LONG-TERM TRENDS IN WATER QUALITY OF THE SWASHES

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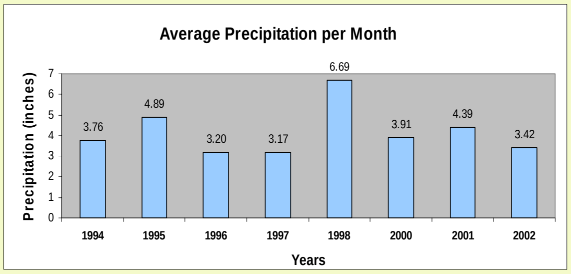

Figure 2: Figure 2 shows the average precipitation per month* during the testing period. These averages are shown over an eight year period over which surf zone grab samples were collected. An El Nino caused high rainfall in 1995 and 1998. Periods of low rainfall occurred in 1996 and 1997 and 2002.

* In 1994, chemical measurements were made during the Fall (October). Measurements during all other years was done during the Spring (January-March).

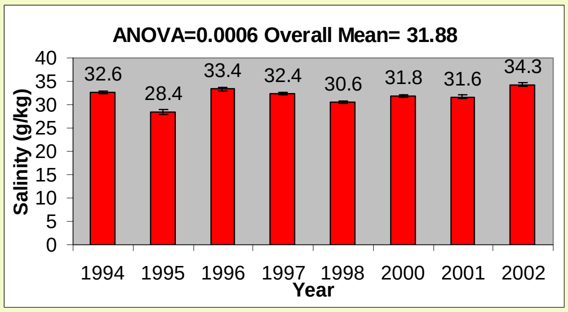

Figure 3: Figure 3 shows that there was a significant difference in salinity over the eight years of testing. This figure shows trends relevant to precipitation, 2002, 1996 and 1997 had higher salinities due to a lower average rainfall and 1995 and 1998 had a lower salinity due to the higher rainfall.

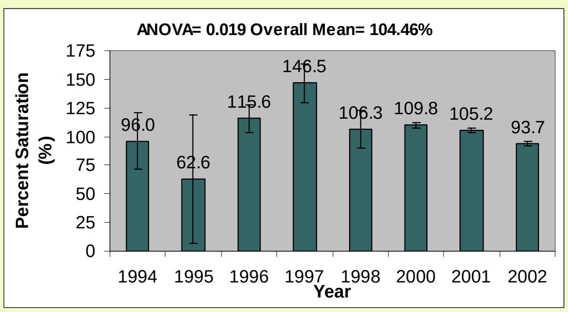

Figure 4: Figure 4 shows that there was a significant difference in the % saturation of dissolved oxygen over the eight years. Focusing in on 1996 and 1997, these two years show higher percents of saturation. 1995 was also very low in comparison with the other years but highly variable. 1994, 1995 and 2002 were years when the DO was on average undersaturated.

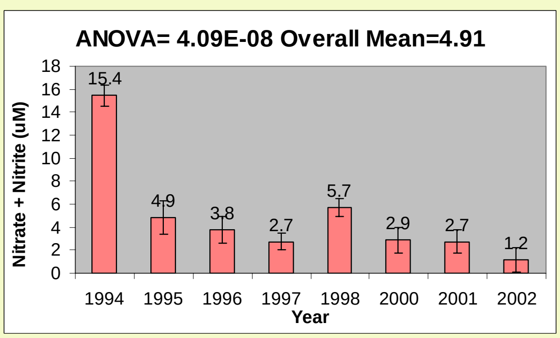

Figure 5: Figure 5 shows there was a significant difference in nitrate + nitrite over the eight year testing period. There was a very high value recorded for 1994 data, possibly associated with convective over turn associated with early winter storms. All the rest of the data was collected during late winter/early spring. The years 1996 and 1997 show lower values in correspondence to the lower precipitation recorded and the higher salinities. The 1995 and 1998 data show higher values that correspond to the higher precipitation measured and the lower salinities.

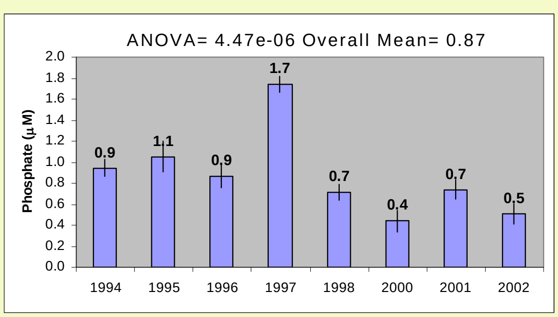

Figure 6: Figure 6 shows that there is a significant difference in phosphate measurements over the eight year testing period. There are low levels of phosphate in both in 2000 and 2002 reflecting the influence of low rainfall. Note that all of these data are classified into a low level of eutrophication based on NOAA criteria for estuaries.

Abstract

Water quality in eight tidal creeks and the adjacent surf zone of the Grand Strand of South Carolina have been measured during the Fall (October) 1994 and Spring (January through April) from 1994 to 2002. Parameters measured include: temperature, dissolved oxygen, salinity, phosphate, nitrate +nitrite, chlorophyll, phaeophytin, pH, alkalinity, and E. Coli. This large data set provides evidence for the effect of climate change on water quality. For example, an intense El Nino resulted in lowered salinities (30.5 with 1s = 0.7 psu) in the Spring of 1998 whereas the current period of extreme drought has resulted in salinities, during Spring 2002, of 35.1 with 1s = 0.5 psu. Large amounts of rainfall were hypothesized to increase runoff of contaminants, such as nutrients, bacteria and oxygen-demanding substances, from the land although concentrations may be lower due to dilution. Larger impacts of nonpoint source pollution on the swashes and adjacent surf zone were expected from sites located in the more developed subwatersheds, such as those located near golf courses.

Hypothesis

Large amounts of rainfall should increase runoff of contaminants, such as nutrients, bacteria and oxygen-demanding substances from the land. Rainier years should have higher surf zone concentrations of contaminants. Contaminant concentrations should be higher at sites located in the more developed subwatersheds, such as those near golf courses.

Methods

Grab samples of seawater were collected in the surf zone at sites along the Grand Strand Samples during the Fall 1994 and Spring 1995-2002 (with the exception of 1999 when no samples were collected) by the students in MSCI 305: Marine Chemistry. Sites were sampled along the total length of the Grand Strand. These included sites as far north as Sunset, NC and as far south as Georgetown, SC. See Figure 1 for site locations.

During 2000, 2001 and 2002, the samples were taken during an ebbing tide

- Within tidal creeks, called swashes.
- 100 feet north of the mouth of the swash
- 100 feet south of mouth of swash

Analytes measured were:

•Dissolved Oxygen by Winkler Titration* [1]

•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*

•E. Coli 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.

[1] Dissolved Oxygen was used to calculate the % Saturation by the following formula:

% Saturation= $[DO]_{observed}$ / $[DO]_{equilibrium}$ x 100.

Figure 1. Sampling Locations

AND SURF ZONE IN THE GRAND STRAND AREA, SC

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Experimental Design

Grab samples were taken from the surf zones at sites along the Grand Strand. See map in Figure 1. Note that runoff enters the surf zone from tidal creeks or swashes. Approximately 30 to 40 samples were collected each year with n = 253 samples for the entire data set. The sampling sites were spread along the county's (Horry) coastline. Year-to-year differences were tested for using ANOVA. Rain data were provided by NOAA (http://cirrus.dnr.state.sc.us/cgi-bin/serce/cliMAIN.pl?sc1997).

Results

The mean values for each parameter are plotted as bar graphs with the ANOVA p value and overall mean value for each parameter at the top of the graph. The error bars represent the confidence interval at the 95% confidence level as described by the ANOVA. The results have been summarized in Table 1.

Table 1: Trend Summary

	Fall	Spring							
	1994	1995	1996	1997	1998	1999	2000	2001	2002
Rain		High	Low	Low	High				Low
Number of Samples	31	20	27	40	33	0	28	23	23
Salinity		Low			Low				High
%Saturation	Under-saturated	Low and very variable		Super-saturated and high					Under-saturated
Nitrate + Nitrite	Very High	High			High				Low
Phosphate	High			High			Low		Low
Chlorophyll	Very High	High			Not Observed				
Phaeopigments	Very High	High			Not Observed				
pH		High		High	Low				
Alkalinity	High		Low	Low			High	High	High
E. Coliforms	Not Observed								Low

Figure 7: Figure 7 shows that there was no significant difference in pH over the eight year testing period. In 1995 and 1997, the pH was relatively high and 1998 was low.

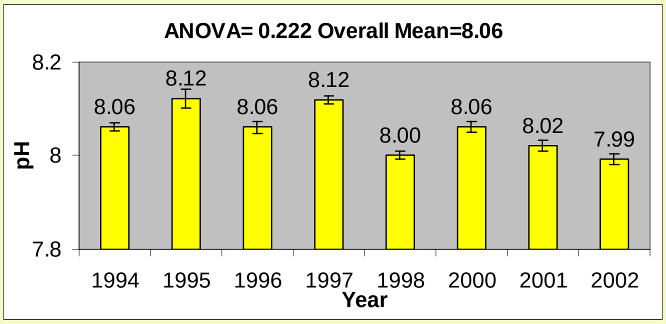
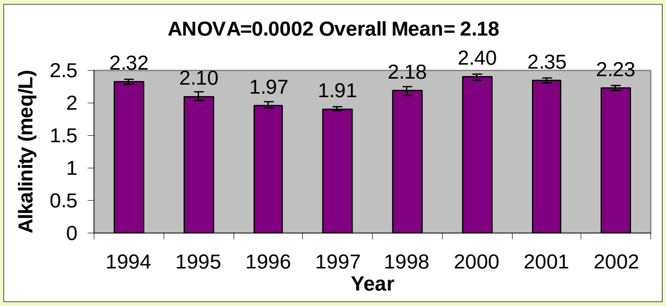


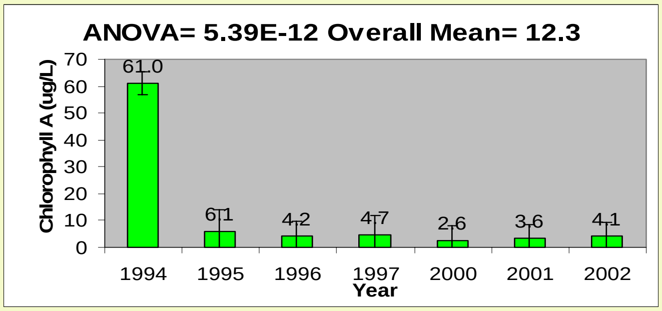
Figure 8: Figure 8 shows that there was a significant difference in the alkalinity over the eight year testing period. In 1996 and 1997 the alkalinity was low. The years 2000-2002 and 1994 were higher than all the other years recorded for alkalinity. In comparison pH continually went down from 2000-2002.



Conclusions

El Ninos occurred during 1995 and 1998 and lead to higher rainfall and depressed salinities. 2002 was reflective of a continuing (4-year period) of drought and salinities were elevated. The same trends were observed in the nitrate and to some degree in the alkalinity. The chlorophyll a and phaeopigment data also show a trend for the continued drought. The influence of convective overturn in the fall sampling is seen in the chlorophyll and phaeopigment data as elevated levels in 1994 (fall) sample. This shows the importance of early winter storms in bringing nutrients back into the euphotic zone and stimulating a fall algal bloom. Phosphate also shows lower concentrations during 1998-2002 because of the drought conditions. Over the past three years, this work has been done in conjunction with a eutrophication study which is providing a more detailed study of sources and fate of contaminants along the Grand Strand.

Figure 9: Figure 9 shows the chlorophyll concentrations over the 8 year period. There is a significant difference in the levels of the concentrations. This is probably due to the presence of a fall bloom in 1994. Spring concentrations were much higher in 1995 compared to other years which coincided with higher nitrate+nitrite in this year. There were no chlorophyll concentrations measured in 1998.



Acknowledgments

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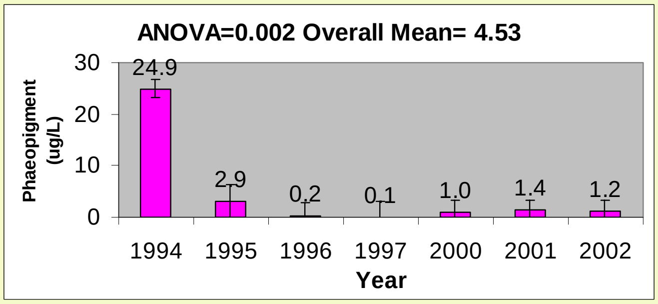
- Fall 1994 and Spring 1995-2002 Marine Chemistry Class, Coastal Carolina University
- Marine Science Department, Coastal Carolina University
- Environmental Quality Lab, Coastal Carolina University
- Colleen Finnegan and Dr. Craig Gilman

Figure 10: Figure 10 shows phaeopigment concentrations. Evidence of a fall bloom is also present in this data set in 1994. The highest Spring concentrations occur in 1995 and are probably due to the increased rain fall. Once again, there were no data collection for 1998.



Chrissy testing for dissolved oxygen.

Nicole taking salinity reading with a refractometer.

Figure 11: Figure 11 shows the concentrations for E. coli. These data were only collected during 2001 and 2002. There is an overall decrease seen in the swash concentrations from 2001 to 2002, however, there is an increase in the surf zone concentrations. The decrease in swash concentrations for 2002 is probably due to the drier conditions during that year, not allowing as much runoff to occur.