MONITORING STRATEGY

An Appendix to the
2019 Comprehensive Conservation and Management Plan
of the Coastal & Heartland National Estuary Partnership

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INTRODUCTION

The Coastal & Heartland National Estuary Partnership (CHNEP) was created pursuant to Section 320 of the Clean Water Act as one of 28 "Estuaries of National Significance" in the National Estuary Program established under the Federal Clean Water Act. Designated in 1995, the CHNEP is comprised of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the waterways within its 5,400 square-mile work area. This Monitoring Strategy supports implementation of CHNEP's Comprehensive Conservation and Management Plan (CCMP), the strategic plan that contains actions to address Water Quality Improvement, Hydrological Restoration, Public Engagement, and Fish, Wildlife, and Habitat Protection priorities identified by the partnership and that guide development of annual Work plans and budgets.

PURPOSE AND OBJECTIVES OF MONITORING STRATEGY

Monitoring Strategy objectives are tied to guiding questions addressed by one or more environmental data collection parameters. In turn, these parameters are tied to indicators for achieving environmental benefits identified in the CCMP. Ultimately, these data measure the effectiveness of CCMP Actions in achieving CCMP Objectives for Water Quality Improvement, Hydrological Restoration, and Fish, Wildlife, and Habitat Protection.

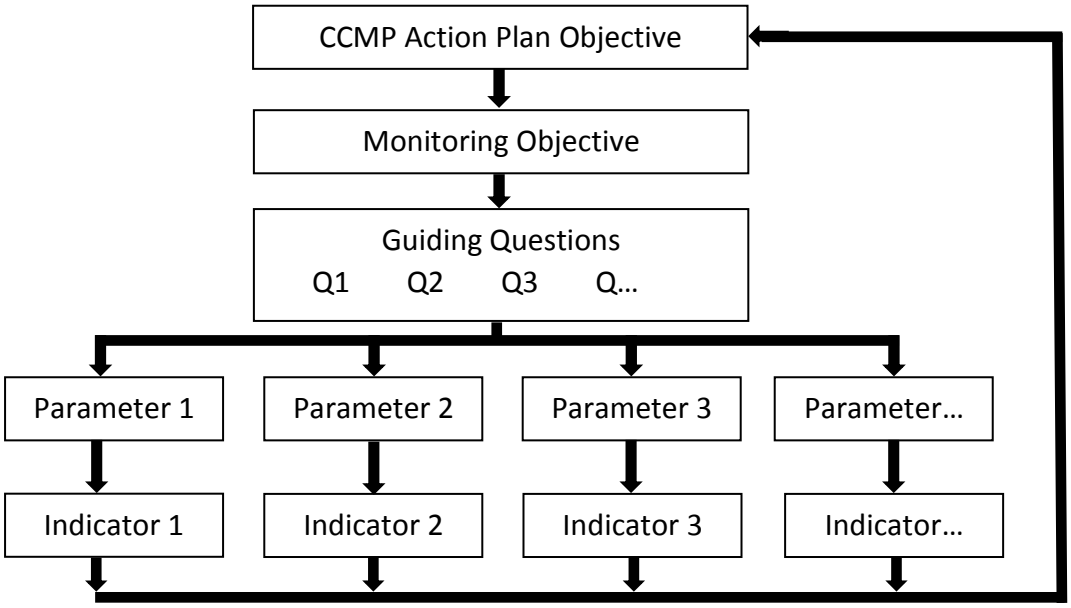

Figure 1. Conceptual framework for the adaptive management approach of environmental monitoring, indicators, and feedback to achieve the environmental objectives of the CCMP.

The environmental objectives of CHNEP are large-scale, involving multiple stakeholders, complex biogeochemical cycles, and long environmental feedback response times to management actions. CHNEP takes an adaptive management approach, with periodic data-driven updates to the CCMP strategy that reflect changing conditions, new information, and new challenges.

A variety of environmental monitoring data are collected throughout the CHNEP area to assess the effectiveness of management actions to achieve environmental results. Many monitoring programs in the CHNEP area are standardized to ensure statistically valid and replicable results over long-term datasets, for example: water quality, seagrass, and fisheries. Some monitoring data are collected for a specific purpose or project and reflect a snapshot of conditions, such as seagrass scarring (Madley et al. 2004) or presence of pharmaceuticals in tidal rivers (Gelsleichter 2008). Data are generally collected in a manner that can provide localized information, by basin or segment, to assess problem areas in addition to overall conditions.

The Management Conference takes a collaborative approach with shared responsibility of multiple partners for environmental monitoring and project implementation. Partners provide data collection and analysis and funding support for various monitoring elements. CHNEP staff coordinates long-term water quality monitoring and data management and supports its integration and dissemination to the public. This Monitoring Strategy is not intended to be a comprehensive unified plan of all monitoring activities in the area; rather it is focused on the coordinated efforts of CHNEP and our partners to measure the environmental progress of CCMP implementation.

The Monitoring Strategy is summarized for each CCMP Action Plan in Tables 1–3 and includes a) objectives and guiding questions, b) data that CHNEP and partners are collecting; c) party/parties responsible for data collection; d) frequency of collection and reporting; e) how data are shared, reported, and used; f) data gaps; and g) additional funding needed for monitoring activities and filling data gaps. Narrative descriptions of the monitoring programs supplement the summary tables. As a technical supplement of the CCMP, this Monitoring Strategy focuses on aspects of monitoring, data collection, analyses, and uses. Refer to CCMP Action Plans for full descriptions of program objectives and performance criteria for guiding each objective, as well as resource management strategies and actions. Within the CCMP, the history, successes, issues, and plans for protecting and restoring the CHNEP area are described in detail, including extensive background documentation relevant to this Monitoring Strategy.

MONITORING OBJECTIVES

The CHNEP objective for water quality improvement is to meet or exceed water quality standards for designated uses of natural waterbodies and waterways with no degradation of Outstanding Florida Waters. The monitoring objective is to support comprehensive and coordinated water quality monitoring programs to assess whether water quality standards are being met.

Three guiding questions frame the water quality monitoring strategy:

1. Is water quality improving, declining, or remaining stable?
2. Are nutrient concentrations above or below established targets?
3. Is water clarity above or below established targets?

Each of these guiding questions is addressed by one or more environmental data collection parameters and tied to indicators of success identified in CCMP Water Quality Improvement Actions. The following table outlines these data collection **parameters**; **entities responsible for data collection**; **frequency of data collecting and reporting**; **data sharing and reporting**; and **data gaps/funding needs**.

Table 1. Monitoring and Indicators matrix for Water Quality Improvement with guiding questions and associated environmental data collection and reporting.

Objective: Meet or exceed water quality standards for designated uses of natural waterbodies and waterways with no degradation of Outstanding Florida Waters.							
Parameter(s)	**CCMP WQ Actions/ Activities**	**Guiding Question(s)**	**Indicator(s) of Success**	**Collection/ Reporting Frequency**	**Responsible Entities**	**Sharing/Reporting**	**Gaps/Funding Needs**
15 water quality parameters (CHNEP 2015, 2019)	1.1, 1.2, 1.3, 1.4	1,2,3	Maintenance or increase in the current spatial and temporal extent of ambient water quality monitoring data collection with appropriate QA/QC Water quality that meets or exceeds waterbody targets (NNC, water clarity)	monthly/ biannually	CHNEP (Lead), SWFWMD, SFWMD, FDEP (Lead for data sufficiency and QA/QC), FDACS, FWC, CHAP, EBAP, County and Municipal Governments. PRMSWSA -Horse Creek Stewardship Program and Mosaic Peace River Monitoring Program (not in WIN). Other entities: SCCF, Calusa Waterkeeper, FGCU (not in WIN, not collected using CHNEP 2019 protocols)	CHNEP Water Atlas; CHNEP annual water quality status summaries for all basins	Sources/concentrations of nutrient pollution (reuse irrigation, atmospheric deposition, agricultural runoff, urban stormwater, incinerators); Emerging pollutants such as pharmaceuticals and microplastics; Need to re-evaluate targets
Nutrient removal efficiency of BMPs	3	1,2,3	Reduced stormwater and agricultural nutrient loading	periodic	UF/IFAS, FDACS, FDEP, County and Municipal governments	Technical Reports	Gaps in spatial coverage; Gap in monitoring/reporting of agricultural runoff and urban stormwater loading.

Parameter(s)	CCMP WQ Actions/ Activities	Guiding Question(s)	Indicator(s) of Success	Collection/ Reporting Frequency	Responsible Entities	Sharing/Reporting	Gaps/Funding Needs
Gallons of overflows and releases	4.1	1,2,3	Reduced sanitary sewer system overflows and reduced discharges of non-AWT reuse water Increased municipalities using AWT for wastewater	event-based/ monthly	County and Municipal Governments (Leads), FDEP, FDOH	Discharge Monitoring Reports; FDEP Public Notice of Pollution reporting website and map; FDEP Class B biosolids maps	More robust standardized and verified reporting requirements for Public Notice of Pollution spill reports; Maps quantifying concentration, distribution, and application of reuse for irrigation; Microbial source and isotope tracer studies for tracking biosolids
Number of OSTDS	4.2	1,2,3	Reduced number of septic systems and small package plants threatening surface water and groundwater	variable	County and Municipal Governments (Leads), FDEP, FDOH	FDOH report and GIS layer	Verified reporting and mapping of new and existing septics

Red tide cell counts; blue-green algae blooms	5.1	1	Tracking and dissemination of information about occurrences of harmful algal blooms and increased understanding of influencing factors	weekly/ daily	FWC (Lead for Red Tide), FDEP (Lead for blue green)	FWC website and map; FDEP website and map; NOAA HAB Program; USF CMS Ocean Circulation Group; HABscope-GCOOS	Harmful algal blooms in fresh water; Influence of climate and land-based pollution on HABs; Human health effects

WATER QUALITY MONITORING PROGRAMS

CHNEP manages the Coastal Charlotte Harbor Monitoring Network (CCHMN), a partnership of agencies initiated in 2001 that collects monthly water quality data using consistent, technically sound sampling design. Long-term random sampling of strategically located stations allows scientific assessment of status and trends. CCHMN field and laboratory partners collect and analyze water samples from 60 randomly selected field sites throughout 10 waterbodies each month, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay and the Tidal Myakka, Peace, and Caloosahatchee Rivers. Fifteen water quality parameters are measured and analyzed using consistent field and laboratory methods (CHNEP 2015, 2016, 2019).

Data are uploaded biannually by partners to WIN (Watershed Information Network), previously called STORET (Storage and Retrieval), a standard, common public database maintained by the Florida Department of Environmental Protection (FDEP). In addition, all contributing CCHMN laboratories and field monitoring agencies participate in Southwest Florida Regional Ambient Monitoring Program (SWF RAMP) quarterly meetings to help ensure region-wide data and methodology comparability. The SWF RAMP serves as a quality assurance forum for comparing split-sample laboratory results, resolving inconsistencies in results, and discussing pertinent water quality monitoring issues throughout the region.

CCHMN supplements other ongoing water quality monitoring programs implemented by partners, including ongoing fixed station monitoring by counties, cities, agencies, and citizen scientists. The Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) is a volunteer-based sampling program coordinated by FDEP Charlotte Harbor Aquatic Preserve (CHAP) and Estero Bay Aquatic Preserve (EBAP). Volunteers collect field measurements and water quality data for 19 parameters at 46 fixed sites on the first Monday of each month within one hour of sunrise. Nine waterbodies across the estuary are sampled, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay and the Tidal Peace and Myakka Rivers. The program follows the Standard Field Procedures for Water Quality Monitoring (CHEVWQMN Monitoring Manual) produced by FDEP Aquatic Preserves.

CHNEP supports the CHEVWQMN program by providing access to data through the CHNEP Water Atlas and training new volunteers as needed. CHNEP also supports Lee County Hyacinth Control District's Pond Watch and Cape Coral's Canal Watch, which engage homeowners to collect water samples from neighborhood ponds, lakes, and canals. Water quality analysis is performed by the sponsoring agency, and results are reported back to volunteers.

Citizen scientists also contribute data on microplastics as part of a collaborative regional monitoring initiative with Florida Sea Grant and NOAA. During coastal cleanup events,

volunteers collect sediment and water samples for lab analysis. Microplastics are sorted by type and size, and data are shared with resource managers and scientists.

Red tide blooms in Florida coastal waters are monitored weekly for red tide cell counts by Florida Fish and Wildlife Conservation Commission's (FWC) Harmful Algal Bloom (HAB) group. FWC coordinates routine and event-response monitoring with state agencies, local governments, and private citizens. FWC also works with Mote Marine Laboratory to monitor coastal waters from Tampa Bay to San Carlos Bay. FWC reports on the current status of red tide blooms using tables, maps, and interactive Google Earth maps. They also provide updates on reported fish kills and respiratory irritation.

An experimental red tide respiratory forecast was developed by the National Ocean and Atmospheric Administration's National Centers for Coastal Ocean Science (NOAA-NCCOS) in partnership with the Gulf of Mexico Coastal Ocean Observing System (GCOOS), FWC, and Pinellas County. Their product, HABscope, provides weekly Gulf of Mexico Harmful Algal Bloom Forecasts that increase to twice weekly during blooms. Forecasts include up-to-date information on where a bloom is located and a 3–4 day forecast for potential respiratory irritation. University of South Florida College of Marine Science's Ocean Circulation Group provides a 4.5-day HAB trajectory forecast based on FWC red tide cell count observations and circulation models.

Blue-green algae blooms are tracked by the Florida Department of Environmental Protection (FDEP). FDEP reviews citizen reports of algal blooms received via the online reporting form or hotline and coordinates with other agencies that are also sampling – SFWMD, SWFWMD, FWC, and Lee County – to determine which sampling team will respond based on the location of the bloom relative to the sampling schedule for that day.

SHARING, REPORTING AND USE OF DATA

CHNEP maintains the CHNEP Water Atlas to ensure continuing access to water quality data and other technical information by area scientists, resource managers and users, elected officials, and the public. Launched in 2011 and managed by the University of South Florida in Tampa, the Water Atlas is a data management system that is user-friendly, web-based, and uses geographic information systems and analyses tools to relay and analyze a massive amount of data. The CHNEP Water Atlas displays water quality and hydrology data using maps and charts, making data easier to visualize and understand. Data are available for 473 groundwater stations and 6,194 surface water stations from 102 different data sources, including biannual updates of CCHMN data from WIN. CHEVWQMN, Cape Coral Canal Watch, and the Lee County Hyacinth District Pond Watch sampling programs also provide data to the CHNEP Water Atlas. From 2013 to 2018, 1,867 new sampling stations and more than 10.6 million new samples were added.

CHNEP Water Atlas users can access pages for individual waterbodies — including lakes, ponds, bays, rivers, and streams to view associated water quality data. The Data Download tool allows

users to view and graph data or to download raw data. The CHNEP Water Atlas Real-Time Data Mapper tool has hundreds of stations that perform near-continuous monitoring of water quality, weather/rainfall, water flow, and water levels, with some sampling intervals as short as 15 minutes.

A core objective of CHNEP is to translate water quality data collected by CCHMN and other programs into actions aimed at protection and restoration. Analysis of water quality status and trends is essential to identify major sources of pollutants, provide more accurate measures of pollutant load limits, develop a basis for management plans, and evaluate effectiveness of management practices. Previous analyses have led to development of water quality targets (CHNEP 2005) and numeric nutrient criteria for the estuary (Janicki Environmental 2010), as well as periodic watershed reports (CSWF 2005, CSWF 2011, CHNEP 2011, CSWF 2017). Annually, CHNEP's county and municipal partners evaluate water quality data from fixed-point monitoring programs to identify trends and corrective actions.

The CHNEP Water Atlas has recently been enhanced by new powerful data analysis tools that provide visualization of water quality status and trends. The Water Quality Contour Mapping GIS tool creates maps using inverse distance weighted interpolation to demonstrate changes in water quality at fixed periods, with monthly contour maps for 12 parameters. The Water Quality Trends tool displays results of a statistical ten-year trend analysis. The model employs techniques to account for seasonality, autocorrelation and duplicate sampling to detect statistically significant trends. The Water Clarity Report Card shows improving, stable, or declining water clarity in areas of the estuary with seagrass protection and restoration targets using the optical model spectral validation and annual water clarity reporting tool (Dixon and Wessel 2014). CHNEP continues to support development and use of these and other types of sophisticated numerical and spatial modeling techniques (*e.g.*, pollutant load models) for protecting and restoring water quality.

Data Gaps and Funding Needs

As environmental conditions change due to anthropogenic and climate stressors, water quality sampling gaps may emerge. There is a need to identify gaps where redundancies exist or where data are insufficient to meet FDEP quality assurance or quality control (QA/QC) requirements for impairment determination, as well as for Total Maximum Daily Load (TMDL) and Basin Management Action Plan (BMAP) development and compliance. Current sampling does not adequately capture information on: 1) the sources/loads of nutrient pollution (reuse irrigation, atmospheric deposition, agricultural runoff, urban stormwater, incinerators), 2) nutrient removal efficiencies of water quality BMPs, 3) nutrient loading from wastewater reuse irrigation, 4) robust mapping of existing septic systems and maintenance, 5) harmful algal blooms in fresh water, 6) influence of climate and land-based pollution on HABs, or 7) emerging pollutants such as pharmaceuticals and microplastics. CHNEP will continue to coordinate and

adapt, working with partners to identify emerging needs and seek funding, equipment, volunteers, and other resources to enable additional sampling and research in essential areas.

HYDROLOGICAL RESTORATION

MONITORING OBJECTIVES

The CHNEP objective for hydrological restoration is to restore adequate aquifer recharge and freshwater volume and timing of flow to support healthy natural systems, meet water quality criteria, and protect the designated use. The monitoring objective is to support data-driven watershed planning and hydrological restoration to protect and restore natural flow regimes and provide sufficient fresh surface water and groundwater to natural systems.

Four guiding questions frame the hydrological restoration strategy:

1. Are hydrologic data gathering and analysis increasing to support hydrological restoration?
2. Is water management improving such that MFLs are being met?
3. Is hydrological restoration increasing?
4. Are aquifer levels improving in the Southern Water Use Caution Area, accounting for rainfall and consumptive use?

Each of these guiding questions is addressed by one or more environmental data collection parameters and tied to indicators of success identified in the CCMP Hydrological Restoration Actions. The following table outlines these data collection **parameters**; **entities responsible for data collection**; **frequency of data collecting and reporting**; **data sharing and reporting**; and **data gaps/funding needs**.

Table 2. Monitoring and Indicators matrix for Hydrological Restoration with guiding questions and associated environmental data collection and reporting.

Objective: Adequate aquifer recharge and freshwater volume and timing of flow to support healthy natural systems, meet water quality criteria, and protect the designated use.							
Parameter(s)	**CCMP HR Actions/ Activities**	**Guiding Question(s)**	**Indicator(s) of Success**	**Collection/ Reporting Frequency**	**Responsible Entities**	**Sharing/Reporting**	**Gaps/Funding Needs**
Flows and levels, and Rainfall	1.1, 2.2	1,2,3,4	Reduced MFL exceedances Return of flow to historic watersheds Increase in long-term average annual levels in aquifers	real-time to monthly/ annually to 5-years	SWFWMD and SFWMD, CHNEP Water Atlas, County and Municipal Governments, Water Supply Authorities, FDEP, USGS	USGS Water Information System; SWFWMD WMIS; SFWMD DBHYDRO; CHNEP Water Atlas; Minimum Flows and Levels Reports	Surface water and groundwater level and flow gages in areas with limited data; Improved surface-groundwater models to incorporate climate stressors in southern portions (SFWMD) of CHNEP area
Water consumption	2.3	2,4	Increased water conservation	Continuous /annual to 5-years	County and Municipal Governments, SWFWMD, SFWMD, FDACS, UF/IFAS Extension, Water Utilities, FDEP, USDA, private sector	Water management district annual estimated water use reports and 5-year Regional Water Supply Plan and Water Supply Assessments	More metering to implement water conservation projects and initiatives

Parameter(s)	CCMP HR Actions/ Activities	Guiding Question(s)	Indicator(s) of Success	Collection/ Reporting Frequency	Responsible Entities	Sharing/Reporting	Gaps/Funding Needs
Acres or linear miles of hydrologically restored or reconnected habitat	3.2	1,2,3	Increased acres or linear miles of hydrologically restored or reconnected habitat that maintain or improve water quality and flood protection	annual/ annual to 5-years	CHNEP (implementation facilitator), FDEP, County and Municipal Governments, SWFWMD, SFWMD, USACE, FWC, USFWS, USDI (NPS and other USDI), USDA, FDOT, FDEP, NGOs, FDACS, Private sector	EPA NEPORT; Habitat Restoration Needs Plan Update	Assessment of impacts of manmade barriers and alterations; Tracking of private reclamation and restoration projects

Hydrological Restoration Monitoring Programs

The U.S. Geological Survey (USGS) currently operates hundreds of monitoring sites in Florida to collect information on surface water, groundwater, water quality, and precipitation. Many sites are equipped with satellite telemetry, which allow data to be posted online for public dissemination. Frequency of data collection ranges from 15 minutes to daily. Many USGS monitoring sites are operated in cooperation with the Southwest Florida Water Management District (SWFWMD), South Florida Water Management District (SFWMD), and other agencies.

SFWMD and SWFWMD also operate and contract large monitoring networks to measure rainfall, stream flow, spring discharge, and surface water and groundwater levels. Frequency of data collection and reporting ranges from real-time to monthly.

In the CHNEP area, collaboration between USGS and Lee County is yielding important monitoring data for hydrologic modeling and assessment of flood conditions in South Lee County flowways. Hydrologic monitoring data from FDEP, USGS, FWC, and Lee County are contributing to the monitoring network for the Charlotte Harbor Flatwoods Initiative, a regional multi-partner effort lead by SFWMD, CHNEP, and FWC to restore historical sheet flow from the Babcock-Webb Wildlife Management Area across the Yucca Pens area.

Sharing, Reporting and Use of Data

Flows and levels data are collected, processed, analyzed, and uploaded to publicly accessible, searchable online databases (USGS National Water Information System, SWFWMD Water Management Information System, and SFWMD DBHYDRO database), as well as on the CHNEP Water Atlas. Water use is estimated and reported annually by the Water Management Districts. The Estimated Water Use Reports are based on metered water pumpage records and reported for predominant use categories. Annual use reports complement the Districts' 5-year regional water supply assessments and plans, which capture current and projected water use.

Data are analyzed to make decisions that help balance consumptive and environmental needs. Models can be used to help predict future water demands and the effects of climate change on these supplies. Accurate data-driven water budget modeling is required to effectively manage and balance the water demands of people for drainage, drinking water, navigation, and recreation while preserving the ecological health of natural systems. It is especially important to develop water budgets that predict future water demands and supplies under climate change scenarios. Hydrologic interactions among factors such as evapotranspiration, precipitation, groundwater pumping, wastewater reuse, watershed connections, impermeable surfaces, constructed conveyances, barriers and reservoirs — in addition to future water demands due to population growth — also need to be modeled.

Data Gaps and Funding Needs

While many areas within the CHNEP have extensive historical hydrologic records, other areas lack them. For these areas, we need to determine the minimum number and appropriate locations of gages to close these gaps. For the southern portions of the CHNEP area, improved monitoring of flow and salinity data will provide a stronger scientific basis to establish minimum flows and levels, assess impacts of manmade barriers and alterations, and forecast future changes related to projected development and consumptive uses. There is a need to improve surface-groundwater models to incorporate climate stressors, particularly the effects of sea level rise. Hydrological restoration projects occurring on private lands need to be better tracked as part of a comprehensive hydrological restoration spatial database that includes all public and private lands.

Fish, Wildlife, and Habitat Protection

Monitoring Objectives

The CHNEP objective for fish, wildlife, and habitat protection is to permanently acquire, connect, protect, manage, and restore natural terrestrial and aquatic habitats. The monitoring objective is to assess changes in the areal extent and quality of critical natural habitats including wildlife dispersal areas, movement and habitat migration corridors, wetlands, flowways, and environmentally sensitive lands and estuarine habitats.

Five guiding questions frame the fish, wildlife, and habitat monitoring strategy:

1. Is the areal coverage and quality of seagrass increasing, decreasing or remaining stable?
2. Are native fish populations and diversity increasing, decreasing or remaining stable?
3. Is the areal coverage of protected habitat increasing?
4. Is the areal coverage of restored habitat increasing?
5. Are coastal habitat zones migrating upslope or otherwise changing?

Each of these guiding questions is addressed by one or more environmental data collection parameters and tied to indicators of success identified in the CCMP Fish, Wildlife, and Habitat Protection Actions. The following table outlines these data collection **parameters**; **entities responsible for data collection**; **frequency of data collecting and reporting**; **data sharing and reporting**; and **data gaps/funding needs**.

Table 3. Monitoring and Indicators matrix for Fish, Wildlife, and Habitat Protection with guiding questions and associated environmental data collection and reporting.

Objective: Permanently acquire, connect, protect, restore, and manage natural terrestrial and aquatic habitats.							
Parameter(s)	**CCMP FW Actions/Activities**	**Guiding Question(s)**	**Indicator(s) of Success**	**Collection/ Reporting Frequency**	**Responsible Entities**	**Sharing/Reporting**	**Gaps/Funding Needs**
Seagrass acreage	1.1	1	Seagrass segments that meet or exceed targets	2-yr or 5-yr/ 2-yr or 5-yr	SWFWMD, SFWMD	CHNEP Water Atlas; District GIS layers	Coordination and synchronization of District surveys; Caloosahatchee Estuary
Seagrass species, abundance, blade length, shoot counts, epiphytes	1.1	1	High abundance and density, and stable diversity of seagrass meadows	biannual/ annual	FDEP Aquatic Preserves, Sea Grant, SCCF, SFWMD, Sarasota County, FWC-FWRI (lead for SIMM)	technical reports	
Oyster reef acreage	1.1	3,4	Increased acreage of oyster reefs	2-yr/2-yr	SWFWMD (adjunct to aerial seagrass mapping, not ground-truthed), USACOE, SFWMD	technical reports	
Oyster reef height, density and size of live oysters	1.1	3,4	High abundance and density of live oysters	annual/ annual	FGCU, Sarasota County, Lee County, TNC, FDEP EBAP, SCCF, FWC	CHNEP Water Atlas; Sarasota Water Atlas	Additional shellfish (hard clams, scallops)

Parameter(s)	CCMP FW Actions/ Activities	Guiding Questions	Indicator(s) of Success	Collection/ Reporting Frequency	Responsible Entities	Sharing/Reporting	Gaps/Funding Needs
Fish diversity and abundance	1.2	2	Stable abundance and diversity of native fish species	monthly/ annual	FWRI-FIM	technical reports	Monitoring in coastal salt marsh, freshwater wetlands; Coverage gaps for Dona/Roberts Bays, Lemon Bay, Caloosahatchee River, Estero Bay, and San Carlos Bay
Tidal tributary water and sediment quality, and fish	1.2	2,3,4,5	Stable abundance and diversity of native fish and invertebrate species	periodic/ periodic	CHNEP, TBEP, SBEP, FWC	technical reports	Coverage gaps for Dona/Roberts Bays, Lemon Bay, Caloosahatchee River, Estero Bay, San Carlos Bay
Native habitat land cover	1.1, 2.1, 2.2	3,4,5	Increased acreage of native upland habitats; Increased acreage of coastal and freshwater wetlands	6-m to 5-yr/ 6-m to 5 yr	FWC/FNAI, SWFWMD, SFWMD, County & Municipal Gov., FDEP	Florida Cooperative Land Cover, Integrated Wildlife Habitat Ranking System (FWC); Integrated Habitat Network Plan (FDEP); Habitat Restoration Needs Plan (CHNEP); Florida Invasive Plants Geodatabase (FNAI); EDDMapS (FISP)	

Acres of acquired and/or restored conservation lands	1.1, 2.1, 2.2, 3.1	3,4,5	Increased acres of permanently protected and/or restored conservation lands	ongoing/ annual	FWC/FNAI, FWC-WMAs, County & Municipal Gov., SWFWMD, SFWMD, FDEP, NGOs, FDACS, NRCS	FNAI; EPA NEPORT; FL-SOLARIS/CLEAR Conservation Easements (FDEP)	Conservation easements (NGO); Ecosystem services of restored habitats

Fish, Wildlife, and Habitat Monitoring Programs

Seagrass: SWFWMD and SFWMD conduct regular aerial mapping of seagrass location and acreage throughout the CHNEP area. SWFWMD maps seagrass every two years in five waterbodies, including Lemon Bay, Cape Haze, Gasparilla Sound, Charlotte Harbor, and the Tidal Myakka and Peace Rivers. SFWMD maps seagrass every five years in six waterbodies, including Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay and the Tidal Caloosahatchee River. Researchers identify and map continuous seagrass, patchy seagrass, and unvegetated tidal flats using ground-truthing and photointerpretation of aerial images. Results are posted to the CHNEP Water Atlas.

FDEP CHAP conduct annual in-water seagrass monitoring along 50 permanent transects extending from shore to the deepest edge of seagrass meadows. CHAP staff and volunteers monitor Lemon Bay, Cape Haze, Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, and the Tidal Myakka and Peace Rivers. EBAP conducts seagrass monitoring at five sites biannually in Estero Bay and Division of Environmental Assessment and Restoration (DEAR) conducts quarterly seagrass monitoring in the Caloosahatchee River. Species presence, abundance, blade length, shoot counts, epiphyte abundance, sediment type, and water depth are monitored. FWC's FWRI Fisheries Independent Monitoring Program assesses the type and quantity of benthic habitat, including seagrass, at each sampling site. SFWMD surveys submerged aquatic vegetation twice per year throughout the Caloosahatchee Estuary.

Oyster reefs: SWFWMD maps oyster reefs biennially as an adjunct to the biennial seagrass mapping using photointerpretation of aerial images for presence/absence, but no information on the overall health or status of mapped reefs is collected. Florida Gulf Coast University's (FGCU) Oyster Monitoring Network for the Caloosahatchee Estuary, funded by SFWMD, conducted oyster monitoring in the Caloosahatchee Estuary and Estero Bay (1999–2017) in support of the Comprehensive Everglades Restoration Plan. FWC continues this work from 2018 to present. EBAP staff also monitor oyster reefs within Estero Bay. Eight sites are assessed annually for parameters including reef height and length, percent cover, density, shell height of live oysters, and predator presence. Sarasota County has an oyster mapping program and has monitored oyster reefs at the mouth of tidal creeks flowing to Dona and Roberts Bays and Lemon Bay since 2003. Data are published on the Sarasota Water Atlas. TNC, in collaboration with CHAP, FWC, CHNEP, and volunteers monitors restored oyster reefs at Trabue Harborwalk in Punta Gorda. Annual monitoring includes data on oyster recruitment, macroinvertebrates, bird presence, and small-tooth sawfish.

Uplands and wetlands: Updated every five years, CHNEP's Habitat Restoration Needs Plan (CHNEP 2019) analyzes the historical and existing acreage of upland, freshwater wetland, and coastal wetland habitats using land cover data provided by the Water Management Districts.

SWFWMD and SFWMD update these data every 4–5 years by photointerpretation and classification of aerial photography. Florida conservation lands, rare plants and animals, and high value natural habitats are tracked by the non-profit Florida Natural Areas Inventory, which issues a pubic summary report annually. In addition, the Florida State Owned Lands and Records Information System (FL-SOLARIS) Conservation Lands, Easements and Recreation (CLEAR) database maintained by FDEP tracks conservation lands and easements within the state of Florida that are owned and retained by federal government, counties and municipalities.

Tidal Creeks: As part of a regional collaborative project to develop numeric nutrient criteria for water quality in tidal creeks, ten of the 55 tidal creeks in the CHNEP area were sampled for water quality, sediment, and fish communities. Selected creeks were located in Charlotte Harbor, Pine Island Sound, Gasparilla Sound, and Upper Matlacha Pass, including tidal Peace and Myakka Rivers. Various other tidal creeks are sampled as part of hydrologic and habitat restoration activities, yielding information on habitat use and habitat condition necessary for supporting native aquatic life. Results are typically shared through published reports and presentations. Florida Fish and Wildlife Research Institute's Fisheries-Independent Monitoring (FWRI-FIM) Program recently added sampling of limited sites in select tidal creeks to their sampling 'universe'. This data will be featured in FWC annual reports.

Fisheries: FWRI-FIM Program regularly samples fish throughout coastal waters of the Greater Charlotte Harbor area, including Charlotte Harbor, Pine Island Sound, Gasparilla Sound, and Upper Matlacha Pass, including tidal Peace and Myakka Rivers and a selection of tidal creeks. The goal of the FWRI-FIM program (initiated in Charlotte Harbor in 1989) is to provide high quality fisheries data to managers regarding fish abundance and population trends. A variety of techniques and sampling gear are used by the FWRI-FIM program to ensure that the wide range of species, sizes, and ages necessary for stock management are sampled during each monthly survey. Analyses of the FWRI-FIM program data are used by resource managers to assess abundance trends for resource species, define essential fish habitat, and describe life-history parameters such as age, growth, and age at maturity. It is important to support continued and expanded monitoring in CHNEP estuaries, as fish abundance and diversity are indicators of the health of water bodies, and robust data sets are needed to establish trends. FWRI-FIM program data are also frequently used to assess the impact of environmental perturbations such as red tides, extreme cold events, and oil spills.

Data Gaps and Funding Needs

While data are being collected to track habitat restoration and species protection, there is a need for more timely updates of conservation lands maps with privately held conservation easements, as there is a delay in recoding and/or non-reporting of new easements. Limited data exist about whether restored habitats are providing expected ecosystem services. Similarly, more data are needed to establish nutrient removal performance standards for habitat

restorations that serve as stormwater BMPs, for example, living shorelines, tidal creek and canal restorations, and other green infrastructure. There are gaps in coverage for in-water oyster reef and other shellfish monitoring throughout the area, and additional seagrass monitoring is needed for the Caloosahatchee River. Additional in-water resources for ground-truthing to complement the aerial estimates of oyster habitat based on the SWFWMD and SFWMD biennial seagrass maps are needed. There are also coverage gaps for fisheries and tidal creeks monitoring in Dona/Roberts Bays, Lemon Bay, Caloosahatchee River, Estero Bay, and San Carlos Bay.

Plan for Assessing Program Performance

Program Performance is assessed every five years during the Program Evaluation Process, as well as with the Annual Progress reports provided to the US EPA. During those processes, information on CCMP implementation achievements is catalogued and synthesized to determine the overall programmatic effectiveness in achieving programmatic objectives. Additionally, CCMP updates every five years embody iterative planning and adaptive management to adjust program objectives as needed to reflect the best available science and changing social, political, and environmental conditions. The CHNEP is due to have its next Program Evaluation in 2020 and every 5 years thereafter.

Conclusions

Ultimately, the success of the CHNEP CCMP will be evident in improvements in environmental conditions — healthy and abundant ecosystems with healthy naturally flowing waters that support a diversity of interconnected habitats and species. Environmental monitoring programs in the CHNEP area are necessary to detect and document these improvements, but due to the complexity of systems and responses, detection and documentation will take time (Tomasko 2018). Environmental monitoring should be adaptive. Data collection techniques, ecosystem responses, emerging threats, management needs, and funding priorities evolve through time, and CHNEPs Annual Work Plans and Quality Assurance Plans provide this flexibility.

Acronyms

AWT	Advanced Wastewater Treatment
BMAP	Basin Management Action Plan
BMP	Best Management Practice
CCHMN	Coastal Charlotte Harbor Monitoring Network
CCMP	Comprehensive Conservation and Management Plan
CHAP	Charlotte Harbor Aquatic Preserve
CHEVWQMN	Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network

CHNEP	Charlotte Harbor National Estuary Program (1995–2019) or Coastal and Heartland National Estuary Partnership (2019–future)
CLEAR	Conservation Lands, Easements and Recreation
CSWF	Conservancy of Southwest Florida
DEAR	Division of Environmental Assessment and Restoration
EBAP	Estero Bay Aquatic Preserve
EDDMapS	Early Detection & Distribution Mapping System
EPA	United States Environmental Protection Agency
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FGCU	Florida Gulf Coast University
FIM	Fisheries Independent Monitoring Program
FISP	Florida Invasive Species Partnership
FL-SOLARIS	Florida State Owned Lands and Records Information System
FNAI	Florida Natural Areas Inventory
FW	Fish, Wildlife, and Habitat Restoration Plan
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
GCOOS	Gulf of Mexico Coast Ocean Observing System
GIS	Geographic Information System
HAB	Harmful Algal Bloom
HR	CCMP Hydrologic Restoration Action Plan
NCCOS	National Centers for Ocean Coastal Science
NEPORT	National Estuary Program Online Reporting Tool
NGO	Non-governmental organization
NNC	Numeric Nutrient Criteria
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
OSTDS	Onsite Sewage Treatment and Disposal Systems
PRMSWSA	Peace River Manasota Regional Water Supply Authority
QA/QC	Quality Assurance/Quality Control
SCCF	Sanibel Captiva Conservation Foundation
SFWMD	South Florida Water Management District
SIMM	Seagrass Independent Mapping and Monitoring
STORET	Storage and Retrieval (now called Watershed Information Network, WIN)
SWFRAMP	Southwest Florida Regional Ambient Monitoring Program
SWFWMD	Southwest Florida Water Management District
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
UF/IFAS	University of Florida Institute of Food and Agricultural Sciences

USACE	U.S. Army Corps of Engineers
USDA	Unites States Department of Agriculture
USDI	United States Department of the Interior
USF-CMS	University of South Florida College of Marine Science
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
WIN	Watershed Information Network
WMA	Wildlife Management Area
WMIS	Water Management Information System
WQ	CCMP Water Quality Improvement Action Plan

REFERENCES

Charlotte Harbor National Estuary Program (CHNEP). 2005. *Environmental Indicators for the Charlotte Harbor National Estuary Program*. Charlotte Harbor National Estuary Program Technical Report Technical Report 05-1. 69 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2011. *Healthy Rivers, Healthy Bays, Healthy Communities: The Charlotte Harbor Seven-County Watershed Report*. Harbor Happenings. Volume 15, Issue 1. 28 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2015. *Coastal Charlotte Harbor Monitoring Network Standard Operating Procedures 2015 Updates*. Charlotte Harbor National Estuary Program Technical Report 15-4. 33 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2016. *Coastal Charlotte Harbor Monitoring Network Lower Charlotte Harbor Field Sampling Quality Assurance Project Plan*. Charlotte Harbor National Estuary Program. 73 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2019. *Habitat Restoration Needs Plan*. 118 pp.

Coastal & Heartland National Estuary Partnership (CHNEP). 2019. *Coastal Charlotte Harbor Monitoring Network Standard Operating Procedures 2019 Updates*. 38 pp.

Conservancy of Southwest Florida (CSWF). 2005. *Estuaries Report Card for Southwest Florida*. Prepared by the Conservancy of Southwest Florida. 199 pp.

Conservancy of Southwest Florida (CSWF). 2011. *Estuaries Report Card*. Prepared by the Conservancy of Southwest Florida. 251 pp.

Conservancy of Southwest Florida (CSWF). 2017. *Estuaries Report Card: A guide to understanding the health of Southwest Florida's rivers, estuaries and bays*. Prepared by the Conservancy of Southwest Florida. 302 pp.

Dixon, K. and M. Wessel. 2014. *The Optical Model Spectral Validation and Water Clarity Reporting Tool Refinement: Draft Final Report*. Mote Marine Laboratory Technical Report No. 1748. 47 pp.

Gelsleichter, J. 2008. *Identities and ecological effects of ecoestrogens present in the tidal Caloosahatchee River*. Final Report Prepared by Mote Marine Laboratory submitted to Charlotte Harbor National Estuary Program. 50 pp.

Janicki Environmental, Inc. 2010. *Empirical Approaches to Establishing Numeric Nutrient Criteria for Southwest Florida Estuaries*. Prepared for Tampa Bay Estuary Program, Sarasota Bay Estuary Program and Charlotte Harbor National Estuary Program. 56 pp.

Madley, KA, J Krolick, B Sargent. 2004. *Assessment of boat propeller scar damage within the greater Charlotte Harbor region*. Prepared for the Charlotte Harbor National Estuary Program by the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute, St. Petersburg, Florida. 27 pp.

Tomasko, D, M Alderson, R Burnes, J Hecker, J Leverone, G Raulerson, and E Sherwood. 2018. Widespread recovery of seagrass coverage in Southwest Florida (USA): Temporal and spatial trends and management actions responsible for success. *Marine Pollution Bulletin* 135: 1128–1137.