C. 1990. Responses of coral reefs and reef organisms to sedimentation. Mar. Ecol. Prog. Ser. 62: 185-202.
- Rogers, C. 1991. Balancing adverse effects of marine-based tourism with marine resource protection in Virgin Islands National Park, St. John, U.S. Virgin Islands. In: Cambers, G. (ed.) Proc. of the Regional Symposium: Public and Private Cooperation in National Park Development. pg. 102-119.
- Rogers, C.S. 1993. Proposal for Inventory and Monitoring Programs: Virgin Islands National Park, Buck Island Reef National Monument, Dry Tortugas National Park. United States Department of the Interior / National Park Service, 49 pg.
- Rogers, C.S. 1997. Implementation Plan: Virgin Islands / South Florida Inventory & Monitoring Program. United States Department of the Interior / U.S. Geological Survey, 52 pg.
- Rogers, C.S., J. Beets 2001. Degradation of marine ecosystems and decline in fishery resources in marine protected areas in the US Virgin Islands. Env. Cons. 28(4):312-322.
- Rogers, C. S., D. Catanzaro. 2002 Conceptual Framework, Monitoring Components and Implementation of the Virgin Islands / South Florida Prototype Long Term Ecological Monitoring Program United States Department of the Interior / National Park Service, 66 pg.
- Rogers, C. S., G. Davis, C. McCreedy. 2007. National Parks and Caribbean Marine Reserves Research and Monitoring Workshop. NPS Water Resources Division Technical Report. NPS/NRWRD/NRTR-2007. 362 pp
- Rogers, C., Garrison, G., Grober, R., Hillis, Z-M., Franke, M.A. 1994. Coral Reef Monitoring Manual for the Caribbean and Western Atlantic. National Park Service. 100 pp. including photographs.
- Rogers, C., V. Garrison and R. Grober-Dunsmore. 1997. A fishy story about hurricanes and herbivory: seven years of research on a reef in St. John, US Virgin Islands. Proc. 8th International Coral Reef Symp 1: 555-560.
- Rogers, C. S., J. Miller 2001. Coral bleaching, hurricane damage, and benthic cover on coral reefs in St. John, US Virgin Islands: a comparison of surveys with the chain transect method and videography. Bull. Mar. Sci. 69(2):459-470.

- Rogers, C. S., J. Miller. 2006. Permanent 'phase shifts' or reversible declines in coral cover? Lack of recovery of two coral reefs in St. John US Virgin islands. *Mar. Eco. Prog. Ser.* 306:103-114.
- Santavy, D.L., J.K. Summers, V.D. Engle, and L. C. Harwell. 2005. The Condition of Coral Reefs in South Florida.2000. Using Coral Disease and Bleaching as Indicators. *Environmental Monitoring and Assessment* 100(1-3):129-152.
- Szmant, A. 1997. Nutrient effects on coral reefs: a hypothesis on the importance of topographic and trophic complexity to reef nutrient dynamics. *Proc. 8th Int Coral Reef Sym 2*: 1527-1532.
- Thompson, W. L., G. C. White, C. Gowan, 1998, *Monitoring Vertebrate Populations*, Academic Press, San Diego, CA, p. 181.
- Weil E. 2002. Coral disease epizootiology: status and research needs. Coral Health and Disease Workshop. Charleston, S.C. January 2002.

Appendix 1. Products associated with this protocol and SOPs

Journal Articles

- Rogers, C. 1999. Dead Porites patch reefs, St. John, US Virgin Islands. *Coral Reefs* 18:254.
- Rogers, C. 1999. Sampling May be Haphazardous to Your Reef Monitoring Program. Pages 57-64 In: (Maragos, J, and R, Grober Dunsmore, eds.) *Proc. of the Hawaii Coral Reef Monitoring Workshop*. June 1998. East-West Center and Hawaii Dept. of Land and Natural Resources.
- Rogers CS, Miller J (2001) Coral bleaching, Hurricane damage, and Benthic cover on coral reefs in St. John, U.S. Virgin Islands: A comparison of surveys with the chain transect method and videography. *Bull Mar Sci* 69:459-470
- Miller J, Beets J, Rogers C. (2001) Temporal patterns of fish recruitment on a fringing coral reef in Virgin Islands National Park, St. John, US Virgin Islands. *Bulletin of Marine Science* 69: 567-577.
- Miller J, Rogers C, Waara R (2003) Monitoring the coral disease, plague type II, on coral reefs in St. John, U.S. Virgin Islands. *Rev Biol Trop*, 51 Sup 4:47-55
- Rogers CS, J Beets. (2001) Degradation of marine ecosystems and decline of fishery resources in marine protected areas in the US Virgin Islands. *Environmental Conservation* 28: 312-322.
- Rogers CS, J Miller. (2001) Coral bleaching, hurricane damage, and benthic cover on coral reefs in St. John, US Virgin Islands: a comparison of surveys with the chain transect method and videography. *Proc. of National Coral Reef Institute Conference*. April 1999. *Bulletin of Marine Science* 69: 459-470.
- Menza C., M. Kendall, C. Rogers & J. Miller. 2007. A deep reef in deep trouble. *Continental Shelf Research* 27: 2224-2230.
- Monaco M. E., A. M. Friedlander, C. Caldow, J. D. Christiansen, C. Rogers, J. Beets, J. Miller and R. Boulon. 2007. Characterizing reef fish populations and habitats within and outside the US Virgin Islands Coral Reef National Monument: a lesson in marine protected area design. *Fisheries Management and Ecology*, 14:33-40.
- Whelan, K. R.T., J. Miller, O Sanchez, and M. Patterson. 2007. Impact of the 2005 coral bleaching event on *Porites porites* and *Colpophyllia natans* at Tektite Reef, US Virgin Islands. *Coral Reefs*

Presentations

Miller, Jeff. October 2005. Is the coral disease White Plague killing Tektite Reef in V. I. National Park. Estuarine Research Foundation. Norfolk, VA.

Miller, Jeff. December 2005. Reef Life within Virgin Islands National Park. Friends of VINP, Board of Directors. St. John, VI.

Miller, J., M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright. 2005. Trends, Power and Sample Size: lessons learned from seven years of coral reef monitoring. Ocean Sciences Meeting. Honolulu HI.

Miller, Jeff. January 2006. Episodic Monitoring for Coral Bleaching in Virgin Islands NP and Buck Island Reef NM. NOAA Bleaching Workshop. St. Croix VI.

Miller, Jeff. January 2006. Reef Life within Virgin Islands National Park. VINP Law Enforcement Training. St. John VI.

Miller, Jeff. February 2006. Trends, Power and Sample Size: Lessons learned from seven years of coral reef monitoring. Ocean Sciences Meeting. Oahu HI.

Miller, J., R. Waara. 2006. Episodic Monitoring for Coral Bleaching in Virgin Islands NP and Buck Island Reef NM. NOAA Bleaching Workshop. St. Croix VI.

Miller, Jeff. 2006. Hot Topics: Coral Bleaching in the USVI. National I&M Meeting. San Diego CA.

Miller, Jeff. 2006. March 2006. SFCN Benthic Monitoring Program "What data is collected, method used and location." BUIS Coral Research Workshop. St. Croix VI.

Miller, Jeff. 2006. April 2006. Coral Crisis in US Virgin Islands National Parks. NBC Nightly News. Palmetto Bay, FL

Miller, Jeff. 2006. April 2006. Invited panel guest for 60 min radio call-in talk program on coral bleaching. Radio Interview, WVWI. St. Thomas.

Patterson, M., W. J. Miller. May 2006 Coral Crisis in the U.S. Virgin Islands National Parks. Presentation at NPS WASO Office, Ft. Collins, CO.

Miller, Jeff. 2006. May 2006. Coral Crisis in US Virgin Islands National Parks. SERO Interpretive Staff Briefing with regional Director Pat Hooks. Atlanta GA.

Miller, Jeff. 2006. May 2006. Coral Crisis in US Virgin Islands National Parks. SERO Interpretive Staff (and others) Briefing. Atlanta GA.

- Miller, Jeff.. 2006. May 2006. Coral Crisis in US Virgin Islands National Parks. Eye Street Briefing. Washington DC.
- Miller, Jeff. 2006. May 2006. Coral Crisis in US Virgin Islands National Parks. NPS Briefing to Director Mainella, Deputy Director Wright, Associate Director for Natural Resource Stewardship and Science, Mike Soukup. Washington DC.
- Miller, Jeff. 2006. May 2006. Coral Crisis in US Virgin Islands National Parks. Coral Reef Task Force Meeting. Washington DC.
- Miller, Jeff. 2006. June 2006. Coral Crisis in US Virgin Islands National Parks. Briefing to USVI Congressional Delegate Christian-Christensen. St. John VI.
- Miller, Jeff. June 2006. Coral Crisis in US Virgin Islands National Parks. Rotary Club Meeting. St. John VI.
- Miller, Jeff. July 2006. Invited panel guest for 20 min radio call-in talk program on coral bleaching. Radio Interview KMUD - Center for Biological Diversity. Sacramento CA.
- Miller, Jeff. July 2006. Research and Monitoring: Evolution, Methods and Case Studies. Marine Protected Area Worskshop. St. John VI.
- Miller, Jeff. August 2006. Coral Crisis in US Virgin Islands National Parks. Fisheries Management Council. St. Croix VI.
- Miller, Jeff. September 2006. Coral Crisis in US Virgin Islands National Parks. Natural Areas Association Meeting. Flagstaff AZ.
- Miller, Jeff. September 1997 – April 2006. The Living Reef. Weekly talk at St. John Eco-Resort, Maho Bay Camps. St. John VI.
- Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. SERO Briefing with Regional Director Hooks. Atlanta GA.
- Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. SERO Interpretive Staff (and others) Briefing. Atlanta GA.
- Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Eye Street Briefing. Washington DC.
- Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. NPS Briefing to

Director Mainella, Deputy Wright, Soukup. Washington DC.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Coral Reef Task Force Meeting. Washington DC.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Briefing to USVI Congressional Delegate Christian-Christensen. St. John VI.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Rotary Club meeting. St. John VI.

Miller, J. 2006. Research and Monitoring: Evolution, Methods, and Case Studies. Marine Protected Area Workshop. St. John VI.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Caribbean Fisheries Management Council. St. Croix VI.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2006. Coral Crisis in US Virgin Islands National Parks. Natural Areas Association Meeting. Flagstaff AZ.

Miller, J. C. Rogers, R. Waara. 2005. Is the coral disease White Plague killing Tektite Reef in V.I. National Park. Estuarine Research Foundation. Norfolk VA.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2007. Coral bleaching and disease combine to cause extensive mortality on reefs in US Virgin Islands. Presentation to the US Coral Reef Task Force. October, 2006. St. Thomas, US Virgin Islands.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2007. Coral bleaching and disease combine to cause extensive mortality on reefs in US Virgin Islands. Presentation during the Virgin Islands Environmental Research Station 50th anniversary workshop. October, 2006. St. John, US Virgin Islands.

Miller, J., E. Muller, M. Patterson, A. Atkinson, J. Patterson, R. Waara, K. Whelan, B. Witcher, A. Wright, C. Rogers. 2007. Coral bleaching and disease combine to cause extensive mortality on reefs in US Virgin Islands. Presentation to selected members of Friends of Virgin Islands National Park and visiting dignitaries. March 2007. St. John, US Virgin Islands.

- Spitzack, T., J. Miller, E. Muller, R. Waara, A. Wright, A. Atkinson, K. Whelan, M. Patterson, J. Patterson. (2007) Coral bleaching and disease combine to cause extensive mortality on reefs in US Virgin Islands. Presentation during the meeting of Associated Marine Labs in the Caribbean. June 2007. St. Thomas, US Virgin Islands.
- Patterson, Matt, Andrea. Atkinson, Brian. Witcher, Kevin R. T. Whelan, Alexandra Wright, Judd Patterson, Jeff Miller and Rob Waara. June 5-9, 2006. "*Selection of Vital Signs for the National Park Service's South Florida/Caribbean Inventory and Monitorin Network*". 2006. Greater Everglades Ecosystem Restoration (GEER) Conference, Lake Buena Vista, Florida.
- Patterson, M., A. Atkinson, R. Waara, B. Witcher, J. Miller, A. Davis. 2007. Reef Monitoring in Dry Tortugas National Park – then and now. Presentation to the NPS DRTO Staff on board the MV Fort Jefferson.
- Miller, J., K. Brady. 2007 Reef Ecology update in the USVI. Presentation to Senator Jay Rockefeller and VI Friends Board of Directors. March 2007. St. John US Virgin Islands.
- Miller, J. 1996. Reef Life. Weekly presentation at Maho Ecocamp from October 1998 - April 2007.
- Whelan, Kevin R. T., Jeff Miller, Rob Waara, Chisty Loomis, and Matt Patterson. February 20-24, 2006. "Long-term temperature record for four United States Virgin Islands reefs". 2006 Ocean Sciences. Honolulu HI.

Posters

- Santavy DL, Summers JK, Engle VD, Harwell LC (2005) The condition of coral reefs in south Florida (2000) using coral disease and bleaching as indicators. *Environ Monit Assess* 100:129, 152
- Miller, Jeff, Andrea J. Atkinson, Rob Waara, Matt Patterson, Alexandra Wright, Brian Witcher, Kevin r. T, Whelan. Feb 20-24, 2006. Trends, Power and Sample Size: Lessons learned from seven years of coral reef monitoring. Ocean Sciences Meeting. Oahu HI.
- Whelan, K. R. T., J. Miller, R. Waara, C. Loomis, and M. Patterson. 2006. Long-term temperature record for four United States Virgin Island Reefs. Ocean Sciences Meeting, Honolulu, Hawaii.
- Miller, J., R. Waara, A. Atkinson, B. Witcher, M. Patterson, K. Whelan, A. Wright, T. Spitzack, E. Muller, C. Rogers B. Schill. (2006) Collaboration in monitoring coral reef ecosystems in the US Virgin Islands. Presentation during the US Coral Reef Task Force meeting (poster). October 2006. St. Thomas, US Virgin Islands.

Pamphlet

Jeff Miller and Kristen Maze. (2006) Look below before you throw. Boater Education and Outreach campaign developed interpretative materials for rental boats as guide to safe anchoring practices. Oct. 2006.

Miscellaneous. Publications

Jeffrey, Christopher F. G., Ursula Anlauf, James Beets, Sherri Caseau, William Coles, Alan M. Friedlander, Steve Herzlied, Zandy Hillis-Starr, Matthew Kendall, Violeta Mayor, Jeffrey Miller, Richard Nemeth, Caroline Rogers, and Wesley Toller. 2005. The State of Coral Reef Ecosystems of the U.S. Virgin Islands. Pp. 45-83. In: J. Waddell (ed.), The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD. 522 pp.

Miller, Jeff and Matt Patterson. Coral Bleaching and Coral Disease: A damaging combination for reefs in Virgin Islands National Park. NPS Natural Resource Year in Review – 2005. April 2006. PP 88-89.

Miller J., C. Rogers, B. Schill, M. Patterson. 2006 Coral Bleaching and Disease Deliver “One-Two Punch” to Coral Reefs in the US Virgin Islands. Department of Interior Fact Sheet for US Coral Reef Task Force meeting.

Jeff Miller 2006 Boater Education Outreach Project. Article written for the 2007 St. John Telephone directory. Caitlin Slodden editor. 198pp.

Jeff Miller 2007 Reef Life. Article contribution to the 2007-2008 Cruising Guide to the Virgin Islands – 13th Edition. Cruising Guide Publications by Nancy and Simon Scott. 344pp.

Braasch G. 2007. Earth under fire. Interview and data provided for book. University of California Press. Berkeley CA. 267 pp.

Standard Operating Procedure 1: Using Videography To Monitor Coral Reefs

Version 1.03 (4/15/2005)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.
1.00	10/16/2003	J. Miller	Expand section	Provide more detail	1.01
1.01	11/2/2004	J. Miller	Include steps for Capture with Studio Pinnacle 9	Sony capture board doesn't work with newer operating systems. Needed capture program option compatible with newer operating systems.	1.02
1.02	4/15/2005	J. Miller	Expand section	Provide more options to adjust image resolution	1.03



Using Videography To Monitor Coral Reefs



U.S. Department of the Interior
U.S. Geological Survey
Florida Caribbean Science Center



U.S. Department of the Interior
National Park Service
Virgin Islands National Park

Using Videography to Monitor Coral Reefs

Prepared by:

Jeff Miller

National Park Service

Virgin Islands National Park

Caroline Rogers

US Geological Survey

St. John, USVI

June 2002

~~~~~

One of a series of monitoring protocols prepared for the Florida Caribbean Science Center  
under the auspices of the Caribbean Field Station, St. John, USVI

**U.S. Department of the Interior**

**U.S. Geological Survey**

## **Acknowledgements**

We'd like to acknowledge and thank the many people that helped bring this protocol alive: Rich Aronson, Elena Astilleros, Winnie Batch, Ed Beaty, Don Catanzaro, Ries Collier, Marcia Creary, Bob Dorazio, Steve Hertzberg, Dennis Hubbard, Karla Hubbard, Marco Flagg, Maryann Franke, Nick Funicelli, Ginger Garrison, Andy Goldstein, Walt Jaap, Judy Lang, Ellen Link, Dulcie Linton, Steve Miller, Thad Murdock, Matt Patterson, Jim Petterson, Brendalee Phillips, Laura Plaut, Kaf Smith, William Stelzer, Rob Waara, Leslie Walling, and Jeremy Woodley.

# Using Videotape to Sample Coral Reefs

## Overview

|                                 |   |
|---------------------------------|---|
| ■ Summary of Protocol .....     | 3 |
| ■ Time requirements .....       | 4 |
| ■ Materials and equipment ..... | 5 |

## Video Equipment Preparation and Handling

|                                                 |   |
|-------------------------------------------------|---|
| ■ Charge the batteries.....                     | 6 |
| ■ Prepare the video housing .....               | 6 |
| ■ Prepare the camera .....                      | 8 |
| ■ Put the camera in the housing .....           | 9 |
| ■ Using the camera settings and functions ..... | 9 |

## Field Activities

|                             |    |
|-----------------------------|----|
| ■ Marking the transect..... | 11 |
| ■ Filming the transect..... | 12 |
| ■ Post-dive tasks.....      | 13 |

## Viewing and Cataloging the Videotapes

13

## Capturing the Video Images

### Using Sony Still Image Capture Board

|                                               |    |
|-----------------------------------------------|----|
| ■ Manual versus auto capture.....             | 14 |
| ■ Storing the captured video images .....     | 15 |
| ■ Starting the capture process .....          | 16 |
| ■ Using the manual capture method.....        | 16 |
| ■ Renaming and exporting the image files..... | 18 |

### Using Pinnacle Studio 9 (modification added 11/2/04)

|                                                                             |           |
|-----------------------------------------------------------------------------|-----------|
| ■ Assemble the components.....                                              | <u>19</u> |
| ■ Capture images.....                                                       | <u>19</u> |
| ■ Rename images after capture .....                                         | <u>21</u> |
| ■ Option to resize and auto-level adjust (modification added 4/15/05) ..... | <u>27</u> |
| ■ Create JPEG from BMP.....                                                 | <u>29</u> |

## Using Adobe Photoshop

|                                  |    |
|----------------------------------|----|
| ■ Setting the scratch disk.....  | 31 |
| ■ Modifying the *.ini file ..... | 32 |
| ■ Loading the actions file.....  | 32 |

## Random Dot Processing Setup

|                                        |    |
|----------------------------------------|----|
| ■ Launch Randomplot.....               | 33 |
| ■ Evaluate size and position.....      | 33 |
| ■ Adjust the size of the plot.....     | 34 |
| ■ Adjust the position of the plot..... | 35 |
| ■ Confirm plot size and position ..... | 36 |

|                                                                     |           |
|---------------------------------------------------------------------|-----------|
| Automating the Dotting Process                                      |           |
| ■ The WinBatch script .....                                         | 37        |
| ■ File management .....                                             | 37        |
| ■ Dotting a batch of captured images .....                          | 38        |
| ■ Backup and long-term data storage .....                           | 39        |
| Substrate Identification and Data Entry                             |           |
| ■ Using MS Excel .....                                              | 40        |
| ■ Setting up the data entry worksheet .....                         | 41        |
| ■ Opening files in Adobe Photoshop .....                            | 41        |
| ■ Entering the data .....                                           | 42        |
| ■ Checking the data .....                                           | 43        |
| Data Summaries and Analysis                                         |           |
| ■ Individual transect data .....                                    | 44        |
| ■ Site data .....                                                   | 44        |
| ■ Documenting transect analysis and file locations .....            | 45        |
| ■ Printing transect data and results tables .....                   | 45        |
| ■ Statistical analyses .....                                        | 46        |
| Guide to Substrate Identification                                   |           |
| ■ Major categories .....                                            | 47        |
| ■ Distinguishing between dead coral with algae and macroalgae ..... | 48        |
| ■ Finding the center of the dot .....                               | 48        |
| ■ Category definitions .....                                        | 48        |
| <b>APPENDICES</b>                                                   |           |
| A. Identification Codes for Benthic Components .....                | 54        |
| B. Glossary of Terms .....                                          | 57        |
| C. Creating Laminated Photos for Transect Relocation .....          | 61        |
| Using Sony Still Image Capture program .....                        | <u>56</u> |
| Using Pinnacle Studio 9 (modification added 10/16/03) .....         | <u>57</u> |
| D. Photos illustrating components of protocol .....                 | <u>60</u> |

## Before Getting Started

Four of the components needed for this protocol can be most efficiently transferred to other users electronically. They will be available on a disk, on a web site, or by e-mail to those wishing to use them. They have been scanned for viruses. To receive them, please contact the authors.

- Randomplot.xls: A Microsoft Excel worksheet containing a macro that generates random points.
- Video Methods.atn: A file containing a set of automatic scripted actions to be loaded into Adobe Photoshop.
- Lola.wbt: A script written for the software program WinBatch for Windows to automates the dotting process.
- Dataentry.xls: A Microsoft Excel worksheet that automatically groups, tabulates, and summarizes video dot analysis data.

This protocol is designed for use on IBM-type computers. Those needing information regarding a Macintosh-based version of this protocol should contact the authors.

### **Disclaimer**

This protocol provides details for each aspect of monitoring coral reefs using videotape. The methods and materials described in this protocol are not the only means to accomplish this monitoring. Other cameras, housings, software, and techniques may be substituted to meet the needs of a particular situation. The use of brand names such as Sony, Adobe Photoshop, Light and Motion, WinBatch, and AquaMap is not meant to be nor should it be taken as an endorsement or recommendation of a product, software or service. The authors believe the inclusion of explicit and detailed instructions for specific equipment will be valuable for those using the same or similar products.

## **Protocol Overview**

Given the constraints of scuba diving, photography provides the most practical means of sampling large areas underwater. While still photographs offer better resolution than video images, the high-resolution video technology now available is adequate for monitoring benthic cover on coral reefs, the objective of this protocol, and videotaping is easier and faster than still photography. A diver needs to be adept at buoyancy control to produce quality video images, but a proficient videographer can cover a far greater area per unit sampling effort than does a still photographer. In addition, video exposures can be automatic, continuous, and do not require developing.

In this method, the diver uses a high-resolution digital video camera fitted with a wide-angle lens and an underwater housing. The diver videotapes while swimming slowly (~30

seconds per meter) along the transect holding the camera perpendicular to the substratum from a height of ~40 cm, producing a “swath” or belt transect that is ~ 40 cm wide. Back in the office, the videotape is viewed to make sure that the clarity and resolution are satisfactory, then catalogued to archive the raw footage. A computer is connected to either the camera or a separate videotape player and the tape is played to “capture” adjacent, non-overlapping frames as still images. In this way, each transect is depicted by a number of unique frames, or video “quadrats,” which are converted to photo files and saved in a computer folder. Random dots are placed on each frame during a process that uses Microsoft Excel and Adobe Photoshop and is automated by WinBatch for Windows, a batch-processing program. After the images have been processed, an analyst identifies the benthic components under the random dots while viewing the frames in Adobe Photoshop. These data can be used to calculate percent cover of substratum categories. Throughout this protocol, these icons are used:



Activities generally done on dry land, usually requiring a computer.



Activities done at the study site, mostly underwater.



A specific step in carrying out the protocol.



Tips to keep you on track.



Precautions to help protect your life, your equipment, or your data.

## ***Time Requirements***

- Videotaping requires ~5 minutes of bottom time per 10-meter transect, plus the time needed for transect location and set-up. Ten 10-meter transects can be filmed during a typical dive (60 to 75 minutes bottom time) using one battery and videotape (digital tapes and batteries last approximately 60 minutes). However, if you are using AquaMap™ to locate sample points, you will probably complete no more than five transects per dive.
- The dotting process requires ~20 minutes per 100 frames, but it is automatic and can be run after hours or at other times when the computer workstation is not in use.
- For image analysis (identification of substrate under random points) and data entry, ~45 to 60 minutes are needed per 10-meter transect.

The time invested in this process, and the cataloging and archiving of the data and tapes, can provide statistically significant comparative data that will be useful for many years.

## ***Materials and Equipment***

This section describes preparation of the necessary equipment, not including standard dive equipment. It is meant to augment, not replace, the manufacturer's instructions.



- Camera and accessories
  - Video camera, mounted on a camera tray
  - Mini digital video cassette tapes for camera
  - Video batteries (charged)
  - Sony AC-V515 AC power adapter/battery charger
  - Zoom-macro diopter
  - Sony DCR-VX1000 digital vi
  - Dry bag to store items



- Housing and Accessories
  - StingRay (Light & Motion brand) underwater camera housing
  - Distance aiming wand (~70 cm)
  - Straps fastened around housing to hold distance aiming wand
  - Lens cap
  - Silicone grease
  - Cotton Q-tip swabs
  - Supplies and equipment for using AquaMap (see AquaMap protocol)



- Miscellaneous underwater equipment
  - Video slate (Magnadoodle type), with pen/pencil attached
  - 25-50m fiberglass survey tapes (as needed, depending on the site) on a plastic reel with metric units shown on at least one side
  - Optional: clipboards, mylar, pencils, rubberbands
- Computer hardware
  - Minimum requirement: 400 MHz processor with 128MB RAM and 2 partitioned hard drive
  - Video capture board (we use Sony DVBK-2000; Sony boards are the only ones we know of that can capture still images rather than video segments and have other needed software features)
- Computer software
  - Adobe Photoshop (5.0 or higher)
  - MS Excel
  - WinBatch for Windows (download from a WinBatch CD or from the Internet at [www.winbatch.com](http://www.winbatch.com))
  - Windows 95 or 98 (Unfortunately, as of 2001 the driver for the Sony capture board has not been updated to work with later versions of Windows)

## Video Equipment Preparation and Handling

*(See the StingRay instruction manual for more details)*

The sealing system for the video housing uses 6 o-rings: 2 rear plate o-rings (red) for use during storage; 2 rear plate active-use o-rings (black); and 2 active-use o-rings under the front optic port (black). The storage o-rings allow partial sealing at atmospheric pressure.



The storage o-rings should never be used when the housing is submerged. However, if the active-use o-rings for the rear plate are used during storage for more than a month, they may become flattened and are more likely to fail when submerged.

### *Charge the batteries.*

The day before the dive, charge the video batteries. Even if you charged the batteries after the last use, it's a good idea to "top" them off. If the batteries have sat for awhile since they were last charged, they may discharge more quickly during use. For example, while batteries and mini-cassettes both last ~60 minutes, a charged battery that has sat for several days may provide power for only 45 to 50 minutes. According to information provided with the batteries, topping off a partially charged battery does not affect its life or memory. Batteries with a green tab exposed are fully charged.

The camera uses a lithium battery which should last about three years. Change this battery every other year to ensure consistent operation of the camera. If the battery happens to fail in the field, the camera will not work. When battery is replaced, you must reset the clock so that the camera to record the proper time code.

### *Prepare the video housing.*

- Remove the back plate from the video housing by rotating the black cam mechanism counter-clockwise.
- Use your fingers or a blunt wooden object (never a sharp or pointed object) to remove the two red storage o-rings from the grooves in the back housing plate.
- Use cotton swabs to clean the grooves of the back housing plate and the o-ring sealing surface that is located at the very back of the camera housing.
- Clean the two black active-use o-rings. Inspect the o-rings for any nicks or signs of wear. Replace with new o-rings, if necessary.
- Apply a dab of silicone grease on your thumb and index finger and rub it onto the active-use o-rings. Use enough silicone to make the o-rings shiny, but not so much that gobs of silicone that will catch debris.
- Inspect the o-rings again for any imperfections or any dirt, lint or hair that may adhere to them. The silicone is not intended to prevent water from getting past the o-ring; it just maintains the o-ring's flexibility so it can change shape in the groove, creating a barrier to the water.
- The two o-rings on the front optic are less subject to wear and tear than those on the rear plate, but they also need to be inspected periodically and cleaned if necessary, i.e., after approximately every 10 uses. See the following section for basic instructions or refer to the video housing instructions for more details.

### Inspecting and Cleaning the Front Housing

There are three places in the front housing to inspect and clean: the o-rings, the grooves into which the o-rings fit, and the sealing surface.

- 1) Position the housing vertically so that the “*Light & Motion*” logo is at the bottom (6:00) as you look into the front port.
- 2) Place your thumb on the black slider mechanism, to the left (at 9:00) of the optic, and move it left.
- 3) Rotate the optic clockwise until it stops (~90 degrees).
- 4) Pull the optic out from the housing.
- 5) Hold the housing so that you may focus your attention on the front view port.
- 6) Inspect the black active use o-rings and the sealing surface on the front of the housing for wear or any foreign matter. If necessary, remove and clean the o-rings, o-ring grooves, and sealing surface, and lubricate it with silicone. You can apply pressure with your fingers to cause a bubble or bend in the o-ring, and then slip it out of its groove.



**Never use a sharp or pointed object to remove an o-ring.**

- 7) When the cleaning and lubricating is completed, replace the o-rings into their grooves.
- 8) This is a good time to clean the inside of the front view port and the red filter if necessary (see page 10 for details on the red flip filter). Use a soft, clean, dry cloth, taking care not to rub any silicone onto the lens or filter. Spots on these surfaces may cause the camera to focus on the dirty lens.
- 9) Apply a thin film of silicone to the o-ring surface area and the sealing surface on the front of the housing. This will allow the black view port to slide more easily when re-installing.
- 10) Place the optic into the opening on the housing until it seats into place. There are three orientations for the optic, all of which permit it to be installed correctly. This is best observed by rotating the optic until it partially “drops” into the front plate.
- 11) Once the optic is seated, push it into the housing to fully seal it and allow it to turn. This may require some force because you are engaging a bayonet-type bore seal on the optic.

- If you are using an aiming rod to keep a constant distance from the substrate, place the straps that hold the rod around the housing, checking to make sure that you can access the camera switches without interference from the straps. Slide the aiming rod under the straps and gently tighten them so that the end of the rod is 40 cm from the front of the lens optic of the housing.

*Prepare the camera.*

- Install a battery in the back of the video camera near the bottom left. The battery compartment door will pop open when you press the release button. Align the battery and slide it into the battery compartment. The battery is held in by the release clip on the back, left side of the battery compartment. The compartment door will click shut when closed properly.

👉 The battery is spring loaded. It will pop out of the compartment when you press and slide the release clip in the direction of the arrow.

- Clean and press the Zoom-Macro diopter onto the front of the camera. This is used to get the full optical properties from the camera. (See the housing instructions for more details.)
- The tray that attaches the camera to the housing also transfers the camera switch features to the housing switches. Connect the three wires from the camera tray to the video camera:
  - The remote/lanc cord is a thin black wire with a plastic probe that travels under the battery compartment door, between the bottom of the camera and the camera tray. It connects to the back upper right hole, labeled “lanc” that has a light blue ring around the fitting. (Remove the semi-triangle-shaped plastic cover if necessary.)
  - *The video-out cord* is a thicker, gray cord with a heavy RCA-type male connector. It runs under the battery compartment door, along the right side of the camera, under the hand strap, and into the yellow RCA fitting on the upper right front of the camera. (Remove the gray plastic cover if necessary.)
  - *The DC-in cord* is a thick black wire with a heavy black plastic connector that has a modified “T” 4-pin probe. It runs along with the video out cord, under the hand strap, to the upper right front of the camera, into the black rectangular connection. You can see the female mate of the modified “T” with 4 pins connection.

👉 All cables should be snug to the camera so that the camera can slide easily into the housing. They should not obstruct the sliding track guide that is located on the sides of the camera tray. You don't need to remove the cables and tray when the camera is not in use.

- Check the camera settings.
  - **Focus:** For filming video transects, we've found it best to use auto focus (the camera selects what to focus on) rather than manual (the operator selects the focus point). You can change from auto to manual focus and vice versa after you're in the water using a switch on the camera housing.
  - **Focal distance:** Set to full wide angle.
  - **Exposure:** We've found it best to use automatic, which allows the camera to select the shutter speed and iris (lens opening). For information about other options, see the camera manual.
  - **Power switch:** Move from OFF to CAMERA.
  - **Option switch:** Move to STANDBY.

### *Put the camera in the housing*

- Before putting the camera and tray in the housing, make sure the camera settings have been adjusted as specified above, a tape is in the camera, and the battery is fully charged.
- Loading the camera: The camera tray is contoured at the front to ease loading. Place the front of the tray into the housing and push on the back of the camera until it docks to the front housing. You can tell when it is properly docked because you will not be able to push it any farther, nor will you be able to pull it out, for the small latch at the bottom left of the tray will be engaged.
- Installing the rear plate: You can install the plate with the housing resting horizontally on a table, but you may find it easier to stand the housing on the end containing the front optic, first checking to make sure that the red lens cap is in place and the o-rings are lubricated and clean.
  - Place the housing in the desired position and align the pins from the back plate with the holes in the camera tray.
  - Make sure the latches are rotated to expose the tracks on their underside. Simultaneously, rotate both latches in toward you a full 270° or until you hear a “snap”. This signals that the plate is fully seated. Both o-rings should be inside the tube and the latches should be parallel to the length of the tube. Engaging the latches together ensures a snug fit and decreases the chance the rear plate gets cocked to one side.
  - Inspect around the entire rear plate to ensure the o-rings are properly sealed.

### *Using the camera settings and functions.*

For this protocol, we use the camera primarily in the “point-and-shoot” mode. That way, instead of manipulating camera functions the diver can concentrate on camera orientation, buoyancy control, and swimming along the transect at a consistent speed, air, depth, and bottom time, etc. Camera operators should be familiar with the housing switches as they are described in the manual and below. To protect the lens from scratches or other damage, leave the housing’s lens cap in place (on the front of the housing) until you are ready to film the slate, then replace it after completing the transect swim-back.

Once the camera is in the housing, all functions are controlled by four switches that can be pushed to the right or left. Depending on what you are trying to do, the switch may need to be held in place for several seconds and then released, or toggled back and forth.

#### • **Power and record/standby**

- **PWR:** To turn on the camera, hold this switch at the PWR position until the camera powers up. This may take 2-5 seconds. It will take another 5 seconds before the camera responds to any commands.

To turn the camera off, hold the switch at PWR for ~5 seconds before releasing. The camera will then begin its power down routine, which may take a few seconds.

- **REC/STBY:** To start recording after the power is on, toggle the switch, i.e., slide it to the REC/STBY position and release it. You can tell the camera is in recording mode by the red dot and the "REC" in the viewfinder.

To stop recording and return to standby mode, toggle the switch again. You can toggle between “record” and “standby” at any time.



As a battery saving feature, the camera turns itself off after it's been in standby mode for three minutes. Check in the viewfinder to make sure you're in the right mode.

- **Zoom**

This feature is not needed for purposes of videotaping benthic transects, where you are trying to maintain a constant focal distance from the substrate. But the camera housing does permit you to zoom in on a subject (telephoto) by holding this switch in the “T” position or zoom out (wide angle) by holding it at “W”. As soon as you release the switch, the camera will stop zooming. Remember, the camera needs to be set to full wide angle during perpendicular transect filming.

- **Auto focus and white balance**

- **AF:** If the camera has been set on manual focus, you can hold this switch in the “AF” position to put the camera in “momentary” auto focus. When you release the switch, the camera will return to manual focus. To put the camera into “full-time” auto focus, toggle the PWR switch. (If you hold the PWR switch in place, the camera will shut off.)
- **WB:** By sliding this switch to the “WB” position and releasing it, you can toggle through the various white balance settings, which are used to normalize the color of light reaching the lens after striking a surface. Due to the light absorption qualities of water (and since this protocol does not include the use of lights), the white balance should be left on automatic. If no icon is visible in the upper-left corner of the viewfinder, you are in auto mode.

- **Focus**

The focus switch works in the same manner as the zoom switch, but it controls the focus of the camera lens. If the camera is in auto focus, sliding this switch in either direction (“N” for near or “F” for far) will automatically change the camera to manual focus mode. To get back to auto focus, toggle the PWR switch.

👉 If using the auto focus setting while pointing the camera at an object more than 3 to 4 meters away, the camera may try to focus on the particles in the water. To prevent this, either get closer to the subject, point the camera at a closer subject, or use manual focus.

- **Red flip filter**

The deeper you go in the water, the greater the loss of perceptible color, with the red wavelengths lost first. At some point below about six meters, you may find that using the camera’s internal red filter restores red tones to a more “natural” level relative to blue tones. The filter is attached to a knob on the outside of the housing in the front plate. Rotating the knob up moves the filter in front of the optic; rotating the knob down moves it out of position. To determine if the filter is necessary, look through the viewfinder with and without the filter, and decide which looks more natural. If you're going to use the filter, make a note on the underwater slate before you start filming the transect to record that the coloration was altered.



## Field Activities

This protocol assumes that you've already determined which transects you are going to videotape and are using AquaMap (as described in the AquaMap protocol) or some other method to locate the transects. After marking the first transect at the site with a survey tape, you start by filming an underwater slate that identifies the transect, then film the transect itself with the camera oriented 40 cm from and perpendicular to the bottom. At the end of the transect, the filming continues at an oblique view as you swim back to the starting point.



Do not make a force-full entry (e.g., back-roll or giant stride entry) into the water while holding the video housing, which may force water past the o-rings. Instead, have the housing handed to you or reach into the boat to retrieve it after you are in the water.

### Using Laminated Photos to Relocate a Transect

Depending on the objectives of your monitoring program, you may want to re-film the same transects over time. (See “Tracking changes on a reef in the US Virgin Islands with videography and SONAR: a new approach” by Rogers *et al.* for a discussion of re-sampling the same transects versus selecting new transects each monitoring period.) Photo captures from the initial filming that have been laminated for use underwater can be helpful in relocating a transect on subsequent dives and accurately lay the transect in the same position even if the transect has been fixed using survey pins or monument structures. For an explanation of the photo capture and lamination process, see Appendix C.

## Marking the Transect

To mark the transect, you will need a fiberglass survey tape with a string leader attached to the free end so that you can secure it to the substrate. After locating the start of the transect:

- Use the string to attach the free end of the tape to a non-living bottom feature as close as possible to the start of the transect so that you can begin filming at the 0 meter point. Take care to avoid injury to any living organisms.
- Run the tape along the designated bearing for the selected transect distance, i.e., 10 meters. However, you may need to extend the tape beyond this distance to find suitable substrate for securing or tying off the tape. There may be gaps where the tape is not flat against the bottom because of bottom contours, but make sure the tape is straight and taut (not moving in the surge/current), and as close to the bottom as possible. It should not entangle, bend, or abrade gorgonians, sponges or other living creatures. It will make your work easier if the tape is metric side up, but this is not necessary.
  - ✦ Re-swim the transect to assure the tape is aligned properly. Time spent carefully laying the tape will pay off later in better video images and easier analysis.
- It's essential to mark the end point of the transect (i.e., the 10m point on the transect line), so that it can be easily identified in the videotape, especially if you have tied off the tape beyond the end of the transect. To indicate the end of the transect, use a marker

to blacken that point on the survey tape (a 2-5cm section, so that it will show up on the videotape) or tie a *small* piece of flagging tape at that point. (A large piece of flagging tape may obscure benthic components when the videotape is analyzed.)

## **Filming the Transect**

Assuming that you've entered the water with a video slate and a loaded and fully-charged video camera in its housing with active use o-rings in place, the aiming rod attached, and the lens cap removed, you are ready to begin filming. If you plan to use captured photos from the videotape to help relocate the transect on future dives, take special care to film the transect origin and terminus and to include identifying features.

- To identify the transect, write the following information on the slate in large letters.
  - date
  - site name
  - transect number
  - if a red filter is being used
  - depth
  - videographer name or initials



Filming legible data on the slate is vital. When the tape is reviewed in the lab, the analyst must be able to determine which transect it is and the circumstances under which it was filmed.

- Hold the slate in front of the camera aiming rod and film it for ~5 seconds. Make sure that the camera is recording by looking in the viewfinder for the red indicator light.
- You can toggle the REC/STBY switch to pause the camera, or continue filming and immediately move to the beginning of the transect tape.
- Hold the camera so that the 40-cm rod is just off the substrate and the camera is perpendicular to the bottom. It must also be oriented so that the long axis of the video image is perpendicular to the transect tape (use the handles of the video housing for a guide). Be careful not to tilt the camera either back-front, or side-side. Make certain that the camera is recording by checking again for the red dot in the viewfinder.
- It should take ~5 minutes to film a 10m transect. To monitor the time, you can put a watch on the video housing. After some experience with filming transects, this pace will become second nature to you.
- At the end of the transect, keep filming as you slowly move the camera to a more horizontal view. Then turn around 180°, aiming slightly back down toward the transect. While swimming ~3-6 feet from the bottom, continue filming as you return along the tape at a comfortable pace. (On a 10m transect, this should take about 1 to 1½ minutes.) It's often difficult to get an overall perspective of the reef from images taken 40 cm away, and this swim back along the tape will provide a “wide-angle,” oblique view of the reef /transect.
- When back at the beginning of the transect, toggle the REC/STBY switch to stop recording.
- Move on to the next selected transect and, after changing the information written on the slate as needed, repeat the steps above.

## Post-Dive Tasks

- Rinse off the equipment. The handle of the fiberglass survey tape will begin to rust immediately, so wash them thoroughly after each use and spray monthly with WD-40 to prolong tape life.
- Rewind the tape to protect it from premature oxidation.
- Remove the tape cassette from the camera, label it, and apply a record-protect tab.
- Store the camera and housing. Put the housing's lens cap on to protect the optic during storage and transport.
- Recharge the batteries.



## Viewing and Cataloging the Videotapes



You *must* view the videotapes promptly after filming to make sure that the quality is sufficient to meet your monitoring objectives.

If you simply assume that everything worked properly, you may find out later that the tapes are unusable because of something that happened or failed to happen. The tapes should be evaluated for qualities required to produce good quality, captured images, e.g., focus, steadiness, rate of filming, and proper transect documentation. This checking should not be done in the field (e.g., in an open boat) or in such a manner as to expose the camera to water. However, it should be done as soon as possible after you have returned to the office. If a videotape is deemed unusable, the transect will need to be re-filmed. The videotapes must also be catalogued in such a way that each transect at a site may be located at a later date with relative ease through a database or spreadsheet. This can be done when viewing the tapes for usable quality. This log will provide a valuable archive of qualitative data, and provide information for quality assurance and quality control issues.

- Open the program that contains your video log (MS Excel, Access, or other database program).
- Find the last entry, if any. If all previous tapes have been entered, give this tape the next sequential number. Any previous tapes that have not yet been logged in should be assigned numbers first and entered into the log as soon as possible. Label each case and the cassette itself with the tape's number in large letters.
- Put the video cassette in the player or select the VTR function on the video camera. The camera back will display the time code in "H" (hours), "M" (minutes), "S" (seconds), and "F" (frames). If you're using a cassette player, you may have to select this display type (refer to the manual).
- Enter the appropriate data in the columns of the spreadsheet, referring to the information filmed on the video slate as needed.
  - Tape number: as already logged in.
  - Date: the date of filming.

- Site: this may include the island, territory, area in that site, as well as transect number. For example: “STX, Buck Island, Back Reef #4 transect.”
- Location: this is the detailed portion of the site. It might include an action or some item of special interest. For example, “0m – 10m,” “swim back along Pin 2,” or “black band disease on CN, brain coral.”
- Tape counter: record the start time and end time displayed that corresponds to what you entered for Site and Location. This may be broken down for significant findings, animals, disease, etc. You do not need to include the frame number.
- Filmed by: the name or initials of the person who filmed the video.
- Camera: the model of the camera that was used for the filming.
- Exposure: generally automatic; note if other setting was used.
- Lens: generally wide angle; note if other setting was used.
- Focus: auto or manual (or A/M if you used both)
- Shutter speed: generally automatic; note if other setting was used.
- Light: note if the red filter was on or off, and if artificial lights were used.
- Comments: any other information that may be useful to someone looking at the tape months or years from now (e.g., poor visibility or surge present).

## Capturing the Video Images

You can capture ~23 to 27 unique frames from a 10m transect (46 to 55 frames from a 20m transect). The process used to select non-overlapping frames from the video transect and save them to your computer’s hard drive depends on the type of capture board installed in your computer. Capture boards often have both manual and automatic capture features.

### ***Manual versus Automatic Capture***

To obtain the best possible results, we recommend using the manual capture feature on the Sony DVBK 2000 Still Image Capture Board. With manual capture, you must concentrate completely on the video playback, watching for each unique frame to be displayed so that you can make the “capture.” With automatic capture, you program the capture card so that frames are selected at a designated time interval, eliminating the need for you to watch the video during the capture process.

Automatic capture is a feasible option only if the entire transect was filmed at a uniform speed, e.g., 1 meter every 30 seconds. Surge and reefs with large vertical features tend to alter the pace of filming, making steady filming difficult if not impossible. If the transect was filmed at a variable speed, using automatic capture will cause under-sampling in areas that were filmed more quickly, creating gaps in the video record, and over-sampling in more slowly filmed areas, resulting in over-lapping frames. Therefore, although it requires more of your concentration, we believe that using the manual capture method is superior to the automatic capture.

## ***Storing the Captured Video Images***

- **File folders:** For a single site, you may have 250 frames (i.e., ten 10m transects with 25 frames per transect). As they are captured, all of these frame files should be stored in one folder. (We use D:/Images/Source.)
- **File format:** Some capture programs allow you to select the format in which the image will be saved. The Sony capture board application creates image files in their proprietary "dvf" format, but they can be converted to another format so you can open them in Adobe Photoshop. We recommend that the files be saved or "exported" as JPEG files (\*.jpg). The JPEG file format is compressed, which results in the loss of some data, but not enough to significantly decrease image resolution.

You can convert the \*.dvf files to \*.bmp files in order to retain all of the image data, but the large size of BMP files (~900 KB per image compared to ~130 KB for JPEG files) slows the automated dotting process and may cause the script to crash. If you want to save the images as BMP files, we recommend that you also save them as JPEG files for dotting and use the BMP files for backup or archival storage.

- **File name:** By assigning a unique name to each captured frame, you can indicate its transect number, where and when the transect was filmed, and the location of the frame within the transect. We use a 10-character format because the WinBatch script is designed to look for a 10-character code in the described format to create a subfolder for each transect's frames.
    - The first two characters are the transect number. If the transect number is a single digit, it should be preceded by a zero.
    - The second two characters indicate the transect location. For example, the fourth transect at Newfound Bay would be 04NF.
    - The next four digits indicate the month and year the video was filmed. For example, November 2000 would be represented by 1100.
    - The last two digits are automatically assigned sequentially by the Sony Capture Board program, starting with "00" for the video frame showing the slate.
  - **Slate image:** The first frame to be captured for each transect should be that of the slate that shows the location and transect number of the site. This redundancy provides another record to link all the frames from a particular transect.
  - **Readme file:** This protocol produces many video transects with thousands of frames. To record notes, comments, or other metadata regarding any step of the image logging, capture, dotting or analysis process, you need to create a "Readme" file that will be kept in the same folder as the image analysis data sheets. This will provide a record for yourself and others to track the progress of analysis at a particular study site. This metadata file records additional information, e.g., transects were recorded or when changes were made during the analysis
- Open a new document (e.g., in MS Word) to begin a metadata file that will be saved in a \*.doc or \*.txt format. In chronological order, keep a record of who did what and when. For example, "11/02/99: Jeff Miller filmed the 8 transects at Bob's Reef. They are numbered 01-08. The video tape was logged in on the video log master list, and recorded as tape number 4." Or, "11/30/99: Ellen Link analyzed transects 01-03."

## ***Starting the Capture Process***

The videotape images are captured by the computer using a “firewire” cable connected to a still image capture board. Plug one end of the fire wire into the capture board at the back of the computer and the other end into the DV in/out port on either the player or, if you don’t have a player, on the back of the camera. Using a larger image will make it easier for you to observe reef details during the capture process, so if possible connect your playback device to a television screen through an RCA-type cable (i.e., video out of playback device to video in of TV).

- Go to START→PROGRAM→SONY DV APPLICATION. This launches the capture program, displaying a small screen with button controls, as on the camera. The video screen will be displayed both on the playback device and on your computer, and you can play and stop the tape using either piece of equipment. However, because the CAPTURE button must be clicked on the computer screen, we find it easier to do all the videotape manipulation on the computer.
- To create a folder where each transect or other subset of captured images will be temporarily stored until they are exported as JPEG files, go to FILE → NEW → ALBUM and create a folder called “Capture.” We use the ”Album” feature instead of “Library” because when new images are captured from within a new album, the capture details are displayed on the screen (i.e., time, date of capture and filming).
- Go to VIEW → NORMAL. This will provide data on the images you are capturing, e.g., time code and frame numbers.

Then proceed with either the automatic or manual capture method, depending on which you have chosen to use.

## ***Using the Manual Capture Method***

- Play the videotape from the beginning until you can clearly read the site details on the slate. Then pause the tape and click on the CAPTURE button. (You can capture a frame without pausing the tape, but you may want to stop it to make sure that the slate is in clear view.) You should see the image added to your Capture folder. This first file in each transect will be assigned a default name ending in “00” until you rename it, as explained in the “Renaming and Exporting the Image Files” section that follows.
- Play the tape until you reach the beginning of the transect or forward to the tape counter number that you identified in your video log. This may take some time, as there will be non-transect tape covering the period after the slate has come into view and before the aiming wand settles at the beginning of the transect tape.
- Pause the tape and click on CAPTURE when the starting point of the transect is at the bottom of the screen.
- Look at the top of the screen to identify a feature, e.g., a sea fan or sand channel.
- After the first transect frame has been captured, follow the feature that was observed as it tracks to the bottom. When it is at the bottom, click on CAPTURE again.
- Repeat this process, capturing abutting, non-overlapping frames as they appear until the end of the transect. You should have ~25 frames per 10 meter transect. The last captured frame should have the flagging tape or other end of transect marker at or near the top of the frame. Click on the square button on your computer screen display (or press the button on your camera) to stop the tape.

## ***Using Auto-Capture***

If you maintained a consistent speed while videotaping the transect, filming about one meter every 30 seconds for the entire transect, you may wish to use the Auto-Capture feature to capture the video frames. (See "Manual vs. Automatic Capture" on page 15.)

- With the Sony DV Application launched and your Capture folder open, go to file→preferences→capture. In this window, you need to indicate the number of frames to be captured, how frequently they are to be captured, and the prefix by which they will be identified.
  - STOP WHEN: For a 10-meter transect, enter "27." This may be more than you need, but it is better to have the program run out of videotape from which to capture frames than to have it stop too soon.
  - TIMING: A conversion factor is used to establish how frequently the frames will be captured. From your video log, determine how long it took to do the transect. If you met the goal of one meter every 30 seconds, this would be 300 seconds for a 10-m transect, or 600 seconds for a 20-m transect. Multiply this number of seconds by 1.2 for a 10-m transect, and 0.6 for a 20-m transect. Enter this number in the box as a numerator divided by 30.
  - PREFIX: Enter the number of the transect followed by the two letter site code. If it is one of the first nine transects, enter a zero first (i.e., 01YZ, 02NF, 05HW, 10TE, 11MB). Space is provided for only four characters.
- When the above information is correctly entered, click on OK.
- Play the tape until the slate showing the site details is in clear view. Then pause the tape and click on the CAPTURE button. You should see the image added to your Capture folder. This first file in each transect will be assigned a default name ending in "00" until you rename it using the 10-character method.
- Play the tape until you reach the beginning of the transect or forward to the tape counter number that you identified in your video log.
- When you are at the beginning of the transect, click on AUTO.
- Watch the videotape to make sure that abutting, non-overlapping frames are being captured. You should be in "normal" view to see the details on the captured frames.
- When the last frame has been captured, you should be at the end of the transect, with the last frame showing the flagging tape or other end of transect marker at or near the top of the frame. Click on the square button on your computer screen display (or press the button on your camera) to stop the tape.

## ***Renaming and Exporting the Image Files***

The Sony capture board application creates images files using their proprietary "\*.dvf" format. With a few mouse clicks, all of these \*.dvf files can be renamed and converted to \*.jpg files so that they can be opened in Adobe Photoshop. If you catalog all of the images in one folder, they will be automatically sorted into folders named for each transect.

- To create the folder where images files will be stored after exporting, go to START and right click to get to EXPLORER. Select the location for the folder that you are making. We recommend "D:\Images" so that the files are on a different partition of the drive than the operating system in case of a system crash. Go to the FILE drop-down menu and choose SELECT NEW → FOLDER. We call the folder "Source."
- To select all the images captured for this transect, go to the Sony Capture Board icon display and choose ALL. (Or choose SELECT ALL on the SELECTION drop-down menu.)
- Go to the IMAGES drop down menu and choose RENAME IMAGES. At this point, assign the file name as explained above: the two-digit numeric prefix that corresponds to the transect number; then the two-character site code, then the four-month/year of the filming, with no spaces between characters.
- Go to the IMAGES drop-down menu and choose EXPORT. Select JPG as the file format and HIGHEST as the option for graphic quality. (The \*.jpg files created in this way will generally be from 100 to 160 KB in size.) Click on OK. This will automatically export the images and convert them to \*.jpg files in the Capture folder that you created, but the process may take a few minutes. When it is completed, you can close the Capture folder while the Capture Board program remains open on your taskbar.

### **Saving Images as BMP Files**

To archive the images as BMP files, follow the preceding steps, except choose BMP as the file format. Save the BMP image files to a separate folder on your hard-drive for later placement on a CD. You do not want to dot BMP files as their large size slows the automated process and will cause the dotting script to crash. When you've completed saving the images as BMP files, repeat the procedure to create JPEG files for dotting.

- Go to START and right click to get to EXPLORER. In the Capture folder you created in the Sony DV Application directory, you'll see a \*.dvf file of each image in addition to the \*.jpg files.
- To sort the file types alphabetically so that you can easily select all the \*.jpg files, go to the VIEW drop-down menu and choose ARRANGE ICONS → BY TYPE.
- Select all the \*.jpg files (select the first \*.jpg file, then hold down the shift key while clicking on the last \*.jpg file) and move them to your Source folder.
- After you've checked to make sure that the \*.jpg files have all been moved to your Source folder, you can delete the \*.dvf files.

**Next transect:** If you have video images from another transect to capture, play the tape forward and pause or stop it when you reach the introductory slate. Double-click on the

Capture folder you created, which should now be empty again. Repeat the steps for the manual or auto-capture method.

## **Image Capture Process using Pinnacle Studio 9 - Including the use of the Batch File Utility and Adobe Photoshop for File Renaming**

Purpose: this procedure describes the steps to capture an image (or images from a sample transect) from video tape using the software Pinnacle Studio 9. It includes the steps necessary for renaming the images using either a Batch File Utility program or using Adobe Photoshop.

### ***A: Assemble the Capture Components***

1. Assemble and install the movie box and Pinnacle 9.1 software according to instructions
  2. Attach the movie box USB wire to your computer USB port.
  3. Attach the mini-DV player or camera (in the player setting) to the movie box fire wire.
  4. Turn on the DV player. (This may boot up Pinnacle Studio); If not proceed to #5.
  5. Double-click on Studio Version 9.1. The default open screen is the “2 Edit” tab.
  6. Click on the “1 Capture” tab.
  7. Select “Setup”, then “Capture Source” from the drop-down menus.
  8. In the Pinnacle Studio Setup Options, under the “Capture source” tab, within the box titled “Capture devices”, select the following by clicking on the drop-down arrow:
    - a. Video: DV Camcorder
    - b. Audio: DV Camcorder
- Then select OK, for the Pinnacle Studio Setup Options box. At this point, the display on the bottom half of the screen should include a side view of a generic video camera graphic.
9. Click on the “2 Edit” tab.
  10. Select “Toolbox”, then “Grab Video Frame” from the drop-down menus. At this point, the display in the upper part of the screen will now include another side-view of a generic video camera graphic.

11. You also now have ‘button control’ with the mouse pointer on the video camera graphic as displayed within the program. This means that when you click on the ‘play-button’, the video in the player will begin to play within the screen on the right side of your computer monitor.

## ***B: To capture images***

1. Click the play button on the video camera graphic. You will see the tape start playing in the display screen.
2. Immediately move the mouse pointer to the pause button on the video camera graphic. When you see the image you want to capture, press the pause button on the video camera graphic.
3. Click on the “Grab” button with your mouse pointer. The image you captured will now appear in the screen between the video display screen and the video camera graphic.
4. Click the “Save to Disk” button.
5. A SAVE AS dialog box will appear asking you to select the location, name, type for the image you captured.
  - a. Location: select the appropriate place. We suggest using the “source” folder as this will mesh consistently with the other protocol steps.
  - b. Name: the default for Pinnacle is “Grabbed Frame X” with X being an integer starting at “1” and increasing by one for each successive capture, while the program is open. To work with the image dotting process recall we want the metadata slate to be image “00”, and the first captured image of the transect to be image “01”, as a two digit number, increasing by one each for each additional image.

**NOTE: it is important to use two digits in the numbering sequence for proper cataloging after the dotting process.**

Therefore, if you have just captured the metadata slate image, rename this image “Captured Frame 00” (without quotes).

- c. Type: You can select a BMP type of JPG type, or both. Select the type of image you want to use.

Once the name, location and type are correct, click Save.

If you want to save the images as both JPG and BMP (to mirror what was done using the Sony Capture Card) you will have to repeat step 5 for each type.

6. Once the metadata slate image has been captured and saved, click on the “play” button on the video display graphic. This will start the movie playing in the screen on the right. The image previously grabbed and saved will remain in the middle display.
7. When the movie proceeds to the place to make the next capture, click on the “pause” button on the video display graphic.
8. Click the “Grab” button. The new image will now appear in the middle screen.
9. Click “Save to Disk” button.
10. In the Save As dialog box, select the appropriate location, name and type. Notice that the location and type are the same as you set up with the first image. The name is “Grabbed Frame  $X+1$ ”. Again, if this is the first image of the transect (the image after the metadata slate), we recommend that you call it “Grabbed Frame 01”.
11. Once the image is properly named, and stored, click on Save.
12. Click on the “play” button on the video display graphic. You can now watch the video in the right-most screen to make the next capture. Conveniently you can still see the last captured image in the middle screen, which can help you make an accurate subsequent capture.
13. When the video is in place to make the capture, click on “pause” from the video display graphic.
14. Click the “Grab” button. The new image will now appear in the middle screen.
15. Click “Save to Disk” button.
16. In the Save As dialog box, repeat the naming and saving process described in #10 above.
17. Repeat the capture process until the transect has finished.

## ***C: Renaming the images after capture: With Batch File Utility Program or Adobe Photoshop***

### **Renaming images using the Batch File Utility program**

This renaming process allows continuity between the protocol as written for the Sony Still Image Capture Board, and this process. As a reminder, each captured image has a unique name that describes the transect number, sample reef location, and date of sample. There are no spaces between any character or number in the name of the images. This is important for proper file management during the dotting process. This batch file utility is used to efficiently and accurately modify file names created in the Studio 9 process to the unique naming sequence used in the dotting process.

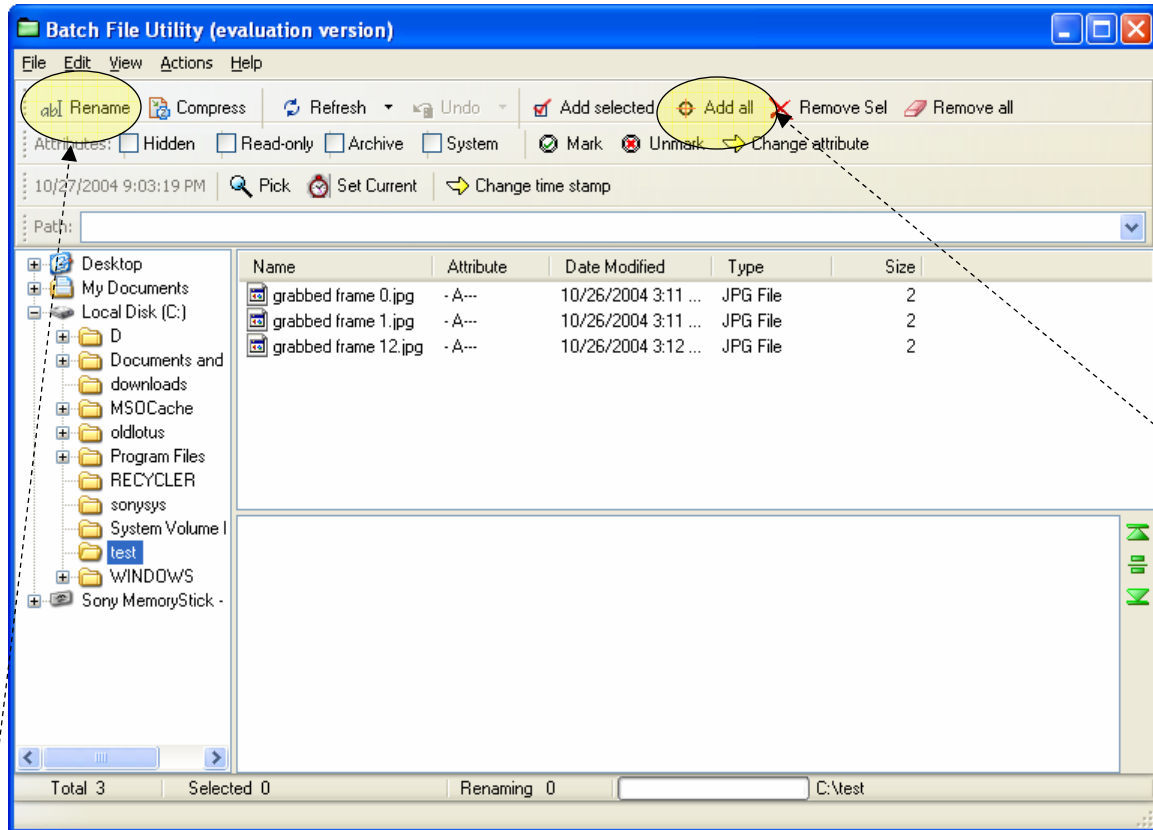
The Batch File Utility shareware, downloaded from the internet at:

**<http://www.flashshare.com/bfu/download.html>**

There is a 14-day free trial, and the purchase price is \$24.95.

## Renaming the images after capture

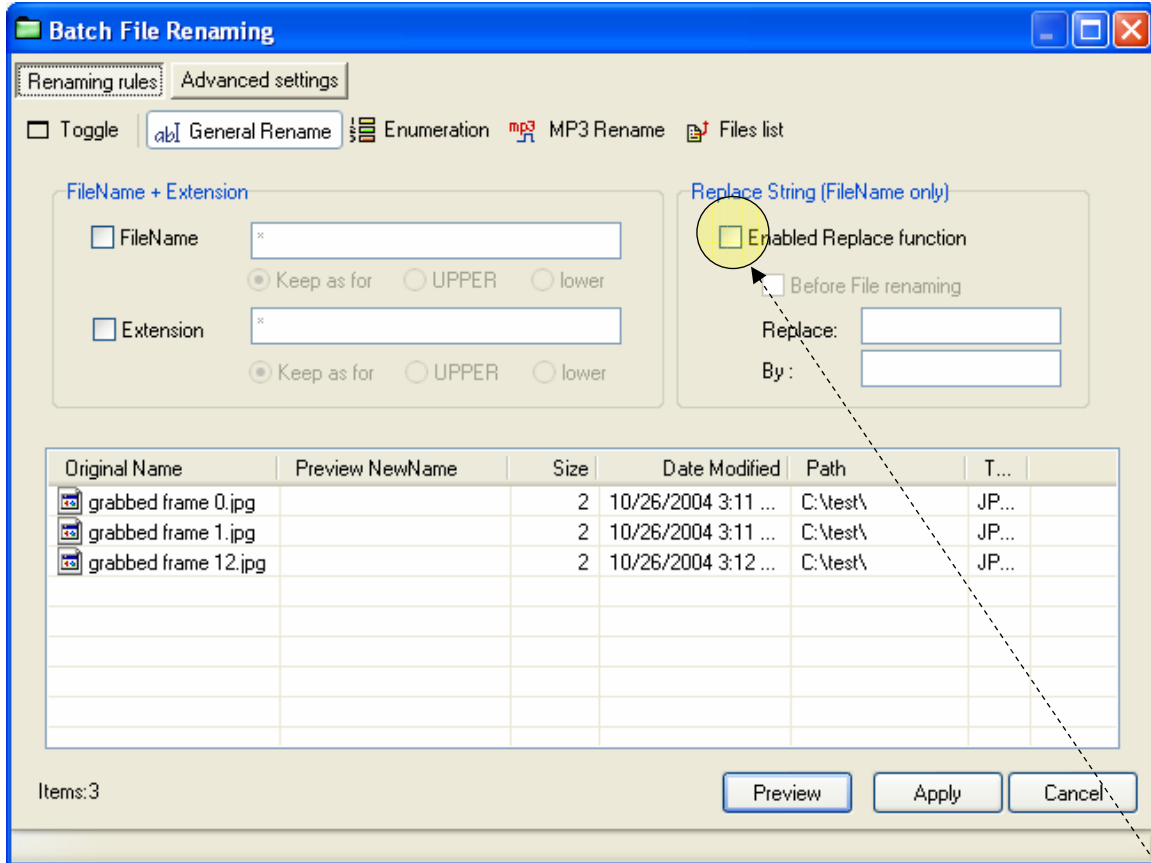
1. Double click the Batch File Utility. When you open the program you are presented with a screen like this.



The left column is where you will select the drive and folder containing the files you want to work with. When you select a folder from the left column, the contents appear in the upper screen to the right. You can then select the files you want to work with in this (upper right) screen.

2. Navigate in the left column to where you are storing your captured images. When you find that folder, click on it. You will see the contents appear in the upper right window.
3. Verify that they are the images that you want to rename. When you are sure of this, select them to be renamed by clicking the “Add all” button in the icon bar.
4. The files you just selected and added will now appear in the bottom window. There are check marks by each file. If (for some reason) you want to deselect a file (do not want that name to be changed) just uncheck it.
5. To change these file names hit the Rename button in the icon bar area.

6. A new window will appear.



7. Place a check in the box Enabled Replace Function located in the block labeled Replace String (FileName only).

8. In the “Replace” box space type in what you want searched for. In this case it would be “Grabbed Frame “.

**NOTE: This is important....there should be a space right after the word frame if this is going to work right.**

9. In the “By” box space, type in the string of numbers and text that is replacing “Grabbed Frame “. The string that we’ve been using is

Two spaces for the transect number

Two spaces for the site code

Four spaces for the date (two for month followed by two for year)

For example, the 7<sup>th</sup> transect at Mennebeck Reef sampled in October 2004 would be labeled:

07MB1004

10. To see how things look after you have done the replacement hit the preview button at the bottom of the screen. The modified names will appear in the Preview New Name column. Check this carefully, assuring there are no spaces between characters.
11. If the replacement is NOT correct, press cancel, and try again.
12. If the replacement IS correct, click “Apply” and the changed are made permanent.
13. The images are now ready to be moved to appropriate storage folders prior to dotting.
14. The renaming needs to be done after each transect. Once the files have been renamed and relocated, go back to the video tape and proceed with capturing images from another transect.

### **Renaming images using Adobe Photoshop automation batch processing**

This process requires that you have the action script titled RENAME – BMP, and SAVE AS JPG; and they are stored in the Video Method Action file folder with Adobe Photoshop.

You will have to create and save the action Rename – BMP and synchronize it to a location on your hard-drive where you will always put the “Grabbed Frame XX.BMP”.

To create the Action file, Rename - BMP

1. You must have an image “Grabbed Frame XX.BMP” in the location and the file structure set up before creating the action. We suggest you put a folder on your hard drive as follows: D:/Dotting Captures. Within that folder, create two folders, Source, and Archive. When you are capturing with the Pinnacle board, have the “Grabbed Frame XX.BMP” stored in D:/Dotting Captures. You can place the renamed BMP’s into D:/Dotting Captures/Archive, and after you complete an entire site-worth of captures (all transects), you will convert the BMP’s to JPG’s and store them within D:/Dotting Captures/Source. These folders can then be copied into a more site-specific storage for dotting.
2. Open Adobe Photoshop.
3. Click the drop-down menu Window, and select Actions. You should see two folders, the Default Actions.atn, and Video Methods.

4. Click on Video Method.
5. Go to the drop-down menu File, then Open.
6. Browse to the folder that you have created in which the “Grabbed Frame XX.BMP”s are located. (e.g.: D:/Dotting Captures)
7. Select “Grabbed Frame 00.BMP” and click Open. The image appears in Photoshop.
8. In the display that shows the actions files, go to the very bottom and select the icon to the left of the trash can. It looks like a piece of paper being turned over. This is the “create new action” icon. Your mouse-pointer should turn into a hand with a finger extended. Press this create new action icon.
9. In the New Action dialog box, name the action, “RENAME – BMP” (no quotes).
10. The SET should read: Video Method, so the new actions goes in that folder.
11. Then click on RECORD. Anything you do with the mouse or function keys will now be recorded under that action.
12. Go to the drop-down menu FILE, and choose SAVE AS.
13. Delete the file name, leaving just the “.” And the extension “BMP”. This can be done by highlighting “Grabbed Frame 00” and pressing DELETE on your keyboard.
14. Then Click SAVE.
15. A BMP OPTIONS dialog box will appear. Don’t change any settings. Click OK.
16. Go back to the display box that shows the actions. At the bottom of that box, click on the left-most icon, the SQUARE. This will stop playing/recording.
17. You have now created the action for renaming your BMP files.
18. Close the image that is displayed, now called “.bmp”.
19. You can close the Actions Display box.
20. Open Windows Exploring and browse to the location where you are storing the “Grabbed Frame XX.BMP” (e.g.: D:/Dotting Captures). You should see the image that you just renamed, “.bmp”. **DELETE IT!**

If you always placed the “Grabbed Frame XX.bmp” files in the same location, this action will work.

### **Rename and Relocate Grabbed Frame XX.bmp files using Photoshop.**

1. Open Adobe Photoshop
2. Open Windows Explorer and navigate to where you have the captured BMP files stored.
3. Rename “Grabbed Frame00.BMP” to the appropriate transect, location and date name and put it in the archive folder.

NOTE: this must be renamed and moved to the archive folder before batch renaming the other images. This image CANNOT remain with the other “Grabbed Frame XX” images during the Automated Batch Processing.

4. Click on Adobe Photoshop to make it active (open).
5. Go to File drop down menu, Automate, Batch.
6. Under Play: select “Video Method”
7. Under Action: select “Rename – BMP”
8. Under Source: select “Folder”
9. Click “Choose...” then browse to the location and select the folder that contains the images that you’ve captured and want to batch rename.
10. Under Destination: select “Folder”
11. Click “Choose...” then browse to the location and select the folder where you want the renamed images to go. It will be the same folder that you previously placed the renamed “Grabbed Frame00.BMP”, usually some type of archive folder.
12. Under File Naming:
  - a. in the first blank bar space, type in the transect number (two digits: 01, 02, 03, ..... 09, 10, ....19, 20)

- b. in the second blank bar space (directly across from the first, not under) type in the two character code for the site. (e.g.: MB, NF...)
  - c. in the third blank bar space (under the first), type in the 4 number sequence corresponding to the date (MMYY)
  - d. in the fourth blank bar space (under the second), use the drop down arrow to select “2 Digit Serial Number”.
  - e. In the fifth blank bar space, use the drop down arrow to select “EXTENSION” (in CAPS).
  - f. Then Click on OK.
13. You will see each image open and close as it is renamed and stored in the location you selected.
14. Open Windows Explorer and navigate to the folder that contains the images you just renamed to verify that the proper number exists and the batch renaming worked.
15. In Windows Explorer, navigate to the folder that contains the images named “Grabbed Frame XX.BMP”. You may notice there is an additional image in this folder titled “.BMP” (no name.BMP). This was created as part of the batch renaming and is a duplicate image. YOU DO NOT NEED TO MOVE OR RENAME THIS IMAGE.

YOU CAN SELECT ALL THE IMAGES “Grabbed FrameXX.BMP” and “.BMP” AND DELETE THEM.

### ***D: Option to resize the images and auto-level adjust.***

Purpose: this procedure details how to alter the size of a captured image, removing a very thin black border that is often an artifact of the capture process, then conduct an automatic adjustment of color to the image once that black border has been removed. Conducting the auto-adjust before the black border is removed will reduce the effectiveness of the adjustment. (modification added 4/15/05)

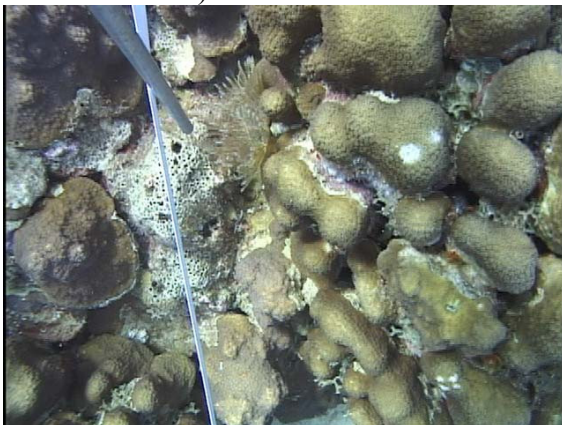


Figure 3. captured BMP; not resized or BMP



Figure 4. Resized and level-adjusted

level-adjusted.

1. At this point evaluate the BMP images to determine if they need color correction.
2. Inspect the image for a very thin (approximately 2 pixel-thickness) black margin appears around the images (fig. 3 and 4)
3. If it is decided to resize the image (to remove the black margin) and auto-level adjust the image put the saved BMP files in the Generic ARCHIVE folder.
4. When all images have been captured for the site,
  - a. open Adobe Photoshop
  - b. Select FILE, AUTOMATE, BATCH
  - c. In the Batch dialog box in the Play section select
    - i. Set: Video Method
    - ii. Action: Canvas Size & Auto Level Adjust
  - d. In the Source section select
    - i. FOLDER
    - ii. Choose: browse to the location of your generic ARCHIVE folder
  - e. In the Destination section select
    - i. FOLDER
    - ii. Choose: browse to the location of your generic SOURCE folder
    - iii. Put check in the box, “override action ‘save as’ command”
  - f. In the File Naming section select
    - i. In the first box, first column, select DOCUMENT NAME
    - ii. In the first box, second column, select EXTENSION
  - g. Select OK, for the Batch dialog box. All the images in the archive folder will now be trimmed slightly (640 pixels wide to 632, removing 4 pixel video black-line on each vertical side), then auto-level adjusted, moving the edges of the histogram 0.1 unit from each black and white side. This is done on the full quality non-compressed BMPs so all data in the image is considered.
5. When the batch size and auto adjust is complete, you will have BMP’s in the source folder. These are very large so you will want to convert the source file BMP’s to JPG’s. To do this
  - a. open Adobe Photoshop
  - b. Select FILE, AUTOMATE, BATCH

- c. In the Batch dialog box in the Play section select
  - i. Set: Video Method
  - ii. Action: Save As JPG
- d. In the Source section select
  - i. FOLDER
  - ii. Choose: browse to the location of your generic SOURCE folder
- e. In the Destination section select
  - i. FOLDER
  - ii. Choose: browse to the location of your generic SOURCE folder
  - iii. Put check in the box, “override action ‘save as’ command”
- f. In the File Naming section select
  - i. In the first box, first column, select DOCUMENT NAME
  - ii. In the first box, second column, select EXTENSION
- g. Select OK, for the Batch dialog box. All the images in the source folder will now be opened and saved as JPGs which will compress them slightly, reducing their size. (Compression will be minimal, saving the image as the highest quality JPG.)
- h. When this is complete, sort the images by type by selecting the TYPE bar within Explorer. This will sort the images by type.
- i. Select all the BMP files and delete them; all the JPG images will remain to be dotted.

6. Run the dotting script as per the protocol (overnight).

***E: Create JPEG images from the BMP with the proper naming convention for the dotting process***

This can be done after all images have been captured (as BMP’s), properly named for dotting and located in the appropriate Archive folder.

1. Open Adobe Photoshop and have it active.
2. Go to File drop down menu, Automate, Batch.
3. Under Play: select “Video Method”
4. Under Action: select “SAVE AS JPG”
5. Under Source: select “Folder”

6. Click “Choose...” then browse to the location and select the folder that contains the BMP images that you’ve just renamed and stored.
7. Under Destination: select “Folder”
8. Click “Choose...” then browse to the location and select the folder where you want the JPG images to go; usually some type of source folder.
9. Put a check in the box for “Override Action “Save As” Commands. If a dialog box is displayed providing additional information, put a check in the box within that dialog box that says “Do not show this message again”.
10. Under File Naming:
  - a. in the first blank bar space, use the drop down arrow to select “DOCUMENT NAME” (with CAPS).
  - b. In the second blank bar space (across from the first, not down), use the drop down arrow to select “EXTENSION” (with CAPS).
  - c. Click on OK.
  - d. You will see each image open and close as a copy is made with the new name, type and location.

## Using Adobe Photoshop

The three tasks explained in this section (setting the scratch disk, modifying the \*.ini file, and loading the actions file) only have to be done one time per computer; the settings do not need to be changed during any subsequent use of Adobe Photoshop.

### ***Setting the Scratch Disk***

Adobe Photoshop will first try to process images using your computer's RAM. If it can't find enough space there, it will create a temporary file in the location that has been designated as the "scratch" disk. Usually the C: \drive or setup file is the default location. To use Adobe Photoshop in processing video frames, you must make sure you have sufficient space on your computer and select the drive with the most available space for the scratch disk.

- To determine the available space on your hard drives:
  - Double click on the MY COMPUTER icon on your desktop.
  - Click once on (C:) to select the C drive. Go to FILE→PROPERTIES. Write down the amount of free space on your C:\drive. Close this window.
  - Repeat the previous step for your D drive and any other hard drive on your computer.
- To designate the drive for the scratch disk:
  - Open Adobe Photoshop (5.0 or higher).
  - Go to FILE → PREFERENCES → PLUG-INS & SCRATCH DISKS.

- As the first choice, select the drive with the most space available, usually D.
- As the second choice, choose the drive with the next most available space or the option “NONE”.
- Choose OK.

### ***Modifying the \*.ini File***

To ensure that Adobe Photoshop will operate smoothly with the dotting process, we recommend that you modify your system’s “\*.ini” file. If you don’t do this and get an error message that the "PASTE command is not available" when you press F8 in Adobe Photoshop, you’ll know you’re in trouble.

- Go to START → FIND → FILES OR FOLDERS. Search for "photo\*.ini" in the directory where Photoshop is located. (If you don't know this, start at the root of C, then try D or another drive.) If you have Photoshop 5.0, it will be the "photo50.ini" file and probably be found in C:\Program Files\Adobe\ Photoshop 5.0\ Adobe Photoshop Settings.
- Open the \*.ini file. Add the exact line of text below as the last line of the \*.ini file. The first letter of each word must be in upper case, with no spaces in the text and no other formatting or punctuation:  

`AlwaysImportClip=1`
- Save and close the file.

Unless this \*.ini file is modified again, in the future Adobe Photoshop will import what is stored on your system clipboard, which is what you need to happen.

### ***Loading the Actions File***

- To load VIDEO METHODS, open Adobe Photoshop, go to the WINDOW drop-down menu and choose SHOW ACTIONS.
- Click on the black triangle in the upper right corner of the Actions palette.
- From the menu which appears, choose LOAD ACTIONS. Each action will be associated with a specific function key on your computer, as listed on page 33 and 42.
- Browse to locate and select the “Video Methods.atn” file. Click on LOAD.
- To hide the Actions palette, click on the X at the top right corner.

## **Random Dot Processing Set Up**

To randomly sample areas on the video frames for benthic identification, MS Excel is used to create a unique plot of 10 random dots per image. This plot is “cut and pasted” (superimposed) onto a video frame in an image file that has been opened using Adobe Photoshop. After some manipulations, you will have 10 randomly located hollow red squares outlined in yellow superimposed on the video frame.

Three computer files have been set up to enable you to create these randomly sampled frames.

- A set of actions, or function key commands, called “Video Methods.atn” which is loaded into Adobe Photoshop.
- An MS Excel spreadsheet called “Randomplot.xls” with a macro embedded within it to create the random plot of points.

- The WinBatch script file called “Lola.wbt” which is run in the program WinBatch for Windows.

In summary, you will paste the plot of points generated by the Randomplot macro onto the video frame displayed in Photoshop, and adjust the plot’s size and position so that it matches the frame exactly. Although you must initially determine the plot’s correct size and position by trial and error, you can then make the adjustment permanent by editing the code in the macro in Excel and the Actions file in Photoshop. Once these edits have been made and saved, LOLA will automatically replicate the necessary size and positioning of the plot for each video frame.



This is the only point at which you can alter the instruction codes for the dotting process, and you can modify them only as described below. Alterations to any other part of the Photoshop Actions file or the Excel macro may jeopardize the performance of the WinBatch script.

### *Launch Randomplot.*

The macro in Randomplot is used to produce the plot of random points, label the points A-J (1-10) and make them into red hollow squares so that they are easier to find.

- In MS Excel, open and maximize the Randomplot spreadsheet. If you get a box prompting you to either "enable" or "disable" macros, choose ENABLE.
- Run the macro by simultaneously pressing CTRL + SHIFT + P. It will take 2 to 4 seconds. Do this two or three times to make sure it runs smoothly. The final step in the macro “cuts” the plot to your computer clipboard. Consequently, you will not see the final plot until it is pasted in Adobe Photoshop unless you view the clipboard.

### *Evaluate the plot size and position.*

The F8 command in Adobe Photoshop (“Paste, clear and move”) pastes the graph generated by the macro onto the JPEG image as a second layer, makes the layer transparent, and moves the graph in an attempt to align the X and Y axes of the plot with the edges of the video frame. However, to ensure that the entire area of the frame is covered by the plot and that any point within the frame may be selected as a sampling point, the size and position of the plot and the frame must match up *exactly*. The extent of adjustment, if any, that must be made to the size and position of the plot to get it to match the frame varies between computers.

To check the size and movement settings:

- In Photoshop, open a JPEG file from your Source folder. If the Photoshop toolbar or any other Photoshop option box is displayed, remove it by pressing the TAB key twice, or go to the WINDOW drop-down menu and choose HIDE TOOLS.

#### **Using the Function Keys in Photoshop**

- F2: brightness adjust
- Shift+F2: undo brightness adjust
- F3: contrast adjust
- Shift+F3: undo contrast adjust
- F4: unsharp mask
- Shift+F4: find edges
- F5: open JPEG file
- F6: open BMP file
- F7: open TIFF file
- F8: paste, clear and move
- F9: flatten, purge and close
- F11: close, no changes
- F12: delete layer

The first six keys listed above may be used during the image analysis process.

- In Excel, open and maximize Randomplot. (If Excel is already open and you previously ran the Randomplot macro, you will notice that the spreadsheet is scrolled down to approximately row #26. You need not change this or any other feature within this sheet to run the macro.)
- Run the Randomplot macro by simultaneously pressing CTRL + SHIFT + P.
- Click on Photoshop in the task bar to display the JPEG file that you opened before.
- Press F8 to paste the plot as a layer on top of the video frame.
- You will need to use your computer keys rather than your mouse to move the top layer (the plot layer) up and to the right to be able to see the X and Y-axis unit labels. You may have to move the plot in order to even see the X and Y-axes.
  - CTRL + ⬆ [or ⬇] = small move right [or left]
  - CTRL + SHIFT + ⬆ [or ⬇] = large move right [or left]
  - CTRL + ⬇ [or ⬆] = small move right [or left]
  - CTRL + SHIFT + ⬇ [or ⬆] = large move right [or left]
- Check the Y-axis by moving the plot layer to the right so that you can see the unit labels. If the tick mark for “0” is at the bottom edge of the video frame and the tick mark for “100” is at the top, the plot is the correct height. If not, you will need to adjust it as described in the next section.
- Using the computer keys, move the plot back to the left so that the Y-axis aligns with the left edge of the video frame.
- Check the X-axis by moving the plot layer. Unless the tick mark for “0” is at the left edge of the video frame and the tick mark for “100” is at the right, you will need to adjust the plot width as described in the next section.
- Press F12 to delete the plot layer.

### *Adjust the size of the plot.*

To adjust the size of the plot, you will need to edit the spreadsheet macro.

- Click on Excel on the taskbar to return to Randomplot and maximize if necessary.
- Press ALT + F11 to open the Visual Basic Editor window.
- If the Project Explorer window does not also open, go to the VIEW drop-down menu and select PROJECT EXPLORER.
- In the Project Explorer window, look in “VBAProject (randomplot)” for the Modules folder. Double-click on module 1. This will display the macro code.



You must follow these instructions exactly so that you do not make any inadvertent changes to the Visual Basic script. If you hit keys that change the script in ways other than that specified below, go to the EDIT drop-down menu, and select UNDO TYPING.

- Go to the EDIT drop-down menu and select FIND. In the FIND WHAT box, type “width” and click on FIND NEXT. This should take you to line 150, reading:  
 “Selection.ShapeRange.ScaleWidth 2.08, msoFalse, msoScaleFromTopLeft”

- It is the number after “ScaleWidth” (2.08) that sets the width of the plot. Increase or decrease this number as necessary, starting out by trying a small change (~0.5 units). If you use 2.00, Visual Basic writes it as “2#”.
- It may take more steps, but we’ve found it saves time in the long run if you adjust the size of only one axis at a time. After you’ve entered a different width to try, go to the FILE drop-down menu, close this file of coded instructions, return to Randomplot and run the macro again: CTRL + SHIFT + P.
- Click on Adobe Photoshop in the task bar to display the video frame again. Press F8 to paste the resized plot on top of it. Check the new width by moving the plot layer with the CTRL (+ SHIFT) + ⬅ [or ➡]. Return to the Visual Basic Editor window to try a larger or smaller width until it is the same as that of the video frame: the tick mark for “0” on the X axis is at the left edge of the frame, and the tick mark for “100” is at the far right.
- When the width is correct, follow the same procedure to adjust the plot height until the tick mark for “0” on the Y axis is at the bottom edge of the frame, and the tick mark for “100” is at the top. The code for the height can be found by going to the EDIT drop-down menu, selecting FIND, typing “height” in the FIND WHAT box, and clicking on FIND NEXT. Line 152 will read:  
“Selection.ShapeRange.ScaleHeight 3#, msoFalse, msoScaleFromTopLeft”
- When you have set the correct width and height, open Randomplot and run the macro: CTRL + SHIFT + P.
- Go the FILE → SAVE, or click on the disk icon (💾) on your toolbar.
- We also recommend writing these width and height values in a place where you can easily find them, so that you don’t have to repeat the sizing process.

### *Adjust the position of the plot.*

The default setting in the Photoshop Actions file attempts to position the axes of the plot layer along the edges of the video frame. Depending upon your computer system, this positioning may have to be adjusted. You can use your computer keys to move the plot layer into the correct position, but to make the positioning automatic each time the plot is pasted onto a video frame, you’ll need to keep track of which key strokes and how many you use to position the plot and modify the Actions file accordingly.

- With the correctly-sized plot layer showing on a video frame as described in the previous section, move the plot so that the Y-axis lines up with the left edge of the frame. Write down the number, direction and size of key commands you are using, e.g., “shift Y-axis to the left with two large moves and one small move.”
  - CTRL + ⬅ [or ➡] = small move left [or right]
  - CTRL + SHIFT + ⬅ [or ➡] = large move left [or right]
- Next, line up the X axis with the bottom edge of the video frame, and record keep the number, direction and size of key commands that you make:
  - CTRL + ⬆ [or ⬇] = small move up [or down]
  - CTRL + SHIFT + ⬆ [or ⬇] = large move up [or down]
- Repeat this process until you’re certain you’ve accurately recorded the number, size, and directions of key commands needed to position the plot correctly.

- To record the number, size and direction of key commands in the action sequence, you need to have a JPEG file open. Run the Randomplot macro to create a plot layer, click on Photoshop on the taskbar, and press F8 to paste the plot on the frame.
- To turn on the Photoshop Action Recorder, go to the WINDOW drop-down menu and select SHOW ACTIONS.
- In the Actions palette, click on the triangle left of PASTE, CLEAR AND MOVE. This opens that action sequence so that you can see the individual instructions.
- Select PASTE with your mouse cursor (which is probably in the shape of a finger pointing). This should result in the PASTE command line being blue.
- At the bottom of the Actions palette, click on the round button. It should turn red, indicating the recorder is turned on. From this point until you turn off the recorder, all key commands will be recorded under the PASTE command line, in the PASTE, CLEAR AND MOVE action sequence.
- Move the plot layer using the number, direction and size of key commands that you have determined necessary for its correct placement on the video frame.
- When the plot layer is correctly positioned, click on the square button at the bottom of the Actions palette (left of the round record button) to stop the action recorder.
- Click on the triangle left of PASTE, CLEAR AND MOVE to close the action sequence.
- To hide the Actions palette, click on the X at the top right corner.

*Confirm plot size and position.*

Run the macro again and place a plot layer on a video frame to make sure that it is correctly placed and sized.

- In Adobe Photoshop, open a JPEG file from your Source folder, or press F12 to delete any layer from the previously opened frame.
- Minimize Photoshop.
- With Randomplot.xls open and maximized, run the macro by simultaneously pressing CTRL + SHIFT + P.
- Click on Adobe Photoshop in the task bar to display the video frame that you opened previously.
- Press F8 to paste the plot generated by the Randomplot macro as a layer on top of the video frame.
- At this point, the plot layer should be properly sized and placed on the video frame. Check this by repeating the sequence of steps under “Evaluate the size and position of the plot” on page 33.

☞ If the plot is correctly sized and positioned, the unit labels for the X and Y axes (located outside the graph) will not be visible on your screen.

## Automating the Dotting Process

Automating the random dot process is not essential to carrying out this protocol, but it can save hours of time and is strongly recommended. We use WinBatch for Windows, a proprietary programming language, to automate the task of activating MS Excel, creating

the random plots, merging each random plot with a video frame in Adobe Photoshop (JPEG file format), and saving it to a designated directory, leaving the original image file unaltered. It also serves to catalog the images in a file system. Running the WinBatch script when the computer is not otherwise occupied enables you to automatically dot up to 1,000 frames in one series, at a rate of ~100 frames every 25 minutes on a Pentium Pro machine with 450 MHz processor and 128 MB RAM.

### ***The WinBatch Script***

A script has been developed to automate the dotting process for this protocol. You will need to install WinBatch on your computer from a WinBatch CD or by downloading it from the Internet. Do not modify this script (Lola.wbt) in any way. If you have questions or problems regarding this script, contact the authors of this protocol.

#### **Downloading WinBatch from the Internet**

Go to <http://www.winbatch.com> and click on DOWNLOAD OUR SOFTWARE. To start the download, choose any of the ftp or http addresses under "WinBatch." The file is ~3MB in size. You receive a free 21-day trial, after which, if you want to purchase it, the cost is \$99 plus shipping/ handling.

### ***File Management***

During the automated dotting process, WinBatch uses a three-directory file management system.

- **The source directory:** This is the same as your Source folder, where the original “un-dotted” video frames are stored as JPEG files. They should not be put into subfolders within this directory, and no other documents or items besides the images should be put in this directory. The dotting process will “dot” whatever is in this directory.
- **The destination directory:** This is where the WinBatch program moves the video frames after the plot layer of random dots has been added. We recommend "D:\destination" so that the files are on a different partition of the drive than the operating system in case of a system crash. Within this directory, WinBatch will create a folder for each transect that is named using the first eight characters of the file names for the video frames in that transect.
- **The working directory:** WinBatch automatically creates a temporary directory (C:\work-ing) and saves each frame in it during the dotting process until it is moved to the destination directory. (Only one frame at a time is put in the working directory.) You won't see this directory on your computer because WinBatch automatically deletes it when the dotting process is complete.

For example, assume you have filmed twenty 10m transects and captured 26 frames (25 from the transect plus 1 for the slate) for each transect and saved them as JPEG files. You now have a total of 520 files. You have stored these 520 JPEG files in your Source folder. If you use the suggested 10-character naming format explained on page 15, WinBatch will take the images from your Source folder and put them in individual transect folders that are named according to the first 8 characters of the image name. Each folder contains the 26 JPEG files for that transect. By using a name that identifies the image date and location (e.g., the slate frame of the first transect named 01CR029800), you can avoid confusing similarly numbered transects filmed at different locations or on different dates.

### **What WinBatch Does Automatically**

- After you specify the directories, the Randomplot macro starts, generating random points three times to assure proper synchronization. Adobe Photoshop also becomes active, and the ChopChop window opens.
- The Randomplot macro runs again and copies an un-dotted video frame from the source directory you specified to the temporary working directory.
- Within Photoshop, the image from the temporary working directory is opened, dots are pasted on the video frame as a second layer; and the two layers are compressed into one image and saved as such in the temporary working directory.
- The image is then moved to the appropriate subfolder that was automatically created by the WinBatch script in the destination directory you designated.
- The Randomplot macro runs again, repeating the process for the next frame, and continuing until 100 images or all the images in the source directory have been processed, whichever comes first.
- The WinBatch script closes Adobe Photoshop and then MS Excel, which takes ~1 minute. WinBatch will then re-open MS Excel and Adobe Photoshop, and continue to repeat the process in batches of 100 until all the frames have been dotted.

## ***Dotting a Batch of Captured Images***

- Launch the WinBatch script by double-clicking on “Lola.wbt”.
- You will be prompted by four dialog boxes to specify:
  - **Image type:** Select the same file format that you used when you saved the captured video frames. (Only one file format can be used per batch.) We use JPEG, which is the default.
  - **Source directory:** Browse to indicate the Source folder where your un-dotted image files are located.
  - **Destination directory:** Browse to indicate where you want the dotted frames to be saved.
  - **Randomplot.xls:** Browse to indicate where this spreadsheet is located.
- After responding to the dialog prompts, you must let your computer run the applications without interruption. You cannot use the computer for any other purpose while the WinBatch script is running. You can monitor the progress by checking the counter, which indicates which frame out of how many total frames is currently being processed. It takes ~20 minutes to process 100 frames on a computer with 450 MHz processor.
- When all the images in the source directory have been dotted and saved to the destination directory, WinBatch will close all applications and open a dialog box indicating the elapsed time for the processing of all frames.
- WinBatch will create one Notepad file for each batch of 100 JPEG files, listing them in the order in which the frames were dotted (Logfile\_1, Logfile\_2, etc.) You can open these files by double-clicking on the Logfile icon on your computer desktop. Check the number of dotted frames to make sure that it is the same as the number of un-dotted image files in the source directory. If it is not, check to see which files are missing. Depending on the number of missing files, you can either dot the frames individually or copy them from your source directory to a separate folder and run WinBatch again, using this new folder as your source directory.
- Save the Logfiles in the same directory as the JPEG files and the data entry worksheet.

The script is set up to close the applications after 100 frames because WinBatch may fail if the large temporary files that created during the processing are not removed. They will automatically be deleted when the WinBatch script closes Adobe Photoshop.

## ***Backup and Long-Term Data Storage***

The efficacy of this protocol relies heavily upon the collection and safe storage of digital data that is easily corruptible and can be permanently lost by a drive failure or virus infection. (Other methods of coral reef monitoring such as chain transects also involve data entry, but they are backed up by hand-written data in data log books.) Although your specific procedures regarding the frequency and method for back-up and long-term storage may depend on the policies of your employer or work unit, the eventual fate of the videotapes, images, and analysis data you produce in the course of your monitoring needs careful consideration, and frequent backing-up of computer drives is advised. To help protect the data, we recommend that you:

- **Partition your hard drive.** Store all images and data on a hard drive partition that does not contain the operating system. That way, when you experience an operating system failure and need to re-format that drive to re-install the operating system, the data will probably be safe.
- **Write data to CD often.** For each site, create a library of CDs for images (captured BMPs, un-dotted and dotted JPEGs). The images can also remain on your hard drive until space or operational efficiency is compromised. A site may be associated with as much as 210 MB of data, including archive, source, and destination files for captured images from twenty 10-m transects; completed data entry sheet; map of the site and sample points derived from AquaMap; various AquaMap operational files; and a metadata record file. A CD can hold 650 MB. If you leave the CD session "open" when transferring the images to the CD, the data sheet and metadata for the site can be added later.

For example, suppose you've completed twenty 10-meter transects at Chalupa's Reef, captured the images and converted them to BMPs, and JPEGs, and run the dotting script, but you don't have time to analyze the dotted images right away. You can copy the three files of images for the site onto a CD, leaving the session open. (If applicable, the configuration, waypoint, and metadata files associated with the use of AquaMap at this site can also be put onto the CD.) When the image analysis is performed, keep the data sheet and Readme file on your hard drive until the analysis for all transects is complete, then copy the data sheet and metadata file to the CD and store.

- **Clearly and accurately label the CDs and videotapes,** making sure that the tapes are fully rewound.
- **Store the CDs and videotapes safely** in a cool, dry, place away from magnets, preferably with climate and humidity control. If building damage from hurricanes or flooding may occur, precautions such as creating off-site or off-island backup copies should be taken.
- **File any associated printed materials.** Data summaries for the site and by transect should be printed and filed along with the metadata and any site sampling maps.

## Substrate Identification and Data Entry

### Using MS Excel

The data for each site is entered on a separate worksheet in MS Excel, using the worksheet that has been set up for this protocol, "Dataentry.xls". The tabs at the bottom of the sheet are labeled 01TRAN to 20TRAN, one for each transect. This file also contains a data table spreadsheet for the intermediate storage of the compiled data, and a print table that tabulates data in a printable format. An extra transect sheet is provided in case the site has more than 20 transects, but it is not linked to the print or data tables.

⚠ Before entering data in the worksheet, you must make sure the "AutoComplete" editing feature has been disabled, or errors will result.

For example, if you enter "MACA" for "macroalgae" and later enter "MA" for "*Montastraea annularis*," the AutoComplete feature will automatically change your "MA" entry to "MACA," and since both are valid entries, the checking process that has been built into worksheet will not notice the error. To disable AutoComplete:

- Go to the TOOLS drop-down menu and choose OPTIONS → EDIT → SETTINGS.

- Go to the bottom of the list of entries and "un-check" the box for "Enable AutoComplete for cell values". Then choose OK.

## ***Setting Up the Data Entry Worksheet***

- Open and maximize Dataentry.xls from D:\DATA ENTRY or wherever it is stored.
- To begin data entry, select the tab that represents the number of the transect you are analyzing. Enter the metadata in cells B1-B8.
  - **B1: Location.** Give general location, e.g., the name of the reef study site, "Newfound", or "Yawzi."
  - **B2: Transect number.** This corresponds to the tab number. Make certain it corresponds to the transect that you are viewing.
  - **B3: Videotape number.** This is the number used to identify the tape in the video log. It should also be written on the cassette and on the white liner of the cassette case.
  - **B4: Date.** The date that the transect was videotaped. It can be found in the video log sheet or in the information filmed on the underwater slate for the transect.
  - **B5: Length of transect.** The length of the transect as measured in meters.
  - **B6: Number of data points.** Do not enter anything in this cell; the number of data points will be automatically calculated as you enter the data. It is derived from the number of frames that were captured along the transect and the number of random dots applied per frame for analysis. Generally, each frame will be analyzed with 10 random points; therefore, if 25 frames were captured for transect, the number of data points will be 250.
  - **B7: Analysis by.** Enter your name.
  - **B8: Date of analysis.** Enter the date of the analysis.
- After the B1-B8 cells have been completed, minimize the Dataentry worksheet.

## ***Opening Files in Adobe Photoshop***

You will record the identification of each sampled point on the Dataentry worksheet by keeping a small portion of it open while viewing the video frame at 100% image size in Adobe Photoshop. This process goes more quickly if you open as many frames within each transect as possible at the same time. Photoshop and your computer have memory/resource allocations that determine how many files can be open at once. For example, on a computer with 128 MB of RAM, this maximum is generally about 20 to 30 JPEG files. Photoshop will open the files sequentially so that the first frame you request ends up at the bottom of the "stack." Because you want to enter the data for the frames in the order in which they appear in the transect, with #01 first, you will need to open the files in reverse order. For example, assume you have a transect folder with 28 frames, but your computer can only have 20 open at time. You would open the first 20 frames in reverse order, starting with #20 and ending with #01. After you have entered the data for a frame, press F11 to close it. When you are finished with the first 20 frames, open the remaining eight frames #21 to #28 in reverse order, starting with #28.

- Open and maximize Adobe Photoshop to the size of your desktop. If the Photoshop toolbar or any other Photoshop option box is displayed, remove it by pressing the TAB key, or go to the WINDOW drop-down menu and choose HIDE TOOLS.
- Determine the maximum number of JPEG files you can have open by experimenting on your computer.
- Go to the FILE drop-down menu and open the maximum possible number of files (or the number of files you need to do, if fewer) in reverse order, so that the file with the lowest number appears on top of the stack. Instead of opening the files one at a time, it's generally faster to click first on the file with the highest number in the sequential set you will be analyzing, and then hold down the shift key while clicking on the file with the lowest number.
  - You may find that this file opening process works better if you reverse the order in which the files are listed. (If the file details are not displayed, click on the DETAILS icon near the upper right corner of the OPEN dialog box; then click on the NAME bar to list the files in descending order, from the highest number to the lowest. If you have used the suggested naming format, it is the last two digits before the extension that change sequentially.)
  - However, if you open a series of files simultaneously, you must check to make sure the files have been stacked in the correct sequence before you start entering data. You may find that Adobe Photoshop has opened the first and/or last file out of sequence, and you will have to rearrange them.
- Adjust the Photoshop window so that it is small as possible while still enabling you to view the image at 100%, and can see the entire video frame and dots without having to scroll up/down or over the frame.

## ***Entering the Data***

- Open the Dataentry.xls worksheet and adjust its size so that it fits on the screen with the first frame you will be analyzing. The worksheet area will be small; only about the first 10 lines that are available to enter data will be visible. Make sure that it is the active window and that the substrate identifications are not being made in some other window.
- The characters A-J in column B indicate which space corresponds to which data point. Starting with dot A, enter in cell A11 the identification code for the benthic group/species found directly under that dot on the video frame. (See the "Guide to Substrate Identification" on page 47 for instructions and Appendix A for the codes.) Continuing sequentially through "dot" J, enter the codes vertically in cells A11 through A20. When you have completed entering data for the first frame, the gray shading indicates that 10 lines of data have been entered, corresponding to the 10 dots on the video frame.

### **Manipulating Images in Photoshop**

Pressing the "+" key while holding down the CTRL key in Photoshop will make the image larger; pressing "-" with CTRL will make the image smaller. The function keys can also be used to manipulate images:

- F2: Brightness adjust
- Shift+F2: undo brightness adjust
- F3: Contrast adjust
- Shift+F3: undo contrast adjust
- F4: Unship mask
- Shift+F4: Find edges

☞ Do not copy and paste data into cells. For example, even if all 10 dots are on DCA, avoid the temptation to copy the first “DCA” and paste it into the next nine cells. Also, if you make a mistake in data entry, do not delete the entire line or “cut and paste.” Delete only the errant letters and re-enter the correct code in the cell.

- Column C is used to enter miscellaneous notes regarding a point and certain codes. Only these codes will be automatically quantified by the spreadsheet:
  - BL = Bleaching
  - BBD = Black Band Disease
  - WBD = White Band Disease
  - PLA = Plague Type II
  - YBD = Referred to as “Yellow Blotch Disease”
- Each time you have completed the data entry for a frame, go to the FILE drop-down menu in Excel and click on SAVE.
- Repeat the process for each frame in numerical order in the transect.

☞ Check to make sure that the frame number you are looking at matches the rows in which you are entering data on the worksheet. For example: frame #1 will be entered in cells A11-A20; frame #2 will begin with A21 and end in A30; frame #9 will begin in cell A91 and go to A100; frame #20 will begin with A201 and end in cell A210.

## Checking the Data

- After you've completed the data entry for a transect, enlarge the dataentry.xls worksheet so that you can see all of it and check the validity of your data entries. The worksheet will automatically count the number of cells containing raw data (column A), compare the spelling of the raw data entries against a master list of possible data entry codes, and compare the results of the two counts.
- Check to see whether yes or no is displayed in cell **G6**.
  - YES means that all of the data codes match those in the master list. Make sure you have saved the worksheet, then proceed to step #4.
  - NO means that the worksheet detects an error, or doesn't recognize a data entry.
- If NO is displayed in cell **G6**, check column E, beginning with cell E11 and scrolling down. If the worksheet recognizes the identification code in column A, the same code appears in the corresponding cell in column E. If the code in column A is not recognized, “#N/A” appears in column E.

☞ Data entries must consist only of characters, with no blank spaces before, within, or after the codes.
- When you find a mistake, correct the code in column A. (You may need to re-open the JPEG file to confirm which identification code should be used.) After you have checked all of the cells in column E, save the worksheet.
- Check the question at line **F6** to see that the answer is YES. If it is not, repeat the above procedure or check to see that the correct number of data points has been entered into cell **B6**.

- When the answer in cell **G6** is YES, click on SAVE. Make sure the file is in the appropriate folder corresponding to the transect location and date. Then open the next set of frames in Adobe Photoshop and repeat the data entry process.

## Data Summary and Analysis

### *Individual Transect Data*

Each of the first 20 sheets in the Dataentry.xls worksheet corresponds to a transect.

- Individual species and other major categories (see "Guide to Substrate Identification" on page 47) are displayed in cells **F11** through **F114**.
- The number of points and their relative percentages are found in corresponding cells **G** and **H**.
- Embedded within each sheet at cell **F124** is a table for coral condition and disease calculations.
- The Shannon-Weaver Diversity Index calculations performed for each transect are displayed in cells B17 to U17 (for 20 transects). Embedded within each sheet at cell **F136** is a chart that summarizes category abundance (points and percentages) for the transect; numbers of points and relative percentages of diseases, bleaching, and the Shannon-Weaver Diversity Index. This summary table is linked to the data tables and print tables sheets within this Dataentry worksheet.

The Shannon-Weaver Diversity Index is calculated for each transect and for the entire site using:  $H' = -\sum p_i \ln p_i$ , where  $p_i = n_i / N$ , in which  $N$  = total number of point (individuals) of all species, and  $n_i$  the number of points of species ' $i$ '. Dots identified as "CORAL" (not identified to species) are *excluded* from this calculation.

### *Site Data*

The Data Tables worksheet contains two tables that are composites of the individual transect summary chart. The values for these tables (and the metadata in rows 1 to 3) are automatically computed and updated as you enter data on the worksheet.

- Percent cover by benthic groups per transect is found in the top table (**rows 6 to 29**).
- Data on bleaching, and/or disease cover (percent cover relative to transect cover, and percent cover relative to coral cover) is summarized within this table in **rows 19 to 28**.
- The Shannon-Weaver Diversity Index for each transect is displayed in **row 30**.
- The number of points of each benthic group and bleaching or disease type per transect is found in the bottom table (**rows 35 to 57**).

Similar to the Data Tables, in the Print Table worksheet, the cumulative sums of number of points for major categories are displayed in a separate chart. However:

- A different font and font size is used to provide a better print-out, and the bleaching/disease data have been removed.
- The mean and standard deviation are calculated using individual transect percent cover values of each major category, and are displayed in cells V5–V16 (mean), W5–W16 (standard deviation).

- The Shannon-Weaver Diversity Index is calculated for each transect and displayed in cells from B17 to U17 (for 20 transects).

The Shannon-Weaver Diversity Index is also calculated for the entire site by summing the number of points of a coral species for all transects. This coding is found in the Print Table worksheet beginning with row AA-AG. The overall site H' value is found in cell AG23. (This value is also found in the percent cover table, cell V17.) To allow for a comparison of the H' between years when *Monastrea annularis* was not broken into its complex species, another calculation of H' is provided in cell AG30 and copied to cell V18. A comparison is made of the number of points identified to coral species versus category "CORAL" in cells AF23 and AF27.

## **Documenting Transect Analysis and File Locations**

It is recommended that you label the name and storage location of the Print Table so that when you have a print copy, you can link it back to the computer file where it is stored and locate the data from which the results were obtained. You can do this by simply writing on the printed copy or by using a function of WinBatch to automatically copy the path and file name to a cell.

- Open Explorer.
- Select the data entry file in which you are working.
- Click the right mouse button and select CLIPBOARD TRICKS.
- Select PATH AND FILE NAME(S) TO CLIPBOARD. The path and file name will be displayed momentarily and copied to the clipboard.
- Return to the data entry sheet in which you are working, select a cell (approximately cell A36) and go to EDIT → PASTE to paste the path and file name into that cell.
- It is also recommended that you type or write the date you last saved this file.

In addition, in the Metadata/Readme file, record what you have done, the transects that have been analyzed, and the names/locations of the files that have been saved. Then save the Metadata/Readme file.

### **What, no database?**

Data summaries per site are produced as the data are entered into the spreadsheet. A database will eventually be created to store information, but it is not ready at this time.



## **A. Printing Transect Data and Results Table**

When you have finished entering and checking data for the last transect for the site or station, you may want to print the results table and individual transect data.

To produce the optimum print-out of the results table:

- Click on the PRINT TABLE tab.
- Delete the columns for transect numbers that were not in this site. For example, if you have 10 transects, delete the columns for transects 11-20. This will allow the mean and standard deviation to be calculated.
- Go to FILE → PRINT PREVIEW to see how many pages will be required to print all of the columns in a given font and paper orientation. Using the default font (8 point Arial) and

landscape orientation, 10 transects will fit on one page. The Shannon Weaver Diversity Index calculations will fit on a separate page.

- Select the pages that you wish to print and click on PRINT.

To print the data for a specific transect:

- Click on the tab for the appropriate transect number.
- Go to the TOOLS menu and choose PROTECTION → UNPROTECT SHEET.
- Go to cell H9, the Percent category, and click on the down arrow. This will give you options from which to filter the analyzed data set. Choose CUSTOM and select NOT EQUAL TO and 0. This will reveal all the species that were present on the transect.
- Select the three rows from F1 to H1 down to the bottom of the summary chart and the total values.
- Go to FILE → PRINT AREA. This sets the area to print what you have selected.
- Go to FILE → PRINT PREVIEW to make sure the columns fit on one page and then click on PRINT. You should check to see that the transect date, and label ("Metadata") are at the top of the printed page.
- Make sure that you do not accidentally save the data sheet in this form, with the “zero” values removed. To restore them:
  - Go to FILE → PRINT AREA → CLEAR PRINT AREA.
  - Go to the Percent box and click on the down arrow. Choose ALL to get all the data back.
- Go to TOOLS → PROTECTION → PROTECT SHEET. Make sure that there is a check mark next to contents; objects and scenarios, then click on OK.

To print another transect, select the tab that corresponds to the transect and repeat the process above.

## **Statistical Analyses**

Results from this method are tabulated in the data entry sheet, data tables or print table. The number of dots and percent cover for each benthic category, plus the Shannon-Weaver diversity index ( $H'$ ) are tabulated per transect. Additionally, an overall mean and standard deviation are calculated for each category for the site using all transects. A Shannon-Weaver diversity index is also calculated for the site in two ways: first, by transect and, second, by pooling all coral species points for all transects.

This protocol recommends the use of permanent randomly selected transects; that is, the same transects are re-visited each year as opposed to randomly selecting a new set of transects each sample period (year). The random selection assures unbiased, independent sampling of the defined area. Revisiting those samples each year allows for application of more powerful statistical tests. (e.g.: t-test for paired data vs. Student's t-test for unpaired data. See Rogers *et al.*, in press, and attached to this document for more details on statistical analysis.)

Initial data analysis should begin by testing data for normality, and incorporating a transformation (e.g.: arcsine) as necessary. If data are normally distributed, parametric

tests can be used; otherwise non-parametric analysis is advised. When comparing cover of substrate categories for the same sample points (e.g. transects) between two years the parametric test would be a paired t-test, while for non-parametric data, the Wilcoxon matched-pairs signed-ranks test is used. If different transects were sampled and the mean percent cover by substrate categories are being compared between two years, a Students T-test is used for parametric data, and the Mann-Whitney *U* test is used for non-parametric data.

When comparing categories for more than two years for data that are normally distributed, a repeated measures Analysis of Variance (ANOVA) can be used for dependent samples (repeating sample locations), while a Standard ANOVA is used when comparing independent samples. If this data are not normally distributed, a Friedman 2-way ANOVA by ranks is used for dependent samples, and the Kruskal-Wallis one-way ANOVA by ranks is used for independent samples.

When comparing greater than five or six time periods, the ANOVA will give way to a trends or time series analysis, however the details of that analysis have not been completed at this time.

## **Guide to Substrate Identification**

This guide is intended to provide assistance in identifying benthic components on videotaped frames; generally, frames that are being randomly sampled through the use of hollow dots that have been applied using WinBatch software. It assumes that the identifications are being made by an analyst who has been trained in the data collection process and is knowledgeable in identification of coral and other marine invertebrates. Identification of reef components on video images should be made with confidence and certainty. Diving experience in the area where the filming was done is an advantage when making identifications, but is not essential.

### ***Major Categories***

The substrate found at most of the reefs we study falls into one of the following major categories:

- living invertebrates (coral, sponges, gorgonians, zoanthids)
- dead coral with algae/turf algae
- macroalgae
- sand
- rubble
- pavement

Although the quality of video images filmed underwater varies, we can usually make accurate identifications of most hard corals to a species or genus level, and some macroalgae to a genus level. Some adjustments, e.g., brightness and contrast, can be made while viewing the image in Adobe Photoshop to assist with identification (see page 33). Identification of the other substrate components has proven to be more challenging.

If there is any doubt regarding identification, the more general or “conservative” category should be selected. For example, a dot that is “probably over *Montastraea cavernosa*” should be entered as “coral”; what “might be *Dictyota*” should be identified as “macroalgae”. However, if you cannot determine the major category (i.e., phylum) for a selected point, such as whether a component is a sponge, tunicate, dead coral with algae/turf or macroalgae, the “Unknown” category is the appropriate choice.

### ***Distinguishing Between Dead Coral with Algae/Turf and Macroalgae***

Distinguishing between dead coral with algae/turf and macroalgae in images captured from a videotaped transect may be difficult, but is worth taking the time to try to do accurately. The predominance of either category of substrate can be an important ecological indicator. Greater macroalgae levels may reflect elevated nutrient levels, and low fish or urchin grazing (and possibly over-fishing), whereas increased DCA/turf may indicate recent coral disease or high levels of grazing by fish/urchins. In the field, we use height (~<2-3 cm) and the absence of identifiable an identifiable macroalgal species to identify DCA. Macroalgae generally attain a height/thickness >2-3cm, and they are fleshy rather than filamentous, often with conspicuous branches or blades.

When deciding whether a dot is on DCA or macroalgae, you will need to evaluate other areas in the image for comparison. As with the hard corals, you should identify the seaweed to the most descriptive level possible, ideally genus. If this is not possible, but the alga appear fleshy and to have a thickness >2cm thick, it should be identified as “macroalgae.” As this video method provides only a two-dimensional view of the reef, the component’s “height” can be difficult to ascertain. Looking around the image, at substrate both similar and different than the area in question, may enable you to interpret features (colors, shading, textures etc.), that resolve the image in a third dimension. DCA would be the more conservative category, as explained on page 51.

### ***Finding the Center of the Dot***

It is also sometimes difficult to determine which benthic component occupies the exact center of the square, hollow sampling “dot.” When a dot falls on the edge of two components, you may find it helpful to use the “rectangular marquee tool” from the tool menu in Adobe Photoshop. This produces a small “+” which can be used to help find the center of the dot.

An experienced analyst can train a new analyst by reviewing the same images and making independent identifications. When differences of opinion arise, the two analysts compare how they reached a decision. This training will help the new observer to use consistent criteria when making identifications, so that in time, he or she will be able to work independently.

### ***Category Definitions***

Category identifications are entered in column A of the Dataentry worksheet, where they are automatically quantified and grouped by species and major category. See Appendix A for the complete list of codes. The codes must be entered exactly with no extra letters or spaces. See “Entering the Data” on page 42 for more details.

■ **CORAL = Hard coral: living hard coral**

Identify hard corals to the most specific taxonomic level possible and enter the applicable code from Appendix A. In many cases this will be the code for the exact species. However, if you know the genus but are uncertain of the species, use the code for the genus (e.g., AGPS for *Agaricia* species). If you cannot be certain of even the genus, use the generic “CORAL” code. Do not use the code for “unknown” (UNK) unless you have decided the component is not any species of coral.

NOTE: The appropriate code should be entered if you can confidently identify whether the species is *M. annularis* (MA), *M. faveolata* (MFAV), or *M. franksi* (MFRA). If you believe it is one of these three species, but are uncertain which one, enter the code for “*Montastraea annularis* complex,” MACX. (In addition to quantifying the number of MACX entries you’ve made, the spreadsheet will also tally the number of entries made for MA, MFAV, MFRA plus MACX in case you need this number for comparison with previous data sets that used MA for all three species. If you can identify the genus as *Montastraea*, but you cannot identify the species, use the generic *Montastraea* code, MSPP.

If a dot is on coral that is alive but bleached or pale and this identification is made with knowledge of present or possible bleaching at the time the coral was videotaped, identify the coral in column A, and enter BL in the Notes column (C). It’s important to note the bleaching so that it will be quantified.

BL = Bleached

☞ Coral bleaching is usually correlated with warmer sea water temperatures and is therefore usually observed in summer and early fall. This may help differentiate coral bleaching from some coral diseases.

### ■ **CORJU = Coral juvenile**

This code is used for coral recruits usually <4 cm in size. If you can identify the species, enter the species code in column A. However, if you cannot identify the species (which is usually the case at this small size), use the CORJU code instead.

### ■ **DCOR = Diseased coral**

This category is used when the dot is on a diseased portion of a coral colony (e.g., the dark ring in black band disease), or on bare coral skeleton that has apparently been recently killed by a disease (i.e., without filamentous algae overgrowth). Be careful in differentiating bare, recently dead skeleton from bleached coral (see above, “BL = Bleached”). Additional information should be put in the Notes column:

BBD = black band disease  
WBD = white band disease  
PLA = plague Type II (a.k.a., White Plague, Type II)  
YBD = “yellow blotch disease”

Other comments about the coral may be made in the Notes column, but only these four codes plus the BL code for bleaching will be included in the automatic quantification.

☞ Be careful not to interpret color variations as a definitive indications of disease. Most coral diseases are difficult to distinguish in the field, much less from an image. There is at present no consensus on definitive identification of coral diseases, so keep abreast of new findings documented in the literature.

### ■ **GO = Gorgonians**

Use the generic code GO for any gorgonian unless one of these more specific codes that indicates form or species applies:

ENGO = Encrusting gorgonian  
FAN = Sea Fan  
PLUME = Plume  
ROD = Rod  
WHIP = Whip  
BRIA = *Briareum asbestinum*  
ERYTH = *Erythropodium caribaeorum*

### ■ **SPO = Sponges**

The generic code SPO can be used for sponges, which come in all shapes, sizes, colors, and textures. Depending on your taxonomic skill, you may use instead a more specific code that indicates the form or species:

BALL = Ball  
BASP = Barrel/Vase  
BOSP = Boring  
ENSP = Encrusting  
ROPE = Rope  
TUBE = Tube  
CLIO = *Cliona delitrix*

■ **ZO = Zoanthids**

Use the generic code ZO for both solitary and colonial cnidarians unless one of these species codes applies:

PALY = *Palythoa caribaeorum*

ZOSO = *Zoanthus sociatus*

■ **ANEM = Anemones**

■ **CMOR = Corallimorpharians**

■ **MACA = Macroalgae**

Macroalgae are usually larger plants (>3 cm) that, compared to DCA, are fleshy rather than filamentous, and often have conspicuous blades or branches. If you can determine that the component is a thick, tall, non-filamentous plant, but you cannot identify the genus, enter MACA in Column A. If you can identify it as one of the following genera, use the applicable genus code instead.

AMPH = *Amphiroa* spp.

CLAD = *Cladophora* spp.

DICT = *Dictyota* spp.

HALI = *Halimeda* spp.

MICRO = *Microdictyon* spp.

LIAG = *Liagora* spp.

LOBO = *Lobophora* spp.

SARG = *Sargassum* spp.

SCHIZ = *Schizothrix* spp. (actually cyanobacteria, “blue-green” algae)

■ **DCA = Dead Coral with Turf Algae**

This category is characterized by a relatively short (<2-3cm) layer of filamentous algae. The algae lack conspicuous branches or blades and may require laboratory analysis for genus or species identification. It's difficult if not impossible to determine whether the coral under the algae is definitively dead. This category includes substrate that varies from being recently dead/recently overgrown, to long-dead/long-overgrown. The algae may appear as thin and sparse; whitish, washed-out, or covered with a thin layer of sand. Compared to macroalgae, turf algae are both smaller in size (<2-3 cm) and lack identifiable “fleshy” or calcareous blades or branches. If the DCA is visible through a thin sand layer, or if a dusting of sand that covers the DCA is estimated at <1cm deep, the component is identified as DCA; if more sand is present, it is identified as sand.

■ **CALG = Coralline Algae**

Coralline algae can be difficult to distinguish from DCA, but color (often pink or purple) and texture (sometimes “crusty”) may be the best clues.

■ **B = Boulder**

■ **S = Sand/Sediment**

In the field, sand is usually identified by measuring to >1cm in depth, or probing with the tip of a pencil, but it can be difficult to distinguish in a video frame. If there is only a dusting or thin (<1cm) layer of sand, the underlying component should be identified. Watch for texture changes that may help define this feature, and look around the dot and throughout the image for clues such as sand ripples to help identify sand.

■ **R = Rubble**

Rubble is generated by the mechanical breakage of coral from storms, surge, anchoring, or even bio-erosion. It can be difficult to distinguish in a video frame. If filamentous turf algae are growing on the substrate, use the DCA code. Pieces of coral (i.e., recently killed coral fragments) that do not appear to have algal growth should be coded “R”.

■ **P = Pavement:**

This is bare, hard substrate without a layer of sand or algal growth, unlike recently killed coral, which will have turf algae. Algae have not overgrown this substrate. This differs from recently killed coral (DCA).

■ **TAPE = Tape**

This is used when the dot falls on the transect tape, the tape reel, handle, or transect pin.

■ **WAND = Wand**

This is used when the dot falls on the aiming wand (the rod attached to the video housing to guide filming 40 cm from substrate).

■ **O = Other**

This code is used for any component for which we don't have a specific category, e.g., a fish, urchin, worm, bivalve, tunicate, hand, finger, bottle, dive gear. The spreadsheet will only recognize “O”, not “Other.” Describe the feature in Column C.

■ **SHADOW = Shadow**

This code is used when the dot is on a dark spot or deep in a crevice. You can use the F2 and F3 key to adjust the brightness and contrast, but sometimes you still cannot make a certain identification. If you cannot confidently identify what is under the dot because it is in a dark place or shadow, use the SHADOW code. Quantifying the extent of shadow may make it possible to determine if using supplemental light may be helpful.

■ **UNK = Unknown**

This is the code to use when you cannot make a confident identification in any of the above categories. For example, if you find yourself debating between identifying a component as a sponge or macroalgae (i.e., different kingdoms!), use this designation. Unlike shadow, in which a component cannot be identified because of its dark location, in this case the component is unknown because of one or more reasons such as insufficient focus or too many benthic features clumped together.

## APPENDIX A: Identification Codes for Benthic Components

### Categories in Column A

| I) Coral Species and Genus Codes |      |                                      |       |
|----------------------------------|------|--------------------------------------|-------|
| <i>Acropora cervicorni</i>       | AC   | <i>Montastraea annularis complex</i> | MACX  |
| <i>Acropora palmata</i>          | AP   | <i>Montastraea cavernosa</i>         | MC    |
| <i>Acropora prolifera</i>        | APR  | <i>Montastraea faveolata</i>         | MFAV  |
| <i>Agaricia agaricites</i>       | AA   | <i>Montastraea franksi</i>           | MFRA  |
| <i>Agaricia fragilis</i>         | AF   | <i>Montastraea</i> spp.              | MSPP  |
| <i>Agaricia grahamae</i>         | AG   | <i>Mussa angulosa</i>                | MAN   |
| <i>Agaricia humilis</i>          | AH   | <i>Mycetophyllia aliciae</i>         | MAL   |
| <i>Agaricia lamarcki</i>         | AL   | <i>Mycetophyllia danaana</i>         | MDA   |
| <i>Agaricia tenuifolia</i>       | AT   | <i>Mycetophyllia lamarckiana</i>     | ML    |
| <i>Agaricia undata</i>           | AU   | <i>Mycetophyllia ferox</i>           | MF    |
| <i>Agaricia</i> spp.             | AGSP | <i>Mycetophyllia</i> spp.            | MYSP  |
| <i>Colpophyllia natans</i>       | CN   | <i>Oculina diffusa</i>               | OD    |
| <i>Dendrogyra cylindrus</i>      | DCY  | <i>Porites astreoides</i>            | PA    |
| <i>Diploria clivosa</i>          | DC   | <i>Porites branneri</i>              | PB    |
| <i>Diploria labyrinthiformis</i> | DL   | <i>Porites divaricata</i>            | PD    |
| <i>Diploria strigosa</i>         | DS   | <i>Porites furcata</i>               | PF    |
| <i>Dichocoenia stokesii</i>      | DSO  | <i>Porites porites</i>               | PP    |
| <i>Eusmilia fastigiata</i>       | EF   | <i>Porites branching</i> spp.        | PBSP  |
| <i>Favia fragum</i>              | FF   | <i>Scolymia cubensis</i>             | SC    |
| <i>Isophyllia sinuosa</i>        | IS   | <i>Scolymia lacera</i>               | SL    |
| <i>Isopyhyllastrea rigida</i>    | IR   | <i>Scolymia</i> spp.                 | SCSP  |
| <i>Leptoseris cucullata</i>      | LC   | <i>Siderastrea radians</i>           | SR    |
| <i>Manicina areolata</i>         | MAR  | <i>Siderastrea siderea</i>           | SS    |
| <i>Madracis decactis</i>         | MD   | <i>Siderastrea</i> spp.              | SSPP  |
| <i>Madracis formosa</i>          | MAFO | <i>Solenastrea bournoni</i>          | SB    |
| <i>Madracis mirabilis</i>        | MM   | <i>Solenastrea hyades</i>            | SH    |
| <i>Meandrina meandrites</i>      | MME  | <i>Stephanocoenia michelinii</i>     | SM    |
| <i>Montastraea annularis</i>     | MA   | <i>Tubastraea aurea</i>              | TA    |
| Other Coral Codes                |      |                                      |       |
| <i>Millepora alcicornis</i>      | MILA | Unknown coral juvenile spp.          | CORJU |
| <i>Millepora complanata</i>      | MILC | Unknown adult coral spp.             | CORA  |
|                                  |      | L                                    |       |

|                            |      |  |
|----------------------------|------|--|
| <i>Millepora squarrosa</i> | MILS |  |
|----------------------------|------|--|

| Gorgonian Species and Forms      |      |                                  |       |
|----------------------------------|------|----------------------------------|-------|
| <i>Briareum asbestinum</i>       | BRIA | Plume form                       | PLUME |
| <i>Erythropodium caribaeorum</i> | ERYT | Rod form                         | ROD   |
| H                                |      |                                  |       |
| Encrusting gorgonian             | ENGO | Whip form                        | WHIP  |
| Sea fan                          | FAN  | All other and unknown gorgonians | GO    |

| Sponge Species and Forms |      |                               |      |
|--------------------------|------|-------------------------------|------|
| <i>Clionia delitrix</i>  | CLIO | Encrusting sponge             | ENSP |
| Ball sponge              | BALL | Rope sponge                   | ROPE |
| Barrel/vase sponge       | BASP | Tube sponge                   | TUBE |
| Boring sponge            | BOSP | All other and unknown sponges | SPO  |

| Zoanthid Species and Generic Codes |      |                 |    |
|------------------------------------|------|-----------------|----|
| <i>Palythoa caribaeorum</i>        | PALY | Other zoanthids | ZO |
| <i>Zoanthus sociatus</i>           | ZOSO |                 |    |

| Macroalgal Species, Genus, and Generic Codes |      |                            |       |
|----------------------------------------------|------|----------------------------|-------|
| <i>Amphiroa</i> spp.                         | AMPH | <i>Liagora</i> spp.        | LIAG  |
| <i>Cladophora</i> spp.                       | CLAD | <i>Lobophora variegata</i> | LOBO  |
| <i>Dictyota</i> spp.                         | DICT | <i>Sargassum</i> spp.      | SARG  |
| <i>Halimeda</i> spp.                         | HALI | <i>Schizothrix</i> spp.    | SCHIZ |
| <i>Microdictyon</i> spp.                     | MICR | Other macroalgae           | MACA  |
| O                                            |      |                            |       |

| Other Categories                |      |                         |        |
|---------------------------------|------|-------------------------|--------|
| Coralline algae                 | CALG | Other live organisms:   |        |
| Dead coral with turf algae      | DCA  | • Anemones              | ANEM   |
| Diseased coral                  | DCOR | • Corallimorpharians    | CMOR   |
| Inorganic substrate components: |      | Non-substrate entities: |        |
| • Boulder                       | B    | • Tape                  | TAPE   |
| • Sand/Sediment                 | S    | • Wand                  | WAND   |
| • Rubble                        | R    | • Shadow                | SHADOW |
| • Pavement                      | P    |                         |        |
| Other identifiable entities     | O    | Unknown entities        | UNK    |

**Codes for Column C** *(will be automatically quantified)*

| <b>II) Coral Bleaching and Diseases</b> |     |                       |     |
|-----------------------------------------|-----|-----------------------|-----|
| Bleached coral point                    | BL  | Plague, Type II       | PLA |
| Black band disease                      | BBD | Yellow blotch disease | YBD |
| White band disease                      | WBD |                       |     |

## APPENDIX B: Glossary of Terms

**Actions:** Adobe Photoshop lets you automate tasks by grouping a sequence of commands into a single action. For example, you can create an action that applies a series of filters to reproduce a favorite effect or combine commands to prepare images for online publishing. Actions can be grouped into sets for easier organization. As in the previous example, you could create a set of actions in which each action applies to a different series of filters. You can use an action on a single file or on a batch (multiple files in the same folder). You use the Actions palette to record, play, edit, and delete actions. It also lets you save, load, and replace action sets. It is located under the Adobe Photoshop Windows drop-down menu (See “Show Actions”).

**Active use o-rings:** The o-rings to be used when the unit or device is submerged or subjected to greater than atmospheric pressure.

**Adobe Action Package:** A folder called “Video Methods” that contains the Action commands for all the components of the video protocol.

**Adobe Photoshop:** Computer program used as the image platform. Photoshop displays the image during the dotting process, and data analysis components.

**Aiming rod:** A stick ~1 cm in diameter that is attached to the video camera housing to enable the diver to accurately guide the camera 40 cm from the substrate; also known as an “aiming wand.”

**Batch:** A group of up to 1,000 images located in a folder, ready to be “dotted.”

**Brightness Adjust:** This Adobe Photoshop feature manipulates the image light levels. A brightness adjustment has been pre-programmed to the F2 Function key through the action palette.

**Camera tray:** A metal plate containing electrical circuitry that attaches to the bottom of the video camera for inserting the camera into the housing.

**Capture – Automatic:** Feature of some capture cards that automatically selects and saves video image frames, usually based on a time interval.

**Capture – Manual:** Operator controlled process of selecting and saving video image frames.

**Capture board:** A computer card installed within the PC case that conducts the video image capture options. This protocol uses the Sony DVBK-2000/2000E capture board.

**Capture album:** The computer folder where captured still images are stored.

**ChopChop:** Temporary name that is automatically given to Adobe Photoshop during the dotting process. It is canceled when the process is complete or when the program (Adobe Photoshop or “chopchop”) is closed. It will not affect or harm any other images or applications on your computer that utilize Adobe Photoshop.

**Contrast:** This Adobe Photoshop feature manipulates the image light levels. A contrast adjustment has been pre-programmed to the F3 Function key through the action palette.

**Destination:** This term is used with the WinBatch script to define the user-selected location of the images after they have gone through the dotting process.

**Drop-down menu:** These are located above the icon bar on a PC to access features within a program.

**Dotted:** An image that has gone through the dotting process and now has “dots” (i.e., hollow red squares) placed upon it.

**Exposure:** The video camera setting that controls the opening of the lens aperture. Auto-exposure is recommended.

**File types:**

**\*.bmp** (bitmap)

**\*.dvi** The digital video file format used by the Sony Capture board when a still image is captured.

**\*.jpg** (JPEG: named for the Joint Photographic Experts Group, the committee that developed this image compression mechanism) JPEG is a useful format for compact storage and transmission of images, but there is some image degradation each time a JPEG file is recompressed, i.e., each time it is edited or otherwise manipulated and re-saved as a file.

**\*.tif** (tagged image file format)

**\*.wbt** Files created by the WinBatch script in WinBatch Studio

**\*.xls** Spreadsheet format for Microsoft Excel.

**Fire wire:** This wire connects the video tape player or video camera, to the capture board communicating digital information from the tape to the computer.

**Flatten:** This Adobe Photoshop process merges multiple layers into one. For our purposes, it is an action contained within the Adobe Action Package that melds the layer containing the random dots to the video image layer.

**Focus – Auto:** This video camera setting allows the camera to pick the dominant object or plane on which to focus.

**Focus – Manual:** This video camera setting requires the operator to pick the dominant object or plane on which to focus.

**Focus – Momentary Auto-Focus:** Toggling the focus switch to AF will set the manual focus at the subject distance.

**Housing view port optic:** The shaped glass contained in the view port for the video camera lens. The Stingray housing uses a “bayonet” mounted, Zoom-Macro system.

**Macro:** A series of commands written in Visual Basic Programming language contained within a Microsoft Excel Worksheet. A series of key commands activates this “program”.

**Metadata:** As used in this protocol, metadata refers to details about the data collection dive and may include depth, time, divers, dive conditions, etc.

**Randomplot:** This is the name of the Microsoft Excel worksheet that contains the macro responsible for creating the random points.

**Readme file:** This computer file is created in a word processing application in order to enter metadata.

**Red flip filter:** This red plastic lens can be manually rotated into position in front of the video camera lens, inside the camera housing.

**Script:** This is a sequence of steps written in windows interface language and used by the WinBatch program to run the dotting process. Similar to macro.

**Show Actions:** This command can be selected in an Adobe Photoshop drop-down menu to display the Action Palette.

**Shutter speed:** This video camera setting affects the video image exposure. It can be set by the operator (manual) or automatically by the camera.

**Storage o-rings:** These are used in devices while they are not being submerged or under greater than atmospheric pressure.

**Sony DV Application (APP):** This is the application that works the Sony capture board to create the image libraries, saves the image types, etc.

**Source:** The WinBatch script uses this term to identify the location of the un-dotted images just prior to the dotting process.

**Time code:** This is a string of data “written/recorded” on the digital video tape that reflects the time, (hours, minutes, and seconds) since the tape started.

**Toggle:** A rapid motion to activate a switch on the video camera housing that involves moving the switch, then releasing the switch to its normal (neutral) position.

**Un-dotted:** Images without dots are usually located in the source directory prior to the dotting process.

**Unsharp Mask:** This filter is used in Adobe Photoshop to improve the focus of an image (sharpen the edges) by increasing the contrast between adjacent pixels. An unsharp mask adjustment has been pre-programmed to the F4 Function key through the action palette

**Video slate:** This device used to record data relevant and just prior to the recording of a transect. We have found the magnetic type work very well for this purpose.

**White balance:** This video camera setting attempts to normalize the color of light reaching the lens after striking a surface. Due to the light absorption qualities of water (and since this protocol does not include the use of lights), the white balance should be left on automatic.

**WinBatch:** This is the program from which the dotting process script is run; it instructs Adobe Photoshop and Microsoft Excel to perform the necessary functions to carry out the dotting process.

**WinBatch – Studio:** This is the application within WinBatch from which the user can launch the WinBatch Script.

**Working directory:** This directory is automatically created by WinBatch during the dotting process for the manipulation of the un-dotted image into the dotted image. It is also deleted automatically, so there will be no evidence of it on your computer system.

**Zoom-Macro Diopter:** This lens, usually encased in rubber, is fitted onto the camera lens, allowing the video housing system to operate from wide angle to zoom.

## APPENDIX C: Creating Laminated Photos for Transect Relocation

If your monitoring program is designed to include repeated monitoring of the same site, you will need to be able to lay the transect so that it is in the exact same position as it was when you collected your baseline data. Even if you are using the AquaMap tracking system (see separate protocol), which can put you within approximately one meter of the original transect origin, this can be difficult. However, we've been able to precisely relocate transects by using laminated photo captures of the video transect in combination with AquaMap. The photos provide helpful information regarding, for example, placement of the transect placement with respect to a sea fan or large coral colony. Depending on the goals of your program, you may decide to install pins in the substrate to mark the origin and terminus of the transects. (copper covered steel survey markers from Forestry Suppliers, Inc. work well), but the installation and maintenance of survey pins inevitably results in some degradation to the environment

👉 If you plan to use captured video images to help relocate a transect, keep this in mind while you are doing the initial filming, and take special care to film the transect origin and terminus, and to include identifying features.

### ***To create the laminated photos using Sony Still Image Capture program:***

- 1) Use the Sony Capture program to capture, convert to JPEGs, and save images from the videotape that show the placement of the transect (see page 16 for more details). These are the images to look for:
  - The best view of the transect placement is generally filmed during the “swim back” portion of the video, so try to capture three of four images that show this long view, preferably including monument-type corals or other identifying features. For example, if you filmed a 10-meter transect, you would look for the best images taken above the 10m point and at about 8m-6m, at 5m-3m, and at 2m to the transect origin.
  - A photo of the transect origin that provides as much detail as possible about the transect tie-off point in relation to the surrounding reef.
  - A photo of the terminal end of the transect.
  - You may also want to capture an image of the slate at the beginning of the videotape that identifies the transect.

Convert these images to JPEGs, selecting “Highest” as the option for graphic quality, and save the images to a file on your hard drive. (The \*.dvf files created by the Sony Capture Program can then be deleted.)

- 2) Use a software program to size the photos (we use MS Publisher) so that each transect can be arranged on a 8½” x 11” page. Depending on the type of laminator you have, you may need to leave a margin of about one-half inch around the edge of the paper. (Ordinary 8½” x 11” paper can be used with some laminators, while others require trimming about a half inch off the edge of the paper in order to ensure watertight sealing.) We lay out the “swim back” photos along the left margin, starting with the 0-2m photo capture at the top.

- 3) Use the “print preview” to make sure that the photos are large enough to provide the necessary detail.
- 4) After printing out the page, use a dark marker to make any notes needed to identify the photos or circle critical points, such as the place where the transect tape was tied off. If an image of the slate was not captured, write the transect number, site name, and data on the photo page. It’s much easier to write on the photo sheet *before* it has been laminated.
- 5) You can put the photo pages back-to-back to reduce the number of laminations required. The laminated sheets can then be placed on a clipboard and secured with rubber bands for use while diving.

### ***To create the laminated photos using Pinnacle Studio 9:***

- 1) Connect the video playback unit to the computer via firewire cable.
- 2) Open the Pinnacle Studio program, if auto-run feature does not open it.
- 3) Press “play” or the play button on the diagram or on the playback unit itself to start the video of the transect.
- 4) Capture slate and save.
- 5) Capture how tape/pin looks at the origin.
- 6) Fast-forward video to the end of the transect.
- 7) Capture an image showing what the transect looks like as the swim-back proceeds from approximately 10m to 7m, 7m to 5m, 5m to 3m, 3m to origin.
- 8) Capture a close-up image of the origin.
- 9) Use the Batch File Utility to rename the images keeping the numerical sequence saved capturing above. Use the name convention:
 

|      |      |      |     |      |
|------|------|------|-----|------|
| Tran | Site | Year | #   | .bmp |
| --   | --   | ---- | 1-9 | .bmp |
- 10) Store renamed images in folder
- 11) Capture next through all transects using steps 1-8.
- 12) When all transect images have been captured, run the “Size, image adjust and save as JPG” script in Adobe Photoshop (see SOP – Suggestions for image resize and auto-adjust using Adobe Photoshop).

Assemble photos in Microsoft Publisher program

- 1) Open template (fig. 1) in MS Publisher
- 2) Determine the number of images you have captured for that transect.
- 3) Open that number “page” on the template.
- 4) Double-click on the first (slate) image. This will open up the insert image dialog box.
- 5) Browse to the folder where the captured, sized and adjusted jpgs are stored. Double click on the first image of the transect. You will see that image is inserted into the publisher template page.
- 6) Save that Publisher image to a folder with a name for that transect, site date.
- 7) Repeat steps 4-5 with the other images in sequence for the transect.
- 8) Repeat the save in step 6.
- 9) When you have completed a transect, insert a page from the template with the appropriate number of images to the “back” of the completed page and proceed to insert the new images into that page. Save the publisher document when finished with the format:

|         |      |       |      |
|---------|------|-------|------|
| Tran    | Site | Year  | .pub |
| -- - -- | --   | ----- | .pub |

***Appendix D: Photos illustrating components of protocol.***



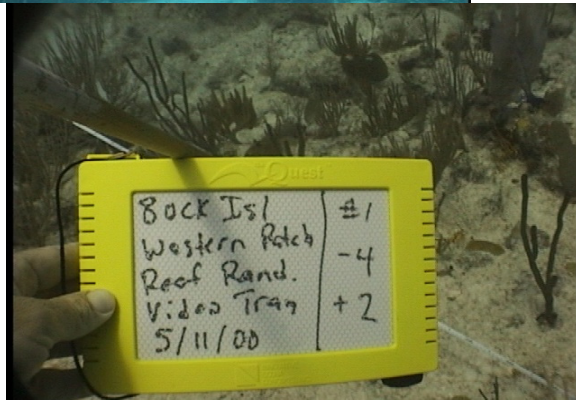
**Pinching o-ring for removal, cleaning and inspection (page 6).**



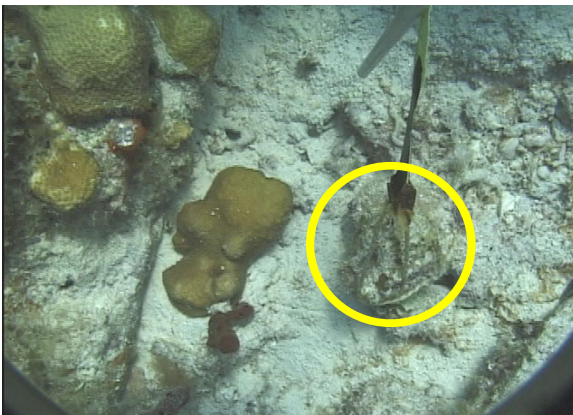
**Removing front optic for cleaning and inspection (page 7).**



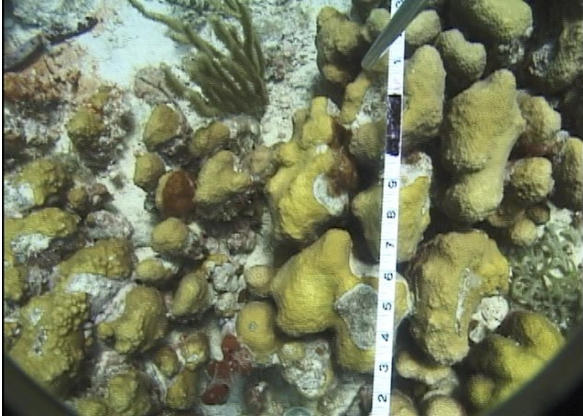
**Measuring distance (40cm) of aiming rod (page 7).**



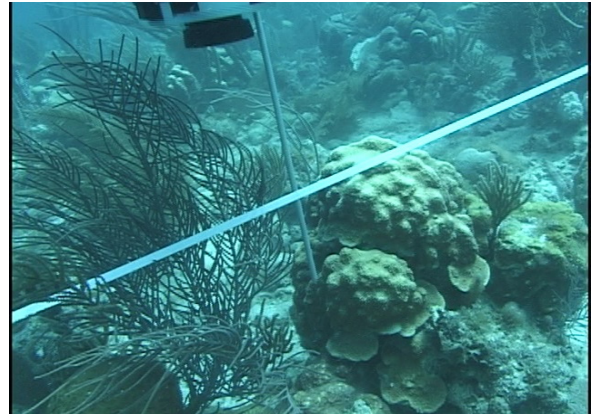
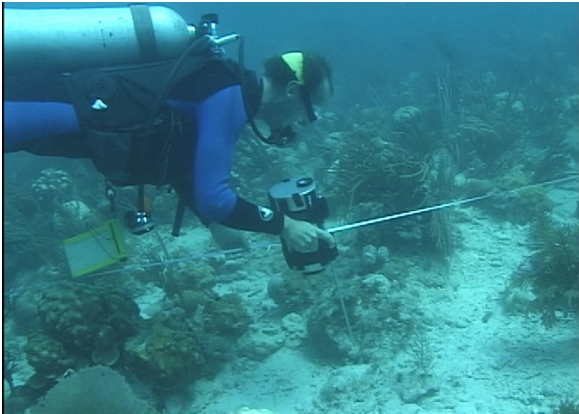
Film transect-specific data from the slate to begin each transect (page [12](#)).



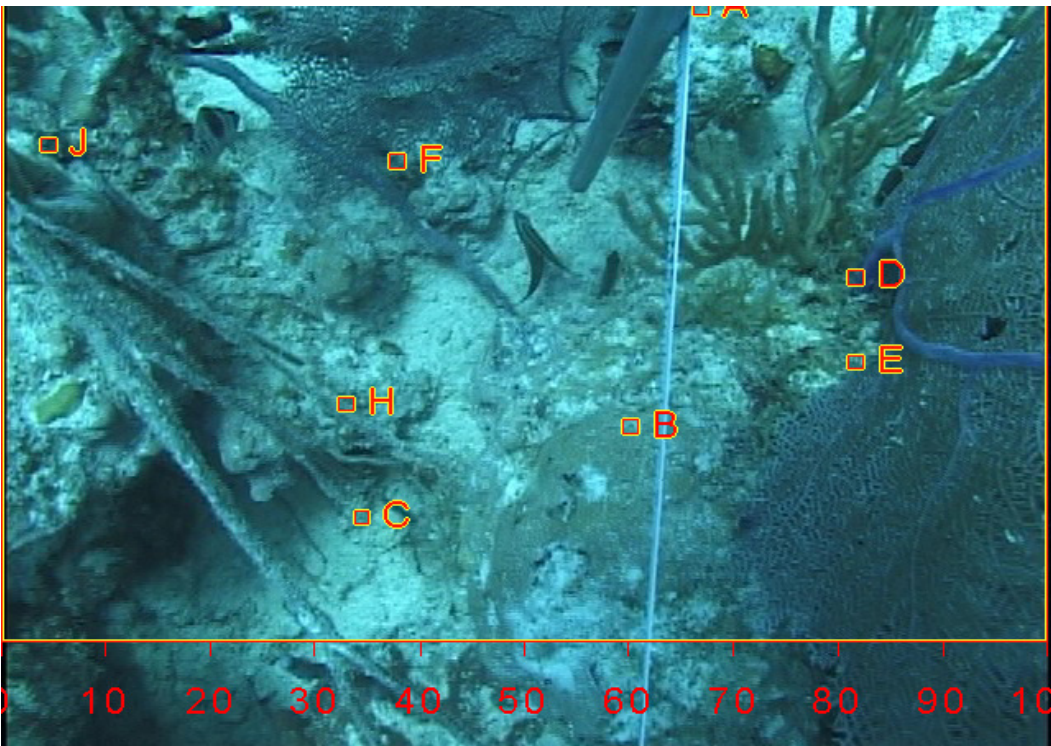
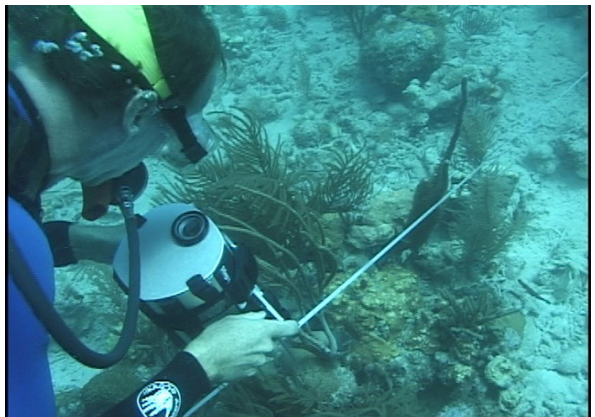
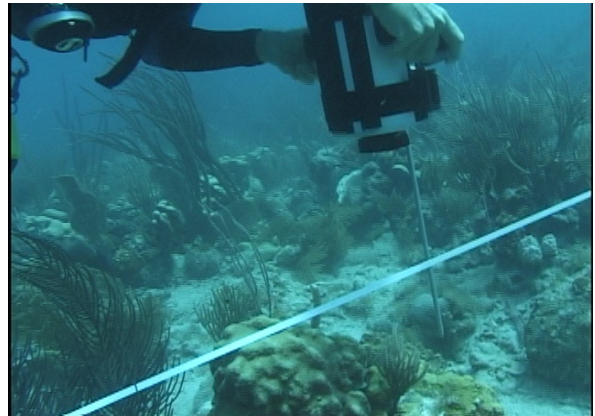
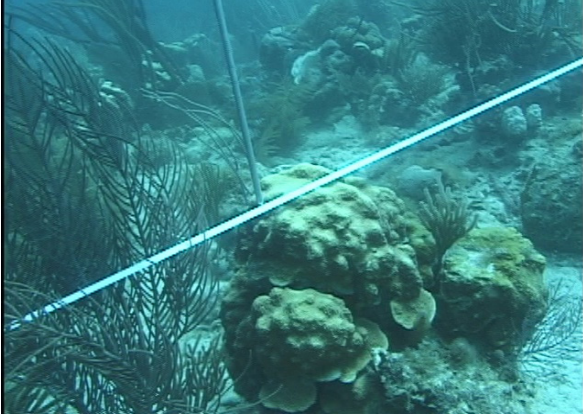
Attach string leader of transect tape to the bottom or pin without harming benthic organisms (page [11](#)).



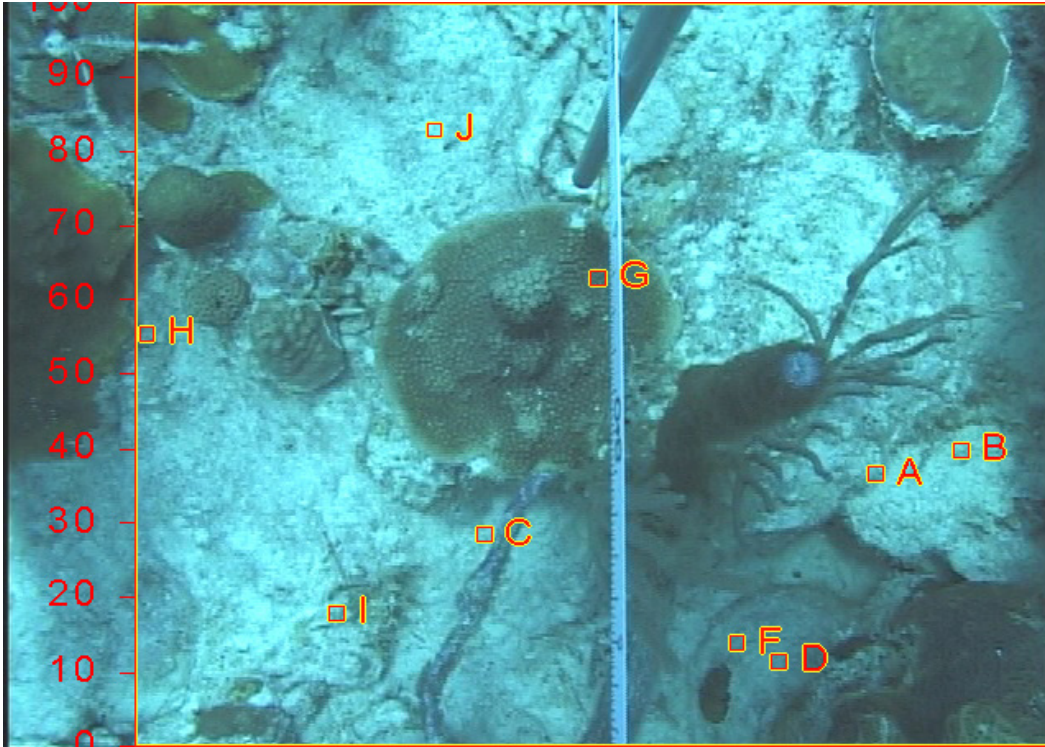
Denote the end of the transect length (page [11](#)).



Point the camera straight down to the bottom, including when encountering coral heads or gorgonians (page [13](#)).



Examples of proper sizing for random plot graph on *X* (above) and *Y* (below) axes (page [31](#)).



# Standard Operating Procedure 2: Using AquaMap at a Study Site

**Version 1.00 (6/30/2002)**

## Revision History Log

| Previous Version No. | Revision Date | Author | Changes Made | Reason for Change | New Version No. |
|----------------------|---------------|--------|--------------|-------------------|-----------------|
|                      |               |        |              |                   |                 |
|                      |               |        |              |                   |                 |
|                      |               |        |              |                   |                 |
|                      |               |        |              |                   |                 |
|                      |               |        |              |                   |                 |

# Using the AquaMap System at a Study Site



U.S. Department of the Interior  
U.S. Geological Survey  
Florida Caribbean Science Center



U.S. Department of the Interior  
National Park Service  
Virgin Islands National Park

# Using the AquaMap System at a Study Site

Prepared by:

**Jeff Miller**  
**National Park Service**  
**Virgin Islands National Park**  
**St. John, USVI**

June 2002

~~~~~

One of a series of monitoring protocols prepared for the Florida Caribbean Science Center
under the auspices of the Caribbean Field Station, St. John, USVI

U.S. Department of the Interior
U.S. Geological Survey

Acknowledgements

We'd like to acknowledge and thank the many people that helped bring this protocol alive: Rich Aronson, Elena Astilleros, Winnie Batch, Ed Beaty, Don Catanzaro, Ries Collier, Marcia Creary, Bob Dorazio, Steve Hertzberg, Dennis Hubbard, Karla Hubbard, Marco Flagg, Maryann Franke, Nick Funicelli, Ginger Garrison, Andy Goldstein, Walt Jaap, Judy Lang, Ellen Link, Dulcie Linton, Steve Miller, Thad Murdock, Matt Patterson, Jim Petterson, Brendalee Phillips, Laura Plaut, Kaf Smith, William Stelzer, Rob Waara, Leslie Walling, and Jeremy Woodley.

Using AquaMap at a Study Site

	Overview	
	■ Materials and Equipment	3
	■ System Components	4
	■ Summary of AquaMap Protocol	5
	■ System Readiness	5
	1. Charge the stations	6
	2. Prepare the diver station	6
	3. Collar and label the baseline stations	7
	4. Prepare to deploy the baseline stations	7
I.	The Range and Noise Tests	
	1. Set up the baseline stations	8
	2. Set up the diver station	9
	3. Conduct the range (TX) test	9
	4. Conduct the noise (RX) test	10
	5. <i>Evaluate the test results</i>	11
II.	Configuring the Stations	
	■ The Configuration File	11
	1. Create and edit the configuration file	11
	2. Download the configuration file	12
	■ Where to Locate the Baseline Stations	13
III.	Orientation Exercise	
	1. Before entering the water	14
	2. Deploy the baseline stations	15
	3. Determine the baseline compass bearings	16
	4. Using the diver station	16
	5. Conduct an initial baseline survey	16
	6. Make an initial tracing of the study site perimeter	19
IV.	Plotting Recorded Data	
	1. Download the data from the diver station	19
	2. Convert the data	19
	3. View the data as a graph	20
	4. Estimate the size of your study site	20
V.	The Definitive Baseline Survey	

	1. Collect the survey data	21
	2. Download and convert the recorded data	22
	3. Determine the depth of the baseline stations	22
	4. Determine the baseline ranges	23
	5. Separate the range data into three sets.....	24
	6. Determine the average and median values	25
	7. Evaluate the results.....	25
	8. Edit and reload the configuration file.....	27
VI.	The Definitive Perimeter Tracing	27
VII.	Defining Waypoints and Transects	
	1. Create the total sample population.....	28
	2. Create a randomized sample population	29
	3. Select a subset of random sample points.....	29
	4. Create a path to connect the points	29
	5. Create a subset of additional sample points	30
	6. Load the sample points into the diver station	31
	7. Check the waypoint coordinates	32
VIII.	Tracking to Saved Waypoints	33

Overview

AquaMap™ is a SONAR (Sound Navigation and Ranging) based survey system. SONAR systems emit and receive high frequency sound. Unlike light and most radio waves, which travel more slowly and shorter distances in water than in air, sound propagates significantly faster and much further in water. Sound is therefore used in many underwater applications including fish finders and depth sounders, as well as by marine mammals to navigate and communicate.

We use AquaMap to:

- map the perimeter of a study site where we will be using video monitoring
- calculate the site area in square meters
- define the population of sample points within that site, and
- randomly select a number of points from that population, and then
- locate those points during initial and subsequent surveys.

Materials and Equipment

(in addition to standard dive equipment)

- AquaMap hardware
 - 1 diver station with SONAR transducer, magnetic pointer, battery charger with power cord, and two dummy plugs (to seal ports while not in use)
 - 3 baseline stations, each with a dummy plug, battery charger with power cord, and a flotation collar with associated nuts, bolts, and washers
 - Data exchange cables and connector adapters for connecting the AquaMap components to your PC
- Computer software
 - AquaMap applications (SmartDive and DT-TEST) and utilities (DiveTerm and Convert)
 - Microsoft Excel
 - AREA plug-in or program
- Miscellaneous underwater equipment
 - Compass
 - Peanut buoy or other flotation device for diver station transducer
 - Rope
 - Miscellaneous floats, pins, sand screws
 - Lift bags, if needed to add positive buoyancy to baseline stations to stabilize them in current

System Components

Our use of AquaMap requires three baseline stations that are deployed in the study site and one mobile diver station.

The baseline stations are cylinders that house batteries, electrical circuitry, and a transducer (the end of the baseline station or cable from which the SONAR pulse is released and received).

The diver station is a hand-held device used to compute positions relative to the baseline stations. Unlike GPS devices, which indicate location using latitude and longitude, the “fixes” computed by the diver station are “waypoints” in an X –Y coordinate system referenced to the location of the baseline stations. However, baseline station positions can be benchmarked using GPS. To create the site map and permit relocation of selected waypoints, the diver station’s features include position recording (tracing your track), and storage of waypoint coordinates. (For details about diver station features, see the AquaMap™ Operators Manual, and DiveTracker Users Manual.) The diver station keypad is operated by using a magnetic pointer.

Throughout this protocol, these icons are used:



Signifies activities generally done on dry land, and usually requiring a computer.



Signifies activities done at the study site, mostly underwater.



Indicates a specific step in carrying out the protocol.



Tips to keep you on track.



Precautions to help safeguard your life, your equipment, or your data.

Summary of AquaMap Protocol and Time Requirements

Procedure	 In the Office	 In the Field
III) Range and noise tests (1 or possibly 2 dives; total time ~1 day)	- Set up tests on diver and baseline stations - Evaluate the test results	Conduct the range and noise tests
IV) Configuring the stations (~ 2-4 hours)	- Create and download the configuration file - Plan where you will locate the baseline stations	
V) Orientation exercise (2 dives are best)		- Determine the baseline compass bearing - Conduct an initial baseline survey - Trace and record site perimeter
VI) Plotting recorded data (~2-4 hours)	- Download and convert the data from the diver station - View the data as a graph - Estimate the size of your study site	If necessary based on results of plotting record, adjust placement of baseline stations. This may also require repeating parts III and IV.
VII) Definitive baseline survey (1 dive plus 1 hour pre-dive and 2-3 hours post-dive)	- Download and convert the data - Determine the baseline ranges - Edit and reload configuration file	- Permanently benchmark the locations of the baseline stations - Collect the baseline survey data
VIII) Definitive perimeter tracing (1 dive plus 2-4 office hours)	- Download and convert the data - Edit and reload configuration file	Conduct the definitive tracing of the site perimeter
IX) Defining waypoints and transects (4-6 hours)	- Identify a population of sampling points in the site and order them randomly - Select a sample of random points that will define your transects and create a path to connect them - Load path into the diver station	

System Readiness

In addition to spending a lot of time familiarizing yourself with how to use the DiveTracker software you've installed on your PC, there are many steps to get through before you begin using AquaMap to locate sample points on your study site. However, whenever you go into the field to use the equipment, you'll need to do the following.

1. *Charge the stations.*

- Before diving, charge the diver station and the three baseline stations. The diver station window will show a charging graph. When charging is complete, the message "DONE" will appear. On the baseline stations, the indicator light patterns will show whether the units are charging or fully charged.



The baseline stations must be using the SmartDive application to be charged; they cannot be charged while in the DT-Test application. However, if the battery gets too low, you may not be able to connect the station to the computer so that you can switch to the SmartDive application. The light flash patterns are similar, so you may not be certain which program is running. But if the station will not initialize and proceed to the proper flash pattern after you have attempted to charge it, the problem may be that it was in the DT-Test application. If so, the only way to charge the station will be to send it back to the company. Therefore, you should switch to SmartDive as soon as possible after you are through with DT-Test.

When charging the diver station, keep track of how long the charging is taking and the voltage level when charging is complete. When you first connect the station to charge, observe the graph in the display window. It will take a minute for the displayed information to accurately reflect the battery charging level and updates are displayed every 15 seconds. It should take approximately 90 minutes to fully charge the battery to approximately 12 volts. If your experience is otherwise, consider the following:

- If the voltage level = 12 volts, but the charging time was much less than 90 minutes (10 to 45 minutes), the battery may not have been "low" when charging began. If so, consider placing the battery on charge again. If it does the same, assume the station is fully charged. If you're certain the battery was low and it still shows fully charged in much less than 90 minutes, consider replacing the battery. (Send it back to company.) Batteries need replacement every three years, depending on storage temperature, use, number of charging cycles, etc.
- If the charge time was < to 90 minutes, and the voltage = 10 or 11, it may be a false full charge reading. Sometimes the voltage "curve" flattens out, simulating a fully charged battery. Consider re-starting the charge. You may see a shorter charge time since you are starting with a partially charged battery, but the voltage should reach 12.
- If the charge time was < 10 minutes and the voltage reading is "Temp Trig," this indicates the Temperature Trigger has been activated. Consider this a system error, and re-charge the station.

2. *Prepare the diver station.*

- Connect the mobile transducer to the diver station so that it can communicate with the baseline stations.

- To elevate the transducer above the diver for optimal signal propagation, attach a float (e.g., a peanut buoy) to the top of the frame around the transducer during the dive.
- Make sure you have the magnetic pointer that operates the diver station and keep a spare one in your BCD pocket.

3. *Collar and label the baseline stations.*

- Fasten a flotation collar snugly around each baseline station.
- To make sure that the same baseline station is deployed at the same location for each dive, label each baseline (BS1, BS2, BS3) and put a matching label on its collar.

These syntactic foam collars provide enough flotation for installation in low-surge, low-current conditions, but in surgy waters, you may find it necessary to add a liftbag or other flotation device to stabilize the baseline station in the water column.

4. *Prepare to deploy the baseline stations.*

To help prepare for field tracking, it is important to “visualize” the deployment of the baseline stations before leaving for the field.

- Each baseline station is ~7 lbs. positively buoyant in salt water, so temporary holding devices (e.g., weight belts or concrete blocks) are needed during the initial stages of mapping and tracking. Later on, sand screws or pins can be installed to more permanently mark where the baseline stations are to be located, and lines can be cut and/or spliced for use at a specific baseline station site.
- The baseline stations should be deployed at a depth of ~ 3 m. During the range and noise test and orientation exercises, reels, tapes, and/or lines may be used to raise the stations to the necessary depth. Brass or stainless clips can be tied to the transducer cage to simplify attachment to lines, reels, or tapes.
- For best results, the baseline station transducers should be at least 2m above the sea floor and no less than 2m below the surface. They should not be so shallow as to be severely affected by wave energy or endangered by boat traffic.
- The signal path from the transducer is similar to the light emitted by a street light in that the energy is radiated down and away from the transducer. The baseline stations need clear signal paths to each other and the diver station. Make sure that terrain features such as boulders or a sloping sea floor do not obstruct the signal path.
- When visualizing and gathering components for deployment of the baseline stations, keep in mind you cannot permit anything to block the signal path from the transducer. Any fastener, clip, knot, float, excess line, tie wrap, lift bag, and marine growth on submerged lines and floats may interfere with signal transmission. Currents, surge, and wave action can loosen objects that are not securely fastened and cause problems during tracking. Do not take the chance that a line “tucked in” will remain so during the entire day of tracking. You must also take the same precautions in regard to the attachment of the float to the diver station transducer.



Before taking the diver and baseline stations underwater, make sure that the data exchange port on each station has been sealed with a dummy plug. This port is used only when connecting the stations to your PC. The connections are water tight to a depth of >100m, but saltwater will corrode the internal connections, causing errors in signal transmission. Since there's generally no reason to take the diver station underwater without its transducer, that dummy plug may never be used underwater. However, it's a good idea to use it while the diver station is out of water and doesn't need to be connected to the transducer.

The Range and Noise Tests

Our experience has shown effective tracking within a 200-meter range. However, the propagation of SONAR signals at a given site may be affected by a combination of bay configurations, biological noise, and substrate composition, and may vary from day to day. When selecting a study site, you will therefore need to determine the effective operational range of AquaMap within the area and consider the site's acoustical qualities.

To do this, download DT-TEST from your PC to one of the baseline stations (set up to transmit continuously) and to the diver station (set up to receive). DT-TEST is a software program that contains the operational commands for both the range/transmit (TX) and noise (RX) tests. The more locations within your study site at which you perform the RX and TX tests, the better your model of signal propagation characteristics will be. But spending even one dive to conduct a range test along a transect and collect noise data at 10 to 15 points will provide a fairly accurate estimate of AquaMap's operational range in a given locale.



1. *Set up the baseline station.*

- Connect the gray data exchange cable to the serial port of your PC (a gender adapter may be necessary).
- Connect the other end of the cable to the appropriate connector adapter (8-pin, box end) and attach the adapter to one of the baseline stations.
- On your PC, go to START and choose: PROGRAMS → DIVETRACKER → DIVETERM.
- When DiveTerm is open, turn the baseline station on by rotating the round on-off knob at the end of the station 180°.
- When a link is established, in the DiveTerm window choose: RUN → DT-TEST.
- Press #7 on your PC keypad to choose "7 (TX)". This will start the baseline station transmitting. You can adjust the frequency and speed, but these settings should be left on the defaults for these tests.

The frequency should be set to the frequency of interest minus 5 kHz. The default setting is 29 kHz, which monitors 34 to 41 kHz. You can adjust the frequency in 1 kHz increments by pressing the F1 function key on your computer keypad. The default speed is "slow." Pressing F2 will alternate between slow and fast speed.

- When the baseline station is clicking (you may hear it, or feel it by putting your finger on the transducer), which indicates that it is transmitting a signal, you can disconnect the station and close DiveTerm.



Do not turn off the baseline station until after the range test has been completed. If it gets turned off, you will have to repeat the entire setup process to enable the station to transmit, and if you are in the field, this requires the use of a laptop computer



2. *Set up the diver station.*

- Connect the diver station to the serial port of your PC via the gray data exchange cable and the appropriate connector adapter (5-pin, round-end).
- After you've made sure the diver station is turned off, on your PC, go to START and choose: PROGRAMS → DIVETRACKER → DIVETERM.
- When DiveTerm is open, touch the magnetic pointer to the small indentation on the left lateral side of the diver station to turn it on.
- When a link is established, in the DiveTerm window choose: RUN → DT-TEST.

If a link is not established, shut down DiveTerm, turn off the diver station, then reboot both.

- Press #6 on the diver station keypad or your PC keypad to select the RECEIVE function. This station will now be listening for the signal from the transmitting baseline station.
- You can adjust the gain and the frequency by using the magnetic pointer on the diver station function keys.
 - The gain controls the amplification of SONAR signals. Pressing F1 will change the gain sequentially through four settings (0,1,2,3). Each increase in gain doubles the sensitivity. Use setting 2 for the noise test.
 - Pressing F2 will change the frequency in units of 1 kHz. The frequency should match that of the baseline station (29 kHz).



3. *Conduct the range (TX) test.*

The purpose of the TX test is to measure the actual operational range of AquaMap at your intended study site by finding out the maximum signal strength at known distances from one transmitting baseline station.

- Place a baseline station in your study area, preferably at the approximate location of where you plan to put Baseline Station 1 or 2.
- Use the diver station to record the noise level at a known distance (e.g., 5 m) from the baseline station. Remain in this position for approximately one minute and record the maximum signal received. Example of diver station display:

Gain (F1): 2

Frequency (F2): 29000

min/max: 006/084

Below the line under “min/max” is a graphic display of transmissions received.
The “min/ max” will update every 10 seconds.

- Moving along a straight line, record the noise level each time you have approximately doubled your distance from the baseline station. (e.g., at 10 meters from the baseline station, then 25 meters, 50 meters, 100 meters, and 200 meters). The effective operational range generally ends at about 200 meters from the baseline station.
- Although the signal propagation should be similar in all directions from the baseline station, if time and patience permit, noise levels may also be recorded for evaluation in other quadrants in the study area.
- When this test is finished, turn off the baseline station but leave the diver station on.



4. *Conduct the noise (RX) test.*

The purpose of the RX test is to determine the general noise characteristics of your study site, with an emphasis on broadband noise, the most common type you will encounter. Broadband noise, which may be caused by biological sources (e.g., snapping shrimp), has frequency components across a wide range. However, you may encounter noise on a specific frequency, such as from a depth sounder or other piece of underwater acoustic equipment. This test will pick up noise from scuba regulators and impacts on the transducer, so try to minimize such occurrences. The baseline station should be turned off after the range test to eliminate the “pings” it emits.

If you suspect noise on a specific frequency, you can alter the frequency at which AquaMap is transmitting signals. To perform a thorough test, run the noise test on all four frequencies that the diver station uses. These frequencies can be found when in the advanced configuration screens of DiveTerm.

During the RX test, the diver station listens on the selected frequency and measures the minimum and maximum signal detected in a five-second period. These signals are displayed numerically and graphically on the diver station screen.

- You will need to have the diver station configured in the receive mode, as it was for the range test, so that it will detect ambient noise on the specified frequency range. Use Gain 2 and a frequency of 29 kHz.
- Swim with the diver station to various locations in the study area, including the perimeter, near tall coral colonies and in both deep and shallow areas. After remaining in a location for at least a minute, record the maximum value you have seen on the diver station display while there. Also note if many signals are considerably below the maximum. (Since the maximum value is determined over a 15-second period, if many or most of the signals are lower than the maximum, your range may not be well represented by the maximum level indication.) Make sure you also record the gain and frequency that were used during the test. Perform the test in as many locations around your site as time and patience permit.
- To end the test, press ENTER on the diver station, and then F4 (OFF). You should now have a reasonable approximation of the noise characteristics in your selected area.



5. *Evaluate the test results.*

Compare the signal received at known distances in the range test with the ambient noise levels as measured in the noise test. When the maximum signal received is equal to the average noise level, you have reached the maximum operational range. It's prudent to have the actual distance between the stations remain somewhat less than the average operational range measured (~75%).

In addition, in order for the system to reliably derive a position, signals must be above the maximum noise level you determined for the site. A good rule of thumb is to set the threshold level at which signals will be received at 1.5 times the average of the maximum values you recorded. For example: assume that the maximum values for the 20 measurements taken during the noise test ranged between 0 and 15, with an average of 10. The AquaMap default setting for the threshold value, which is 12, could be used since it is close to 1.5 times the average noise level for the area. If the average value during the test was larger than 10, you could increase the threshold value as part of the process of creating or editing the configuration file for the stations, as explained in the following section.



Configuring the Stations

The Configuration File

The configuration file defines the operational parameters and working environment during AquaMap use at a particular site and tells the diver station and the baseline stations how to communicate with each other. Later on, you will also store the “waypoints” used for data sampling in the configuration file.

You create the configuration file with the DiveTerm utility by entering some information in the "config" pages on your PC and then download the file to your diver and baseline stations. You will need to create an initial configuration file after completing the RX/TX tests at your study site. As you gain more information about the site and the location of your baseline stations, you will need to go back and edit this file and reload it into the stations.

Once you have created an initial configuration file, you may also edit that file for use at another study site in a similar environment rather than create a new file from scratch.

6. *Create and edit the configuration file.*

- On your PC, go to START and choose: PROGRAMS→ DIVETRACKER→ DIVETERM.



A message will appear: “No link, please reset station.” Ignore this. The diver station does not have to be attached to your PC in order for you to create or edit a configuration file.

- Go to the FILE drop-down menu and choose CREATE A CONFIGURATION FILE or EDIT A CONFIGURATION FILE, depending on which you need to do
- If you need to change the threshold level, choose ADVANCED CREATE or ADVANCED EDIT. Otherwise SIMPLE CREATE or SIMPLE EDIT is sufficient. If you are editing an existing file, open it in the Select Configuration File window.
- You will pass through three screens for SIMPLE CREATE or SIMPLE EDIT (five for ADVANCED), but you need to concern yourself with only some of the settings at this point. Listed below are

some of the more common entries you may need to check. Click on NEXT when you are ready to go to the next screen.

In the CONFIG-1 screen (SIMPLE):

- Environment Type: We use the default, OPEN OCEAN.
- Number of Surface Transducers: We use the default, 0.

In CONFIG-2 (SIMPLE or ADVANCED):

- Number of baseline stations: The default is 2; we use 3.
- Number of mobile stations: We use the default, 1 (for the diver station).

In CONFIG-3 (SIMPLE or ADVANCED):

- Water Temperature: The default is 10°C; we use 28°C in the Caribbean.

In CONFIG-4 (ADVANCED):

- Detection Threshold Level: The default is 12. Change this if necessary as a result of your noise test or subsequent experience at the site.
- AGC (Automatic Gain Control): If there is a checkmark in the space, the AGC is enabled. The AGC does a gain adjust every 3-5 minutes. If you have bubbles impacting the diver station transducer when the gain adjustment is made, the AGC may be set too high, eliminating signals. You may wish to disable the AGC (remove the checkmark) to avoid this.

To add or edit waypoints, go to CONFIG-3 (SIMPLE) or CONFIG-5 (ADVANCED).

- When you are at the last configuration screen click on OK if you are satisfied with your choices. If not, choose BACK to return to a previous screen and change what needs changing.
- When you click on OK, you will be prompted to save the file with a name and location. Use a name (with a *.par extension) that corresponds to the site where you will be tracking and the default file location, then click on SAVE.

7. *Download the configuration file.*

After the configuration file has been saved, you need to download it into the diver and baseline stations.

- Connect the diver station to your PC using the gray data exchange cable (a gender adapter may be necessary) and the 5 pin, round-end adapter connector.
- Open DiveTerm on your PC (if it isn't already open) and turn on the diver station.
- Within a few seconds, you should see a message on your PC that the link has been established. If you do not, turn off the station, close DiveTerm, and start over.
- When a link has been established, click on RUN (the small button on the lower left side of the display) and, when the application window appears, choose SMTDIVE (the most recent version, if more than one is listed).
- When the Terminal window appears, go to the COMMAND drop-down menu and choose CONFIGURE STATION.
- When the Location window is displayed, select the appropriate configuration file and click on OPEN.

- When the Download Configuration File window appears, select the station that's connected to your PC and choose DOWNLOAD. A numeric display will show the progress of the download.

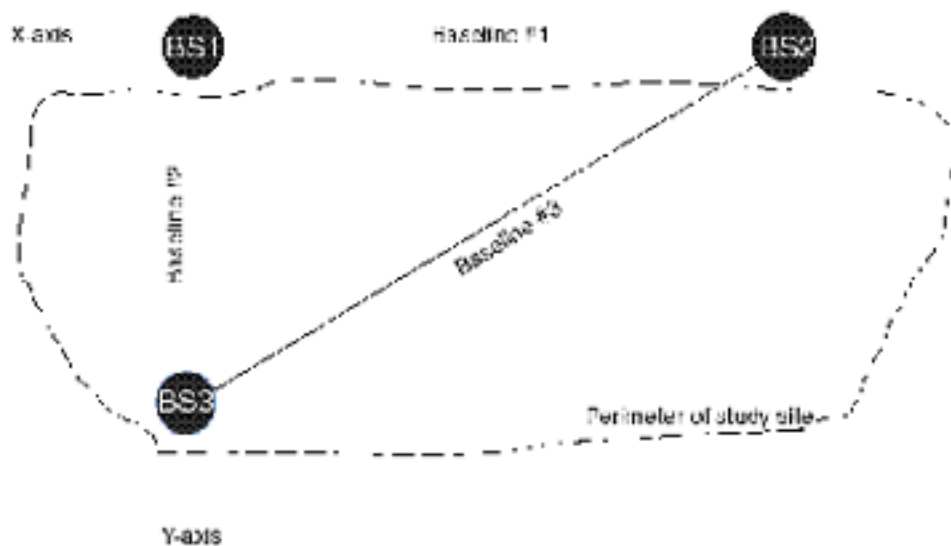
If you get an error message or no progress is indicated by the numbers, close DiveTerm and turn off the station. Re-launch DiveTerm and, when it is open, turn on the diver station and repeat the steps above.



When the download to a station is complete, first disconnect the station and then turn it off. Do *not* choose DONE on your PC until you have configured all of the stations.

- After the configuration file had been downloaded to the diver station, you will be prompted to download the file to Baseline Station #1. After making sure it is turned off, connect Baseline Station #1 (verify label on either the station or the flotation collars) to your PC using the data exchange cable and appropriate connector adapter.
- Turn on Baseline Station #1 and repeat the downloading procedure for it and the other baseline stations. Although the diver station displays a message that a link has been established, with the baseline stations you will need to watch the flash patterns. When you see one rapid flash per second, the link has been established.
- When all of the stations have been configured, choose DONE. Turn off the last station and insert dummy plugs into all the cable connection ports.

Example A



Where to Locate the Baseline Stations

Using maps, charts, photographs and/or notes taken while conducting reconnaissance snorkels or dives, make a preliminary, pre-dive determination of the best positions for deploying the baseline stations in or around the study site. Here are some points to keep in mind.

- We have found that an L-shaped arrangement with the three stations placed near the perimeter of the site often works well. As shown in Example A, the line connecting Stations 1 and 2 will correspond to the X-axis on a plotted graph of your site and is referred to as

Baseline #1. When you are positioned at Station 1 and facing Station 2, Station 3 must be to your right, as close as possible to 90°. When Station 3 forms a 90° angle with Stations 1 and 2, Baseline #2 will correspond to the negative Y-axis on a plotted graph of your site.

- As shown in Example A, you may find it best to orient Baseline #1 on the long axis of the site, if there is one, and slightly beyond the site perimeter. For example, if the deep side of the site boundary is a forereef slope to a sandy plain, Stations 1 and 2 could be positioned 10m to 15m from the forereef slope in the sandy plain. This will permit better SONAR signal reception when tracking along the forereef slope.
- However, other arrangements may also work, depending upon the particular characteristics of your site. As shown in Example B, it is possible to set up the baseline stations so that all four quadrants on the X and Y axes can be tracked in, or, as shown in Example C, so that none of the baseline stations are located within the study area.
- AquaMap works best if the baseline stations are 50-150m apart, and no closer than 30m.
- Signals from only two baseline stations are needed to “fix” a position with the diver station. However, if the system has been configured for three baseline stations, then AquaMap has to receive signals from all three stations in order to determine which two baseline stations provide the best geometry for calculating the position; the signal from the third station is then used to determine which side of the baseline for the fix. You therefore need to arrange the stations so that at any point within the study site, the maximum distance from the diver station to the farthest baseline station is within the operational range established by the TX test.

Example B



Orientation Exercise

Before you begin actually using AquaMap to track around in your study site, you need to:

- familiarize yourself with the reef features and how AquaMap will function in the site;
- determine the compass bearings of Baseline #1;
- conduct an initial baseline survey; and
- make an initial tracing of the proposed perimeter of your study site.

To accomplish these goals, you can carry out the following exercise at your study site.

8. *Before entering the water.*

- Plan how you're going to determine the compass bearing of Baseline #1. This can be done in many ways; however, we've found the best method is to apply temporary surface floats to the baseline stations.



When considering the use of surface floats, keep in mind that wave action may be transmitted through a surface float and line to a baseline station, moving the station and decreasing position accuracy. Although helpful when determining the baseline orientation, floats are generally not a good idea during routine tracking and mapping. Leaving them on makes it easier to locate the stations, but their presence increases the risk that the stations will be jostled during deployment.

- If the longest distance is between BS1 and BS2, you may want to anchor the boat midway between these locations as defined in your pre-dive planning. In that case, one diver would take the stations for BS1 and BS3, and a second diver the station for BS2.
- Turn on the baseline and diver stations before entering the water. Leave the baseline stations on while they are in the water. Check the flashing light near the on-off switch.
 - One blink per second means the baseline station is standing by, waiting for an interrogate, i.e., waiting to be surveyed.
 - A fast double blink means an interrogate has been received.
 - Continuous rapid blinking means the battery is low.



Caution: This is a strenuous technical dive with risks of entanglement and over-exertion. Divers are carrying both extra weight and flotation while swimming long distances. All divers must be familiar and comfortable with the dive plan and aware of emergency contingencies before starting.



9. *Deploy the baseline stations.*

- Attach each station to the clips on its reel or line, from which it will float to the surface.
- Use the reel to position the station at a depth of ~3m.
- Attach weight belts to the reel and lay them carefully on the bottom so as not to harm any fragile bottom component.
- Run a fiberglass measuring tape between the stations to make sure they are accurately placed. This also permits easy relocation of the stations in case of AquaMap system failure and helps orient divers to the site.



Remember: No part of the deployment assembly or flotation system may block the baseline station transducer. The exact sequence of steps followed in deploying the baseline stations, e.g., at what point the weight belts are attached, will depend on factors such as waves, current, surge and swimming distance.

10. Determine the baseline compass bearing.

You need to determine the compass orientation of Baseline #1 (the line between Stations #1 and #2 as shown in Example A). For this exercise, we temporarily mark the locations with surface floats, then maneuver the boat in such a way as to acquire a compass bearing from the float on Baseline Station #1 to #2. Write this bearing someplace safe, as you will need to enter it into the diver station configuration file.

11. Conduct an initial baseline survey.

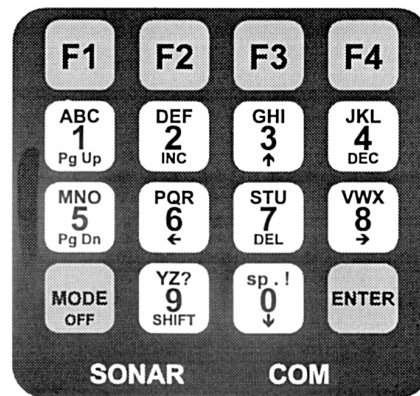
A baseline survey is necessary to establish the exact positions of the baseline stations relative to each other. Although this may be conducted using external methods such as DGPS or laser ranging, this protocol uses the AquaMap diver station to register the position (range bearing and depth) of each baseline station.

- Position yourself anywhere in the study site.
- Press the MODE button on the diver station to call up the main menu.
- Use the 0/↓ key to move to select BASELINE.
- Press ENTER to display the BASELINE DEFINE screen.
- Press F4 (OK) to display the BASELINE CONFIG screen.
- Press ENTER to clear any previous data from the ALIGN field.
- Press the numeric keys to enter the bearing for Baseline #1 in the ALIGN field, then press ENTER. If a wrong number is entered, press F3 (DEL) to delete the mistaken entry and enter the correct number.
- The cursor is now placed to enter data in the S-Depth field. But this is for the depth of the surface station, which we do not use, so just press ENTER. Although you do not see the data, the diver station is also noting the depths of the baseline stations.
- The display will fill with zeros. Confirm this configuration by pressing F4 (OK). The diver station will beep and return to the DIVER STATUS screen.

Conducting a single baseline survey as described above is used to determine the depths of the baseline stations, and it is sufficient for precise tracking and mapping during a single dive. However, the “error” in the data obtained in a single survey may be significant enough to affect the accuracy of mapping, tracking, and point relocation on subsequent dives. The data obtained in repeat baseline surveys are inevitably variable; two surveys done during two different dives may produce slightly different positions for the baseline stations even if you deploy them in exactly the same locations .

This may be considered an issue of sample size. Therefore, for repeatable, geo-referenced tracking and sample point relocation, the position data must draw from a larger sample, increasing the reliability of the data by increasing the number of signals on which the data are based. The process of obtaining this more reliable data, which must be done on a subsequent dive, is described in Part V, “The Definitive Baseline Survey,” beginning on page 21.

12. *Using the diver station.*



Diver Station Keypad

You can track around in your study site to practice using the diver station. To press a key on the keypad, use the magnetic pointer. A feedback beep indicates that the key has been triggered. Most of the display screens have four labels across the bottom, positioned over the four function keys. These indicate the command that will be triggered by pressing that function key, e.g., pressing F1 when it appears under NXT on the screen will move you to the next screen. Most other keys on the keypad have multiple functions. The arrow keys are used to select entries from a list or to move around a data field. Refer to the AquaMap manual to learn about the information that is displayed on the diver station and how to get to the different screens. Your focus will be on the two navigation screens: general and precision. Important features to note:

- ***Time since last fix.*** This is displayed in the upper left of the general navigation screen, and lower right of the precision navigation screen, next to the label “L”. During good signal communications, the diver station may be able to fix its location every 2 to 3 seconds. If you are moving and the time since last fix exceeds 30 seconds, your position may not be accurately reflected by the diver station. Try changing your depth and check to make sure that the transducer is not blocked by your dive buddy or your exhaled air bubbles.
- ***Baseline signal indicator.*** This is displayed on the lower left of the precision navigation screen, next to BASE. An “L” means that a pulse was received during the last positioning attempt. You should also see three “+” signs, one for each baseline station. If a “-” sign appears, it means that that signal is not getting through (e.g., if there’s a minus sign in the second space, it means Baseline Station 2 is not commu-

nicating). An “I” means "idle," i.e., no signal was received. An "S" indicates that a signal has been received but its location could not be calculated, e.g., the baseline station is out of range.



Even in tropical waters, differences in temperature may affect signal propagation, so the diver station transducer should be in the same water temperature as the baseline station transducers. You can use your own sense of temperature to determine this; you don't need a thermometer. If you feel a significant thermocline (as often occurs near the water surface under intense sun), the signal may have difficulty passing through.

- **RMS error.** This measurement of the quality of the recorded fixes is also displayed in the precision screen. The diver station maintains a queue file of the last 2 or 10 fixes, depending on which option has been selected. The typical RMS error reflects the average distance between each position fix in the queue and the average position of all position fixes that have been received. A large RMS error indicates that the positions were widely scattered, suggesting little confidence in the data (e.g., while you are moving around rapidly). A small error shows that the positions in the queue closely match each other, resulting in high data confidence (e.g., when you are stationary).

The number of fixes used to determine the RMS error is displayed on the lower right of the precision navigation screen, next to label “C”. The default number is 10, but you can change it to 2 by pressing the F3 (CLR) key. This is helpful when you have just arrived at a spot. If the number has been set at 10, the position queue still contains a string of fixes tracking your path, resulting in a high RMS error. This will gradually be reduced as additional fixes are taken at your new location, but you can hasten this process by pressing F3 to reduce the queue to 2.

- **Standby/Record.** “Standby” is the default mode. The alternative, “record” mode, can be used to outline or trace a feature by recording all position fixes in the diver station memory. To do this, press F4 to select RECORD, then circumnavigate the feature. Pressing F4 again will return you to STANDBY.



Depending on how frequently position fixes are received, the diver station memory will eventually fill up. For example, if fixes are received once per second, it will be full in about two hours. To retrieve the data, you must download the file (SmartDive refers to it as a “tape”) to a PC. Then you can clear the memory and fill it again.



13. Make an initial tracing of the site perimeter.

To see how the SONAR signals are received throughout your study site and begin the process of identifying a sample population, you will want to record a tracing of your study site perimeter. Like the baseline survey, this step will need to be repeated after you have collected more data about your site.

- Go to the site boundary and choose an identifiable point from which to start.
- At the DIVER STATUS screen, press F2 to go to the GENERAL NAVIGATION screen.
- Press ENTER to display the PRECISION NAVIGATION screen.
- Press F4 to change from standby to RECORD mode.
- Circumnavigate the study site, swimming at a comfortable speed and making sure your dive partner does not block the SONAR signal path.
- During this swim, monitor the "time since last fix" and the "baseline signal indicator" to check the SONAR signal reception in the study site.
- When you are back at your starting point, press F4 to return to STANDBY mode.
- If you are done tracking for the day, you can retrieve and turn off all stations.



Plotting Recorded Data

14. Download the data from the diver station.

To download the diver station memory "tape" into your PC:

- Connect the diver station to your PC and go to DIVETERM.
- Turn on the diver station.
- When a link has been established, go to RUN → SMTDIVE.
- When the terminal window appears, go to the COMMAND drop-down menu and choose READ "TAPE" MEMORY (SMARTDIVE/MICROTRACK).
- When the Select File window is displayed, select a name and location for the record file. We recommend using the default location.
- Click on SAVE. A numerical percent display will indicate the progress of the data download.
- When the download is complete, turn off the diver station, disconnect it from the computer, and close DiveTerm.

15. Convert the data.

Before you can view the data you have just downloaded, you must convert it to points plotted on a graph:

- On your PC, go to start and choose: PROGRAMS → DIVETRACKER → CONVERT.
- Go to the FILE drop-down menu and choose LOAD A NEW RECORD.
- You will be prompted to select the *.rec file that you wish to plot, and the configuration file that was being used when the record file was being created.
- When prompted to confirm that the download was created from a mobile station, answer YES.

- When the Settings window appears, make sure that a “0” is entered in all five fields. (The default settings are all “0” except for Baseline orientation.) When all five fields contain a zero, click on OK.
- In the next display window, the product you wish to view will determine which if any option you choose.
 - To evaluate SONAR signal effectiveness, select SHOW RAW AUTO-POSITION DATA click on OK.
 - To view only baseline lengths and stations depths, do not select either option. Click on OK.
 - To create an outline map of the site, select SHOW X/Y AUTO-POSITION DATA and click on OK. You will see the conversion taking place.

When the conversion is complete, go to FILE → POSITION DATA FOR IMPORT. In the Save for Import window, put a checkmark next to FIELD (NORTHING) and FIELD (EASTING). In the Delimiter box, put a semicolon (;). Then click on OK. In the Save Import box, select a name and location for this new *.dbi file. (We use the default location, C:/Program Files/DiveTracker/Record/.dbi.) Then click on SAVE.

16. View the data as a graph.

- On your PC, go to START and right click to get to EXPLORER. Go to the C drive, and choose: PROGRAM FILES → DIVETRACKER → AREA.EXE. (You may find it easier to create a shortcut on your desktop.)
- When the Area program opens, you will see a Graph window and a Waypoints window. By moving the Waypoints window to the right, you will be able to see the Commands window which is located directly beneath it. Go to FILE → LOAD FILE and select the applicable *.dbi file. (Default location = C:/Program Files/DiveTracker/Records)

The plot of recorded points will be displayed on the graph. Some points may appear as “outliers;” these usually indicate noise received during the recording.

To modify the size of the graph:

- Go to the WINDOWS drop-down menu and choose DISPLAY PARAMETERS.
- Enter the numbers you choose in the spaces provided for the X and Y Origin.
- Enter the numbers for the desired length of each axis in the X and Y Extent.

The graph will change as you enter the numbers.

17. Draw the site perimeter and estimate its size.

To calculate the area contained by the recorded points (to approximate the area selected for study), you can use your mouse to outline the points.

- In the Commands window, choose DRAW POLY.
- Press the left mouse button, and connect the dots in one continuous tracing. If you botch it and need to start over, click on the UNSET button.
- When your drawing is complete, choose CALCULATE AREA. The area will be displayed in a message box. Clicking on OK will remove the message box.

18. Check the location of your baseline stations.

Based on the map of your study site that you've created from the recorded data, you may decide you need to adjust the placement of the baseline stations, e.g., if gaps in your data indicate places where no signal was received. Depending on how much you move the stations, you may need to repeat the orientation exercise and re-plot the recorded data.

The Definitive Baseline Survey

Because the AquaMap system locates positions within a study site relative to the positions of the baseline stations, the location of the baseline stations' locations relative to each other must be defined as precisely as possible. This is done through the definitive baseline survey and the subsequent data analysis, which will determine:

- the depth of each baseline station,
- the distance between each baseline station, also referred to as the baseline range,
- the angle between baseline #1 and #2.

These data will be entered or "hard coded" into the configuration file that will be used for that particular site.

The most rigorous method of performing a baseline survey is to position yourself at each of the baseline stations and use the system's ability to measure RAW ranges (absolute distance). First repeat the initial baseline survey as described on page 16 to allow the system to remote function and obtain the baseline station depths, then you can conduct the more definitive baseline survey outlined below. So that you don't overload the diver station memory, make sure you've erased the "tape" of any previous records before conducting another survey.

To erase the tape:

- Press the MODE button on the diver station to call up the main menu.
- Use the 0/↓ key to move to select ERASE TAPE.
- Press ENTER to execute the erasure.



19. Collect the survey data.

- Position yourself with the diver station at Baseline Station 1 and hold the transducers of the two stations approximately 0.3m apart without altering the location of the baseline station or blocking the signal path.



Depending on current, surge, and wave action, positioning the diver station transducer can be difficult. We've found it best to remove the float from the diver station transducer and hold it by the PVC collar or cord 0.3m from the baseline station transducer. Remember: don't let your body block the signal path. (Photo here?)

- Press F2 and then ENTER to get to the PRECISION NAVIGATION screen.
- Press F4 to change from standby to record mode. Keep the diver station at the baseline station for as long as possible while in record mode (at least 2 minutes, but more ideally 5 minutes). Using signals received every few seconds, the diver station will repeatedly record the horizontal

distance measured between it and the three baseline stations. The vertical component of the distance (the result of any difference in the depth of the stations) is automatically removed.



Be careful not to move the baseline station during the survey and to minimize the motion of the diver station transducer, which serves as the reference point for multiple range calculations. Any movement will degrade the accuracy of the survey.

- Press F2 and then ENTER to get to the PRECISION NAVIGATION screen.
- Press F4 to change from standby to record mode. Keep the diver station at the baseline station for as long as possible while in record mode (at least 2 minutes, but more ideally 5 minutes). Using signals received every few seconds, the diver station will repeatedly record the horizontal distance measured between it and the three baseline stations. The vertical component of the distance (the result of any difference in the depth of the stations) is automatically removed.
- When you're done at Station #1, press F4 to return turn off the recording feature and remain in standby mode while swimming to Station #2. This will make it easier to extract the baseline survey ranges that are needed
- Repeat the transducer positioning and recording process at Baseline Stations #2 and #3. This data will give you the distance between the three stations.



20. *Download and convert the recorded data.*

See "Download the data" on page 19 for instructions on how to download the baseline survey data from the diver station into your PC.

- When the download is complete, go to START and choose: PROGRAMS→DIVETRACKER → CONVERT.
- Go to the FILE drop-down menu and choose LOAD A NEW RECORD.
- You will be prompted to choose the file that you want to convert (the one you just downloaded and saved), and the configuration file that was being used when the recorded file was created.
- When prompted to confirm that the download was created from a mobile station, answer YES.

21. *Determine the depth of the baseline stations.*

- At this point, do not place a checkmark next to either the option to show RAW auto position data or to show X-Y auto position data.
- The screen will display a single line of data for each baseline station. The information that you need to copy in a safe place concerns the depth of the baseline stations. This can be found in the far right column, measured in meters. It will be used when you edit the configuration file to add the baseline station range data.
- Exit CONVERT.



In CONVERT, B0= Baseline Station 1, B1=Baseline Station 2, and B2=Baseline Station 3. B4 will not contain data since we only use three baseline stations.

22. Determine the baseline ranges.

- To get the baseline ranges, go back to the FILE → LOAD A NEW RECORD. Reload the same file, choose the configuration file that was being used when the recorded file was created, and confirm that the download was created from a mobile station.
- But this time, place a checkmark next to SHOW RAW AUTO-POSITION DATA.”
- When the data has been converted (<1 minute), go to FILE → SAVE POSITION DATA FOR IMPORT.
- In the OBSERVATION fields, checkmark all four boxes for ROUND TRIP LENGTHS: 1, 2, 3, and 3 (3 appears twice). Leave the DELIMITER as a semicolon. Click on OK.
- You will be prompted to save this as a *.dbi file; do so with a unique name to the default location (C:/Program Files/DiveTracker/Records), then close CONVERT.
- Open a blank worksheet in MS Excel.
- Go to file → open. Select the *.dbi file you just saved (usually in (C:/Program Files/DiveTracker/Records).



If you don't see any *.dbi files listed, make sure you've selected all files on the "Files of type" menu in the file →open dialog box.

- A text import wizard will appear. Within the field for CHOOSE ORIGINAL DATA TYPE, select DELIMITED (usually the default). Click on NEXT.
- In the DELIMITER field, remove the checkmark in the Tab box and place one next to “semicolon”.
- Click on FINISH. The converted data will be displayed on the spreadsheet.

To determine the distance between baseline stations, you will need to separate the spreadsheet data into three sets according to which baseline station the signals were recorded at, determine the average and median for the baseline ranges, and use the Law of Cosines to determine the angle between Baselines #1 and #2.

B1 Data Series					B2 Data Series					B3 Data Series				
0.7366	95.5802	44.45000	-1		98.04400	0.254	116.459	-1		46.30420	116.5606	0.3556		
0.7366	95.30080	44.98340	-1		-1	1.3462	-1	-1		43.89120	116.63680	0.0508		
0.8636	96.95180	47.0682	-1		-1	0.6334	-1	-1		44.47540	115.57	0.3302		
1.4478	-1	45.1866	-1		96.95180	1.3716	117.65280	-1		47.54880	115.57	0.1778		
0.6858	95.70720	45.38980	-1		96.36760	0.254	116.35740	-1		45.03420	115.41760	0.127		
1.7526	95.42780	46.71060	-1		95.17380	0.635	116.07800	-1		44.78020	115.36680	0.381		
0.635	95.0214	44.55160	-1		96.03740	1.3716	-1	-1		44.78020	116.43360	0.2794		
1.4478	95.04680	-1	-1		-1	0.762	-1	-1		45.61840	115.82400	0.2032		
0.9398	95.22460	45.05960	-1		82.06740	0.4572	117.85600	-1		45.49140	116.05260	0.3302		
0.8382	95.70720	45.77080	-1		-1	0.4826	-1	-1		47.32020	115.62080	0.1524		
1.5494	-1	-1	-1		95.73260	0.2794	-1	-1		44.42460	115.97640	0.1778		
0.6858	95.19920	45.11040	-1		97.33280	0.5842	118.79580	-1		43.91660	116.05260	0.1016		
0.5842	95.88500	45.5676	-1		97.48520	0.635	-1	-1		43.91660	115.57	0.0508		
0.508	95.8088	44.80580	-1		-1	1.1938	-1	-1		43.99280	115.62080	0.2032		
0.6604	94.86900	44.70400	-1		-1	0.1524	-1	-1		43.84040	117.60200	0.4572		
0.6604	94.9198	44.577	-1		96.54540	0.1016	-1	-1		44.17060	116.25580	0.127		
3.1242	-1	44.83100	-1		96.26600	0.0762	117.22100	-1		43.94200	115.39220	0.4572		
1.5494	95.98660	44.3992	-1		96.4692	-1	-1	-1		43.81500	115.84940	0.1016		
0.2286	95.12300	44.37380	-1		95.88500	0.1524	-1	-1		-1	-1	0.2794		
0.127												0.0254		
												0.3302		
												0.1016		

Sample Spreadsheet of Range Data

23. Separate the range data into three sets

The spreadsheet will display the data in four columns. The values in columns A, B, and C indicate the distance in meters from the diver station to each of the three baseline stations (BS1, BS2, and BS3), as recorded by the diver station every few seconds while you were receiving signals at the site. Column D is all null data because it is for a channel that looks for data from a surface station or a fourth baseline station, neither of which we use.

The values in Column A, which indicate the distance between the diver station and BS1 should start out close to zero and generally be less than 1 meter because you were positioning the diver station transducer as close as possible to the BS1 transducer. (Ignore any negative values, i.e., -1, -2, -3, as these indicate errant signals.) As you scroll down, you will notice that when you reach a certain row, the values in Column A abruptly increase and the values in Column B drop close to zero. This row is the first data you recorded after moving to BS2. Consequently, the distance from the diver station to BS2 (shown in Column B) is very small, while the distance indicated to BS1 (Column A) is now similar to that in Column B in the preceding rows.

- To separate the data recorded at the BS1 position from that recorded at the BS2 position, scroll down until you reach the row where the values in Columns A and B abruptly change. HIGHLIGHT the four cells in that row and the rest of those four columns down to the end of the data.
- CUT that data and PASTE it at the top of Column F.
- Scroll down until the values in Column F abruptly increase while those in Column H drop close to zero. This indicates the first row of data that you recorded after moving to BS3. HIGHLIGHT the four cells in that row and the rest of those four columns down to the end of the data.
- CUT that data and PASTE it at the top of Column K.
- You have now divided the data into three sets according to the baseline station at which it was recorded. You can label these data sets by inserting a row above the data and entering the label, "B1 Data Series" in cell A1, "B2 Data Series" in cell F1, and "B3 Data Series" in cell K1.

24. *Determine the average and median values.*

Use the average and median of the data to make a best estimate as to the distance between the three baselines stations. The angles are determined using the ranges obtained with the Law of Cosines, as described on the baseline survey spreadsheet.



When calculating average and median values, be sure to exclude the negative values in the Excel formula cell range.

- To calculate the average and median range for Baseline #1 (the distance from BS1 to BS2), take the average and median of the values of Columns B and F.
- To calculate the average and median range for Baseline #2 (the distance from BS1 to BS3), take the average and median of the values of Columns C and K.
- To calculate the average and median range for Baseline #3 (the distance from BS2 to BS3), take the average and median of the values of Columns H and L. Although Baseline #3 is not used in the field, the value is used in the Law of Cosines to find the angle between Baseline #1 and Baseline #2. It is necessary to include this angle in the configuration file to complete the definitive baseline survey.

The Law of Cosines

$$c^2 = a^2 + b^2 - 2ab(\cos[a])$$

“a” = the angle between Baseline #1 and Baseline #2.

OR

$$\text{“a”} = \text{inverse cosine of } \frac{(\text{Baseline \#1})^2 + (\text{Baseline \#2})^2 - (\text{Baseline \#3})^2}{2 \times (\text{Baseline \#1} \times \text{Baseline \#2})}$$

all divided by (180x Pi)

25. *Evaluate the results.*

- Look at the differences between the average and the median for each range. Keep in mind that although negative numbers should be excluded, the average values do include any noise or poor signals. The median value represents the “middle” of the list of numbers, and may be the better option. Choose one value to use for the length of Baseline #1 and one for Baseline #2.
- In addition to using these values to edit the configuration file as described in the next step, these data and the depths of the baseline stations should be stored permanently somewhere safe so that you do not have to repeat this process if the electronic configuration file becomes corrupted, deleted or lost.



The main purpose of this data analysis is to enable you to be consistent in positioning the baseline stations and in the range and angle data entered in the configuration file. If you *always* position the baseline stations in the same place, and *always* use the appropriate data in the configuration file, AquaMap will attempt to locate the points in the same place. The actual accuracy of the baseline ranges becomes significant only if you want to geo-reference sample points using GPS.

26. *Edit and reload the configuration file.*

Now you need to add the baseline range data to the configuration file. However, to make sure that no depth is entered for the non-existent surface station, first make this value "0". See page 11 for more details on how to edit a configuration file.

- On your PC, open DiveTracker and go to DIVETERM → FILE → EDIT a CONFIGURATION FILE → ADVANCED EDIT.
- In the Select Configuration File window, open the same configuration file that you used to do the definitive baseline survey.
- In CONFIG-2, in the field for NETWORK TYPE, choose “single surface transducer station, three baseline stations,” then click on NEXT.
- In CONFIG-3, in the field for surface transducer depth, enter “0” and click on PREV.
- In CONFIG-2, in the field for network type, choose “no surface, three baseline, mobile station interrogated,” then click on next.
- In CONFIG-3, enter the depth you recorded for each baseline station in its appropriate box at the top of the screen. Then:
 - Enter the Baseline #1 range.
 - Enter the bearing from Baseline Station #1 to Baseline Station #2 (the value you measured under "Determine the baseline compass bearing" on page 16)
 - Enter the Baseline #2 range.
 - Enter the bearing between Baseline #1 and #2. This is the value determined using the Law of Cosines. (This cell looks misleading, as the display and heading are similar to the above “Bearing from Baseline Station #1 to #2,” but the values are derived by different means.)
- Click on NEXT twice to pass through CONFIG-4 and CONFIG-5.
- When you click on OK, you will be prompted to save the file with a name and location. Use a name with a *.par extension that corresponds to the site where you will be tracking and the default file location, then click on SAVE.



Always use this configuration file when surveying this particular site. If you must move the baseline stations later on, you will need to repeat the definitive baseline survey and re-edit the configuration file.

- After the configuration file has been edited, you need to reload it into the diver and baseline stations as explained on page 12.

The Definitive Perimeter Tracing

Now that you have completed the definitive baseline study and clarified the boundaries of your study site, you need to repeat the process of tracing and recording the site perimeter (see page 19) and then download the perimeter recording. You must create a perimeter record using the configuration file created with the definitive baseline survey; you cannot use an earlier perimeter tracing to generate random points.



Defining Waypoints and Transects

After you have completed the definitive baseline and perimeter survey, you will use the data to generate a total population of sample points separated by a designated distance. Then, using the AREA program, you will create a number of files containing X-Y coordinates (waypoints) and eventually select number of points to be sampled (each waypoint designating the start of a video transect). So that you can easily track to them, these waypoints will be loaded into the configuration file and downloaded into each station.

During this process, you will create the following files containing waypoints:

- **Total sample population.** These sample points are numbered sequentially in a serpentine pattern.
- **Randomized sample population.** This file contains the same points as the total population, but they have been renumbered randomly..
- **Subset of randomized sample population.** You select the minimum number of sample points that you will need to analyze a particular study site.
- **Additional subset** from the randomized sample population. You select an additional number of points that may be needed if any of those in the initial subset are found to be in an unacceptable or undesired sample habitat. These “spare” points are also loaded into the diver station to be used if necessary.



You have the option of including these spare points in the same file as the initial subset to simplify the loading of the waypoints into the stations. However, the AREA program includes a feature that will re-sequence a set of points into a more efficient path in order to minimize the distance you must swim. To preserve the statistical validity of the random sampling process, you cannot take advantage of this feature unless you keep the spare points in a separate file. If you create a single set of waypoints that includes the potential spares, you must track to the points in their random sequence until you have found the needed number in acceptable habitat.

The first file of the four files listed above is needed only to create the randomized sample population and does not have to be saved; the latter three must be saved for future use.

27. *Create the total sample population.*

- On your PC, go to PROGRAM FILES → DIVETRACKER → AREA.EXE. This will open the Waypoints window and the Commands window directly beneath it.
- At the FILE menu, choose LOAD FILE and select the applicable *.dbi file (C:/Program Files/DiveTracker/Record) to display the plot of points on as a graph.
- Adjust the size of the graph, if necessary, and draw the perimeter of your study site as explained on page 20).
- In the Waypoints window, use the grid divisions to enter the X spacing and Y spacing (i.e., the number of meters) between the sample points. For our videotaping protocol, we are using 10-meter separation on both the X and Y-axes.
- Choose MAKE to see the total population of possible points within the perimeter of your outlined study area, given the spacing interval you have defined. The points are numbered sequentially in a serpentine pattern, beginning in the lower left.

This file does not have to be saved; it will be modified in the next step to create a randomized sample population.

28. *Create a randomized sample population.*

- Choose SELECT AND RANDOMIZE ALL. The numbers will turn red, and their order will be scrambled.
- For reasons of statistical validity, you will only do this scramble once; that is why this file must be saved. Click on SAVE at the bottom of the waypoints window.
- Select the name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/Configs...) Click on SAVE again.
- When prompted to confirm whether the points are in meters, click on YES.
- The Area program will confirm that the points are in meters and how many points were saved in the file. Click on OK. Do not close the Area program.

29. *Select a subset of random sample points.*

From the randomized sample population, you will select a subset of waypoints based on the number of samples necessary for the site analysis. For example, this protocol calls for the use of 20 ten-meter transects within the study site, so it will require creating a file containing the coordinates for 20 waypoints, each of which will indicate the starting point for a 10-meter transect

- Choose SELECT RANGE to bring up the Input Text **Start** Index window.
- Enter the number of the first waypoint (i.e., “1”) in the permutation that you want to find, then click on OK.
- The Input Text **End** Index window will open. Enter the number of the last waypoint you want to include in this sub-sample (i.e., 20), then click on OK.
- The subset of the random population will be displayed in red; the other sample points are in black. To conceal the black waypoints and view only those in the subset, choose ONLY SHOW SELECTED WAYPOINTS.
- Click on SAVE at the bottom of the Waypoints window.
- In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/Configs...). Click on SAVE again.

30. *Create a path to connect the points.*

The sequence in which the waypoints appear may not provide the most efficient path for traveling from one point to the next. If you are certain that you will need to use *all* of the sample points in this subset, the Waypoints window offers two ways to create a more efficient path. These alternate paths include the same waypoints; only the numbers indicating their sequence change.

- If you choose MAKE PATH SERP, the waypoints will be rearranged in a serpentine pattern beginning in the lower left, progressing to the right.
- If you choose MAKE PATH GREEDY, the waypoints will be rearranged using the “greedy” algorithm.

In both cases, a message will indicate the distance you would travel if using that particular path. Click on OK to close the message box.



Remember: So as not to violate statistical principles of random sampling, you can only re-sequence points that you will definitely use for sample analysis. This means that if your subset of randomized subset contains 20 waypoints and you re-sequence them to create a more efficient path, you must use *at least* 20 sampling points in your data analysis. That's because if you re-sequence 20 points and then use only the first 10 in your analysis, those 10 points are no longer considered randomly selected; their selection reflects a bias toward the points that are positioned at the beginning of the most efficient path.

To use one of the two alternate paths:

- Click on MAKE PATH SERP or MAKE PATH GREEDY to display each option. Click OK when distance is displayed.
- Click on SAVE at the bottom of the Waypoints window when the path you want is displayed in it.
- In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/Configs...) Click on SAVE again. Do not close the AREA program.

31. *Create a subset of additional sample points.*

Inevitably, study sites contain locations that are not suitable for sampling. For example, in a spur and groove reef zone, a transect may fall in a sand groove. If >5 meters of a transect are in sand, then the sample point is discarded. If you must discard any waypoints from your initial subset because they are in unacceptable locations, you will need additional points in order to sample the desired number of waypoints.

For example, we select 1-20 as our initial subset of random sample points, then select an additional ten points to be used in case any of the original 20 points are found in unacceptable habitats. If all 20 of the original subset are found to be acceptable, none of the additional points are used. If the videotape for a transect filmed from the initial subset of waypoints turns out blurry, you cannot replace it with a transect filmed from the additional subset, as this would violate statistical principles of random sampling.

- To create this file of additional waypoints, deselect (un-check) the box next to ONLY SHOW SELECTED WAYPOINTS.
- Then repeat the steps under “Select a subset of random sample points” (see page 29). However, the START INDEX and END INDEX numbers will change. For example, if the initial subset of waypoints had a start index of 1 and an end index of 20, then a subset for 10 alternate waypoints will have a START INDEX of 21 and an END INDEX of 30.
- You can display these additional points by selecting ONLY SHOW SELECTED WAYPOINTS.
- Click on SAVE at the bottom of the Waypoints window.

As explained at the beginning of this section (page 28), you cannot use the MAKE PATH SERP or MAKE PATH GREEDY option to create a more efficient path for a set of points unless you are certain that you'll use all of the points in the set. Since you don't know how many spares you will need, these additional sample points must therefore remain in the sequence in which they were chosen.

- In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We recommend using the default location, C:/Program Files/DiveTracker/ Configs...) Click on SAVE again.
- Close the AREA program.

Although the initial subset of sample points can be automatically transferred, this additional subset must be manually entered into the configuration file for eventual downloading to the stations. To do this, you must view the actual waypoint coordinates in the *.wpt file.

- Go to START and choose: PROGRAMS → ACCESSORIES → WORDPAD.
- Go to the FILE drop-down menu and open the *.wpt file containing the 10 points you just saved.
- Regardless of other unit designations you have made, these values are displayed in feet. Before adding them to the diver station, you must convert them to meters. Multiply by 0.3048. Write down the converted values and close the file.

32. Load the sample points into the diver station.

You will need to load the files containing the subset of random sample points and additional waypoints into the configuration file for eventual transfer into the AquaMap stations. The automatic transfer is a two-step process in which the *.wpt file is loaded into the configuration file and the edited configuration file is loaded into the diver station. (Refer to page 11 for more information about editing and downloading the configuration file.) This is faster than manually entering the waypoint coordinates and avoids the possibility of transcription errors. However, the file containing the additional points have to be entered manually, as explained below.

- Open DiveTerm and go to FILE → EDIT A CONFIGURATION FILE → ADVANCED EDIT.
- In the Select Configuration File window, open the appropriate *.par file.
- Click on NEXT until you get to CONFIG-5 of the configuration file.
- Choose EDIT WAYPOINTS near the bottom on the left of the screen. A Waypoints window will be displayed, into which you can either manually or automatically enter the waypoint coordinates.
- **Automatic transfer:** To enter the coordinates for the first subset of random sample points automatically, choose LOAD FILE.
- In the Save Waypoints window, select the *.wpt file that you created earlier.
- Click on OPEN. This automatically loads the waypoint coordinates into the configuration file.



Given the recommended arrangement of the baseline stations (see page 13) the coordinates should be in a *positive X, negative Y* format. If this is not the case, there may be an error in the creation of the waypoints.

- **Manual entry:** Manually enter the coordinates in the Waypoints window in sequential order, e.g., starting with 21. (Click your mouse pointer in the appropriate cell or use the TAB key to move through the cells.)

- Because the precision navigation screen shows only the coordinates for your current position, it's a good idea to have all of the waypoint coordinates recorded on paper so that you can copy them onto a slate or a piece of duct tape that's been applied above the display window on the diver station.
- Click on OK in the Waypoints window and in the CONFIG-5 screen.
- You will be prompted to save the configuration file, since it has now been modified with the newly saved waypoint coordinates. Select a name and location. (We use the default location, C:/Program Files/DiveTracker/ Configs...) Click on SAVE.
- Download the edited configuration file into the diver station and baseline stations (see page 12) so you can track to the waypoints on each path.



AquaMap uses both Waypoints and Saved Points. Waypoints, which are those entered into the configuration file, begin with "W". Saved Points, which are saved through the diver station (typically in the field), begin with "S".

33. *Check the waypoint coordinates.*

It is a good idea to confirm that the waypoints have been correctly entered into the diver station before going out in the field. To do this:

- Turn on the diver station.
- Select the MODE key.
- Select "0"/ ↓ four times to select WAYPOINT.
- Press ENTER. This will display the View Waypoint screen. Use the function keys to move through each of the waypoints so you can verify their X , Y coordinates.



If you hit the F3/DEL key, you will delete a waypoint from the list and have to reinstall it by editing the configuration file.

- When you are done checking all the waypoints, select F4/OK to return to the diver status screen.

To reload a permutation of random points at a later date:

- Open AREA.EXE.
- Go to the FILE drop-down menu and choose LOAD FILE.
- In the LOAD FILE box, select the applicable *.dbi file that outlines the study site.

In the Waypoints window, select the *.wpt file that contains the permutation of points you want to load. When prompted to confirm whether the points are in meters, click on YES.



Tracking to Saved Waypoints

After the configuration file has been edited to include the definitive baseline survey data and waypoints, and you've reloaded the file into the diver station and baseline stations, you can proceed to locate the waypoints. To navigate to a particular point, you will monitor the general and precision navigation screens. To move between the two screens, press ENTER.

- To get to the GENERAL NAVIGATION screen from the DIVER STATUS screen, press F2. In this screen, you call up the destinations for navigation. The system will scroll through Home, B1, B2, B3 (indicating the three baseline stations), then the waypoints. (If you are not using a surface station, Home and B1 are the same location.)
- To get to the saved waypoints, press F2 again, or you can press #2 (INC) on the diver station keypad to go “up” the queue (i.e., Home, B1, B2, B3, then Waypoints 1, 2, 3, 4, etc.) Pressing #4 (DEC) will take you “down” the queue, reversing the order of waypoints.
- To navigate to a selected waypoint, use a hand-held or hose-mounted compass at least six inches away from the diver station. Use the “bearing to destination” on the upper right of the general navigation screen as a guide. While moving on that bearing, the “range to destination” (upper left of screen) should decrease. The “cross track error” number below the “range to destination” tells you how far you are from the line that connects two consecutive waypoints. It is useful if you are proceeding up the queue from one consecutive waypoint to another, but not if you are navigating to non-consecutive waypoints or selecting a waypoint “down the queue” of saved points.



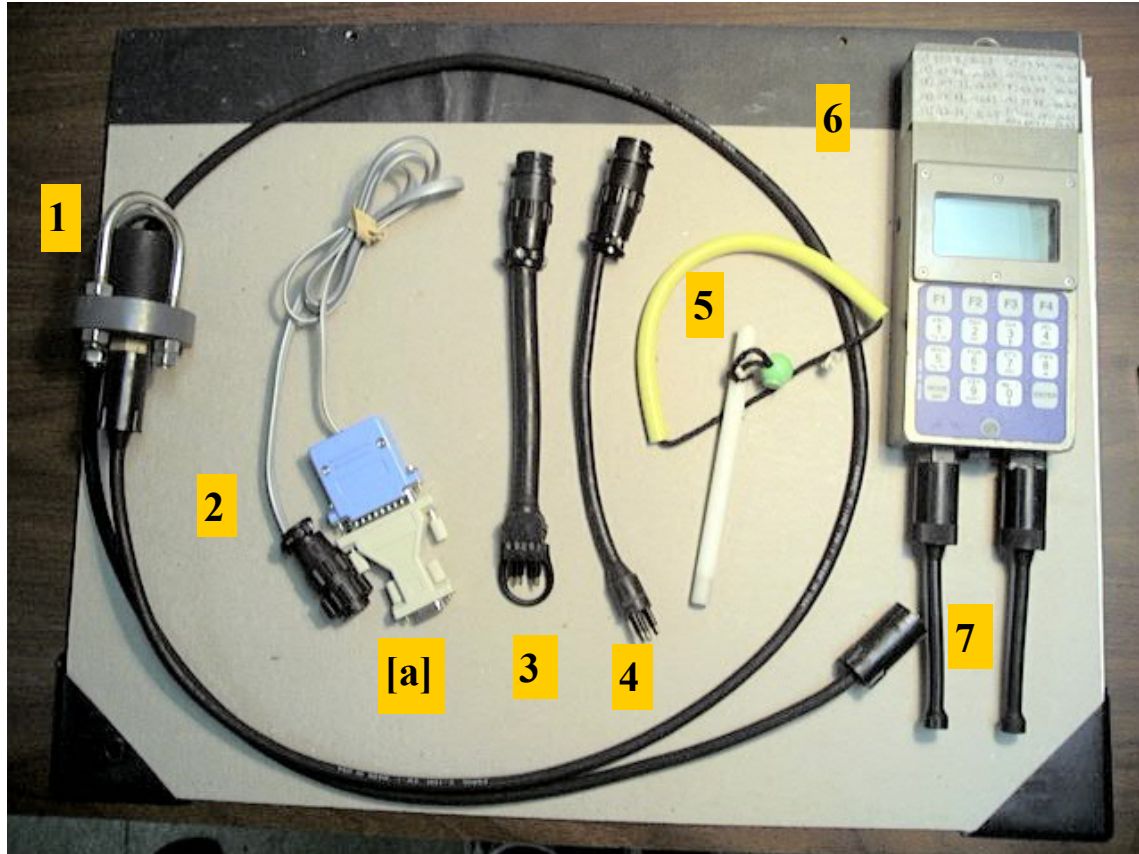
To prevent needle deflection, hold the compass as far away as possible from the diver station, which is metal and contains batteries.

- Use the X and Y location coordinates stored on right side of the general navigation screen or written on the duct tape on the diver station to find out where you're supposed to be heading. As the range decreases to <10m, slow your swimming speed. The bearing will fluctuate around the saved waypoint, trying to home you in on the exact spot.
- When the range reads <3m, press ENTER to switch to the PRECISION NAVIGATION screen. This will display your X and Y position and the RMS Error (“E”) so that you can fine-tune your position and measure the quality of the position fix. The larger the error number, the lower the data confidence. As explained under “Using the Diver Station” (seen page 11) this number will be large when you first arrive at a spot because the queue of data used to calculate it includes position fixes taken while you were swimming. You can wait a few moments for the RMS error to decrease, or reduce the queue to the two last positions by pressing F3.



It is “faster” to see the position error with the 2 positions queue, but if you are remaining in the same place, you get a more accurate position fix by using the 10 positions queue length. If the readings on your position fix are erratic, go to the precision navigation screen to see what happens to the RMS error when you press F2.

- Also monitor the “time since last fix” shown after the label “L,” which is located in the upper left of general navigation screen and the lower right of the precision navigation screen. This will tell you the time interval since the last successful communications between the transducers.
- Use your mental image of the image of the reef and the axis system to guide you in the proper direction, modifying the X and Y coordinates of your actual location so that they match as close as reasonably possible those of the location you are trying to track. This may take several minutes of adjustment and slight movements. Use good buoyancy control to avoid contact with the reef and having the transducer signals blocked by the reef or your dive partner
- Once the position has been found, signal your dive partner and lay the transect line, as explained in the section on the videotape protocols.



Aqua Map Diver Station Components (page 3):

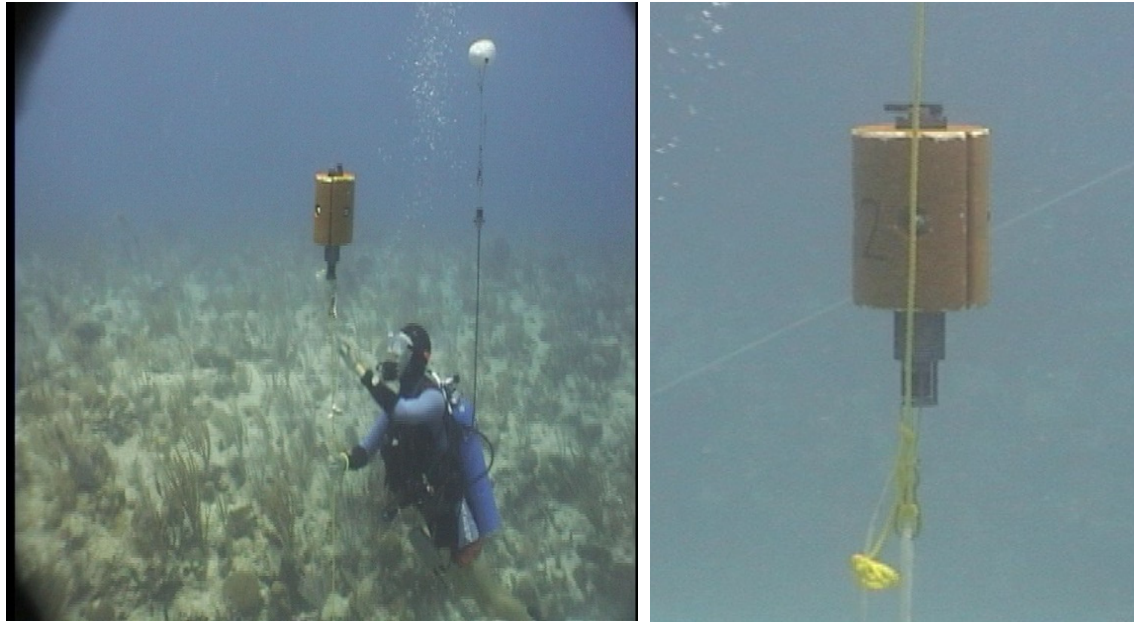
- 1. Diver Station Transducer**
- 2. Data Exchange Cable ([a] with gender adapter)**
- 3. Baseline Station Connector Adapter**
- 4. Diver Station Connector Adapter**
- 5. Magnetic Pointer**
- 6. Diver station**
- 7. Dummy Plugs**



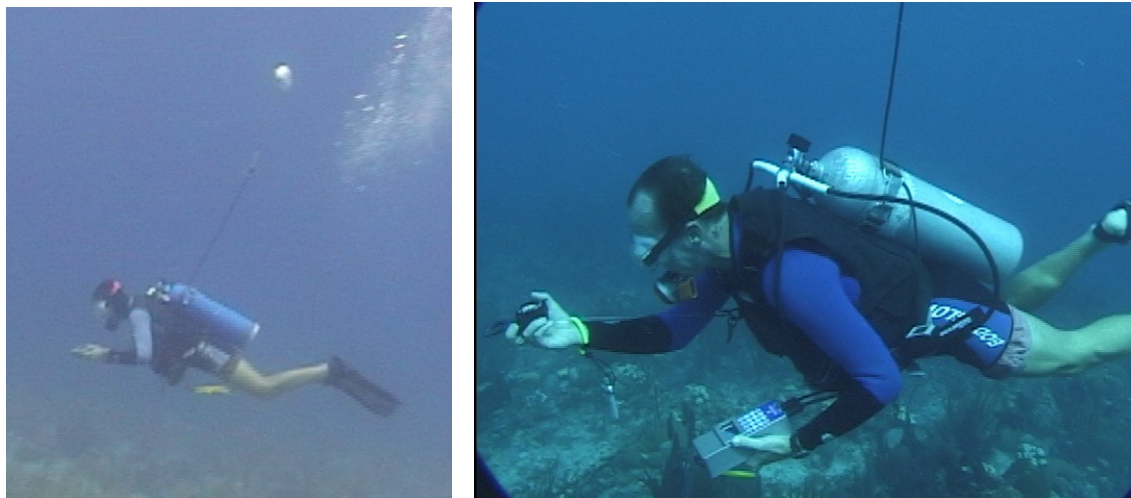
**Lift Bag or float attachment
at top of the diver station.
(page 7)**



**Weaving line through the
diver station. (page 7)**



Deploying a Baseline Station (page 15).



Navigating with the Diver Station (page 16).

Standard Operating Procedure 3: Selecting Random Sample Points using GPS

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: This procedure describes a relatively inexpensive method to conduct random sample selection (as opposed to haphazard) at an underwater study site. This protocol would involve snorkeling around the perimeter of a study site making a recording of the positions with a GPS in some kind of waterproof bag. They would download that recording/tracing and then load it into ArcView. From there, using scripts and extensions, they can generate random points within that study area, sort them for ease of navigating to them, then get a list of range and bearings from one point to another. Those ranges and bearings would be written on a slate and using a transect tape and compass, the divers could navigate from random one point to another.

If the site were to be monitored "permanently", it would be beneficial to pound in a pin at the random point to aid in return relocation. Additionally, having someone on the surface with the GPS could increase accuracy of navigating to the random points (along with the divers using the range and bearings).

Objectives:

- 1) Outline a study site of interest.
- 2) Download that outline into ArcView.
- 3) Randomly select a number of sample points.
- 4) Be able to locate those sample points.
- 5) Be able to go back to those sample points over time.

Procedure:

- 1) You will need the following extensions:

ArcView 3.x (3.2 or 3.3)

Dnrsample.avx

Pathfind.avx

Random_sites.avx

TNCTools.avx

dist_matrix_jen.avx

These all go in the Esri\av_gis30\arcview\ext32 folder.

When you open ArcView, you will need to activate these extensions (see below).

2) You will need to activate these extensions for this work.

- a) Open Arcview
- b) Go to the File drop down menu
- c) Select Extensions
- d) You may also want to put a check in the Mr. Sid and Imagine.
- e) Scroll down and put a check in the following:

DNR Random Sampling Tools
Path w/ distance & Bearings
Random Points
TNC Tools
Distance Matrix v.2.1

- f) You may want to put a check in the box for this to be the default.
- g) Select OK.

You have activated these extensions within your ArcView program.

To Save a dbf table from an excel spreadsheet:

- a) Enter data into three columns including Point ID (A), Northing (B), Easting (C).
- b) Highlight B and C (Northing and Easting) Columns. F Format Cells, Number, Decimal places = (reflect the number in the data)
- c) Select the A column = POINT. Format Cell, Chose “number” (even though it is a ‘name’), Decimal places “0”.
- d) TO SAVE AS DBF:
Insert, Name, Define
Under “Names in Workbook”: type in ‘database’.
Go to excel import thingy (lower-right). This will take you to the spreadsheet where the data is, and the sheet will be active.
Select the cells containing the data (numbers and headers)
Go back to the dialog box “Define Name” – select OK.
- e) Go to the down-arrow (the “name box”) located to the left of the equation bar – choose DATABASE.
- f) File, Save as, chose appropriate name (no spaces in name; underscore OK) and location.
Save As Type: DBF-4 (dBASE IV) – Choose OK
- g) Dialog Box, “Do you want to keep the workbook in this format?” Select YES.
- h) Then close. Dialog box – “Do you want to save the changes you made to” Select NO.
- i) Add this above stuff to the existing. Then proceed with “Add theme”.

To Bring in a dbf table (similar protocol for bringing in a .csv file that should be saved as txt):

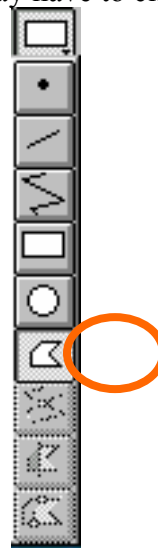
3) Open a new project in ArcView

- a) Select TABLE from the ArcView project box.

- b) Select Add, then browse to the location of the database file of the perimeter trace. You should see the table name added to the window.
- c) Select VIEW.
- d) Select New. A new view window will open for this project.
- e) Go to drop down menu View, then Add Event Theme.
- f) TABLE: enter the database (perimeter) table
- g) X-Field: enter Eastings
- h) Y-Field: enter Northings
- i) Select OK.
- j) Put a check in the box, to display the database. Make this the active theme.
- k) Be sure that either: all points in theme are selected or no points in theme are selected
- l) Go to theme menu: Convert to shapefile. Save in appropriate location with appropriate name.

This section is for defining random sample points using ArcView (as opposed to importing random points from the A-map system).

- 4) You need to create a new polygon shape file over the perimeter trace.
 - a) Go the drop down menu View.
 - b) Select "New Theme"
 - c) Select "polygon" as the feature type from the New Theme dialog box by clicking on the down arrow and selecting "polygon" from the list. Select OK.
 - d) Choose the name and storage location for the new theme.
 - e) The new shape file will appear in the active view. It will be ready for editing or creating.
 - f) From the tool boxes, select the draw polygon tool. You may have to click on and hold



another tool, to cause new icons to appear below the tools.

- g) Trace the outline of your perimeter with you mouse; double click when you are at the finished tracing. The polygon you created will be selected (highlighted).
- h) Go to the drop down menu Theme, and select Stop Edits. A save edits dialog box will appear: select YES to save the creation of the polygon.

- i) Click on the new shapefile's name to make it the active theme.

5) You can determine the number of points that can be created within your site within the defined sample area:

- a) From the drop down menu, choose Sampling Tools.
- b) Select Systematic Point Sample from the list. A Base File dialog box will appear.
- c) Enter the appropriate sample parameters
 - 1. Spacing X (): 10
 - 2. Spacing Y (): 10
 - 3. Minimum distance from polygon boundary: 0
 - 4. Then select OK.
- d) Another dialog box will appear requiring you to choose the name and location of the shape file you are about to create. Enter names and storage location, and then select OK.
- e) The shape file containing the points will appear in the view window. Put a check in the box to see the points displayed and make it the active theme.
- f) To see the positions and the number of points created, select the Open Theme Table button. Scroll down the table to see the number of point. You can save this shape file/theme or delete it. The value is knowing the number of points that could be created within your study area (given the defined spacing).

6) Create Random Points within your polygon

- b) Make the polygon theme the active theme.
- c) Select the theme. (It should still be selected. If not, choose the select feature button



, then click on the polygon in the view window.)

- d) Click on the tool button that Generates randomly-distributed points .
- e) A dialog box will appear. Make the appropriate selections for the following:
 - 1. Polygon Boundary: select the name of the polygon for your site outline.
 - 2. Number of sites to generate: e.g. 20.
 - 3. Minimum distance between points: e.g. 10
 - 4. Minimum proximity to polygon: e.g. 0
 - 5. Output point theme: select location
 - 6. Press the button: "Do It". The points will appear in the polygon.
- f) The new theme will appear and the random points will be displayed in the view.
- g) Click on the new theme to make it the active theme.

Ordering the Points:

8) Label the points

- a) Make the random point theme/shape file the active theme.
- b) Go to Theme drop down menu
- c) Select Auto-label
 - 1. Label field - ID
 - 2. Use Theme's Text label placement property.
 - 3. Scale label should be checked.

4. Select OK
 - d) The labels should appear by the dots
- 9) Open Attribute Table for the random points.
- a) Click on the icon “open theme table” from the menu bar.
 - b) An attribute table of the active theme containing the coordinates (UTM) for each random point will be displayed.
- 10) We need to arrange the points in the order that we will be visiting them.
- a) Open the Theme Table (use icon or double click on the table from the project menu box).
 - b) Go to drop down menu Table - select Start Editing.
 - c) Go to drop down menu Edit - Select Add field
 - d) In the field definition box
 1. In the space for name, type ORDER
 2. The type option should be NUMBER
 3. Fill in Width: 3
 4. Leave all else as defaults
 5. Select OK to close box
 - e) The new field column will be added to the attribute table.
 - f) Press the “edit” icon  to be able to add numbers to the attribute table.
 - g) Evaluate the arrangement of random points. Decide a path through the points. You will want to decide which labeled point you want to visit first, second, third, fourth, etc.....
 - h) When you have done this go to the attribute table and find the label for the point you wish to visit first.
 - i) Enter in the corresponding ORDER column space, “1”.
 - j) Find the label for the point you wish to visit second.
 - k) Enter in the corresponding ORDER column space, “2”.
 - l) Find the label for the point you wish to visit third.
 - m) Enter in the corresponding ORDER column space, “3”.
 - n) Repeat these two steps until you have accounted for all the points. When you have finished entering the last value (20), be sure to hit return. This will make sure that that value is recorded.
 - o) Go to Drop down menu Table, and select Save Edits, then Stop Edits. A dialog box will ask if you want to save edits; select YES.
 - p) Select the column header “ORDER”.
 - q) Go the drop down menu FIELD
 - r) Select Sort Ascending (or just choose the icon from the task bar).
 - s) This will re-arrange the points in the attribute table in the order you wish to visit them.

If you want to modify the swim order in order to swim a subset of points differently than originally planned:

- a) If you need to re-define the sampling order, please do not edit the order in your master data set. This is your record of what you did.
- b) Select the points that you want to visit in a given day. Go to Theme, Convert to shapefile, and save in appropriately location with appropriate name (site_subset_date)
- c) Then re-do the above procedure for ordering for that particular subset. You can then do the find bearing and distance procedure listed below for that subset as well.

Getting the Distance and Bearing between points: 2 methods

14) Derive Bearing and Distance between ordered points

- a) Click on the View Window to make it active (blue).
- b) Click the “Find Path” icon from the tool bar. This will open an input theme dialog box.
 
- c) Select the following from within the dialog box (see dialog_1.gif):
 - a. INPUT DATA: choose the shape file that contains the randomly generated points.
 - b. Select input data, ID FIELD: choose ID.
 - c. Select input data, SERIES FIELD: choose ORDER.
 - d. Select OK to close this window.
- d) The dialog box titled “Data for RESULTS table” will open. This dialog box is in two columns. The left column represents the “FROM” feature data; the right column represents the “TO feature data. Put a check in the box next to the following items in both columns:
 - a. “FROM” ID (left column) and “TO” ID (right column)
 - b. Under the sub-header titled: Feature Connection Options, select Distance between Centroids and Bearing between Centroids.
 - c. Under the sub-header RESULTS format, put a check in RESULTS table and Polyline Shapefile of individual path segments.
 - d. Click OK to close the dialog box.
- e) The dialog box titled “CONNECTION LINES- centroids and closest edges” will open. Select (put a check) the following features:
 - a. Connect CENTROIDS: No lines
 - b. Connect CLOSEST EDGES: No lines
 - c. Select OK to close the dialog box.
- f) A dialog box asking where you would like the results table? Browse to select the location then select OK to close this box. You can also choose to rename the table at this point.
- g) A dialog box asking where you would like the Path shapefile? Browse to select the location then select OK to close this box. You can also choose to rename the shapefile at this point.
- h) The table displaying the bearings and distances will be opened.

You will need to copy this data in some way to take it with you in the field.

- 15.) To create a distance and bearing matrix for the entire site. This may be useful for swimming between points in any order (not necessarily the order that is given in the attribute table).
- This method can be done without actually drawing any lines or creating any shapefiles between points.
 - Copy and Paste the "dist_mat_jen.avx" extension into the EXT32 Folder.
 - Load the points shapefile into ArcView.
 - Turn on the Distance Matrix extension (it is called Distance Matrix v2.1).
 - Click on the Distance Matrix Button on the toolbar (.
 - In the dialogue box: "Distance: Select theme for Matrix columns": Select the appropriate theme and select the point ID field as the ID FIELD.
 - In the dialogue box: "Distance: Select theme for Matrix rows": Select the appropriate theme and select the point ID field as the ID FIELD (same as selected above).
 - Enter in the appropriate decimal places (=2) and the click OK.
 - Save the output as a comma-delimited text file by an appropriate name then underscore 1 (ie.ha_1) in an appropriate location. *In order to have the combine function work properly, the files MUST be saved with the name_1 and name_2 naming convention.
 - Minimize or close the Matrix Report
 - Click on the Azimuth Matrix Button on the toolbar (.
 - In the dialogue box: "Azimuth: Select theme for Matrix columns": Select the appropriate theme and select the point ID field as the ID FIELD.
 - In the dialogue box: "Azimuth: Select theme for Matrix rows": Select the appropriate theme and select the point ID field as the ID FIELD (same as selected above).
 - Enter in the appropriate decimal places (=0) and the click OK.
 - Save the output as a comma-delimited text file by an appropriate name then underscore 2 (ie.ha_2) in an appropriate location. *In order to have the combine function work properly, the files MUST be saved with the name_1 and name_2 naming convention
 - Select OK and close the Matrix Report.
 - You can then combine the matrices by clicking on the  button. As long as the files are named as above, they will combine into one file that can be opened in excel.
 - Shift select both files in the "select files to combine into complete matrix" dialogue.
 - Name the file and put it into an appropriate location. Click OK.
 - Close the "Combine files Report."
 - Navigate to the chosen location and rename the file extension from .txt to .csv.
 - The file may then be opened up in Excel.

Standard Operating Procedure 4: Counting Long-Spined Sea Urchin, *Diadema antillarum*, on Coral Reefs

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: this procedure describes the steps to count the long-spined sea urchin, *Diadema antillarum*, along a sample transect. This invertebrate is a substantial marine herbivore and can have an effect on the algal cover in coral reefs. Algal removal is a major step in the coral recruitment process. During the 1980's, this sea urchin suffered Caribbean-wide mortality at levels approaching 90%. Within the past 5 years, some scientific and anecdotal information suggest numbers of *Diadema* are increasing. Using this method, the number of all long-spined sea urchins (adult and juvenile) found along a 1-meter belt transect on both sides of the sample transect used in the Coral Reef Monitoring protocol are counted during the sampling of the transect (filming with video camera). This SOP is used along with the "SOP 1– Using videography to monitor coral reefs." NOTE: Diver's must get very close to the reef when collecting *Diadema* data, therefore extreme caution must be used not to cause damage to the reefs being measured.

Procedure:

1. Slowly swim along the transect searching in the various reef cracks and under ledges in a "belt" or swath, one-meter directly adjacent and along one side of the transect.
2. When a *Diadema* is found, there is no need to remove the urchin. Just identify and count its presence.
3. Continue along the transect searching the 1-meter wide belt until you reach the end (0m or 10m) of the transect.
4. Turn around (make a "U-turn") then proceed along the opposite side of the transect (side unsearched previously in step 1 above) conducting an intensive search for the *Diadema*, tallying their number when observed.
5. End the search at the end of the transect (0m or 10m).
6. Record the number of *Diadema* on data sheet (see sample data sheet in "SOP 6- Measuring Coral Disease").

Standard Operating Procedure 5: Measuring Rugosity on Coral Reefs

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: this procedure describes the steps to measure rugosity, the verticality of a reef along a sample transect. A known length of small-link, light-weight chain (e.g. dog chain) is laid along the contours of the reef beneath the defined transect. The ratio obtained between the length of chain divided by the length of transect over the bottom is the rugosity value. For example, if the bottom was perfectly flat, it would take 10m of chain to cover 10m of bottom, $10\text{m}/10\text{m}=1.0$. If the bottom has moderate structures, for example, 16.5 meters of chain could cover 10m of bottom the rugosity value would be 1.65 ($16.5/10=1.65$). Rugosity should be measured every 5 years or after an episode of significant bottom disturbance (e.g.: hurricane, ship grounding, or major coral die-off). This SOP is used along with the SOP – Using videography to monitor coral reefs. NOTE: Diver's must get very close to the reef when collecting rugosity data, therefore extreme caution must be used not to cause damage to the reefs being measured.

Procedure:

1. Lay the first link of chain at the origin of the transect.
2. Proceed directly under the transect tape, unspooling the wrap of chain, and draping it over the contours of the bottom. This method aims to measure the rugosity of the hard structure of the reef, thus it is important to follow only the contour of the lithified components (fig 1).
3. Often the transect tape will run underneath an overhang or a fire coral. The chain must still be placed over the structure, as it contributes to the relief of the reef.
4. Three errors may often occur when laying down the chain, and should be avoided:
 - a. The chain must not be allowed to “bunch up”, because this would cause an erroneously high reading.

- b. When passing over an object or structure the diver may tend to pull the chain away from the bottom. The chain will then lay at an angle and not match the contour, causing an erroneously low reading.
 - c. When laying down the chain, it is important to keep it as straight as possible with respect to the transect tape and avoid sinuosity that can cause an erroneously high reading.
5. If a gap between structures is too small for the chain to be inserted and removed without causing damage to the substrate, consider the structures as one feature, draping the chain over the small gap. In such cases the adjacent structures do not individually contribute significantly to rugosity, therefore it is most appropriate to measure them as one larger feature.
6. When the entire length of chain has been used, note the location (bottom feature and distance along the chain) at the end of the chain. Carefully reel in or gather up the chain, then begin to drape the chain where the first length of chain ended. It is important to retrieve the chain carefully to avoid causing damage to the reef. The chain often may work itself into crevices and must be removed gently.
7. Record or remember the number of times the length of chain has been deployed. This will be multiplied by the length of the chain and added to the length of chain used to reach the terminus of the transect.
8. When reaching the terminal end of the transect (usually 10m), stop laying the chain.
9. Measure the length of chain (to the nearest centimeter) that it took to reach the terminal end of the transect.
10. Multiply the length of the transect by the number of times it was deployed. Then add the length of chain it took to reach the terminus. Record that number along with the transect number on data sheet printed on underwater paper (see sample data sheet in “SOP-Measuring Coral Disease”).

Example:

A diver uses a reel with 6 meters of chain. The entire length of chain was deployed twice. The diver needed 3.16 meters into the third deployment of the chain to reach the terminus of the transect.

The length of chain it took to cover the bottom is $2 \times 6\text{m} = 12\text{m} + 3.16 = 15.16$.

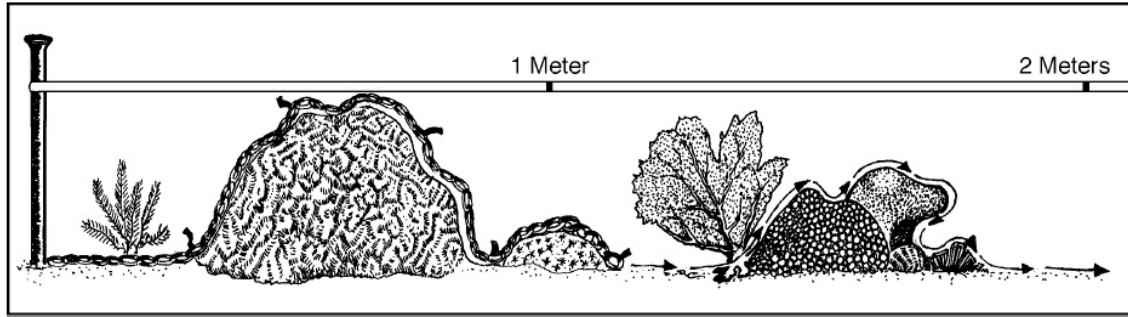


Figure 5-1: positioning the chain.

Standard Operating Procedure 6: Measuring Coral Disease

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: This procedure describes the steps to measure recent mortality from suspected coral disease at the index sites (described in the South Florida/Caribbean Network Coral Reef Monitoring Protocol). Identification, measurement and digital photographs are taken of bright white areas of coral skeleton (recently killed = not encrusted with any algae, turf or otherwise), also called lesions, within a 1-meter belt along each side of the transect sampled during the SOP – Using videography to monitor coral reefs. Pathogenesis for most coral diseases remains unknown, so field observations remain the most effective way of documenting coral diseases. Taking samples of the recently dead area(s), nearby tissue, or healthy coral tissue is encouraged but not covered under this SOP.

Procedure

1. Begin at the origin of the transect, and proceed along the transect searching in a belt/swath one-meter to each side.
2. When an area of bright white coral skeleton is observed, it should be assessed to determine if the cause of mortality fits the characteristics defined to be suspected coral disease (see Woodley et al., 2003, Weil et al, 2006, Southerland et al, 2004).
3. If the area has characteristics of coral disease, the following information is recorded on attached data sheet (see sample data sheet):
 - d. Type of coral disease
 - e. Coral species affected
 - f. Location along transect
 - g. Approximate distance from transect
 - h. Length of recent mortality
 - i. Longest-length perpendicular to measurement above (3d).

4. The area is photographed with a digital camera. When more than one photograph can be taken that is noted with the information in 3 above.
5. Proceed in a 1-meter belt up one side of the transect (0m to 10m) then down the other side in a 1-meter belt (10m to 0m) searching for lesions.
6. Data entered into a spreadsheet/database include
 - j. Study site
 - k. Date of observation
 - l. Name of coral disease
 - m. Name of coral affected
 - n. Length of lesion
 - o. Width of lesion
 - p. Location along transect
 - q. Distance from transect
 - r. Number of photo of photo label

References

Sutherland, K., J. Porter, C. Torres. 2004. Disease and immunity in Caribbean and Indo-Pacific zooxanthellate corals. *Marine Ecology Progress Series*. 266:273-302.

Weil, E., S. Garriet, D. L. Gil-Agudelo. 2006. Status and progress in coral reef disease research. *Diseases of Aquatic Organisms*. 69:1-7.

Woodley, C.M., A. W. Bruckner, S. B. Galloway, S. M. McLaughlin, C. A. Downs, J. E. Fouth, E. B. Shotts and K. L. Lidie. 2003. *Coral Disease and Health: A National Research Plan*. National Oceanic and Atmospheric Administration, Silver Spring, MD. 72 pp.

Site

Date

Observer

	Transect				
	1	2	3	4	5
Rugosity					
Diadema					

	Transect				
	6	7	8	9	10
Rugosity					
Diadema					

	Transect				
	11	12	13	14	15
Rugosity					
Diadema					

	Transect				
	16	17	18	19	20
Rugosity					
Diadema					

Disease data								
Transect								
length along transect								
distance away from transect								
name of coral disease								
coral species affected								
length								
width								
# pictures taken								
notes								

Disease data								
Transect								
length along transect								
distance away from transect								
name of coral disease								
coral species affected								
length								
width								
# pictures taken								
notes								

Standard Operating Procedure 7: Coral reef monitoring database user's guide.

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: This SOP provides instructions on how to enter videography analysis data into the database and describes the how the database is structured.

Procedures:

The data form input screen is broken down into 3 separate sections:

- 1) The Locations,
- 2) Events, and
- 3) Video Data.

The menu buttons at the top of the form can be clicked to navigate between them. Note that the current LocationID and EventID are shown at the top of the form. More on this later.

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

EXIT Click Here

Coral Reef Video Monitoring ver. 1.8 11/18/2004

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: BISC_CoraVideo_AM_01 Event ID: BISC_CoraVideo_20040609

I. Locations

The site locations are documented using a LocationID field that includes the following information: Park Code, Monitoring Protocol, Site Name, and Transect Number. These sections are placed together in the LocationID with an underline that separates them as follows:

Park Code_Monitoring Protocol_SiteCode_TransectNumber

For example **VIIS_CoralVideo_HA_01** refers to the Virgin Islands N.P. Coral Video monitoring protocol at Haulover, transect#1.

It may help if you think of each transect as a different location. The location is NOT the site with a group of transects. The location IS a transect, within a Park, with a specific monitoring protocol and site name.

Currently all the LocationIDs are stored in the table tblLocations and have been created for ongoing video monitoring at BISC, BUIS, DRTO and VIIS for the following combinations of parks, protocols, and study site locations:

<u>Park</u>	<u>Protocol</u>	<u>Site Code</u>
BISC	CoralVideo (AquaMap Random Transect Coral Video)	AM – Amanda’s Reef
BISC	CoralVideo (AquaMap Random Transect Coral Video)	BB – Ball Buoy

BUIS	CoralVideo (AquaMap Random Transect Coral Video)	WSG – Western Spur and Groove
BUIS	Coralvideo (AquaMap Random Transect Coral Video)	SFR – South Fore Reef
DRTO	CoralVideo (AquaMap Random Transect Coral Video)	BK– Bird Key
DRTO	CoralVideo (AquaMap Random Transect Coral Video)	BKN– Bird Key North
VIIS	CoralVideo (AquaMap Random Transect Coral Video)	HA – Haulover
VIIS	CoralVideo (AquaMap Random Transect Coral Video)	MB – Mennebeck
VIIS	CoralVideo (AquaMap Random Transect Coral Video)	NF – Newfound
VIIS	CoralVideo (AquaMap Random Transect Coral Video)	YZ – Yawzi Point
VIIS	CoralChainVideo (Video of Chain Transects)	NF – Newfound
VIIS	CoralChainVideo (Video of Chain Transects)	YZ – Yawzi Point
VIIS	ReRand_CoralVideo (Video of re-randomized Transects)	NF – Newfound
VIIS	DiseaseVideo (Video of disease transects)	TK – Tektite

Generating New LocationIDs

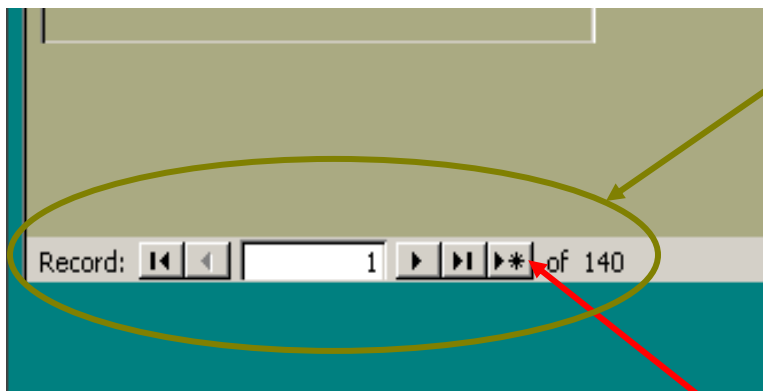
You will need to generate new location ID's when

- 1) new site(s) are added, or
- 2) additional transect(s) are desired within an existing site.

REMEMBER: a location ID refers to a transect, not just a site with transects.

To Generate a new Location ID:

- 1) Going to the bottom of the LocationID screen and find the Record scroll:



- 2) Then press the add record button (the right-most >*) to add a new LocationID.

Choose the correct ParkName and Project. The drop down arrows will provide a menu of choices or you can type in a new entry.

3) Click “Generate LocationID”.

The screenshot shows a web form titled "Select Location:". It contains a table with columns "LocationID", "ParkCode", and "Project". Below the table are input fields for "LocationID", "ParkName", "Project", "Description", "StartUTMX", "StartUTMY", "StopUTMX", "StopUTMY", "Datum", "EstHError", and "AccNotes". A "Generate Location ID" button is also present. Annotations include: a red dashed arrow pointing from the instruction text to the "ParkName" dropdown; a green dashed arrow pointing from the instruction text to the "Project" dropdown; a blue dashed arrow pointing from the instruction text to the "Generate Location ID" button; a blue oval around the "Generate Location ID" button; a red oval around the "ParkName" dropdown; a green oval around the "Project" dropdown; and a dashed arrow pointing from the instruction text to the scrollbar on the right side of the table.

LocationID	ParkCode	Project
BUIS_CoraVideo_WSG_01	BUIS	Coral Video
BUIS_CoraVideo_WSG_02	BUIS	Coral Video
BUIS_CoraVideo_WSG_03	BUIS	Coral Video
BUIS_CoraVideo_WSG_04	BUIS	Coral Video
BUIS_CoraVideo_WSG_05	BUIS	Coral Video

LocationID: BUIS_CoraVideo_WSG_01

ParkName: Buck Island NM

Project: Coral Video

Description:

StartUTMX:

StartUTMY:

StopUTMX:

StopUTMY:

Datum:

EstHError:

AccNotes:

Generate Location ID

- 4) To complete the LocationID, type the site code (IN CAPS), then underscore, then transect number (2 or 3 letter code followed by two digit transect number e.g.: MB_03, YZ_02, HA_18, SFR_20, WSG_10 etc) to complete the LocationID.
- 5) Then hit “Enter” on you keyboard.
- 6) If you now scroll down on the right side of the listed LocationIDs, you will find your newly added entry.
- 7) Remember, each transect is designated by a unique locationID, so if you are entering locations for a new study reef with 20 transects, you will do the process above 20 times, changing the transect number sequentially after each new entry. When you are done entering the transects, you will need to enter an EVENT ID (see section II. Events [below]).

II. Events

Each field sample event is documented using an EventID that is comprised of the same ParkCode and Protocol conventions as used in the LocationID, plus the date, given in YYYYMMDD format. In general, one EventID is used for each time the LocationID is visited. On the example screen below, VIIS_CoralVideo_NF_07 has been visited annually between 1999 and 2003, so there are 5 entries in the EventID section. Also note there is a checkbox titled “Only show events associated with LocationID VIIS_CoralVideo_NF_07” shown in the example data entry screen below. By checking this box, the program filters out all other EventIDs in the *tblEvents* that aren’t associated with that particular LocationID. Otherwise, you are shown all EventIDs for all LocationIDs. At this point the EventID defaults to the first event listed (chronological) for that location. e.g.: VIIS_CoralVideo19990324.

Location ID: **VIIS_CoralVideo_NF_07**

Event ID: **VIIS_CoralVideo_19990324**

Select Event

Only show events associated with LocationID VIIS_CoralVideo_NF_07 ☒

EventID	Project	StartDate	StartTime
▶ VIIS_CoralVideo_19990324	Coral Video	03/24/1999	
VIIS_CoralVideo_20000322	Coral Video	03/22/2000	
VIIS_CoralVideo_20010306	Coral Video	03/06/2001	
VIIS_CoralVideo_20020312	Coral Video	03/12/2002	
VIIS_CoralVideo_20030310	Coral Video	03/10/2003	

EventID: VIIS_CoralVideo_19990324

Project: Coral Video

Year: 1999

StartDate: 03/24/1999

Field Observers

[Generate Event ID](#)

Generating New EventIDs

There are two occasions where new EventIDs need to be generated:

- 1) when a new set of LocationIDs has been added [as when you add a new study site to your monitoring efforts], and
- 2) when an additional sample event needs to be added for a pre-existing LocationID.

Most of the time, the latter instance will be the case, since you normally will want to add another year's worth of data to a study site that already exists.

- 1) **From within the LOCATIONS screen, SELECT (with a mouse-click to place a black triangle) the LocationID entry for which you want to create an EVENT ID.**
- 2) Then click the Event menu area at the top of the screen to transition to the **EVENTS** section.

VIIS: Coral Image Video

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

Virgin Islands National Park

Coral Reef Video Monitoring

ver.1.71 12/29/03

EXIT

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: VIIS_CoraVideo_NF_01 Event ID: VIIS_CoraVideo_19990323

Select Location:

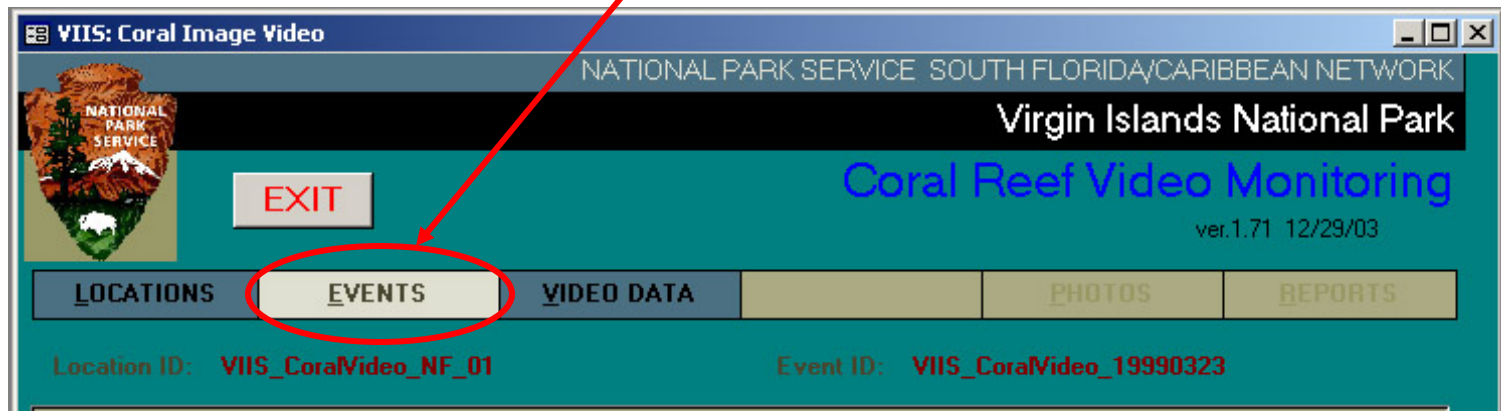
LocationID	ParkCode	Project
VIIS_CoraVideo_MB_20	VIIS	Coral Video
▶ VIIS_CoraVideo_NF_01	VIIS	Coral Video
VIIS_CoraVideo_NF_02	VIIS	Coral Video
VIIS_CoraVideo_NF_03	VIIS	Coral Video
VIIS_CoraVideo_NF_04	VIIS	Coral Video

LocationID: VIIS_CoraVideo_NF_01 [Generate Location ID](#)

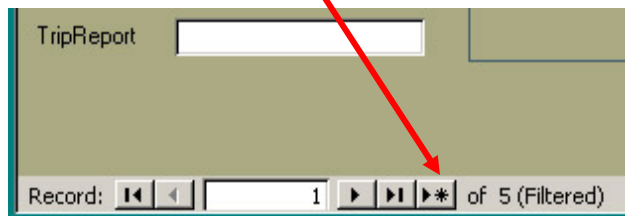
ParkName: Virgin Islands NP StartUTMX: 323785.945 Datum:

Project: Coral Video StartUTMY: 2029593.46 EstHError:

3) Make certain that you are looking at the EVENTS page/screen by seeing it in white at the top of the page.



4) Similar to when you are adding LocationIDs, you need to go to the bottom of the screen and find the Record scroll. Then press the add record button (the right-most >*) to add a new EventID.



- 4) Choose the correct Project (arrow will provide list), type in the Year and Start Date (using MM/DD/YY).
- 5) Then click the “Generate EventID”.

VIIS: Coral Image Video

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

Virgin Islands National Park

Coral Reef Video Monitoring

ver.1.71 12/29/03

EXIT

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: VIIS_CoraVideo_NF_01 Event ID: VIIS_CoraVideo_19990323

Select Event Only show events associated with LocationID VIIS_CoraVideo_NF_01 ☒

EventID	Project	StartDate	StartTime
▶ VIIS_CoraVideo_19990323	Coral Video	03/23/1999	
VIIS_CoraVideo_20000317	Coral Video	03/17/2000	
VIIS_CoraVideo_20010305	Coral Video	03/05/2001	
VIIS_CoraVideo_20020310	Coral Video	03/10/2002	
VIIS_CoraVideo_20030310	Coral Video	03/10/2003	

EventID VIIS_CoraVideo_19990323 Generate Event ID

Project Coral Video

Year 1999

StartDate 03/23/1999

Field Observers

- 6) Type in the correct 4-letter ParkCode at the beginning of the partial EventID in the EventID Box and then hit “Enter” on your keyboard.
- 7) To see your newly added entry uncheck the LocationID filter checkbox and look for it in the list using the scroll bar,
- 8) Once found, SELECT (with a mouse-click to place a black triangle) check the EventID that you just created.

VIIS: Coral Image Video

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

Virgin Islands National Park

Coral Reef Video Monitoring

ver.1.71 12/29/03

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: VIIS_CoraVideo_NF_01 Event ID: VIIS_CoraVideo_19990323

Select Event Only show events associated with LocationID VIIS_CoraVideo_NF_01 ☒

EventID	Project	StartDate	StartTime
VIIS_CoraVideo_19990323	Coral Video	03/23/1999	
VIIS_CoraVideo_20000317	Coral Video	03/17/2000	
VIIS_CoraVideo_20010305	Coral Video	03/05/2001	
VIIS_CoraVideo_20020310	Coral Video	03/10/2002	
VIIS_CoraVideo_20030310	Coral Video	03/10/2003	

EventID: _CoraVideo_19990323 Generate Event ID

Project: Coral Video

Year: 1999

StartDate: 03/23/1999

Field Observers

- 9) NOTE: The link between the LocationID and newly entered EventID won't be made until you have gone on to the Video Data screen and prepared it for data entry.
- 10) Now fill in the observers in the Field Observers box (arrow provides list) and click on the Video Data section to proceed.

III. Video Data

Now comes the fun part when you prepare the database for data entry! There are two separate occasions when you will open up the Video Data section:

- 1) After entering a new EventID, in which case you will need to Generate Frames and Points to create the empty records that you will fill in once you are analyzing the Video Image Data, and
- 2) Displaying data that has already been entered for a particular combination of LocationIDs and EventID.

The first example is discussed first. You should be in the VIDEO screen of the main database entry form.

The screenshot shows the 'VIIS: Coral Image Video' application window. The title bar includes 'NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK' and 'Virgin Islands National Park'. The main header area contains the National Park Service logo, an 'EXIT' button, and the text 'Coral Reef Video Monitoring ver.1.6 12/11/03'. Below this is a navigation bar with tabs: 'LOCATIONS', 'EVENTS', 'VIDEO DATA' (which is highlighted with a red circle and a red arrow), 'PHOTOS', and 'REPORTS'. The 'VIDEO DATA' section displays 'Location ID: VIIS_CoraVideo_HA_01' and 'Event ID: VIIS_CoraVideo_20040101'. A 'Select Frame' table is shown with columns: FrameID, LocationID, EventID, Transect, and Frame. Below the table are input fields for 'FrameID (AutoNumber)', 'LocationID', 'EventID', 'Transect', and 'Frame'. A red message states 'Transect is Locked! Frame and Point data cannot be edited'. A link 'Generate Frames and Points' is visible. At the bottom, there is a 'Points for Frame' section with a table header: 'ControllID', 'Point', 'SpeciesCode', 'Disease', and 'Notes'. The status bar at the bottom indicates 'Record: 1 of 1 (Filtered)'.

Generating Frames and Points

In order to enter newly analyzed data (new dotted images) into the database, you will need to add a blank set of records for that combination of LocationID and EventID by using the “Generate Frames and Points” screen

- 1) Make sure that the correct LocationID and EventID have previously been selected from their respective data entry screens. This is verified by looking at the LocationID and EventID display within the Video Screen.
- 2) Click on “Generate Frames and Points”.

VIIS: Coral Image Video

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

Virgin Islands National Park

Coral Reef Video Monitoring

ver.1.6 12/11/03

EXIT

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: VIIS_CoraVideo_HA_01

Event ID: VIIS_CoraVideo_20040101

Select Frame

FrameID	LocationID	EventID	Transect	Frame
---------	------------	---------	----------	-------

FrameID (AutoNumber)

LocationID

EventID

Transect

Frame

Transect is Locked !
Frame and Point data cannot be edited

Generate Frames and Points

3) After clicking “Generate Frames and Points”, you will see the following screen:

4) Type in the Transect number for which you are entering the number of frames. (This number must be consistent with the LocationID and the EventID – see figure from the page above.)

Generate Frames and Points

Transect 1

Frames From 1 To 25

Points From A To J

Generate Cancel

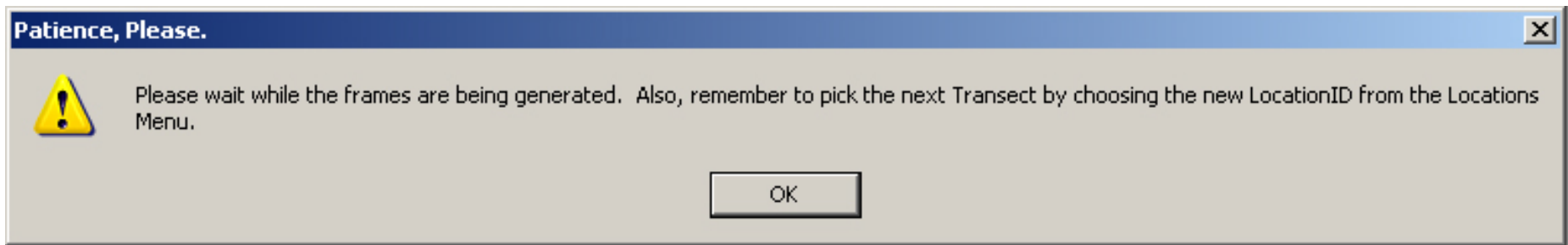
5) You don't need to change the number in the “From” box, the data frames will always start with 1.

6) Type in the “To” frame (e.g. you will need to find out how many images have been captured and dotted for that particular transect. It typically varies from 23 to 30 frames for a given transect).

7) The Points “From” and “To” is always kept at “A to J” since there are 10 dotted points on each captured video frame. Therefore, do not change these.

8) Click “Generate” and wait until the newly generated Frames, Transects, and Points appear on the screen in front of you (see below). Do not click “Generate” twice since this will generate double the numbers of transects and frames that you want. If this does happen, you will need to ask the data manager for their help to make the changes. If you make a mistake before you hit the “Generate” button, click on cancel and the screen will close and you can start again.

9) A “Patience, Please.” alert message will remind you to go back to the Locations page to select the new LocationID, then go to the Events page and verify the appropriate EventID before generating new frames or a new location. Choose OK from that message bar.



10) Access will display “calculating...” at the bottom left of the Access Window screen. When the process is done, the screen will change to show a screen where you can enter the data (see below).

FrameID: 14300
LocationID: VIIS_CoraVideo_HA_01
EventID: VIIS_CoraVideo_20040101

Transect: 001
Frame: 001

[Lock Frames and Points for this Transect](#)

[Generate Frames and Points](#)

Points for Frame (10 Point Records)

ControlID	Point	SpeciesCode	Disease	Notes
142991	A		No	
142992	B		No	
142993	C		No	
142994	D		No	
142995	E		No	
142996	F		No	
142997	G		No	
142998	H		No	
142999	I		No	
143000	J		No	

Record: 1 of 25 (Filtered)

11) If you are entering frames and points for more transects, you will need to go back to the Locations menu, select the next transect from the list of LocationIDs, and then go back to the Video Data screen and click on “Generate Frames and Points” to create the next set. Failure to select the next LocationID from the Locations menu and just entering the next transect in the Generate Frames and Points screen will add new records, but will put the wrong LocationID associated with those records. Again, if this happens, ask the data manager for their assistance to make the corrections.

IV. Data Entry

After all the transects and frames have been added to a new EventID, you are ready to enter data. Be sure to again double-check that you have selected the correct LocationID and EventID for the data you wish to enter from the Locations and Events screens, respectively.

VIIS: Coral Image Video

NATIONAL PARK SERVICE SOUTH FLORIDA/CARIBBEAN NETWORK

Virgin Islands National Park

Coral Reef Video Monitoring ver.1.6 12/11/03

EXIT

LOCATIONS EVENTS VIDEO DATA PHOTOS REPORTS

Location ID: VIIS_CoraVideo_HA_01

Event ID: VIIS_CoraVideo_20040101

Select Frame

FrameID	LocationID	EventID	Transect	Frame
14300	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	001
14301	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	002
14302	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	003
14303	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	004
14304	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	005
14305	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	006
14306	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	007
14307	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	008

1. Scroll down to the “Points for Frame” data entry screen. For each point, select or type in the Species Code that corresponds to what lies below the dot on the captured video frame. Hit “Enter” on your keyboard to move between points. NOTE: if a species code is entered that does not match the master list (see appendix), an error message will be displayed, prompting you to choose a species code from a list. You can either re-type the species code, or select from the list.
2. If evidence of disease is associated with a particular point type in “Yes” in the corresponding disease box. (“No” is the default.)

Notes may be added for any remarkable item. For example, levels of bleaching can be added using BL1-4.

FrameID 14300
LocationID VIIS_CoraVideo_HA_01
EventID VIIS_CoraVideo_20040101
Transect 001
Frame 001

[Lock Frames and Points for this Transect](#)
[Generate Frames and Points](#)

Points for Frame (10 Point Records)

ControllID	Point	SpeciesCode	Disease	Notes
142991	A		No	
142992	B		No	
142993	C		No	
142994	D		No	
142995	E		No	
142996	F		No	
142997	G		No	
142998	H		No	
142999	I		No	
143000	J		No	

Record: 1 of 25 (Filtered)

3. When you have finished entering all 10 points associated with that particular frame, select the forward arrow key in the scroll bar or scroll to the upper screen and select the next frame.

4. Repeat this process until you have completed all frames for a transect.
5. After you have entered all the data for that transect and you have checked and verified it, you can click on the “Lock Frames and Points for this Transect” section just beneath the upper screen (see image previous page). By doing this, you will protect those records from accidental deletion or modification. Once a transect has been locked, a message is depicted in red writing that says, “**Transect is Locked! Frame and Point data cannot be edited**” If you accidentally select the Lock Frames and Points box before you have finished typing all the data in for that transect, contact your friendly data manager to go behind the scenes for assistance.

Location ID: VIIS_CoraVideo_HA_01 Event ID: VIIS_CoraVideo_20040101

Select Frame

FrameID	LocationID	EventID	Transect	Frame
14300	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	001
14301	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	002
14302	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	003
14303	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	004
14304	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	005
14305	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	006
14306	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	007
14307	VIIS_CoraVideo_HA_01	VIIS_CoraVideo_20040101	001	008

FrameID: 14300
LocationID: VIIS_CoraVideo_HA_01
EventID: VIIS_CoraVideo_20040101

Transect: 001
Frame: 001

**Transect is Locked !
Frame and Point data cannot be edited**

[Generate Frames and Points](#)

Pre-existing Data

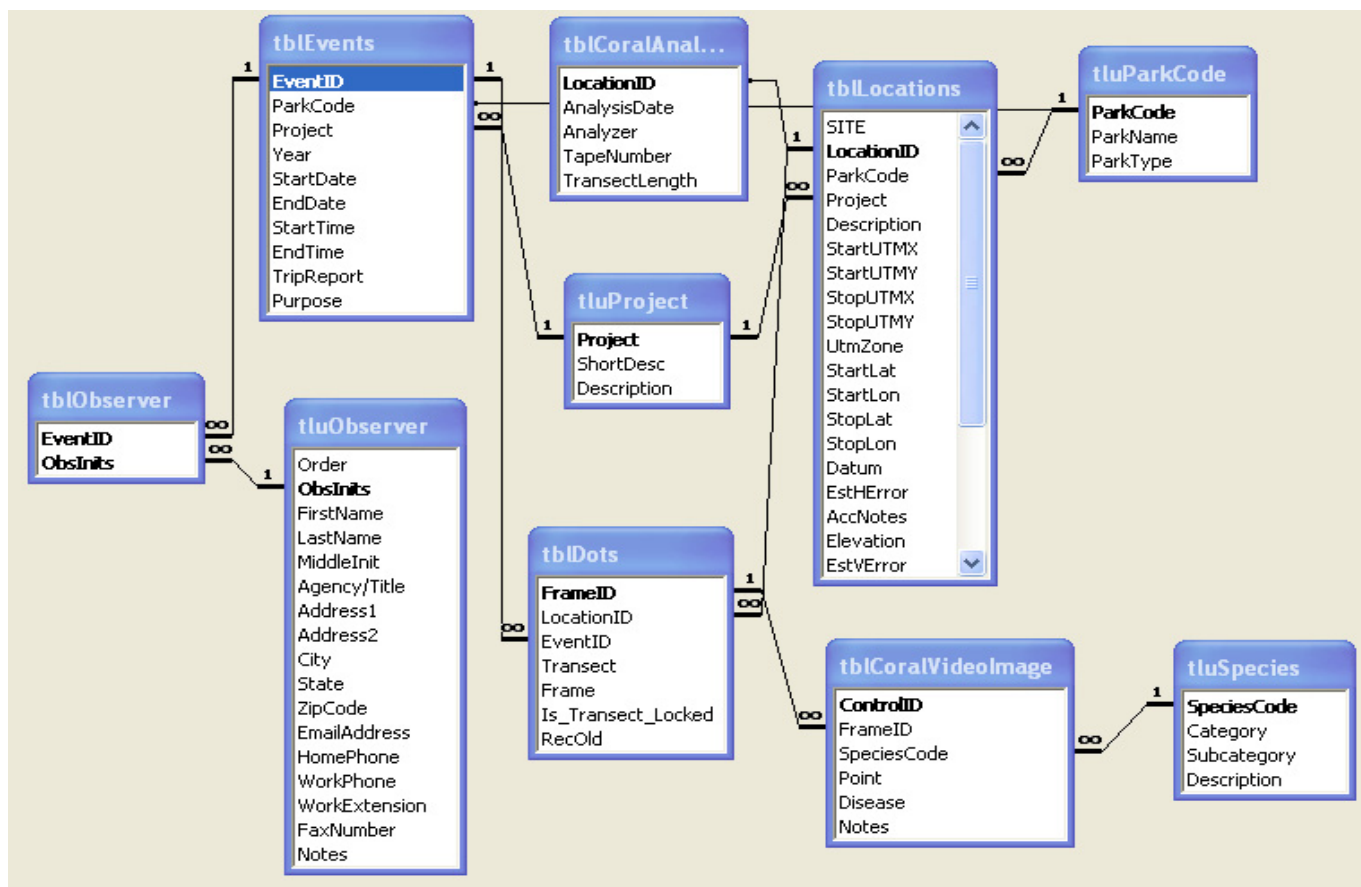
The second application for using the Video Data screen is when you want to examine data that has been previously entered for a site and sample event. In this case, select the LocationID and EventIDs for the site and sample period desired from the respective menus, then click on Video Data button. You will see the Species Code records for the sample period selected that are associated with each frame for the transect that has been chosen with the LocationID. You can move around between frames and transects as you did above. Note that you will not be able to edit data that has already been entered and locked with the Lock Transect Button.

Simultaneous Data Entry

Remember that for simultaneous data entry to be permitted by different users over the network, each user must start the program from the “non-administrative user” standpoint (i.e. not use ctrl-shift while opening up the file).

Deleting Records

There may be some instances when records may need to be removed as a result of inadvertently adding extra frames/points during the “Generate Frames” process (see above) or in the case where data entry errors were noticed after the “Lock Transect” box has been checked. In order to better understand the recommended procedure to delete records, it will be helpful to understand the relational linkages between the various data tables. The following shows the “Relationships” diagram from the program:



The order in which it is necessary to delete records is dictated by these relationships between tables. The *tblDots* serves as the key linking table that ties together the LocationID and EventID associated with the combination of particular study site and sample event with actual video image data for that site. Each study site consists of 20 transects, each of which contains anywhere from 22 to 30 frames that have been captured off the video tape. Each frame has 10 dots that have been randomly superimposed onto the image and it is the cover type that lies under each dot that is entered as the data in “Species Code” of the form and ultimately gets written to the *tblCoralVideoImageData*. The key field in *tblDots* is the FrameID that links the unique combination of LocationID and EventID and its associated combination of Transect and Frame. The FrameID is the link between the site and sample event info in *tblDots* and the Species Code data in *tblCoralVideoImageData*.

To Remove Incorrect LocationIDs or EventIDs that have had Frames and Points Generated:

1. Open *tblDots* first to see which FrameID you need to start deleting from in *tblCoralVideoImageData*. To do this, look for the correct combination of LocationID and EventID that pertains to the section of data you are interested in. You should write down a start and end FrameID to refer to when you go into *tblCoralVideoImage*
2. Open *tblCoralVideoImage* and remove all associated records for the range of FrameIDs you wrote down from *tblDots*.
3. Open *tblDots* and remove all associated records for the range of FrameIDs you wrote down previously.
4. Open *tblLocations* and remove the records that you want deleted.
5. Open *tblObserver* and remove the record that is associated with the EventID you want to remove.
6. Open *tblEvents* and remove the record that you want deleted.

To Remove Incorrect LocationIDs that have NOT had Frames and Points Generated:

1. Open *tblLocations* and remove the records that you want deleted.

To Remove Incorrect EventIDs that have NOT had Frames and Points Generated:

1. Open *tblObserver* and remove the record that is associated with the EventID you want to remove.
2. Open *tblEvents* and remove the record that you want deleted.

NOTE: The use of Autonumbers means that the FrameIDs used in *tblDots* and *tblCoralVideoImageData* are not all contiguous.

Queries

The following queries were developed to assist in data analyses. The following prefixes are used to designate what kind of query is used:

mqry – Make Table Query >>>>>>> name of table created by query

cqry – Crosstab Query >>>>>>>>> name of table created by query

Benthic Cover Categories

All of these queries use the categorization scheme present in the lookup table called *thuSpecies*. In particular they use the field called “Category

1. mqryNew_FrameMax >>>>>> tblFrameMax

Produces a table that lists the number of frames for each LocationID and EventID.

2. mqryNew_BioticCategoryCounts >>>>>> tblNew_BioticCategoryCounts

Produces a table that counts for each transect (LocationID) and EventID, the total number of times each category of benthic cover has been enumerated by the dot analysis process. It does not count so-called “nonbiotic” categories such as EQUIP or UNKNO. To decide what is a biotic category, the lookup table called, *thuSpecies* is used. The query also repeats the number of frames for that transect that was produced by mqryNew_FrameMax.

3. mqryNew_Biotic_TotalCounts >>>>>> tblNew_Biotic_TotalCounts

Produces a table that lists for for each transect (LocationID) and EventID, the total number of times that “biotic” benthic categories have been counted and the total number of possible points for that transect (10*(# of Frames)). This figure is used to calculate the relative cover values for each category.

4. mqryNew_CoverClassHits >>>>>> tblNew_CoverClassHits

This query brings together in one table the results from the previous 2 queries. It produces a table that lists for for each transect (LocationID) and EventID, the total number of times each category of benthic cover has been enumerated by the dot analysis process, the total number of times that “biotic” benthic categories have been counted, and the total number of possible points for that transect (10*(# of Frames)). These values will be used in the subsequent mqry to compute the benthic cover values for each benthic category that is listed in *thuSpecies*.

5. mqryNew_BenthicCoverAllsites >>>>>> tblNew_BenthicCoverAllsites

Produces a table that summarizes the cover values for each benthic category listed in *thuSpecies*. The formula used is:

$$\text{Cover} = \frac{\text{\# of hits for each benthic category}}{\text{Total number of biotic hits}} \times 100$$

6. cqryNew_BenthicCoverSummary >>>>>>

This crosstab query takes the information depicted in the previous query and organizes it so that for each transect, the benthic cover categories present are listed for every year separately. This format is useful for exporting the data to SigmaPlot or statistical analysis software packages (e.g. JMP).

7. cqryNew_CoralCoverSummary >>>>>>

This crosstab query extracts only the coral category from all benthic cover categories.

Benthic Cover Subcategories

These queries are very similar in design to the previous section, except that the benthic subcategory field of *thuSpecies* is used to enumerate the numbers of dots that have been enumerated during the analysis process.

1. mqryNew_FrameMax >>>>>> tblFrameMax

2. mqryNew_BioticSubCategoryCounts >>>>>> tblNew_BioticSubCategoryCounts

3. mqryNew_BioticSubcategoryTotalCounts >>>>>> tblNew_BioticSubcategoryTotalCounts

4. mqryNew_SubcategoryCoverClassHits >>>>>> tblNew_SubcategoryCoverClassHits

5. mqryNew_BenthicSubcategoryCoverAllsites >>>>>> tblNew_BenthicSubcategoryCoverAllsites

6. cqryNew_BenthicSubcategoryCoverSummary

7. cqryNew_SubcategoryCoralCoverSummary

Coral Species Breakdowns

The purpose of these queries is to examine only the coral category and breakdown the individual species into their own cover values. These can then be used in data analysis by either ranking them in order of occurrence or the actual cover values can be used.

1. mqryCoralSppHits >>>>>> tblCoralSppHits

Produces a table that counts for each transect (LocationID) and EventID, the total number of times each species of coral has been enumerated by the dot analysis process, the total number of times that “biotic” benthic categories have been counted, and the total number of possible points for that transect (10*(# of Frames)). These values will be used in the subsequent mqry to compute the coral cover values for each species of coral that is listed in *thuSpecies*. The query also repeats the number of frames for that transect that was produced by mqryNew_FrameMax.

2. mqryCoralSppCover >>>>> tblCoralSppCover

Produces a table that summarizes the cover values for each coral species code listed in *tluSpecies*. The date is also extracted from the EventID to make it easier to use in other applications. The formula for cover used is:

$$\text{Cover} = \frac{\text{\# of hits for each species of coral}}{\text{Total number of biotic hits}} \times 100$$

3. cqryCoralSppCoverSummary

This crosstab query takes the information from the previous table and organizes it so that the each transect contains the cover values for all coral species found at that location and breaks it down by years in the column headings.

III. Documentation of Database Tables

Table: tblCoralVideoImage

Description: Primary table that stores data such as the species detected and whether or not disease is present. One record for each of the ten points per frame.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
ControlID	Long Integer	8	Unique frame id
LocationID	Text	255	Location ID code
Point	Text	1	Points A-J
Disease	Yes/No	4	Denotes whether or not disease is present
Notes	Text	255	4-character Species code based on AOU system

Table: tblDots

Description: Primary table that stores data about each individual frame. One record for each frame from a transect. There are 25-30 frames per transect.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
FrameID	Long Integer	8	Unique frame id
LocationID	Text	255	Location ID code
EventID	Text	255	Sampling event ID code
Transect	Double	2	Transect where video was collected
Frame	Double	2	Frame number 1-30
Is_Transect_Locked	Yes/No	4	Transect is locked to prevent editing

Table: tblLocations

Description: Standardized table for storing information about the sampling location for each transect. tblLocations is shared with other monitoring protocols. There is one record for each transect location.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>	
SITE	Text	50	General name used to describe are where transects are located	
LocationID	Text	255	Location ID code	
ParkCode	Text	50	4-character Park Code	
Project	Text	10	1-15 character Project Code (Coral Monitoring, etc.)	
Description	Text	255	Description of this location (<256 characters)	
StartUTMX	Double	8	UTM X (easting) coordinate for the center of the plot or location OR	starting point of a
line or polygon (double precision to 15 significant digits)				
StartUTMY	Double	8	UTM Y (northing) coordinate for the center of the plot or location OR starting	point of a line or
polygon (double precision to 15 significant digits)				
StopUTMX	Double	8	UTM X coordinate (easting) of ending point of line or polygon (double precision	to 15 significant
digits)				
StopUTMY	Double	8	UTM Y coordinate (northing) of ending point of line or polygon (double	precision to 15
significant digits)				
UtmZone	Text	4	UTM zone	
StartLat	Double	8	Latitude in decimal degrees for the center of the plot or location OR starting	point of a line or
polygon (double precision to 15 significant digits)				

StartLon	Double	8	Longitude in decimal degrees for the center of the plot or location OR starting point of a line or polygon (double precision to 15 significant digits)	point of a line or
StopLat	Double	8	Latitude in decimal degrees for the ending point of a line or polygon (double precision to 15 significant digits)	precision to 15
StopLon	Double	8	Longitude in decimal degrees for the ending point of a line or polygon (double precision to 15 significant digits)	precision to 15
Datum	Text	5	Datum of mapping ellipsoid	
EstHError	Single	4	Estimated horizontal accuracy error	
AccNotes	Memo		Comments about how positional (horizontal) accuracy was determined	
Elevation	Single	4	Elevation in meters	
EstVError	Single	4	Estimated vertical accuracy error in meters	
Aspect	Text	5	Aspect (N, S, E, W)	
Slope	Long Integer	4	Slope in degrees	
Notes	Memo		Any additional comments about this sampling location	
Bearing	Long Integer		Transect bearing in degrees. All transects within a site have the same bearing.	bearing.

Table: tblEvents

Description: Standardized table containing the starting and ending dates and times for period during which all the locations at a given site are monitored. tblEvents is shared with other monitoring protocols.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>	
EventID	Text	255	Sampling event ID code	
ParkCode	Text	50	Looks up Park code in tluparkccode	
Project	Text	15	1-15 character Project Code	
Year	Long Integer	8	4-digit year when sampling occurred	
StartDate	Date/Time	8	Date (mm/dd/yy) when sampling began	
EndDate	Date/Time	8	Date (mm/dd/yy) when sampling ended	
StartTime	Date/Time	8	Time (hh:mm) when sampling began	
EndTime	Date/Time	8	Time (hh:mm) when sampling ended	
TripReporte	Hyperlink		Pathname to trip report in MS Word including protocol used and special circumstances	circumstances
Purpose	Purpose	50	Time (hh:mm) when sampling ended	

Table: tblCoralAnalysis

Description: Table containing the metadata related to video analysis.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
LocationID	Text	50	Location ID code
AnalysisDate	Date/Time	8	Beginning date the image data was classified
Analyzer	Text	50	Person who analyzed the image data
TapeNumber	Long Integer	8	Numeric reference on video tape
TransectLength	Long Integer	8	Length of transect

Table: tluSpecies

Description: Lookup table containing the 8-character species code, category, subcategory, description (includes scientific name).

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
SpeciesCode	Text	255	Alphanumeric Species code
Category	Text	50	Grouping of species into general types (coral, algae, etc)

Subcategory	Text	50	Smaller grouping within a specific category
Description	Text	255	Description of benthic organisms

Table: tluParkCode

Description: Lookup table for park codes and park names where sampling occurs.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
PARKCODE	Text	4	4-character park code used by NPS
PARKNAME	Text	255	name of park
PARKTYPE	Text	255	

Table: tluProject

Description: Lookup table for project codes and descriptions.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
Project	Text	10	name of project (e.g., vital sign being monitored)
ShortDesc	Text	255	
Description	Text	255	description of this project

Table: tluObserver

Description: Lookup table for observers.

<u>Field Name</u>	<u>Field Type</u>	<u>Size</u>	<u>Field Description</u>
Order	Long Integer	10	
ObsInits	Text	3	Observer initials
FirstName	Text	50	First name
LastName	Text	50	Last name
MiddleInit	Text	4	Middle initial
Agency/Title	Text	255	Agency and title
Address1	Text	255	Address
Address2	Text	255	Address
City	Text	50	City
State	Text	2	State/Territory
ZipCode	Text	10	Zipcode
EmailAddress	Text	50	Email address
HomePhone	Text	20	Home phone
WorkPhone	Text	20	Work phone
WorkExtension	Text	5	Work phone extension
FaxNumber	Text	20	Fax number
Notes	Memo	255	Notes

Standard Operating Procedure 8: Operation and maintenance of NPS vessel, Acropora

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.



General

-Acropora is a useful vessel if operated properly. Please take time to read through the following to ensure a safe trip.

-IMPORTANT: If you are not Motorboat Operator Certification Course (MOCC) certified do not operate this vessel.

-Take the time to check out the weather and swell advisories for the day. It will make your day much more enjoyable if you know what to expect when you get out on the water. You can try this website WWW.CARIBWX.COM

Specifications:

Boat type: Boston Whaler 25' Challenger

Over all Length: 26'7"

Weight: 6200

Draft: 21"

Beam: 10'

Engines: (2) 2006 150 Evinrude V6 E-Tec:

(1) Model #: E150DCXSU (counter rotation)

Serial #: 05167852

(1) Model #: E150DPXSU

Serial #: 05159811

Prop size and pitch: Counter Rotating Stainless

15" Diameter 17" Pitch

Fuel capacity: 171 gallons

Oil Capacity: (2) 3 gallon containers still Evinrude/Johnson XD 100

Battery type: (2) starting 12 volts, 1 deep cycle

Operation

-Keys for the boat are located at the Biosphere in building 1 hanging on the wall by the door.

-Replace keys when back from the field.

-When getting on the boat conduct a general visual survey.

-Are there dock lines in the water or chaffing on dock lines?

-Is the rub rail intact?

-Is the boat listing to one side?

-Is the boat sinking, water in stern or in the cabin (could be due to the bilge pumps not working)?

-Are there any broken windows?

-Can you smell any fuel?

-If any of these problems appear to be severe enough to cancel the trip. Do so and call Island Marine Outboard (340-714-7860) and schedule an appointment.

NOTE: The local children play on the boats and throw rocks at them so look around for possible damage that might have occurred.

- All the boats in the fleet should be equipped with the proper safety equipment such as a first aid kit, life jackets, fire extinguishers, flares, throw able pfd, and noise producing device. Do a quick overview in the cabin to make sure all is there. Also check the VHF to see if it is working. Turn it on and see if you can hear any chatter (channel 16). Try a radio check with VI radio.
- Acropora is equipped with a Lowrance Navigation System, which has a GPS, depth gauge and navigational charts of the area. Please familiarize yourself with the equipment prior to leaving the dock. You want to know how to use it before you need it! The operational manual can be found in the file cabinet in building 3.
- Roll up the canvas and open the windows.



Helm of the boat.

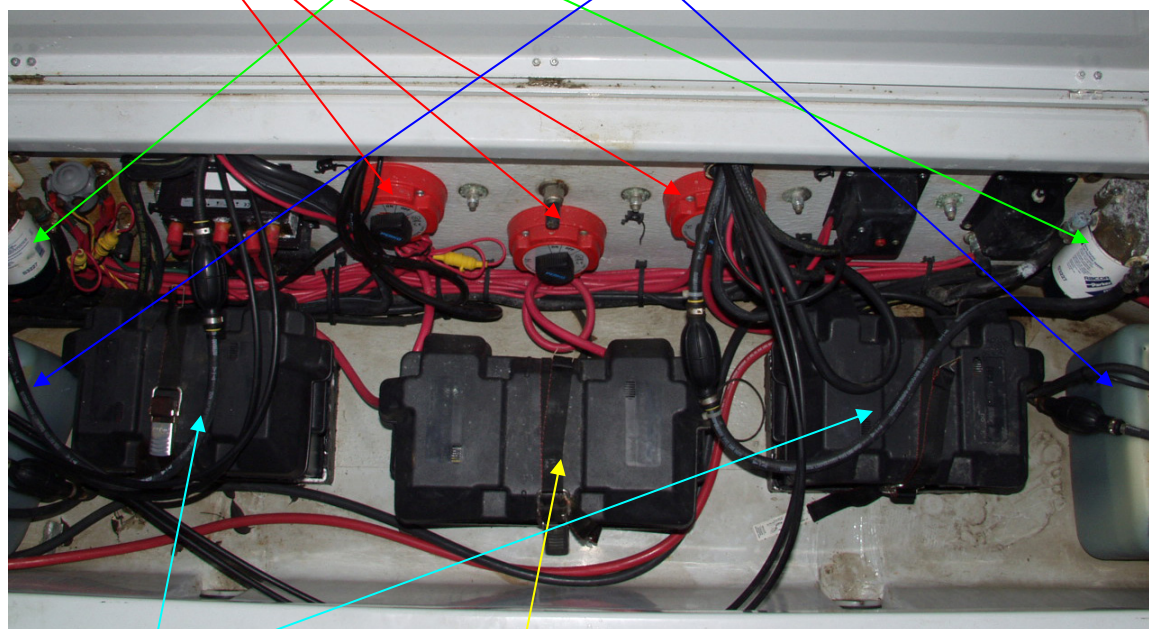
Engine

- Go to the back/stern of the boat and open up the rear hatch.
- turn on all three battery switches.

Battery switches

Fuel separators

Oil Reservoirs



Starting batteries

Deep cycle battery (This is for electronics operation, such as the inverter and the Lowerance)

-While there check the oil level in both containers port and starboard it should be over $\frac{1}{2}$ if not please refill. The oil is located in the storage shed at the end of the dock (TCW-3 2 cycle outboard oil).

NOTE: Do a quick overview of the hoses and wires to see if you can see any leaks or exposed wires (usually green with corrosion). It only takes a couple of minutes but well worth it.

-After shutting the hatch take a look at the props to see if

- any knicks or odd bends on the blades.

- also look for plastic, fishing line, or rope tangled up around the props or below the cavitation plate. **-If the props appear to have severe enough damage to cancel the trip. Do so and call Island Marine Outboard (340-714-7860) and schedule an appointment.**

-Now go to the helm/steering area and on the throttles are the tilt switches, lower the engines AT THE SAME TIME this causes less stress to the steering linkage.

NOTE: Due to where Acropora is located only lower the engines $\frac{1}{2}$ or $\frac{3}{4}$ or the way down. It is shallow here and you will bury the engines in the bottom. This is both better for the props and helps keep sand and silt out of the impellers. Make sure the lower foot of the engine is below the sea surface to ensure proper cooling.

Fuel

- Check your fuel gauge. If it is below $\frac{1}{2}$ please refuel. Refueling also depends on where you are going and how long you plan on running the engines.
- Also check the logbook. You can see when it was last fueled and how many hours were used since then. The boat uses 7 gallons/hour so estimate the amount of fuel remaining in the boat. I know this seems redundant but it is worth doing since the fuel gauges are not always accurate.

Log

- Log book is located next to the helm in the orange bag.
- When checking the logbook look at the entries. It states hours on the engines starting and ending for both starboard and port, destination, fuel, who was on board and a notes area which is important in that this is where you log in any problems the boat may have had such engine alarms or bad bilges etc.
- Please fill this out upon returning to the dock. As stated previously this is a great help in keeping the boat running.

Starting

- When starting make sure that the throttles are in the Neutral position. Try pushing forward and back and find the middle/neutral detent. Make sure the kill switch key is in place. Next go to the back/stern of the boat open up the hatch and pump the fuel bulbs 2-4 times till they are not squishy. Try starting by turning the keys. If they do not turn over check for neutral again and then try. If they turn over but do not start try choking the engines by pushing the key in and turning. If it turns over but does not start turn the keys again but do not choke it this time. The engines should be running by now if not there are other things wrong and you will need to get maintenance sustenance.
- If the engine problems appear to be severe enough to cancel the trip. Do so and call Island Marine Outboard (340-714-7860) and schedule an appointment.**

Leaving and returning to the dock

- With the engines running you can now be on your way.
- Before putting engines into gear look behind the boat for any obstructions.
- Undo the stern line first.
- If you have someone else with you have them untie the bow and pull towards the dock. This will pull the stern out away from the dock and make it easier to pull away.
- Once you are free lower the engines the rest of the way and off you go. Upon returning remember that it is shallow near the bulk head/dock so tilt the engines up to $\frac{1}{2}$ to $\frac{3}{4}$ position.
- NOTE: Try not to lift them too early or too high because you lose steerage and power by tilting the engines up.
- Have someone on the bow ready with the bow line but instruct them not to obstruct your view.
- Remember the stern line is mounted to the dock not the boat.

- Once you are tied to the dock
 - Put out the fenders
 - Raise the engines
 - Turn off the battery switches
 - Fill out the log and note any problems that may have occurred.
 - **If the problems appear to be severe enough call Island Marine Outboard (340-714-7860) and schedule an appointment.**
 - Close the windows and roll down the canvas.
 - Do a quick overview to see if you forgot anything and everything looks OK.
 - Place the keys back in Building one where you found them.

Local Notes and Procedures

- VIIS
 - Always take a park radio with you. NOTE: Familiarize yourself with the radio SOP. Call in with the vessel name, number of passengers, expected time out and tasks. If there is no response from dispatch do not fret it will be recorded so complete the radio transmission. When returning to the harbor call dispatch to let them know you have returned.
- BUIS
 - Talk with Zandy and crew and set up a float plan with departure and return times. If a cell phone is available call them upon leaving and returning.
 - Remember before venturing into open water towards St Croix take the PLB, it could save your life. It is stored by the Bio Techs desk.

Remember

- All boats are sinking -- all we do is find ways to prevent it.

Boat Maintenance

- Every 60 days or 50 hours
 - Inspect bilges (you do check these each time you run the boat but please do a visual)
 - Thorough inspection of the wiring, clamps and hoses in the stern compartment.
 - While in the stern check the batteries and terminals and clean if necessary.
 - Test all running lights.
 - Windshield wipers and blades.
 - Lubricate all control cables with marine grease, steering linkage including tie bars.
- Every 90 days
 - Inspect and change fuel filters. (If the engines have been run a lot they should be changed)
 - PLB (Personnel Locator Beacon) should be tested before each trip to St. Croix.

Yearly Maintenance

-Island Marine Outboards will be conducting the annual maintenance each September.

NOTE: They **do not** want us to change the lower unit oil. They need to see what the oil looks like to determine any problems if any are occurring.

Standard Operating Procedure 9: Revising the protocol

Version 1.00 (12/15/2007)

Revision History Log

Previous Version No.	Revision Date	Author	Changes Made	Reason for Change	New Version No.

Purpose: this log is to be used to track changes within the protocol.

When used: changes can be suggested at any time following the procedures outline below.

Procedures:

1. In the event the Coral Reef Monitoring Protocol requires editing, all edits must be reviewed for technical merit. Minor changes to the protocol will only require in-house review by network staff. Major changes in the protocol require external review by subject matter experts.
2. Protocols edits and versioning are tracked in the revision history log attached to each narrative and SOP. Major changes results in an update by whole numbers (i.e. version 1.0, version 2.0, etc.) and minor changes by hundredths (e.g., version 1.01, version 1.02, etc.) Record the previous version number, date of revision , author of the revision, describe the change, provide a rationale for the change, and assign a new version number.
3. Inform the data manager about the changes to the protocol narrative or SOPs, so the new version number can be incorporated in the project database metadata. The data manager may need to edit the database if the changes affect the database structure.
4. Post new protocol versions on the network website and National Inventory and Monitoring Program protocol database and forward copies to all individuals with a previous version of the affected protocol or SOP.

**National Park Service
U.S. Department of the Interior**



Natural Resource Program Center

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™