Eutrophication Assessment of Swashes in

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Hypothesis

Storm water runoff has a significant effect on the degree of eutrophication in the swashes and surf zone along the Northeastern coast of South Carolina (Grand Strand).

Eutrophication

- Eutrophication is a syndrome caused by nutrient loading, particularly of the elements, nitrogen and phosphorus. These nutrients can come from stormwater runoff containing:
  - Fertilizers
  - Feces (also contains coliform bacteria). Sources of feces include:
    - Humans
    - Pets
    - Livestock
    - Wildlife
- Nutrient loading stimulates algal growth (this algal growth is measured as chlorophyll).
- The resulting organic detritus is decomposed by aerobic heterotrophic bacteria.
- Oxygen deficits result (as measured by dissolved oxygen and percent saturations).

SUMMARY OF EUTROPHICATION CRITERIA

Eutrophication is a widespread problem. Various government agencies in the United States have proposed several sets of criteria for diagnosing the degree of pollution.

Analytes	Estuary **	Rivers*		South Carolina Lakes Class FW$
		Ecoregion XII	Ecoregion XIV	
Phosphorus (ppm P)	0.01	0.04	0.031	0.06
Nitrogen (ppm N)	0.1	0.9	0.7	1.5
Chlorophyll a (ppb)	5	0.4	3.8	40
Turbidity (NTU)	NA	1.9	3	50

***in draft form: Ambient Water Quality Criteria Recommendations from US EPA's Office of Water**

Ecoregion XII: Southeastern coastal plain of FLA, GA, MISS, ALA
Ecoregion XIV: SC, NC, VA, MD, DE, NJ, NY, CT, RI, MA, NH, ME
(The coastal plain of SC fits in Ecoregion XII better than Ecoregion XIV)

**** in draft form from: National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries (Bricker et al. 1999) from NOAA**

$South Carolina: R.61-68 Water Classification and Standards approved 2001. Shown are the criteria for lakes that fall in the Class Freshwater category.

Sampling Strategy

- A total of nine swashes (small tidal creeks) were sampled (some in duplicate)
  - The samples were taken in the swash during an ebbing tide
  - Samples were taken in in the surf zone of the ocean.
    - 100 feet north of the mouth of the swash
    - 100 feet south of mouth of swash

This procedure resulted in 42 sampling sites
Samples were collected by the 50 students in MSCI 305: Marine Chemistry in Spring 2002

- Analytes tested included:
  - Eutrophication Benchmarks
    - Dissolved Oxygen and Percent Saturation of Dissolved Oxygen
    - Nitrate + Nitrite
    - Phosphate
    - Chlorophyll
  - Some others
    - Salinity (tracer of fresh water mass)
    - pH (indicator of the degree of organic matter decay)
    - Alkalinity (indicator of the degree of organic matter decay)

Sampling Sites

A number of sites were sampled along the total length of the Grand Strand. These included sites as far north as Little River Inlet and as far south as Dogwood Swash. This broad range of sites produced a picture of the total eutrophication all along the Grand Strand. The sites included:

- Cherry Grove (Little River Inlet)
- Singleton Swash
- Cane Patch Swash
- Deephead Swash
- 30th Avenue North (control, beach site)
- Withers Swash
- Midway Swash
- Ocean Lakes Swash
- Dogwood Swash

Map views of the locations of the swashes:

Sampling Dates

Due to the large number of samplers, different analytes were sampled for on different days. This allowed for proper collection and analysis of data. Those dates were:

- Dissolved Oxygen, Salinity, Temperature and Bacteria
  - February 13 and 14, 2002
- pH and alkalinity
  - March 13 and 14, 2002
- Nutrients and Chlorophyll
  - April 10 and 11, 2002

Methods

A number of different methods were used to analyze the samples. These included:

- Dissolved Oxygen by Winkler Titration*
- Salinity by Knudsen Titration
- Temperature by Thermometer
- pH with pH meter
- Alkalinity by Gran Titration*
- Phosphate and Nitrate + Nitrite by Beer's Law*
- Chlorophyll and Phaeopigement by Fluorometry*
- Total and E. Coliforms by Membrane Filtration using Hach™ m-Coli Blue media

*Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. A Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press, N.Y., 173 pp.

DATA

Salinity (psu)
Anova p = 1.08 E-10

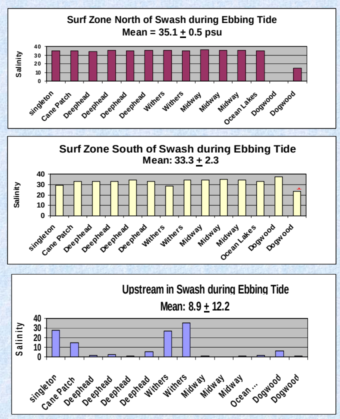

Figure 1: Figure 1 shows the results of the salinity analyses. An ANOVA (p= 1.08×10^{-10}) demonstrates that the salinity in the swash was lower than the surrounding ocean salinity indicating the presence of a significant amount of freshwater discharge. The few high values observed in the swash are probably the result of sample collection on a flooding tide. The salinity south of the swashes was significantly lower (p= 0.007) than the salinity north of the swashes suggesting that the longshore current carries swash water in a southerly direction.

Dissolved Oxygen (ppm DO)
Anova p = 0.160

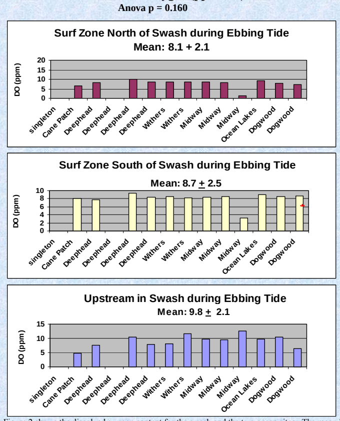

Figure 2: Figure 2 shows the dissolved oxygen content for the swash and the two ocean sites. The mean DO in the swash was higher than in the ocean, but this difference was not significant (p = 0.160). The higher DO's in some of the swashes are most likely the result of algal growth associated with eutrophication.

Certain swashes have supersaturated conditions suggesting the input of oxygen from an algal bloom. Some swashes are undersaturated, suggesting removal of oxygen. This removal may be from aerobic respiration from the decomposition of organic matter (possibly a previous algal bloom). There are corresponding highs and lows in the ocean sites south of the swash suggesting a southerly longshore current.

% Saturation
Anova p = 0.948

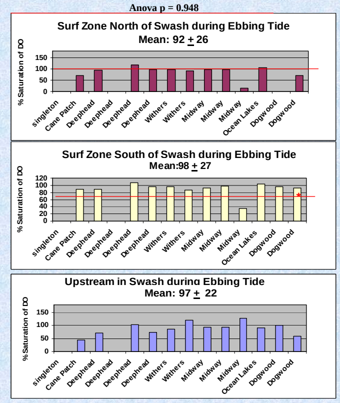

Figure 3: Figure 3 shows the percent saturation of oxygen for the swash and corresponding ocean sites. Percent saturation of oxygen differs from a dissolved oxygen reading in that it negates the effect of atmospheric mixing of oxygen with the water surface. Many of the swashes are supersaturated with oxygen and actually exceed the recommended criteria (indicated by the blue line). This information gieves further evidence for the presence of an algal bloom.

pH
Anova p = 4.02 E -3

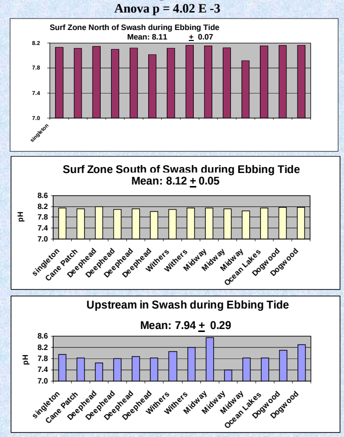

Figure 4: Figure 4 shows the pH values for the swashes and corresponding ocean sites. Freshwater systems do not have the bicarbonate buffer system for pH as the ocean has. Therefore, changes in pH have the potential to cause more problems in the swash. The pH values are significantly lower in the swash. The pH values in the ocean north of the swash correspond with the swash values, suggesting a northward flow of the longshore current.

Alkalinity (meq/L)
Anova p = .936

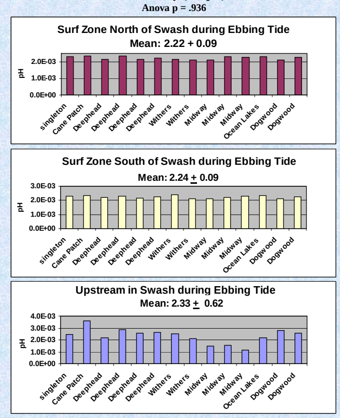

Figure 5: Figure 5 shows the alkalinity values for the swash and corresponding ocean sites. The alkalinity values are significantly lower between the swash sites and the oceanic sites. This is further indication of the lack of the bicarbonate buffer system. The swash has lower alkalinity values because there is not the same amount of buffer in the freshwater. Two of the swash sites appear to be alkalinity sensitive. The ocean sites indicate northward flow of the longshore current.

the Grand Strand Area, South Carolina

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Total Nitrogen (µM N)

Anova p =.038

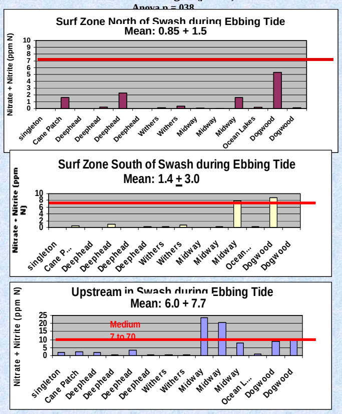

Figure 6: Figure 6 shows the nitrate values for the swash and corresponding ocean sites. The nitrate values for most of the swashes fall into the medium level of eutrophication status. Others fall into the low level of eutrophication status. The ocean sites south of the swash correspond with the swash values, indicating a southerly flow of the longshore current.

Phosphate (µM P)

Anova p =.001

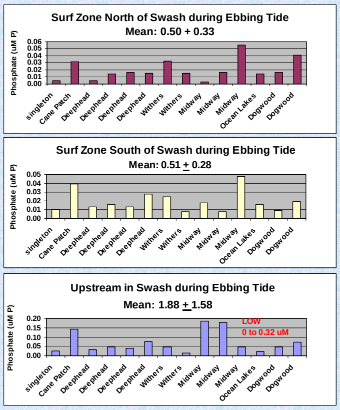

Figure 7: Figure 7 shows the phosphate values for the swashes and corresponding ocean sites. All of the swashes, except one, fall into the medium eutrophication level status. The ocean sites south of the swash correspond with the swash values, indicating a southerly flow of the longshore current.

Chlorophyll (mg/m^3)

Anova p =.088

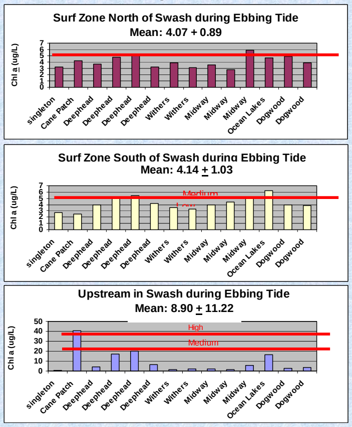

Figure 8: Figure 8 shows the values for chlorophyll for the swashes and corresponding ocean sites. All the swashes are either in the low or medium eutrophication level status. The ocean sites to the south of the swash correspond with the swash values. This indicates that the longshore current in flowing in a southerly direction.

Total Coliforms (CFU/100 mL)

Anova p =.001

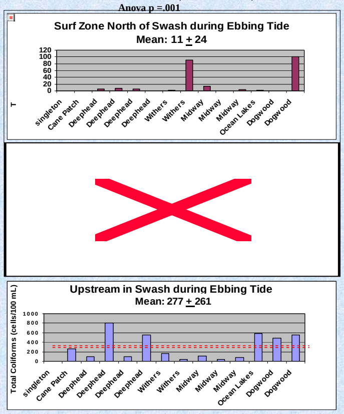

Figure 9: Figure 9 shows the values for total coliform bacteria in the swash and corresponding ocean. The swash shows significantly elevated levels of bacteria as compared to the ocean ($p = 8 \times 10^{-12}$). Seven of the swashes exceeded the US EPA's swimming water criteria of 200 colony forming units per 100 mL. The lower values in the ocean are reflect the toxic effect of salt on the bacteria.

E. Coli (CFU/100 mL)

Anova p =.026

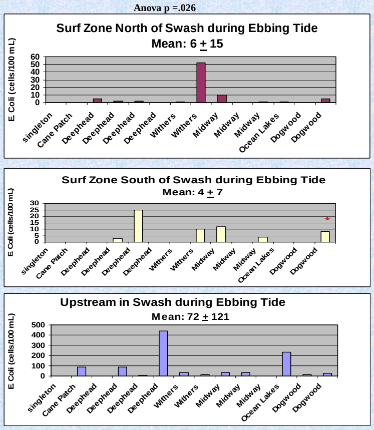

Figure 10: Figure 10 shows the values for E. coli in the swash and corresponding ocean sites. As in figure 9, the bacteria levels are higher in the swash as compared to the ocean (p = 0.001). Four of the sites exceeded the US EPA's swimming criteria*. E. coli bacteria are of special note because of its possible pathogenic effect. The lower values in the ocean are reflect the toxic effect of salt on the bacteria. 1) a geometric mean of

*The current critiera are: 1) 126 organisms/100 ml based on several samples collected during dry weather conditions or 2) 235 organisms/100 ml for any single water sample. These limits correspond to approximately 8 gastrointestinal illnesses per 1000 swimmers. (Dufour, Alfred P. 1984. Health effects criteria for fresh recreational waters. EPA-600/1-84-004. Office of Research and Development, USEPA, Washington, DC.)

Conclusions

- The swashes show elevated levels of the following analytes suggesting influence of nonpoint runoff of sewage and/or fertilizers. Nonpoint runoff is the run-off from fields and the ground during rain events.
  - Chlorophyll
  - Nitrate + Nitrite
  - Phosphate
  - Bacteria
  - Dissolved Oxygen (showed levels of supersaturation)
- The swashes have low levels of:
  - pH and alkalinity (due to organic matter decay)
  - salinity (due to the influence of freshwater)

•The evidence for eutrophication includes:

–Chlorophyll (low levels of eutrophication)

–Nitrate + Nitrite (low levels of eutrophication)

–Phosphate (medium levels of eutrophication)

–Dissolved Oxygen (the supersaturated level of dissolved oxygen indicates an algal bloom.)

• The majority of the analytes indicated a southerly flow of the longshore current. This is important in predicting which area of the surf zone will be affected most by the outflow from of the swashes.

•There was evidence of bacterial contamination suggesting that at least some of the nutrient loading was associated with feces.

–Some sites exceeded the swimming standard of 126 CFU/100 mL for E. Coli AND the 200 CFU/100 mL standard for fecal coliforms. (These are US EPA swimming water criteria). These sites include:

–Deep Head Swash

–Withers Swash

–Ocean Lakes Swash

–Elevated levels were observed in the swash AND the surf zone at these sites.

Acknowledgments

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