



Monitoring Nekton in Salt Marshes

A Protocol for the National Park Service's Long-Term Monitoring Program, Northeast Coastal and Barrier Network

Natural Resource Report NPS/NCBN/NRR—2012/579



ON THE COVER

Nekton monitoring

Photographs by: Robin Baranowski, Mary-Jane James-Pirri, and Erika Nicosia.

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Protocol Narrative

This protocol is an adaptation of the protocol developed by Raposa and Roman (2001a) for use in the Cape Cod Ecosystem Monitoring Program. The original protocol can be found at the National Park Service Inventory and Monitoring website:

http://science.nature.nps.gov/im/monitor/protocols/caco_nekton.pdf

Portions of text have been excerpted or revised from Raposa and Roman (2001a) and are presented in this document.

The following table lists all changes that have been made to this Protocol Narrative since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to Standard Operating Procedure (SOP) 10: Revising the Protocol or SOPs.

Revision History Log:

New Version#	Previous Version #	Revision date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00					

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Introduction

Information about how, when, and why natural systems change over time is critical for making sound management decisions. To address this need, the National Park Service (NPS) has initiated natural resource monitoring through the Natural Resource Challenge funded by Congress in 2000. The Inventory and Monitoring Program, a key component of this effort, organizes 270 park units into 32 networks tasked with conducting long-term monitoring. Each network links parks that share similar geographic and natural resource characteristics to improve efficiency and reduce costs. Networks must develop a monitoring plan and conduct long-term monitoring of key ecosystem indicators or “vital signs.” Vital signs are defined as measurable, early warning signals that may indicate changes in the long-term status of natural systems. Early detection of potential issues allows park managers to take steps to restore or maintain the integrity of park natural resources. The purpose of long term monitoring is to provide a reference point for comparison with desired or future conditions and to provide a means to measure progress of performance goals. This protocol was developed as part of the Northeast Coastal and Barrier Network (NCBN) Vital Signs Monitoring Plan (Stevens et al. 2005). This protocol details how salt marsh nekton communities will be monitored and was adapted from the protocol developed by Raposa and Roman (2001a) for use in the Cape Cod Ecosystem Monitoring Program at Cape Cod National Seashore (CACO).

Nekton, defined here as a community of fishes and free-swimming epibenthic crustaceans (e.g., shrimp, crabs), are an abundant estuarine fauna. Nekton respond to environmental change and thus are desirable for inclusion in a coastal monitoring program (Neckles and Dionne 2000, Neckles et al. 2002, Raposa et al. 2003, Kneib 1997). Development of the Index of Biotic Integrity (Karr 1981) and the Estuarine Index of Biotic Integrity (Deegan et al. 1997) attests to the value of monitoring nekton to document ecosystem level responses to environmental stressors. The foundation of these indices lies in the notion that fishes and crustaceans incorporate and reflect multiple ecosystem processes, and therefore indicate overall ecosystem integrity. Figure 1 identifies some of the linkages between human-induced and natural environmental stressors (e.g., altered hydrology, nutrient enrichment, storms, and sea level rise), associated changes in estuarine habitat structure, and responses of the nekton community.

The estuarine nekton community is an integral link among primary producers, consumers, and top predators and is likely to respond to top-down (e.g., removal of predatory fishes – Deegan et al. 2007) and bottom-up estuarine perturbations (e.g., nutrient loading) and thus represents an ideal monitoring component. For example, nutrient enrichment may affect nekton by altering submerged vegetated habitats (Valiela et al. 1992, Harlin 1995, Matheson et al. 1999). Nitrogen loading has led to changes in fish abundance, species richness, and growth rates of a common salt marsh species, the mummichog (*Fundulus heteroclitus*) (LaBrecque et al. 1996, Tober et al. 1996). The role of salt marshes in supporting migratory shorebird and waterbird populations is well-documented (e.g., Burger et al. 1982, Brush et al. 1986). Nekton represent a significant portion of the diets of many piscivorous birds, economically valuable fishes, and marine mammals (Friedland et al. 1988, Sekiguchi 1995, Smith 1997). Removal of predatory fishes through overfishing could induce responses in the forage or prey nekton guild through a trophic cascade (Carpenter and Kitchell 1985). Several studies have also indicated that nekton respond rapidly (e.g., within days to months) to the alteration of salt marsh hydrology such as restoration

of tidal flow (Rey et al. 1990, Taylor et al. 1998, Dionne et al. 1999, Able et al. 2000, Roman et al. 2002, Kimball and Able 2007, Eberhardt et al. 2011). Long-term monitoring could also document the introduction or expansion of invasive species (e.g., Asian shore crab, *Hemigrapsus sanguineus*), interactions among invasive and native species and their subsequent impact on nekton community dynamics, and changes in species ranges.

This protocol describes the background, objectives, sampling design, and includes Standard Operating Procedures (SOPs) for monitoring salt marsh nekton communities in shallow (< 1 m) habitats (e.g., pools, creeks and ditches) as part of the NCBN Vital Signs Monitoring Program.

Monitoring Objective

Objective: Identify temporal trends in nekton communities (species composition and abundance) and life history use patterns.

Question 1: Are salt marsh nekton communities changing over time (e.g., decades)?

Vital Sign 1: Salt marsh nekton species composition and abundance.

Question 2: How do salt marsh nekton communities change in response to acute perturbations (e.g., oil spills, storms) in the environment?

Vital Sign 1: Salt marsh nekton species composition and abundance.

Question 3: How do salt marsh nekton communities change in response to management actions (e.g., re-introduction of tidal flow to restricted environments, invasive species control, marsh landscape restoration)?

Vital Sign 1: Salt marsh nekton species composition and abundance.

Question 4: How does the life history status of individual species in salt marshes change over time and in response to environmental perturbations?

Vital Sign 2: Individual nekton species length and/or size distribution.

Measures: nekton composition, nekton abundance, nekton length

Protocol History and Development

The original Salt Marsh Nekton protocol (Raposa and Roman 2001a) was developed for Cape Cod National Seashore, a National Park Service prototype monitoring park. Development of the Cape Cod protocol was based on quantitative data (Raposa 2000, Raposa and Roman 2001a, 2001b, Raposa 2002) that were collected in five southern New England estuaries. From these data, guidelines for the temporal and spatial frequency of sampling, appropriate replicate sample size, and appropriate statistical analyses were developed (Raposa et al. 2003). The result was the development of the original protocol entitled Monitoring Nekton in Shallow Estuarine Habitats: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore (Raposa and Roman 2001a).

As part of the Inventory and Monitoring Program, the original Cape Cod protocol was tested at nine National Parks within the NCBN and the Northeast Temperate Network (NETN) during the summers of 2003 to 2005 (Figure 2): Assateague Island National Seashore (ASIS, MD and VA), Cape Cod National Seashore (CACO, MA), Gateway National Recreation Area (GATE, NY and NJ), Fire Island National Seashore (FIIS, NY), Sagamore Hill National Historic Site (SAHI, NY), Colonial National Historical Park (COLO, VA), George Washington Birthplace National Monument (GEWA, VA), Boston Harbor Islands National Recreation Area (BOHA, MA), and Saugus Iron Works National Historic Site (SAIR, MA). During the testing phase, monitoring sites within parks were selected using a stratified random sampling design, a desire to co-locate

sampling with other monitoring programs, or based on specific needs of the individual park. After the initial testing phase, the sample design components of the Raposa and Roman (2001a) protocol were revised to include a completely random process and incorporated in the protocol presented herein.

The Raposa and Roman (2001a) protocol was also used in a US Fish and Wildlife Service (FWS) study of open marsh water management impacts on salt marsh nekton communities at several FWS refuges from Massachusetts to Delaware from 2001 to 2006 (James-Pirri et al. 2011, 2008). This study included the design and use of a nekton enclosure sampling device for salt marsh ditches (James-Pirri et al. 2010) which has been incorporated into the protocol presented herein.

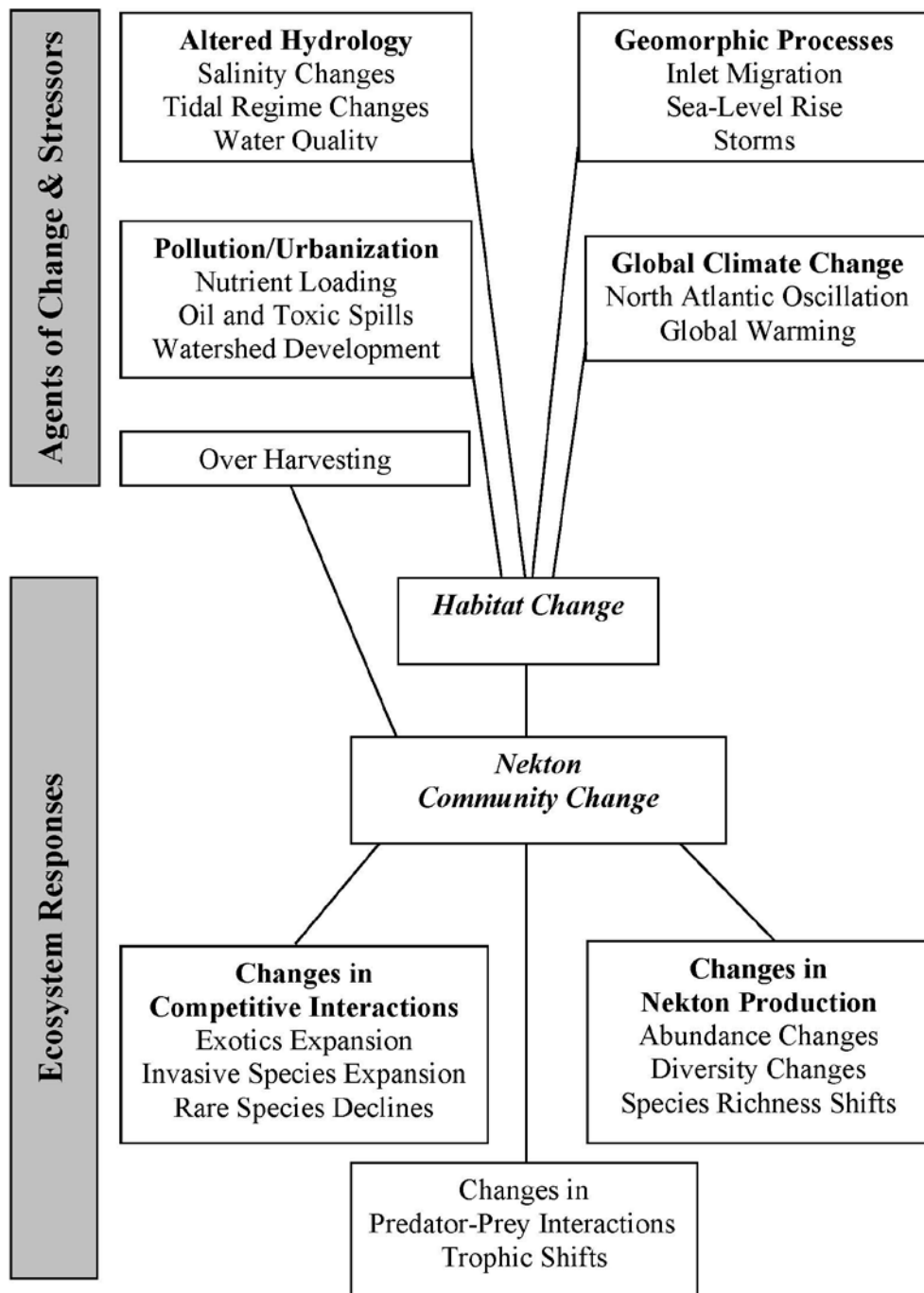


Figure 1. Linkages among environmental stressors and nekton responses in shallow estuarine environments (excerpted from Raposa & Roman 2001a).

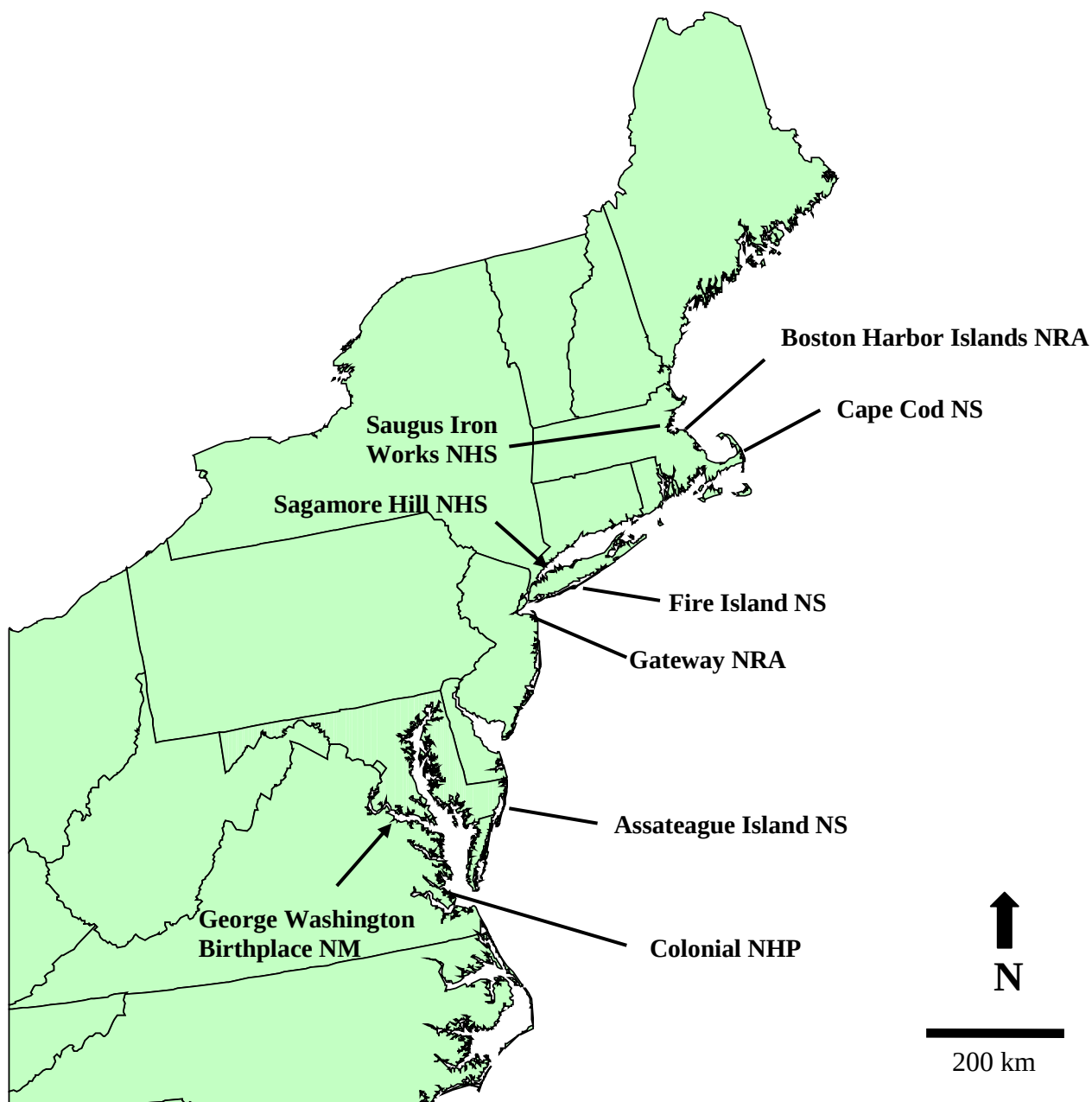


Figure 2. Northeast Coastal and Barrier Network and Northeast Temperate Network National Parks where the nekton protocol has been tested and / or is currently being implemented (as of 2010).

Protocol Summary

This protocol describes in detail the methods used to sample nekton in shallow (< 1 m), salt marsh subtidal habitats, such as salt marsh pools, tidal creeks, and ditches, with the objective to identify temporal trends in nekton communities (species composition and abundance) and life history use patterns. Information gained from monitoring nekton should be used to augment concurrent monitoring of other estuarine and salt marsh resources and processes, including vegetation, marsh elevation responses to sea-level rise, and nutrient enrichment.

Three to nine monitoring sites, approximately five to eight hectares in size, are randomly selected from the population of all potential monitoring sites so that statistical inference can be extended to all salt marshes within each park unit. Within each monitoring site, sampling stations are randomly located around the perimeter of pools, and along creeks and ditches. Nekton are sampled exclusively in shallow water habitats with quantitative enclosure gear: throw traps (creeks, pools) and ditch nets (ditches or narrow creeks). There are two daytime sampling periods per year; one in early summer (mid-June through July) and another in late summer-early fall (August through September). A minimum of 15 throw trap samples from pools and/or larger creeks (this sample size is the combined number of stations from pools and/or creeks), and 10 ditch net samples from ditches (depending on the availability of habitat) are collected from each monitoring site during each sampling period, yielding an annual sample size of ~30 throw trap samples and ~20 ditch net samples per monitoring site. All nekton are identified to species and counted at each sampling station. Length is recorded for 15 haphazardly selected individuals of each species at each sampling station or, for species with ≤ 15 individuals collected, length is recorded for all individuals. Environmental parameters collected concurrent with nekton sampling include water temperature, salinity, water depth, dissolved oxygen, tide direction (ebb, flood), submerged aquatic vegetation cover, and a description of sediment type and surrounding marsh vegetation.

This protocol is presented as a minimum for monitoring the structure of the shallow water salt marsh nekton community. If additional time, personnel, or funds are available, supplementary sampling can be conducted; for example, sampling in multiple seasons, diurnal sampling, use of multiple sampling gear types, marsh surface sampling, tidal phase sampling, measurements of nekton biomass, growth rates, migration trends, or other variables that assess functional and trophic aspects of the nekton community.

Sampling Design

The sampling design for this protocol has been developed after extensive research and field sampling (Raposa and Roman 2001a, James-Pirri et al. 2008; 2010; 2011, Raposa et al. 2003). The rationale for the sampling design is briefly presented in this section.

Monitoring Site Selection

Existing salt marsh in each park is derived from available Geographic Information System (GIS) data (refer to SOP 3: Selecting Monitoring Sites and Establishing Nekton Sampling Stations). All salt marshes within the park unit are delineated into potential monitoring sites of five to eight hectares in size. Throughout this protocol, the term “monitoring site” or “site” is used when referring to the delineated salt marsh monitoring site. The boundary delineation of salt marsh monitoring sites is based on geographic features using GIS. Geographic features include tidal creeks, salt marsh-upland borders, ditches, bay front, and other distinguishable features. Monitoring sites are then randomly selected from the entire population of potential monitoring sites in the park. If three (or fewer), five to eight hectare salt marsh sites are present in the park unit, then all salt marsh monitoring sites are sampled. If four or more salt marsh monitoring sites are present within the park, then three or more sites are randomly selected from the population of all potential sites. The exact number of sites selected depends on resources available for monitoring, the extent of the salt marsh within the park unit, and the specific needs of the park. By randomly selecting monitoring sites from all salt marsh habitat within a park, or conducting a complete sample in parks with smaller marsh area, statistical inference extends to all salt marshes within a park.

Marsh accessibility and availability of nekton habitat (e.g., pools, creeks, ditches) are considered when randomly selecting monitoring sites. If a monitoring site does not meet these criteria, then that monitoring site may be excluded from the population of all potential monitoring sites. Once the monitoring sites are selected, they become permanent sites and are re-sampled in subsequent years.

The rationale for discrete monitoring sites is strictly logistical. Field technicians can travel to the monitoring site (often by boat or 4x4 vehicle) and then establish sampling stations within a confined area, thereby reducing the amount of time and effort required to travel or walk between sampling stations.

Sampling Unit

There are numerous methods to sample nekton in salt marsh open water habitats that include passive (fyke net, flume net), towed (seine, trawl), and enclosure gears (throw trap, ditch net, block net, cast net), each with its advantages and disadvantages in regards to catch efficiency, recovery efficiency, and area sampled. Rozas and Minello (1997) report that enclosure gear are preferred samplers because they provide the most repeatable and quantitative estimates of nekton communities in shallow estuarine habitats.

This protocol uses two types of enclosure traps, throw traps and ditch nets, as the sampling units. Enclosure traps have high and consistent capture efficiency in most habitats, tend to better represent benthic nekton, and are small enough to permit sampling in specific microhabitats (Rozas and Minello 1997).

Throw traps

The throw trap is a square 1-m² box (measuring 1 m wide x 0.5 m high), with 3-mm galvanized wire screen sides, that is open at the top and bottom (Figure 3). The height of the throw trap can be increased to 1 m (for sampling water up to 1 m deep) by attaching a 3-mm mesh floating skirt. Throw traps are best used within sand or mud-bottomed shallow water habitats such as salt marsh pools, tidal creeks, and bay fronts. The throw trap should not be used in habitats with gravel or rocky bottoms because the seal between the trap bottom and the substrate is often not tight and capture efficiency decreases. Nekton are removed from the throw trap with a dip net (1-mm mesh) that fits snugly in the trap. The mesh of the dip net is smaller (1-mm mesh) than the throw trap (3-mm mesh) to facilitate the removal of small or elongated nekton (e.g., young-of-the-year fishes or juvenile American eels) from the throw trap. The 3-mm mesh is the size that should be stated when referring to this gear. No gear can effectively sample the entire nekton community in all habitats, but the high and consistent capture efficiency of throw traps make them a preferable sampling gear (Rozas and Minello 1997, Raposa and Roman 2001a, Raposa et al. 2003).

Ditch nets

Ditches are common features within salt marshes. These ditches were created in the 1930s mostly for mosquito control. They vary in width from 45 cm to 100 cm and provide suitable nekton habitat (Corman and Roman 2011). This habitat is sampled using a ditch net (Figure 4). The ditch net is an enclosure gear designed to sample narrow ditches and smaller tidal creeks up to 1 m wide and 1 m deep (James-Pirri et al. 2010). The ditch net has 3-mm nylon mesh netting suspended like a hammock between four supporting stakes. Two mesh doors, one on each side of the body of the net, slide up along runner lines attached to the stakes; when the trigger lines are pulled, the doors are raised and the net encloses a known surface area of water.

The primary rationale for selecting the ditch net as a sampling gear for tidal ditches is that other enclosure sampling gears are not effective for this environment. Smaller versions of the throw trap have been tested, but ditches are too narrow to allow proper deployment of this sampling gear.

Sample Size

Sample size formula calculations and power analyses were conducted during development of the Cape Cod protocol to determine the appropriate number of replicates for sampling nekton with the 1-m² throw trap (Raposa et al. 2003). The objective of these analyses were to determine the minimum number of replicates necessary to detect differences in species community structure (density and species composition) between nekton communities of salt marshes. Based solely on the sample size formula Raposa et al. (2003) recommend a sample size from 20 to 25 throw trap sample stations for marsh pools and creeks, while the power analysis indicated a sample size of 15. To satisfy the minimum sample size, this protocol is recommending a sample size of 15 throw trap stations at each site (pool, creek, and bay front stations combined) during each sampling period (mid-summer and late summer) for ~30 throw trap samples (pool, creek, and bay front stations) annually per site. During analyses, data can be combined in various ways as long as the minimum replicate sample size of ~30 is maintained for statistical analyses. For example, the first and second sampling periods can be combined by each site; all sites within a park unit can be combined by sampling period; or all sites and sampling periods can be combined for a park unit.

Based on a similar power analysis conducted for determining the appropriate number of ditch net samples, it is recommended that a minimum of ten ditch net sampling stations at each marsh site should be collected during each sampling period for a total annual sample size of ~20 ditch net samples (James-Pirri et al. 2010).



Figure 3. Throw trap (top left) and dip net (top right). Bottom photo shows procedure for dip-netting nekton from the throw trap (photos courtesy of M. J. James-Pirri).



Figure 4. Photo of ditch net deployed in a ditch with doors down (top photo) and with doors up (bottom photo) (photos courtesy of M. J. James-Pirri).

Placement of Sampling Stations

Pools sampled with the throw trap must be at least 2 m² in surface area, as it is difficult to precisely throw the trap (i.e., so the trap lands entirely within the pool) in pools that are smaller. Throw trap stations are randomly assigned to pools within each site, and the exact station location on a pool is randomly located along the perimeter of each pool. Depending on its size, a pool may have up to three sampling stations each spaced at least 30 m apart (refer to SOP 3: Selecting Monitoring Sites and Establishing Nekton Sampling Stations). If throw trap stations are placed closer than 30 m apart, they should be sampled at least 30 minutes apart.

Locations of throw trap sampling stations along creeks and bay fronts are randomly located, and are placed at least 30 m apart. If closer placement of throw trap stations is necessary to achieve adequate replicate size, adjacent stations in creeks or bay fronts should be sampled at least 30 minutes apart.

Ditch nets are used to sample ditches and narrow tidal creeks of salt marshes. Ditches should be at least 15 cm wide to allow free passage of nekton through the net prior to triggering, and have between 10 cm and 1 m depth of water when triggered. Ditch net stations are randomly located along the length of the ditch or narrow tidal creek (< 1 m wide), and must be at least 30 m apart.

The locations of sampling stations within the monitoring site remain permanent for the two sampling periods within each sampling year, but are re-randomized in subsequent years. It is possible that the same pools, creeks, and ditches will be selected in future years, especially where there is limited habitat from which to choose. However, the station location on the pool, creek, or ditch is re-randomized between years, thus the exact sampling location (i.e., microhabitat) may differ between years.

Data Collection

Each individual captured is counted and identified to species. These data will provide estimates of nekton density, species richness, and community composition. Additionally, up to 15 haphazardly selected individuals of each species are measured for total length (fish and shrimp) or carapace width (crabs) at each station. For species with ≤ 15 individuals collected, length is recorded for all individuals. Raposa and Roman (2001a) recommend measuring at least 15 individuals of each species, particularly if distinct cohorts (e.g., young-of-the-year, adults) are present or if analyses of trends in life history stages are desired. Moran (2011) recommends a sample size of 19 to achieve repeatable estimates of average size for marine fish. In the length analyses, data for each species are pooled across all stations sampled annually, yielding a possible maximum sample size of 450 for an individual species ($n = 30 \text{ stations} \times 15 \text{ individuals} = 450$). Less abundant species would have a smaller sample size for length-frequency and other analyses. Measuring the length of species can demonstrate year-to-year changes in size distributions, perhaps emphasizing the influx of young-of-the-year in summer (Raposa et al. 2003, Able and Fahay 2010) or understanding responses to climate and other changes.

In conjunction with nekton sampling, environmental data are collected during each sampling period. At each nekton sampling station, the following environmental data are recorded: water temperature (°C); water salinity (ppt); dissolved oxygen (mg l⁻¹); water depth (cm); ditch or creek depth (cm); estimate of percent cover for macroalgae, submerged aquatic vegetation, or any

marsh vegetation within the throw trap (using cover class categories); and a description of sediment type and surrounding dominant vegetation (refer to SOP 7: Sampling Procedures). These environmental data are intended to describe habitat conditions at the time of sampling; the sampling design may not be appropriate for long-term trend analyses.

Sampling frequency

Nekton monitoring data are collected every two years. There are two daytime sampling efforts per year; one in early summer (mid-June through July) and another in late summer-early fall (August through September).

Spatial variability in nekton abundance is much higher than temporal variability in freshwater systems due to habitat heterogeneity (Peterson and Rabeni 1995). These authors found that collecting a larger number of samples on fewer dates optimizes sampling efforts, as opposed to taking a smaller number of samples spread over multiple dates. To our knowledge, a similar detailed analysis of spatio-temporal variability does not exist for estuarine nekton; however, an analysis using nekton densities in tidal creeks from three southern New England salt marshes suggests that variability patterns may be similar for estuarine nekton (Raposa and Roman 2001a). On average, spatial variability in density (i.e., variability among samples taken on the same sampling date) was 21 times greater than temporal variability among sampling dates. Because of this, we adopt the sampling strategy described by Peterson and Rabeni (1995) and suggest that a larger number of samples be collected on fewer dates to address spatial variability and improve sampling precision.

Time of year

The highest nekton density and richness occurs during warm weather temperatures in temperate estuarine habitats (Pearcy and Richards 1962, Recksiek and McCleave 1973, Adams 1976, Cain and Dean 1976, Hoff and Ibara 1977, Orth and Heck 1980, Pihl and Rosenberg 1982, Pihl Baden and Pihl 1984, Ayvazian et al. 1992, Rountree and Able 1992, Able et al. 1996, Lazzari et al. 1999, Raposa and Roman 2001a; 2001b, Able and Fahay 2010). In some cases the exact timing of nekton peaks depends on latitude and/or habitat type. For example, nekton abundance in eelgrass beds peaked in June in Chesapeake Bay (Heck and Orth 1980, Orth and Heck 1980), but peaked in late summer and fall in Nauset Marsh on Cape Cod, MA (Heck et al. 1989). In Cape Cod and other southern New England salt marshes, abundance peaked in landward habitats (marsh pools, upstream tidal river) later in the year than in seaward habitats (marsh creeks, downstream tidal river) (Raposa and Roman 2001a). Despite the variability in the timing of peak abundance and richness, both are generally highest between June and September in temperate estuaries, and monitoring efforts should be concentrated during this period to maximize information gained per sampling effort. It is recommended that nekton sampling occur twice per year, once in early summer (mid-June through July) and another in late summer-early fall (August through September). The time-frames for sampling nekton will vary due to differences in climate in the Network's region, for example nekton in Massachusetts can be sampled after June 15 and before September 15, whereas sampling in Virginia is recommended from June 15 through September 30. Each sampling effort for a park should be concluded within 7 to 10 days. Seasonal sampling could be conducted, providing valuable information, but it is not feasible for this protocol.

Tidal cycle

Monitoring estuarine nekton is dependent on the tidal cycle of the marsh. Sampling in subtidal salt marsh habitats (e.g., creeks and pools) with a throw trap occurs only when the marsh surface is drained of tidal water (during ebb or flood tides) and when there is an adequate water depth for sampling (> 10 cm). If the marsh surface is flooded during sampling, densities of species that utilize the marsh surface will be underestimated. It would be ideal to standardize sampling for a specific portion of the tidal cycle (e.g., ebb tide only) but it is not feasible for this protocol due to time constraints.

Sampling with the ditch net should occur when water has drained off the surface of the marsh, but when there is still adequate depth of water in ditches and smaller tidal creeks to sample (> 10 cm depth). The timing of sampling is more critical for ditch net samples than for throw trap samples; the nets need to acclimate at least 30 minutes prior to sampling to allow recovery from disturbance when the nets were deployed. If the nets are set too late into an ebbing tide, the ditches may be drained before the nets are sampled.

Time of day

Studies have demonstrated differences in estuarine nekton composition and abundance between day and night periods (e.g., Rountree and Able 1993, Heck et al. 1989). Raposa and Roman (2001a) documented significantly higher densities of green crabs (*Carcinus maenas*) at night at Hatches Harbor on Cape Cod, MA; however, densities of all other species did not differ between day and night sampling. This protocol suggests sampling only during the day. This approach should provide accurate representations of the densities of most species in the monitoring sites, keeping in mind that some species, due to their diurnal rhythms (particularly decapods), may be underrepresented during the day. The logistics of daytime sampling are more accommodating for field technicians and day sampling facilitates comparisons with a larger number of datasets. Night sampling could be initiated in the future to augment regular daytime sampling if time and resources allow, or if a particular question can only be addressed by night sampling.

Field Methods

Brief Monitoring Site Description

Prior to field sampling, a brief written description of the monitoring sites is required based on available aerial imagery and preliminary site visits and/or site reconnaissance (refer to SOP 3: Selection of Monitoring Sites and Establishing Nekton Sampling Stations). The site description should address the following:

- What are the dominant vegetation communities (e.g., *Spartina alterniflora*, *S. patens*, *Phragmites australis*, *Typha* spp.) of each monitoring site?
- Are creeks and/or pools present?
- Based on available information, what is the tidal range and salinity (e.g., freshwater, brackish, marine) of the monitoring site or in the vicinity of the site? Site reconnaissance may be required to determine the site-specific tide and salinity characteristics.
- Describe potential anthropogenic stressors to the site including ditching, tidal restrictions, adjacent upland development, and others.
- This brief written monitoring site description should be revised at the end of the sampling period to incorporate new or updated information that was obtained during field sampling. A description of any unusual events that occurred during the June to September sampling period (e.g., major storms, oil spills, local fish kills, etc.) should also be included.

Preparing for the Field Season

The locations of nekton sampling stations are determined using GIS prior to the field season (refer to SOP 3: Selecting Monitoring Sites and Establishing Nekton Sampling Stations). Field maps include the location of each sampling station, marsh boundaries, and helpful navigation points (e.g., points of access). All sampling gear is checked and repaired (or built) if necessary. All field equipment (e.g., GPS, water quality probes, meter tapes, flagging) is acquired, calibrated, and tested. Field technicians are trained in the use of all equipment, and are familiar with the methods for conducting nekton sampling prior to the first sampling event. In addition, it is required that all field technicians and staff associated with the monitoring program read the entire Nekton Protocol document prior to conducting any fieldwork. Any safety concerns should be addressed as soon as possible. If a boat is required to access sampling sites, arrangements must be made well in advance of the first sampling. Personnel operating any motorized boat must be certified by the Department of the Interior Motorboat Operator Certification Course (MOCC).

Developing the Sampling Schedule

The tidal regime of sampling sites is the factor limiting the number of potential field days, and thus the amount of sampling that can occur. Nekton sampling occurs after the marsh surface has drained of tidal water (during either ebb or flood tides); if monitoring sites have the same tidal regime, the number of sites that can be sampled may decrease, since only two weeks of every month will have tides favorable to sampling during the daytime. Conversely, if the tidal regimes rarely result in flooding of the marsh surface at some sites, these sites will have more acceptable sample days and more sites can be sampled. In addition, the number of field technicians and the type of gear used will also influence the amount of sampling that can be conducted in a single

field season. Sampling with ditch nets requires more time than sampling with throw traps, as the nets must be deployed 30 minutes prior to sampling. If timed appropriately, both ditch net (10 stations) and throw trap (15 stations) samples can be collected by four field technicians in one to two days at a park unit. It would likely require a team of two field technicians two to three days to sample both throw trap and ditch net stations.

Sampling Methods

A minimum of two field technicians is required to sample nekton. SOP 7: Sampling Procedures describes in detail the specific methodology of field sampling.

Two types of enclosure traps are used to sample salt marsh nekton, depending on the habitat. Throw traps are used to sample salt marsh pools, tidal creeks, and bay fronts. Ditch nets are used to sample ditches and smaller tidal creeks (< 1 m wide). Both of these methods provide quantitative estimates of nekton abundance and density (number of fish per m²). Detailed instructions for building throw traps and ditch nets are provided in SOP 4: Construction of Throw Traps and Dip Nets and SOP 5: Construction of Ditch Nets.

Throw traps

To use the throw trap, the sampling station is quietly approached and the trap is tossed into the pool or tidal creek (refer to SOP 7: Sampling Procedures). Nekton are removed from the throw trap by sweeping the dip net through the trap. The trap is considered empty after three consecutive sweeps with the dip net yield no nekton (refer to SOP 7: Sampling Procedures). All nekton within the trap are identified, counted, and the lengths (mm) of 15 haphazardly selected individuals for each species are measured. All nekton are returned alive back into the pool or creek. Voucher specimen(s) of any unknown or questionable identification should be humanely sacrificed, preserved, and transported to the laboratory for positive identification.

Ditch nets

The ditch net is suspended between four stakes and covers a 1-m length of ditch bottom (refer to SOP 7: Sampling Procedures). Once the ditch net is deployed, nekton can freely traverse through the net. After an acclimation period of at least 30 minutes, the sample is obtained by pulling trigger lines, which raise the doors and causes the net to enclose a known surface area of the water column and trapping nekton within the net. Two people are required to sample the ditch net. Each person quietly approaches the trigger lines that have been laid on the marsh surface (3 m from the ditch net), and simultaneously pull on the lines to raise the doors of the net. The stakes are grabbed and pulled from the ditch, trapping all nekton in the net. The net is laid on the marsh surface, all nekton are counted, identified, and the lengths (mm) of 15 haphazardly selected individuals for each species are measured. All nekton are returned alive back into the ditch. Voucher specimen(s) of any unknown or questionable identification should be humanely sacrificed, preserved, and transported to the laboratory for positive identification.

Collection of environmental data

To avoid disturbing the nekton community prior to sampling, associated environmental variables such as water temperature (°C), salinity (ppt), and dissolved oxygen (mg l⁻¹) are recorded *after* the throw trap is tossed and *before* the fish are removed with the dip net or *after* a ditch net is pulled from the ditch (refer to SOP 7: Sampling Procedures). Vegetation cover (including macroalgae, submerged aquatic plants, and marsh plants) within the throw trap, if present, should

be estimated (as percent cover of *living* species) prior to dip netting fish, as dip netting may disturb the vegetation and influence cover estimates. Vegetation adjacent to a station (i.e., surrounding a pool, along a creek or ditch) as well as the sediment type (mud, sand) within the throw trap or ditch net is recorded on the field data form to provide additional information about the sampling location.

Data Management

Detailed information regarding the management of salt marsh monitoring data is provided in SOP 8: Data Management. In order to ensure that datasets remain standardized, complete, accurate, and up to date, it is imperative that all field data are recorded on appropriate field data forms during each sampling event. Any unknown specimens are identified immediately upon return to the laboratory and the correct identification indicated on the field data form. Edits, changes, or corrections to the data are noted on the field data form with the date and person (initials) verifying the change or correction. All GPS coordinates are entered into a GIS program to verify the locations of sampling stations.

Data Entry and Verification

All data are entered into the NCBN Monitoring Program Salt Marsh Database as soon as possible after collection. The database has been designed to reduce errors associated with data entry by using features such as drop down lists (i.e., species lists, value ranges), reducing errors due to spelling and multiple synonyms for species names. It is the responsibility of the Network Data Manager and Project Leader to ensure that individuals responsible for data entry have been properly trained to use the database, and have the most recent version of the NCBN Salt Marsh Monitoring Database, as well as the Database Users Guide.

Data entry is verified by staff with expertise in estuarine nekton ecology. All records are exported from the database and a visual review and comparison with the original field data forms are conducted for all data. Errors are marked and corrected on both the field data form and digital database(s) as soon as possible.

Data Archiving

At the end of the field season, all hardcopies of field data forms are archived as described in SOP 8: Data Management. All field data forms, marked field maps, and any other notes are scanned, and the database containing the data from that field season are archived as electronic copies.

Data Analysis and Reporting

All data are entered and stored in the Northeast Coastal and Barrier Network Monitoring Program Salt Marsh Database. Summaries and analyses require the export of data from the database into other spreadsheet or statistical programs. Detailed descriptions of analytical procedures and information can be found in SOP 9: Data Analysis and Reporting.

Reporting Schedule

The sampling schedule for each park, data summaries, and problems or special circumstances/events that were encountered are documented in annual reports and submitted to park Natural Resource Managers. Annual reports are generated and submitted no later than the spring following the monitoring season.

A trend analysis report is generated for every three to five years of data. This is a comprehensive report that includes an overview of the Network nekton monitoring program, management plans, summaries of all data to date, statistical comparisons among years (if appropriate), any concerns or problems, and suggestions to improve or augment the existing monitoring program. The most

important component of the trend report is the analysis of the long-term monitoring data for each monitoring site and park.

Data Summaries and Statistical Analyses

Annual reports include species composition (species lists), mean total nekton density, and total number of individuals collected for each monitoring site. It may also be of interest to report mean densities of fish and crustaceans separately, or densities and size distributions of individual species. Mean lengths of nekton and means for environmental variables are also reported. An estimate of error (standard error or standard deviation depending on how data are summarized) and sample size (number of stations sampled or number of individuals measured) are presented in tables and graphs if appropriate.

Trend Reports are used to determine if nekton density, nekton length frequency distributions, or community structure are changing over time. At a minimum, the trend analyses should compare changes in individual monitoring sites over time, as well as describe changes in nekton attributes at the park unit level. Examples of the types of analyses that can be conducted are: an Analysis of Variance to determine if nekton densities for a specific monitoring site are changing over time. Distribution tests, such as the Kolmogorov-Smirnov test, can be used to determine if size-frequency distributions of a specific species are changing over time. Changes in community structure (species composition and abundance) can be assessed by using, for example, analyses that are part of the PRIMER software package (e.g., ANOSIM, PERMANOVA+ for PRIMER) (Primer-E Ltd, Plymouth, UK) Clarke and Warwick 2001, Anderson et al. 2008). ANOSIM is just one example of a non-parametric multivariate analysis, similar to multivariate analysis of variance (MANOVA) but without the generally unattainable assumptions of parametric tests (Clarke and Warwick 1994, Carr 1997). SOP 9: Data Analysis and Reporting provides details on these analyses and summaries.

Revising the Protocol

Data collected through the implementation of this protocol are intended to provide the National Park Service with information to assess the status of salt marsh habitats. Precise and accurate data collection is crucial to detect statistically significant changes in condition of salt marsh nekton communities.

Since this protocol is intended to be used for long-term monitoring, it is important to review data trends on a regular basis. As a better understanding of nekton communities and their relationship to salt marsh changes is developed, it is likely that the monitoring protocol will need to be re-examined and adjusted. All changes must be fully documented. Major changes in methodologies must be reviewed by qualified scientists to determine if the revised procedures will meet the objectives of this protocol. Any changes or updates to the Protocol Narrative and its associated SOPs will be distributed to anyone using the methods described herein. Complete instructions for logging revisions to this protocol are described in SOP 10: Revising the Protocol or SOPs.

Operational Requirements

Operational requirements for implementation of the nekton protocol include a sampling schedule (refer to SOP 1: Field Season Logistics), staff to conduct sampling and oversee aspects of the monitoring and data analyses, and funds for supplies and travel expenses. The personnel required for implementation of the nekton protocol include one project leader and at least two field technicians. The project leader oversees all aspects of the monitoring from coordination with parks, to the initial marsh monitoring site selection, sampling station location, sampling schedule, equipment manufacture and repair, field technician training, data collection, species identification and verification, data entry, and data analyses. Field technicians are responsible for collecting nekton data, data entry and verification, and equipment maintenance.

For safety and efficiency a minimum of two field technicians are required to conduct the nekton sampling. Four technicians (two teams of two technicians) can sample more monitoring sites, and this is recommended if more than one park is monitored in the same year, especially if multiple protocols are implemented in the same year.

Since monitoring nekton requires close coordination with the specific tidal regimes of monitoring sites (which may only occur two weeks of every month), it is advised that the nekton monitoring should be the primary responsibility of the field technicians. Field technicians may be able to conduct other monitoring protocol responsibilities (e.g., salt marsh vegetation monitoring, sediment elevation table monitoring) if scheduling permits.

Field technicians should be trained in the identification and ecology of estuarine fishes, and field sampling procedures. Throughout the sampling effort, the project leader should conduct refresher training. It is suggested that the project leader initiate contacts with estuarine fish experts at local academic institutions or other agencies to assist with identification of unknown species. Regional field guides include, but are not limited to, Able and Fahay (2010), Collette and Klein-MacPhee (2002) (refer to Appendix A). All field technicians should be physically fit, able to spend long hours in field conditions (hot and humid weather, walking on uneven ground), and be able to carry and deploy the required field equipment.

Literature Cited

- Able, K. W. and M. P. Fahay. 2010. Ecology of estuarine fishes: temperate waters of the Western North Atlantic. John Hopkins University Press, Baltimore, Maryland.
- Able, K. W., R. S. McBride, R. A. Rountree, and K. J. Smith. 1996. Fishes of polyhaline estuarine shores in Great Bay-Little Egg Harbor, New Jersey: a case study of seasonal and habitat influences, p. 335-353. *In* K. F. Nordstrom and C. T. Roman, editors. Estuarine Shores: Evolution, Environments and Human Alterations. John Wiley and Sons, Ltd. West Sussex, UK.
- Able, K. W., D. M. Nemerson, P. R. Light, and R. O. Bush. 2000. Initial response of fishes to marsh restoration at a former salt hay farm bordering Delaware Bay, p. 749-773. *In* M. P. Weinstein and D. A. Kreeger, editors. Concepts and Controversies in Tidal Marsh Ecology. Kluwer Academic Publishers, The Netherlands.
- Adams, S. M. 1976. The ecology of eelgrass, *Zostera marina* (L.), fish communities. I. Structural analysis. *Journal of Experimental Marine Biology and Ecology* 22:269-291.
- Anderson, M. J., R. N. Gorley, and K. R. Clarke. 2008. PERMANOVA+ for PRIMER: Guide to software and statistical methods. Plymouth, UK: Primer-E Ltd.
- Ayvazian, S. G., L. A. Deegan, and J. T. Finn. 1992. Comparison of habitat use by estuarine fish assemblages in the Acadian and Virginian zoogeographic provinces. *Estuaries* 15:368-383.
- Brush, T., R. A. Lent, T. Hruby, B. A. Harrington, R. M. Marshall, and W. G. Montgomery. 1986. Habitat use by salt marsh birds and response to open marsh water management. *Colonial Waterbirds* 9: 189-195.
- Burger, J., J. Shisler, and F.H. Lesser. 1982. Avian utilization on six salt marshes in New Jersey. *Biological Conservation* 23:187-212.
- Cain, R. L. and J. M. Dean. 1976. Annual occurrence, abundance and diversity of fish in a South Carolina intertidal creek. *Marine Biology* 36:369-379.
- Carpenter, S. R. and J. F. Kitchell. 1985. Cascading trophic interactions and lake productivity. *Bioscience* 35: 634-639.
- Carr, M. R. 1997. PRIMER (Plymouth Routines in Multivariate ecological Research) User Manual. Plymouth: Plymouth Marine Laboratory.
- Clarke, K.R., and R.M. Warwick. 2001. Change in marine communities: an approach to statistical analysis and interpretation. 2nd edition. PRIMER-E, Plymouth, Devon, UK.
- Clarke, K. R. and Warwick, R. M. 1994. Change in marine communities: an approach to statistical analysis and interpretation. Plymouth: Plymouth Marine Laboratory.

- Collette, B. B., and G. Klein-MacPhee, eds. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine. 3rd ed. Smithsonian Institution Press, Washington, DC.
- Corman, S. S. and C. T. Roman. 2011. Comparison of salt marsh creeks and ditches as habitat for nekton. *Marine Ecology Progress Series* 434:57-66. doi: 10.3354/meps09189.
- Deegan, L. A., J. T. Finn, S. G. Ayvazian, C. A. Ryder-Kieffer, and J. Buonaccorsi. 1997. Development and validation of an estuarine biotic integrity index. *Estuaries* 20:601-617.
- Deegan, L. A., J. L. Bowen, D. Drake, J. W. Fleeger, C. T. Friedrichs, K. A. Galván, J. E. Hobbie, C. Hopkinson, D. S. Johnson, J. M. Johnson, L. E. LeMay, E. Miller, B. J. Peterson, C. Picard, S. Sheldon, M. Sutherland, J. Vallino, and R. S. Warren. 2007. Susceptibility of salt marshes to nutrient enrichment and predator removal. *Ecological Applications* (Supplement) 17: S42-S63
- Dionne, M., F. T. Short, and D. M. Burdick. 1999. Fish utilization of restored, created, and reference salt-marsh habitat in the Gulf of Maine, p. 384-404. *In* L. Benaka, editor. Fish habitat: essential fish habitat and rehabilitation. American Fisheries Society, Symposium 22, Bethesda, Maryland.
- Eberhardt, A. L., D. M. Burdick, and M. Dionne. 2011. The effects of road culverts on nekton in New England salt marshes: Implications for tidal restoration. *Restoration Ecology* 19: 776-785. doi: 10.1111/j.1526-100X.2010.00721.x
- Friedland, K. D., G. C. Garman, A. J. Bejda, and A. L. Studholme. 1988. Interannual variation in diet and condition in juvenile bluefish during estuarine residency. *Transactions of the American Fisheries Society* 117:474-479.
- Harlin, M. M. 1995. Changes in major plant groups following nutrient enrichment, p. 173-187. *In* A. J. McComb, editor. Eutrophic shallow estuaries and lagoons. CRC Press. Boca Raton, Florida.
- Heck, K. L., Jr. and R. J. Orth. 1980. Structural components of eelgrass (*Zostera marina*) meadows in the lower Chesapeake Bay-decapod crustaceans. *Estuaries* 3:289-295.
- Heck, K. L., Jr., K. W. Able, M. P. Fahay, and C. T. Roman. 1989. Fishes and decapod crustaceans of Cape Cod eelgrass meadows: Species composition, seasonal abundance patterns and comparison with unvegetated substrates. *Estuaries* 12:59-65.
- Hoff, J. G. and R. M. Ibara. 1977. Factors affecting the seasonal abundance, composition and diversity of fishes in a southeastern New England estuary. *Estuarine and Coastal Marine Science* 5:665-678.
- James-Pirri, M. J., R. M. Erwin, and D. J. Prosser. 2008. US Fish and Wildlife Service (Region 5) salt marsh study, 2001-2006: An assessment of hydrologic alterations on salt marsh ecosystems along the Atlantic coast. USGS Patuxent Wildlife Research Center and University of Rhode Island, Final Report to U.S. Fish and Wildlife Service, April 2008.

http://ftpext.usgs.gov/pub/er/md/laurel/OMWM/Region5_salt_marsh_FINAL_REPORT_April12_2008.pdf
accessed 26 March 2012.

- James-Pirri, M. J., R. M. Erwin, D. J. Prosser, and J. Taylor. 2011. Responses of salt marsh ecosystems to mosquito control management practices along the Atlantic Coast (U.S.A.) Restoration Ecology. doi:10.1111/j.1526-100X.2010.00767.x (published online Feb 2011).
- James-Pirri, M. J., C. T. Roman, and J. L. Swanson. 2010. A quantitative gear to sample nekton in salt marsh ditches and small tidal creeks. *Transactions of the American Fisheries Society* 139:413-419.
- Karr, J. R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21-27.
- Kimball, M. E. and K. W. Able. 2007. Tidal utilization of nekton in Delaware Bay restored and reference intertidal salt marsh creeks. *Estuaries and Coasts* 30:1075-1087.
- Kneib, R. T. 1997. The role of tidal marshes in the ecology of estuarine nekton. *Oceanography and Marine Biology* 35:163-220.
- LaBrecque, E., C. Fritz, J. Tober, P. J. Behr, and I. Valiela. 1996. Abundance and age-specific growth rates in relation to population densities of *Fundulus heteroclitus* in Waquoit Bay estuaries subject to different nitrogen loads. *Biological Bulletin* 191:319-320.
- Lazzari, M. A., S. Sherman, C. S. Brown, J. King, B. J. Joule, S. B. Chenoweth, and R. W. Langton. 1999. Seasonal and annual variations in abundance and species composition of two nearshore fish communities in Maine. *Estuaries* 22:636-647.
- Matheson, R. E. Jr., D. K. Camp, S. M. Sogard, and K. A. Bjorgo. 1999. Changes in seagrass-associated fish and crustacean communities on Florida Bay mud banks: the effects of recent ecosystem changes? *Estuaries* 22:534-551.
- Moran, D. 2011. Sampling effort required to obtain repeatable average size estimates of juvenile fish. *Aquatic Biology* 11:239-242.
- Neckles, H. A. and M. Dionne (editors). 2000. Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, Maine. <http://www.pwrc.usgs.gov/resshow/neckles/gpac.htm>
accessed 26 March 2012.
- Neckles, H. A., M. Dionne, D. M. Burdick, C. T. Roman, R. Buchsbaum, and E. Hutchins. 2002. A monitoring protocol to assess tidal restoration of salt marshes on local and regional scales. *Restoration Ecology* 10:556-563.
- Orth, R. J. and K. L. Heck. 1980. Structural components of eelgrass (*Zostera marina*) meadows in the lower Chesapeake Bay-fishes. *Estuaries* 3:278-288.
- Pearcy, W. G. and S. W. Richards. 1962. Distribution and ecology of fishes of the Mystic River estuary, Connecticut. *Ecology* 43:248-259.

- Peterson, J. T. and C. F. Rabeni. 1995. Optimizing sampling effort for sampling warmwater stream fish communities. *North American Journal of Fisheries Management* 15:528-541.
- Pihl Baden, S. P. and L. Pihl. 1984. Abundance, biomass and production of mobile epibenthic fauna in *Zostera marina* (L.) meadows, western Sweden. *Ophelia* 23:65-90.
- Pihl, L. and R. Rosenberg. 1982. Production, abundance, and biomass of mobile epibenthic marine fauna in shallow waters, western Sweden. *Journal of Experimental Marine Biology and Ecology* 57:273-301.
- Raposa, K. B. 2000. Nekton utilization of tidally restricted, restoring, and reference New England salt marshes. Dissertation. University of Rhode Island, Kingston, Rhode Island.
- Raposa, K. B. 2002. Early responses of fishes and crustaceans to restoration of a tidally restricted New England salt marsh. *Restoration Ecology* 10:665-676.
- Raposa, K. B. and C. T. Roman. 2001a. Monitoring nekton in shallow estuarine habitats. Part of a series of monitoring protocols for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, Coastal Research Field Station, University of Rhode Island, Narragansett, RI 02882.
- Raposa, K. B. and C. T. Roman. 2001b. Seasonal habitat-use patterns of nekton in a tide-restricted and unrestricted New England Salt marsh. *Wetlands* 21:451-461.
- Raposa, K. B., C. T. Roman, and J. F. Heltshe. 2003. Monitoring nekton as a bioindicator in shallow estuarine habitats. *Environmental Monitoring and Assessment* 81:239-255.
- Recksiek, C. W. and J. D. McCleave. 1973. Distribution of pelagic fishes in the Sheepscot River-Back River estuary, Wiscasset, Maine. *Transactions of the American Fisheries Society* 102:541-551.
- Rey, J. R., J. Shaffer, and D. Tremain. 1990. Effects of re-establishing tidal connections in two impounded subtropical marshes on fishes and physical conditions. *Wetlands* 10:27-45.
- Roman, C. T., K. B. Raposa, S. C. Adamowicz, M. J. James-Pirri, and J. G. Catena. 2002. Quantifying vegetation and nekton response to tidal restoration of a New England salt marsh. *Restoration Ecology* 110: 450-460.
- Rountree, R. A. and K. W. Able. 1992. Fauna of polyhaline subtidal marsh creeks in southern New Jersey: composition, abundance and biomass. *Estuaries* 15:171-185.
- Rountree, R. A. and K. W. Able. 1993. Diel variation in decapod crustacean and fish assemblages in New Jersey polyhaline marsh creeks. *Estuarine, Coastal and Shelf Science* 37:181-201.
- Rozas, L. P. and T. J. Minello. 1997. Estimating densities of small fishes and decapod crustaceans in shallow estuarine habitats: a review of sampling design with focus on gear selection. *Estuaries* 20:199-213.

- Sekiguchi, K. 1995. Occurrence, behavior and feeding habits of harbor porpoises (*Phocoena phocoena*) at Pajaro Dunes, Monterey Bay, California. *Aquatic Mammals* 21:91-103.
- Smith, J. P. 1997. Nesting season food habits of four species of herons and egrets at Lake Okeechobee, Florida. *Colonial Waterbirds* 20:198-220.
- Stevens, S., B. Milstead, M. Albert, and G. Entsminger. September 2005. Northeast Coastal and Barrier Network Vital Signs Monitoring Plan. Technical Report NPS/NER/NRTR—2005/025. National Park Service, Boston, Massachusetts.
- Taylor, D. S., G. R. Poulakis, S. R. Kupschus, and C. H. Faunce. 1998. Estuarine reconnection of an impounded mangrove salt marsh in the Indian River lagoon, Florida: short-term changes in fish fauna. *Mangroves and Salt Marshes* 2:29-36.
- Tober, J. C. Fritz, E. LaBrecque, P. J. Behr, and I. Valiela. 1996. Abundance, biomass, and species richness of fish communities in relation to nitrogen-loading rates of Waquoit Bay estuaries. *Biological Bulletin* 191:321-322.
- Valiela, I., K. Foreman, M. LaMontagne, D. Hersh, J. Costa, P. Peckol, B. DeMeo-Anderson, C. D'Avanzo, M. Babione, C. H. Sham, J. Brawley, and K. Lajtha. 1992. Couplings of watersheds and coastal waters: sources and consequences of nutrient enrichment in Waquoit Bay, Massachusetts. *Estuaries* 15:443-457.

SOP 1: Field Season Logistics

Version 1.00 (September 2012)

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Introduction

Implementation of this protocol requires careful planning. This SOP describes staffing needs as well as training and experience requirements, and the necessary field season preparations required to ensure a safe and efficient field season. Prior to any sampling:

- Field technicians are hired and trained.
- Field equipment, materials, and supplies are ordered and built prior to the start of the field season (refer to SOP 4: Construction of Throw Traps and Dip Nets, SOP 5: Construction of Ditch Nets, and SOP 7: Sampling Procedures).
- Prior to field sampling, a brief written description of the monitoring sites is required based on available aerial imagery and preliminary site visits and/or site reconnaissance. The written description should include the following:
 - What are the dominant vegetation communities (e.g., *Spartina alterniflora*, *S. patens*, *Phragmites australis*, *Typha* spp.)
 - Are creeks and/or pools present?
 - Based on available information what is the tidal range and salinity (e.g., freshwater, brackish, marine) of the monitoring site or in the vicinity of the site? Site reconnaissance may be required to determine the site-specific tide and salinity characteristics.
 - Describe potential anthropogenic stressors to the monitoring site including ditching, tidal restrictions, adjacent upland development, and others.
- During the reconnaissance visit, a map of the site is taken into the field to verify the existence of creeks, ditches, and pools that are of adequate water depth for sampling (> 10 cm at low water). Information regarding travel time, and access points are noted. At least one person who will be doing the actual field sampling is present during this visit.
- Detailed sampling schedules are developed.

Staffing Requirements

A minimum of one supervisor and two field technicians is required to efficiently and accurately collect nekton monitoring data. If timed appropriately, all ditch nets (10 stations) and throw trap (15 stations) samples can be collected by four field technicians in one to two days. It would likely take two field technicians two to three days to sample both throw trap and ditch net stations, as sampling must be closely coordinated with daily tides.

Staff Qualifications

Field technicians must be physically fit, able to work long hours in field conditions, and able to carry and utilize the necessary equipment (e.g., throw traps, ditch nets). Conditions in the field can be harsh, so it is imperative that individuals conducting the sampling are able to tolerate typical summer conditions while working in the salt marsh (e.g., sun exposure, extreme heat, mosquitoes, ticks, physical labor, extensive walking through unstable substrates in hip boots, waders, or wetsuit). Sampling nekton requires careful scheduling with regard to tides, therefore, technicians must be able to meet travel and sampling constraints to ensure that data are collected in a timely manner. A background in estuarine ecology and familiarity with fishes is preferred. If possible, at least one field technician should be certified by the Department of the Interior Motorboat Operator Certification Course (MOCC) prior to the field season. This significantly reduces complications with vessel scheduling.

Training Procedures

Field technicians should be trained in the identification and ecology of estuarine fishes and other estuarine nekton, and field sampling procedures. Throughout the sampling effort, the project leader should conduct refresher training. In addition, it is required that field technicians read the entire Nekton Protocol document prior to conducting any fieldwork. Personnel who have previously sampled nekton using these protocols train new field technicians. Tossing the throw trap and properly deploying ditch nets must be practiced extensively before sampling in the field. A trial sampling trip is conducted prior to the first sampling event, so field technicians can practice nekton identification and field sampling methods. All individuals conducting nekton sampling should be able to identify common nekton, and be familiar with fish anatomy, terminology used in field guides, and common identifying characteristics of nekton. If voucher specimens are available, they should be studied by new field technicians. It is strongly urged that staff involve experts from local universities or other agencies to assist with nekton identification. Regional field guides include, but are not limited to: Able and Fahay (2010), Collette and Klein-MacPhee (2002) (refer to Appendix A). Field technicians must know how to use a GPS unit, YSI, refractometer, and be familiar with data that will be collected and recorded. All safety procedures must be reviewed (e.g., refer to SOP 2: Field Safety) and necessary safety training must be completed prior to field sampling.

Establishing a Sampling Schedule

The tidal regime of monitoring sites is the limiting factor to the number of potential field days, and thus the amount of sampling that can occur. If monitoring sites have the same tidal regime, the number of possible sites sampled may decrease, as only two weeks of every month will have tides favorable to sampling during daylight hours. Conversely, if the tidal regime rarely results in the marsh surface flooding at some sampling sites, these sites will have more sampling days.

In addition, the number of field technicians and the type of gear used will also influence the amount of sampling that can be conducted in a single field season. Sampling with ditch nets requires more time than sampling with throw traps, as the nets must be deployed 30 minutes prior to sampling. If timed appropriately, both the ditch nets (10 stations) and throw trap (15 stations) samples can be collected by four field technicians in one to two days. It would likely require two field technicians two to three days to sample both throw trap and ditch net stations.

The sampling schedule should consider the following:

- There are two daytime sampling efforts per year; one in early summer (mid-June through July) and another in late summer-early fall (August through September).
- Northern parks are sampled from June 15 – September 15, whereas southern parks may be sampled June 15 - September 30.
- Sampling salt marsh pools, creeks, and bay fronts with a throw trap occurs only when the marsh surface is drained of tidal water (during ebb or flood tides) and when there is an adequate water depth for sampling (> 10 cm at low water)
- Sampling with the ditch net occurs when water has drained off the surface of the marsh, but when there is still enough water in the ditches and smaller tidal creeks to sample (> 10 cm depth). The timing of sampling is more critical for ditch net samples than for throw trap samples; the nets need to acclimate at least 30 minutes prior to sampling to allow recovery of nekton from disturbance that may have occurred during net deployment. If the nets are set too late into an ebbing tide, the ditches may be drained before the nets are sampled.
- To ensure ample time for sampling, the time required to get to and from monitoring sites is considered when preparing the sampling schedule.
- For each of the two sampling periods, all monitoring sites within a park should be completed within seven to ten days.
- If more than one park will be monitored during the same field season, travel days between parks must be included in the schedule.
- Arrangements for boat use and scheduling boats should be made well in advance of the field season. Personnel operating boats must be MOCC certified.
- Flexibility needs to be incorporated into the sampling schedule as it may be necessary to re-schedule a field day due to weather (e.g., storms) or other unanticipated events.

SOP 2: Field Safety

Version 1.00 (September 2012)

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Introduction

While it is the goal of the NPS to ensure a safe working environment for field technicians, each individual is responsible for ensuring his or her own safety in the field. Safety concerns should be brought to the attention of the Project Leader as soon as possible. This document is not a comprehensive source of safety information, but rather a guide for becoming familiar with safety procedures and potential hazards associated with working in salt marshes.

It is likely the field technicians will conduct salt marsh monitoring in more than one park during the field season. It is critical that individual park policies regarding safety are respected and followed. Fieldwork is never conducted alone.

Working as a Team

To ensure a safe and successful field season, it is important that field technicians recognize their roles as members of the monitoring team, and that all individuals take steps to be informed about potential hazards and individual park policies. Each field technician needs to arrive at work on-time, every day, and be ready to participate fully in whatever work is scheduled for that day. The Project Leader will review the equipment each technician is expected to have with them at all times (e.g., compass, batteries, cell phone or radio, field guides, water, sunscreen, insect repellent). In addition to equipment used for salt marsh monitoring, individuals are responsible for packing any personal items needed for working in the salt marsh.

Safety Equipment Carried in the Field

The following is a list of safety materials and personal items that are commonly used when conducting salt marsh monitoring:

- Cellular phones (required for each field technician)
- 2-way radio
- First aid kit

- Mosquito head netting
- Insect repellent
- Boots (e.g., hip boots, waders, wetsuit booties)
- Drinking water and snacks / lunch
- Hat, sunscreen, and sunglasses
- Work gloves

If a particular park requires the use of a two-way radio, it will be provided. A cellular phone is required for each field technician regardless of whether or not a 2-way radio is used. Mosquito head netting and jackets, and first aid kit(s) for use during the field season are provided to all field technicians. A first aid kit must always be brought into the field. Individuals must provide (and pack) their own boots, food and drinking water, bug repellent, sunscreen and other personal items needed for each field day.

Maintaining Communication

An emergency contact person must be identified prior to each sampling excursion. This person should be made aware of the location where the field technicians will be sampling, estimated departure and return time, vehicle or boat used for transportation to the field site, and other contact information (e.g., cellular phone numbers). All field technicians must have the appropriate emergency and park contact numbers programmed into their cellular phones before entering the field. A point person in each park should be contacted by the field technicians upon completion of field sampling each day. If a field technician fails to contact the emergency contact person by the pre-arranged return time, emergency notification procedures should be enacted.

Allergies / Medical Conditions

All allergies or special conditions must be brought to the attention of the Project Leader and *all* field technicians prior to the beginning of the field season. Individuals are required to carry any necessary medications (i.e., EpiPens, inhalers) and medical alert tags on their person at all times.

Boat Safety

Any field technician who will be operating a motor boat during the field season is required to complete a week-long Department of the Interior Motorboat Operator Certification Course (DOI MOCC). Completion of the course does not necessarily mean that a field technician will be allowed to independently (without additional NPS supervision) operate an NPS vessel—this is at the discretion of individual parks. Personal Flotation Devices (PFDs) must be worn *at all times* while in a boat. Field technicians with MOCC training are responsible for making sure the boat has the appropriate type and number of PFDs, as well as any other US Coast Guard required safety equipment (e.g., flares, fire extinguishers, radio). Each park may implement specific boating requirements, and field technicians are responsible for following individual park protocols.

Recognizing the Potential Hazards of the Salt Marsh

Plants, insects, and wildlife

Field technicians should be acquainted with potential wildlife/plant and marine organism hazards encountered during fieldwork, including ticks, mosquitoes, stinging insects, jellyfish, and poison ivy. Technicians should be able to identify and be alert to the presence of noxious plants (e.g.,

poison ivy, poison oak) so contact may be avoided whenever possible. Field technicians should be aware of their individual sensitivity to noxious plants, pre-treat with a skin barrier product, and wash thoroughly at the end of the day (washing with liquid dish detergent helps to remove noxious plant oils from the skin). Warning labels on insect repellants should be read thoroughly and only the minimum amount of repellant needed for protection should be applied. Insect repellant is only applied to clothing and not under clothing.

Guidelines for preventing tick borne illness:

- A good source of information regarding Lyme Disease and other tick borne illnesses is the Center for Disease Control website, available at <http://www.cdc.gov/ncidod/dvbid/lyme/index.htm>.
- If sampling is conducted in areas where ticks are present, precautions (e.g., light colored clothing, long sleeves and pants) should be taken to minimize exposure to tick bites. Pants should be tucked into socks and taped. Shirts should be tucked into pants.
- Apply insect repellant containing DEET (20-30% concentration) to your clothing for further protection. Permethrin kills ticks on contact. If using Permethrin, do not apply to clothes while they are being worn. Clothing should be treated and allowed to dry prior to wearing. Permethrin should be applied to clothing only—when applied to skin it loses effectiveness within 20 minutes.
- Check field clothes for ticks before entering living space or vehicles.
- Conduct daily self-checks for ticks immediately upon returning from the field. Pay particular attention to armpits, navel, ears, and groin, and use a mirror when doing self-checks.
- If a tick is found, remove it from the skin as soon as possible. Use fine-tipped tweezers to firmly grasp the tick very close to the skin. With a steady motion, pull the tick's body away from the skin. Clean the area with alcohol or soap and water. Avoid crushing the tick's body. Prior to removal, do not attempt to burn or smother the tick as this will increase the chances of it regurgitating fluids and increase the risk of disease transmission. The tick's mouthparts may remain in the skin after the tick is removed. As long as the tick's head and body are removed from the skin, it can no longer transmit disease.
- Document the tick bite; include the date and time of discovery as well as the location of fieldwork over the last two to four days.
- If a tick bite is found, monitor yourself closely for signs and symptoms of tick borne diseases for up to 30 days. Symptoms of tick-borne illnesses typically take several days to weeks to develop. Most people develop a single itchy red welt at the site of a tick bite. This welt can be up to the size of a quarter and may last for several weeks. This welt does not indicate infection with a tick borne illness. More severe rashes and rashes that spread, or cover a large area will require medical evaluation.
- Seek medical attention if symptoms of tick borne illnesses develop within 30 days of removing an attached tick. These symptoms may include a large bull's eye rash around the tick bite, a pronounced spotted rash on extremities, high fever, headaches, or unexplained joint aches. When seeking medical attention, select a doctor who is familiar with tick borne illnesses.

Guidelines for preventing mosquito-borne illnesses:

- A good source of information regarding West Nile Virus and encephalitis is the Center for Disease Control website:
<http://www.cdc.gov/ncidod/dvbid/westnile/index.htm> and
<http://www.cdc.gov/ncidod/dvbid/arbor/eeefact.htm>
- Stay informed about the presence of West Nile or encephalitis at or near monitoring sites.
- To reduce mosquito bite, wear long pants and head-nets, consider wearing long sleeves. Tuck pants into socks and tuck shirts into pants. Reinforce thin areas of clothing (such as pockets) with duct tape.
- Spray clothing with insect repellent as a barrier or use clothing made of repellent-impregnated fabric.

Other environmental hazards

In addition to wildlife and plant hazards, field technicians should be prepared to work in uneven or muddy terrain. Salt marshes are generally in the open, without significant sources of shade. Therefore, steps must be taken to prevent heat injuries such as dehydration and heat exhaustion. Stay informed about the weather, and be prepared for sudden changes.

Heat - dehydration, heat exhaustion

- Be alert for early signs of heat-related illness, such as thirst, headache, confusion, crankiness, muscle weakness, or excessive or unusual fatigue. Monitor yourself and others.
- If you do notice signs of heat illness, take immediate steps to remediate the problem, such as drinking more water and resting in the shade for ½ to 1 hour. If symptoms do not lessen, seek medical assistance.

Cold - hypothermia

- Be aware of the risks of hypothermia. Hypothermia can occur in mild temperatures especially if it is windy or if clothing is wet. Dress in layers.
- Be alert for early signs of cold-related illness, such as chills, shivering, stiffening or whitening of extremities, confusion, slurred speech, muscle weakness, or excessive or unusual fatigue. Monitor yourself and others.
- If symptoms of cold illness occur, take immediate steps to remediate the problem, such as putting on more layers, moving to a warm place, drinking a warm beverage, and engaging in increased physical activity. If symptoms do not lessen, seek medical assistance.

Uneven terrain - tripping, loose footing

- Be aware of ditches. Ditches can be much deeper than they look or may be partially covered by vegetation.
- Look for and test secure footing.
- Take slow and cautious steps when crossing tidal creeks and large pools—the sediment is often unconsolidated.
- Maintain good communication with co-workers.

Adverse weather

- Be acquainted with park policies regarding safety during adverse weather (i.e., high wind, rough seas, thunderstorms). You may be required to return from the field early.
- Re-schedule or shorten field days accordingly if thunderstorms are likely.
- Cover is generally limited on salt marshes, and you are usually the tallest point increasing the risk of a lightning strike. You are in danger from lightning if you hear thunder.
- If caught in a lightning storm, call the emergency contact to inform them you will be out of radio / phone contact until the lightning storm passes. Call back in after the storm has passed. If you cannot get inside and if you feel your hair stand on end, lightning is about to strike: Make yourself the smallest target possible and minimize contact with the ground (do not lie flat on the ground). Crouch down on the balls of your feet and keep your feet close together. Place your hands on your knees and lower your head. Members of a party should stay separated by at least ten feet. Information regarding lightning safety is available at <http://www.lightningsafety.noaa.gov/>

Tides

- Be alert for rising tides that may rapidly flood tidal creeks, ditches, and the marsh surface, isolating field technicians from the upland or boat.

SOP 3: Selecting Monitoring Sites and Establishing Nekton Sampling Stations

Version 1.00 (September 2012)

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Introduction

This SOP describes methods for selecting suitable monitoring sites for conducting salt marsh nekton monitoring and establishing nekton sampling stations on marsh pools, tidal creeks, and ditches.

Selecting Monitoring Sites

Monitoring sites, approximately five to eight hectares in size, are randomly selected from the population of all potential sites so that statistical inference can be extended to all salt marsh within each park unit (Figure 5). All salt marsh habitat within a park unit is identified and delineated into five to eight hectare areas using GIS. Delineation is based on geographic features such as tidal creeks, salt marsh upland borders, ditches, and bay front. Maps of salt marsh cover types or aerial imagery can be used to aid in delineation of monitoring sites. The rationale for discrete marsh monitoring sites, five to eight hectares in size, is strictly logistical. Field technicians can travel to the monitoring site (often by boat or 4 x 4 vehicle) and then establish nekton sampling stations in a confined area, thereby reducing the amount of time and effort required to travel or walk across a larger expanse of marsh. Permanent monitoring sites are chosen randomly from the entire set of delineated potential monitoring sites.

If there are three or fewer monitoring sites within the park, all of the sites will be sampled. If four or more sites are available within the park, three to nine monitoring sites will be selected randomly from the population of all potential sites. The exact number of monitoring sites selected will be determined based on the extent of the park's marshes, the specific needs of the park, and the feasibility of completing sampling according to time constraints.

A randomly selected monitoring site for nekton sampling should meet the following criteria:

- Monitoring site is logistically accessible.
- Since nekton is the target monitoring variable for this protocol, there must be available habitat (e.g., marsh pools, creeks, ditches) to sample within each monitoring site (refer to later sections in this SOP: Establishing Throw Trap Stations on Pools, Establishing Throw Trap Stations on Creeks, and Establishing Ditch Net Stations on Ditches).

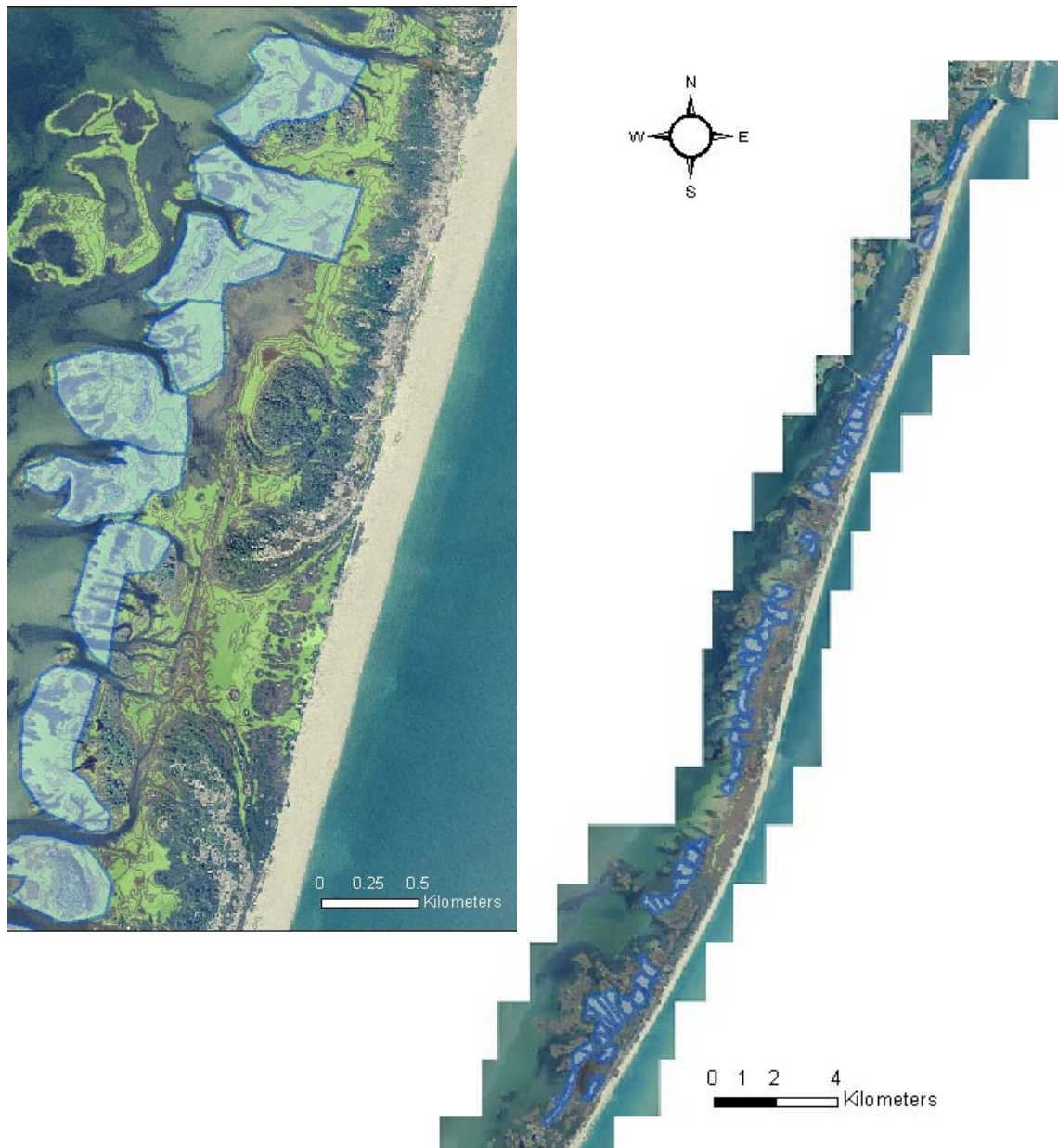


Figure 5. An example of the delineation of salt marsh monitoring sites within Assateague Island National Seashore (ASIS). Inset shows nine of the 54 marsh sites. The aerial photo has been overlaid with salt marsh vegetation (green) to aid in the delineation of salt marsh habitat.

Establishing Throw Trap Sampling Stations on Pools

Depending on the nature of the salt marsh, the combination of techniques used to determine sampling station locations may vary. The most important thing to remember when locating stations, regardless of the method used, is that they are selected randomly.

Classification of pool size

Before the exact locations of sampling stations are determined, all pools are classified according to size. A pool may have up to three sampling stations (depending on size), so even if there are fewer than 15 pools, there may be 15 or more acceptable stations available for sampling. If more than one station is located on a pool, they must be located at least 30 m apart, or if stations are closer than 30 m they must be sampled at least 30 minutes apart.

Pools are classified as either small, medium, or large:

- Small pools have only one station, are defined as those with a perimeter ≤ 60 m, and are often just large enough to fit the throw trap (at least 2 m²).
- Medium pools may have two stations, and are defined as those with a perimeter ≥ 60 m but ≤ 90 m.
- Large pools may have a maximum of three stations, and are defined as those pools with a perimeter ≥ 90 m.

Location and selection of pool sampling stations

The specific locations of sampling stations on the perimeter of a pool (i.e., where the throw trap will be thrown) are randomly located and are established during the field reconnaissance. A compass bearing between 0° and 360° is randomly selected using a random number table (in the field) or a random number generator (in the office), and an imaginary line is drawn from the pool's center along the compass bearing. The intersection of the compass bearing with the pool's edge indicates the position of the station (Figure 6).

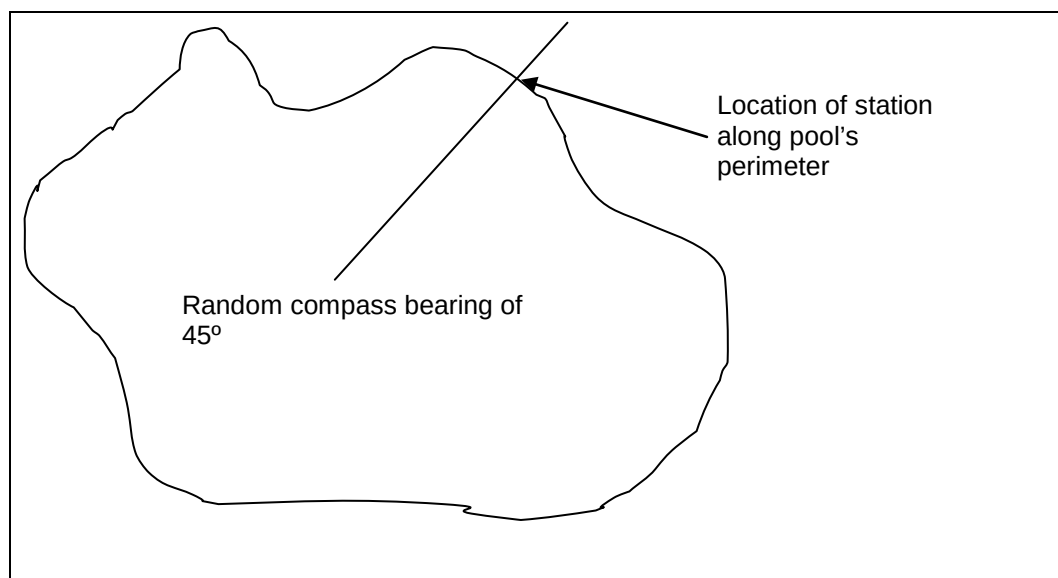


Figure 6. Diagram of random compass method to locate nekton sampling station along pool's perimeter.

Identifying pools at each monitoring site

If aerial photography of sufficient quality is available, identifying pools is done by GIS.

- Classify each pool by size and determine the number of stations it can have (never more than three) using the compass bearing method. Number each potential sampling station.
- Randomly select the minimum number of sampling stations ($n = 15$) from the population of all potential sampling stations. The minimum number of throw trap sample stations ($n = 15$ for each sampling period) is for pools, creeks, and bay fronts combined. In addition, randomly select a few stations as replacements for those that may be unsuitable for sampling. For example, if 15 pool stations are to be sampled, randomly choose 15 numbers between 1 and the maximum number of suitable stations, these 15 numbers correspond to the stations that will be sampled. More stations can be sampled if time and staff permit.
- If there are 15 or fewer available stations, all stations are sampled.
- Pools are preferentially sampled over tidal creeks and bay fronts. If there is a combination of both pools, tidal creeks and/or bay front, establish a minimum of 15 pool stations first, and then establish a few (five or more) throw trap stations on tidal creeks and/or bay fronts (see following section for a description of how to select creek and bay front stations).
- Prior to field sampling, all stations are visited to ensure they can be sampled with the throw trap (e.g., pools $\geq 2 \text{ m}^2$, minimum depth $> 10 \text{ cm}$, accessibility).

If aerial imagery is not available, the goal remains to identify and classify all pools by size within the monitoring site. The following field habitat reconnaissance procedure is suggested:

- Transects are used to systematically traverse the entire monitoring site to ensure all pools are identified.
- Transects are evenly dispersed over the monitoring site. Spacing transects approximately 40-60 m apart is appropriate. It is helpful to have three people walking the transect swath. This allows for one person to walk along the transect with one person walking 20-30 m away along either side, establishing a survey swath, so all pools are encountered.
- Maps used for conducting a habitat reconnaissance include monitoring site boundaries, transects, and coordinates for access points / trails to the monitoring site (if needed).
- Walk each transect, recording the locations of pools as they are encountered. Record the UTM coordinates in a GPS unit as well as on a field data form.
- Classify each encountered pool according to size (small, medium, large).
- Determine the locations of the sampling stations on each pool by using the compass bearing method described above. Record the UTM coordinates in a GPS unit as well as on a field data form. Record other descriptive notes that will help when relocating the station.
- Throw traps are best used within sand or mud bottomed shallow water habitats such as salt marsh pools, pannes, tidal creeks, and bay fronts. The throw trap should not be used in habitats with gravel or rocky bottoms because the seal between the trap bottom and the substrate is often not tight and capture efficiency decreases.
- The time it takes to accomplish this will obviously depend on how many pools there are. In the past, it has taken four days to complete a site reconnaissance at nine monitoring sites marshes that were all five to eight hectares in size.

- Take detailed notes regarding tidal stage, as well as site accessibility and any questions or concerns that are raised during this habitat reconnaissance.
- Randomly select the minimum number of sampling stations ($n = 15$) from the population of all potential sampling stations. The minimum number of throw trap sample stations ($n = 15$ for each sampling period) is for pools, creeks, and bay fronts combined. In addition, randomly select a few stations as replacements for those that may be unsuitable for sampling. For example, if 15 pool stations are to be sampled, randomly choose 15 numbers between 1 and the maximum number of suitable stations, these 15 numbers correspond to the stations that will be sampled. More stations can be sampled if time and staff permit.
- Pools are preferentially sampled over tidal creeks and bay fronts. If there is a combination of both pools, tidal creeks and/or bay front, establish a minimum of 15 pool stations first, and then establish a few (five or more) throw trap stations on tidal creeks and/or bay fronts.
- Complete a brief written description for each monitoring site. The description should be revised at the end of the sampling period to incorporate new or updated information that was obtained during field sampling. Also include a description of any unusual events that occurred during the June to September sampling period (e.g., major storms, oil spills, local fish kills, etc.).
- All GPS waypoint data are downloaded to a computer and backed-up at the end of each field day.

Establishing Throw Trap Stations on Creeks and Bay Fronts

Monitoring sites with tidal creek and bay front habitat have sampling stations established along the creek or bay front edge. The minimum number of throw trap sample stations ($n = 15$ for each sampling period) is for pools, creeks, and bay fronts combined. Throw trap stations on tidal creeks and/or bay fronts are randomly located, and are placed at least 30 m apart, or if stations are closer than 30 m they must be sampled at least 30 minutes apart.

- All suitable creek and/or bay front habitat within each monitoring site is mapped using GIS and potential sampling stations are determined using a 1 meter interval between points.
- Potential sampling stations are assigned a random number between 1 and the total number of available stations.
- Prior to field sampling, all creek stations are visited to ensure they can be sampled with the throw trap (e.g., minimum depth > 10 cm, accessibility).
- Stations located less than 30 m apart must be sampled at least 30 minutes apart.
- Pools are preferentially sampled over tidal creeks and bay fronts. If there is a combination of pools, tidal creeks and/or bay front, then a minimum of 15 pool stations are established first, and then a few (five or more) throw trap stations on tidal creeks and/or bay fronts are chosen.
- All GPS waypoint data are downloaded to a computer and backed-up at the end of each field day.

Establishing Ditch Net Stations on Ditches

Ditch net stations (on ditches or narrow creeks) are randomly located and **MUST** be at least 30 m apart (sampling 30 minutes apart is NOT an option). A minimum of 10 ditch net stations are established at each site.

- Using GIS, all ditch habitat is first digitized by a single line and then those lines divided into 30 meter segments, and the midpoint of each segment located.
- Each midpoint is assigned a random number starting with number 1 and ending with the total number of segments.
- Each midpoint is assessed in the field to determine if the ditch net can be deployed at that location. There must be > 10 cm of water, and no obstructions in the ditch (e.g., overgrown vegetation, large rocks, or logs). If the segment at the midpoint is not fishable, the point is moved 1-m upstream from the mid-point to re-locate the station, if still not fishable, the point is moved 1-m downstream from the mid-point and relocating the station. Repeat this process until a fishable station is located and the station is at 30 m away from closest adjacent ditch net station.
- Nekton sampling stations are established at the first 10 randomly selected fishable segments.
- All GPS waypoint data are downloaded to a computer and backed-up at the end of each field day.

Marking sampling stations (optional)

- Nekton stations can be flagged during the first round of data collection. If the pools are so close together that navigating using a GPS to a particular sampling station is difficult, flagging prior to data collection is suggested to eliminate disturbing the nekton.
- Stations are labeled with unique station IDs.
- Oak stakes (1 m in length) are a good marker, bio-degradable, and readily available from local hardware stores. Station numbers can be indicated on the oak stake with a permanent marker or burned into the wood (branded). Colored flagging can be attached to the stakes to aid in locating the stations. PVC flagging can be used as an alternative, but they may fade between sampling periods so station names must also be recorded on a map of the study site. All stakes or other markings should be removed from the marsh at the final sampling event of the season. Sampling stations will be re-randomized during the next monitoring event.
- UTM coordinates of each sampling station are recorded using GPS.
- All GPS waypoint data are downloaded to a computer and backed-up at the end of each field day.

SOP 4: Construction of Throw Traps and Dip Nets

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Introduction

This SOP describes the materials needed for the fabrication of throw traps and the dip net used to remove nekton from the trap. In addition to constructing the minimum number of traps needed to conduct data collection, it is recommended that at least one replacement of each gear type (including dip nets) be available in the event that equipment is damaged or lost. Many of the materials may be purchased in bulk, which helps minimize costs. With proper maintenance, throw traps and dip nets will last several field seasons.

The throw trap is a 1-m² box (measuring 1 m wide x 0.5 m high) with 3-mm mesh galvanized wire screen sides that is open at the top and bottom (Figure 7). When reporting results from this method, investigators should cite a 3-mm mesh size, the size of the galvanized wire screen (part # 7, below). If water depths are expected to exceed 0.5 m depth, the height of the trap can be extended to 1 m by attaching a skirt (3-mm mesh nylon netting) to the top of the trap. The skirt is equipped with float-cord along the top edge to ensure that the top of the skirt floats at the water surface. The dip net is a metal frame (dimensions just smaller than 1 m) with 1 mm mesh netting sewn to it (Figure 7). This mesh size facilitates the capture of all nekton from the throw trap.



Figure 7. Photo of nekton sampling throw trap (left) and dip net (right) (photos courtesy of MJ James-Pirri).

1-m2 Throw Trap: Materials and Construction

Materials

- Part # 0 (P 0) (refer to Figure 8 for location of part numbers during construction): Vertical Corner Brackets - aluminum angle bar: 2.5 mm (1/8") thick X 31.0 mm (1 1/4") wide (side A) X 31.0 mm (1 1/4") wide (side B) X 50.0 cm (19 11/16") long, 4 pieces.
- Part #1 (P 1): Top and Bottom Horizontal Brackets—aluminum angle bar: 2.5 mm (1/8") thick X 25.4 mm (1.0") wide (side A) X 12.7 mm (1/2") wide (side B) X 100.0 cm long (~39 3/8"), 8 pieces.
- Part #2 (P 2): Top and Bottom Horizontal Straps- Aluminum flat bar: (for the two sides permanently attached to the vertical corner bracket) – 2.5 mm (1/8") thick X 19.0 mm (3/4") wide X 100.0 cm (~39 3/8") long, 4 pieces.
- Part#3 (P 3): Top and Bottom Horizontal Straps: aluminum flat bar (for the two sides detachable to the vertical corner bracket) – 2.5 mm (1/8") thick X 19.0 mm (3/4") wide X 96.0 mm (~38 7/16") long, 4 pieces.
- Part #4 (P 4): Side Vertical Straps: aluminum flat bar (for the two sides permanently attached to the vertical corner bracket) – 2.5 mm (1/8") thick X 19.0 mm (3/4") wide X 46.0 mm (~18.0") long, 4 pieces.
- Part #5 (P 5): Side Vertical Straps: aluminum flat bar (for the two sides detachable to the vertical corner bracket) – 2.5 mm (1/8") thick X 19.0 mm (3/4") wide X 49.4 mm (~19 7/16") long, 4 pieces.
- Part #6 (P 6): Side Vertical Clip Straps: aluminum flat bar (for the two sides detachable to the vertical corner bracket) – 2.5 mm (1/8") thick X 19.0 mm (3/4") wide X 44.8 mm (~17 5/8") long, 4 pieces.
- Part #7 (P 7): Galvanized Wire Mesh or screen 49.4 cm (19 7/16") high X 99.8 cm (~38 1/4") wide with 3 mm (~1/8") mesh size.
- Part #8 (P 8): Stainless Steel Rivets –1/8" diameter X 3/8 – 1/2 grip length - ~ 150 pieces.
- Part #9 (P 9): Stainless Steel Machine Screw and Nuts - # 8-32 X 3/4 Phillip w/ pan head and # 8-32 nuts ~ 50 pieces including spare.

Tools

- Measuring Tape
- Hacksaw
- Drill
- Drill Bits (1/8" and 1/4 ")
- Rivet Gun
- Heavy duty scissors
- C-clamps
- Square Rule
- Vise-grip

Construction

- Cut all the materials to proper length as given in the material list
- Cut the Galvanized Wire Screen (P 7) to the measurements given in the material list.
- Assemble first the two sides that are permanently attached to the Vertical Corner Bracket (P 0) following these steps (Figure 8).
 1. Attach the Galvanized Wire Screen (P 7) to the Top and Bottom Horizontal bracket (P 1) by placing it in the inner side of the angle bar. Clip it with the Top and Bottom Horizontal Strap (P 2). Secure the set-up with a couple of C-clamps and drill through the Galvanized Wire Screen (P 7) and the Top and Bottom Horizontal strap (P 2) well aligned to the pre-drilled holes of the Top and Bottom Horizontal Bracket (P 1) using a 1/8" drill bit. Permanently rivet the pieces together using 1/8 S/S Rivets (P 8).
 2. Attach the set-up to the outer side of the angle bar of Vertical Corner Bracket (P 0) by aligning the four corners and temporarily securing it with a vice grip or a C- clamp. Make sure the four corners are squared (90degrees) by checking it with a square rule.
 3. Drill two 1/4" hole through each corner and slightly diagonal to spread the holes apart, making it a little resistant to shifting movement.
 4. Secure the four corners with a S/S Machine Screw and Nuts (P 9). Make sure it is screwed in tight then remove the temporary clamp.
 5. Attach the Side Vertical Strap (P 4) to the Vertical Corner Bracket (P O), clipping the exposed edge of the Galvanized Wire Screen (P 7)
 6. Drill 1/8" holes on the Side Vertical Straps (P 4), by starting right at the middle of the total length, working your way to both sides with ~ 10 cm. interval and in the middle of the width of the stock. These holes should go through the Galvanized Wire Screen (P 7) and Vertical Corner Bracket (P O) and permanently riveted with 1/8" S/S Rivets (P 8).
 7. Repeat the whole process for another side since there are two sides that are permanently attached to the Vertical Corner Bracket (P O).
- Assemble the two sides that are independent (the detachable sides) of the Vertical Corner Bracket (P O) following these steps.
 1. Attach the Galvanized Wire Screen (P 7) to the Bottom Top and Horizontal bracket (P 1) by placing it in the inner side of the angle bar. Clip it with the Top and Bottom Horizontal Strap (P 3). Secure the set-up with a couple of C-clamps and drill through the Galvanized Wire Screen (P 7) and the Top and Bottom Horizontal strap (P 3) well aligned to the pre-drilled holes of the Top and Bottom Horizontal Bracket (P 1) using a 1/8" drill bit.
 2. Attach the set-up to the Side Vertical Strap (P 5) by aligning the four corners and temporarily securing it with a C-clamp. Drill a 1/8"hole right in the middle through each corner and secure it with 1/8 S/S Rivets. Make sure all four corners are squared (90 degrees).
 3. Attach the Side Vertical Clip Strap (P 6) to the Side Vertical Strap (P 5) clipping the exposed edge of the Galvanized Wire Screen (P 7).
 4. Drill 1/8" holes on the Side Vertical Clip Straps (P6), by starting right at the middle of the total length, working your way to both sides with ~ 10 cm. interval and in the middle of the width of the stock. These holes should go through the Galvanized Wire Screen (P 7) and Vertical Corner Bracket (P 0) and permanently riveted with 1/8" S/S Rivets (P 8).

5. Repeat the whole process for another side since there are two sides that are detachable to the Vertical Corner Bracket (P 0).
6. Attach these two detachable sides to the open outer side of the Vertical Corner Bracket (P 0) that is already permanently attached to two other sides. Align the four corners on both sides and temporarily secure them with a C-clamp or vise grips.
7. Drill two ¼ holes that are slightly diagonal in each corner and fasten them with S/S Machine Screws and Nuts. (These screws and nuts are the removable ones for disassembly making it easy to transport). Once this is done, the throw trap is assembled.

Skirt: Materials and Construction

The 3-mm mesh skirt is attached to the top outside edge of the throw trap so the trap can sample up to 1 m water depth. The skirt is slightly wider than 0.5 m and slightly larger than 4 m in diameter and is equipped with a float-cord along the top edge to ensure that the top of the skirt floats at the water surface.

Materials

- Nylon netting, 3-mm mesh, 4 m long (plus extra) by 0.5 m width (plus a little extra)
- 4 m of float rope (plus extra).
- Cable ties
- Scissors
- Needle
- Nylon carpet thread

Construction

- Sew nylon netting into a 4 m x 0.5 m high cylinder (approximate size) with nylon carpet thread (cotton thread gets weak when wet). Skirt should be only slightly larger than the throw trap circumference to prevent gaps where nekton could escape.
- Attach float rope to one end of the cylinder with cable ties. Cable ties should be spaced close enough together to prevent gaps where nekton could escape. Trim ends of cable ties.
- Attach assembled skirt to the outside of the throw trap with cable ties (or by sewing). Cable ties should be spaced close enough together to prevent gaps where nekton could escape.

Dip Net: Materials and Construction

Materials

- 1.3 cm (1/2 in) aluminum rod, approximately 4 m long for frame.
- 1-mm mesh nylon netting, 1.25 m X 0.75 m.
- Needle and nylon thread (or cable ties) for attaching net to frame.
- 0.5 m length of 2.5-5.0 cm diameter steel or PVC pipe to strengthen handle (optional).

Construction

- Bend the aluminum rod into the shape of the dip net (1 m long by 0.5 m wide) with a 0.5 m handle.

- Sew the 1 mm mesh nylon net to the dip net. Cable ties can be used, but they tend to snag and the net will need more frequent repairs.
- 0.5 m length of 2.5-5.0 cm diameter steel or PVC pipe can be fit over the aluminum rod handle of the dip net to strengthen the handle.

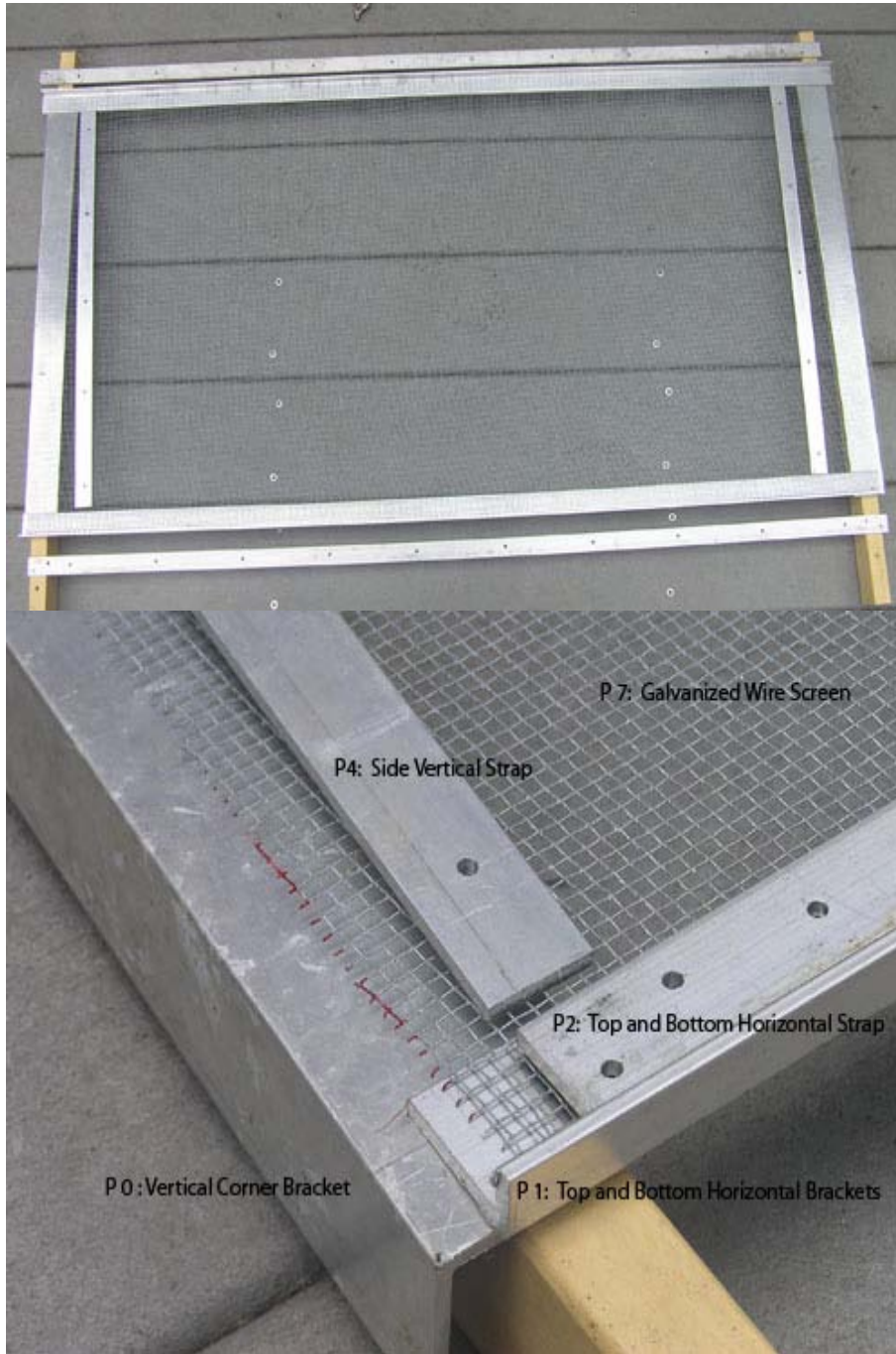


Figure 8. Parts of the throw trap before they are assembled. Two of the throw trap sides are permanently attached to vertical corner brackets (P0 on materials list). The wooden boards are used to support these corner brackets during trap assembly.

SOP 5: Construction of Ditch Nets

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, refer to SOP 10: Revising the Protocol or SOPs.

Revision History Log:

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1.00					

Introduction

This SOP, adapted from James-Pirri et al. (2010), describes the materials needed for the fabrication of ditch nets. In addition to constructing the minimum number of nets needed to conduct data collection, it is recommended that back-ups be available in the event that equipment is damaged or lost. Many of these items may be purchased in bulk, which helps minimize costs. Most supplies can be purchased from any hardware store. With proper maintenance, ditch nets should last several field seasons.

Ditch Net Materials List (for 1 ditch net) and Construction

The material list given below is for **1 ditch net**. This protocol requires a minimum of 10 ditch net samples per monitoring site, so 10 ditch nets should be constructed. It is recommended that at least one replacement ditch net be available in the event that equipment is damaged or lost.

Materials

- Staple gun and 3/8 inch stainless steel staples
- Hog ringer gun and c-ring fasteners, or cable ties (c-ring fasteners are preferred as cable ties are more likely to snag the net).
- Nylon netting, 24-lb test, 1/8 in (3 mm) mesh, at least 1 m wide and 5 m long for each net.
- 20 m of nylon rope, 3/16 in (approx. 5 mm) diameter: Four 4-m lengths for trigger lines and four 1-m lengths for runner lines of the doors.
- 5 m of lead core line: Two 1-m lengths for the top of the doors, and three 1-m lengths for the floor of the net.
- Four stainless steel eye-hooks with 2.5 cm eyes.
- Four oak stakes – 1.5 to 2 m long, 2.5 cm square.
- 25 to 30 plastic D-rings or links from plastic chain approximately 2.5 cm diameter.
- Meter stick (for measuring net and rope).

Construction

- Net center: Cut a 1-m by 3-m section of the nylon netting for the center of the net.
- Net doors: Cut two 1-m by 1-m sections of nylon netting for the doors of the net.
- Attach the doors of the net to the center section. The doors should be centered on the main body of the net along the 3 m net center piece (Figure 9a). To attach the doors take a 1 m length of lead core line and wrap the nylon netting from the leading edge of the door and the center 1 m middle section of the net body around the lead core, fastening the two pieces of nylon netting to the lead core line with the hog ringer gun and c-ring fasteners.
- Attach a length (approximately 1 m) of lead core line to the bottom center of the net (Figure 9b) on the outside of the net using the hog ringer gun and c-ring fasteners. This is to weigh down the center of the net so it does not float up when placed in the ditch.
- Attach the net to the four oak stakes using a staple gun and stainless steel staples. The free edges of the net (Figure 9a, side C, and Figure 9b between points E and F) are stapled to the oak stakes. The portion of the net closest to the doors should be stapled starting at approximately 30 cm from the bottom of the oak stake, and continue up towards the top of the stake. The bottom 30 cm of the stake should be free of the net so that the stake can be pushed into the substrate to hold the net in place while it is deployed.
- Attach 5 to 7 plastic D-rings to sides of the doors (side A in Figure 9a). Use the hog ringer gun and c-ring fasteners to attach the rings to the nylon netting. The rings should be attached to the edge of the netting so the center of the ring is clear of the netting. The trigger line that pulls the doors up passes through these rings.
- Attach a short length of lead core line to the top of each door (Figure 9a, side B) using the hog ringer gun and c-ring fasteners. This is to weigh down the top of the net so it does not float during deployment.
- Attach 3 to 5 D-rings (5 is better) to the top of the door (side B in Figure 9a). Use the hog ringer gun and c-ring fasteners to attach the rings to the nylon netting. The rings should be attached to the edge of the netting so the center of the ring is clear of the netting.
- Cut four 1.1-m lengths of rope for the runner lines. The runner lines hold the plastic D-rings close to the stake, so when the door is pulled up the net remains close to the stake. Attach the bottom of runner lines to the interior of the stakes (on top of the stapled netting). The bottom of the runner line should be attached at the intersection of the net doors and main body of the net. Tie a few knots in one end of the runner line. Staple the end with the knot to the stake using several staples close together on each side of the knot so the line will not pull loose.
- Pass the free end of the runner line through the 5 plastic D-rings that are attached to side A (Figure 9a) of the door closest to the stake (Figure 9b, runner line [G] and plastic rings [H]). The bottommost ring is threaded first, then the next ring, until all rings for that door side are on the runner line. Once all rings are on the line, tie a knot at the end of the line. The runner line is then pulled taut against the stake and the free end is stapled approximately 5 to 8 cm above the end of the net. Staple the line to the oak stake on both sides of the knot.
- Tie one trigger line to the center ring on the top of the door, and pass the free end through the rings on the top of the door. Then pass the trigger line through the top ring on the corner of the door that is attached to the runner line. Attach the other trigger line to the

same center ring, and pass it through the other top rings, and the corner ring on the other side of the door. When the trigger lines are pulled, they pull on the top rings attached to the doors, which in turn pull the sides of the doors up the stakes to enclose the sides of the net.

- Attach the trigger lines to the other door of the net as described above.
- Attach one eye-hook to each oak stake. When the net is held upright, with the 4 stakes in the ground, the eye-hook should be placed on the outside of the stake, on the side that is flush with the door. The free end of the trigger line is passed through the eye-hook. When the trigger lines are pulled the line should pass easily through the eye-hook, so the doors pull up smoothly.
- Label the stakes A, B, C, and D. Be sure to label each net exactly the same. The labels are used to set the net correctly in the ditch and to measure the distance between the stakes in order to determine the surface area of the water that the net fishes (refer to field data form). For example, stakes A and B are placed on one side of the ditch and stakes C and D are placed on the opposite side of the ditch.
- Test the net to be sure that the trigger lines pull up the doors smoothly and quickly.

Reference documents:

James-Pirri, M. J., C. T. Roman, and J. L. Swanson. 2010. A quantitative gear to sample nekton in salt marsh ditches and small tidal creeks. *Transactions of the American Fisheries Society* 139:413-419.

Bottom of oak stake (not attached to netting)

Plastic rings (H)

The runner line (G) will pass through the plastic D-rings (H) on the door.

Runner line (G)

Stake

Lead core

Oak stake

Netting is attached to oak stake from point E to F (runner line is not shown for clarity)

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SOP 6: Using a Handheld GPS for Salt Marsh Monitoring

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, refer to SOP 10: Revising the Protocol or SOPs.

Revision History Log:

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1.00					

Introduction

This SOP describes the procedures for using a handheld GPS unit to locate sampling stations, and for saving, and deleting information to and from the GPS. All field technicians must be able to use the GPS to navigate to sampling locations and be able to save waypoints to the GPS.

Definition of Terms

Coordinates are a set of numbers describing your exact location on the earth's surface. Latitude and longitude are one example of a coordinate system. The NCBN uses the UTM (Universal Transverse Mercator) coordinate system when referring to the location of a sampling station.

A horizontal **datum** is used as a reference point for determining a specific location on the earth's surface in a coordinate system such as latitude and longitude, or UTM. For example, the coordinates of a particular sampling station will be based on its location relative to a specific reference point, or datum. The NCBN uses NAD 83 (North American Datum 1983) as the datum when conducting salt marsh monitoring.

A **waypoint** is a set of coordinates that are either recorded with a GPS or uploaded to the GPS for navigational purposes, and represent the location of sampling stations or other features (i.e., marsh access points).

WAAS (Wide Area Augmentation System) is an array of satellites and ground stations that provide GPS signal corrections. WAAS does not help the GPS unit determine your location, but rather it helps to make the position calculation more accurate.

Configuring the Handheld GPS Unit

Use the User's Manual to navigate the menu options. Verify the following:

- Datum is set to NAD83.
- Position or Location Format is UTM/UPS.
- Verify that the correct UTM zone is selected.
- Units for distance, speed, and other parameters are set to metric units (meters, meters / sec).
- Compass heading is set to 'true'.
- WAAS is enabled.
- Route preference is set to 'off road'. If 'off road' is not selected, the GPS will try to navigate to the site and sampling stations using roads, which is not at all helpful in a salt marsh.

Preparing for Field Sampling

- Check battery levels—at least 8 hours before use, ensure that batteries are fully charged.
- Always have at least two sets of fully charged batteries available at all times.
- Upload coordinates for sampling stations (waypoints) to GPS units.
- Print out maps of monitoring sites with access points and sampling station locations labeled.

Using the Handheld GPS unit to Navigate to Known Locations

- The GPS unit can be used to navigate to known locations (i.e., previously uploaded or saved waypoints).
- Turn on GPS, and allow it to acquire signals from available satellites. Wait until the GPS status indicates '3D differential.'
- Select the waypoint to which you would like to navigate.
- The GPS will indicate the direction and distance to the waypoint.

Saving Waypoints to the Handheld GPS unit in the Field

Waypoints are recorded when conducting a marsh reconnaissance to determine suitable sampling locations. In addition to saving waypoints to the GPS unit, the waypoint ID and coordinates are recorded on a waterproof field data form. This prevents loss of data in the event of equipment malfunction.

To save a waypoint:

- Consult the User's Manual for specific instructions for saving waypoints.
- For increased accuracy it is best to 'average' your location. Collect positions until the measurement count reaches 90-120 and the accuracy is 5 m or less.
- Save 'averaged' waypoint.
- Record waypoint number, UTM X and UTM Y coordinates, and estimated horizontal error on the field data form.

Reference Documents

A reference manual for creating quality GIS data with GPS technology is available at:

<http://www.nps.gov/gis/gps/gps4gis/>.

SOP 7: Sampling Procedures

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, refer to SOP 10: Revising the Protocol or SOPs.

Revision History Log:

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1.00					

Introduction

This SOP describes all necessary materials and methods for collecting nekton data using the recommended gear. All staff and field technicians must be familiar with these methods prior to the first sampling event.

Staffing Requirements

For safety and efficiency a minimum of two field technicians are required to conduct the nekton sampling. Four technicians (two teams of two technicians) can sample more monitoring sites, and this is recommended if more than one park is monitored in the same year, especially if multiple protocols are implemented in the same year.

Sampling Schedule

Nekton monitoring is conducted twice per year, once in early summer (mid-June through July) and again in late summer-early fall (August through September). Generally, northern parks are sampled from June 15 – September 15, whereas southern parks may be sampled from June 15 - September 30. Sampling in subtidal salt marsh habitats (e.g., creeks and pools) with a throw trap occurs only when the marsh surface is drained of tidal water (during ebb or flood tides) and when there is an adequate water depth for sampling (> 10 cm at low water). Sampling for a specific period at a specific park should be completed within 7 to 10 days.

Supplies and Equipment

This protocol uses two types of enclosure traps, throw traps and ditch nets, as the sampling gear (Figures 10 and 11). The throw trap is used to sample shallow water (< 1 m) in marsh pools and along tidal creeks and bay fronts. The ditch net (Figure 12) is an enclosure gear designed to sample narrow ditches and smaller tidal creeks up to 1 m wide and 1 m deep.

Materials for locating nekton sampling stations

- Aerial photo and map of monitoring site that shows the site boundaries and nekton sampling stations.
- GPS unit.
- Compass.
- Random number table - to be used in the event that adjustments to station locations are done in the field.

Materials for marking station locations (optional)

- Oak stakes or flags to mark sampling stations.
- Mallet to pound stakes into ground.
- Black permanent markers to apply sampling station number on stakes.
- Colored flagging (optional) to tie to oak stakes.

Materials for data collection

- Field data forms printed on waterproof paper, pencils.
- Small metric rulers (mm increments).
- Meter stick.
- Field guides (or laminated species identification sheets).
- Non-mercury thermometer.
- Refractometer to measure salinity.
- YSI for measuring dissolved oxygen (optional).
- Throw trap (for pool, creek and/or bay front sample stations).
- Dip net (for throw trap).
- Ditch nets (for ditch sampling ditches, if needed).

What to do if a Sampling Station is Dry

Nekton sampling stations can be sampled with water ≥ 10 cm depth, stations with less than 10 cm of water are considered to be “dry”. If there are stations that may go dry during the summer in between sampling periods (e.g., shallow pannes), additional sampling stations should be randomly selected prior to the beginning of the season to compensate for the possibility of some stations becoming dry during the second sampling period.

- Occasionally, a sampling station selected during reconnaissance will be dry during the sampling period. If the sampling station is dry, and it is the first round of sampling, the station should be deleted and a new station should be randomly relocated. If the station cannot be relocated (due to lack of pools, creeks, ditches), record as much data (e.g., coordinates, surrounding vegetation) as possible on the field data form, and note that the station was dry—this station will be revisited during the second round of nekton sampling.
- If the station was previously sampled in the first sampling period and is dry during the second period, note that the station was dry and record as much data (e.g., coordinates, surrounding vegetation) as possible on the field data form. Stations that were sampled in the first sampling period that go dry in the second sampling period are not replaced.

Sampling Procedure for the Throw Trap

- Only the person throwing the trap approaches the sampling station, all others remain at a distance (> 10 m) from the station to avoid startling the nekton.
- Sampling stations are approached slowly and quietly with light tread to minimize disturbance to nekton. Once within a few meters throwing distance (depending on the ability of thrower), the person quietly remains motionless for a minimum of 2 minutes to allow any disturbed nekton to settle. Then the trap is quickly thrown into the pool, creek, or bay front. It is important to minimize disturbance to nekton prior to throwing the trap and individual throwers may have slightly different approach methods.
- There are two methods for throwing the throw trap depending on the physical ability of the person conducting the sampling.
 - Method 1: The trap is thrown into the water by tossing it from the hip like a giant frisbee (Figure 10). The trap is then quickly pushed down into the sediment to prevent escape of nekton from under the trap.
 - Method 2: The trap is thrown overhead (Figure 11). The distance the trap is propelled in the air is often less using this method, requiring the thrower to stand closer to the station, which is less desirable as nekton may be disturbed before the trap lands in the water.
 - Regardless of the method used, the thrower must throw the trap a distance of 3 to 4 meters to insure that the method is standardized among different field crews and that disturbance of nekton is minimized as the trap is thrown.
- Repeat attempts at the same sampling station (if the trap lands wrong) are taken at least 30 minutes apart. It must be noted on the field data form if repeat attempts were required.
- Once the sample is secured, nekton are removed using the large dip net.
 - The dip net is slid downward into the trap, flush against the sides of the trap. The net is moved across the bottom of the trap with the forward edge of the net always remaining flush or slightly below the sediment until the opposite side of the trap is reached. In muddy sediments, the dip net often goes through a thin layer of surface sediment.
 - The dip net is then lifted out of the trap, again keeping the leading edge flush against the far wall of the trap.
 - All nekton captured in the dip net are processed (refer to later sections of the SOP).
 - The dip net is used from all four sides of the trap because nekton may be located in the trap corners.
 - The dip-netting procedure is repeated until three consecutive dips from three different sides of the trap, do not capture any animals or if the first four consecutive dips (on all four sides) come up empty. When this occurs the trap is considered empty.
- Density estimates for nekton sampled using the throw trap are presented as number of nekton per m^2 .



Figure 10. Sampling technique for the throw trap. The trap is tossed like a frisbee into the pool that is being sampled. Note: the throw trap in the photo has a mesh skirt attached to the top outside edge (photos courtesy of MJ James-Pirri).



Figure 11. Overhead method for throwing the throw trap (photo courtesy of MJ James-Pirri).

Sampling Procedure for the Ditch Net

Deploying the ditch net

- Ditch nets are placed at the sampling station in the ditches at least 30 minutes before sampling.
- Two people are required to deploy a ditch net, with each person standing on opposite sides of the ditch.
 - One person will take stakes labeled “A” and “B” and place the stakes into the bottom of the ditch close to the side of the ditch.
 - The other person will take stakes labeled “C” and “D” and place them on the opposite side of the ditch.
 - The bottom of the net should be stretched tight between stakes “A” and “B” and stakes “C” and “D” so that approximately a 1 m section of ditch is sampled (Figure 12).
- The trigger lines from the doors should be pulled to test that the lines are not fouled or tangled and that the doors will pull up smoothly and quickly.
- Push the doors and the center of the net down into the bottom of the ditch with the meter stick. Make sure that the net lies on the bottom of the ditch, so that nekton passage through the net is not impeded.
- Measure the distance between all the stakes (e.g., “A” to “B”, “B” to “C”, “C” to “D”, and “D” to “A”) and the diagonal distance between stakes “A” and “C” and record these on the field data form. These distances are measured when the net is placed in the ditch and are necessary to calculate the surface area (sum of two irregular triangles) that is sampled (refer to Figure 13).
- Lay the trigger lines from the doors out on the marsh surface as far from the ditch net as possible without pulling on the doors (approximately 3 m).
- Note the time that the ditch net is deployed on the field data form.

Sampling ditch nets

- Ditch nets are not sampled until they have been deployed for at least 30 minutes. This acclimation period is necessary to minimize any disturbance to nekton caused by placing the net in the ditch.
- Ditch nets are sampled when water has drained off the surface of the marsh, but when there is still adequate water in the ditches and smaller tidal creeks to sample (> 10 cm depth).
- Two people are required to trigger the ditch nets to obtain a sample.
- The ditch nets are quietly approached with light tread from opposite sides of the ditch, one person on each side.
- Upon reaching the trigger lines from the doors, each person kneels and waits quietly for approximately two minutes. The trigger lines to the doors should not be handled during this time, as the vibrations on the lines can be transmitted to the stakes and possibly disturb nekton that are in or near the net. At a pre-determined signal, both people quickly pull on the lines and run towards the net. The doors of the net will pull up, enclosing nekton within the net (Figure 12).
- The ditch net is quickly lifted out of the ditch and onto the marsh surface. Both people pull the stakes out simultaneously (while still maintaining pressure on the trigger lines from the doors).

- All four stakes are then handed to one person who will lift the net out of the ditch and onto the marsh surface. Pulling the stakes and net out of the ditch creates a bag of netting in the center of the net where nekton are trapped.
- The ditch net is then laid out on the marsh surface and the nekton are identified, counted, and measured.
- In the office, the surface area sampled by the ditch net is calculated from the sum of two irregular triangles (Figure 13) and density estimates for nekton are presented as number of nekton per m².

Processing the Samples

- Nekton may be identified using any number of field or taxonomic guides (refer to Appendix A).
- For each throw trap or ditch net sample, all nekton are identified and counted. Additionally, up to 15 haphazardly selected individuals of each species captured are measured, or for species with ≤ 15 individuals collected length is recorded for all individuals. Nekton are measured to the nearest millimeter for total length (from the tip of the snout to the tip of the caudal fin for fishes; from the tip of the rostrum to the tip of the telson for shrimp) or carapace width for crabs (the distance between the two furthest points across the carapace).
- Voucher specimen(s) of any unknown or questionable identification should be humanely sacrificed, preserved, and transported to the laboratory for positive identification. All voucher specimens should be stored in appropriate containers and clearly labeled with the contents (type of preservative), species, sample date, monitoring site, and sampling station number.
- Environmental variables (water temperature, salinity, dissolved oxygen, water depth, creek depth) should be measured *after* the throw trap is tossed and before dip-netting or *after* the ditch net is pulled from the ditch and the sediment has settled (refer to Measuring Environmental Variables in this SOP).



Figure 12. Photos of ditch net in the field showing correct deployment (top), doors being pulled up (middle), and the net once the doors have been pulled (bottom) (photo excerpted from of MJ James-Pirri et al. 2010).

Calculating the Surface Area Sampled by a Ditch Net

The surface area of a ditch net is calculated as the sum of two irregular triangles. The areas of the two irregular triangles are calculated from the five distances between the stakes that are measured in the field.

$$\text{Area sampled (m}^2\text{)} = \sqrt{[s_1 * (s_1 - a_1)(s_1 - b)(s_1 - c_1)]} \text{ Where:}$$

a_1 = side one of triangle 1

c_1 = side two of triangle 1

b = diagonal between triangle 1 and 2

a_2 = side one of triangle 2

c_2 = side two of triangle 2

$$s_1 = \frac{(a_1 + b + c_1)}{2}$$

$$s_2 = \frac{(a_2 + b + c_2)}{2}$$

For example, a net with the following dimensions:

Where:

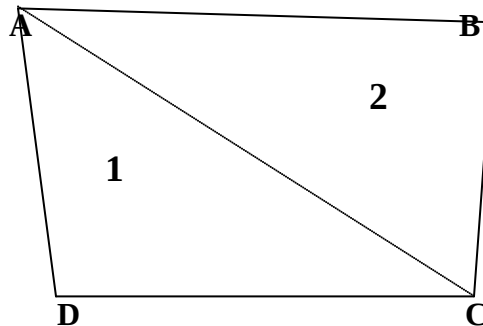
A to B = 81 cm

B to C = 73 cm

C to D = 71 cm

D to A = 76 cm

A to C (diagonal) = 109 cm



$$s \text{ for Triangle 1: } s = \frac{(71 + 76 + 109)}{2} = 131.5$$

The area of Triangle 1:

$$\sqrt{[131.5 * (131.5 - 81)(131.5 - 73)(131.5 - 109)]} = 2956.5 \text{ cm}^2$$

$$s \text{ for Triangle 2: } s = \frac{(81 + 73 + 109)}{2} = 128$$

The area of Triangle 2:

$$\sqrt{[128 * (128 - 71)(128 - 76)(128 - 109)]} = 2684.9 \text{ cm}^2$$

The total area of the net would be: $2956.5 \text{ cm}^2 + 2684.9 \text{ cm}^2 = 5641.4 \text{ cm}^2$ or 0.56 m^2

Figure 13. Example of the calculation required to estimate the surface area of water sampled for a ditch net.

Field data form

The nekton field data form is used to record nekton data and environmental conditions at each sampling station. Examples of field data forms are provided in Appendix B.

Field data forms are completely filled out before moving on to the next sampling station. It is important the form is reviewed carefully to make sure all data fields are completed. Unknown species may be vouchered and identified in the lab. Upon returning from the field, all forms are checked to make sure they include all information. If any information is missing, every attempt should be made to complete the missing information. Mistakes are not erased—a single line is drawn through the mistake and the corrected information is written above or to the side of the original entry. Any corrections or edits to information on the field data form are dated and initialed by the person making the change.

Nekton field data form

- Site: Park Code and Site Code (monitoring site).
- Date: Date of sample collection (month, day, year).
- Station ID: Unique number for the sampling station.
- Time: Time throw trap station was sampled; time ditch net was set and pulled.
- Sampling Crew: The initials of the field technicians conducting the sampling.
- Coordinates: The GPS coordinates of the sampling stations recorded during the sampling event. The preferred coordinate system is UTM, meters.
- Horizontal error of the GPS.
- Habitat Type: The appropriate habitat type is circled: pool, creek, shoreline for throw trap stations; or plugged or open ditch for ditch net stations.
- Temperature: Water temperature (°C) is taken mid water column.
- Salinity: Salinity of water (ppt) is taken mid water column.
- Dissolved Oxygen (optional): Dissolved oxygen of water (mg l^{-1}) is taken mid water column.
- Ditch Net Dimensions (for ditch net field data form): Record the distances in cm between labeled ditch net stakes.
- Water Depth: Depth of water in pool, creek, or ditch (cm) is measured from the bottom of the pool, creek, or ditch to the water surface. Three haphazardly selected measurements from inside the throw trap or ditch net are taken and are averaged to obtain a mean water depth.
- Ditch Depth (ditch net only): Depth of ditch (cm) is measured from the bottom of the ditch to the marsh surface. Three haphazardly selected measurements are taken and averaged to obtain a mean ditch depth.
Creek Depth: Depth of creek (cm) is measured from the bottom of the creek to the marsh surface. Three measurements are taken from the same position that water depth was measured and averaged to obtain a mean creek depth.
- Sediment Type: appropriate sediment type (mud or sand) is circled.
- Tide: The appropriate tidal stage (ebb, flood, slack) at time of sampling is circled.
- Percent cover of submerged aquatic vegetation or salt marsh vegetation within the throw trap (list species and circle appropriate cover category).

- **Adjacent vegetation:** List the dominant vegetation species immediately adjacent to pool, creek, or ditch net stations.
- **Species:** List each species that is collected. If common names are used in the field, the scientific names are noted on the field data form at the end of the field day as soon as possible to ensure accurate information is entered into the Access database.
- **Length:** The length (mm) or carapace width (mm) of 15 individuals.
- **Tally:** A tally of the number of individuals of a species that were collected not including the measure fish (these will be added later to the final tally). This can be short hand notation (i.e., +10, +12, +36, +2, +5, etc.), as long as the total number (see below) is filled in upon returning from the field.
- **Total:** The total number of individuals of a species that were sampled (the 15 measured individuals plus the tally).

Measuring Environmental Variables

In conjunction with nekton measurements, environmental data are collected to help characterize each station. These environmental variables are collected at each nekton sampling station during each sampling visit. To minimize disturbance to the nekton community prior to sampling, these measurements are taken after the throw trap is tossed and before dip-netting or after the ditch net is pulled from the ditch.

Water Temperature

Water temperature (°C) is measured at each sampling station using a stick thermometer or temperature probe. Temperature is taken at mid-depth of the water column.

Salinity

Water salinity (ppt) is measured at each sampling station using either a refractometer or a water quality probe. Salinity is taken at mid-depth of the water column.

Dissolved Oxygen (optional)

Dissolved oxygen (DO) is a common water quality variable that is often collected in conjunction with nekton sampling; however, single measurements are often difficult to interpret. A diurnal time series provides more useful information (Raposa and Roman 2001, Corman and Roman 2001). However, since this variable is easily measured, DO readings are recorded at each sampling station if equipment is available.

The DO concentration of water (mg/l) is measured at mid-depth of the water column at each sampling station using a water quality probe. Readings are taken in an area with little sediment disturbance. It may be necessary to measure DO concentration a slight distance from where the throw trap landed or where the ditch net was pulled to avoid getting erroneous readings due to sediment disturbance.

Water Depth

Water depth (cm) in the throw trap or ditch net is measured to the nearest cm using a meter stick. The throw trap often lands on an uneven bottom, and thus, depth is measured at three haphazardly selected locations inside the trap to obtain a mean water depth.

Water depth for the ditch net is measured *after* the ditch net is removed from the ditch. This is because water in ditches may increase or decrease between the time the net was deployed and the time it is pulled from the ditch. Three haphazardly selected measurements are taken to obtain a mean water depth.

Ditch Depth (Ditch Net)

Measuring ditch depth is useful for determining the flooding stage of the ditch. Ditch depth at the ditch net station is measured from the marsh surface to the bottom of the ditch using a meter stick. Three haphazardly selected measurements are taken to obtain a mean ditch depth.

Creek Depth

Measuring creek depth is useful for determining the flooding stage of the creek. Depth of the creek (cm) is measured from the marsh surface to the bottom of the creek using a meter stick. For throw trap stations, three haphazardly selected measurements are taken (from the same three locations where water depth is measured) to obtain average creek depth. If a ditch net is used to sample a narrow creek, three haphazardly selected creek depth measurements are taken at the location where the net was deployed.

Percent Vegetative Cover

If macroalgae and/or vegetation (aquatic or salt marsh vegetation) are present inside the throw trap, percent cover of each species is recorded. These data provide a measure of the complexity of habitat available to the estuarine nekton. Prior to dip-netting for nekton, the percent cover of each plant species should be visually estimated according to the following cover class categories (< 1% cover, 1-5%, 6-25%, 26-50%, 51-75%, >75%). Percent cover of vegetation is not estimated for ditch nets because the ditch net must be set in an area free of vegetation for correct deployment.

Adjacent Vegetation

Dominant vegetation (e.g., *Spartina alterniflora* or *S. patens*) immediately adjacent to the nekton sampling station is recorded. This is a simple species list (no cover class) of the dominant vegetation surrounding a pool, or growing along the edge of a creek or ditch. This information helps to better characterize the station location.

Sediment Type

The sediment type (sand or mud) at each nekton sampling station is recorded.

Reference Documents

Corman, S. S. and C. T. Roman. 2011. Comparison of salt marsh creeks and ditches as habitat for nekton. Marine Ecology Progress Series 434:57-66. doi: 10.3354/meps09189.

James-Pirri, M. J., C. T. Roman, and J. L. Swanson. 2010. A quantitative gear to sample nekton in salt marsh ditches and small tidal creeks. Transactions of the American Fisheries Society 139:413-419.

Raposa, K. B. and C. T. Roman. 2001. Monitoring nekton in shallow estuarine habitats. Part of a series of monitoring protocols for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, Coastal Research Field Station, University of Rhode Island, Narragansett, RI 02882.

SOP 8: Data Management

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, refer to SOP 10: Revising the Protocol or SOPs.

Revision History Log:

New Version#	Previous Version #	Revision date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00					

Introduction

Proper data management and standardization are essential to the effective utilization of information gained through long-term ecosystem monitoring activities. This SOP provides guidelines for the development, storage, and distribution of monitoring data associated with the Network's Salt Marsh Nekton Monitoring Protocol. This document describes how information and data generated at various points during the data collection, analysis, and reporting processes are to be organized, stored, and disseminated. This SOP describes the file management system used for this protocol, and details how monitoring data are stored in the NCBN Salt Marsh Monitoring database. The SOP also outlines the procedures for performing data quality assurance and quality control (QA/QC), archiving both spatial and tabular datasets, and making the data publicly accessible via biological information clearing houses.

A formal information management plan for all NCBN monitoring protocols is available at http://science.nature.nps.gov/im/units/ncbn/d_im_plan.aspx and should be consulted for more detailed policy information.

Definition of the Salt Marsh Nekton Dataset

The Salt Marsh Nekton Monitoring program will produce a number of electronic and paper data files that will include formal written reports, a Microsoft Access database, and both paper and scanned field data forms. The large number and variety of files will require conscientious and formal attention to their management. It is the responsibility of the Network Data Manager and Project Leader to assemble, maintain, and make available the various components of the Salt Marsh Nekton dataset described here.

The primary repository for all data collected for the protocol is a Microsoft Access database consisting of a main, front-end database (.mdb) file, one back-end file (.mdb) containing lookup tables and information common to all Network databases, one back-end file (.mdb) containing the actual field data collected for the protocol, and an accompanying folder containing digital

photographs obtained during field data collection and linked to records within the protocol database. For QA/QC purposes, however, hard- and digital copies of the original field data forms are also maintained.

In addition to this primary field data, Network staff will periodically produce annual and long-term (five-year) reports summarizing and interpreting the results from analyses of the above data. Copies of these reports will be delivered to the NCBN Data Manager / Project Leader and stored primarily as Adobe Portable Document Format (.pdf) files.

The Microsoft Access Database

All raw data collected annually as part of the Salt Marsh Nekton Monitoring Protocol will be entered into the NCBN Salt Marsh Monitoring database, a Microsoft Access database which is compliant with the NPS Inventory and Monitoring Program Natural Resource Database Template, version 3.2

(<http://science.nature.nps.gov/im/datamgmt/applications/template/index.cfm>). Key aspects of the database design include:

- Ease of data entry, mirroring as closely as possible the processes for recording data on Protocol field data forms.
- Built-in quality control features (e.g., primary keys, cascading edits through multiple tables, lookup tables, numeric range limits, etc.).
- Standardized formatting allowing for ease of data sharing and cross dataset analyses.

File Management

The master (i.e., most current) version of the Salt Marsh Monitoring database will reside on the Network file server under the main drive in the file structure outlined in Figure 14.

Prior to annual data entry or analysis activities, the Project Leader will obtain the most recent version of the database from the Network Data Manager. A copy of the database is made in the '01_Planning' folder within the appropriate ANNUAL folder for the current fiscal year (Figure 14). This copy of the database will migrate through the remaining folders 02 through 04 as the raw data undergoes QAQC checks before reaching its final form. (See Network Data Server Directory Structure appendix in the NCBN Information Management Plan for more details).

The database consists of three Microsoft Access (.mdb) files and an accompanying folder for storage of digital photographs taken in the field during sampling. The three files and the folder should always be placed in the same location within a given directory structure. See NCBN and CACO Salt Marsh Monitoring Database User's Guide, Section 1 (http://science.nature.nps.gov/im/units/ncbn/products/Monitoring/VS/Saltmarsh/NCBN_Saltmarsh_DB_UsersGuide_20091214.pdf).

In addition, the Project Leader will place a copy of the database on each laptop that will be used by field technicians for data entry purposes while stationed at a park.

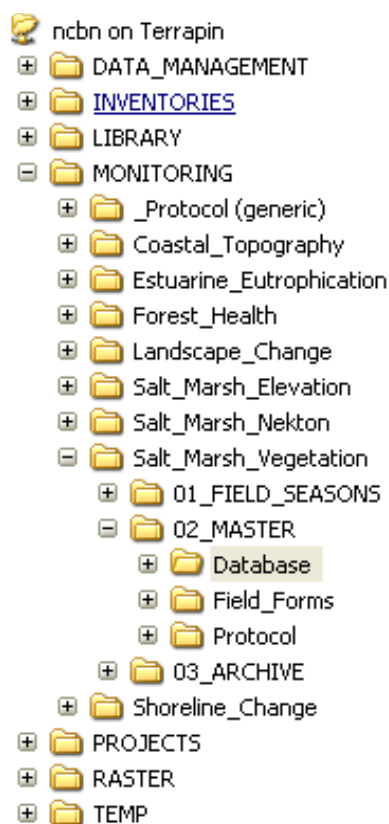


Figure 14. Location of Access database within the Network file server directory structure.

Data Entry

The Project Leader will be responsible for either entering or overseeing data entry by technicians. Data collected using paper field data forms will be entered as soon as possible following data collection when field technicians' memories are fresh and discrepancies in the data are more easily resolved. Ideally, data entry should take place immediately following the field technicians' return from the field on a given day. The *NCBN and CACO Salt Marsh Monitoring Database User's Guide*

(http://science.nature.nps.gov/im/units/ncbn/products/Monitoring/VS/Saltmarsh/NCBN_Saltmarsh_DB_UsersGuide_20091214.pdf) provides comprehensive instructions on entering raw data into the Microsoft Access application.

Incremental backups

As noted in Section 1.3, *NCBN and CACO Salt Marsh Monitoring Database User's Guide*, it is important for personnel entering data to back up the main back-end database file (NCBN_Saltmarsh_Monitoring_BE_[date].mdb) before each data entry session, as changes to fields or records are saved automatically in Microsoft Access. Users are prompted to back up the main back-end database file by the application whenever they open the database.

In addition, once a field technician has completed data entry for a given day, he or she must back up the updated database file in a location other than the field laptop. Acceptable procedures would include saving a copy of the database file to an external hard drive; burning the file to CD, DVD, or other media; or uploading a copy of the file to an NPS FTP server. The Network Data

Manager will assist the Project Leader in providing appropriate storage media prior to the initiation of the field season.

Database synchronization

Upon completion of the field season, the Project Leader will provide the Network Data Manager with copies of the most current database files from each of the field laptops. The Data Manager will then synchronize all field versions with the Master database on the NCBN Data Server and provide the Project Leader with a single, merged copy of the database for data verification and validation purposes.

After each field season, the Network Data Manager will also obtain a copy of the three database files from the salt marsh monitoring personnel. However, all additions to the main species list (tbl_Species) located in the shared back end file containing common lookup tables (NCBN_Saltmarsh_Monitoring_NER_be_[Date].mdb) will be incorporated into a single, master version.

Following the completion of all QA/QC procedures, the Project Leader will provide a “clean” copy of the database to the Data Manager. The Data Manager will archive the database and will also synchronize the database with the Salt Marsh Monitoring Master Database (containing data collected for all field seasons) on the NCBN Data Server (Z:\MONITORING\Salt_Marsh_Vegetation\02_MASTER\Database).

QA/QC of Tabular and Spatial Data

Data verification

To minimize transcription errors, someone other than the person who entered the data will verify each line of data against the original field data forms. If no staff members are available, the Project Leader or Data Manager should verify 100% of the data entry. Fields indicating the verification of records (date verified, reviewer’s name, etc.) are included within the database. In addition, 10% of records will be reviewed a second time by the Project Leader. The Project Leader will convey the results of this comparison to the Data Manager, who will incorporate the information into the database’s metadata file during the final review / archiving process. Table 1 is an example of a checklist used to track progress in the data verification and archiving process. Once all field data for a season have been entered into the database, the Project Leader should export the *Nekton - All Data Except Vegetation* Excel file and check each record against the original field data form (this Excel file summarizes data that are otherwise stored or displayed in multiple tables and forms within the database, greatly facilitating visual inspection of the records).

Finally, in order to ensure that all records have indeed been verified for a field season, the Project Leader should export the *Nekton - Data Verification* Excel file and determine that the *Last_Name* and *Verified_Date* fields are completely populated.

Tabular data validation

Although a number of validation measures have been included in the design of the monitoring database itself, a critical examination of some specific tables and fields is still necessary in order to identify missing records and to evaluate other possible inconsistencies in the data. Several export features have been included in the database to assist the Project Leader in identifying such problems and can be found from the database Main Menu by clicking ‘Analysis and Reports’ →

‘Export Data to Excel.’ Following the initial data verification process, the Project Leader will examine the following fields:

- a. *Nekton - Station Count: Station_Count* field. Verify that the number of stations for all sites at a specific park and year correspond to the number of stations sampled as indicated by the field data forms.
- b. *Nekton – All Stations by Park and Year: Site and Station* fields. Verify that all sites and stations for the appropriate park and year are present.

Table 1. An example of a checklist of tasks used to track progress of data verification and archiving process.

Task	Responsible Person(s)	Date completed	Comments
All data entered into access database	Field technicians or Project Leader		
Data have been exported and verified against field data forms	Field technicians or Project Leader		
Field data forms scanned and converted to .pdf	Field technicians or Project Leader		
Verified data uploaded from working database to master project database	Data Manager		
Verified data have been used to generate the semi-automated annual summary report	Project Leader and Quantitative Ecologist		
Draft of Final Report Completed	Quantitative Ecologist		
FGDC compliant Metadata have been developed for all spatial data	Data Manager		
NBII Biological Data Profile has been developed/updated for project database	Data Manager		
Copies of Final Report, verified biological and spatial data, and metadata are archived digitally	Data Manager		
Verified data, metadata posted to NPS Data Store	Data Manager		
Final Report posted to NatureBib	Data Manager		
NPSpecies updated (as needed)	Data Manager		

Spatial data validation

The actual UTM coordinates recorded on the field data form for each sampling station are recorded in the tbl_Locations table of the protocol database. The location of all sampling stations should be validated in a GIS once data entry is complete. The Project Leader or a designated technician familiar with GIS software will do so using the following procedures:

a. In a GIS, generate point features from the coordinates in tbl_Locations and overlay them on available, well documented GIS vector data and imagery for the park unit. The NCBN Data Manager will provide the appropriate spatial datasets, such as:

- Digital Orthophoto Quarter Quads (DOQQs) or other orthophotography
- Georeferenced park visitor maps
- Best available park boundary coverages
- Wetlands
- Hydrography
- Roads

b. Label and visually inspect the location of all station features. Note any apparent discrepancies, such as:

- Features located partially or wholly outside of the park boundary.
- Features associated with habitat types other than salt marsh. (*Note: such discrepancies could be due to 1) a temporal change in habitat type relative to date of ancillary data acquisition, or 2) thematic classification error in ancillary data 3) spatial error related to scale differences in comparison datasets, or 4) other sources of spatial error related to interpretation and delineation*).
- Two or more sampling stations sharing the same coordinates.

c. Inspect each station feature in relation to the original coordinates generated prior to the field season. Note any stations located a significant distance from the initially selected sampling location (significant distances would be those located 2 or more times the reported average horizontal accuracy of the GPS unit used).

d. For all noted discrepancies, it is advisable to first consult the database to rule out possible errors resulting from manipulating the original coordinate data in Excel, text editors, etc. Potential errors would include those arising from the transcription of coordinates or incorrect UTM zone information in the database. Remaining questions should be resolved by first consulting the associated field data forms and / or contacting the technician who collected the data. All changes should be indicated and initialed on the field data form and noted in the protocol database.

Local Database Backup

Tape backups of the Salt Marsh Monitoring project directory (including the protocol database) are made daily per an arrangement with the University of Rhode Island Field Technical Support Center (URI FTSC). Incremental (daily) backups of NCBN data drives are maintained on a weekly basis, culminating in a full backup at the end of each week. Weekly backup tapes are retained for six months. Semi-annual full backups are retained in perpetuity at an off-site data archive.

Export to ASCII for backup

As software and hardware evolve, datasets must be consistently migrated to new platforms, or they must be saved in formats that are independent of specific platforms or software (e.g., ASCII delimited files). NCBN archiving procedures include saving datasets in both their native format (typically MS-Access or Excel spreadsheet format) and as of ASCII text files. As a platform- and software-independent format, ASCII text files ensure future usability of the data in a wide range of applications and platforms.

As part of the annual archiving of the Salt Marsh Monitoring Database (see section below), the Network Data Manager will produce such ASCII text files for all tabular data within the database. A Microsoft Access utility designed for this task called “Exportdb” is available via the NPS I&M Intranet (http://www1.nrintra.nps.gov/im/datamgmt/dtbases/links_sources/data_tools/exportdb.zip), or on the NCBN main data server at \DATA_MANAGEMENT\Tools\NRDTv3\add_ons. Exportdb will write the following ASCII comma-delimited text files for each database:

- TABLEDEF.txt - This file will contain one record for every table in the selected database. Fields in the file include Table_Name, Table_Description, Table_Format, Number of Fields, Export_Date.
- FIELDDEF.txt - This file will contain one record for every column in every table in the selected database. Fields in the file include Table_Name, Field_Name, Field_Description, Field_Type, Field_Width.
- One comma-delimited ASCII text file containing all the data rows in each table in the selected database.

Exportdb displays a single form containing three function buttons (Figure 15):



Figure 15. Exportdb display screen.

The "Clear all attached tables" button will clear all tables linked from previous sessions. The "Link Database Tables" button will open a browse window to allow the selection of the Microsoft Access database you wish to export (note: the utility will not export tables that are linked to a back-end database). The "Export Tables" button will open a browse window to allow selection of the destination directory for the text files. Once a directory is selected, the export will be performed.

Alternatively, the following procedure can be used to export tables directly from the Monitoring Database:

1. In the Database window click the name of the table you want to export, and then on the File menu, click Export.
2. In the Save As type box, click Text Files (*.txt; *.csv; *.tab; *.asc).
3. Click the arrow to the right of the Save in box, and select the drive or folder to export to.
4. In the File Name box, enter a name for the file (or use the suggested name), and then click Export.

Database Revision Control

Because the Salt Marsh Monitoring Database follows the NPS I&M Program's Natural Resource Database Template v.3x (NRDT v.3x), a table describing database revision history (tbl_Db_Revisions) and linking to the database metadata (tbl_Db_Meta) is included as a core table in each component database file (i.e., front end and two back end Access files). Revisions will be performed periodically by or in conjunction with NCBN staff as the need arises and should be documented fully in the above tables, as well as in the database metadata.

On an annual basis, the Project Leader is responsible for identifying and documenting any changes needed for the Salt Marsh Monitoring Database. The Data Manager is then responsible for making these changes to the database, the User's Guide, and this Data Management SOP (refer to SOP 10: Revising the Protocol or SOP).

Reports

The final products to be included in the Salt Marsh Nekton Monitoring dataset are the Adobe pdf reports outlined in SOP 9: Data Analysis and Reporting. These reports are completed for each park unit and include: (1) an annual report for each field season, and (2) a long-term trend report that is developed every five years. Project reports will be completed by the Project Leader. Reports will be delivered as Adobe .pdf files to the Network Data Manager for documentation, storage, and archiving.

Field Data Forms

The Field Data Forms provide information essential to the verification of the dataset. Field data forms will be scanned and converted to Adobe .pdf files (preferred) or photocopied by the Data Manager / Project Leader as soon as possible upon return from the field. To ensure consistency and to aid in retrieval, the .pdf file will be named according to the following naming convention: [Park Code]_[Year]_[Project Leader last name]_FieldSheets_Archive.pdf. For example, a field sheet from ASIS in 2008 would be named, "ASIS_2008_Patenaude_FieldSheets_Archive.pdf." Files should be stored in the appropriate directory location (e.g.,

\\MONITORING\\Salt_Marsh_Nekton\\01_FIELD_SEASONS\\20xx\\02_Data\\02_Final\\01_Field_forms) and also included in annual data archives (see *Archiving* below).

In addition to the above electronic versions, all original paper field data forms will be housed in the NCBN central files at the University of Rhode Island, Kingston, RI. The central files are maintained by a URI FTSC staff member under the guidance of the Network Data Manager and Program Manager.

Archiving

Datasets associated with the Salt Marsh Monitoring Protocol will be archived on an annual basis, both in their native formats as well as ASCII text files. Archived datasets will include both tabular data in MS-Access format as well as spatial data. Network staff are responsible for preparing tabular data from the protocol for archiving following completion of standard QA/QC procedures. The Network Data Manager then prepares the tabular data for archiving by creating:

- A set of ASCII comma-delimited text files for the tabular data files and tables comprising the dataset.
- An XML file that preserves relationships between tables for each MS-Access database.
- A readme.txt file that explains the contents of each ASCII file, file relationships, and field definitions.

Quality control checks are performed on these ASCII files to ensure that the numbers of records and fields correspond to the source dataset and that conversion has not created errors or data loss. If possible, a second reviewer, preferably a program scientist, checks the ASCII files and documentation to verify that tables, fields, and relations are fully explained and presented in a way that is useful to secondary users.

Digital spatial data associated with the sampling design for the salt marsh monitoring program are also archived. Spatial data in ArcGIS personal geodatabase format will be maintained for each park and updated as necessary before the commencement of each field season. If necessary, the Network Data Manager will convert ArcGIS data to an upgraded format. Personal geodatabases will also be converted to sets of ASCII text files for archiving. Two ASCII files are required for each spatial data file. One file stores coordinate data with a unique identification code for each feature, and the second file stores attribute information that can be linked to the corresponding coordinate data by means of a common identification code.

On an annual basis, the Data Manger will archive off-site a dataset consisting of the following elements:

1. An updated Salt Marsh Monitoring database with accompanying metadata (i.e., NBII Biological Data Profile).
2. Spatial datasets and FGDC-compliant metadata for all sampling stations visited during the past year.
3. ASCII text file versions of both the tabular and spatial data products mentioned above.
4. Digital (.pdf) copies of the field data forms from each survey for that year.
5. A digital (.pdf) copy of the final Annual Report.

6. Once every five years, a copy of the Long-term Report.

When a project dataset is ready to be archived, the Data Manger will package all relevant files into a compressed archive file (e.g., ZIP or RAR file format), which will adhere to the following naming convention: NCBN_[Date]_[Author]_SMMonData_Archive_Final.rar. The archive will be placed on the NCBN data server in the appropriate directory location (i.e., \\MONITORING\Salt_Marsh_Nekton\03_ARCHIVE\[Year]). Archives, along with all data files residing on the NCBN data server, are backed up daily by the URI Environmental Data Center, and archived off-site with the NPS Boston Support Office twice per year.

Data Distribution

Access to NCBN data products will be facilitated via a variety of information systems that allow users to browse, search, and acquire Network data and supporting documents. All annual and long-term reports will be posted Integrated Resource Management Applications (IRMA) website (<http://irma.nps.gov>). Raw data can be requested by contacting the NCBN Data Manager.

SOP 9: Data Analyses and Reporting

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to Instructions for Recording Revisions of SOP 10: Revising the Protocol or SOPs.

Revision History Log:

New Version#	Previous Version #	Revision date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00					

Introduction

This SOP describes methods for summarizing nekton monitoring data. The protocol's monitoring objectives are to characterize the community structure of nekton utilizing salt marsh habitat in NCBN parks and to eventually determine trends in community structure.

Annual reporting procedures are described here in detail. Trend reporting procedures are discussed briefly and will be addressed further following three to five years of nekton data collection and trend reporting methods have been reviewed.

Annual Reporting

Annual reports submitted to each park will follow a standard format that includes information on data collection for that park's most recent field season and a detailed data summary of the single year of data. Since nekton and vegetation monitoring often occur in the same year, annual reports will include summaries of both datasets.

Formatting Nekton Data for Annual Reports

Nekton data are exported from the NCBN MS-Access database. Prior to calculation of summary information, additional variables must be created. These variables will facilitate cross tabulation of summary results by nekton species, nekton community, physical variables, site, and year, as well as other variables of interest. To import data into various statistical software programs, data are usually saved as .csv (comma delimited) files or tab delimited files, although some programs (e.g., SAS) can directly import Excel format files (.xls or .xlsx.). Nekton data, exported from the NCBN MS-Access database, are organized by the individual sampling station, with a listing of all species (single species column) that were captured at that station. Table 2 shows the variables and their formats in the spreadsheet output from the Access database

Table 2. Variables and formats used in the NCBN salt marsh database. Variables noted with a '*' are created or reformatted by the data analyst before formatting and summarizing the data.

Variable Name	Variable Description
Station (XXXXXXXX_XXX_YYYY)	Unique identifying code for individual nekton sampling stations. Pool Stations: site code + 'P' + pool station number_bearing_year (eg. G1P1_270_2008) Creek Stations: site code + 'C' _meter along creek_year (eg. G1C_15_2008) Ditch Station: site code + 'D' +ditch segment number_year (eg. F3D45_2008) Note that length of the station name and number of underscores will vary depending on park unit, habitat, station number, etc.
Start_ Date (MM/DD/YYYY)	Date nekton was sampled.
Sampling Event (X)	Numeric code (1: first sampling event, 2: second sampling event) created based on Start Date for each sample location, used for cross-tabulation summaries
*Site (XX)	Numeric code for site location, used for cross-tabulation summaries.
Year (YYYY)	Code for year, used for cross-tabulation summaries
Gear	Sampling gear used for nekton sampling (throw trap or ditch net)
Net_Area	Area for the throw trap is 1 m ² , area for the ditch net is variable. Area is used to calculate densities
Habitat	Type of habitat sampled (creek, pool/panne, ditch, etc.)
Water_Depth_cm	Depth of water where sample was taken, expressed in centimeters (cm)
Water_Temp_C	Temperature of water where sample was taken, expressed in degrees Celsius (°C)
Salinity_ppt	Salinity of water where sample was taken, expressed as parts per thousand (ppt)
Dissolved Oxygen	DO concentration of water at sample station, expressed as milligrams per liter (mg/L)
Species_Count	Number of individuals of a given species caught at a given sample station.
Nekton Length	Measured length, expressed in millimeters (mm), of 15 individuals of each species caught at each sample station. If less than 15 individuals of a species are caught, all lengths are reported in the data.
Scientific Name	Preferred scientific name, as identified by Integrated Taxonomic Information System (www.ITIS.gov)
Common Name	Preferred common name, as identified by Integrated Taxonomic Information System (www.ITIS.gov)
SPCD (XXXX or XXXXXX)	Four-digit species code (or six digits if two species have same four letter code).

Using the raw data, nekton counts are summarized by species, station, and sampling event. This summarized dataset will have a single row for each station and sampling event and a single column for each species code (SPCD) as well as columns for environmental variables such as water depth. The process for summarizing nekton length data is discussed in a later section of this document.

The cell entries in this summarized dataset will show the number of individuals of each species caught at each sampling station (Table 3a) during each sampling event. If no individuals of a species were caught, then the cell for that species at that station during that event will contain a zero. The species count data are then standardized by the area (m^2) sampled to reflect individual species density. Density for each station is calculated by dividing the total number of individuals of each species (species count) by the area sampled by the gear and is expressed as individuals per m^2 (Table 3b). The area sampled differs depending on sampling gear used. If a throw trap was used, the area sampled will always be 1 m^2 . If a ditch net was used, the net dimensions are recorded at the time of data collection, and the area sampled is calculated for each individual net. Tables 3a-b show examples of how density estimates per m^2 are calculated using the area sampled. These two tables represent output tables resulting from summarizing the data using statistical software. Each output table includes the variables used for summarizing species count data by station, e.g., 'Station', the station ID, 'Start_Date', the sample date for the station which indicates during which sampling event (1 or 2) the data were collected, 'Event', the sampling event (1 or 2), 'Gear', the type of gear used for the sample, (Ditch Net or Throw Trap), the 'Net Area', the area sampled by the gear for that sample record, and 'Habitat', the habitat type for each sample location.

Table 3a-b. Example output table showing a subset of (a) nekton counts, the number of individuals of each species caught at each station, and (b) nekton densities (m^2), number of individuals of each species caught at each station divided by the net area.

(a)

Station	Start_Date	Event	Gear	Net_Area (m^2)	Habitat	No. of Individuals Captured			
						CASA	CYVA	FUHE	MEME
F1D17_2009	6/30/2009	1	Ditch Net	0.894	Open Ditch	0	0	0	6
F1D1_2009	6/30/2009	1	Ditch Net	0.727	Open Ditch	0	0	1	0
F2D13_2009	6/25/2009	1	Ditch Net	0.811	Open Ditch	0	0	1	16
F2D15_2009	6/25/2009	1	Ditch Net	1.158	Open Ditch	0	0	1	44
F2D17_2009	6/25/2009	1	Ditch Net	0.663	Open Ditch	1	0	1	4
F2D18_2009	6/25/2009	1	Ditch Net	0.831	Open Ditch	0	0	1	0
F2D1_2009	6/25/2009	1	Ditch Net	1.413	Open Ditch	1	0	2	94
F3P10_54_2009	6/24/2009	1	Throw Trap	1	Pool/Panne	0	0	5	0
F3P11_82_2009	6/24/2009	1	Throw Trap	1	Pool/Panne	0	0	8	0

(b)

Station	Start_Date	Event	Gear	Net_Area (m^2)	Habitat	Nekton Density (m^2)			
						CASA	CYVA	FUHE	MEME
F1D17_2009	6/30/2009	1	Ditch Net	0.894	Open Ditch	0	0	0	6.7
F1D1_2009	6/30/2009	1	Ditch Net	0.727	Open Ditch	0	0	1.4	0
F2D13_2009	6/25/2009	1	Ditch Net	0.811	Open Ditch	0	0	1.2	19.7
F2D15_2009	6/25/2009	1	Ditch Net	1.158	Open Ditch	0	0	0.9	38
F2D17_2009	6/25/2009	1	Ditch Net	0.663	Open Ditch	1.5	0	1.5	6
F2D18_2009	6/25/2009	1	Ditch Net	0.831	Open Ditch	0	0	1.2	0
F2D1_2009	6/25/2009	1	Ditch Net	1.413	Open Ditch	0.7	0	1.4	66.5
F3P10_54_2009	6/24/2009	1	Throw Trap	1	Pool/Panne	0	0	5	0
F3P11_82_2009	6/24/2009	1	Throw Trap	1	Pool/Panne	0	0	8	0

Summarizing and Presenting Nekton Data for the Annual Report

Throughout the annual report, data are reported separately for each sampling event and for the two sampling events combined. This SOP also shows examples of how data can be summarized and presented separately for each site within a park and further separated by both site and sampling event.

Data are presented by site and sampling event to provide summary information to parks. The temporal sampling design of two repeated sampling events at stations within a single year was not designed to examine differences between sites and sampling events on an annual basis. Examples of how to present these data by sampling event and site are provided to demonstrate methods for conveying the extent of spatial and temporal variability in the nekton data we collect.

Estimating Total Nekton Density

Total nekton densities are summarized by sampling event and habitat. For reference purposes, Table 4 reports the number of unique sample locations, i.e. stations, sampled in each habitat during each event. The 'Events 1 & 2' column in Table 4 shows the total number of unique sample locations (stations) that were visited during that year at that park during both sampling events. Note that if a station was only sampled during one of the two sampling events, the data from that single event provides the annual estimate for that station. In many cases there will be a slight difference in the number of stations sampled during the two sampling events (e.g., when a station is dry during one event. Table 5 demonstrates how density and sample size is estimated for a hypothetical site.

Table 4. Example of annual report table indicating number of stations sampled in each habitat type, during each sampling event. The number of stations reported in the 'Events 1 & 2' column is the total number of unique sample locations (stations) sampled during that year at that park, not the number of samples recorded.

Habitat	No. of Stations		
	Event 1	Event 2	Events 1 & 2
Unobstructed Ditch	30	30	30
Obstructed Ditch	20	20	20
Pool/Panne	8	9	10
All	58	59	60

Table 5. Example output table demonstrating how densities from the two sampling events are averaged for each station. Data in columns 'Event 1' and 'Event 2' are estimated nekton densities for each station during those respective sampling events. Data in the 'Events 1 & 2' column shows the average density for that station based on data from both sampling events. '-' indicates that a station was not sampled during that sampling event because the sample location was dry. 'n' is the number of unique sampling locations (stations) visited during sampling event 1, sampling event 2, and in both events. The 'Station' column shows examples of the unique identifier associated with each station in the data. 'n' = the number of unique sampling stations.

Station	Nekton Density (m ²)		
	Event 1 (n = 9)	Event 2 (n = 9)	Events 1 & 2 (n = 10)
F4D1_2011	0.0	2.5	1.2
F4D2_2011	1.7	10.3	6.0
F4D4_2011	1.8	-	1.8
F4D6_2011	0.0	2.4	1.2
F4D7_2011	0.0	9.3	4.7
F4D8_2011	0.0	0.0	0.0
F4P009_2011	0.0	0.0	0.0
F4P010_2011	1.0	1.0	1.0
F4P011_2011	-	1.3	1.3
F4P014_2011	1.0	0.0	0.5

Nekton density summaries include the average, standard error, and the total number of nekton captured (Table 6). To calculate the average density for the sampling year based on data from both sampling events, it is necessary to first average the nekton densities/m² for each station over both sampling events (Table 5), and then find an average and standard error of all of the unique stations. The number of stations reported in the 'Total column' in Table 6 is the total number of unique stations sampled during that year at that park, not the number of samples recorded.

Table 6. Example of annual report table illustrating total nekton density [individuals per 1 m² ± SE (number of nekton)] summarized by sampling event and habitat. 'n' = number of unique stations sampled at all monitoring sites within the park.

Habitat	Average Density [individuals per 1 m ² ± SE (number of nekton)]		
	Event 1 (n = 58)	Event 2 (n = 59)	Events 1 & 2 (n = 60)
Unobstructed Ditch	22.1 ± 15.8 (526)	12.6 ± 5.2 (184)	17.3 ± 8.1 (710)
Obstructed Ditch	0.9 ± 0.6 (16)	7.1 ± 2.0 (62)	4.0 ± 1.1 (78)
Pool/Panne	2.6 ± 0.7 (21)	0.7 ± 0.4 (6)	1.4 ± 0.4 (27)
All	12.1 ± 8.2 (563)	8.9 ± 2.8 (252)	10.2 ± 4.1 (815)

Alternatively, the data in Table 6 can be presented by site and sampling event. Site density information will be included as an appendix to NCBN park annual reports (Table 7).

Table 7. Example of annual report table illustrating total nekton density [individuals per 1 m² ± SE (number of nekton)] summarized by sampling event and site. 'n' = the number of unique stations sampled during each sampling event.

Site	Average Density [individuals per 1 m ² ± SE (number of nekton)]	
	Event 1 (n = 58)	Event 2 (n = 59)
1	1.1 ± 1.1 (7)	5.4 ± 2.1 (26)
2	10.4 ± 3.9 (105)	7.3 ± 2.8 (43)
3	38.4 ± 31.5 (442)	3 ± 1.5 (25)
4	0.8 ± 0.2 (8)	4.2 ± 1.6 (23)
5	0.2 ± 0.2 (1)	29.3 ± 14.5 (135)

Estimating Species Richness

Species richness is estimated based on the algorithm and formulae of Heltshe and Forrester (1983). Species richness is calculated for the entire park for each sampling event by treating all stations as if they belong to one large 'site'. To attain an estimate of species richness for a single site (or park) based on data from both sampling events, species counts from events 1 and 2 are summed for each station individually before calculating species richness for the site (or park). Site specific information will be included as an appendix to the NCBN annual reports. Below we include a detailed, step by step, tutorial of how to estimate species richness and the associated standard error for a hypothetical site as described in Heltshe and Forrester (1983). Table 8 provides explicit definitions of the terms used in the tutorial.

Table 8. Definition of terms used in species richness calculation algorithm shown in the steps below.

Term	Definition
unique species	A unique species is one that is found at one and only one station.
J	j is the possible number of unique species found at a single station at the site. In order to complete the species richness calculation, we examine each possible level j from 1 to the maximum number of unique species found at a single station.
f_j	f_j is the number of occurrences of each value of j . For example, if there are 2 stations that each contain two unique species, then $f_2 = 2$.
K	k is the total number of unique species found at the site
S	s is the total number of species, both unique and non-unique, found at the site.
$\hat{S}$	$\hat{S}$ is the estimated species richness value that incorporates the total number of species and gives extra value to unique species.

The following steps for calculating species richness for each site are based on the algorithm and formulae in Heltshe and Forester (1983).

1. After summing counts for each species at each station, convert those counts to presence absence values. For each station, if a species was present, replace the count with a 1 for present. If no individuals of a species were present, then the cell for that species at that site should contain a 0 to represent the species was absent.
2. Find the number of species present at each station.
3. Determine which species are unique, i.e., were found at only one station. These species are shown in **bold** in Figure 16.
4. Find the number of stations, f_j , containing j unique species for $j = 1, 2, 3, \dots, s$, where s is the number of observed species at the site. In our example site data (Figure 1) there are 3 unique species. There is one station with one unique species present so $f_1 = 1$ and there is also one station with two unique species present so $f_2 = 1$.
5. Find $(j \times f_j)$ and $(j^2 \times f_j)$ for each pair of (j, f_j) values in step 4 and sum these products over all values of j . Using the notation in Heltshe and Forester (1983), k equals the sum of the products of $(j \times f_j)$ for all values of j at a single site and should also equal the number of unique species. We also find the sum of the products $(j^2 \times f_j)$ for all values of j . Using the data from Figure 1 as an example, we have:

$$k = \sum_{j=1}^2 (j \times f_j) = 3 \quad \text{and we also have the equation} \quad \sum_{j=1}^2 (j^2 \times f_j) = 5$$

6. In addition to the two values found in step 5, the species richness estimate and variance equation incorporate n , the number of unique sample stations and s , the number of observed species at the site (or park). Using our example data, the estimate of species richness for a site, $\hat{S}$, is calculated as

$$\hat{S} = s + \left(\frac{n-1}{n} \right) \times k = 6 + \left(\frac{5-1}{5} \right) \times 3 = 8.4$$

Note that if there are no unique species present, $k = 0$, and $\hat{S}$ simplifies to s , the number of species found at the site.

7. The variance of the species richness estimate for each site is calculated as

$$Var(\hat{S}) = \left(\frac{n-1}{n} \right) \times \left[\left(\sum_{j=0}^s j^2 \times f_j \right) - \frac{k^2}{n} \right] = \left(\frac{5-1}{5} \right) \times \left[5 - \frac{3^2}{5} \right] = 2.56$$

Note that if there are no unique species present, $k = 0$, and there are no value of j and f_j to sum, so variance equals zero.

8. The standard error of the species richness estimate for each site (or park) is calculated as the square root of the variance estimate divided by the square root of the sample size, i.e., number of unique sample stations. It is best to find the standard error before rounding off the estimate.

	Station 1	Station 2	Station 3	Station 4	Station 5	No. of Stations	j	f_j	$j \times f_j$	$j^2 \times f_j$
Species 1	0	1	0	0	0	1	1	1	1	1
Species 2	0	1	0	0	0	1	2	1	2	4
Species 3	1	1	1	0	0	3			3	5
Species 4	0	1	0	1	0	2				
Species 5	0	1	1	0	0	2				
Species 6	0	0	0	1	0	1				
No of Unique Species	0	2	0	1	0	$k = 3$				

Figure 16. Example used to illustrate how j and f_j are found using species presence/absence data. Species richness is calculated using these values, as described in Heltshe and Forrester (1983).

The species richness calculations for each site as well the number of stations sampled and the number of species observed can then be formatted into a concise table as shown in Table 9. As mentioned previously, if there are no unique species present at a site, then species richness equals s , the number of observed species, and the variance (and standard error) or the species richness estimate equals zero.

Species richness is summarized by sampling event over all stations at all sites, as shown in Table 9, and is calculated by treating all unique stations as being part of one site. If a station was sampled during one sampling event, but not the other, it will be evident in the table because the number of stations sampled during each event is reported. The total number of stations for sampling events 1 and 2 combined is the total number of unique stations sampled that year, not the number of samples recorded. Table 5 demonstrates how this number of unique stations is found for a hypothetical site.

Table 9. Example of annual report table illustrating estimated nekton species richness (Est. Species Richness $\pm$ SE). Data are summarized by sampling event over all stations at all sites and over both sampling events. Estimated species richness and associated standard errors are calculated using the Heltshe and Forrester algorithm (1983). If there are no unique species, then estimated standard error equals 0 and it is omitted. The number of stations for sampling events 1 and 2 is the total number of unique sampling stations sampled during that year at that park, not the number of samples collected.

Event	No. of Stations	Observed No. of Species	Est. Species Richness $\pm$ SE
1	58	5	6.0 $\pm$ 0.1
2	59	5	5.0
1 & 2	60	5	5.0

Alternatively, species richness can also be presented by site or by site and sampling event. Species richness summarized by site will be provided in the appendix of NCBN annual reports (Tables 10a-b).

Summarizing Species and Life History Group Composition (percent)

Nekton counts are summarized for all stations for each sampling event and for both events combined to calculate the percent of the total nekton catch attributed to each species and life history group, e.g. resident fish, transient fish, resident shrimp, etc (Table 11). The summed counts for each individual species are divided by the sum of the counts for all species and then multiplied by 100%. The sum of the species composition will equal 100% for each column. Species percents are also summed by life history group. Within each life history group, the species are sorted by percent with the largest percent values at the top of each category.

Table 10a-b. Example of annual report table illustrating estimated nekton species richness (Est. Species Richness $\pm$ SE). Data are summarized by (a) site over both sampling events and by (b) site for each sampling event. Estimated species richness and associated standard errors are calculated using the Heltshe and Forrester algorithm (1983). If there are no unique species, then estimated standard error equals 0 and it is omitted. 'No. of stations' is the number of unique sample locations (stations) sampled.

(a)				
Site	No. of Stations	Observed No. of Species	Est. Species Richness $\pm$ SE	
1	10	5	5.9 $\pm$ 0.3	
2	10	5	5.9 $\pm$ 0.3	
3	16	5	5.0	
4	14	2	2.0	
5	10	5	6.8 $\pm$ 0.4	

(b)				
Site	Event	No. of Stations	Observed No. of Species	Est. Species Richness $\pm$ SE
1	1	10	1	1.9 $\pm$ 0.3
1	2	10	5	5.9 $\pm$ 0.3
2	1	10	5	5.9 $\pm$ 0.3
2	2	10	2	2.9 $\pm$ 0.3
3	1	15	4	4.9 $\pm$ 0.2
3	2	15	4	4.0
4	1	13	2	2.0
4	2	14	2	2.0
5	1	10	1	1.9 $\pm$ 0.3
5	2	10	5	6.8 $\pm$ 0.4

Table 11. Example of annual report table illustrating species and life history group composition. Species composition (%) is calculated for each of the two sampling events separately and both sampling events together. 'n' = total number of nekton caught during that sampling event.

Life History Group/Species	Common Name	Group/Species Composition (%)		
		Event 1 (n = 563)	Event 2 (n = 252)	Events 1 & 2 (n = 815)
Resident Fish		97.0	47.2	81.6
<i>Fundulus heteroclitus</i>	Common mummichog	92.7	40.9	76.7
<i>Cyprinodon variegatus</i>	Sheepshead minnow	4.3	6.3	4.9
Transient Fish		2.5	28.2	10.4
<i>Menidia menidia</i>	Atlantic silverside	2.5	28.2	10.4
Resident Shrimp		0.4	22.2	7.1
<i>Palaemonetes pugio</i>	Daggerblade grass shrimp	0.4	22.2	7.1
Transient Crustaceans		0.2	2.4	0.9
<i>Callinectes sapidus</i>	Blue Crab	0.2	2.4	0.9

Alternatively, the data in Table 11 can also be presented by site (Table 12). For parks where multiple sites are sampled, species and life history group composition for each site will be provided in the appendix to the NCBN annual park reports. Additionally, this information can be presented by site and sampling event as shown in Table 13.

Table 12. Example of annual report table illustrating species and life history group composition. Data are summarized by site. 'n' = total number of nekton caught during that sampling event. '-' indicates species was not present.

Life History Group/Species	Common Name	Group/Species Composition (%)				
		Site1 (n = 33)	Site 2 (n = 148)	Site 3 (n = 467)	Site 4 (n = 31)	Site 5 (n = 136)
Resident Fish		78.8	89.9	96.4	100.0	18.4
<i>Fundulus heteroclitus</i>	Common mummichog	63.6	86.5	91.9	77.4	16.9
<i>Cyprinodon variegatus</i>	Sheepshead minnow	15.2	3.4	4.5	22.6	1.5
Transient Fish		3.0	2.0	2.4	-	51.5
<i>Menidia menidia</i>	Atlantic silverside	3.0	2.0	2.4	-	51.5
Resident Shrimp		12.1	7.4	0.9	-	28.7
<i>Palaemonetes pugio</i>	Daggerblade grass shrimp	12.1	7.4	0.9	-	28.7
Transient Crustaceans		6.1	0.7	0.4	-	1.5
<i>Callinectes sapidus</i>	Blue Crab	6.1	0.7	0.4	-	1.5

Table 13. Example of annual report table illustrating species and life history group composition for two sites. Data are summarized by site and sampling event. Species composition (%) is calculated separately for each site and sampling event. 'n' = total number of nekton caught during that event. '-' indicates that a species was not present.

Life History Group/Species	Common Name	Group/Species Composition (%)			
		Site 1		Site 2	
		Event 1 (n = 7)	Event 2 (n = 26)	Event 1 (n = 105)	Event 2 (n = 43)
Resident Fish		100.0	73.1	95.2	76.7
<i>Fundulus heteroclitus</i>	Common mummichog	100.0	53.8	90.5	76.7
<i>Cyprinodon variegatus</i>	Sheepshead minnow	-	19.2	4.8	-
Transient Fish		-	3.8	2.9	-
<i>Menidia menidia</i>	Atlantic silverside	-	3.8	2.9	-
Resident Shrimp		-	15.4	1.0	23.3
<i>Palaemonetes pugio</i>	Daggerblade grass shrimp	-	15.4	1.0	23.3
Transient Crustaceans		-	7.7	1.0	-
<i>Callinectes sapidus</i>	Blue Crab	-	7.7	1.0	-

Summarizing nekton length for each species

Average length, standard error, and number of individuals measured are reported for each nekton species by sampling event and both visits combined (Table 14). Minimum and maximum lengths for each species are also summarized by sampling event and for both visits combined (Table 14b). Nekton species are organized identically to species composition information (Table 11) for consistency. The length and species of individual nekton captured and the sampling event during which the individual was caught are the only information needed to summarize these data for the annual report.

Table 14a-b. Example of annual report table illustrating (a) average length [mm $\pm$ SE (no. measured)] and (b) maximum and minimum length (mm) measured for each nekton species. Data are summarized by sampling event and for both sampling events combined.

(a)		Average Length [mm $\pm$ SE (no. measured)]		
Life History Group/Species	Common Name	Event 1	Event 2	Annual
Resident Fish				
<i>Fundulus heteroclitus</i>	Common mummichog	25.0 $\pm$ 1.0 (127)	33.8 $\pm$ 1.0 (99)	28.8 $\pm$ 0.8 (226)
<i>Cyprinodon variegatus</i>	Sheepshead minnow	16.7 $\pm$ 1.3 (24)	29.4 $\pm$ 2.0 (16)	21.8 $\pm$ 1.5 (40)
Transient Fish				
<i>Menidia menidia</i>	Atlantic silverside	18.6 $\pm$ 1.3 (14)	41.3 $\pm$ 1.3 (37)	35.0 $\pm$ 1.8 (51)
Resident Shrimp				
<i>Palaemonetes pugio</i>	Daggerblade grass shrimp	12.5 $\pm$ 2.5 (2)	27.1 $\pm$ 0.9 (45)	26.4 $\pm$ 1.0 (47)
Transient Crustaceans				
<i>Callinectes sapidus</i>	Blue Crab	75.0 (1)	81.2 $\pm$ 5.3 (6)	80.3 $\pm$ 4.5 (7)

(b)		Event 1		Event 2		Events 1 & 2	
Life History Group/Species	Common Name	Min.	Max.	Min.	Max.	Min.	Max.
Resident Fish							
<i>Fundulus heteroclitus</i>	Common mummichog	10	69	12	81	10	81
<i>Cyprinodon variegatus</i>	Sheepshead minnow	6	31	14	41	6	41
Transient Fish							
<i>Menidia menidia</i>	Atlantic silverside	11	32	23	64	11	64
Resident Shrimp							
<i>Palaemonetes pugio</i>	Daggerblade grass shrimp	10	15	17	51	10	51
Transient Crustaceans							
<i>Callinectes sapidus</i>	Blue Crab	75	75	72	106	72	106

Summarizing Environmental Variables by Habitat and Sampling Event

Water depth (cm), water temperature (°C), salinity (ppt), and Dissolved Oxygen (mg L⁻¹) are physical metrics measured at each nekton sampling station. The average, standard error, and sample size for each physical metric will be summarized by sampling event and habitat in the annual report. An example subset of the formatted table is shown in Table 15.

Sample sizes for each of these variables may not be equal to the total number of stations sampled. If equipment was not operable on a particular sampling day, some stations will have missing values for one or more of these variables. These disparities in samples sizes are noted in the table caption.

Table 15. Example subset of environmental variables [Average ± SE (no. of stations)] recorded during nekton sampling. Sample sizes may vary by habitat type due to equipment limitations (e.g., not enough water, equipment malfunction). ‘-’ indicates variable was not measured.

Habitat	Average ± SE (no. of stations)		
	Event 1		
	Ditch		Pool/Panne
	Obstructed	Unobstructed	
Depth (cm)	28.6 ± 1.9 (30)	20.8 ± 1.6 (20)	9.9 ± 1.2 (8)
Temperature (°C)	23.1 ± 0.4 (30)	24.1 ± 0.7 (20)	29.3 ± 0.3 (8)
Salinity (ppt)	24.5 ± 0.8 (29)	23.6 ± 0.7 (20)	27.0 ± 0.8 (8)
Dissolved Oxygen (mg/L)	7.3 ± 0.5 (26)	-	8.1 ± 0.9 (7)

Trend Reporting

This portion of the SOP is currently in development. Table 16 shows the collection of metrics we tentatively plan to examine, the methods we will use, and the questions of interest we intend to address with our analyses. Trend reporting for a park will begin after three sampling years of data have been collected at that park. Subsequent trend reports will be published at regular time intervals that are appropriate for the scale of change seen in the data, approximately every 5 years.

Table 16. Tentative list of metrics, analysis methods and questions of interest that will be addressed in NCBN salt marsh nekton trend reports.

Metric	Analysis	Question of Interest
Nekton Species Counts	Adonis Community Analysis	Is the nekton community of species changing over time?
Nekton Life History Groups (LHGs)	Adonis Community Analysis	Are nekton community LHGs changing over time?
Nekton Life History Groups (LHGs)	Multinomial Response Repeated Measures Mixed Effects model	Is the proportion of nekton categorized in each LHG changing over time?
Nekton Density	Bayesian Hierarchical Model treating Life History Group and Site as Random Effects	After accounting for the inherent random variability due to site differences and the different behaviors of the distinct LHGs, are there discernible trends in nekton density?
Nekton Length	Bayesian 'dual' model examining trends in both mean length and between event variability in length for key resident fish species	Are average lengths and variability in length (between sampling events) of key species changing over time?
Species Richness	Repeated Measures Mixed Effects Model	After accounting for the inherent random variability due to site differences, are there discernible trends in nekton species richness?
Nekton Condition	Repeated Measures Mixed Effects Model	After accounting for the inherent random variability due to site differences, are there discernible trends in nekton condition?

Reference Documents

Heltshe, J. F. and N. E. Forrester. 1983. Estimating Species Richness Using the Jackknife Procedure. *Biometrics* 39: 1-11.

SOP 10: Revising the Protocol or SOPs

Version 1.00 (September 2012)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page.

Revision History Log:

New Version#	Previous Version #	Revision date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00					

Introduction

The following Master Version Table (Table 20) tracks the relationships between the Protocol Narrative and the associated Standard Operating Procedures, as discussed in Instructions for Recording Revisions in this SOP.

Table 17. Master Version Table.

Master Version Table: Ocean Shoreline Position Monitoring Protocol and Standard Operating Procedures												
Date of Revision	Protocol	Narrative	SOP #1	SOP #2	SOP #3	SOP #4	SOP #5	SOP #6	SOP #7	SOP #8	SOP #9	SOP #10

Scope and Applicability

Due to the long-term nature of the NCBN monitoring program, periodic revisions to the Protocol Narrative and to individual SOPs will be necessary (O’Ney, 2005). Careful documentation of changes to the Protocol Narrative and its related SOPs, along with a library of previous versions, are essential for maintaining consistency in the collection, summary, analysis, and reporting of data.

The Revision History Logs found at the beginning of the Protocol Narrative and each SOP document contain any edits and/or changes to the section. Information entered in the logs should be concise and complete. The logs track the previous version date and number, date of revision and new version number, author(s) of revision, location of changes within the document, description of change, and the reason the change was made. Author information must include full name, title, and affiliation.

Instructions for Recording Revisions

Protocol users must promptly notify the Project Leader about recommended and/or required changes. The Project Leader will then review and incorporate all approved changes, update the Revision History Log and Master Version Table, and change the date and version number on the title page of the master document as well as any SOPs to which the revisions apply.

Minor revisions

Minor revisions are those that *do not* represent a change in the underlying methods or procedures used to generate data values for the protocol's existing data set. Minor revisions include small changes in, or clarification of procedures. Version numbers for minor revisions increase incrementally by hundredths (1.01, 1.02, 1.02, etc.).

Major revisions

Major revisions are those that involve changes in methodology that could influence the resulting data values and the ability to compare newly-collected data with data collected using a previous version. The Project Leader should consult with NCBN Salt Marsh Technical Group for input on major revisions. Major revisions are designated with the next whole number in the sequence (2.0, 3.0, 4.0, etc.) and include items such as:

- Addition of monitoring objectives
- Changes to the sampling design
- Changes to reporting requirements
- Addition of new monitoring parameters

Coordinating narrative and SOP versions

In order to track the most current version number of all SOPs in this protocol, the Project Leader maintains a Master Version Table (Table 20). A new entry must be made each time the Protocol Narrative and/or SOP(s) are modified. In cases where the Protocol Narrative and/or one or more SOP have undergone only minor revisions (Instructions for Recording Revisions, above), the protocol version number will itself increase incrementally by hundredths. In cases where the Protocol Narrative and/or one or more SOP have undergone a major revision (whether or not other sections have undergone minor revisions), the protocol version number will increase incrementally by whole numbers (Figure 17).

The Project Leader updates all associated field data forms to reflect the change in protocol version. Users noting discrepancies in versions between the protocol, SOPs, data values, and field data forms should notify the Project Leader so that corrections can be made and documentation kept current.

Master Version Table: Salt Marsh Vegetation Monitoring Protocol and Standard

Operating Procedures

Date of Revision	Protocol	Narrative	SOP #1	SOP #2	SOP #3	SOP #4	SOP #5	SOP #6	SOP #7	SOP #8	SOP #9	SOP #10
1/1/2007	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6/1/2007	1.01	1.01	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.01	1.01
8/2/2007	2.00	1.01	1.01	1.00	1.00	2.00	1.01	1.00	1.00	1.00	1.01	1.01
1/10/2008	3.00	2.00	1.01	1.00	1.01	2.01	1.02	1.00	1.00	1.01	1.02	1.01

Figure 17. Example of a Master Version Table reflecting possible revision scenarios and associated numbering of the protocol.

Reviewing Suggested Protocol Revisions

All suggested edits require review by the Project Leader for clarity and technical soundness. Small changes or additions to existing methods are reviewed by NCBN staff; however, if a significant change in methods is recommended, additional expert review may be required.

Communicating Changes to Investigators / Users

Once changes have been made, the updated document is posted on the NCBN web site (<http://www.nature.nps.gov/im/units/ncbn/>) and is added to the National Vital Signs Monitoring Protocol Database (<http://science.nature.nps.gov/im/monitor/protocoldb.cfm>). All previous versions are archived in the NCBN information system and can be obtained by contacting the Data Manager. Each time an SOP is revised, the Project Leader ensures that all known users obtain a current copy of the SOP and receive the necessary briefing material and/or training to understand and incorporate the change(s). Users are encouraged to visit the network web site and/or contact the Project Leader at least once per season to check for updates associated with the monitoring protocol.

Reference Documents

O’Ney, S. E. 2005. Standard operating procedure #11: Revising the protocol, Version 1.0. *In*: O’Ney, S. E. 2005. Regulatory water quality monitoring protocol. Version 1.0. Bozeman (MT): National Park Service, Greater Yellowstone Network.

Appendix A. Sources of Information to Aid in Nekton Identification

The following identification guides are useful in assisting with nekton identification. This is not an exhaustive list, and staff are urged to draw upon local experts to assist with identification when necessary. Several websites also have extensive information on fish species. If voucher specimens are kept for later identification, they must be retained in a fashion that preserves their characteristics. Nekton can be kept alive, and later released to the same site where they were collected, or humanely sacrificed, preserved, and transported to the laboratory for positive identification.

Books:

- Able, K. W. and M. P. Fahay. 2010. Ecology of estuarine fishes: temperate waters of the Western North Atlantic. John Hopkins University Press, Baltimore, MD. ISBN-10: 0801894719, ISBN-13: 978-0801894718
- Able, K.W. and M. P. Fahay. 1998. The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight. Rutgers University Press, New Brunswick, NJ. ISBN: 0-8135-2500-4.
- Bigelow, H. B. and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service, Vol. 53, United States Government Printing Office, Washington, D. C.
- Collette, B. B., and G. Klein-MacPhee, eds. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine. 3rd ed. Smithsonian Institution Press, Washington, DC. ISBN-10: 1560989513, ISBN-13: 978-1560989515
- Eddy, S. and J. C. Underhill. 1978. How to Know the Freshwater Fishes. Wm. C. Brown Company Publishers, Dubuque, IA. ISBN: 0-697-04750-4.
- Gosner, K. L. 1978. A Field Guide to the Atlantic Seashore. Houghton Mifflin Company, Boston, MA. ISBN: 0-395-24379-3.
- Raasch, M. S. 1997. Delaware's Freshwater and Brackish-Water Fishes. Delaware Nature Society, Dover, DE.
- Robins, C. R., and G. C. Ray. 1986. A Field Guide to the Atlantic Coast Fishes. Houghton Mifflin Company, Boston, MA. ISBN: 0-395-39198-9.
- Whitworth, W. R. Freshwater Fishes of Connecticut. 1996. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection. Second Ed., Bulletin 114, Hartford, CT. ISBN: 0-942081-08-0. (DEP Maps and Publication Office, 79 Elm St., Hartford, CT 06106, 806-424-3555).

Weiss, H. M. 1997. Marine Animals of Southern New England and New York State Geological and Natural History of Connecticut Department of Environmental Protection, Bulletin 115, Hartford, CT. ISBN: 0-942081-06-4.

Websites:

University of Wisconsin fish identification database: <http://www.wiscfish.org/fishid/>

FishBase- A Global Information System on Fishes: <http://www.fishbase.org/home.htm>

Appendix B. NCBN Field Data Forms

Park Code: _____	UTM Zone: _____	Start Time: _____
Site Code: _____	Datum: _____	End Time: _____
Station ID: _____	UTM X (meters): _____	Crew (Initials): _____
	UTM Y (meters): _____	Data Entered (Y/N): _____
	Est. Horiz. Error (meters): _____	Data Verified (Y/N): _____

Habitat Type (circle): Pool/Panne Creek Shoreline	Water Measurements	Tide (circle): Ebb Flood Sediment (circle): Sand Mud Creek Depth (cm): _____, _____, _____
	Temp (C): _____	
	Salinity (ppt): _____	
	DO (mg/L): _____	
	Depth (cm): _____, _____, _____	

Vegetation Species Enclosed in Trap (circle % cover)	
Species #1:	Veg. %Cover: <1% 1-5% 6-25% 26-50% 51-75% >75%
Species #2:	Veg. %Cover: <1% 1-5% 6-25% 26-50% 51-75% >75%
Vegetation Species Adjacent to Sampling Station (ie along creek, surrounding the pool):	

species	*length in (mm)															total	
	length																
	tally																
	tally																
	tally																
	tally																
	tally																
	tally																
	tally																

Notes (photos taken? problems, observations, etc):

 NCBN Saltmarsh Nekton Monitoring Protocol
Throw Trap Field Form

Appendix B Figure 1. NCBN Throw Trap Field Data Form.

Park Code: _____ UTM Zone: _____ Start Time: _____
 Site Code: _____ Datum: _____ End Time: _____
 Station ID: _____ UTM X (meters): _____ Crew (Initials): _____
 UTM Y (meters): _____ Data Entered (Y/N): _____
 Est. Horiz. Error (meters): _____ Data Verified (Y/N): _____

Habitat Type (circle): Open Ditch Plugged Ditch	Water Measurements		Tide (circle): Ebb Flood
	Temp (C):		Sediment (circle): Sand Mud
	Salinity (ppt):		
	DO (mg/L):		Ditch Depth (cm): _____
Depth (cm): _____			

Ditch Net Dimensions (cm)	A to B:	B to C:	C to D:	D to A:	Diag. A to C:
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Vegetation Species Adjacent to Sampling Station (ie along the ditch):
Notes on Condition of Ditch (lots of debris, mucky, sides caving, etc):

NCBN Saltmarsh Nekton Monitoring Protocol
Ditch Net Field Form

*length in (mm)														
species	length													total
	tally													
	length													
	tally													
	length													
	tally													
	length													
	tally													
	length													
	tally													
	length													
	tally													

Notes (photos taken? problems, observations, etc):

Appendix B Figure 2. NCBN Ditch Net Field Data Form

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 962/117023, September 2012

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

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