NJ Department of Environmental Protection
Division of Science and Research

A Factsheet: Salt Marsh Ponds as Harmful Algae Reservoirs

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What was the purpose of the study?

Salt Marsh Ponds (SMPs) are a vital component of New Jersey coastal marshes. Despite their small size, they provide unique microhabitats for diverse aquatic organisms, including algae, snails, fish, crustacea, and insects, supplying year-round food sources for birds and other animals that are dependent on marshes for food and shelter (Lathrop et al. 2000, MacKenzie and Dionne, 2008). In these ponds, microscopic algae are widespread, diverse, and form a vital component of the food web (Currin et al. 2003). However, some of these microscopic algae can develop excessively and produce toxic compounds that are harmful, and thus, they are called harmful algal bloom (HAB) species. The purpose of this study was to verify if such HAB species are present in the SMPs and what kind of toxins they can potentially produce.

What was the general approach to the study?

The objective of the study was to determine the presence and extent of HABs and related toxins in six SMPs located in the Sheepshead Meadow peninsula in Tuckerton, New Jersey. The studied SMPs had similar pond size and depth and were located in marsh areas under different mosquito control management regimes: Parallel Grid Ditching (PGD), Open Marsh Water Management (OMWM), and unaltered natural marsh (Fig. 1). The study comprised one-year of monthly sampling for microalgae and water quality field measurements, performed between May 2022 and June 2023, and three additional samplings performed July and August 2023 for HAB toxin detection. The monthly samples were used to investigate the temporal and spatial changes of microalgae, with a focus on identifying harmful algae species and their potential algal/bacterial toxins. The samples collected in July and August 2023 were used for toxin detection in the SMP microalgae samples.

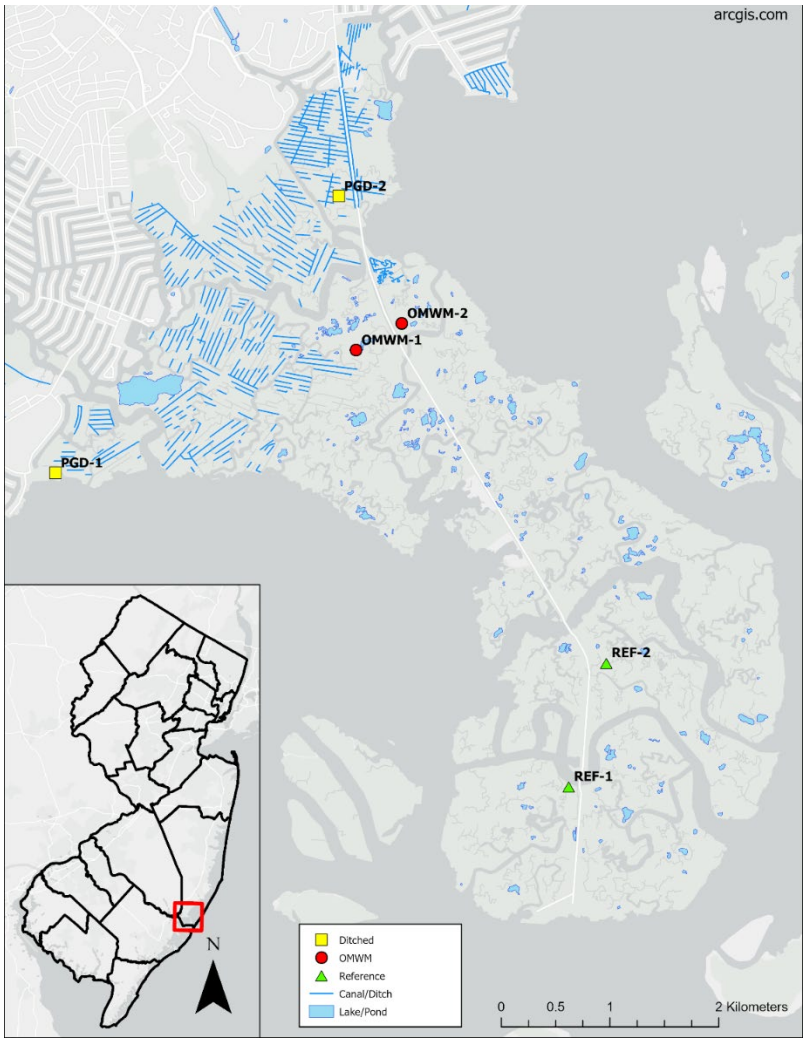

Figure 1. Map of the study area: Sheepshead Meadow peninsula, Tuckerton, New Jersey, showing three segments with different alteration histories, including PGD (parallel grid ditches), OMWM (open marsh water management), and REF (reference, un-altered). Two study ponds were selected in each segment. Map metadata description: National Hydrography Dataset (NHD) Waterbody 2015 for New Jersey - Overview (arcgis.com) (Map produced by Kirk Raper, at New Jersey Department of Environmental Protection)

Each month, microalgae samples were collected, and water parameters were measured in the field at each of the six SMPs. Water parameters included temperature, salinity, pH, conductivity, dissolved oxygen (DO) concentration, and DO saturation (DO%). Water parameters were measured in the field using an instrument produced by Yellow Springs Instruments (YSI). Microalgae samples were collected by gently stirring the pond bottom sediments to mix the floating (phytoplankton) algae with the algae attached to plants and surface sediment to produce a mixed sample. In addition, a few pond surface water samples were collected without mixing with bottom sediments to compare the composition of microalgae in the water to the mixed samples. After collection, the microscopic algae were identified and counted using a microscope at magnification up to 400x.

Toxin analyses were conducted on mixed and surface water samples collected in July and August 2023 using specific methods called ELISA immunoassay tests. The purpose of these analyses was to test if HABs are producing different types of toxins and if the toxins are related to specific HAB species. More information about test procedures used in this study can be found at https://www.beaconkits.com/products.

In addition to microscopic identification, microalgae composition was also investigated using DNA analyses to allow comparison with the identifications performed under the microscope.

A project webpage was developed to share the project findings on harmful algae. The documentation on HAB species consists of images and videos recorded from microscopic observation, as well as information on the potential toxicity and ecological characteristics based on published literature. https://dep.nj.gov/dsr/nj-smp-hab-reservoirs/

Overall, what did the studies show?

Our investigation revealed the presence and dominant role of HAB species for the first time in the six studied intertidal SMPs. HABs were present in all six ponds under different management regimes: PGD, OMWM, and reference sites. Sixteen HAB species were recorded through microscopy observations and belonged to various groups of microscopic algae: diatoms, dinoflagellates, raphidophytes, haptophytes, and cyanobacteria. DNA-based analysis found higher HAB species diversity in dinoflagellates and cyanobacteria taxa. The HABs were found in each pond of the three management regimes during the summer season (June-August) and occasionally in the spring (March-May) and winter (December-January). Often, in specific ponds, the HABs could reach extremely high abundance and dominance of one or two HAB species. In many cases, the HABs accounted for more than 60% to 98% of total algal abundance. On the other hand, over the study period, the HAB species were highly diverse across all the ponds.

Only a small portion (7%) of the variance in non-harmful microalgae and HABs found in the study ponds was explained by the measured water quality parameters over the one-year study - water temperature, salinity, pH, and DO (Fig 2). This implies that other factors that were not included in this study can be important contributors to these variations. Factors such as nutrients, organic matter, presence and abundance of grazers, as well as sediment type and benthic communities, which were not assessed in this study due to funding limitations, may play significant roles in the proliferation of HABs in the SMPs.

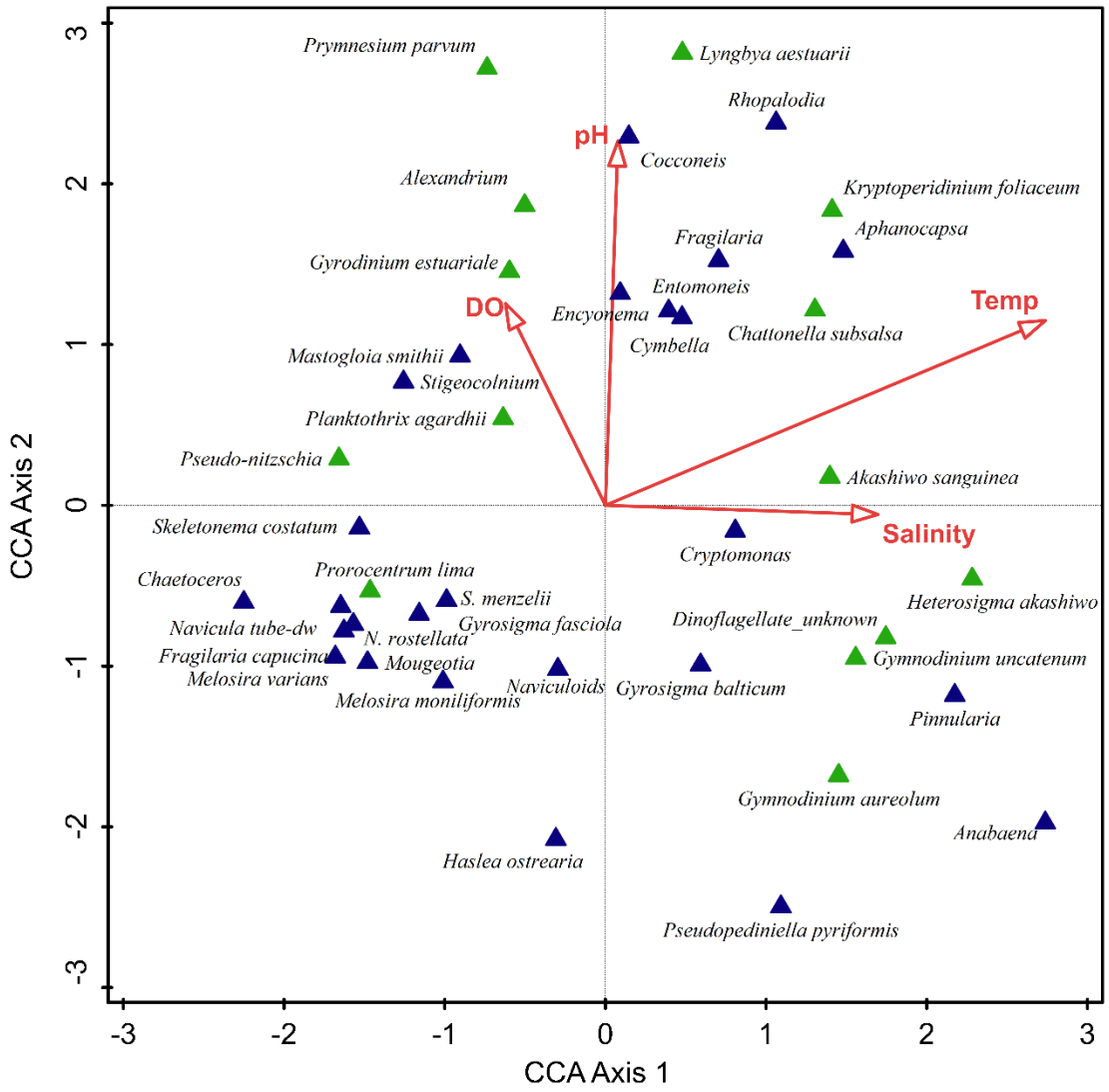

Figure 2. Species-Environment biplot derived from canonical correspondence analysis (CCA) in salt marsh ponds from May 2022 to June 2023, showing the first 30 taxa with the highest weight. Red arrows are environmental variables: water temperature (Temp), salinity, dissolved oxygen (DO), and pH; these explained only 7% of species composition and abundances. Symbols in green are HAB species; blue symbols are non-HAB species.

In July and August 2023, five algal toxins were detected in the SMPs, including Brevetoxin, Saxitoxin, Okadaic acid (OA), Microsytins, and Cylindrospermopsins. Furthermore, the analysis showed that multiple toxins were present simultaneously in over half of the samples. A high concentration of OA (> 270 µg/L) was detected in one of the ponds at the end of July (Table 1). It is worth noting that toxins were not always detected at the same time as HABs. This shows that the relationship between the presence of toxic species and toxin production is complicated.

Table 1: Results of HAB derived biotoxins in the SMP samples collected from 5/17/2023, 7/28/2023, 8/11/2023, and 8/30/2023. nd: not detected. LOD: limit of detection

Sample ID	Site ID	Collection date	Volume (ml)	Brevetoxin (µg/L)	Saxitoxin (µg/L)	Okadaic acid (µg/L)	Microcystins (µg/L)	Cylindros-permopsin (µg/L)
SMP0167	REF-1	7/28/2023	120	0.43	0.53	*nd*	*nd*	*nd*
SMP0169	REF-2	7/28/2023	150	*nd*	0.32	*nd*	*nd*	*nd*
SMP0171	PGD-1	7/28/2023	100	*nd*	0.33	*nd*	*nd*	0.37
SMP0173	PGD-2	7/28/2023	90	*nd*	*nd*	*nd*	0.63	5.89
SMP0175	OMWM-1	7/28/2023	100	*nd*	0.61	*nd*	0.78	0.76
SMP0177	OMWM-2	7/28/2023	70	2.03	0.91	273.60	*nd*	2.16
SMP0180	REF-1	8/11/2023	50	*nd*	0.71	*nd*	*nd*	*nd*
SMP0182	REF-2	8/11/2023	50	*nd*	4.49	*nd*	*nd*	*nd*
SMP0184	PGD-1	8/11/2023	130	*nd*	*nd*	*nd*	*nd*	*nd*
SMP0186	PGD-2	8/11/2023	50	*nd*	1.91	*nd*	0.90	0.50
SMP0188	OMWM-1	8/11/2023	50	1.42	0.58	*nd*	10.60	*nd*
SMP0190	OMWM-2	8/11/2023	50	*nd*	*nd*	15.70	*nd*	0.80
SMP0192	REF-1	8/30/2023	80	*nd*	1.27	*nd*	*nd*	*nd*
SMP0196	PGD-1	8/30/2023	90	*nd*	*nd*	*nd*	*nd*	0.44
SMP0198	PGD-2	8/30/2023	90	*nd*	4.62	*nd*	2.13	6.89
SMP0200	OMWM-1	8/30/2023	80	1.10	0.68	*nd*	*nd*	0.41
SMP0202	OMWM-2	8/30/2023	80	*nd*	0.43	43.69	*nd*	22.13
SMP0151	OMWM-1	5/17/2023	70	*nd*	2.78	*nd*	*nd*	*nd*

* Method limit of detection (LOD): Brevetoxin: 0.1 µg/L; Saxitoxin: 0.03 µg/L; Okadaic acid: 0.2 µg/L; Microcystins: 0.05 µg/L; Cylindrospermopsin: 0.05 µg/L

A website has been constructed to hold a total of 49 images and 21 videos illustrating 13 HAB species. The site is accessible at: https://dep.nj.gov/dsr/nj-smp-hab-reservoirs/. For each HAB species, documentation on morphology, ecology, toxicity, distribution, and occurrence is provided. The website serves as an educational resource for the general public and students K-12 or higher about HABs in NJ coastal marshes. It also serves as an interface for connecting with NJ communities, informing them of the presence of HABs in these ponds and the potential for toxin presence.

How will DEP use the data?

This study demonstrated, for the first time, that HABs contribute to the dynamics of SMPs in New Jersey coastal marshes and the presence of HAB-derived toxins in these ponds. This finding has significant implications for wetland ecology, as well as environmental and human health. Climate change and sea level rise, through increased marsh flooding, could heighten the potential for more frequent HAB inoculation as SMPs are more regularly connected to estuarine open waters and their fisheries. It is increasingly important to integrate SMPs into the assessment of wetland conditions, their role in HAB dynamics, and their effects on land cover and coastal waters.

A first recommendation would be to explore and understand the factors contributing to the proliferation of HABs in the NJ salt marsh ponds and their potential role as a source for offshore bloom development. A second recommendation would be to explore the factors that contribute to toxin releases by HAB species and which factors inhibit the release of toxins. A third recommendation is related to the use of DNA-based metabarcoding for the identification of HABs. This project

demonstrated that microscopy combined with DNA analyses produces a better assessment of HAB diversity when monitoring SMPs. It is recommended that future studies apply a combination of the two methods. A last recommendation would be to verify if the HABs are present in other salt marsh ponds to acquire a better understanding and improve the protection of human and ecosystem health along the New Jersey coast.

Please review the full report for more detailed information at:
https://hdl.handle.net/10929/145921

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Who to contact with further questions:

For additional information or questions regarding this study, please contact Mihaela Enache (mihaela.enache@dep.nj.gov) in the NJDEP Division of Science and Research.

References:

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