

# AN ASSESSMENT OF SOUTH CAROLINA WATERS: PHYTOPLANKTON COMMUNITY STRUCTURE AND DISTRIBUTION

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**Abstract.** Coastal communities across the nation are dealing with the impacts of increased development. South Carolina in particular is one of the fastest developing coastal regions in the country. One of the primary concerns associated with this development is the potential for the degradation of the water bodies adjacent to these areas through the effects of eutrophication. One of the effects of eutrophication is an increase in algal biomass. With this increase of biomass comes the increased potential for the development of harmful algal blooms (HABs). A survey of coastal South Carolina waters was conducted, sampling 18-20 fixed sites from Myrtle Beach, SC to Hilton Head, SC monthly during the same tidal stage in one day for 14 months. The purpose of which was to assess phytoplankton distribution and general community structure along the coast. Additional parameters were measured to assess water quality based on the criteria set by the United States Environmental Protection Agency 2004 National Coastal Condition Report. By using a fixed site sampling routine, spatial and temporal trends in water quality for the sites studied can be discerned and their potential influence on phytoplankton assemblages understood. Samples were collected and screened within 24 hours and the primary constituents of the phytoplankton community documented. Phytoplankton assemblages seen within the coastal survey were typically dominated by a mixed diatom community. However, specific sites had a prevalence of HAB species occurring each month. There was no notable seasonal emergence of HAB species across the entire coast. HAB species presence was typically site specific and those sites often contained HAB species throughout the year. The coastal survey identified a significant number of sites in which HAB species were routinely present and by further investigating the water quality conditions at those sites compared to the rest of the coast, a better understanding

of HAB dynamics may be discerned and better management practices developed.

## INTRODUCTION

Coastal tourism generated nearly 1.67 million jobs and \$13.6 billion USD in workers wages in 2000 alone (Dorfman, 2006). Due to this large influence on the economy of coastal communities, many groups have been taking part in monitoring coastal resources to ensure a healthy environment and thus the continued influx of tourism money (Dorfman, 2006). Accordingly, coastal South Carolina has become one of the fastest growing areas in the nation. Given the importance of tourism to the area and its unprecedented population growth, it has become vital to safeguard the health of the coastal water ways. Phytoplankton community structure analysis is a useful tool for determining the health of an ecosystem. In degraded systems the emergence of toxin producing or otherwise harmful algal bloom (HAB) species is more prevalent (Paerl, 1997). HAB species can have a significant impact on coastal waters through the production of scum or mats, noxious smells or skin irritants, which can negatively impact tourism (GEOHAB, 2000). Also toxins produced by HAB species can travel through the food chain and affect everything from marine mammals and birds to human health and have a massive impact on the ecosystem as a whole (Work et al, 1993 and Scholin et al, 2000).

Some sampling programs in South Carolina address water quality issues either by sampling once a year over a large spatial area (SCECAP) or frequent samplings of limited areas (NERRS). The first, while invaluable, lacks seasonal resolution and provides a once a year snap shot of the health of South Carolina's water ways. While the latter, focuses on only two geographic areas of the state

(North Inlet and ACE Basin). Members of the SCAEL developed and implemented a monitoring project that combined the best of both monitoring programs. A series of fixed sites along the South Carolina coastline were chosen based on their use by the local community and accessibility for scientific staff. Many of these sites were adjacent to boat landings or near bridges over heavily used bodies of water. Readily accessible sites facilitated a sampling routine that provided the same spatial and temporal coverage of programs that already exist, and helped to further expand their assessments.

## MATERIALS AND METHODS

A series of 18-20 sites (Figure 1) were sampled on a monthly basis. Sites were selected for their ease of sampling and each site was sampled within 2 hours of predicted low tide. A hand held YSI 85 was used to record physical parameters; temperature, salinity, and dissolved oxygen. A hand held pH meter was used to record pH in the field and secchi disk measurements were taken to assess light penetration. Water samples were collected in acid washed polyethylene bottles and processed within 3 to 4 hours of collection. Concentrations of  $\text{NH}_4^+$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\text{PO}_4^{2-}$ , and  $\text{SiO}_2$  were assessed using auto analyzers (Hayes, et al, this proceedings). Water samples were screened for dominant algal species within 24 hours of collection, and if any blooms of harmful species were present they were enumerated using Lugol's preserved samples collected and preserved in the field using 50 mL sterile centrifuge tubes.

## RESULTS

Phytoplankton assemblages at the sites sampled during the SCAEL coastal survey were generally dominated by a mixed diatom community. However, HAB species

**SCAEL Coastal Survey Monitoring Sites**

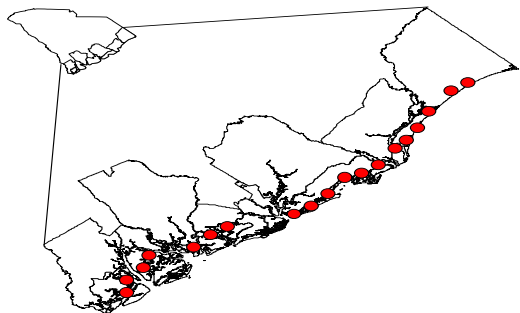


Figure 1: Sites sampled along the South Carolina coast during the SCAEL Coastal Survey

were routinely present in some portion of sites sampled each month. Broad River, Albergoti Creek, Shem Creek, and East Bay sites had a HAB species present every time they were sampled. Other sites that had HAB species present a majority of the times they were sampled were Pirateland Swash, Pawley's Island, and Murrell's Inlet. The Ashepoo River, Edisto River, Moore's Landing, Buck Hall Landing, Robert Ashley Landing, and Clambank Creek all frequently had HAB species present. However, other than a few isolated samplings the May River, the Colleton River, the Chechessee River, and Toogoodoo River had no HAB species present (Table 1).

The HAB species present most often were the dinoflagellates *Karlodinium veneficum*, *Kryptoperidinium foliaceum*, and *Heterocapsa* sp. However other potentially harmful species were observed as well. These included the cyanobacteria, *Pseudanabaena* sp. and *Oscillatoria* sp., the diatom *Pseudo-nitzschia* sp., the chrystophyte *Prymnesium parvum*, and the Raphidophytes *Chattonella subsalsa*, *C. cf. verruculosa*, and *Heterosigma akashiwo*. Based on the data collected *K. foliaceum* and an undescribed Scrippsielloid dinoflagellate are South Carolina's most widely distributed HAB and were present at the most sites along the coast (Table 1). Also of note is the presence of these two dinoflagellates throughout the year. Only during the January sampling were they not a dominant species. Similarly, *K. veneficum* and *Pfiesteria*-like species were present throughout most of the year; however, they were not as widely distributed as *K. foliaceum*. Other species experienced some seasonal trends. *Prorocentrum minimum* occurred most often between November and January. Cyanobacteria (*Oscillatoria* sp.) were present typically in early summer and then again in the fall. While the Raphidophytes tended to be present mainly in the summer and early fall.

## DISCUSSION

In South Carolina, harmful algal blooms are typically expected to occur from early spring through mid summer (Lewitus et al. 2003). This range seems rather narrow in light of the data gathered during the SCAEL Coastal Survey. As stated, *K. foliaceum* and the Scrippsielloid were found to be a dominant member of the community in multiple locations year round. Also documented year round was the dinoflagellate *K. veneficum* as well as other *Pfiesteria* -like species. SCECAP has documented an increase of harmful dinoflagellates since 2001, which has been attributed to effects from ongoing drought conditions (Van Dolah et. al, 2006). However, the harmful effects of *Kryptoperidinium* and the other dino-

Table 1. Sites with HAB species as a dominant constituent of the algal community during a Coastal Survey

Site	2007						2008							
	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
May River	Green	Yellow	Green	Green	Green	Green	Green	Green	White	Green	Green	Green	Green	Green
Colleton River	Green	Green	Red	Green	Green	Red	Green	Green	White	Green	Yellow	Green	Yellow	Green
Chechessee River	Green	Green	Red	Green	Red	Green	Green	Green	White	Green	Green	White	White	Green
Broad River	Red	Red	Green	Red	Red	Red	Green	Green	White	Green	Red	White	White	Red
Albergotti Creek	Red	Red	Yellow	White	Red	Red	Red	Red	Green	Red	Red	Red	Red	Red
Ashepool River	Green	Yellow	Green	Red	Red	Red	Green	Green	White	White	Green	Green	Yellow	White
Edisto River	Yellow	Red	Green	Green	Green	Red	Red	Red	Green	White	Green	Green	Yellow	White
Toogoodoo Creek	Red	Yellow	Green	Green	Green	Green	Green	Red	White	Green	Green	White	White	Green
Shem Creek	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Red	Red	Yellow	Red	Red
Moores Landing	White	Red	Red	Green	Green	Green	Red	Yellow	Green	Green	Red	Yellow	Red	Green
Buck Hall Landing	Green	Green	Green	Green	Red	Green	Red	Red	Green	Green	Red	Red	Green	Green
Robert Ashley Ldg.	Green	Red	Green	Green	Green	Green	Yellow	Red	White	Green	Red	Red	Yellow	Green
N. Santee River	Red	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Yellow	Green	Red
East Bay Landing	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green
Clambank Creek	Green	Yellow	White	Yellow	Red	Red	Red	Yellow	Red	Green	White	Yellow	Green	Red
Pawleys Isl.	Red	Yellow	Red	Red	Red	Red	Red	Red	Yellow	Red	Yellow	Yellow	Green	Red
Murrell's Inlet	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Red	Red	Red
Pirateland Swash	Red	Red	Yellow	Yellow	Red	Red	Green	Red	Red	Yellow	Red	Red	Red	Red
Withers Swash	Green	Green	Yellow	Green	Green	Red	Yellow	Red	Green	Yellow	Yellow	Red	White	Yellow



flagellates were not seen year round (i.e. low D.O., etc).

Other common harmful algal groups observed included the Raphidophytes and Cyanobacteria. The Raphidophytes were found to be major constituents of the algal community during the same time of year as previously documented. From April 2001 to November 2002 Lewitus et. al. (2004) documented that Raphidophytes were most abundant from mid-spring through September, suggesting that any environmental impacts that have resulted in an increase of harmful dinoflagellates has not effected the Raphidophyte population. Cyanobacteria, while typically a freshwater group, has been found migrating into brackish water as documented by SCECAP and the SCAEL. SCECAP reports that the emergence of cyanobacteria in their sites has been a recent development in 2003-2004 (Van Dolah et. al, 2006). However, during this coastal survey *Oscillatoria* sp. was found at the most sites between October and December and their presence could have been occurring before 2003-2004, but gone undocumented.

*Prorocentrum minimum* is also likely under represented in reports on the distribution of harmful species as it was

present mostly in the winter (Dec.- Jan.). During which time monitoring efforts are typically not as intensive. While, the species itself is highly temperature tolerant it does not have a specific affinity for cold temperatures. However, in North Carolina it is most commonly found in winter months as well (Heil et al., 2005). This suggests it may have a competitive advantage in the colder temperatures of the winter months in the Southeast.

#### CONCLUSIONS and RECOMENDATIONS

HABs are present on an annual basis along the South Carolina coast. The presence of *Kryptoperidinium* and other harmful dinoflagellates through the entire year is alarming. However, the seasonal trends seen in the other HAB groups, like the Raphidophytes and *P. minimum* are similar to those previously documented by other monitoring programs. This suggests perhaps it is something unique to dinoflagellates that is responsible for this increased presence, and that is a clue as to where to start in understanding this occurrence. An effort to continue this type of work to look at plankton distribution

in South Carolina both spatially and temporally needs to be made, since it appears the presence of HAB species is increasing. This could be a sign that major problems for coastal South Carolina await. However, without continued monitoring it will be hard to discern if the effects are related to current draught conditions or if it is the first sign of a larger problem related to coastal development. Without that understanding, it will be difficult to formulate an effective approach to mitigate any impact an increase in HAB species may create for coastal South Carolina.

There are multiple approaches to gaining that necessary understanding. The first would be to expand currently established programs; adding a seasonal component to SCECAP or expanding the NERRS monitoring network in South Carolina. However, another option would be to develop a unified statewide volunteer network much like the one's supported by the EPA; California, Maine, and Massachusetts all have extensive volunteer monitoring programs that often contain 20 or more groups (80 individuals) monitoring the coastline on a weekly basis (Green, 1998). Utilizing proven and existing groups in South Carolina such as Coastal Carolina University's Waccamaw Watershed Academy and the South Carolina Phytoplankton Monitoring Network could far exceed the resolution capable by a single agency or group. Regardless of the approach, year round monitoring is necessary.

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