Ecological Monitoring Program at VIMS ESL
Annual Report 2024

Photo Credit: Darian Kelley, VIMS-ESL

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VIMS Eastern Shore Laboratory Technical Report No. 13

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Virginia Institute of Marine Science
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Contents

2024 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.

Highlights of the 2024 EMP follow. Requests for access to full data sets and potential collaborations should be addressed to the editors. Real-time water quality data collection was enhanced with the addition of a third station in Burton's Bay near Wachapreague. Weekly biofilm growth on standardized plates provided a biological sensor for water quality, system level microbial productivity, and microbial diversity. Data on oyster settlement rates reflected the present and potential future condition of seaside oyster populations, combining historical records with ongoing assessment. In 2024, annual cumulative spat set as high as 6,287 oysters per m^2 was recorded. Overall, it was a relative low year for this settlement. Oyster population demographics in 2024 were similar to benchmarks established in 2018-2023, and continue to show a potentially increasing oyster population. The hard-substrate epi-benthic community was described based on data gathered from >5,700 individual organisms representing ~ 70 genera. We were able to continue to establish baselines in 2024 for highly mobile fauna based on >11,500 individuals representing >40 species collected in trawls and seines.

The EMP has been supported by donations from Chuck and Janet Woods for operational expenses and an intern scholarship and other private donors to the VIMS ESL summer intern program. VIMS ESL summer interns are high school and undergraduate students receiving paid internships from the Bonnie Sue Scholarship Program. During 2024, 3 local college undergraduate and 2 local high school students participated in EMP research activities.

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

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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 program 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*. The Smithsonian Institution includes the seaside coastal habitats of the ESVA part of their *Marine Geo* global biodiversity network of sites. Data collected within the VIMS ESL program is available to the international *Marine Geo* network of reseaerchers.

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 support natural and commercial seafood value of the regional marine resources. The region provides an excellent sentinel site to integrate 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 advisory 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, originating with Dr. Mike Castagna at the VIMS ESL for the research, development, and training in the 1960-1970s. Excellent quality high salinity seawater and habitats adjacent to the laboratory, including leased bottom maintained specifically for research purposes provides the perfect setting for general marine research and aquaculture. The Seawater Laboratory provides access to raw and filtered seawater and custom setups for research and education, and the Castagna Shellfish 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 providing sophiscated shore support and efficient marine operations; access to high quality, high salinity seawater in laboroatories; and access to a relatively pristine and complex barrier island/coastal lagoon system in the mid-Atlantic region. Consistent long-term records for environmental data were generally lacking for this outdoor laboratory. Water quality data, bathymetric maps, biotic assessments of local community associations to diversity trends are common absences in the science world focused on short-term funding and experimental maniupulative science. Sentinel, benchmark, and monitoring data are typically not funded by agencies supporting short duration project cycles, yet are important to understand the implications of experimental work in the context of larger spatial and temporal scale environmental processes.

The need for such data is widely acknowledged, even if budget cycles and priorities make support difficult. Current sea-level rise, coastal change, and periodic disasters such as hurricanes

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 and another station established in October 2018 in Willis Wharf (Parting Creek). A third station was established in 2024 in Burton's Bay near Cedar Island. 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 in the Wachapreague vicinity, and have been invaluable to the aquaculture industry hatcheries in Willis Wharf.

Specific objectives for the ESL-EMP

1. <u>Collect spatial and temporal data that provide environmental characterizations:</u> 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. <u>Establish status and trends for coastal environmental change analysis:</u> 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. <u>Support aquaculture industry and commercial and recreational fishing communities:</u> 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. <u>Support student research and education:</u>

   a. *Provide research opportunities for the Batten School of Marine Science at 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-2024

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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 2018-2024. 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 beginning 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. 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 *ScholarWorks*. Cumulative usage data, by report year, is provided from this repository:

Usage	2018-2019 Report	2020 Report	2021 Report	2022 Report	2023 Report
Abstract views	248	166	191	155	183
Download Count	214	176	191	193	213

- 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. The following either focused on EMP data or utilized parts of the various datasets it contains:
  - Brahmey, E.I., K.J. McGlathery, and S.C. Doney, Quantifying seasonal to multi-decadal signals in coastal water quality using high- and low-frequency time series data, Cambridge Prisms: *Coastal Futures*, 2, e8, https://doi.org/10.1017/cft.2024.6
  - *Poster presentation at a conference*:

    Ross PG, SA Krueger-Hadfield, DM Kelley, RA Snyder "The Mid-Atlantic Coastal Marine Ecological Monitoring Program at VIMS Eastern Shore Laboratory" Phycological Society of America, Seattle, WA, July 2024

  - *Oral presentation at a conference*:

    Krueger-Hadfield SA, AP Oetterer, DM Kelley, WH Ryan "As the mudflat turns: the phenology of fixed and free-living Gracilaria vermiculophylla thalli along the

Delmarva Peninsula" Phycological Society of America, Seattle, WA July 2024

    o *Invited seminar*:

Krueger-Hadfield SA "At the convergence of life cycles and reproductive systems: insights into the evolution of sex" Marine and Environmental Biology Section, The University of Southern California, Los Angeles, CA (February 2024) **Graduate student invited seminar speaker

    o *Invited symposium talk at a workshop/Conference*:

Krueger-Hadfield SA "At the convergence of life cycles and reproductive systems: insights into the evolution of sex" Algae and the Environment Workshop at PEREC, George Mason University, VA June 2024 (oral)

Krueger-Hadfield SA "The role of natural history in understanding coastal resilience" Atlantic Coastal Resilience Workshop – Ecosystem Health, Johns Hopkins Advanced Physics Laboratory, MD, May 2024 (oral)

- <u>EMP data is an integral part of the following projects:</u>

McDowell, J, T. Tuckey, M. Fabrizio, R. Snyder, and H, Bi. 2024. Combining environmental DNA (eDNA) and adaptive resolution imaging sonar (ARIS) to assess restoration -mediated changes in habitat use by fishes. VIMS Internal Seed Funding.

Patrick, C., R. Snyder, M. Fabrizio, J. McDowell, R. Latour, B. Lusk, and H. Bi. 2023-2027. A whole system restoration of seagrass, bay scallops, and associated ecosystem functions in the coastal lagoons of Virginia's northern Eastern Shore. VA Coastal Zone Management Program, NOAA.

Krueger-Hadfield, S.A. 2022-2027. CAREER: At the convergence of life cycles and reproductive systems: insights into eukaryotic diversity (DEB-2436117). National Science Foundation Division of Environmental Biology Evolutionary Processes – Faculty Early Career Development Program.

Krueger-Hadfield, S.A. 2024-2025. Environment, epibiota, and evolution of complex life cycles. W&M Seed Funding Research Grant.

Student Involvement

       Students from the institutions below participated in the 2024 EMP during May-August as part of the ESL summer internship program.
- Virginia Tech

- James Madison Universtiy
- Homeschool in Accomack County
- 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	X	X
	Oyster Biometrics				X	X	X			X	
Clam Population	Hard Clam Settlement							Test	Test	X	X
	Clam Demographics (dredging)							Test	Test		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	On hold until we see obvious changes		
	Sediment Characterization	X	X		X		X			X	
	Macroalgal mapping	X		X	X	X	X	X	X	X	X
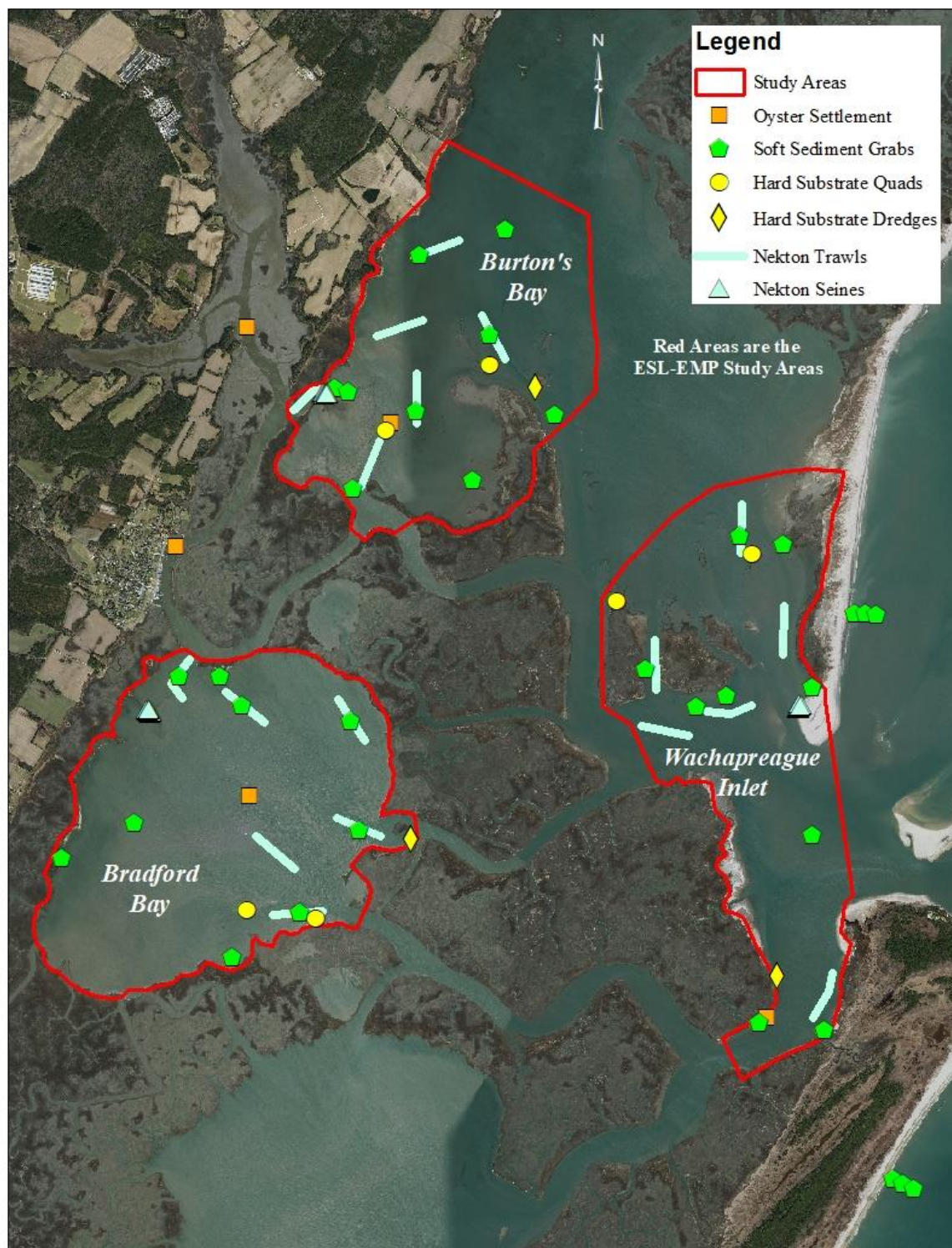
Figure 2-1 Three geographic regions of the ESL-EMP with current sampling locations: Bradford Bay, a portion of Burton's Bay, and the Wachapreague Inlet vicinity. Additional samples were taken on the ocean side of Cedar and Parramore Islands in 2022-2024 (See Chapter 14).