



# Oceanography Department Student Research Presentations 1 May 2009



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Abigail Phillips	Case Study of Tornadic Development within an Extra-Tropical Cyclone	Whisenant	MI091
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# An Analysis of the 24-27 March 2003 Extra-Tropical Cyclone and Dust Storm During Operation IRAQI FREEDOM

MIDN 1/C Samantha Andrews, Oceanography, Spring 09'  
Professor Michelle Whisenant, Oceanography Department

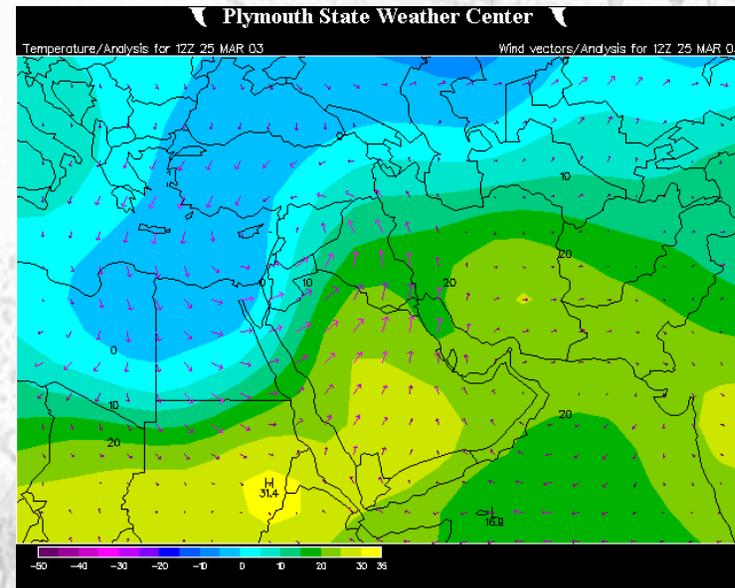


## Abstract

This storm system was carefully analyzed by referencing basic conceptual models of mid-latitude cyclone development theory and dust storm development. The analysis of the ETC development is carried out with the use of synoptic surface and pressure level analysis charts, and is framed within the Baroclinic Instability and Polar Front conceptual model theories of extra-tropical cyclone development. Satellite imagery and surface observations confirmed the stages of development of the cyclone as well as providing evidence of the timing and extent of the concurrently developing dust storm.

## Results/Conclusions

The analysis confirms that the system fits the classic development of a strong winter shamal. ETC development is enhanced when two distinct surface low pressure centers merge, and self-amplification of the storm is concurrently maximized by ideal upper-level support. The storm reaches its strongest stage of development at 12Z on March 25. Throughout the following 12 hour time period, strong surface winds elevate observed dust concentrations to peak values over Baghdad. Dust remains suspended in the atmosphere through 00Z 27 March when the extra-tropical cyclone finally moves northeast away from the region.



850 mb heights (in m) and temperature (°C) at 12Z on March 25, 2003

## Relevance

The 24-27 March 2003 dust storm resulted in United States forces halting their operations at the most crucial moment during Operation IRAQI FREEDOM. Reports from Operation ENDURING FREEDOM cite dust as is the most common and significantly adverse impact to military operations in Afghanistan. Post-analysis of these storms is crucial to better understanding of their development in the effort to improve the accuracy and timing of forecasting. This will ultimately benefit military planning in this operationally active region of the world.



# CASE STUDY OF TORNADIC DEVELOPMENT WITHIN AN EXTRA-TROPICAL CYCLONE



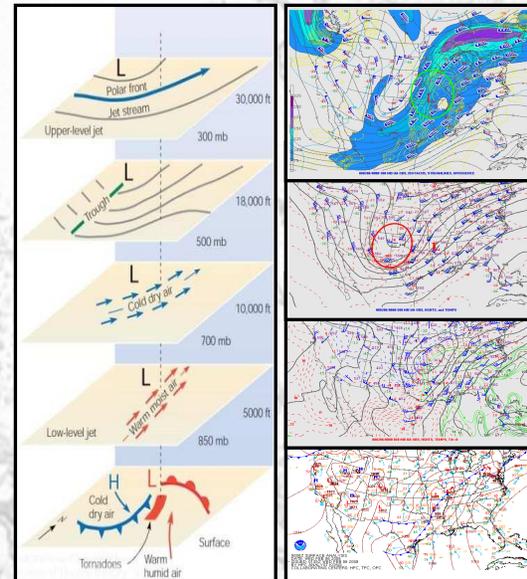
MIDN 1/C Abigail Phillips, Oceanography, Spring 09'  
LCDR Michelle Whisenant, Oceanography Department

## Abstract

The purpose of this case study was to examine the presence of well known and studied factors that contribute to mesocyclone development within an extra-tropical cyclone, and how these factors play into the severity of the weather that is produced. Observations and imagery from a severe weather outbreak in the U.S. Mid-west on the evening of February 5, 2008 were analyzed to identify and quantify specific synoptic scale and mesoscale factors that contributed to the development of tornado-producing supercell thunderstorms.

## Results/Conclusions

Analysis of this case study proved that many factors worked together to produce the strong long lived tornadic supercells. The combination of strong convergence at the surface and 850 mb levels with divergence at the 300 mb level enhanced upward vertical motion, which triggered and sustained convection. Strong convection of warm moist air into the region of the storm by the 850 mb southerly jet enhanced instability and provided fuel for the development and longevity of thunderstorms. Atmospheric sounding data illustrated that the combination of helicity, wind shear and CAPE in the region of the tornadic activity were all very conducive to mesocyclone development.



The conceptual model for supercell development within an ETC (left) and observed synoptic conditions at the time of the tornado outbreak (right).

## Relevance

Severe weather impacts both civilian and military operations. Civilian property, infrastructure, and lives are at risk anytime severe weather occurs. Military air and sea operations are affected by straight line winds, tornadoes, water spouts, and downbursts associated with thunderstorms. Between 1964 and 1985, 500 fatalities and 200 injuries aboard aircraft occurred due to thunderstorm downdrafts. Understanding the factors that contribute to severe weather can enhance the quality and accuracy of forecasts and thus help to minimize the damage, injuries and fatalities caused by severe weather.



# TORNADO PREDICTION PARAMETERS: CONVECTIVE AVAILABLE POTENTIAL ENERGY AND STORM RELATIVE HELICITY



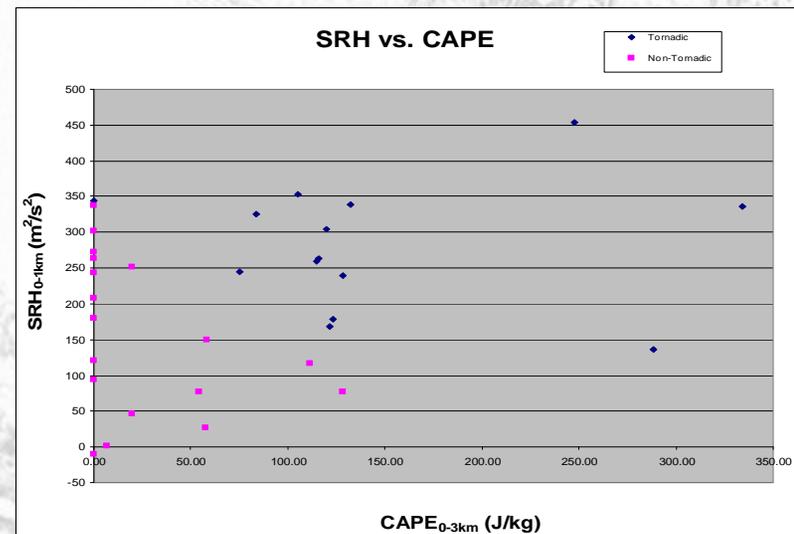
MIDN 1/C Jeremy Runco

## ABSTRACT

Tornado prediction is one of the most challenging feats in meteorology today. In the effort to advance prediction techniques, many sounding-derived parameters have been studied and utilized. Previous studies have determined that Convective Available Potential Energy (CAPE), low-level Storm Relative Helicity (SRH), and the combination of both into Energy Helicity Index (EHI) are good predictors in distinguishing between tornadic and non-tornadic supercells.

This research extends a previous investigation of the use of SRH, CAPE, and EHI as predictors of the likelihood of tornadic vs. non-tornadic development within supercell thunderstorms. By using similar methods as the previous investigation with a new dataset of atmospheric soundings from severe weather events during 2007, 2008, and 2009, the goal of this study is to test and confirm the validity of conclusions of the original investigation.

The results of this research support that of the original study, that the combined use of near-surface CAPE and SRH is an accurate indicator of tornadic development. The data used reveal that tornadic supercells have significant values of both near-surface CAPE and SRH. Values of SRH varied from weak to significant for non-tornadic supercells, but consistently lacked CAPE, the lifting mechanism required for tornadic development.



SRH vs CAPE for RUN 2007-2009

TORNADO CLASS							
DATE	# OF TORNADOS	HAIL/LARGE HAIL RATIO	1 km Helicity (m2/s2)	Press. LFC (mb)	Press.3km (mb)	Tp-Te Avg. (Celsius)	CAPE 0.3km (J/kg)
April 10 2009	57	202/21	398	850.00	700.00	6.00	338.38
April 2 2009	43	152/8	339	850.00	675.00	2.00	132.32
April 2 2009	10	73/0	353	800.00	700.00	2.75	105.39
Mar 27 2009	23	94/7	259	800.00	700.00	3.00	114.97
Mar 25 2009	17	35/6	137	900.00	700.00	4.00	288.51
Feb 18 2009	21	126/10	454	850.00	685.00	4.00	247.76
Jan 7 2008	75	136/7	263	850.00	675.00	1.75	115.78
Feb 5 2008	131	126/12	304	850.00	690.00	2.00	119.70
May 5 2008	31	178/4	240	850.00	680.00	2.00	128.08
May 10 2008	85	215/9	344	0.00	0.00	0.00	0
May 23 2008	63	102/12	168	750.00	640.00	2.67	121.54
Dec 9 2008	35	20/0	325	850.00	700.00	1.50	83.58
April 23 2007	29	82/2	178	850.00	650.00	1.50	123.19
April 21 2007	19	103/8	245	800.00	615.00	1.00	75.48
		Meets Minimum					
		Does not Meet Minimum					
NON-TORNADO CLASS							
DATE	# OF TORNADOS	HAIL/LARGE HAIL RATIO	1 km Helicity (m2/s2)	Press. LFC (mb)	Press.3km (mb)	Tp-Te Avg. (Celsius)	CAPE 0.3km (J/kg)
April 5 2009	3	48/0	208	0	0	0	0
Mar 29 2009	0	45/0	94	0	0	0	0
Mar 29 2009	9	53/0	177	850.00	700.00	2.30	128.16
Mar 7 2009	7	61/0	302	0	0	0	0
Feb 27 2009	1	42/1	117	850.00	700.00	2.00	111.45
Feb 11 2009	2	47/1.0	338	0	0	0	0
Feb 10 2009	7	104/10	349	775.00	700.00	2.00	58.42
Jan 29 2008	3	29/0	627	0	0	0	0
Feb 26 2008	4	29/0	180	0	0	0	0
Mar 14 2008	1	135/3	120	0	0	0	0
Jun 1 2008	2	176/6	77	900	700	2.075	54.10
Jun 2 2008	4	195/25	10	0	0	0	0
Jun 10 2008	1	193/4	2	750	700	0.33	6.53
Jun 15 2008	0	214/9	46	750	700	1	19.80
Jun 16 2008	1	307/7	251	750	700	1	19.80
July 20 2008	1	62/1	27	800	700	1.5	67.48
Oct 21 2008	0	17/0	243	0	0	0	0
Nov 5 2008	1	86/1	263	0	0	0	0
Jun 9 2007	0	58/3	273	0	0	0	0

RUN 2007-2009 Data Spreadsheet (Top: Tornadic Bottom: Non-tornadic)

## Analysis/Conclusions

The most convincing data was that obtained from the SUP events. Little or no surface CAPE was calculated for over half of the SUP events. The events with some near-surface CAPE were less than 60 J/kg, half the magnitude of near-surface CAPE required to produce significant tornadoes. Approximately half of the SUP events met or drastically exceeded the minimum value of SRH needed for development of tornadoes in significant number (as seen on January 29, 2008). Many values of SRH<sub>0-1</sub> in the SUP category were in the 100's and 200's. However, despite these large values, little or no near-surface CAPE was calculated in these cases. This result further supports the conclusion with respect to the necessity of near-surface CAPE in regards to significant tornadic activity. The data shows that a rotating column of air is present for the majority of both the tornadic and non-tornadic supercell events, indicated by the high SRH<sub>0-1</sub>, and that the separating factor differentiating tornadic and non-tornadic supercell development is the presence or lack of near-surface CAPE.

# The Growth Rates of *Crassostrea virginica* at Varying Depths

Stephen Sweeney, Oceanography, Spring 2009

Professor Stepe, Oceanography



## Abstract

Improving the water quality of the Chesapeake Bay has been an important objective for residents of the watershed. Restored oyster (*Crassostrea virginica*) bars have been used in an effort to replace the filter effect that natural oysters provided before their stocks were depleted. This experiment compares growth and survival rates of oysters placed at different depths on an artificial grow-out structure with those of animals on a restored oyster bar. The experiment is meant to determine which depth and environment combination will allow the oysters maximum growth and minimal mortality.

## Results/Conclusions

Kruskal-Wallis analysis revealed no predictable significance in growth rates among trays or between trays and the natural bar. The similar performance observed between the vertical aquaculture array *C. virginica*, and those on a restored bar demonstrates that utilizing similar vertical arrays of trays off a hardened shoreline could viably supplement efforts already underway to improve *C. virginica* stocks. However, the surface trays suffered 100% mortality due to freezing over the winter. With this in mind, any future deployment should have the top tray located at least 1 meter below the surface during mean low tide. This is roughly equivalent to the depth at which tray 2 was located. The effectiveness of the vertical array also demonstrates that more of the water column can be used to restore oyster populations in Chesapeake Bay.

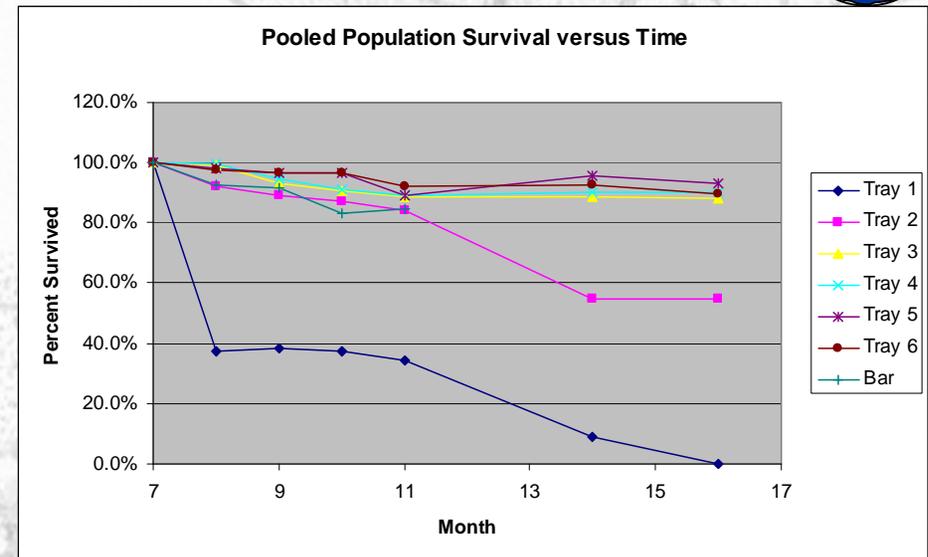


Figure 1. Percent survival throughout the course of the experiment, from July (7) to April (14). Both surface trays suffered 100% over-winter mortality, while survival rates in the deeper trays were consistently high.

## Relevance

Decreasing oyster population decreases water quality through the loss of water filtration. Poor water quality increases the health risk of DoD personnel operating in or near Chesapeake Bay. With so much money and effort being spent to try to restore the oyster populations, it is important to study the effects of depth on the oyster growth and mortality rates. Recovery have focused on restoring historical oyster bars, while this experiment focused on the less expensive, and potentially equally effective method of utilizing aquaculture techniques off a hardened shoreline.



# Transport of drifters at the mouth of Severn River; an initial assessment of stretching rates and divergence

Stephen DeVries, Oceanography, Spring 2009

Professor Steppe, Oceanography



## Abstract

Understanding transport of material in tributaries such as the Severn River is important for determining the fate of pollutants, sediment, and organisms with limited swimming capabilities, such as early stage larvae of estuarine fish and invertebrates. In this study we observed the surface flow in the Severn River via analysis of the trajectories of four satellite-tracked lagrangian drifters on 4 August 2008. Though the time series (four hours) was too short to assess diffusion rates, stretching and divergence of the cluster were calculated.

## Results/Conclusions

Substantial stretching and divergence occurred during the four hours sampled (Figure 1).

Stretching rate was  $0.2686 \times 10^{-4} \text{s}^{-1}$  and horizontal divergence was  $1.245 \times 10^{-4} \text{s}^{-1}$ .

Likewise the aspect ratio of the drifter cluster (ratio of length to width) increased from 0.83 at 1115 to 1.79. These are the first measurements of divergence and stretching in the Severn. The stretching rate in the Severn was similar to that observed in Delaware Bay, and yet divergence was larger in the Severn.

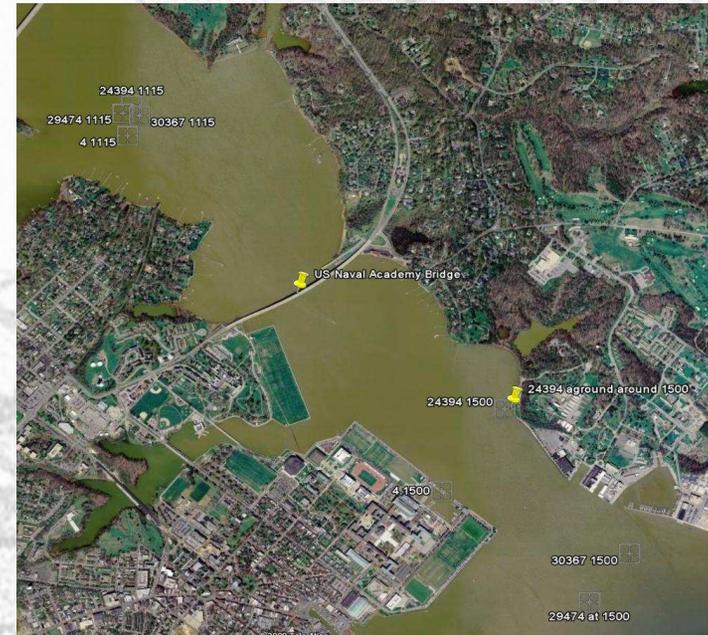


Figure 1. The position of the four buoys at deployment (1115 EDT) and at the end of the period of study, 1500. Substantial spreading was observed, and the aspect ratio increased to align the drifter cluster with the main axis of the Severn River.

## Relevance

Assessing how materials such as pollutants, sediments, and planktonic organisms are distributed in space and time is needed to determine where the material will ultimately be transported. Further studies should include tracking buoys over a longer time periods in order to determine changing divergence and stretching rates, and also to assess diffusion.



# CONNECTING SUBDUCTION ZONE EARTHQUAKE CHARACTERISTICS TO TSUNAMI GENERATION

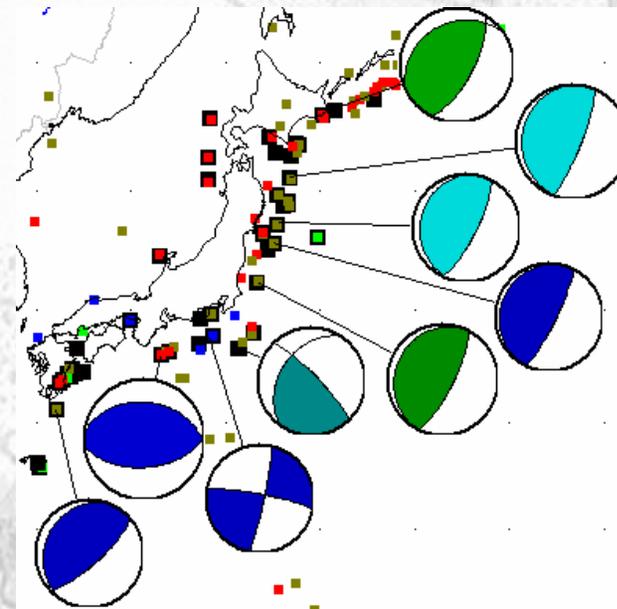
MIDN 1/C Leah Jordan, Oceanography, Spring 09'  
Professor Peter Guth, Oceanography Department

## Abstract

This research aimed to parameterize the main characteristics of subduction zones at convergent plate boundaries (focal orientation, strike, dip, plunge, focal depth) to determine the circumstances of earthquake seismicity sufficient for tsunami generation. A geographic overlay of recorded earthquakes was superimposed on locations of known tsunami-generating earthquakes. Following a filter of geographic proximity, fault and magnitude similarity, seismic moment tensors ("beachball" solutions) compared tsunami and non-tsunami generating earthquakes.

## Results/Conclusions

Characteristics of tsunami-generating earthquakes were compiled via historical and scientific records, plotted and compared to seismic events from the Harvard University Centroid Moment Tensor Catalog. Due to geographic concentration and local characteristics, earthquake analysis occurred over seven regions based on a specified tectonic boundary. In the end, analytical comparison depended on identifying tsunami-generating earthquakes and/or comparable seismic events, which rendered multiple regions unfeasible for in-depth study. In viable areas, inadequate historical records and recurrences of seismic events of magnitude 6.5 and above limited conclusive findings.



Earthquake focal mechanisms of earthquakes along Japan. Black squares indicate tsunami-generating earthquakes. The size and color of each focal mechanism indicates the magnitude and depth of earthquake.

## Relevance

Tsunami-warning systems have been developed, but require further improvement to provide civilian and military populations adequate time to prepare and/or evacuate. As the devastation of the Sumatra earthquake in 2004 proved, understanding subduction zone characteristics linked to tsunami-generating earthquakes would allow better scientific monitoring of certain regions. This would provide advance warning to affected locations and effectively direct military resources in recovery efforts.



# Sub Bottom Profiler Study of the Mouth of the Severn River

MIDN 1/C Alan Terwey, Oceanography, Spring 09'  
Professor Peter Guth, Oceanography Department

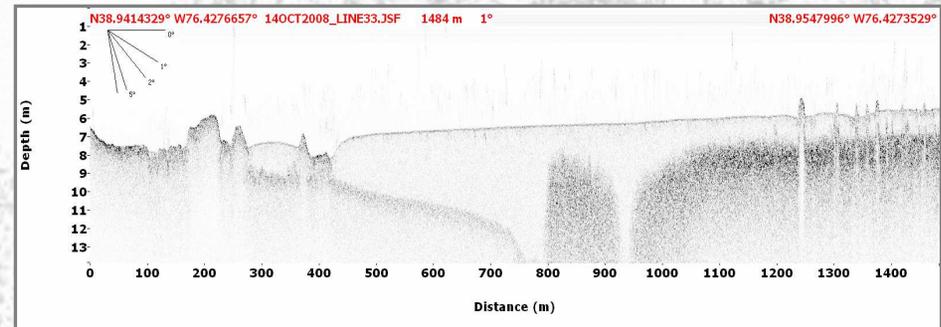


## Abstract

This research aimed to find the buried channel of the Severn River near where the current channel enters the Chesapeake Bay. The study took over six miles of sub bottom profiling transects near the entrance to the bay in search of sub bottom evidence of an old channel. Yard Patrol Craft 686 was utilized to take the transects. The river basin has gradually been filling up with sediment since it first occupied its current position approximately 18,000 years ago. Since that time the river has filled with tons and tons of sediment.

## Results/Conclusions

After taking the data back the lab and analyzing it using MICRODEM, there was no evidence of an old channel in the area studied. The study did reveal a sloping sub bottom layer with areas of suspected gas deposits in the deepest parts studied. The presence of this gas means a large amount of biological life was present around the time when sea level rose and covered the area in sediment. The large amount of biological life means the area was either low lying or actually a part of the old channel. However, there was no evidence of a channel cut in the area the gas appeared.



Sub bottom profile image with sloping sub bottom layer and gas deposits on the right side.

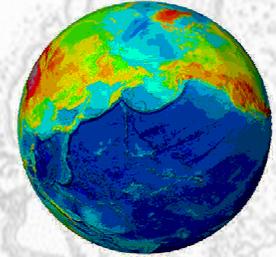
## Relevance

To keep the Severn River basin from filling up or having to be dredged frequently a solution is needed to keep sediment from depositing in the mouth of the river. By studying where the sediments fall, where they come from, and what areas fill up first solutions can be proposed to keep the sediment from depositing in areas with high traffic levels. This study also shows the usefulness sub bottom profiling can be to the military when it comes to finding buried objects, offshore construction, and even mine hunting.



# The Battle of Attu Island

## Alpine Warfare at Sea Level



MIDN 2/C Elizabeth Byers, History (Honors), Spring '09  
Professor Peter Guth, Oceanography Department

### Abstract

Alpine warfare differs from conventional warfare in many ways, including difficult terrain, harsher climate, and strategic and logistical challenges which directly affect the mentality of soldiers and the role of leaders in combat situations. In addition, positions in mountainous terrain are more easily defensible and difficult to attack. The World War II Battle of Attu Island exhibits many aspects of alpine warfare at sea level in high latitudes.

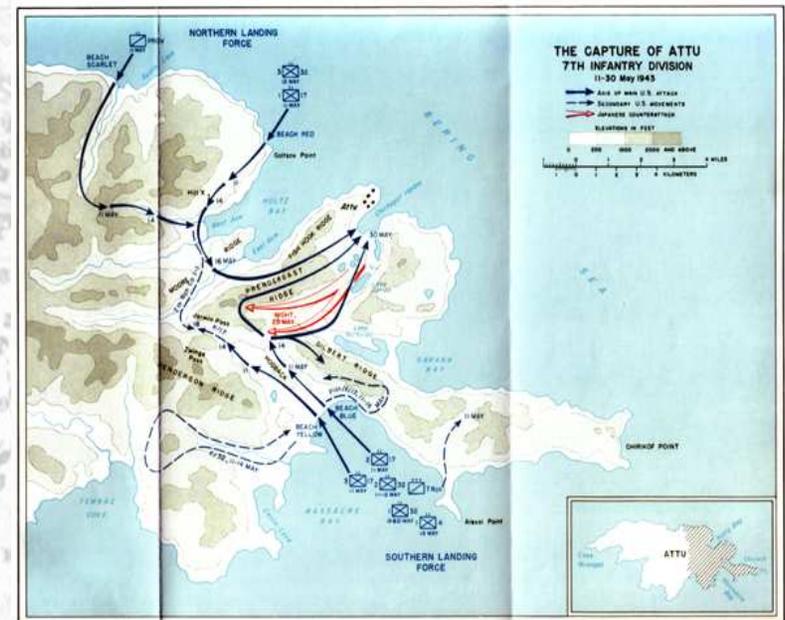


### Results

The Battle of Attu Island, one of the Aleutian Islands, was fought from 11-29 May, 1943. The terrain, below 1000 m in elevation, posed many of the same challenges as mountainous terrain in the rest of the world, including precipitous crags, snowcapped peaks, and flat rock faces. Soldiers on the ground, not trained for mountainous warfare, had to contend with persistent fog, soggy tundra, frequent storms, and constant dampness of the environment. Poor conditions delayed the initial attack by four days. Those same weather conditions severely limited combat support and logistics of naval and air units, creating semi-isolated combat conditions for the ground troops. The American military knew almost nothing about the topography of the island, aside from a rough map showing the shoreline and a few aerial shots through the fog. Due to the lack of intelligence before the attack, logistics and communication were extremely inadequate during the battle. Roughly 2400 Japanese successfully defended Attu from 15,000 Americans for almost three weeks by utilizing vantage points located over the passes within the mountains.

### Relevance

Soldiers involved in retaking Attu encountered and overcame many of the same challenges presented by the environment and nature of alpine war-fighting faced in hostile mountainous areas of the world today. While Attu Island does not fit the traditional definition of alpine warfare, a case study of the battle of Attu Island provides many important insights into alpine warfare and warfare under difficult environmental and meteorological conditions.



MAP III



# The Flushing Time of the South River using the Tidal Prism Method

Tenley L. Fullington, Oceanography, Spring 2009

Advisor: Professor A. Muller, Oceanography



## Abstract

The flushing time is defined as the amount of time it takes to exchange the volume of water in an estuary. Because the flushing time cannot be directly measured, it must be calculated using equations generated from an estuary model. As a small, well-mixed embayment, the South River's flushing time is best approximated using a simple tidal prism model. The tidal prism method focuses on water transport under the influence of the astronomical tide. The results of this method generally produce a shorter flushing rate due to assumption of a completely mixed flow. However, for a small embayment such as the South River, the simple model errs conservatively and yields a relatively accurate flushing time.

## Results/Conclusions

Using an appropriate tidal prism method yields accurate results for the flushing rate of the South River. Calculating the flushing time with each of the equations from (1) to (3) produces a flushing time of 8.41, 4.72, and 8.12 days respectively, while the Maryland Department of the Environment found the flushing time to be 9.6 days. The biggest impact on the flushing time was the use of a correct model, and selection of a justifiable value for the return flow factor. The simple model could be improved in the future by including meteorological forcing and freshwater inflow.

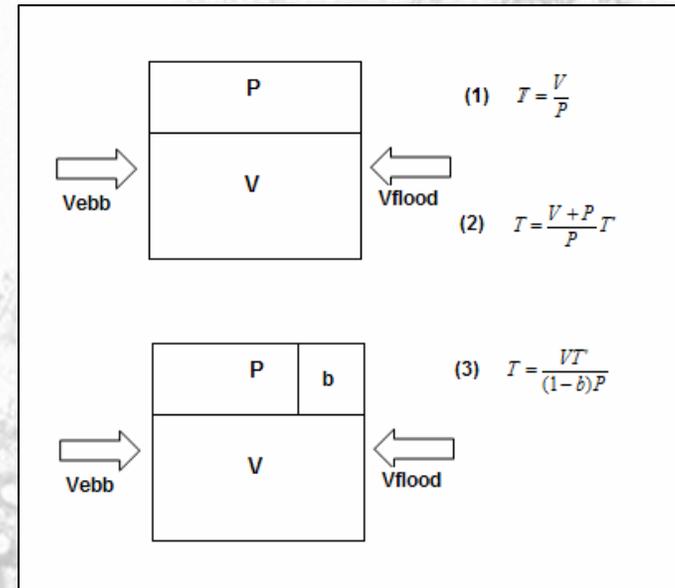


Figure 1 shows the two box models used to calculate the flushing time as well as the corresponding equations for each model. Equations (1) and (2) pertain to the first model and Equation (3) pertains to the second model.

## Relevance

The flushing time is one of the most important physical parameters to find in a body of water. It estimates the time to replace the water in the body with new water. This provides useful information for knowing the time to flush out both conservative and non-conservative tracers in a water body, including pollution and biota as well as nutrients.



# ANALYSIS AND VERIFICATION OF EMANUEL'S 1995 FINITE AMPLITUDE TROPICAL CYCLONE MODEL

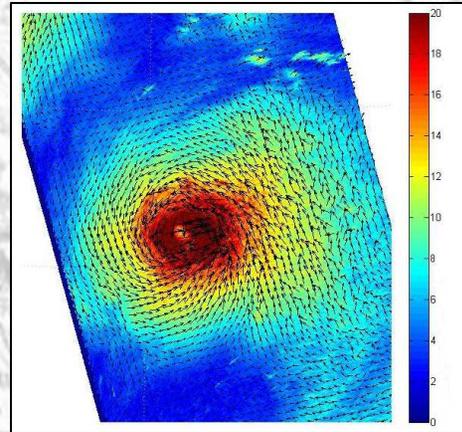


MIDN 1/C Lauren Milliron, Oceanography, Spring 2009

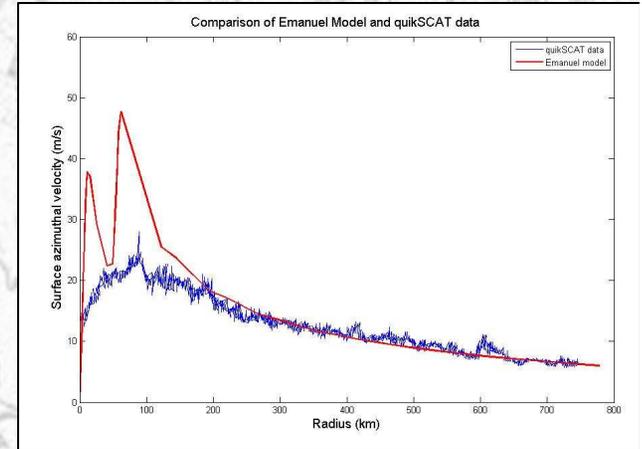
LCDR Jeremy Bruch, Oceanography Department

## Abstract

This study aims to analyze and verify Emanuel's 1995 balanced, finite amplitude, axi-symmetric tropical cyclone model. Comparing the results of this model with QuikSCAT satellite data from Hurricane Gordon provides insight into how well the model represents the evolution of an actual tropical cyclone. Adjustment of the model parameters to best fit the empirical observations demonstrates which environmental features provide the strongest contribution and changes to hurricane intensification.



High resolution QuikSCAT surface wind vector field of Hurricane Gordon on 16 September 2006.



Emanuel Model output data and QuikSCAT data comparison of surface azimuthal wind velocities.

## Results/Conclusions

The surface azimuthal winds versus radial distance plot shows that the two data sets correlate strongly at a radius of 200 km beyond from the center. However, the model overestimates the wind speeds in the vicinity of the eye wall possibly because the hurricane was losing intensity, from category 3 to 2, on the date of the QuikSCAT capture. This downgrade could have limited the equilibrium between surface enthalpy and entrainment of low entropy air that is necessary for Emanuel's model. Additional studies could determine if the model routinely overestimates wind speed near the center of the cyclone. On the whole, Emanuel's model provides a useful tool in analysis of tropical cyclone development and evolution.

## Relevance

Progress in tropical cyclone modeling can provide significant savings to the military in terms of time and financial cost. Specifically, accurate track and intensity prediction is vital to naval ship routing and disaster response readiness. With more refined tropical cyclone models, scientists will gain further insight into which physical features have the most impact on the development and maintenance of tropical cyclone intensity and ultimately lead to better operational forecasts.



# ARCTIC SEA ICE

## The Effect of Air Temperatures on Ice Movement and Depletion



MIDN 1/C Julie Barca, Oceanography, Fall 2009

LT John Woods, Oceanography Department

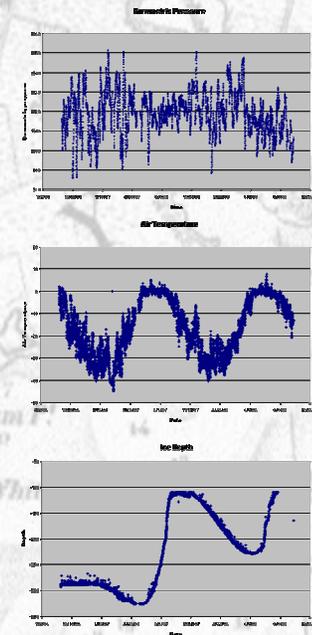
### Abstract

It is hard to deny that the Arctic Region is experiencing significant change today and throughout the past several decades. One of the biggest concerns regarding the Arctic is why the melting period has hit such high peaks in the past several years. In a comparison of the temperature data from 2006-2008 in the Arctic to the movement of a buoy in the same region, similarities exist that show significant reason to believe that the two are closely related. As the temperatures begin to rise, a strong pattern develops that corresponds to ice decrease. The feedback loop that currently exists in the Arctic includes both a growth and melting stage. At the current rate, the ice is predicted to completely melt out to leave an open ocean during the summer time in the northern most part of the hemisphere.

### Results/Conclusions

The Arctic region is one of the first regions to experience the effects of atmospheric differences because it is a sensitive system. The warming climate leads to more melting of the sea ice which leads to more open ocean causing greater Arctic amplification to finally even greater warmth for a continuous cycle. Each peak in temperature corresponds with a delayed melt. Growth of the ice occurs after a delay following the coldest temperatures. So long as the temperatures fluctuate, the feedback system is not going to stop, and the ice will soon diminish to a few pieces of frozen sea water scattered in the vast and open ocean during the summer melt period.

Corresponding graphs of Buoy 2006C showing barometric pressure, air temperature, and ice depth from September 2006- November 2008.



### Relevance

The world has been experiencing significant changes in temperature that have become more prominent in the last several years. At the same time, the sea ice in the Arctic has shown a significant decrease in extent. This research helps to provide a link between global atmospheric conditions in order to gain a better understanding of sea ice conditions so that any foreseeable future conditions and concerns can be well researched and understood.



# ACTIVE DISRUPTION OF UNDERWATER COMMUNICATIONS USING SNAPPING SHRIMP NOISE

MIDN 1/C William F. Jenkins II, USN, Oceanography, Fall 2008 - Spring 2009

CDR Carl Hager, USN, Oceanography; CDR Ed Tucholski, USN, Physics

Jeff Schindall, Ph.D., Naval Research Laboratory



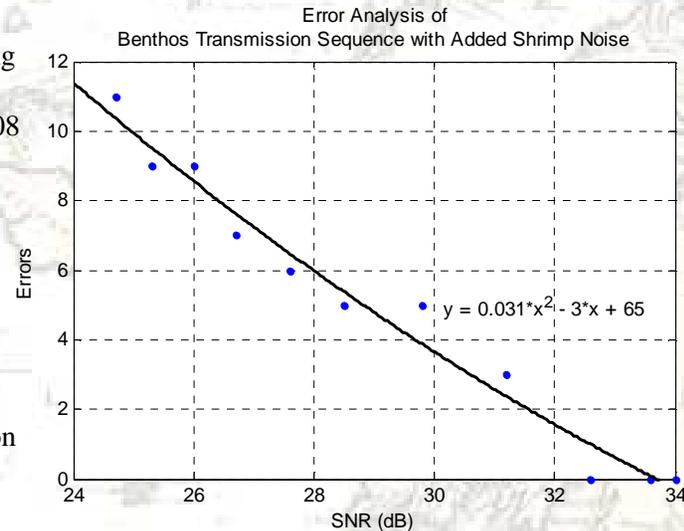
## Abstract

The object of this research was to determine the feasibility of using snapping shrimp noise to disrupt underwater acoustic communications (ACOMMS). Basebanded transmitted and received JANUS waveforms from the UNET-08 Halifax experiment were processed with basebanded shrimp noise and resulting bit error rates were analyzed. Shrimp noise was also analyzed in the frequency domain, and methods for synthesizing shrimp noise by increasing acoustic energy in higher portions of the frequency (15-19 kHz) were discussed.

## Results & Future Investigation

Added shrimp noise successfully caused signal processing and demodulation algorithms used aboard commercial acoustic modems to fail. Errors were detected by an 8-bit cyclic redundancy check (CRC), as well as observationally by whether or not a catastrophic failure in the algorithms caused a premature termination of the signal processing. CRC failure typically occurred at bit error rates of 12.5% for clipped data. Visual comparisons were also made between sets of batch processed data in order to discern whether the degree of noise scaling significantly impacted the occurrence of errors, though nothing conclusive could be developed from this information in this context.

With continued research and development, the ability to effectively disrupt underwater communications using shrimp noise – or other biologic sounds – is completely feasible. Implementation of this methodology would require the coupling of this research with operational research and tactical studies, and could result in the development of a deployable underwater jamming network.



Bit error analysis of the processed JANUS transmission waveform with added shrimp noise reveals the relationship between degrading signal-to-noise ratio (SNR) and hard bit errors. The JANUS message was 72 bits long; CRC failure typically occurred at SNR values of 26 dB.

## Relevance

Advances in signal processing, channel equalization and channel characterization in the underwater medium are yielding continuously more robust methods of underwater communications. As these technologies are introduced into the fleet in coming years, similar developments are being made by foreign nations and by the private sector. Advanced underwater communications technologies are already widely commercially available, illustrating that this technology could, in the hands of hostile entities, be aligned against elements of the Navy or other American interests both domestic and abroad. One way to mitigate such potentially threatening developments is to develop a means of disrupting – or jamming – underwater transmissions.

# Spectral polarization of clear and hazy coastal skies

MIDN 1/C Orlando Samudio, Oceanography, Spring 2009

Research Professor Raymond Lee, Oceanography

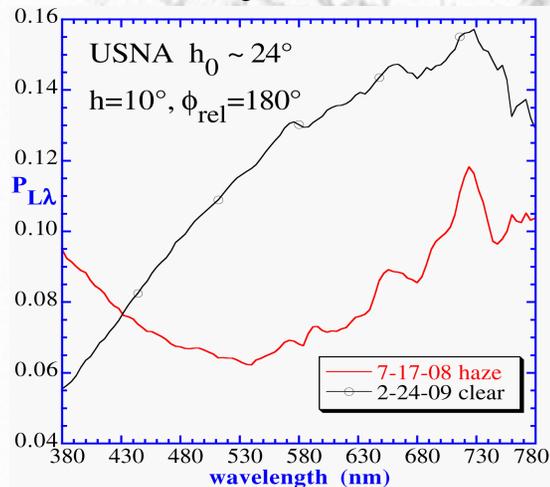
## Abstract

At visible wavelengths, light from the clear daytime sky is partially linearly polarized. The degree of linear polarization  $P_L$  ranges from near 0% in the solar and antisolar directions to a local maximum (typically 65%-85%) along an arc  $\sim 90^\circ$  from the sun.

Scattering by molecules and aerosols such as haze solution droplets determines  $P_L$ 's spectral and spatial details, but mapping their *combined* distribution has been impossible before this project's use of spectral digital imaging of  $P_L$ .

## Results/Conclusions

A digital camera equipped with a linear polarizing filter and calibrated with a spectroradiometer produced maps of polarized sky radiance spectra, from which  $P_L$  spectra were calculated. Such maps are comparable in accuracy to those directly from the radiometer (below), but have *far greater* angular detail and coverage.



This semester's research produced the first-ever maps of clear and hazy  $P_{L\lambda}$ , and these reveal many new, unexplained features. In the vicinity of polarization neutral points, the  $P_{L\lambda}$  usually undergo marked spectral shifts, shown here as hue and vividness changes. Existing models of skylight polarization seem not to reproduce such features, which thus provide an entirely new way to test the models' realism.

## Relevance

These early results clearly show that the as-yet unexplored spectral and spatial distributions of  $P_L$  are at least as important as its integrated or monochromatic magnitudes. Digital imaging techniques now make possible systematic surveys of  $P_L$  spectra, with applications ranging from new standards for radiative transfer models to new ways of remotely sensing haze microphysical properties.



# Inter-Creek Variability of Water Quality Indicators in a Sub-Estuary of the Chesapeake Bay



MIDN 1/C Kirby Jones, Oceanography, Spring 2009

Professor Andrew Muller, Oceanography Department

## Abstract

This project used statistical analysis of three specific parameters- salinity, dissolved oxygen content, and secchi depth- which could each be a practical indicator of water quality in an estuarine watershed. Using one-way ANOVAs for multiple comparisons on MATLAB, the data from ten different creeks off of the South River was analyzed to ascertain whether any of the individual creeks were significantly different from the others for one or more of the variables. This possible inter-creek variability can give indication as to which creeks have a lower water quality and are in need of further study to determine the cause of their environmental distress.

## Results/Conclusions

One of the parameters which showed a high level of dissimilarity between the creeks was secchi depth. The averaged mean over the five years, for all the creeks, fell below one meter, the accepted standard of a healthy creek. Turkey Island was different from five of the other creeks with a fairly high mean of just over 0.9 meters. This fact is not unexpected though because it is located at the mouth of the river nearer to the main stem. However, both Duvall Creek and Church Creek have averages just around 0.7 meters and are different from four of the other creeks spread throughout the length of the river. They are both creeks on the north bank of the river and this could suggest some possible correlation in their levels of health. Broad Creek is significantly different from all of the other creeks with a mean of only 0.5 meters, far below the healthy standard.

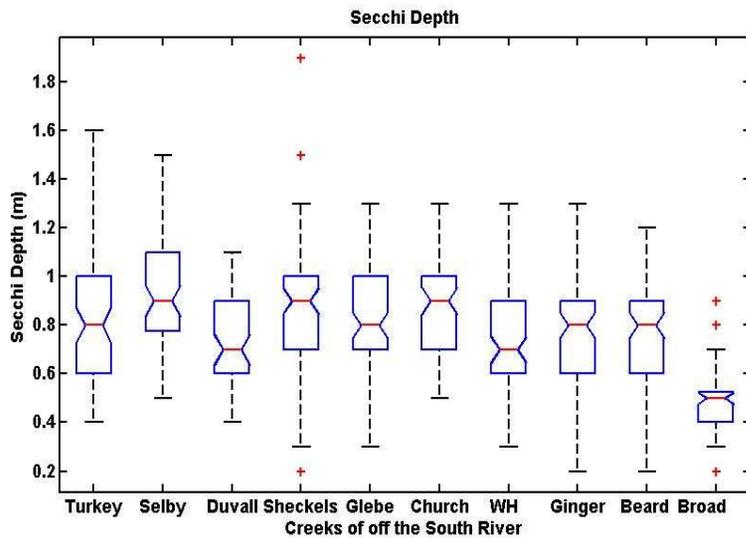


Figure 1. A box plot test shows the means and data distributions for secchi depth.

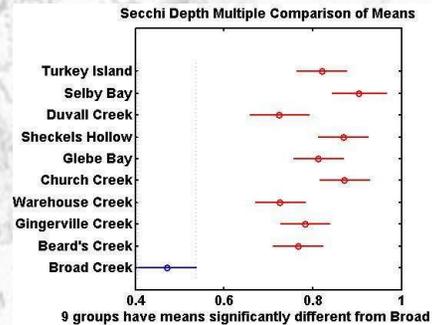


Figure 2. Demonstrates the discrepancy between Broad Creek and the other creeks in secchi depths.

## Relevance

It is difficult to determine the exact level of distress in which any particular area of the Chesapeake Bay or its tributaries could be. Using Water Quality Indices and analysis such as was performed here can provide a strategic tool for distinguishing which creeks or rivers are in a more degraded state of health. The data showing which creeks are significantly different can be cross-referenced with location, land-use, and other environmental factors to investigate possible situational causes.



# VERTICAL LOCALIZATION OF A SYNTHETIC ODONTOCETE VOCALIZATION



Alfonso Meidus, Oceanography, Spring 2009

Advisor, CDR Carl A. Hager, Oceanography Department

## Abstract

The goal of this experiment was to localize a synthetic Odontocete vocalization in the vertical axis. This was accomplished using a four path ray model that was cross-correlated with the actual received data. The model output was created at incremental depths by predicting four distinct multi-path arrivals and consolidating their waveforms through constructive and destructive interference. The model estimates were then compared to data collected during transmission at a known source depth (15 m) to determine depth of the source.

## Results/Conclusions

The results show that the four path ray theory model is a good tool to use when trying to estimate the depth of a sound source. Hydrophones 77 and 78 had distinct high correlation values. The modeled interference pattern or resultant amplitude modulation was determined to be an accurate representation of the actual data arrival waveform.

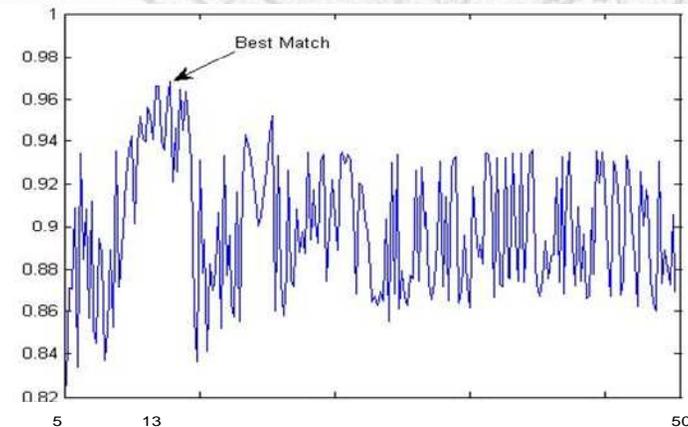


Figure 1. The cross-correlation of the received data vs. the modeled data for hydrophone 78 is displayed. The peak value (approximately 13 m) reveals the best time domain waveform match.

## Relevance

This research project is of special interest to the US Navy and demonstrates the ability to provide accurate vertical location estimates with the use of existing bottom mounted hydrophones. Given three dimensional localization of vocalizing Odontocetes on Navy acoustic ranges, unintended harm can be avoided.



# HORIZONTAL LOCALIZATION OF A SYNTHETIC ODONTOCETE VOCALIZATION

Jonathon Lagrew, Oceanography, Spring 2009

Advisor, CDR Carl A. Hager, Oceanography Department



## Abstract

Horizontal localization of Odontocete vocalizations was accomplished using widely separated hydrophones utilizing time-lag techniques. The sound source used came from Station 7 and the bottom hydrophones used were 69, 70, 77, and 78. A range-dependent acoustic model was used to predict time-lags expected at each sensor within the array, while observed time-lags were measured through an incoherent correlation process. An ambiguity surface was then created using MATLAB to compare observed and predicted time-lags. The observed time-delays were calculated using a least squares model. A horizontal localization was accurately plotted.

## Results/Conclusions

The results show that the Model vs Data least squares comparison clearly identifies the true location of sound source transmission. Hyperbolic methods further refined the location estimate.

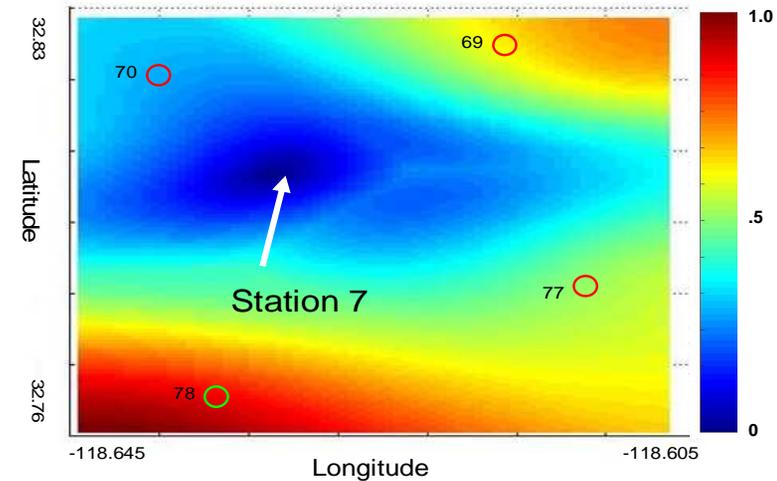


Figure 1. Horizontal localization was accomplished using least squares error estimation. The minimum error between model grid and data time lags is displayed in blue. The model to data comparison matched the horizontal GPS position of the sound source at Station 7.

## Relevance

This research project is of special interest to the US Navy and demonstrates the ability to provide accurate vertical location estimates with the use of existing bottom mounted hydrophones. Given three dimensional localization of vocalizing Odontocetes on Navy acoustic ranges, unintended harm can be avoided.



# LONG-TERM MONITORING OF TURBIDITY AND SEDIMENTATION IN CHURCH CREEK

Adam Gregory, Oceanography, Spring 2009

Professor Muller, Oceanography



## Abstract

Improving the water quality of Chesapeake rivers and tributaries has been an important effort for decades. Despite improvement in certain areas, the South River region struggles more than ever. Quantification of the various water pollutants would allow for better understanding of the region's failing health and subsequently more pointed solutions. Data was provided by Anne Arundel County Department of Public Works and also gained through core sediment samples taken from the creek bed. The research hopes to monitor and quantify shifts in water quality to aid efforts in focusing on the right problems for health restoration.

## Results/Conclusions

TSS quantities had the most significant results. The maximum allowed TSS daily value in accordance with the MDE is 60mg/L. In 2006 TSS values spiked to 800mg/L and have since remained well over 200 mg/L (see fig. 1). Research on the area indicates that the Annapolis Town Center was also constructed near 2006. This newly introduced point source of pollution occurring at a very similar time with the TSS spike strongly suggests a correlation. The fact that BOD and nitrate averages remained relatively stable, helps confirm that the cause to the jump in TSS was not some other point source.

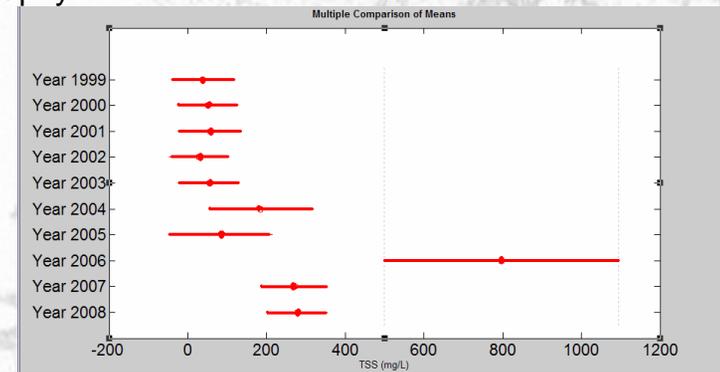


Figure 1. Multiple Comparison test of TSS values Parole between 1999-2008. This shows significant increase in 2006 TSS averages and maintained increase in 2007 and 2008.

## Relevance

To gauge long term effects of poor storm water management, a sediment core was taken from Church creek. Nearly .5 m of silt has accumulated over the healthier, moss and plant filled layer (Fig.4). With increased TSS, turbidity will increase, which will kill the plants within the creek, creating oxygen debt and eventual uninhabitable waters. Stronger action and greater cooperation from business and other point source pollutants must be achieved or the health of Church Creek, South River, and beyond may never be restored.