

Program Summary

National Park Service
U. S. Department of the Interior

Inventory & Monitoring Program
Southeast Coast Network



Coastal Water and Sediment Quality Monitoring

Background

In 1999, the National Park Service's (NPS) Inventory and Monitoring (I&M) Program initiated a long-term ecological monitoring program to provide parks with current and scientifically credible information about select indicators (or *Vital Signs*) of the condition of natural resources in and around parks (Fancy et al. 2009). The Southeast Coast Network (SECN; Figure 1) is one of 32 groups of parks where monitoring protocols have been designed and implemented to meet the specific needs of parks with similar environmental settings. Located along the South Atlantic coast, the SECN includes 14 park units with significant coastal resources including beaches, dunes, salt marshes, tidal creeks and estuaries. The SECN conducts estuarine sediment and water quality monitoring at seven parks (Figure 1).

The goal of the Southeast Coast Network Vital Signs monitoring is to support science-based management of NPS resources by:

- Determining the status and trends in select indicators of the condition of park ecosystems to allow managers to make better-informed decisions.
- Providing early warning of abnormal conditions to help develop effective mitigation measures and reduce costs of management.
- Providing data to better understand park ecosystems and to provide reference points for comparisons with other, altered environments.
- Providing data to meet legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Providing a means of measuring progress towards performance goals.

Because of the importance of water resources to

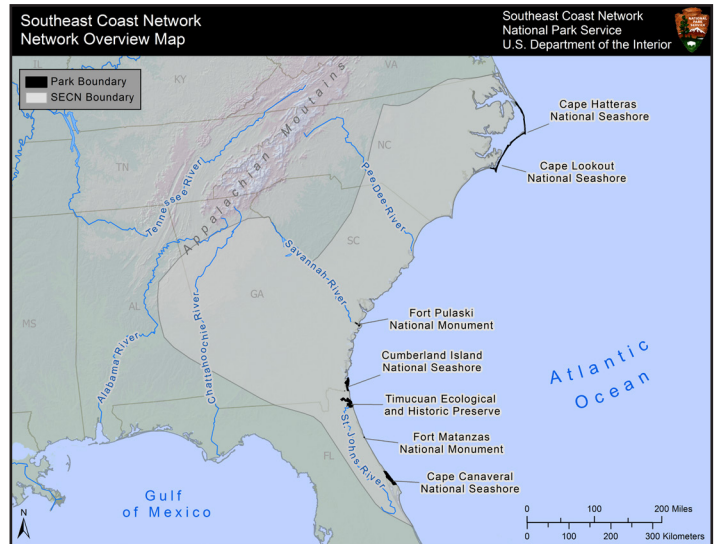


Figure 1. Locations of coastal park units of the National Park Service in the Southeast Coast Network where water and sediment quality monitoring occurs.

park management from ecological, regulatory, and visitor experience perspectives, estuarine water and sediment quality in and around parks was selected as one of several Vital Signs to be monitored by the I&M program (DeVivo et al. 2008). Data collected as a part of this effort will help foster a better understanding of water resources in and around parks, and contribute to a better understanding of park ecological processes (Gregory et al. 2013).

Approach and Objectives

To effectively monitor the diverse and dynamic set of estuarine water resources, the SECN has implemented a two-pronged monitoring approach: collecting data from continuous monitoring at permanent stations (fixed stations) located in each park, and also collecting periodic discrete water samples during park-wide synoptic surveys (Figure 2, Table 1; Gregory et al. 2013). Both the fixed stations and the periodic sampling provide comparable data using the same instrumentation and have comparable analyses

Table 1. Estuarine Water and Sediment Monitoring Protocol activity in SECN parks. Previous and future sampling events at smaller coastal parks are included.

Park	Fixed-station monitoring (NOAA-NEER adapted methods)		Park-wide monitoring (USEPA-NCA adapted methods)			
	Continuous data (15 to 30 minute intervals)	Nutrients and chlorophyll <i>a</i> (monthly to bimonthly)	Water quality, nutrients, chlorophyll <i>a</i> , (5-year rotation with dates)	Sediment quality, metals, TOC, and organics (10-year rotation with dates)		
CAHA	1	1	30 ¹	2010, 2015, 2020	30 ¹	2010, 2020
CALO	2	2				
CANA	1	(5) ²	30	2009, 2014, 2019	30	2009, 2019
CUIS	1	1	30	2007, 2012, 2017, 2022	30	2007, 2017
FOMA	1	(1) ³	30	2012, 2017, 2022	30	2017
FOPU ⁵	1	1	30	2007, 2013, 2018	30	2007, 2018
TIMU	1	(12) ⁴	30	2008, 2013, 2018, 2022	30	2008, 2018

¹Waters of Pamlico Sound are assessed as a single water body during the same sampling event.

²Monthly nutrients and chlorophyll *a* collected at park and four additional locations by St. Johns River Water Management District.

³Monthly nutrient and chlorophyll *a* data collect by GTM NERRS Program at site near FOMA visitors.

⁴Nutrient and chlorophyll *a* data collected bimonthly by City of Jacksonville at 12 sites throughout park as park of partnership

⁵Sediment and core water quality parameters were sampled during 2007 as part of parks baseline water quality inventory.

conducted on water column nutrient constituents. When combined, these two approaches give a more complete picture of physical processes and their variability (temporal and spatial) during critical portions of the year than either could if implemented singularly.

The SECN has identified four specific monitoring objectives for which data are collected and analyzed:

1. Determine daily and seasonal water quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at fixed monitoring stations using continuous data loggers.
2. Determine monthly and seasonal patterns in nutrients (nitrogen, phosphorus, and chlorophyll *a*) at fixed monitoring stations by collecting discrete water samples.
3. Determine status and spatial variability of



Figure 2. Examples of sampling designs for Timucuan Ecological and Historic Preserve (left) and Cape Lookout National Seashore (right) fixed-station monitoring networks. Red symbols indicate location of continuous monitoring sites. Black symbols show locations of additional monthly monitoring sites jointly monitored with Three Rivers Conservation Coalition at Timucuan Ecological and Historic Preserve.

water and nutrient chemistry conditions in estuarine waters every five years.

4. Determine status and spatial variability of benthic sediment quality (organic contaminants, carbon, and metal levels) every ten years in estuarine waters.

Monitoring is conducted by NPS SECN staff in partnership with the City of Jacksonville, Saint Johns Water Management District, NOAA National Estuarine Research Reserve Program, and the North Carolina Department of Environment and Natural Resources Division of Coastal Management. Detailed methods for collection, management, and analysis of data collected as a part of this program have been documented in a protocol and several standard operating procedures (Gregory et al. 2013).

Fixed-Station Water Quality

Field methods and laboratory criteria for the fixed-station monitoring portion of the estuarine water and sediment quality protocol follow those in use by the NOAA-NERRS Programs (Wenner and Geist 2001, NERRS 2011, NERRS 2012). This includes a combination of continuous data collection by automated data loggers (sondes) and monthly sampling of physical parameters and nutrient and chlorophyll *a* concentrations.

Continuous Data

Eight permanent monitoring stations have been installed in or near seven SECN parks where dissolved oxygen, pH, specific conductance, temperature, depth and turbidity data are collected at 15- or 30-minute intervals (this varies depending on the park). Readings for these parameters are collected using multi-parameter water quality sondes equipped to log data for up to eight weeks (Figure 3). To maintain data integrity, stations are visited at two- to four-week intervals and sondes are exchanged for newly-calibrated units. The duration of each deployment depends on the amount of instrument bio-fouling, which varies among locations in the Network as well as seasonally. At each park the monitoring station consists of a PVC tube attached vertically to pilings or rails of docks with the sonde suspended approximately 1 m from the bottom.

Monthly Discrete Data

Monthly water samples are collected approximately 0.5 m from the surface near the monitoring station using a cleaned Niskin bottle or Van Dorn sampler. These discrete samples are analyzed for total dissolved nitrogen and phosphorus, and chlorophyll *a*. In addition to monthly samples, quarterly samples are collected and processed for the inorganic and organic fractions of nitrogen and phosphorus to allow total nutrient pools to be estimated. Samples are analyzed for total nitrogen and phosphorus, ammonium, nitrite + nitrate, phosphate, and chlorophyll.

In addition to chemical measures of water quality, water clarity is estimated monthly based on Secchi disk measurements (the depth to which objects

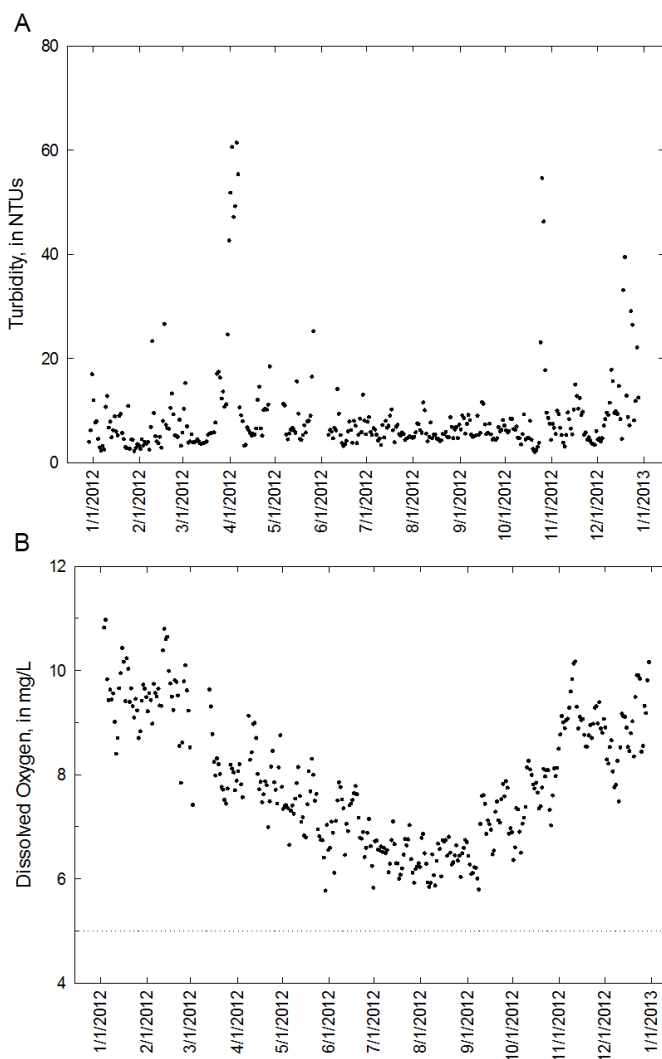


Figure 3. Example of mean daily water quality parameters for fixed-station monitoring: (A) turbidity and (B) dissolved oxygen (DO).

can be seen) and adjusting for naturally-occurring clarity conditions based on the water body being sampled (naturally turbid, moderately turbid, or clear water estuaries). This method of estimating water clarity condition is generally used when information on light transmission in the water column is missing and ensures data consistency among parks in the SECN.

Park-Wide Assessments

Field methods and laboratory criteria for conducting park-wide assessments follow those in use by the USEPA National Coastal Assessment Program (USEPA 2009) and provide data that allow for an evaluation of park estuarine ecosystem conditions in comparison to other coastal waters in the region. During each sampling event, 30 sites are selected where water chemistry, sediment chemistry, and physical parameters are collected. Due to cost constraints, fish tissue contaminants and benthic macroinvertebrate communities (also measured nation-wide as a part of the NCA program) are not currently being monitored in SECN parks.

SECN coastal assessments are conducted once every five years during the summer months (July through September) when biota are most active and hypoxia is most prevalent. Sites are visited by boat and completed within 3–5 day time periods so that data collected over the sampling event are comparable. If practical, sampling events are also planned to occur without major rainfall-runoff event interruptions that would make data interpretation more difficult. Sediments are sampled on a 10-year rotating basis due to the overall cost of sediment analysis, and the expected slower rates at which sediment contaminants to accrue (Table 1).

Water Chemistry

Water samples are collected at up to three depths at each site depending on the total depth at the site. Water samples are obtained by either pumped systems or by using Niskin bottle or Van Dorn samplers, and are analyzed for total nitrogen and phosphorus, ammonium, nitrite + nitrate, phosphate, and chlorophyll.

Sediment Chemistry

Sediments are collected for a variety of analyses using a 1/25 (0.04) m² stainless steel, Young-modified Van Veen grab sampler from a boat. This sampler is constructed entirely of stainless steel and is coated to allow for collection of sediment samples for both biological and chemical analyses without contamination. Sediments are only sampled every ten years (Table 1) at each park due to the overall cost of sediment analyses and the expected slower response time for sediment contaminants to accrue. Sediment samples are analyzed for the following constituents:

- Total Organic Carbon
- Sediment Grain Size
- Metals
- Mercury
- PAH Compounds
- PCB Compounds
- Pesticides
- PCBs

Physical Parameters

At each sampling location basic physical information is recorded including weather conditions, habitat types, and the presence of submerged aquatic vegetation or marine debris. Hydrographic profiles are recorded using a multi-parameter water quality meter. Profiles include recording temperature, turbidity, conductivity, pH, dissolved oxygen levels and conductivity values at 1 meter intervals.

Assessment Criteria

For both the fixed station discrete data and for parameters measured during park-wide assessments, water quality conditions are evaluated in comparison to site criteria in EPA's National Coastal Assessment II Report (Table 2, Table 3). Categorical assessments of "good," "fair," and "poor" are made at the site- and park-level for measurements of chlorophyll *a*, nutrients, dissolved oxygen and water clarity and are intended to highlight a range of conditions including acutely degraded water quality conditions. For park-wide assessments, these data are also combined into overall water quality and sediment quality indices (Figure 4).

Table 2. USEPA (2005) coastal water quality monitoring condition criteria for water quality parameters collected by the Southeast Coast Network.

Rating	Water Clarity Index	Chlorophyll a (µg/L)	Total Dissolved Nitrogen (mg/L)	Total Dissolved Phosphorus (mg/L)	Dissolved Oxygen
Good	<2.3	<5	<0.1	<0.01	>5
Fair	2.3–2.99	5–20	0.1–0.5	0.01–0.05	2–5
Poor	>3.00	>20	>0.5	>0.05	<2

Quality Assurance and Control

QA/QC procedures are based on the NOAA-NERRS Program (Small et al. 2010, NERRS 2012) for fixed-station monitoring and the USEPA-NCA for the Network's five and ten year sampling efforts (USEPA 2001). Data sondes are pre- and post-use calibrated according to the manufacturer's specifications and data are stored with the original data records and distributed as metadata. The SECN does not apply corrections to original field data but provides pre- and post-calibration data with original files to be used at the discretion of the data user.

To further ensure comparable data among parks and partners, the NPS-SECN requires all participating laboratories use approved USEPA methods and quality assurance criteria that meets or exceeds recommendations by the National Water Quality Monitoring Council for the National Water Quality Monitoring Network. Standard QA/QC procedures require that at least 10% of samples as duplicate samples and blanks be submitted along with regular samples. QA/QC sample collection is scheduled ahead of time to ensure that QA/QC samples are collected at different fixed-station sites throughout the year and/or on different days of coastal assessments. As part of overall data quality procedures, all members of the SECN Water Branch are trained

in the proper methods for recording data, using instruments, collecting samples, and processing data.

Data Reporting

Data reports are published as short, concise NPS Natural Resource Data Series reports that highlight the most recent data collection efforts as well as any issues or areas of potential concern. Reports summarize known conditions or major water quality issues present in or near the park and provide a brief outline of methods used to collect samples and process data.

Fixed-station and coastal assessment data reports contain a bulleted list of significant findings as part of the executive summary and are published in conjunction with a two-page resource brief containing an abbreviated subset of significant findings along with limited project information including broader programmatic overview of the sampling effort. Reports documenting the status of waters within a park are closely tied to the data collection efforts with fixed-station reports being published by April of the following year. Coastal assessment reports are published at five-year intervals following field work by no more than six months. Fixed-station reports provide an overview of intra- and inter-annual variability at a

Table 3. Median measurements of monthly water quality data from sampling stations maintained by St. Johns River Water Management District at Canaveral National Seashore. Numbers in brackets indicate the number of months in 2011 when water quality measurements indicated a poor rating. Green (■) = good; yellow (■) = fair; red (■) = poor.

Station Name	Water Clarity (k)	Chlorophyll a (µg/L)	Dissolved Oxygen (mg/L)	TDN (mg/L)	TDP (mg/L)
IRLML02	1.34[2]	12.97[4]	6.6[0]	1.050[11]	0.029[0]
IRLML169	1.34[2]	8.95[3]	7.0[0]	0.665[9]	0.033[1]
IRLV11	1.67[1]	8.33[2]	6.8[0]	0.398[5]	0.033[1]
IRLV17	1.43[0]	8.81[2]	7.3[0]	0.400[5]	0.029[1]
IRLV05	1.11[0]	6.95[1]	7.7[0]	0.245[1]	0.027[0]

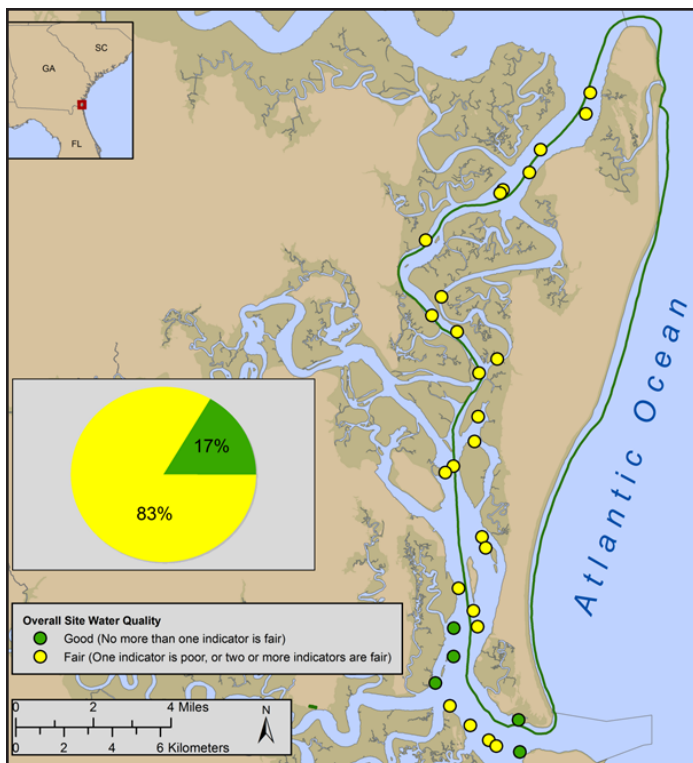


Figure 4. Water-quality index rating by site near Cumberland Island National Seashore, 2012. Graph shows percentage of sites in each condition category.

small spatial scale, while coastal assessments give a snapshot of conditions at a broad spatial scale.

To date the SECN has published numerous reports summarizing fixed-station and coastal assessment data (see Box 1 for examples). Reports are available for download from the Integrated Resource Management Applications portal (IRMA; <http://irma.nps.gov>).

Data Archiving

In addition to reports, the SECN publishes all data from fixed-station and park-wide monitoring efforts, including data from fixed-station data sondes, field measurements of physical parameters, results of laboratory nutrient and sediment analyses, and geospatial data files containing sampling locations. Once per year, data and metadata from fixed-station and park-wide monitoring efforts are exported into the NPSTORET following the guidance of the National Park Service, Water Resources Division (<http://www.nature.nps.gov/water/infoanddata/index.cfm>) for inclusion in USEPA STORET database. Data are also available through IRMA (<http://irma.nps.gov>).

Box 1. Recent publications from the SECN Estuarine Water and Sediment Quality Program.

Dingle, J. L., M. B. Gregory, C. Wright, and E. Thompson. 2012. Fixed station water quality monitoring at Cape Lookout National Seashore: 2010 data summary. Natural Resource Data Series NPS/SECN/NRDS—2012/323. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Canaveral National Seashore: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/389. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Cape Hatteras National Seashore: 2010 data summary. Natural Resource Data Series NPS/2012/NRDS—2012/367. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Cape Hatteras National Seashore: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/387. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Cape Lookout National Seashore: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/388. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Cumberland Island National Seashore: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/390. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Fort Matanzas National Monument: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/391. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Fort Pulaski National Monument: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/392. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Wright, W., M. B. Gregory, A. Rinehart. 2012. Fixed station water quality monitoring at Fort Pulaski National Monument: 2011 Data Summary. Natural Resource Data Series NPS/SECN/NRDS—2012/393. National Park Service, Fort Collins, Colorado. ([Full Report](#), [Resource Brief](#))

Literature Cited

DeVivo, J. C., C. J. Wright, M. W. Byrne, E. DiDonato, and T. Curtis. 2008. Vital Signs Monitoring in the Southeast Coast Inventory & Monitoring Network Report. Natural Resource Report NPS/SECN/NRR – 2008/061. National Park Service, Fort Collins, Colorado.

Fancy, S.G., J. E. Gross, S. L. Carter. 2009. Monitoring the Condition of Natural Resources in US Parks. Environmental Monitoring and Assessment. Vol. 151 pp. 161-174.

Gregory, M. B., J.C. DeVivo, E. M. DiDonato, C. J. Wright, and E. Thompson. 2013. Protocol for Monitoring Estuarine Water and Sediment Quality in Selected Southeast Coast Network Parks. Natural Resource Report NPS/SECN/NRR—2013/644. National Park Service, Fort Collins Colorado.

National Estuarine Research Reserve System. 2011. System-Wide Monitoring Program Plan. Technical Document. National Oceanic and Atmospheric Administration. Silver Springs, Maryland.

National Estuarine Research Reserve System. 2012. Nutrient and Chlorophyll Monitoring Program and Database Design (Version 1.6). Technical Document prepared by NOAA/NERRS Nutrient Monitoring Committee. National Oceanic and Atmospheric Administration. Silver Springs, Maryland.

Small, T., M. R. Ide, and J. M. Keese. 2010. CDMO NERR SWMP Data Management Manual (Version 6.3). National Estuarine Research Reserve, Centralized Data Management Office, Georgetown, South Carolina.

Wenner, E.L., and M. Geist. 2001. The National Estuarine Research Reserves Program to monitor and preserve estuarine waters. Coastal Management 29: 1-17.

USEPA. 2009. National Coastal Condition Assessment: Field Operations Manual. EPA-841-R-09-003. U.S. Environmental Protection Agency, Washington, DC. 133 pgs.

USEPA. 2005. National Coastal Condition Report II. EPA-620/R-03/002. Office of Research and Development / Office of Water, Washington, DC. (available online at

http://water.epa.gov/type/oceb/2005_index.cfm; accessed April 2011).

USEPA. 2001. Environmental Monitoring an Assessment Program (EMAP). National Coastal Assessment Quality Assurance Project Plan 2001 – 2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002.

For More Information

SECN Home Page: <http://science.nature.nps.gov/im/units/secn/index.cfm>

SECN Reports and Publications: <http://science.nature.nps.gov/im/units/secn/publications.cfm>

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Data Downloads via the Natural Resource Information Portal: <http://nrinfo.nps.gov/Home.mvc>

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