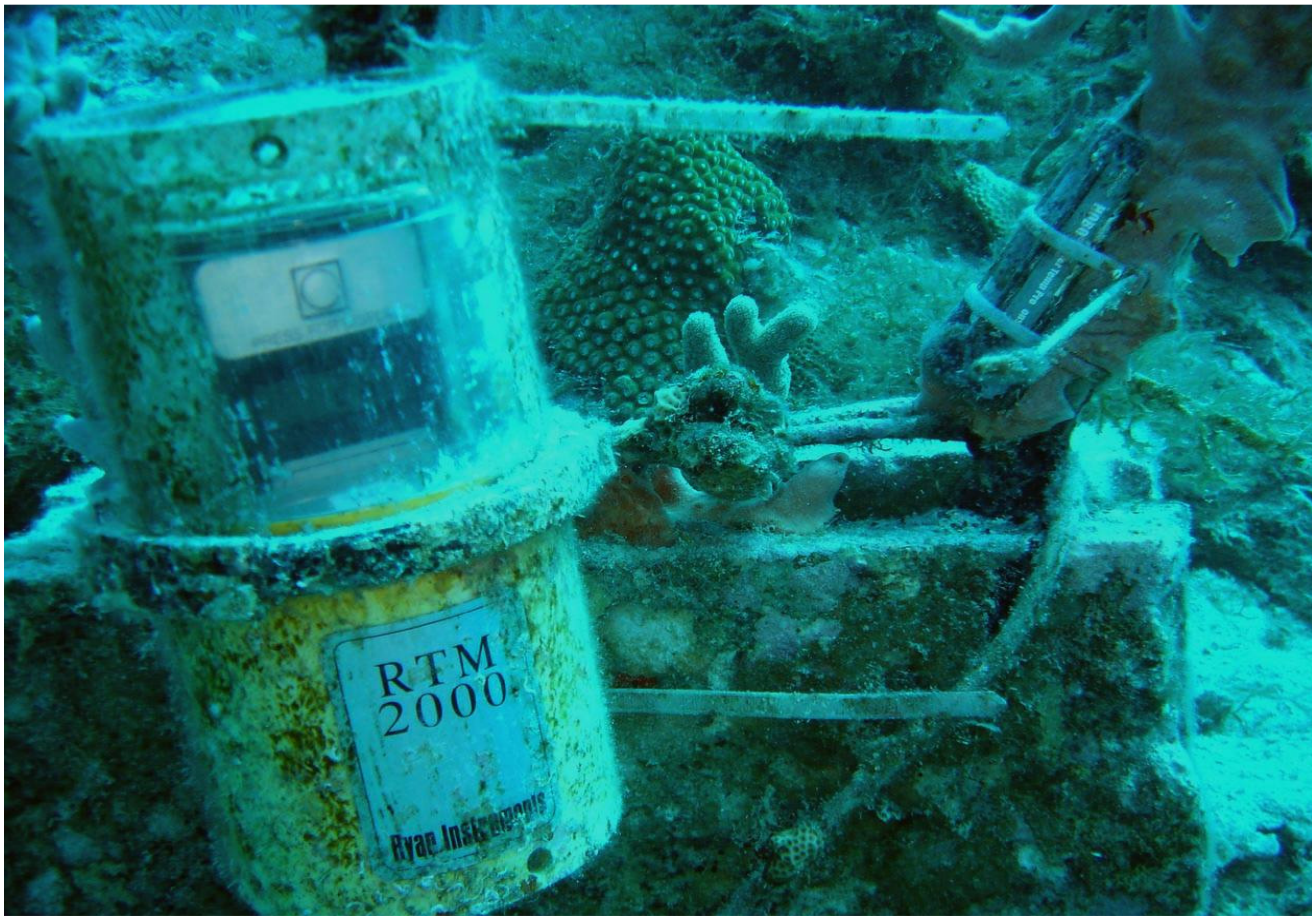
National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Coral Reef Water Temperature Monitoring Protocol

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



ON THE COVER
Ryan Industries Thermisters and Onset Hobo Temperature Pro
Photograph by: Jeff Miller and Rob Waara

Coral Reef Water Temperature Monitoring Protocol

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

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Collaborative project of
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Draft – December 15, 2007

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National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Davis, A., C. Loomis, J. Miller, C. Rogers, R. Waara, and K.R.T. Whelan. 2007 Coral Reef Water Temperature Monitoring Protocol - Natural Resource Report NPS/SER/SFCN/NRR—2007/004. National Park Service, Miami, Florida.

NPS D-XXX, December 2007

List of Acronyms

AM = Amanda's Reef
BB = Ball Buoy
BICY = Big Cypress National Preserve
BKN = Bird Key North
BK= Bird Key
BISC = Biscayne National Park
BUIS = Buck Island Reef National Monument
DRTO = Dry Tortugas National Park
EVER = Everglades National Park
FWRI = Florida Wildlife Research Institute
HA = Haulover Bay
MB = Mennebeck
NF = Newfound Bay
NPS = National Park Service
SARI = Salt River Bay National Historical Park & Ecological Preserve
SFR = South Fore Reef
TK = Tektite
USGS = United States Geological Survey
USVI = United States Virgin Islands
VIIS = Virgin Islands National Park
VICR = Virgin Islands Coral Reef National Monument
WS = Windspirit Reef
WSG = Western Spur and Grove
YSI = Yellow Springs Instruments
YZ = Yawzi Point

Executive Summary

Water temperature has been historically collected as a basic environmental parameter of water quality monitoring efforts at coral reef sites throughout the world. There are numerous references in the literature suggesting a link between water temperature anomalies and coral colony survivorship. Reef water temperature has been found to be a critical covariate when trying to understand long-term coral survival. Coral bleaching occurs when the coral polyp expels the zooxanthellae due to physiological stress, most-often related to high water temperatures and/or high incidence of solar radiation. Additionally, unusual cold water temperature events have been found to affect coral survivorship. Reef water temperature data have been collected from 1988 to date in St. John by the National Park Service (NPS) and the United States Geological Survey (USGS). The water temperature loggers have been deployed at reef depth as part of long-term index coral reef monitoring program that originally began in Virgin Island National Park (VIIS). There are now 11 sites with long-term water temperature monitoring occurring at reef depth being conducted by SFCN. In this Natural Resource Report we present the protocol used for this sampling program.

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Background and Objectives

Rationale and Background

Water temperature has been historically collected as a basic environmental parameter of water quality monitoring efforts at coral reef sites throughout the world. There are numerous references in the literature suggesting a link between water temperature anomalies and coral colony survivorship (Whelan et al 2007; Santavy et al. 2005; Winter et al. 1998; Brown 1997). Many marine organisms, including corals, exist in a narrow range of temperature. Seawater temperature data thus provide information that is important to analyze conditions of marine systems. As global warming is increasingly discussed in scientific literature, the significance of water temperature monitoring has taken on a new dimension in helping to understand ecological dynamics associated with these changes. An example of this can be found in the 4 th Intergovernmental Panel on Climate Change which stated that "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (Solomon 2007).

Reef water temperature has been found to be a critical covariate when trying to analyze long-term coral reef monitoring results (see use of the data). Coral bleaching occurs when the coral polyp expels the zooxanthellae due to physiological stress, most-often related to high water temperatures and/or high incidence of solar radiation (Whelan et al., 2007; Santavy et al., 2005; Winter et al., 1998; Brown, 1997). Additionally, unusual cold water temperature events have been found to affect coral survivorship (Jaap, 1984).

Reef water temperature data have been collected from 1988 to date in St. John by the National Park Service (NPS) and the United States Geological Survey (USGS). The water temperature loggers have been deployed at reef depth as part of long-term index coral reef monitoring program that originally began in Virgin Island National Park (VIIS). There are now 11 sites with long-term water temperature monitoring occurring at reef depth being conducted by SFCN. The original five sites were all located in the United States Virgin Islands (USVI); however, due to the expansion of the index coral reef monitoring sites, two sites were added to each of the following parks: Buck Island Reef National Monument (BUIS), Biscayne National Park (BISC) and Dry Tortugas National Park (DRTO). In addition to the SFCN, the Florida Wildlife Research Institute (FWRI) has adopted a similar reef water temperature monitoring procedure that places water temperature loggers at reef depth since 2002 (Pers. Comm. Mike Callahan).

The original temperature instrumentation was Ryan® RTM2000 temperature loggers. In 2003, HOBO® water temp pro v1 data loggers replaced the Ryan loggers and in 2005 at some sites HOBO® water temp pro v2 data loggers have now replaced v1 sensors. There have been some data gaps in the long term temperature record due to sensor failure and loss from storms. To help prevent this in the future there are now two loggers installed at each of these sites.

Reef water temperature data has already proven useful in evaluating changes in coral communities by showing both the extent and duration of a stress event compared with baseline data and triggering increased coral community monitoring. In 2005, a coral bleaching event

associated with abnormally high water temperatures in the Northeast Caribbean took place in the U.S. Virgin Islands (USVI). Temperature data triggered episodic monitoring (using a SFCN benthic monitoring protocol at an increased monitoring frequency) to document >50% loss in coral cover at the SFCN index monitoring sites in the USVI national parks and monuments (Miller et al. 2006). Evaluation of the temperature data and the benthic monitoring revealed temperature was positively correlated with coral bleaching. However the triggered episodic monitoring also showed the surprising result that a large proportion of the coral mortality was caused by a post-bleaching disease outbreak (Whelan et al. 2007). This reef water temperature data set has been reported numerous times, including 19 presentations using this data in 2005 and 2006. Refer to section 8 below for a list of these presentations. Many articles have also been published using the reef water temperature data (Miller et al. 2003; Miller et al. 2006; Miller and Patterson, 2005).

Measurable Objectives

There are three primary objectives that this monitoring protocol aims to achieve:

1. Provide a long-term record of water temperatures at reef depth in situ at the index coral monitoring sites established in BISC, BUIS, DRTO, SARI, and VIIS.

2. Determine occurrence and duration of warm and cold water events that are above and below thresholds known to cause stress to coral species for the purpose of interpreting trends in coral community metrics.

3. Assess any correlations of warm water events and/or cold water events with coral bleaching events and coral disease outbreaks.

Sampling Design

Rationale for selecting this sampling design over others

Monitoring water temperatures using data loggers provides data directly applicable to stress experienced by coral communities, is efficient and cost-effective, and has low environmental impact.

Applicability to coral reef monitoring:

Sea surface measurements that occur with standard water quality sampling and satellite generated data generally do not reflect benthic conditions. Temperature measurements in situ more accurately reflect temperature conditions at reef depth. Satellites provide large area surface water temperatures. The satellites use passive multi-channel infrared measurements that correlate to water temperatures in the shallow sea surface waters (0.1 mm depth). Temperature loggers positioned within the marine communities and water column are more representative of the water temperatures affecting the coral reef. Resource-depth temperature monitoring is critical to connecting temperature changes with effects on benthic organisms. Co-locating data loggers at sites with benthic monitoring allows for combined analysis and establishment of potential linkages between water temperature and changes in these organisms. Such monitoring provides efficient and relatively inexpensive data collection of a covariate that is important to understanding coral reef ecosystems.

Efficiency and cost effectiveness:

Minimal person time is required for sensor deployment and retrieval along with reduced sponsor cost (Approximately $120.00 per sensor). The data sets are highly reproducible with relatively good precision (±0.2 ºC) and have simple procedure to learn along with low maintenance requirements.

Very low environmental impact:

Very low impact to environment because the HOBO® Water Temp Pro v1 logger and the HOBO® Water Temp Pro v2 logger only need to be downloaded annually and are made of inert material. The loggers are attached via cable ties to benthic attachment location for the AquaMap ® base station. These cable ties are removed and replaced annually.

Site selection, within-site placement, site history

Coral reef index monitoring sites were 2-5 higher cover coral reef sites per park selected using best judgment to reflect sites of management interest in a program initiated under the NPS Prototype Inventory and Monitoring Program. Sites range in size from 7,125 – 40,753 m^2. The coral reef water temperature sampling is designed to represent the general water temperature conditions occurring at those index sites at the reef depth. The population of interest is the water that comes in contact with the coral reef at the index coral reef sites. At the scale of interest having one temperature sampling location per index coral reef site seems adequate to make this generalization.

Placement of temperature sensors within each site was dependent on using established monuments that would allow easy location of the sensors over many years. Original locations were selected by best judgment of the original researchers. Initially one data logger was placed at a site. This has since been updated to 2 co-located data loggers within a site.

Two loggers per site are located at five sites in VIIS, two in BUIS, two in DRTO, and two in BISC. More detailed information is given below.

Virgin Islands National Park (VIIS):

Ryan® RTM2000 temperature loggers were installed at reef depth in Yawzi Point (YZ), Newfound Bay (NF) and Haulover Bay (HA). These loggers collected temperature data continuously every two hours, and were later replaced with HOBO® Water Temp Pro v1 loggers. Two other sites were added at Mennebeck (MB) and Tektite (TK), also using the HOBO® Water Temp Pro v1 loggers. In 2005 a second HOBO® Water Temp Pro v1 logger was placed at each site to act as a backup sensor in case of logger failure. This backup sensor is attached to the same mounting location as the original sensor.

VIIS Area of index study reef and date of first deployment (5 sites)

1. Yawsi Point (YZ): 7,125 m^2; May 1989
2. Newfound Bay (NF): 13,768 m^2; October 1991
3. Haulover Bay (HA): 13,568 m^2; January 1998
4. Mennebeck (MB): 12,495 m^2; Oct 2001
5. Tektite (TK): 18,711 m^2; Sep 2005

Buck Island Reef National Monument (BUIS):

Two HOBO® Water Temp Pro v1 loggers were also deployed per site and collected data at two-hour intervals at reef depth in BUIS at the Western Spur and Groove (WSG) and South Fore Reef (SFR). SFCN personnel collect and record data from these additional sites.

BUIS Area of index study reef and date of first deployment (2 sites)

1. Western Spur and Groove (WSG): 26,365 m^2; May 2001
2. South Fore Reef (SFR): 40,753 m^2; Feb 2002

In addition to SFCN monitoring, a Ryan® RTM2000 temperature logger has been deployed at the eastern fore reef slope since 1991, recording data continuously on a two-hour interval. These have since been replaced with HOBO® water temp pro data loggers in 2003. An additional monitoring site was established at this time on the backreef at an approximate depth of two meters. BUIS personnel maintain these loggers and record the data.

Dry Tortugas National Park (DRTO):

One HOBO® Water Temp Pro v1 logger per site was installed in 2005 and collected data at two-hour intervals at reef depth at the monitoring sites of Bird Key (BK) and Bird Key North (BKN). These were replaced with two HOBO® Water Temp Pro v2 loggers per site in 2006.

DRTO Area and date of first deployment (2 sites)

1. Bird Key Reef (BK):19765 m^2; Jun 2005
2. Bird Key North Reef (BN): 25642 m^2; Jun 2005

Biscayne National Park (BISC):

Two HOBO® Water Temp Pro v1 loggers per site were installed in 2005 and collected data on a two-hour cycle at reef depth in Biscayne National Park, at Amanda's Reef (AM) and Ball Buoy (BB). These were replaced with two HOBO® Water Temp Pro v2 loggers per site in 2006.

BISC Area and date of first deployment (2 sites)

1. Amanda's Reef (AM): 20240 m^2; Jun 2005
2. Ball Buoy (BB): 14136 m^2; Jun 2005

Salt River Bay National Historic Park & Ecological Preserve (SARI):

No temperature data is currently being recorded at this location. Future temperature data sampling may use HOBO® Water Temp Pro v2 loggers, but depth constraints may restrict their use in some areas.

Sampling frequency, timing and replication

HOBO® Water Temp Pro v1 and v2 sensors are deployed year round and sample at two hour intervals. Two sensors are deployed together at each site to provide redundancy as a precaution against anomalous and/or lost data. The two sensors should be viewed as sub-samples rather than true replicates. Sensors are inspected and downloaded once a year, before impending hurricanes or more frequently when a potential thermal stress event is occurring.

Level of change that can be detected for the amount/type of sample being instituted:

HOBO® Water Temp Pro v1 and v2 operation range is -20º to 50 º C in water ± 0.2 ºC with a resolution of ± 0.2 ºC at 25 ºC. The level of change that can be detected significantly will be determined after 3 years of monitoring using the coral reef water temperature monitoring protocol. Typical analysis is to include detection of unusual temperature patterns and comparison of mean seasonal or monthly temperatures to a baseline.

Field Methods

Field season preparations and equipment setup

A field log shall be maintained with specific information pertaining to each data logger at each site. Logger serial number, date, time of deployment, site, battery life, depth, and coordinates shall be recorded in this log. Replacement loggers shall be available in case of failure. A laptop computer with attached HOBO® launcher/reader shall be used for data download.

Calibration of each Hobo sensors occurs prior to field deployment. Cross calibration is also done for multiple sensors at this time. Multiple sensors are placed in a body of water (recording every 5 minutes) for 1 hour. The water solution is an ice-water mixture (approximately 5° C; use a standard thermometer to check) and then placed in a second water bath mixture (approximately 30° C). All sensors are checked for recorded temperatures and compared. The temperature compared is the average temperature for the last 15 minutes of each water bath emersion.

Field operations

Sequence of events during field season and details of taking field measurements are discussed below. Loggers are visited coincident with the annual coral monitoring schedule. Each site is revisited during the same month of the year with different sites visited during different months. Both data loggers are retrieved to the boat as part of the coral monitoring visit. Data is downloaded to a laptop computer with attached HOBO® launcher/reader and checked for problems. Loggers are launched and re-deployed at the site. Files are downloaded in the field. The naming convention is the name of the site along with the logger serial #. This is automatically displayed when you download the HOBO. Naming convention example: Haulover-629585-2-145827.dtf. The file is then stored on the "desktop" of the field laptop computer. Once the files are downloaded to the laptop computer, the marine biological technician is able to check the record by looking at the graphical display. This allows observation of the data pattern to determine if each sensor is recording data correctly. The duplicate sensor deployment allows the marine biological technician to perform a correlation analysis with the two sensors from the same reef location. Any outliers are noted and removed from the corrected data file. All data files are truncated to start the temperature data record stream at midnight the day the sensor was deployed into the field. The data stream ends at midnight before the day the sensor is recovered. Temperature readings after midnight are disregarded to eliminate erroneous data recorded during transit to the site. Marine biological technician (So. Fla.) is responsible for clipping the temperature files.

The sensor serial number is used to track individual sensors and this information is uploaded into an MS ACCESS database. This is accomplished by adding a column to the temperature data file in which the sensor number is pasted.

Data collection, download and storage procedures are delineated in the "HOBO® Temperature Data Collection and Storage" SOP. The SOP is an integral part of this protocol.

Post-collection processing of data

Data is downloaded temporarily on the field laptop computer and then transferred to a permanent database for subsequent analysis as described in the "HOBO® Temperature Data Collection and Storage" SOP. This database is replicated in an alternate location to provide redundancy as a safeguard to prevent data loss. Data is stored on both the servers (VIIS, and SFCN main).

The current location for the original HOBO® temperature file is located in: Z:\SFCN_Projects\Water_temperature\data\HoboData and then in its appropriate site location.

The Excel data set is exported from the HOBO® format and is then stored in: Z:\SFCN_Projects\Water_temperature\data\ProcessedData and then in its appropriate site location. This excel sheet contains the original temperature date

Once temperature data has been retrieved the period of record is truncated to midnight of the day of deployment and the midnight the day prior to recovery. This process removes the logging of temperature while the sensor is not at the reef location and allows the sensor to equilibrate to background water temperatures. Additionally the two sensors at a site are checked for gross discrepancies. Further validation of data occurs once data has been uploaded to the database.

All data shall be reviewed for QA/QC and proper data storage by the project manager. Once data has been approved (validated) by the project manager, the data is turned over to the data manager for archiving and storage as outlined below in the Data Handling, Analysis, and Reporting section.

A field log notebook shall be maintained and the following information will be recorded during every visit:

1. Name of the site
2. Date of visit
3. Location of the site (recorded in UTMs Northing and Easting coordinates)
4. Depth at which loggers are deployed
5. Serial # for each of the two loggers at a site
6. Time of deployment
7. Percent battery life
8. Days/years left on logger
9. Notes: Any pertinent information not mentioned above shall be recorded in this section
10. A copy of the new field log page(s) shall be kept at an alternate location as a back-up.

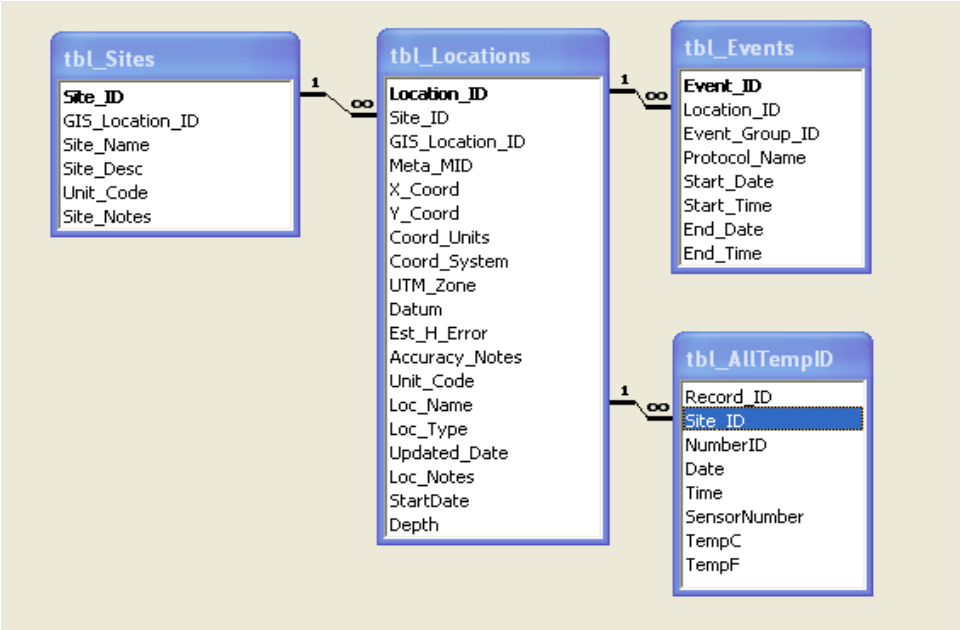
Data Handling, Analysis and Reporting

Metadata procedures

Metadata for each sensor deployment is collected using the procedure outlined in the Data entry, verification and editing section. This information is stored within the database. Metadata for the spatial location of the sample sites is stored with the shapefile. For further discussion concerning metadata requirements please see section 8.3 of the network data management plan.

Overview of database design

Database design is a legacy dataset that has been migrated into the NRDT format. Current design is shown in the following figure.



Data entry, verification and editing

Data retrieval and storage is delineated in the "HOBO® Temperature Data Collection and Storage" SOP, attached at the end of this document. The data retrieval event is recorded in the field log and in the accompanying spreadsheet. The following information is collected.

1. Serial Number of Data logger
2. Location
3. Date
4. Time of deployment
5. Battery life left %
6. Depth (in ft)
7. GPS coordinates (in Northings and Eastings)
8. Datum (default is NAD83)

Example of excel sheet:

HOBO Temperature gauge location and deployment data field sheet.

Serial #	Location/ Site	Date	Time of deployment.	% Battery Life	Years left on logger	Depth	GPS Coordinates UTM	Notes
939719	*WSG*	*4/5/2007*	*0:00*	*91%*	*4.92*	*33*	*N:19687051 E: 32*	*Log in 2 hr intervals, delayed start 04/06 at 00:00 AM. Recording in °C*
939720	WSG	*4/5/2007*	*0:00*	*91%*	*4.92*	*33*	*N:19687051 E: 32*	*Log in 2 hr intervals, delayed start 04/06 at 00:00 AM. Recording in °C*

Recommendations for routine data summaries, statistical analyses to detect change, and reporting

An annual summary across and within sites for mean, variance, maximum, and minimum water temperature will be performed. The number of days with average temperatures above temperatures known to cause coral bleaching (29.5^{o}C) and presence and duration of any unusually cold-water events will also be reported. In years where these thresholds are exceeded, more detailed reporting will occur (monthly) and comparisons with historical data range will be made where sufficient data has been collected.

Data will be used where applicable to assess associations between temperatures observed and degree of coral bleaching, disease and other signs of stress in the field.

As a covariate this data is tied to the index coral reef monitoring reporting schedule and will be reported as part of the SFCN Coral Reef Monitoring Protocol report.

Data archival procedures

Initial archiving is started once the Project manager has conducted the appropriate QA/QC procedures for a specific field seasons 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 Water Temperature database would be copied onto the network server under Archives/Projects/Water_Temperature/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.

Personnel Requirements and Training

Roles and responsibilities

Personnel assigned to data collection analysis and storage shall be properly trained in the procedures relevant to the assigned tasks. Responsibility of proper adherence to procedure, quality control and quality assurance shall rest with all pertinent personnel.

Rules and regulations applicable to the performance of these tasks shall be observed, with particular note to individual park policies.

Nothing in this protocol is implied or meant to imply deviations from established federal, departmental or local safety rules and regulations applicable to the performance of assigned tasks. It is the responsibility of each individual to be familiar with such rules and regulations.

Qualifications

The following qualifications are accepted minimum standards to perform relevant procedures. Tasks may be performed by personnel in training status, under the supervision of properly qualified persons. Specific guidelines and applicable regulations shall be strictly adhered to in such cases. This list is not meant to be all inclusive and may be supplemented by individual park regulations and qualifications.

- NPS Blue Card Diver (Ref RM4, 485 DM 27)
- MOCC (ref 36 CFR part 3, 485 DM 22)
- HOBO® equipment training

Training Procedures

Field operations training relevant to the tasks shall be conducted for personnel that are otherwise fully qualified to carry out the task. The Regional Dive Officer may permit Divers-In-Training to participate in such training at his/her discretion; in such cases the Park Dive Officer shall be notified as well (National Park Service, 1995). Motorboat Operation training may only be performed under the supervision of a qualified instructor.

There are no restrictions to training in any procedure that does not entail diving or boating activities by the trainee. Nevertheless, trainees shall not be allowed to perform tasks unless under supervision.

Operational Requirements

Annual workload and field schedule:

Workload is expected not to exceed one person hour per site for a total of 11 annual hours. Field visits shall coincide with concurrent coral reef monitoring efforts.

Equipment needs:

A compatible computer workstation with attached HOBO® launcher/reader is sufficient to process the water temperature data. Laptop computers are sufficient to download and view the data on field trips, provided that SOP procedures are followed to safeguard the equipment from damage. All sites are accessible by boat, while HOBO® installation or removal at each site must be done using SCUBA equipment.

Startup costs and budget considerations:

HOBO Water Temp Pro v2 sensors cost $110.00 each

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Presentations

The following presentations used the coral reef water temperature data set.

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

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

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

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

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

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

Miller, J. 2006. Coral Crisis in US Virgin Islands National Parks. SERO Briefing with Regional Director Hooks. Atlanta GA.

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

Miller, J. 2006. Coral Crisis in US Virgin Islands National Parks. Eye Street Briefing. Washington DC.

Miller, J. 2006. Coral Crisis in US Virgin Islands National Parks. NPS Briefing to Director Mainella, Deputy Wright, Soukup. Washington DC.

Miller, J. 2006. Coral Crisis in US Virgin Islands National Parks. Coral Reef Task Force Meeting. Washington DC.

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Standard Operating Procedure - HOBO® Temperature Pro v1. Data Collection and Storage

Revision History Log

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

Purpose:

The purpose of this standard operating procedure (SOP)) is to delineate and describe the stepwise procedure for collection and storage of the HOBO® Water Temp Pro v1 logger data. This SOP is an integral part of the South Florida / Caribbean Network "Coral Reef Water Temperature Monitoring Protocol".

Procedures:

A. Launching Hobo temperature Pro v1:

1. Open program Boxcar Pro 4.3 located on the desktop of the field laptop computer
2. Click on "launch Hobo water temp pro" to launch the Hobos.
3. Click on "launch logger"
4. Set the launch time for next odd hour. The reason for this is that the two loggers will be synchronized using the notebook computer clock and will record data at the same time which allows the database to match like reading using the time stamp.
5. Confirm that the unit is set to record in a 2 hr interval, delayed start.
6. Attach the units to the respective reef depth stake as described in "2." below.

B. Retrieving temperature data from the loggers in the field:

1. Before downloading Hobo data the following equipment will be needed:
   a. Two 12 inch cable ties per unit
   b. Hobo field log and fine point felt-tip pen
   c. Field laptop computer
   d. Onset® wireless receiver
   e. Laminated map of the reef showing the specific location where logger is deployed
2. The Hobos are deployed inside a rubber boot, attached to a stake with two cable ties at reef depth in a vertical position and inverted with respect to each other. Exact information about where the stake is located can be found in the field log. It is

necessary to cut the cable ties to retrieve the loggers and the used cable ties must also be also retrieved for disposal.

3. Remove the HOBO® Water Temp Pro (Hobo) logger from the respective boot. The Hobo logger and the boot must be rinsed and dried with a clean towel or cloth.
4. Connect the Onset® wireless receiver to the computer.
5. Check the serial number on the Hobo logger. It must match with the respective file name listed in the field log.
6. Place the Hobo so that it faces the wireless receiver.
7. Open program Boxcar Pro 4.3 located on the desktop of the field laptop computer.
8. Open the "logger" drop down menu
9. Open the "Hobo Water Temp Pro" menu
10. Click on the "readout" button. The dialog box "Logger list for readout" will open.
11. Select the Hobo unit that the reader finds - the unit name should match one of two units deployed at the particular site in accordance with the field log.
12. Click on the "readout" button. The dialog box "logger is launched" should appear.
13. Click on "stop logging, download data". The "Offload" dialog box should appear.
14. Save the file to the desktop. Use the following file name format:

    location[underscore]logger number[underscore]serial#[space]numerical year[underscore]three letter abbreviated month[underscore]numerical date

Ex: Yawzi_1_544282 2007_Sep_26

15. Record the following information in the field log book:
    a. Serial Number
    b. Location
    c. date
    d. Time of deployment
    e. Battery life left %
    f. Time left of deployment in days
    g. Depth (in ft)
    h. GPS coordinates (in Lat and Long)
    i. Datum (in Northings and Eastings)

16. Make any additional relevant notes, such as:
    a. Damage observed
    b. Difficulty downloading data
    c. Discrepancies with name, serial # or data
    d. Any other information that may seem relevant

C. HOBO logger v.1 BoxCar Pro 4.3 data export from a HOBO file to a Excel file.

1) Open the HOBO file from the selected site in BoxCar Pro 4.3
   a. NOTE: this depends on the HOBO logger being used, there are two versions and each has it own operating software
2) Once the file is open click on "Export Excel Spreadsheet" icon

3) Click on the “Export” button
4) Choose the appropriate folder for the Excel file to be exported to. Ex.(Z:\SFCN_Projects\Water_tempurature\data\ProcessedData\BISC_AM)
5) Click on the “Save” button
6) Navigate to the appropriate folder on the server
7) Add additional page and copy the data to this page for manipulation. This will leave two different pages in the excel file. One for the original transfer and the other the manipulated version. The naming of these pages should follow the naming sequence of the original HOBO file. Ex.(Amandas_Reef_2_Export Data and CUT DATA EVERY TWO HOURS)
8) Truncate file to the midnight of date deployed and truncate to midnight of the day before retrieval date.
9) Within the page named CUT DATA EVERY TWO HOURS you will need to insert three columns prior to the TIMEDATE column. These columns should be labeled “NumberID”, “Site” and “Sensor” respectively. Populate the columns with the appropriate Sensor serial #, Site abbreviation, Sensor number (1 or 2). Save and close Excel

At the soonest available opportunity the data must be imported to the Access data file following procedures outlined in SOP: Water Temperature Database Documentation.

Standard Operating Procedure - HOBO® Temperature Pro v2 Data Collection and Storage

Revision History Log

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

Purpose

The purpose of this standard operating procedure (SOP)) is to delineate and describe the stepwise procedure for collection and storage of the HOBO® Water Temp Pro v2 logger data. This SOP is an integral part of the South Florida / Caribbean Network "Coral Reef Water Temperature Monitoring Protocol".

Procedures

A. Launching Hobo temperature Pro v2:

1. Open HOBOware® version 2.2 program
2. Plug in the HOBO Optic USB Base Station into the computer
3. Click on "Device" drop down menu
4. Click on "launch "to launch logger
5. Type in site name and logger number (ex. Yawzi_1)
6. Set the launch time for next odd hour. The reason for this is that the two loggers will be synchronized using the notebook computer clock and will record data at the same time which allows the database to match like reading using the time stamp.
7. Confirm that the unit is set to record in a 2 hr interval, delayed start.
8. Attach the units to the respective reef depth stake as described in "2." below

B. Retrieving temperature data from the loggers in the field:

17. Before downloading Hobo data the following equipment will be needed:
    a. Two 12 inch long cable ties per unit
    b. HOBO® water proof shuttle
    c. Hobo field log and fine point felt-tip pen
    d. GPS coordinates and laminated map of the reef showing the specific location where logger is deployed
18. The Hobos are deployed inside a rubber boot, attached to a stake with two cable ties at reef depth in a vertical position and inverted with respect to each other. Exact

information about where the stake is located can be found in the field log. It is necessary to cut the cable ties to retrieve the loggers and the used cable ties must also be retrieved for disposal.

19. While underwater remove the HOBO® Water Temp Pro v2 logger from the protective boot and attach the HOBO® waterproof shuttle.
20. Squeeze the plastic handle on the shuttle and down load the data. The yellow "Transfer" light will blink when downloading and the green "OK" light will blink when it is complete. This should take a couple minutes to occur. NOTE: Be sure to have the logger lined up and pushed all the way in the shuttle so there is little to no space between the logger and shuttle read out or it will not download properly.
21. Once the data has been successfully downloaded replace the protective boot on the data logger and reattach it.

22. Record the following information in the field log book:

    a. Serial Number
    b. Location
    c. Date
    d. Time of deployment
    e. Time left of deployment in days
    f. Depth (in ft)
    g. GPS coordinates (in UTM)
    h. Datum

23. Make any additional relevant notes, such as:

    e. Damage observed
    f. Difficulty downloading data
    g. Discrepancies with name, serial # or data
    h. Any other information that may seem relevant
    i. Length of time the logger has been deployed. NOTE: The loggers will be switched out every 4 years.

C. Transferring data from HOBO® water proof shuttle to server. (to be completed on boat or back in office)

1. Rinse and dry shuttle
2. Download data off of shuttle
    a. Unscrew back of shuttle
    b. Hook up USMB to shuttle connection and the computers USB port
    c. Open HOBOware® version 2.2 program
    d. Open the "Device" drop down menu
    e. Click on "readout"
    f. Put a check in save box in front of the files to be saved to the computer
    g. Click on "choose" box and browse to the appropriate storage file for Temperture data.
    h. Use the following file name format:

location[underscore]logger number[underscore]serial#[space]numerical year[underscore]three letter abbreviated month[underscore]numerical date

Ex: Yawzi_1_544282 2007_Sep_26

i. Click on the "Save checked box"
j. Once the files have been offloaded and the files have been double checked to see if they are stored put a check in the box in front of the folders to be deleted and click on the "Delete checked" box to clean up the shuttle.

D. HOBO logger v.2 Hoboware v2. data export from a HOBO file to an Excel file.

1) Open the HOBO file from the selected site in HOBOware.
   a) NOTE: this depends on the HOBO logger being used, there are two versions and each has it own operating software.
2) Once the file is open click on "Export table data" icon
3) Click on "Export multiple files" button
4) Click on "choose" button and choose the appropriate folder for the Excel file to be exported to. Ex.(Z:\SFCN_Projects\Water_tempurature\data\ProcessedData\BISC_AM)
5) Click on the "Export" button
6) Navigate to the appropriate folder on the server
7) Add additional page and copy the data to this page for manipulation. This will leave two different pages in the excel file. One for the original transfer and the other the manipulated version. The naming of these pages should follow the naming sequence of the original HOBO file. Ex.(Amandas_Reef_2_Export Data and CUT DATA EVERY TWO HOURS)
8) Truncate file to the midnight of date deployed and truncate to midnight of the day before retrieval date.
9) Within the page named CUT DATA EVERY TWO HOURS you will need to insert three columns prior to the TIMEDATE column. These columns should be labeled "NumberID", "Site" and "Sensor" respectively. Populate the columns with the appropriate Sensor serial #, Site abbreviation, Sensor number (1 or 2). Save and close Excel

At the soonest available opportunity the data must be imported to the Acsess data file following procedures outlined in SOP: Water Temperature Database Documentation.

Equipment Specifications:

HOBO® Water Temp Pro v2 has 12-bit resolution and a precision sensor for ±0.2°C accuracy over a wide temperature range. The v2 version has twice the memory compared to the v1, an Optic USB Base Station, and works with the new HOBO® Waterproof Shuttle. Designed with a streamlined case for extended deployment in fresh or salt water, the Water Temp Pro is equipped with an Optic interface for data offload in the field, even when the logger is wet.

Measurement Range: -20° to 50°C (-4° to 122°F) in water; –20° to 70°C (-4° to 158°F) in air
Waterproof: To 120 m (400 ft)
Accuracy: ±0.2°C at 0 to 50°C (± 0.36°F at 32° to 122°F)
Resolution: 0.02°C at 25°C (0.04°F at 77°F)

Standard Operating Procedure: Coral Reef Water Temperature Monitoring Database Documentation

Revision History Log

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

I. Importing data files to Access

Following the completion of the relevant HOBO® Temperature Data Collection and Storage SOP the resulting Excel file needs to be imported into the SFCNTemp database.

1. Within the database window (press F11 to navigate there) select the Tables tab
2. Click "New", "Import Table", "OK"
3. Navigate to the Excel file that you wish to import.
4. Select the page named "DATA EVERY TWO HOURS" and click "OK"
5. Allow the table name to default to "CUT DATA EVERY TWO HOURS."
6. Within the Queries window select and run qryAppLogger. This will append data from the newly imported table to tbl_AllTempID

II. Documentation of Database Tables

The following section shows the overall relationships between each of the database tables as well as the specific design for each table.

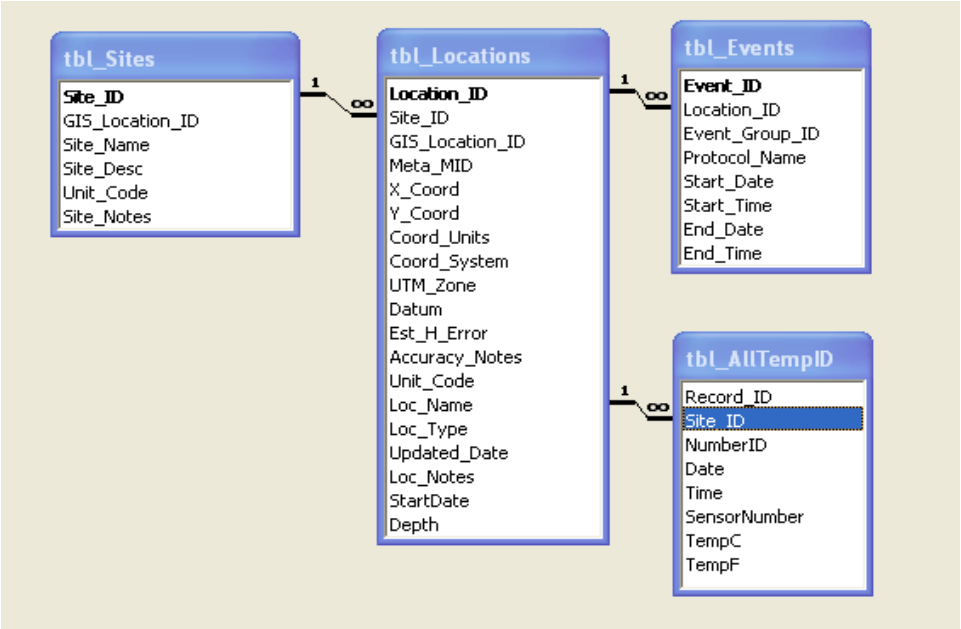

Table: **tblAllTempID**
Description: Table containing the value recorded by the temperature data loggers.

Field Name	***Field Type***	***Size***	***Field Description***
Record_ID	Long Integer	50	Unique identifier
Site_ID	Text	255	Site abbreviation
NumberID	Text	255	Sensor ID number
Date	Date/Time	8	Date of collection
Time	Date/Time	8	Time of collection
SensorNumber	Text	50	Sensor number 1 or 2
TempC	Double	4	Temperature in degrees Celsius
TempF	Double	4	Temperature in degrees Fahrenheit

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.

Field Name	***Field Type***	***Size***	***Field Description***
Location_ID	Long Integer	50	M. Location identifier
Site_ID	Long Integer	50	MA. Link to tbl_Sites
GIS_Location_ID	Text	50	MA. Link to GIS feature, equivalent to NPS_Location_ID
Meta_MID	Text	50	MA. Link to NR-GIS Metadata Database
X_Coord	Double	50	M. X coordinate
Y_Coord	Double	50	M. Y coordinate
Coord_Units	Text	50	M. Coordinate distance units
Coord_System	Text	50	M. Coordinate systemsignificant digits)
UTM_Zone	Text	50	MA. UTM Zone (UTM_Zone)
Datum	Text	50	M. Datum of mapping ellipsoid (Datum)
Est_H_Error	Single	8	MA. Estimated horizontal accuracy
Accuracy_Notes	Text	255	MA. Positional accuracy notes
Unit_Code	Text	12	M. Park, Monument or Network code
Loc_Name	Text	100	M. Name of the location
Loc_Type	Text	25	MA. Location type category
Updated_Date	Text	8	MA. Date of entry or last change
Loc_Notes	Memo		MA. General notes on the location
StartDate	Date/Time	8	Date Data Collection Began (month/year) OR date archiving began for designated location of information

Depth	Long Integer	2	Depth in feet

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.

Field Name	***Field Type***	***Size***	***Field Description***
Event_ID	Long Integer	50	M. Event identifier
Location_ID	Long Integer	50	M. Link to tbl_Locations
Event_Group_ID	Long Integer	15	MA. Link to tbl_Event_Group
Protocol_Name	Text	8	M. The name or code of the protocol governing the event
Start_Date	Date/Time	8	M. Starting date for the event
Start_Time	Date/Time	8	MA. Starting time for the event
End_Date	Date/Time	8	M. Ending date for the event
End_Time	Date/Time	8	MA. Ending time for the event

Table: **tluParkCode**
Description: Lookup table for park codes and park names where sampling occurs.

Field Name	***Field Type***	***Size***	***Field Description***
Park_Code	Text	4	4-character park code used by NPS
Park_Name	Text	255	Park name
Park_Type	Text	255	

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