Ecological Monitoring Program at VIMS ESL
Annual Report 2023

Paige G Ross and Richard A Snyder, Eds.

VIMS Eastern Shore Laboratory Technical Report No. 12

Eastern Shore Laboratory
Virginia Institute of Marine Science
William & Mary, Wachapreague, VA

April 2024

Contents

2023 Executive Summary

An Ecological Monitoring Program (EMP) has been established at the Virginia Institute of Marine Science Eastern Shore Laboratory (VIMS ESL) for the coastal environment near the Wachapreague lab. The goals of the initiative are to 1) provide status and trends information to scientists who study and regulators who manage Virginia's marine resources, 2) provide a scientific context for short-term research and grant proposals 3) provide pedagogical enrichment for educators to use in their classes, and 4) build capacity in staff expertise and training of interns and students at VIMS ESL.

The program formalizes and standardizes data collection for a long-term status and trends database as an asset of VIMS ESL in addition to our marine operations and shore support facilities. The EMP standard methods also provide visiting scientists and educators with protocols for consistent and comparable work and training. The EMP includes electronic water quality stations, oyster settlement and adult population dynamics, microbial biofilm growth, characterization of benthic communities in soft sediments and oyster reefs, sediment characteristics, and drone surveillance of salt marsh die back, Wachapreague Inlet dynamics and macroalgae distribution on mudflats. While this document focuses on these core areas of our monitoring activities, results of other VIMS ESL research on shellfish aquaculture, bay scallop restoration, and shorter-term grant supported research projects are reported elsewhere.

Real-time and archived water quality data, both the current electronic systems and records beginning in the 1960s, have been in demand by the aquaculture industry and scientists. In addition to summarizing 2023 data, we explore this data in the context of these historic water quality datasets. Weekly biofilm growth on standardized plates provides a biological sensor for water quality, system level microbial productivity, and microbial diversity. Data on oyster settlement rates reflects the present and potential future condition of seaside oyster populations, combining historical records with ongoing assessment. In 2023, annual cumulative spat set as high as 309,000 oysters per m^2 was recorded. Overall, it was the highest annual oyster settlement that we have recorded during seaside monitoring efforts. While this may bode well for seaside natural oyster reefs, there may be less positive impacts to aquaculture activities due to excessive fouling. Oyster population demographics in 2023 were similar to benchmarks established in 2018-2022, although there was a slight decrease in numbers and biomass in 2023. We also report additional data on oyster population biometrics. The soft-sediment benthic community was described based on data gathered from >1,200 individual organisms representing ~ 70 genera. We began sampling the nekton community in 2021-2022, and were able to continue to establish baselines in 2022 for late-spring, summer, and late-summer for these migratory and seasonal fauna based on >6,400 individuals representing >45 species.

The full report is available at the website: https://www.vims.edu/esl/research/emp/

Section 1: Ecological Monitoring Program (EMP) at the Virginia Institute of Marine Science Eastern Shore Laboratory (VIMS ESL)

Chapter 1. Context of the EMP

Authors: PG Ross and Richard A Snyder

Virginia Institute of Marine Science, Eastern Shore Laboratory, Wachapreague, VA

The VIMS ESL mission is to serve as a field station and coastal seawater laboratory for basic marine science and aquaculture research, marine science education, outreach, and advisory service to the Commonwealth of Virginia, particularly with regard to marine resources and citizens of the Eastern Shore of Virginia. To implement this mission, VIMS ESL provides a platform for field and lab research, education, and advisory service activities by both resident and visiting researchers and educators from around the world.

This monitoring program was designed to support the VIMS ESL mission in three ways:
1. To provide an environmental context for researchers and educators who may only visit briefly, establishing a value-added backdrop in which to make greater sense of short-term research results and educational programing.
2. Establish a record of long-term environmental data for tracking status and trends of this largely unspoiled coastal region.
3. Engage interns and students in rigorous technical scientific training while they contribute to a larger long-term scientific program.

We consider this mission support to be as vital as the marine operations and onshore facilities support we provide for high quality marine education and research in a remote and undeveloped region of U.S. mid-Atlantic coastal marine habitat.

Geographic Setting and Rationale

The Eastern Shore of Virginia (ESVA) is the narrow southern end of the Delmarva Peninsula, averaging 10 miles wide and 85 miles long from Pocomoke Sound on bayside and Chincoteague Island on seaside to Fisherman's Island National Wildlife Refuge at the mouth of the Chesapeake Bay. Its remote and rural setting features pristine natural barrier islands, bays, creeks and marshes along the Atlantic coast unfettered by human development and now

protected by the Nature Conservancy, the Commonwealth of Virginia, and the federal government. The region has been designated by the United Nations Education, Scientific, and Cultural Organization (UNESCO) as part of their *Biosphere Reserve System*, has *National Natural Landmark* status with the US Department of the Interior, and is part of the *Western Hemisphere Shorebird Reserve Network*. Within the past year, we have been negotiating with the Smithsonian Institution to make the seaside coastal habitats of the ESVA part of their *Marine Geo* global biodiversity network of sites. Data collected within the VIMS ESL program will be uploaded to *Marine Geo* as part of that collaboration.

Short watersheds with limited freshwater make the bayside estuaries and seaside creeks and shallow coastal bays unique within the Chesapeake Bay region. Extensive marshes, oyster reefs, and seagrasses add to the natural and commercial seafood value of the regional marine resources. The region provides an excellent sentinel site that integrates broader anthropomorphic impacts and environmental change in a relatively undeveloped coastal environment.

The VIMS ESL is in Wachapreague, VA, directly located on Wachapreague Channel, a location that is well situated to provide access and facilities support for research, education, and service pertaining to these regional marine resources. Extensive aquaculture occurs in the region for oysters and hard clams. The hard clam industry on the ESVA is the largest producer of cultured hard clams in the nation. Dr. Mike Castagna at the VIMS ESL was largely responsible for the research and development that created the current clam industry, taking advantage of excellent quality high salinity seawater and habitats adjacent to the laboratory, including leased bottom maintained specifically for research purposes. The Seawater Laboratory provides access to raw and filtered seawater and custom setups for research and education, and the Castagna Research Hatchery and nursery is dedicated to aquaculture research and shellfish restoration.

The VIMS ESL, as a launch point for diverse research and education activities, is somewhat unique in its access to high quality, high salinity seawater and a relatively pristine and complex barrier island/coastal lagoon system in the mid-Atlantic region. Long-term records for environmental data are generally lacking for this outdoor laboratory. From water quality data to bathymetric maps and from local community associations to diversity trends, the dearth of long-term datasets is not unique to this research lab. Sentinel, benchmark, and monitoring data are typically not well funded by agencies supporting short duration project cycles, yet are important to understand the implications of experimental work in the context of longer-term environmental processes.

The need for such data is widely acknowledged, even if budget cycles and priorities make support difficult. Current sea-level rise and climate change require records if we wish to track status and trends in the environment and marine resources. There are few examples of large-scale regional collaborative projects that endeavor to holistically develop benchmark and sentinel monitoring programs (e.g., Sentinel Monitoring for Climate Change in the Long Island Sound

Estuarine and Coastal Ecosystems of New York and Connecticut 2011; Smithsonian Institution Marine Geo program).

A lack of high resolution multiparameter water quality data in support of research and education was addressed in 2016 with the creation of continuously monitored stations in Wachapreague Channel at VIMS ESL, in southern Burton's Bay for the VIMS intertidal oyster research lease (Custis Channel), and a third station established in October 2018 in Willis Wharf (Parting Creek). Data from these stations are accessible in near-real time (~15-minute increments) online (see Chapter 2 for details), and archived records are provided on request. They have been extremely useful to researchers and educators in the ESL-Seawater Lab, for background to ongoing field research on the Custis Channel reef, and have been invaluable to the aquaculture industry hatcheries in Willis Wharf.

Specific objectives for the ESL-EMP

1. Collect spatial and temporal data that provide environmental characterizations: The EMP dataset and reports will provide visitors with the background and context for education activities and focused research proposals and funded projects. This is a value-added asset in support of education and research conducted at VIMS ESL.

2. Establish status and trends for coastal environmental change analysis: A lack of baseline and continuing environmental data hampers analysis of change and management of marine resources in the dynamic coastal ecosystems. VIMS ESL is uniquely situated to access unspoiled coastal marine habitats that integrate regional and global environmental impacts, and thus provides access and an excellent outdoor laboratory and sentinel site for broader environmental trajectories.

3. Support aquaculture industry and commercial and recreational fishing communities: Documenting episodic events and elucidating real long-term trends can help inform local decision making by private enterprise and government regulators, enhancing resilience of this important economic sector.

4. Support student research and education:

   a. *Provide research opportunities for VIMS and William and Mary students*. The VIMS-ESL has dedicated endowment funds to support student research and education. This program will provide training and tasks that get students involved with contributing to a larger scale scientific endeavor. The program also provides contextual background data allowing data mining opportunities and background for undergraduate and graduate research projects.

   b. *Provide research opportunities for interns*. ESL has an ongoing summer internship program supported by donors to the Bonnie Sue Scholarship Program.

The interns are provided summer employment and research experiences with ESL staff and visiting scientists. Projects and tasks within the EMP provide a wide range of training and experiences to assist interns in developing their careers.

c. *Enhance ESL education programs*. The EMP supports educational field trips/lab experiences with a quantitative data gathering/sharing experience for visiting groups, who can both add to the data and use the multi-year data for instructional purposes.

5. Facilitate capacity building:

a. *Maintain/develop staff expertise*. Over the last several decades the ESL has developed a reputation for its benthic ecology work, identifying and quantifying community assemblages. The ongoing EMP facilitates maintaining and developing standardized procedures and equipment, staff skills, and taxonomic expertise in this area in support of collaborations, visiting researchers, and grant proposals.

b. *Attract new users*. The EMP provides a complimentary asset to the marine operations and shore facilities provided by VIMS ESL, a value-added enrichment for scientists seeking platforms for grant funded research and educators seeking to provide opportunities for students to explore new environments.

c. *Providing data for future funding/research*. The environmental characterization provided by the EMP program has already been used by researchers seeking grant funding to work at ESL. The opportunity to conduct research within the context of a broader understanding of the regional environment makes proposals seeking precious grant funding more competitive.

Chapter 2. Ecological Monitoring Program Overview-2023

Authors: PG Ross and Richard A Snyder

Virginia Institute of Marine Science, Eastern Shore Laboratory, Wachapreague, VA

Metrics

The EMP framework was designed to document the status and trends of environmental and ecological processes near the Eastern Shore Laboratory. Table 2-1 provides a list of data collected during 2018-2023. Details of specific data collection methods and locations can be found in the respective chapters. Sampling the nekton community was added 2021 and continued therafter with an additional season added in 2023.

The overall strategy was based on accumulated experience and observations of ESL staff during work on many different research projects. A stratified scheme of three geographic areas with different features was established (Fig. 2-1): Bradford Bay (shallow, diffuse tidal currents, adjacent to uplands); a portion of Burton's Bay (shallow, oyster reefs, tidal currents) and the Wachapreague Inlet vicinity (high energy, offshore weather impacts, deep channels, tidal currents). The following metrics were sampled within this geographic matrix:

- Oyster settlement
- Biofilm growth
- Benthic community: soft sediments (intertidal, shallow subtidal and channel edge)
- Epi-benthic community: hard substrate (intertidal and subtidal)
- Nekton community: mobile macrofauna
- Sediment mapping (intertidal, shallow subtidal and channel edge)

Other metrics have either logistical constraints (e.g. water quality stations) or are very specific to certain locations (e.g. mapping and education-related efforts) and are not, therefore, designed with the geographic stratification:

- Water quality
- Finney Creek marsh dieback mapping
- Wachapreague Inlet and marsh island mapping
- Macroalgal mapping

10-Year Plan

It is our intention that the EMP be a long-term dataset. To initiate the effort, we have developed a 10-year plan for collecting various metrics (Table 2-1). The potential for rates of change in the individual metrics was used to space effort temporally. The plan is subject to annual adjustment based on data results, funding, needs of visiting researchers and educators, and demands of other projects on staff and resources.

Dissemination of Data

Data summaries and raw data will be made available to visiting researchers, students and the general public upon specific requests. The EMP program has been used in several grant proposals by VIMS and outside research scientists, adding a contextual backdrop and broader impacts to specific research plans. A course instructor (VIMS) who requested background data for a field trip out of ESL responded "This is perfect!". The results of the EMP have also been made available through the following venues:

- VIMS ESL EMP Annual Report (this document): Annual report of EMP progress and results. This and previous reports are archived in William & Mary's *Scholar Works*. Cumulative usage data, by report year, has been provided from W&M Scholarworks repository:

Usage	2018-2019 Report	2020 Report	2021 Report	2022 Report
Abstract views	220	150	166	96
Download Count	168	129	127	102

- Marine Life Day Display: Public open-house held on the third Saturday of September each year. Updated data for biodiversity and environmental conditions, analysis of status and trends for seaside ESVA.
- VIMS ESL dedicated webpage: The lab website has links to downloadable reports and other products from this effort: https://www.vims.edu/esl/research/emp/index.php.
- VIMS ESL Facebook page: Ongoing analysis of results of interest to regional science and aquaculture, such as the weekly oyster spat set results, unique or unusual events: https://www.facebook.com/VIMSESL
- Peer-reviewed publications will be submitted in appropriate journal outlets and presentations of data will be made at professional meetings, especially as data are accumulated sufficiently to identify trends.
    - An overview of the EMP was presented as a poster at the Coastal and Estuarine Research Federation (CERF) biennial meeting in Portland, Oregon in November 2023: *The mid-Atlantic coastal marine ecological monitoring program at VIMS Eastern Shore Laboratory, Wachapreague, Virginia, USA* (Paige Ross and Richard Snyder)
    - Acknowledged in recent publication for mentorship and use of EMP data and oyster settlement protocols:

        Farmer MA, Klick SA, Cullen DW, Stevens BG. 2023. *Eastern oysters Crassostrea virginica settle near inlets in a lagoonal estuary: spatial and temporal distribution of recruitment in Mid-Atlantic Coastal Bays (Maryland, USA)*. PeerJ 11:e15114 DOI 10.7717/peerj.15114

Student Involvement

Students from the institutions below participated in the 2023 EMP during May-August as part of the ESL summer internship program.

- Virginia Tech
- Old Dominion Universtiy
- University of Virginia
- Northampton High School

Funding Gratefully Acknowledged

Table 2-1. VIMS ESL Ecological Monitoring Program 10-year sampling plan.

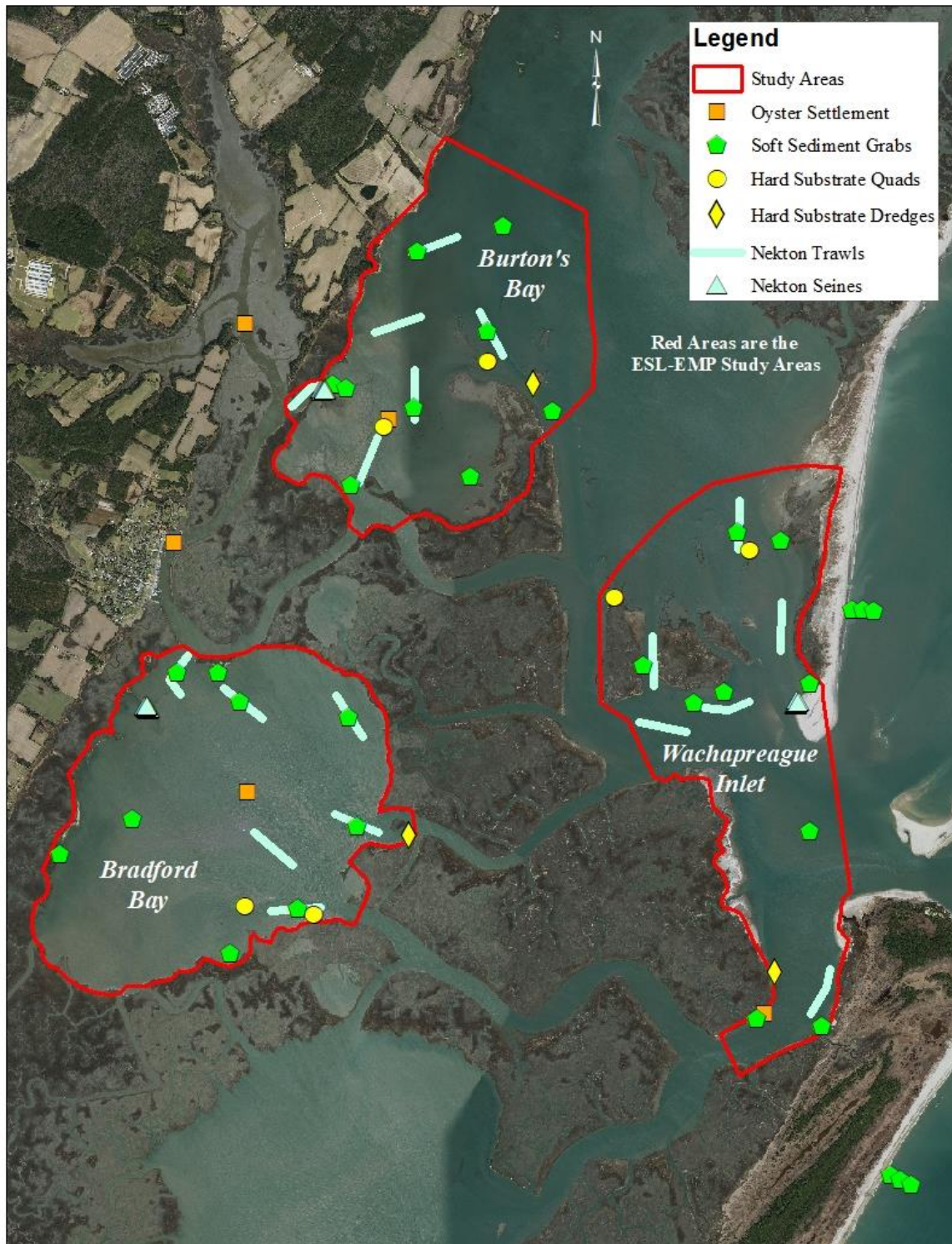| Component		2018 Yr 1	2019 Yr 2	2020 Yr 3	2021 Yr 4	2022 Yr 5	2023 Yr 6	2024 Yr 7	2025 Yr 8	2026 Yr 9	2027 Yr 10
Water Quality	Water Quality: Fixed Sensor	X	X	X	X	X	X	X	X	X	X
	Water Quality: Data Flow	X			X	X	X	X	X	X	X
Biofilms	Biofilm Community	X	X	X	X	X	X	X	X	X	X
Oyster Population	Oyster Settlement	X	X	X	X	X	X	X	X	X	X
	Oyster Demographics	X	X	X	X	X	X	X		X	
	Oyster Biometrics				X	X	X		X		X
Clam Population	Hard Clam Settlement							X	X	X	X
Faunal Community Structure	Benthic Soft Sediment	X	X	X	X	Partial	X		X		X
	Epi-benthic Hard Substrate (Intertidal)	X	X	X	X	X		X		X	
	Epi-benthic Hard Substrate (Subtidal)	X	X	X		X		X		X	
	Nekton Community				X	X	X	X	X	X	X
Mapping Coastal Change	Wachapreague Inlet Shoreline	X	Partial	X	X				VBMP?		
	Finney Creek Marsh Dieback	X		X		X		X		X	
	Sediment Characterization	X	X		X		X			X	
	Macroalgal mapping	X		X	X	X	X	X	X	X	X

Figure 2-1 Three geographic regions of the ESL-EMP with current sampling locations: Bradford Bay, a portion of Burton's Bay, and the Wachapreague Inlet vicinity. Additional samples were taken on the ocean side of Cedar and Parramore Islands in 2022-2023 (See Chapter 14).