APNEP's Water Resources Monitoring & Assessment Review

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Albemarle-Pamlico National Estuary Partnership

Water Resources Monitoring & Assessment
16 March 2022

Outside Today's Review

- APNEP mission
- APNEP implementation area
- Ecosystem-based management
- Six other APNEP resource monitoring & assessment teams
- APNEP indicator definition

APNEP Water Resources Monitoring & Assessment (2008-2010)

- Develop a monitoring strategy for Water Resources metrics within the APNEP region
- Metric-specific monitoring proposals
- Indicators to be featured in the 2012 APNEP Regional Ecosystem Assessment

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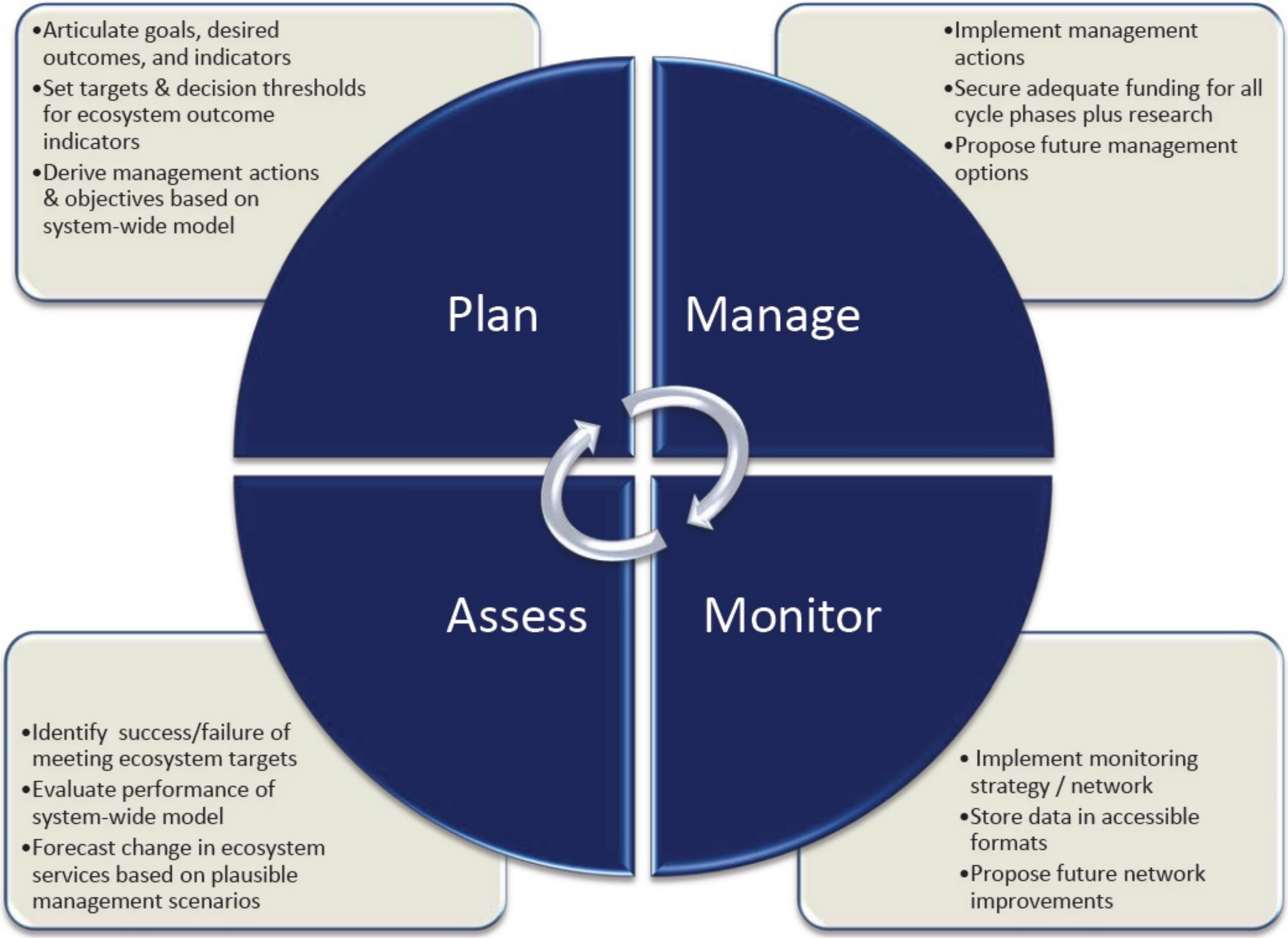
APNEP's Ecosystem Health Goals

- A region where human communities are sustained by a functioning ecosystem
- A region where aquatic, wetland, and upland habitats support viable populations of native species
- A region where water quantity and quality maintain ecological integrity

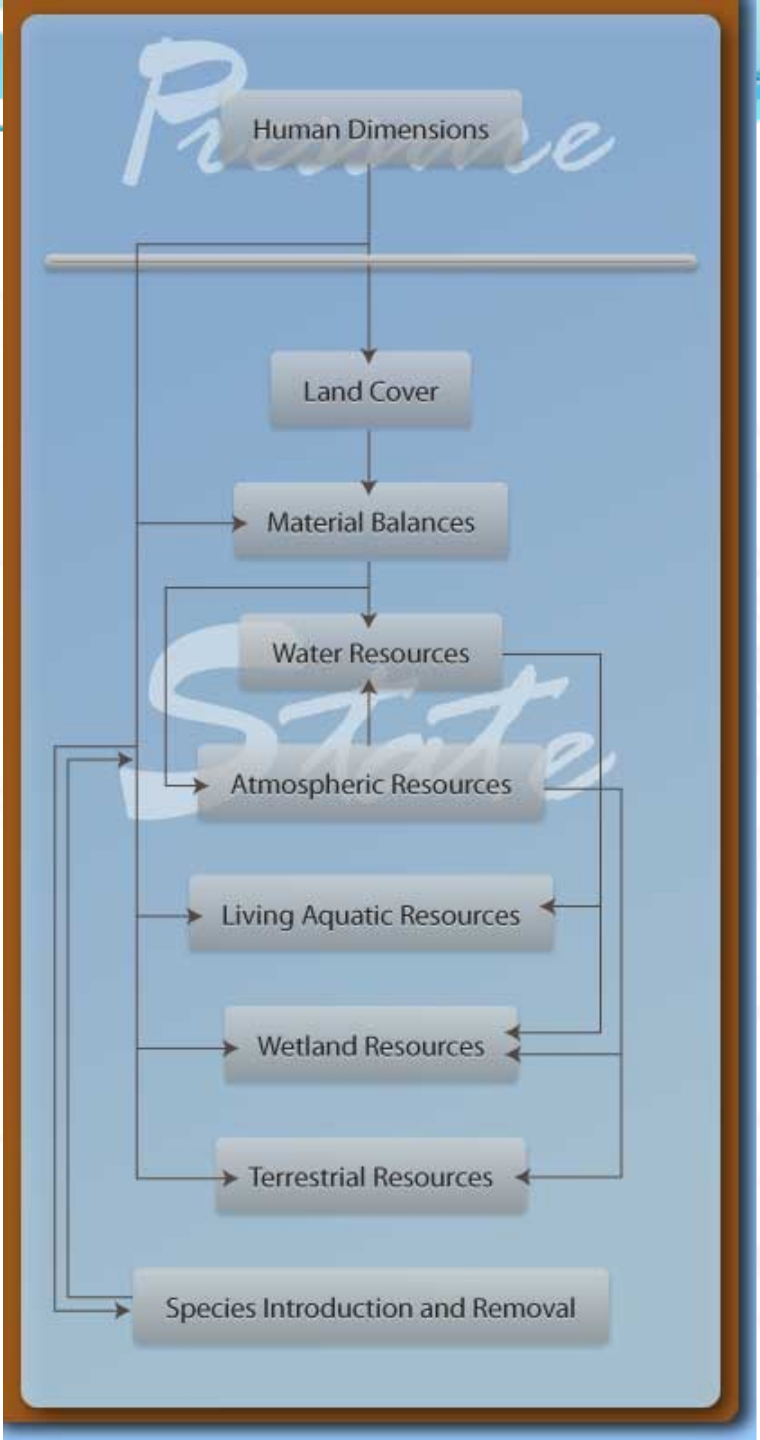
Figure 2: APNEP's adaptive management cycle.



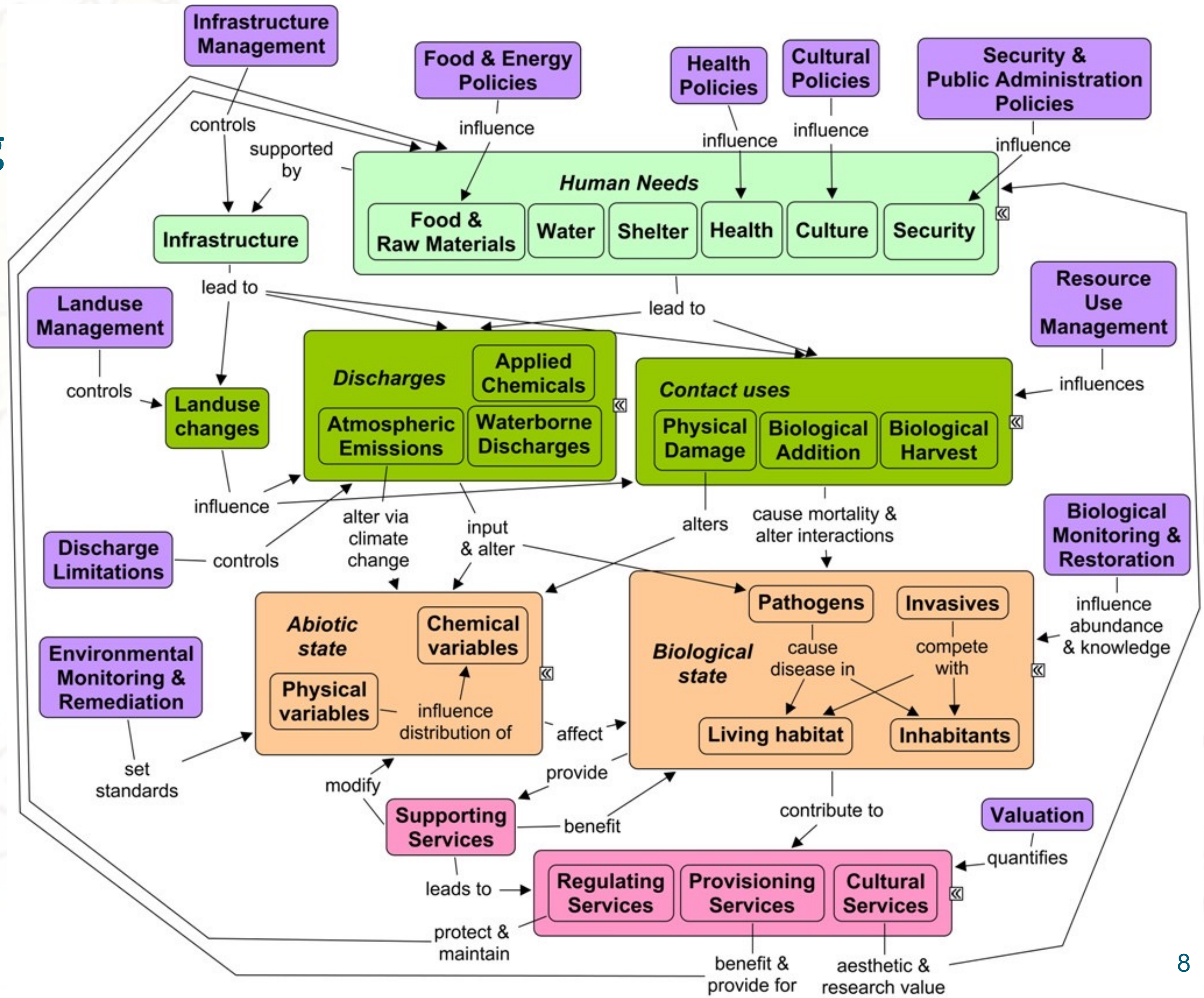
APNEP Deliverables 2022-2023

- Comprehensive Conservation & Management Plan (CCMP) 3.0
- Regional Ecosystem Assessment 2.0
- Integrated Monitoring Framework 1.0

Regional Ecosystem Model



DPSER Modeling



Lt. green = Drivers
Dk. Green = Pressure
Orange = State
Red = Ecosystem Services
Purple = Response

EPA-ORD-ESRP 2010

EPA Indicator Development for Estuaries

- Program Planning
- Conceptual Model Development
- Indicator Specification
- Monitoring Program Development
- Implementation
- Reassessment

APNEP Indicator Criteria

- Utilization: Address a key process or property, and answers (or makes an important contribution toward answering) an important question about conditions in the A-P region
- Objectivity: Developed and presented in an accurate, clear, complete, and unbiased manner
- Integrity: Underlying data should be characterized by sound collection methodologies and data management systems adequate to protect its integrity, and to comply with quality assurance procedures
- Availability: Data should be available and timely, or will likely be available in the future, to maintain the indicator's utility
- Representation: Trends should accurately represent the underlying trends in the target population
- Clarity: The indicator should be clearly defined and reproducible. The specific data used and the specific assumptions, analytical methods, and statistical procedures employed are clearly stated

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A-P Ambient Monitoring Program

- Precise goals and specific measures for monitoring policy effectiveness should be designed and tested at the time that a policy is implemented
- Status Quo: APNEP 2000 monitoring survey update

APNEP Monitoring Proposal

- Justification for indicator
- Goal of sampling/monitoring program
  - What the optimum sampling/monitoring program will achieve and why that is important
- Existing sampling/monitoring program
  - Objectives - What the existing program is designed to measure.
    - Example: *Conduct periodic aerial mapping to monitor dramatic change of SAV presence over 5-year increments in four of six APES regions*
  - Methods
  - Costs
  - Data quality control (data quality objective)
  - Data analysis, statistical methods and hypotheses

APNEP Monitoring Proposal

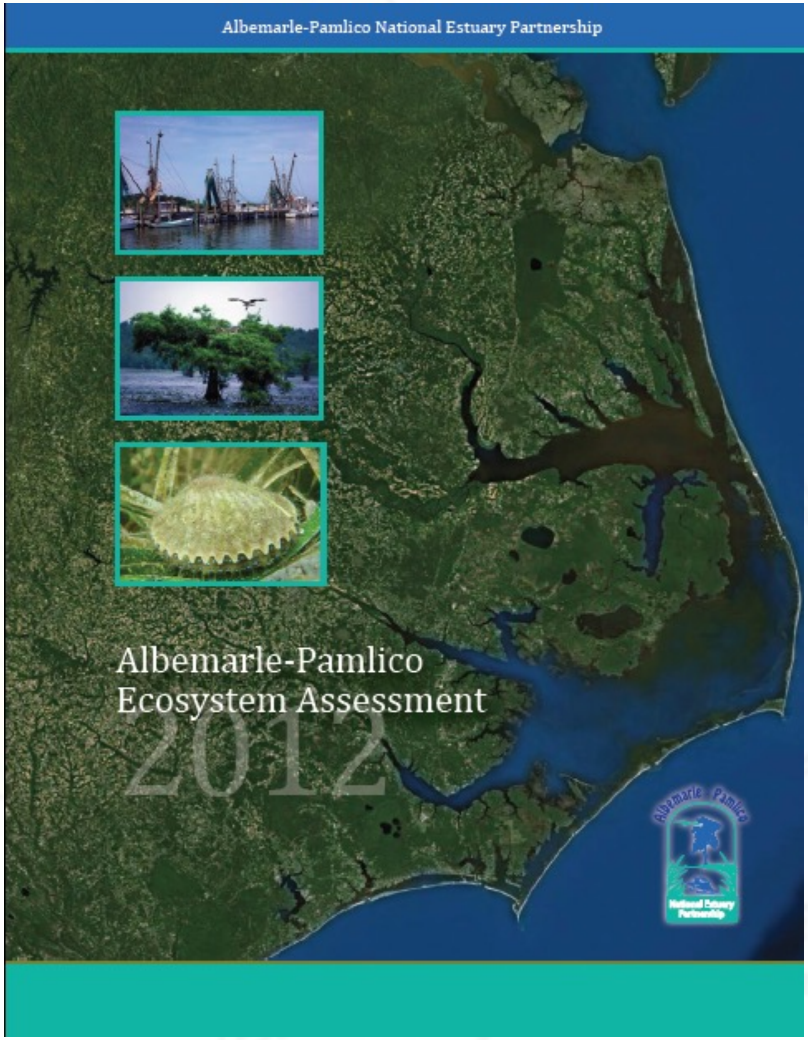
- Enhanced sampling/monitoring program
  - Objectives - what the enhanced sampling/monitoring program is designed to measure.
    - Example: *Estimate the areal distribution and abundance of SAV along the western shorelines of APES and be capable of detecting significant change in SAV distribution and abundance*
  - Methods
  - Costs
  - Data quality control (data quality objective)
  - Data analysis, statistical methods and hypotheses
- Reference(s)
- Contact Person

Monitoring Integration Continuum

- Independence: Knowledge of partners monitoring strategies
- Cooperation: Taking advantage of common geography, timing
- Collaboration: Opportunities to leverage partners' monitoring networks
- Integration: Working toward a common set of regional ecosystem objectives

Step 6: Assess performance

- "Interim" regional ecosystem assessment (2012)
  - Select provisional indicators
  - Status & trends from 1995 to 2012
  - Heinz Center format
- Phase 2 assessment
  - Diagnosis
- Phase 3 assessment
  - Forecasting



Chapter 3 System-Wide

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Chapter 4 Coasts, Sounds, and Near-Marine

Chapter 5 *Fresh Waters*

Chemical and Physical Characteristics

ESTUARINE SALINITY CONCENTRATION

Lindsay Dubbs[37]

Why are Estuarine Salinity Concentrations Important?

Salinity can be highly spatially and temporally variable within estuarine systems because of riverine freshwater (0 ppt) and ocean saltwater (~35 ppt) influences. Bacteria, plants, and animals are adapted to specific ranges of salinity. Salinity across an estuarine system dictates the distribution of organisms, affects productivity, and influences the cycling of nutrients, metals, and toxins.

Changes in precipitation patterns and water table levels associated with climate change, and the demand for and use of freshwater, influence river flows and thus influence estuarine salinity. Sea level rise and changes in the number and locations of inlets can also cause changes in the salinity regime. Thus, climate change and an increasing human population within the Albemarle-Pamlico Region are expected to cause changes in the spatial and temporal patterns of salinity.

What Does This Indicator Report?

- Monthly mean salinity concentrations in the estuarine waters of Albemarle-Pamlico sub-regions (Figure 1) from 1980 to 2009.

What Do the Data Show?

The annual mean salinity concentrations in the Lower Chowan, Roanoke, and Tar and Middle Neuse sub-basins were less than 1 ppt over the 30-year record. Monthly mean salinity concentrations in the Lower Chowan (Fig. 2a), Lower Roanoke (Fig. 2b), Lower Tar (Fig. 2c) and Middle Neuse (Fig. 3a) sub-basins spanned slightly wider ranges (0-3 ppt, 0-4 ppt, 0-8 ppt, and 0-10 ppt, respectively). However, the monthly means remained relatively constant and increased slightly over the 30-year period. The increases were statistically significant ($\alpha = 0.10$) at all six Lower Chowan River stations, all three Lower Roanoke River stations, and one of three

Assessment Planning

"The greatest challenge in developing a large-scale biogeographic assessment is the synthesis and subsequent analysis of spatial data collected at different scales for varied objectives."

Source: NOAA 2003, citing Gotway and Young 2002

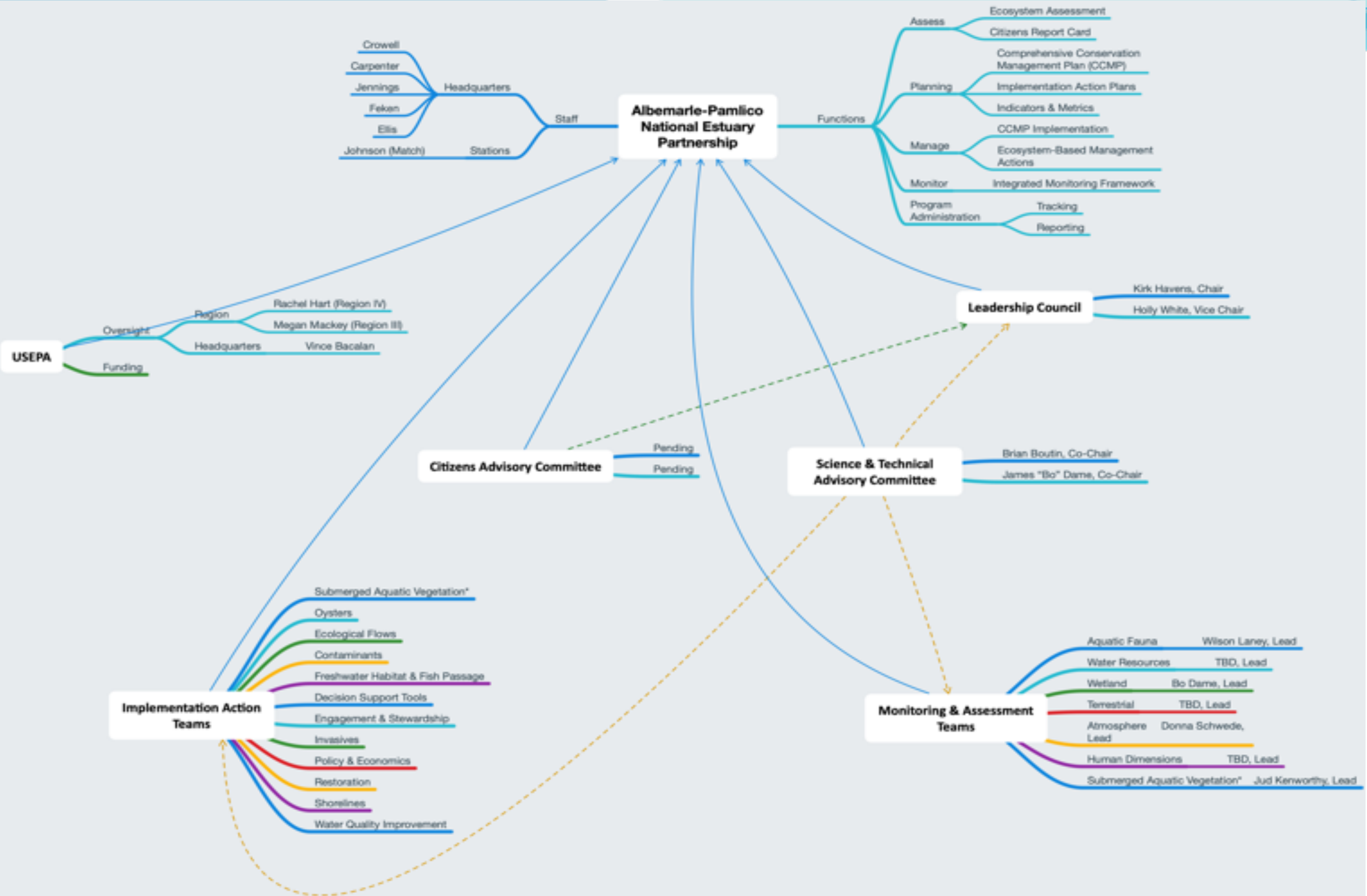
Bioregional Assessment Questions

- What were historic ecological, social, and economic conditions, trends, and variability?
- What are current ecological, social, and economic conditions?
- What are trends and risks under current policies and management?
- What policy choices will achieve ecological sustainability consistent with social well-being?
- What are the implications of these choices?

Source: Erman (1999)

Step 7: Manage adaptively

- Most difficult step?
- Senior management engagement
- Trigger levels in plan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Staff
Headquarters
Crowell
Carpenter
Jennings
Feken
Ellis
Stations
Johnson (Match)
Functions
Assess
Ecosystem Assessment
Citizens Report Card
Planning
Comprehensive Conservation Management Plan (CCMP)
Implementation Action Plans
Indicators & Metrics
Manage
CCMP Implementation
Ecosystem-Based Management Actions
Monitor
Integrated Monitoring Framework
Program Administration
Tracking
Reporting
USEPA
Oversight
Region
Rachel Hart (Region IV)
Megan Mackey (Region III)
Headquarters
Vince Bacalan
Funding
Leadership Council
Kirk Havens, Chair
Holly White, Vice Chair
Citizens Advisory Committee
Pending
Pending
Science & Technical Advisory Committee
Brian Boutin, Co-Chair
James "Bo" Dame, Co-Chair
Implementation Action Teams
Submerged Aquatic Vegetation*
Oysters
Ecological Flows
Contaminants
Freshwater Habitat & Fish Passage
Decision Support Tools
Engagement & Stewardship
Invasives
Policy & Economics
Restoration
Shorelines
Water Quality Improvement
Monitoring & Assessment Teams
Aquatic Fauna
Wilson Laney, Lead
Water Resources
TBD, Lead
Wetland
Bo Dame, Lead
Terrestrial
TBD, Lead
Atmosphere
Donna Schwede, Lead
Human Dimensions
TBD, Lead
Submerged Aquatic Vegetation*
Jud Kenworthy, Lead

18 Feb 2022

CCMP's Four Questions

- **What is a healthy Albemarle-Pamlico Estuarine System?**
- **What is the status of Albemarle-Pamlico Estuarine System?**
- **What are the biggest threats to Albemarle-Pamlico Estuarine System?**
- **What actions should be taken that will move us from where we are today to a healthier Albemarle-Pamlico Sounds by 2027?**

Estuarine Water Quality Assessment Questions

- *Are estuarine water quality conditions suitable to sustain the ecosystem services…*
  - *… provided by SAV species?*
  - *… associated with recreational activities (e.g., swimming, canoeing and kayaking)?*
  - *… provided by estuarine fauna (e.g., fishing, clam and oyster harvest)?*
  - *… provided by coastal wetlands (e.g., sediment loading)?*
  - *…provided by coastal landscapes, including natural vegetation (e.g., coastal forests), wildlife (e.g., fish and bird habitat) and aesthetics (e.g., attractive viewpoints, estuarine debris)?*

MONITORING PLAN FOR THE ALBEMARLE-PAMLICO ESTUARINE SYSTEM

Estuarine Monitoring: Submerged Aquatic Vegetation

Version 1.0
March 2021

Prepared by

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ACKNOWLEDGMENTS

The authors wish to recognize the following APNEP Submerged Aquatic Vegetation Team and Science & Technical Advisory Committee members who participated in a series of APNEP monitoring subcommittee meetings during Fall 2020, and whose consensus from their deliberations form the basis of SAV metrics and monitoring strategies outlined in this plan: Reide Corbett (ECU), James "Bo" Dame (Chowan University), Anne Deaton (NCDMF), Matthew Duval (NRCS), Donald Field (NOAA), Joel Fodrie (UNC-CH), Peter Kalla (USEPA), Casey Knight (NCDMF), Wilson Laney (USFWS ret.), Joseph Luczkovich (ECU), Michelle Moorman (USFWS), Brandon Puckett (NC-NERR). The authors also recognize the APNEP Management Conference and staff who provided valuable feedback on draft versions of this document.

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Table 5. Summary of APNEP SAV monitoring elements. MAT = Monitoring and Assessment Team

Component	Metric	Spatial Scale (Grain & Extent)	Temporal Scale (Grain & Extent)	Method	MAT Lead
Mesohaline to Polyhaline Waters: Bogue, Back, Core, Eastern Pamlico Sounds	SAV Areal Extent by Cover Class	0.3 m-resolution census of targeted sub-region in annual rotation	Bi-seasonal (May and mid-Sept. to mid-Oct.) every 3-5 years	Aerial survey via digital mapping camera, four-band color Cover class interpretation, manual	SAV
	SAV Maximum Depth Distribution	0.3 m-resolution census of targeted sub-region in annual rotation	Bi-seasonal (May and mid-Sept. to mid-Oct.) every 3-5 years	Aerial survey via digital mapping camera, four-band color Edge interpretation, manual	SAV
	SAV Species Presence	75-150 sites randomly assigned and spatially balanced, majority at targeted sub-region in annual rotation	Bi-seasonal (May and September), majority every 3-5 years, minority annually	Species identification during Braun-Blanquet survey	SAV
	SAV Relative Abundance	75-150 sites randomly assigned and spatially balanced, majority at targeted sub-region in annual rotation	Bi-seasonal (May and September), majority every 3-5 years, minority annually	Braun-Blanquet, 4 replicate quadrats per site	SAV
Oligohaline Waters: Neuse Estuary, Pamlico Estuary, Western Pamlico Sound, Albemarle Sound, Currituck Sound, Back Bay	SAV Areal Extent by Cover Class	Five roughly equal segments of total shoreline for each sub-region, majority at targeted segment per sub-region in annual rotation	Seasonal (Months TBD), majority every 5 years, minority annually	Sonar at two shore-parallel isobaths (0.75 m and 1 m) plus shore-normal sonar transect(s) past SAV maximum depth	SAV
	SAV Maximum Depth Distribution	Five roughly equal segments of total shoreline for each sub-region, majority at targeted segment per sub-region in annual rotation	Seasonal (Months TBD), majority every 5 years, minority annually	Determined from shore-normal sonar transect data	SAV
	SAV Species Presence	75-150 sites randomly selected and spatially balanced, majority at targeted segments in annual rotation	Seasonal (Months TBD), majority every 5 years, minority annually	Species identification during Braun-Blanquet survey	SAV
	SAV Relative Abundance	75-150 sites randomly selected and spatially balanced, majority at targeted segments in annual rotation	Seasonal (Months TBD), majority every 5 years, minority annually	Braun-Blanquet, 4 replicate quadrats per site, possible near-shore (< 0.5 m depth) UAV survey	SAV

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2.2.8. Abiotic-Stressor Metric: Salinity

Rationale: Estuaries by definition are areas of maximum spatial and temporal variation in salinity regime. Given that salinity tolerances vary widely among SAV species, it should be of little surprise that the salinity regime is an important predictor variable in determining SAV community composition at waterscape scales[61], as well as productivity and growth. Estuarine salinity is often classified into three zones: low (oligohaline), medium (mesohaline), and high (polyhaline). SAV communities within the three salinity zones can have different interannual dynamics and responses to stressors[62], with oligohaline communities being especially sensitive to salinity changes on the order of a few parts per thousand (ppt).

There is a very good understanding of the spatial/quantitative characteristics of the salinity gradient in APES (Section 1.1). The knowledge gap is how temporal fluctuations in salinity alter this structure with respect to its influence on SAV. Stressors that influence the salinity regime include extreme freshwater inputs from droughts, tropical storms, flood control[63], and impervious land surfaces. Also, the introduction of salt from water treatment facilities with reverse osmosis technologies can affect local salinity. Relative sea-level rise affects the tidal prism and increases saltwater flow into the estuarine interior.

Status: While many APNEP partners monitor salinity (mesohaline and polyhaline) or conductivity (oligohaline) of estuarine waters, it remains to be determined whether the spatial and temporal resolution of their collective network is adequate to reflect shallow-water salinity in all sub-regions. Few partners monitor salinity continuously (Table 4).

Citizen Volunteering: Volunteers if provided with refractometers (approximately $300 each) can monitor surface-water salinity, or with calibrated water quality meters or multi-parameter sondes.

3.2.8. Abiotic-Stressor Metric: Salinity

Assessment Points: Currently with limited information on SAV-salinity dynamics, it is challenging to identify assessment points for directions on monitoring sensitivity. The prospects should improve however, as we build a better understanding of species composition, distribution and relative abundance of SAV in low-salinity waters.

Needs and Recommendation: The need is to Intensify (spatially and temporally) salinity monitoring in low-salinity waters. Beginning in 2021, we recommend compiling and analyzing salinity databases to identify priority gaps, plus measurements taken during Tier-2 sampling events.

DRAFT

MONITORING PLAN FOR THE ALBEMARLE-PAMLICO ESTUARINE SYSTEM

Estuarine Monitoring: Water Resources

Version 0.1
March 2022

Prepared by

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Table 3. Module/Sub-Module/Indicator/Metric hierarchy addressed in this plan. * = metrics that were recommended for continuous long-term monitoring in APNEP's first (1989) baseline water quality monitoring plan. ^ = metrics also supporting the "Harmful Algal Blooms" indicator. @ = metric also supporting "Water Column Transparency".

Module/Sub-Module	Indicator	Metrics
Aquatic/Estuarine	Water Column Fecal	Enterococcus concentration
		Total coliform
	Microbiota	Chlorophyll *a* ^@
		Phytoplankton
	Harmful Algal Blooms	Extent & frequency of algal blooms
		Phytoplankton community composition: Cyanobacteria density + Dinoflagellates + Raphidophytes
		Algal toxins: Microcystin + Anatoxins + Cylindrospermospsin
	Organic Carbon	DOC
		POC
	Sediment Condition	Sediment contaminant chemistry
		Sediment toxicity
		Sediment moisture content
		Sediment organic content
		Benthic community
	Water Column Transparency	PAR attenuation
		Secchi depth/ transparency
		Turbidity
		CDOM
	Nutrients	Dissolved nutrients: DIN + DIP
		Total nutrients: Total N + Total P
	Water Column Temperature	Water temperature*
	Water Column Salinity	Estuarine (water column) salinity*
	Dissolved Oxygen	Dissolved oxygen concentration*^
	Water Column Alkalinity	Hydrogen ion concentration (pH)^
	Dissolved Metals	Dissolved metals concentration
	Water Column Emerging Contaminants	Plastics
		Pharmaceutical & personal care products (PPCPs)
	Relative Sea Level	Water level

Extent of Submerged Aquatic Vegetation

High-Salinity Estuarine Waters

Metric Report

Don Field [1], Jud Kenworthy [1], Dean Carpenter [2]

INTRODUCTION

Why Is the Extent of Submerged Aquatic Vegetation Important Within the Albemarle-Pamlico Estuarine System?

Underwater vascular plants are key components of aquatic ecosystems. They play multiple roles in keeping Albemarle-Pamlico Estuarine System (APES) waters healthy by providing habitat, food, and shelter for aquatic life; absorbing and recycling nutrients and filtering sediment; and acting as a barometer of water quality (Thayer et al. 1984). More commonly called "submerged aquatic vegetation" (SAV), these plants enrich shallow aquatic environments around the world, providing sanctuaries for mollusks, crustaceans, and finfish as well as sustenance for waterfowl (Bergstrom et al. 2006). SAV includes marine, estuarine, and riverine vascular plants that are rooted in sediment (NCDEQ 2016) and is one of five types of aquatic plants in APES waters, the others being floating aquatic vegetation, emergent aquatic vegetation, micro- and macroalgae, and blue-greens (cyanobacteria) (Bergstrom et al. 2006). Because SAV are rooted in anaerobic sediments, they need to produce a large amount of oxygen to aerate the roots, and therefore have the highest light requirements of all aquatic plants (NCDEQ 2016). SAV can become stressed by eutrophication and other environmental conditions which impair water transparency and/or diminish the oxygen content of water and sediments. The plant's response to these factors enables them to be sensitive bio-indicators of environmental health (Biber et al. 2004).

While more than 500 species of SAV inhabit the world's rivers, lakes, estuaries, and oceans (Bergstrom et al. 2006), APES and its tidal tributaries are home to about 14 common species (NCDEQ 2016). High-salinity (10-30 ppt) species, commonly referred to as seagrass include a temperate species, eelgrass (*Zostera marina*), tropical species, shoalgrass (*Halodule wrightii*) and the eurytolerant species widgeongrass (*Ruppia maritima*) and the co-occurrence of these three species is unique to North Carolina (NCDEQ 2016). Beds of SAV occur in North Carolina in subtidal water generally less than two meters deep, and occasionally in intertidal areas of sheltered estuarine and riverine waters where there is unconsolidated substrate (loose sediment), adequate light reaching the bottom, and moderate to negligible current velocities or

[1] NOAA National Centers for Coastal Ocean Science, APNEP Science & Technical Advisory Committee
[2] APNEP

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