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13. ABSTRACT (Maximum 200 words)

The final report for N00014-01-1-1070 contains the report of inventions and subcontracts DD Form 882 as well as copies of the technical reports submitted on the two research projects completed under this award: 1)"SST Serving as Determining Factors for Sea Turtle Locations in the Atlantic Ocean" and 2) Dolphin Presence/Absence Probability on the Virginia and North Carolina Coast as Correlated with SST and Chlorophyll-a Levels". A copy of the presentation made during the most recent program review is included also. One of the major activities associated with the project was scholarship support for students. $371,250 has been awarded. A color flier documenting the scholarship recepient's activities is in the final part of this report.

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REPORT OF INVENTIONS AND SUBCONTRACTS

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5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR *(If "None," so state)*

NAME(S) OF INVENTOR(S) (Last, First, Middle Initial) a.	TITLE OF INVENTION(S) b.	DISCLOSURE NUMBER, PATENT APPLICATION SERIAL NUMBER OR PATENT NUMBER c.	ELECTION TO FILE PATENT APPLICATIONS (X) d.				CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER (X) e.	
			(1) UNITED STATES		(2) FOREIGN			
			(a) YES	(b) NO	(a) YES	(b) NO	(a) YES	(b) NO
NONE								

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(1) (a) NAME OF INVENTOR (Last, First, Middle Initial) NONE	(2) (a) NAME OF INVENTOR (Last, First, Middle Initial)	(1) TITLE OF INVENTION	(2) FOREIGN COUNTRIES OF PATENT APPLICATION
(b) NAME OF EMPLOYER	(b) NAME OF EMPLOYER		
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DD FORM 882, DEC 2001 PREVIOUS EDITION IS OBSOLETE

Sea Surface Temperature Serving as Determining Factors for Sea Turtle Locations in the Atlantic Ocean

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Award #: N00014-01-1-1070
http://nia.ecsu.edu/ureoms2002/index.html

LONG-TERM GOALS

The long-term goal of this project was to determine the correlation between sea surface temperature and sea turtle locations. In addition, the overall goal will determine other possible indicators that may influence the presence of sea turtles.

OBJECTIVES

The Mid-Atlantic serves as a host environment for a number of sea turtle species that encompasses their seasonal migration routes. Global evidence suggests that migration routes are strongly influenced by two factors: sea surface temperature and chlorophyll-a concentrations. Data gathered from the Pacific Ocean presents compelling evidence of this relationship. In contrast, findings from studies conducted in the Atlantic have not yet confirmed the role of these factors.

This studies objective attempted to establish a correlation between sea turtle locations in the Atlantic Ocean in relation to sea surface temperature. Currently all five species of sea turtles in continental United States waters are protected under the Endangered Species Act of 1973 (PL93-205). Monitoring and studying sea turtles is imperative to the overall survival of the species.

APPROACH

The Physical Oceanography Distributed Active Archive Center (PO.DAAC) provided the data source for the project. Multi-Channel Sea Surface Temperature (MCSST) data derived from Advanced Very High Resolution Radiometer (AVHRR) was utilized for this project in addition to sea turtle point source data from WhaleNet. WhaleNet is an interactive educational website which focuses on whales and marine research.

The AVHRR data was acquired in GeoTiff format. This format was selected due to its compatibility with ArcView GIS. Sea surface temperature ASCII files for each dataset were collected to determine water temperature at turtle locations.

After obtaining all satellite images and ASCII files, GeoTiffs were imported into ArcView GIS. Turtle locations were then plotted on the image.

WORK COMPLETED

MCSST datasets have been collected in addition to turtle point source data for January 1999 to August 1999. ASCII files have been examined and water temperatures have been assigned to each turtle sighted.

RESULTS

An upper and lower thermal limit was identified for the sea turtles sighted. The upper thermal identified was 30.1 C while the lower thermal was 17.1 C. The period investigated for this study was January 1, 1999 to August 29, 1999. That time period was selected based on the availability of MCSST data and sea turtle point source data. Figure 1.2 represents the most frequent sea surface temperature for each turtle citied during its given week and month. Figure 1.1 represents data acquired and utilized from PO.DAAC during the first week of January, April, and August. Figures 1.3, 1.4, and 1.5 represent sea surface temperatures for each turtle sighted within the months of January, April and August.

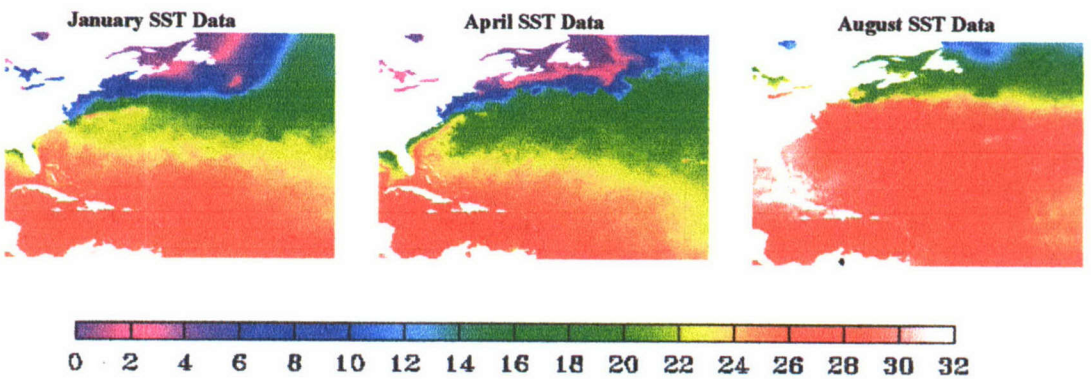

Figure 1.1 – This figure represents MCSST SST data collected from PO.DAAC.

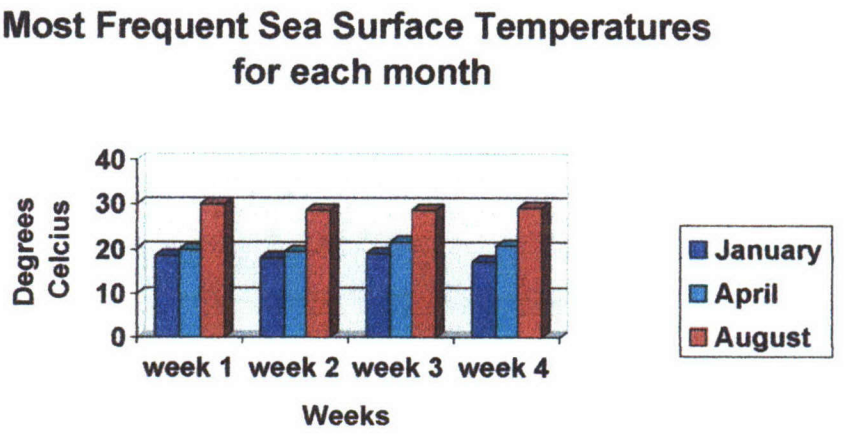

Figure 1.2 – This figure represents the most frequent temperature recorded for each week.

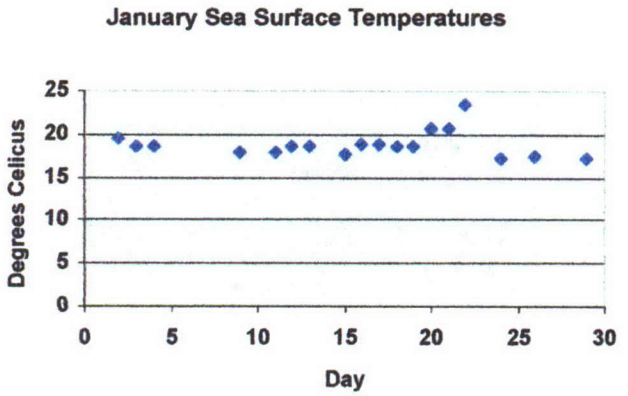

Figure 1.3 – This figure represents the sea surface temperature for turtles sighted in January.

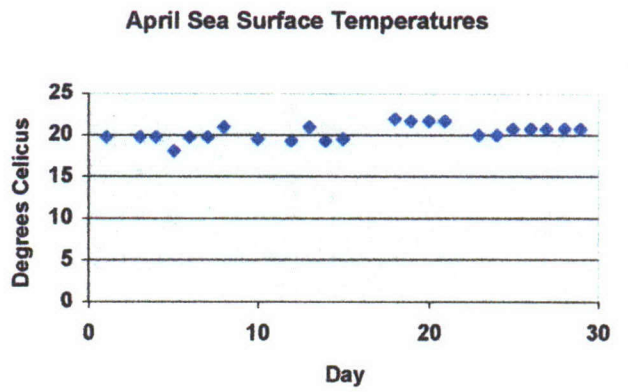

Figure 1.4 – This figure represents the sea surface temperature for turtles sighted in April.

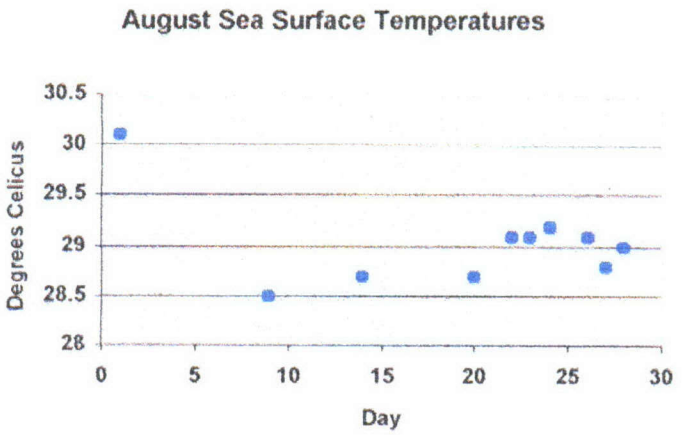

Figure 1.5 – This figure represents the sea surface temperature for turtles sighted in August.

Aerial survey of turtle distribution over North Carolina waters indicates that sea turtles may not be randomly distributed. Their positions may be restricted by water temperature (Coles, 2000; Lutcavage and Musick, 1985; Epperely et al., 1995), with turtles occurring in water greater than 11 C (Epperely et al., 1995). However, the correlation between the location of sea turtles and sea surface temperatures or fronts is poorly understood.

Sea turtles were not geographically randomly distributed but stayed within preferred temperature ranges. For example, during the first week of April out of the six citings, five of them were located in waters with a temperature of 19.8 C. During the first week of January out of the 3 citings, two were located in waters with temperatures of 18.6. A wide range of water temperatures was available during each sampling day as shown in figure 1.1, but the turtles were only found in small portions of the range.

William C. Coles has conducted a similar study entitled Satellite Sea Surface Temperature Analysis and Correlation with Sea Turtle Distribution off North Carolina. The objective of Coles study was to determine a correlation between temperatures and turtle locations, using archived satellite derived images of sea surface temperatures and aerial survey data, which determined positions of sea turtles. Upper thermal limits as well as lower limit to preferred turtle temperatures were identified. The available temperature range for the turtles to occupy during Coles study (May 1991 to Sept 1992) was 4.9 to 32.2 C, but turtles were only observed in water from 13.3 C to 28 C. The results from the study conducted confirm findings from Coles research.

There are known problems that should be considered when analyzing results. The first row of weekly MCSST data contains erroneous data in the flag set for the entire time series. Erroneous data also exist in the valid and interpolated data sets for the period between week 322 of 1986 and present at this latitude.

Furthermore, the weekly data provided to the PO.DAAC from the University of Miami were originally stored as 16-bit integers in DSP Format. The PO.DAAC converted these

data from 16-bit integers to 8-bit raster images in Hierarchical Data Format (HDF). The digital numbers ranged from –20 to 350. To convert data from integers to bytes, the data had to scaled to values ranging from 0 to 255. As a result, the HDF values of sea surface temperature could vary from the DSP values of sea surface temperature by as much as 0.15 degrees Celsius.

IMPACT/APPLICATION

This project can be extended for future research at the Center of Excellence in Remote Sensing Education and Research (CERSER) located at Elizabeth City State University. The findings will also aid in contributing to the knowledge currently available on this endangered species.

Further research should be conducted to determine the role of wind speed to the migration patterns and water temperatures. The project could also be extended to examine the effects of El Nino and La Nina on the location of sea turtles.

RELATED PROJECTS

While Coles's study had similar objectives different approaches were used to analyze data. Coles's approach for determining turtle location was based off aerial photography collected from North Carolina. This study however used turtle data gathered from WhaleNet to determine the exact longitude and latitude of the turtle position. Though the methods for analyzing the data were quite different, similar results were yielded for both projects.

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Dolphin Presence/Absence Probabilities on the Virginia and North Carolina Coasts as Correlated with SST and Chlorophyll-_ Levels

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SCIENTIFIC AND TECHNICAL OBJECTIVES

The North Atlantic Bight area of the northwest Atlantic is an area that serves as habitat for bottlenose dolphins (*Tursiops truncatus*). The population there can be divided into three subgroups, or stocks: Offshore, Year-round Resident, and Seasonally Migratory. The movements of the migratory stock are of concern, due to the necessity of compliance with the Marine Mammal Protection Act of 1972. Studies have shown that the likelihood of presence of many marine mammals can be correlated with both sea-surface temperature (SST) and the levels of chlorophyll-a (Sykes, et al., 2003). Previous work in this area has shown that the migratory stock may be responding to a critical temperature ranging from 13° to 16° C, (Barco, et al., 1999; Shoemaker, et al. 2004) yet there have been sightings below this temperature.

This objective of this study is to attempt to refine the critical temperature conclusions of prior researchers, and to attempt to correlate the probability of presence with chlorophyll-a levels. By producing a better model of prediction of the presence or absence of this stock of this species, it is hoped that remote sensing data may be used as a surrogate for the need for direct observation. This would allow any agency or group to be aware of the potential presence of this protected species based on this remote data, and to act accordingly to reduce any impacts upon them.

APPROACH

A number of sources were used as sources of data for this project. Remotely sensed data was acquired from two sources: the Rutgers University Coastal Ocean Observation Lab (RU COOL), and the Goddard Space Flight Center (GSFC). The data from RU COOL is from the Advanced Very High Resolution Radiometer (AVHRR) satellite, while the GSFC data is from both Sea-viewing Wide Field-of-view Sensor (SEAWiFS) on board the SeaStar satellite and Moderate Resolution Imaging Spectroradiometer (MODIS) on board the Aqua (EOS-PM1) satellite.

The data was retrieved from the two sites as JPEG format Level 3 Standard Mapped Images. In this format, the raw satellite data has been processed to remove transmission and scanning errors, georeferenced, and SST and chlorophyll-a levels derived from spectral intensities. This data is then mapped to uniform space-time grid scales. In the GFSC site, the MODIS data is available as 4 km resolution, while the SeaWiFS data is at a 9 km resolution. Both use an absolute scale to show temperature and chlorophyll concentrations. The AVHRR data from Rutgers is also in 9km resolution, but uses a scale relative to the distribution of the variables in each image.

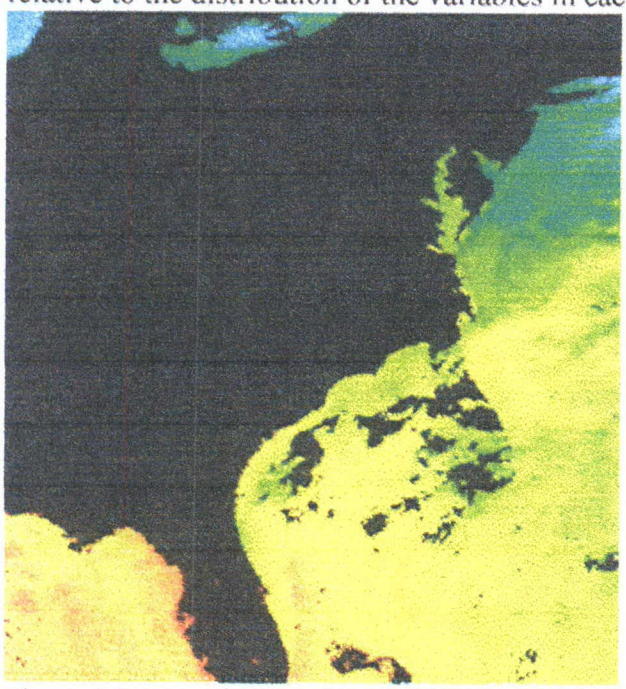

Fig. 1. SST data from AQUA/MODIS (weekly mean SST)

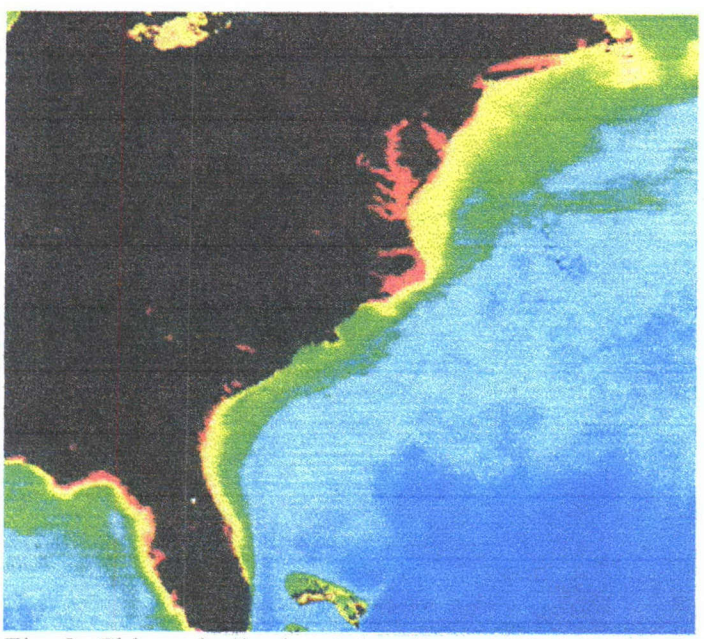

Fig. 2. Chlorophyll-a level data from AQUA/MODIS (weekly mean levels)

Temporally, the Rutgers data was available as single moment images, while the GFSC data was available at varying timescales of daily, weekly, monthly and annual means.

Presence/absence data for dolphins was taken from archived data from Christopher Newport University's Dolphin Project dataset, and from the Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) site of Duke University. The field data was taken using standard small boat, passive observation techniques along set transects. The data from CNU represented data covering both positive and negative observation, allowing effort-evening and determination of probability of sightings to be made. The OBIS-SEAMAP data, while only including sighting events, allowed for greater spatial and temporal coverage. In addition, field surveys were taken during the course of the program to provide the students with field experience.

After recording the dates of effort and when dolphins were actually found in a spreadsheet in MS Excel, the SST and chlorophyll-a data were recorded as weekly means. A previous study (Loftus, et al.) shows that due to the likelihood of gaps in the data from cloud cover and scanning errors a weekly mean of SST and chlorophyll-a levels produces the greatest likelihood of effectively matching location data with simultaneous satellite data. The two variables were then correlated against the presence/absence of dolphins. To improve the consistency of the results, the temperature data was binned into two-degree C categories, while the chlorophyll-a concentration data was binned into five mg/m^3 categories. The probability of sighting at each bin was calculated by dividing the number of sightings at that bin with the total effort for that bin. These results were then analyzed graphically and using T-test to test for statistical significance.

CONCISE ACCOMPLISHMENTS

Using the field observations and archived data to compare against the satellite SST and chlorophyll-a data, there was a significant difference found in the temperature where dolphins were likely to be found. Chlorophyll-a data, however, showed no significant variation in the likelihood of encountering dolphins with the level of chlorophyll-a.

EXPANDED ACCOMPLISHMENTS

The data showing the presence and absence of bottlenose dolphins was compared against the remotely sensed SST and chlorophyll-a data. This sighting data was normalized to eliminate the inherent bias in the uneven effort over the temperature range. This, when compared against the remotely sensed SST, gives a percent chance of sighting dolphins for each of the two-degree C data bins. In Fig. 1, it can be seen that the predominance of the sightings were in the 16° C and above bins. The outlier, at 12° C represents a single sighting for two effort periods. From 16° to 26°, the number of effort periods ranges from 26 to 131 per bin. Despite an effort unit at 28°, there were not sightings at that

temperature. A t-test was run on the data to determine if the mean temperature of non-sightings differed from that of sightings. This test found that the difference between the two means was significant (P=0.032).

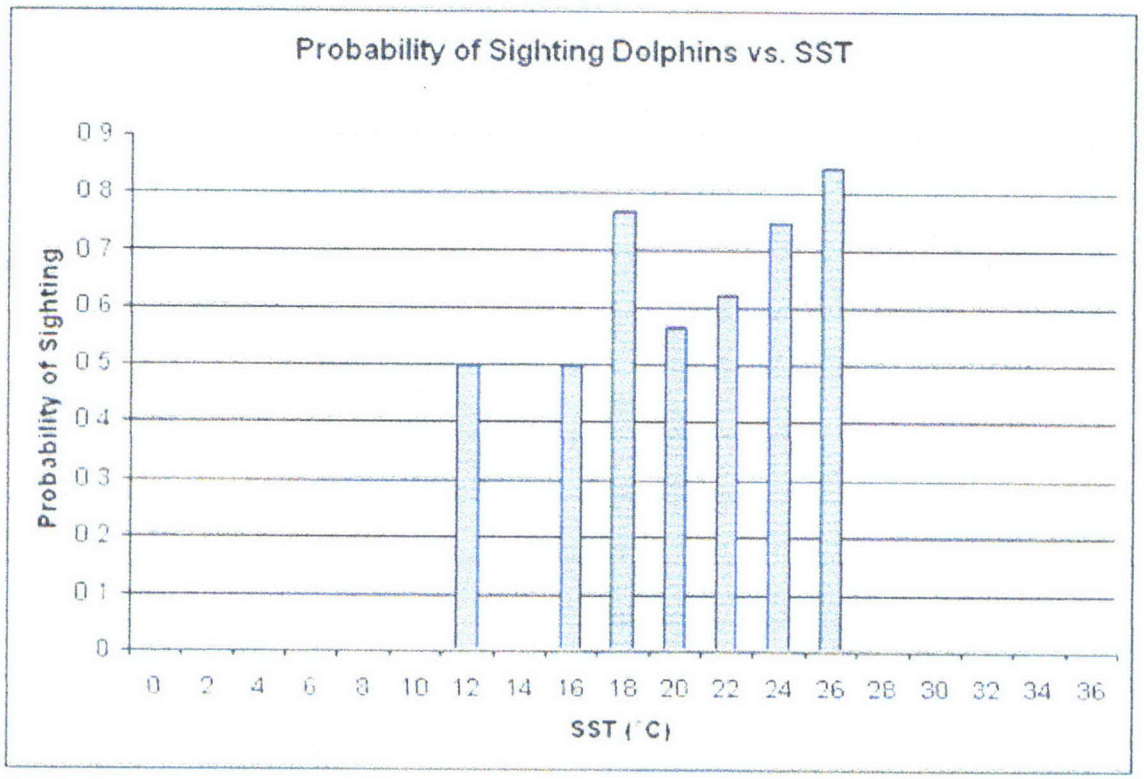

Fig. 3. Percent probability of sighting bottlenose dolphins versus Sea Surface Temperature.

It should be noted that the outlier in this figure represents only two effort units, and so is unlikely to reflect an accurate probability for that temperature range.

In addition to the percent probability of sighting bottlenose dolphins, a comparison was made on the size of the groups sighted at each SST. In Fig. 2, the size of the groups sighted varies with temperature, with only pairs of animals sighted at temperatures lower than 17°. At 18° and above, the spread in the numbers seen at each temperature increases, with the greatest group size (75 animals) sighted at 26°.

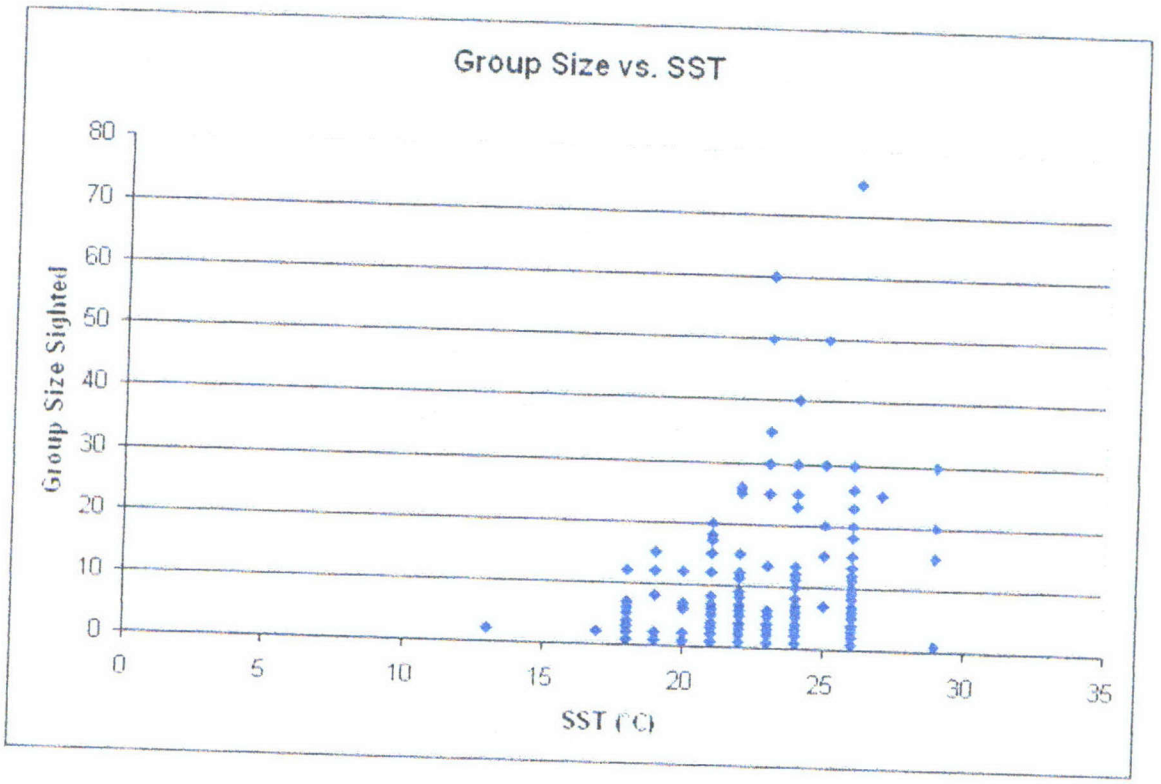

Figure 4. Size of groups sighted vs. SST

This shows that in addition to the likelihood of sighting dolphins being far greater over 18°, the numbers of dolphins sighted at any given time also increases with temperature.

Comparisons were also made between sighting probabilities and the level of chlorophyll-a found in the area. As seen in Fig. 5, the probability of sighting for levels from 0 to 30

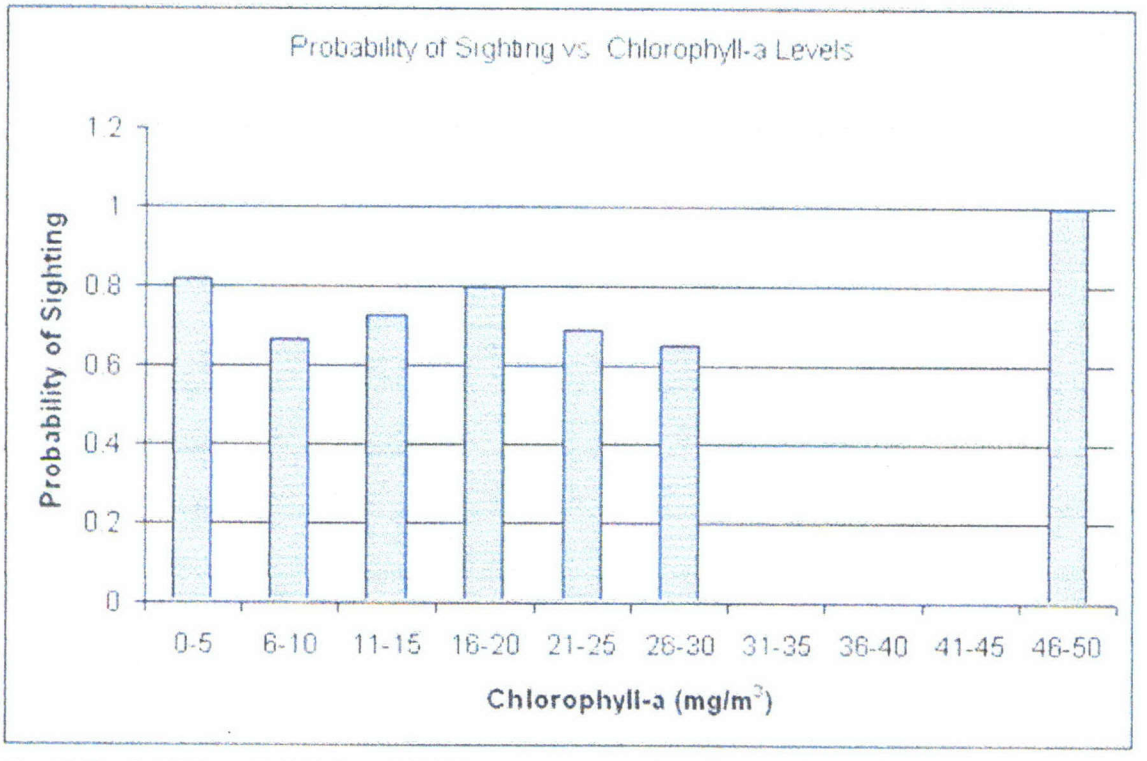

Fig. 5. Probability of sighting dolphins as compared to the levels of chlorophyll-a.

mg/m^3 varies between 0.65 and 0.82, with a gap from 31-45 mg/m^3 and a peak at 50 mg/m^3. This gap reflects a lack of effort while those levels of chlorophyll-a were present. The effort for the lower bins ranges from 11 to 149, while the 50 mg/m^3 peak represents 8 effort units. Again, a t-test was used to determine if there was a significant difference between the mean levels for sightings and non-sightings. The results were shown to be non-significant ($P=0.82$), thus showing no relationship between the probability of sighting dolphins and the local level of chlorophyll-a.

In Fig. 6, the number of dolphins sighted at each bin is shown. There is some variation in the number seen at each level, but this does not represent any significant variation. A trendline added yields an R^2 of only 0.0001, again showing the lack of significant relationship between the levels of chlorophyll-a and the numbers of dolphins present.

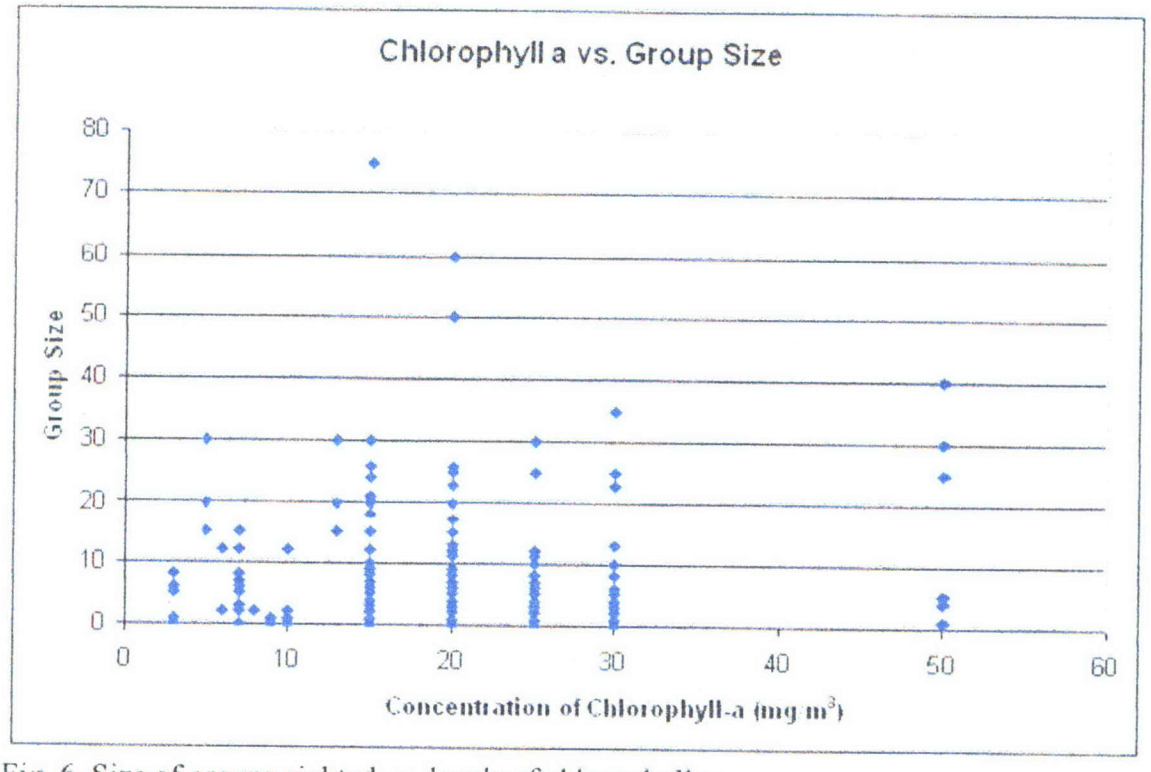

Fig. 6. Size of groups sighted vs. levels of chlorophyll-a.

These findings indicate that at least for the seasonally migratory stock of the Mid-Atlantic coast of the United States, SST is the major remotely-sensed factor that can be used to determine the likelihood of the presence of bottlenose dolphins. The critical temperature appears to be at 17° C, with dolphin presence occurring almost entirely above this temperature, and an almost complete lack of observations of the animals below this. Despite its relationship to the overall productivity of an area the level of chlorophyll-a, which represents the amount of primary productivity, cannot be used as a remotely-sensed factor in determining the likelihood of the presence or absence of bottlenose dolphins.

WORK PLAN

The students made direct field observations to obtain location data on dolphins. This work was done via standard small boat transect protocols on the Elizabeth River of Virginia. Additionally, there are archived location data from multiple sources which were be used to give a higher level of possible observation points for both the Elizabeth River and the coast of North Carolina. The field and archive data were then formatted to a common base to provide a usable set of information for analysis.

SST and chlorophyll-_ levels for the dates and areas of interest were determined by analysis of satellite data which has been retrieved from NASA data stores on the internet. These levels were then compared with the location data to determine the probability of

the presence or absence of bottlenose dolphins. Statistical tests were used to test the significance of the relationships.

It was found that there is a statistically significant relationship between the probability of sighting bottlenose dolphins and the SST of the area. Only two sightings were made below 18° C, and 99.8% of the animals sighted were seen at temperatures over 18° C.

There was no statistically significant relationship found between either the presence or number of dolphins and the level of chlorophyll-a in the area.

PROBLEMS/ISSUES

The major problem found during this study was the lack of effort data from the OBIS-SEAMAP dataset. This data, while giving presence and location data for a greater span of time and location, does not reflect the effort involved, nor does it reflect the negative data where effort was expended but no dolphins found. This lack of negative data can skew the results where probabilities are required. Inclusion of this negative data would allow much better correlation of environmental variables and the probability of presence of the animals under investigation.

Another problem is that of coverage of these areas by the satellites. Using infrared and visible spectral bands for sensing, they rely on clear, unobstructed views of the ocean surface to get good data. This is a problem inherent to this method of remote sensing, as cloud cover prevents readings. In coastal areas especially, with their local weather affected by the temperature differences between land and water, cloud cover can greatly reduce the number of possible observations of any given location. Due to this, weekly means of SST and chlorophyll-a levels were required to give a statistically valid number of correlates.

Finally, due to the nature of field observation of this species, continuous tracking is not possible using the observation procedures given here. This could lead to a bias in the information due to the inability to track movements over long periods of time and the lack of night observations. As seen in Fig. 1 above, the effort is naturally skewed towards warmer temperatures, due both to the lack of animals during the colder months, and the exigencies of operating small boats during these periods. Both of these potential biases could be overcome by the use of satellite tags tracked by the ARGOS satellite, which would allow for continuous location tracking over the long periods needed to accurately delineate the migratory stock's seasonal movements. Tagging of a relatively small number of the migratory stock, and tracking their movements over the course of the migration should provide the data needed to show the movement patterns of the stock as a whole.

Ecologically speaking, chlorophyll-a may not be useful in determining the presence or absence of bottlenose dolphins due to a number of reasons. First, the levels of chlorophyll-a represent the amount of primary productivity of an area. This level can vary somewhat in near-shore waters due to events on land such as heavy rainfalls. As dolphins

represent the highest level on the local food web, there are a number of trophic levels between the dolphins and the primary productivity. This can lead to a latency period, where there is a delay in the increase of food available to the dolphins as the productivity increases travel up through the other trophic levels. This could only be determined via a regression analysis and prey sampling to see if local food supplies increase after events where the primary productivity increases. Second, this species is highly mobile, and is capable of movement over the range of hundreds of miles within a few days. This mobility may enable them to exploit resources that had temporal origins days or even weeks before. Thirdly, the levels of chlorophyll seen in the near-shore waters are generally very high, due to nutrient run-off from the land. These stable high levels can produce mainly seasonal variations in production, which would likely vary with SST, again making it the determining factor.

Images Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE

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2. Duke University School of Environmental Science, 2004 OBIS-SEAMAP, source of some bottlenose dolphin location data http://seamap.env.duke.edu/species/
3. Goddard Space Flight Center, source of SeaWiFS and Aqua-MODIS SST and chlorophyll-a data. http://seawifs.gsfc.nasa.gov/cgi/level3.pl
4. Loftus, C., Norris, T., Fiedler, P., Armstrong, E. 2003 Satellite Oceanographic Data versus In-Situ Data as Inputs for Predictive Models of Marine Mammal Occurrence. 15th Biennial Conference , Society of Marine Mammalogy, 14-19 December, Greensboro, NC
5. Rutgers University Coastal Ocean Observation Lab, source of AVHRR SST data. http://marine.rutgers.edu/cool
6. Shoemaker, M. L., 2004 "Relative Winter Sea Surface Temperature Limit of Atlantic Coast Migratory Bottlenose Dolphins Using GIS Techniques" Southeast and Mid-Atlantic Marine Mammal Symposium, 26-28 March, 2004 Ft. Pierce, FL
7. Sykes R, Allen J, Owens C (2003) Factors influencing the seasonal distribution of sightings of bottlenose dolphins (Tursiops truncatus) along the Dorset coast. Annual Meeting of the European Cetacean Society, Tenerife, Spain

Coastal Ocean Observations: Correlation of AVHRR SST Data with Presence of Marine Mammals

Linda Hayden, PhD
Kevin Foss, MS
Elizabeth City State University

Marine Mammal S&T/R&D Program Review

16-18 March 2005

1

OBJECTIVE

- To refine the critical temperature conclusions of previous researchers, and to correlate the presence/absence probabilities of bottlenose dolphins with chlorophyll-α levels.
- To produce a better prediction model for this stock of the protected species, using remote sensing as a surrogate for the need for direct observation.
  - This would allow any agency or group to be aware of the potential presence of this stock based on remote data, and to act accordingly to reduce potential impacts.

2

TECHNICAL APPROACH

- Data sources used:
  - Remotely sensed data
  - On site data

3

TECHNICAL APPROACH

- Remotely sensed data
  - Advanced Very High Resolution Radiometer (AVHRR) satellite data - Rutgers Coastal Ocean Observation Lab (RU COOL)
  - Sea-Viewing Wide Field-of-view Sensor (SEAWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) – Goddard Space Flight Center

4

TECHNICAL APPROACH

- On-site source data
  - Archived local sea-surface temperature (SST) data from NOAA
  - In-situ temperature measurements from Christopher Newport University (CNU) Dolphin Project
  - Presence/absence data from CNU Dolphin Project archives and current research

5

TECHNICAL APPROACH

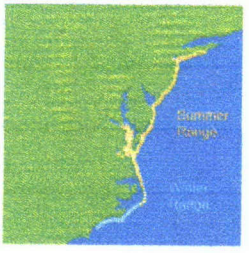
- Species under assessment:
  - Bottlenose dolphin, *Tursiops truncatus*
  - Northwest Atlantic population divided in to five stocks:
    - Southern/Northern coastal residential
    - Southern/Northern coastal migratory
    - Offshore
- Stock of interest:
  - Northern coastal migratory

6

TECHNICAL APPROACH

The Northern Migratory Stock:

- **Population is seasonally migratory**
- **Winter range extends from Southern North Carolina coast to roughly Nags Head, NC area**
- **Summer range extends from Nags Head to New Jersey/Long Island**



7

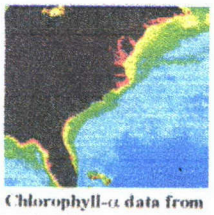
TECHNICAL APPROACH

- As top-level predators, dolphin movements generally follow those of their prey.
- As surrogates for monitoring the distribution of prey, environmental factors such as sea surface temperature and levels of chlorophyll-α can be used.
  - Many of the prey species of bottlenose dolphins are also seasonally migratory, and rely on changes in water temperature as migratory cues.
  - Chlorophyll-α serves as an indicator of local primary production, and thus the amount of energy available to the food chain.

8

TECHNICAL APPROACH

SST Data from Aqua/MODIS Satellite – weekly mean



Chlorophyll-α data from Aqua/MODIS – weekly mean

9

TECHNICAL APPROACH

- Data of chlorophyll-α levels and SST were derived from remote and on site sources
- Study by Loftus, et al showed utility of using weekly means of SST and chlorophyll-α to eliminate data dropouts, cloud cover interference and coverage gaps
- Temperature data binned into 2 degree C categories, chlorophyll-α binned into 5 mg/m categories to give an even distribution along the range.

10

TECHNICAL APPROACH

- Method used for correlations
  - For each bin of the environmental data, the probability of sighting was determined from the field data
  - In addition to sighting probabilities, the number of animals sighted also taken into account
- Sighting data then correlated with the two variables

11

ACCOMPLISHMENTS

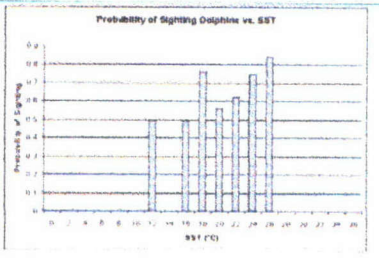


Fig. 1 Percent probability of sighting bottlenose dolphins vs. SST

12

ACCOMPLISHMENTS

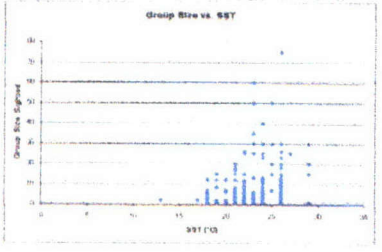


Fig. 2 Size of groups of bottlenose dolphins vs SST

13

ACCOMPLISHMENTS

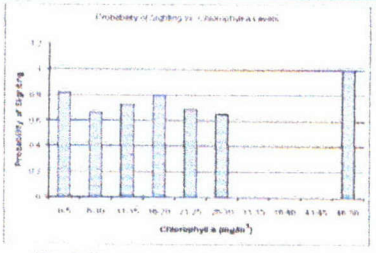


Fig. 3 Percent probability of sighting bottlenose dolphins vs. chlorophyll-a

14

ACCOMPLISHMENTS

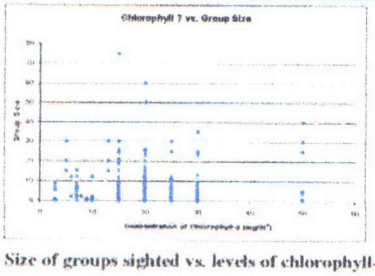


Fig. 4. Size of groups sighted vs. levels of chlorophyll-a.

15

ACCOMPLISHMENTS

•Description of results

- •The probability of sighting the migratory population of dolphins is 0.5 for any temperature over 16° C.
- •This probability generally rises with temperature to 26-27° C
- •Local water temperatures did not exceed 28° C during the periods of study
- •Additionally, the numbers of animals sighted also rises with temperature.

16

ACCOMPLISHMENTS

•Description of results

- •There was no clear correlation with chlorophyll-a for either presence/absence or for numbers of dolphins sighted.

17

CONCLUSIONS

•SST is the primary remotely-sensed parameter that can be useful in determining the likelihood of finding bottlenose dolphins

- **•17 degrees C appears to be the critical temperature at the 95% confidence level (5% or less chance of finding bottlenose dolphins below this temp)**

18

CONCLUSIONS

- Chlorophyll-a data is not usable
  - Limited variation in levels in coastal vs. oceanic areas
  - Confusion of chlorophyll-α levels with sediment load
  - Lag between changes in chlorophyll-α levels and effects on higher trophic levels

Chlorophyll a Concentration (mg / m^3)

19

CONCLUSIONS

- Problems with remotely sensed data
  - Data from satellites is prone to loss from extended cloud cover over area
  - Also some data lost due to satellite coverage for time of interest
- Potential substitutes for lack of continuous tracking
  - ARGOS satellite tagging of some members of migratory population would yield continuous data on location, habitat preferences
- OBIS-SEAMAP was considered as source for presence data, but lack of data on effort expended cannot give probabilities of sighting.

20

Recommendations

- Expand ARGOS satellite tagging to include northern migratory stock
- Develop new or alter current algorithms of satellite data analysis to differentiate coastal sediment loads from chlorophyll-α remotely
- Northward extension of research range on northern migratory stock to cover entire range

21

CURRENT AND FUTURE WORK

AVHRR Sea Surface Temperature and SeaWiFS chlorophyll concentrations serving as indicators for the movement of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles in the Mid-Atlantic.

The Mid-Atlantic serves as a host environment for a number of sea turtle species that encompasses their seasonal migration routes. Previous research suggests that migration routes are strongly influenced by two factors, sea surface temperature and chlorophyll concentrations. Studies in the past have only focused on one turtle species, the *Caretta caretta*. This study will include two species of sea turtles, the *Caretta caretta* and *Chelonia mydas*. These turtles will be tracked along the Mid-Atlantic to determine if a correlation exists between migration routes, sea surface temperature, and chlorophyll concentrations. Archived AVHRR sea surface temperature and SeaWiFS chlorophyll data will be derived, processed, and analyzed at the Center of Excellence in Remote Sensing Education and Research located on the campus of Elizabeth City State University.

22

RECENT PUBLICATIONS, PATENTS, AWARDS

Hayden L. B., Harrison K., Correlations of AVHRR Sea Surface Temperature with the Presence of Sea Turtles, IEEE- IGARSS Proceedings, Sydney Australia, July 2001

Hayden, L. B., Harrison, K. Mentoring Minority Undergraduates Through Remote Sensing and Geo-Information Science Research, African Association of Remote Sensing of the Environment (AARSE) 2004 bi-annual conferences, Nairobi, Kenya, Oct. 18-21, 2004

Hayden, L. B., The Center of Excellence in Remote Sensing Education and Research (CERSER) Undergraduate Research Experience in Ocean and Marine Science, IEEE- IGARSS Proceedings, Toulouse, France, July 2003.

Fogg, Tiffany, Foss, Kevin, Hayden L. B., Dolphin Presence/Absence Probabilities on the Virginia and North Carolina Coast as Correlated with Sea Surface Temperature and Chlorophyll-A Levels. IEEE- IGARSS Proceedings, Seoul Korea, July 2005.

25

BACK-UP SLIDES REQUIRED FOR PROJECTS SUPPORTED WITH 6.4 FUNDS

31

RELEVANCE TO NAVY

By refining the earlier estimates of the critical temperature relating to the migration of this protected species, this work can show the greatest likelihood of encountering bottlenose dolphins in areas heavily trafficked by naval vessels, and allow Naval personnel to use SST as a surrogate variable to determine how much effort must be expended to comply with the MMPA.

25

FY05 PROGRAM PLAN

Explain precisely what you will do this year. This should mirror the milestones. If appropriate, define and discuss GO/NO GO decision points in the multi-year program. Identify any deviation from your original plan.

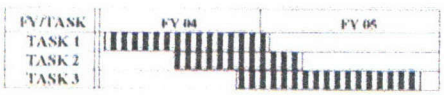
EXAMPLE:

- Characterize the pathways for degradation of XXX $100K
- Perform kinetics studies of each of the pathways $100K
- Determine the degradation end products using NMR, mass spectroscopy, and quantitative analysis $100K
- GO/NO GO decision for remainder of program

TOTAL $300K

26

PROJECT PLAN



NOTE: Tasks should be as reflected in your Project Plan.

27

PROGRAM FUNDING

		Navy $K	Other $K
FY 2004			
Task 1		100	100
Task 2		100	100
Task 3		100	100
	Total	300	300
FY 2005			
Task 1		100	100
Task 2		100	100
Task 3		100	100
	Total	300	300

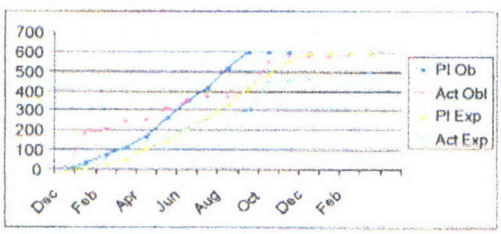
NOTE: List actual FY04 funding and requested FY05 funding (if appropriate) by performer and task. Also identify other funding sources that may be contributing to this effort.

28

OBLIGATIONS AND EXPENDITURES

FY04 and FY05 FUNDS

Create a graph showing planned/actual obligations and expenditures for FY04 and FY05.



29

TRANSITION PLAN

Identify how you will transition this research and to whom through Demonstration/Validation into field use. This can be through Service-funded programs or it may be through commercialization by a private industry partner.

Describe your efforts to include the user community in your research effort and/or to assure user community "buy in" of the final product.

30

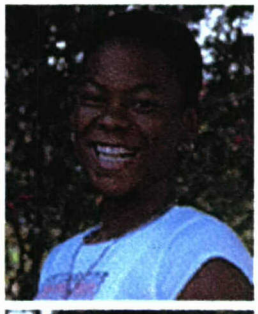
NERT Nurturing Ecsu Research Talent

2005-2006 Program Highlights / Summer 2006 Research Abstracts

Jerome Mitchell - Senior, Computer Science
Mentor: Dr. Mark Fahnestock
Internship: University of New Hampshire
Title: Using Active and Passive Microwave Records For Detecting Firn Characteristics In Greenland: A New Indication Of Melt

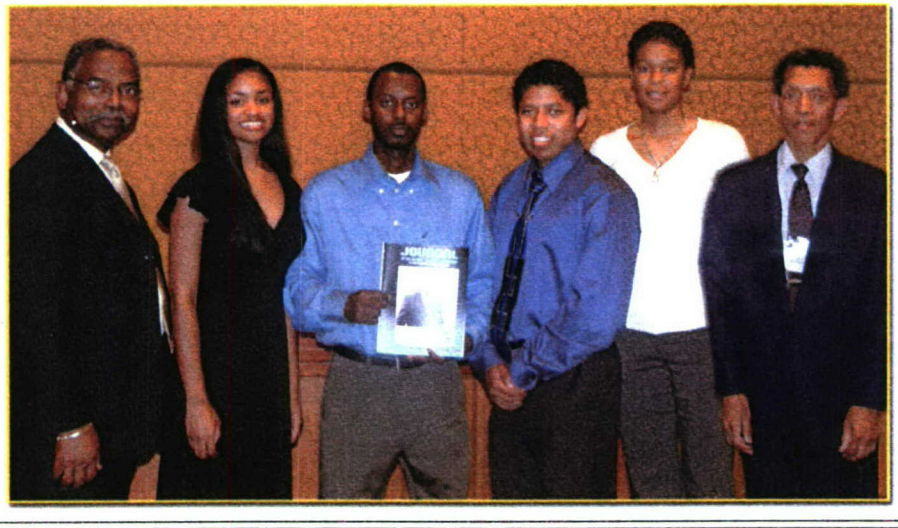
Satellite-based active microwave imaging instruments (Synthetic Aperture Radars and Scatterometers) and passive microwave radiometers are recording the modification of the structure of the firn, the compacted snow layer that has remained at or near the surface of an ice sheet for one season but has not yet compressed into glacial ice, on the Greenland ice sheet caused by new melting at high elevation. Even a few days of melt at a site on the ice sheet that has not melted in decades can produce a large sustained change in the microwave scattering properties of the snowpack; this change is clearly reflected for years, diminishing only slowly as the layer generated by the melt event is buried. In the last 5 years, x% of the area of the dry snow zone has been modified in this manner by surface melt, compared with y% (little modification) in the previous 9 (to 13 or 20+ years, depending on the data used); these effects decay slowly, and if the present trend toward increased melting continues, the dry snow zone (melt-free snowpack) of the interior of Greenland could disappear completely in the near future. A melt detection technique calculated data for the passive microwave record, and it produced an approximate amount of melt days compared to the active microwave records done by previous investigators; this allowed for a new indication of melt as well as greater time series in the passive microwave record.

Cheniece Arthur - Junior, Computer Science
Bryce Carmichael - Sophomore, Computer Science
Mentor: Dr. Arvin Agah
Internship: Center for Remote Sensing of Ice Sheets (CReSIS), University of Kansas
Title: Simulating Deployment & Retrieval of Seismic Sensors



The primary objective of our project was to successfully create a robotic simulation that illustrated how numerous robots will assemble in order to collect seismic data. In contrast to the human approach of physically deploying and receiving seismic data, robots would instead be used to collect data. Once a designated location has been determined, the robot would plant the geosensor and collect the vibration data after the seismic source has taken place. With the use of robots, human life is not at risk. Due to the harsh and dangerous weather conditions in the Antarctic and Greenland environment, robots would replace manual labor. With an abundance of robots, we would be able to collect a large amount of data over a short period of time.

We utilized a 3-D graphical interface program called "Webots" to simulate how a team of mobile robots would assemble into grid formation and migrate from one location to another. Webots is a mobile robotic simulation software package that allows one to model robots and test in a world created by the user. This program uses physics as well as code to validate and test different methods when an action is declared. As we continued to gain knowledge of Webots, we created and tested different formations using the robots in the program. The formations completed their work in different shapes and patterns in order to follow the desired paths.



2006 National Technical Association Symposium Student Winners
(l to r) Dr. William Lupton, past president of the NTA, Tashara Banks, Kenneth Kimari, ONR research students Bryce Carmichael and Cheniece Arthur, and Dr. George Carruthers during the 2006 NTA Symposium in Chicago, Illinois.

Undergraduate Research Experience 2006-2007

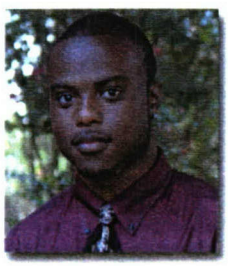
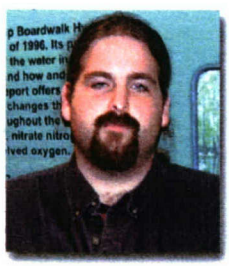
ELIZABETH CITY STATE UNIVERSITY

Seniors

Anthony Anderson - CS
Brandi Brehon - CS
Jerome Mitchell - CS
Erica Pinkney - PHY






Juniors

Cheniece Arthur - CS
Gregory Brown - CS
Brian Campbell - Geo
Kaiem Frink - CS

Sophomores

Ebony Addison - CS
Akeem Archer - CS
Jamika Baltrop - CS
Bryce Carmichael - CS
TreAsia Fields - Math

Brittany Lynch - CS
Kevin Reynolds - Math Ed
Lee Smalls, Jr - CS
Unquiea Wade - CS
Carrie Williams - CS










Freshmen

Kordarius Berry - CS
Travis Capehart - CS
Fayana Graham - CS
Jermaine Moore - CS
Lovell Pendleton - CS

Jasmin Rivers - CS
Illiana Thomas - CS
Tiwana Walton - CS







http://nia.ecsu.edu/ur.html

Kaiem Frink - Junior, Computer Science
Lee Smalls, Jr. - Sophomore, Computer Science
Mentor: Dr. Malcolm LeCompte, ECSU - CERSER
Internship: Undergraduate Research Experience in Ocean and Marine Science, ECSU
Title: Estimating Antarctic Firn Average Emissivity Trends at the Ski Hi Automatic Weather Station

Firn is compacted, near-surface snow enduring for more than one season not yet compressed into glacial ice. Knowledge of firn surface temperature trends across the Antarctic ice sheet is useful for documenting and quantifying change and providing a temporal and spatial context for research during the Antarctic International Polar Year (IPY). Satellite passive microwave radiometer data can provide surface temperature trend estimates across limited temporal and spatial gaps in Automatic Weather Station (AWS) coverage. Techniques to derive surface temperatures from passive microwave data have been pioneered by Jezek et al., (1993) and. Shuman et al., (1995).

Using the methods of previous researchers, the Summer 2006 Undergraduate Research Experience (URE) Antarctic Temperature Mapping Team, is comparing archived surface temperature data from an AWS on the West Antarctic Ice Sheet with coincident daily brightness temperature data collected by the Special Sensor Microwave Imager (SSM/I) aboard the Defense Meteorology Satellite Program (DMSP) polar orbiting meteorology satellite series. The ratio of passive microwave brightness temperature and AWS in-situ near surface temperature provides the firn emissivity estimate necessary to extrapolate surface temperature trends across temporal and spatial gaps in either the AWS or SSM/I record. The relationship between emissivity and surface temperature is generally known as the 'Rayleigh-Jeans Approximation' (Hall and Martinec, 1985). The spatial and temporal variability of firn emissivity is not well understood but known to be much less variable than daily temperature.

AWS temperatures at 3 hourly intervals for the "Ski Hi" AWS site (75° South Latitude, 71 ° West Longitude) in West Antarctica were obtained from the AWS Project data archive at the University of Wisconsin's Space Science and Engineering Center (SSEC). The passive microwave time-series of daily DMSP SSM/I brightness temperatures, geographically and temporally coincident with the Ski Hi site were obtained from Dr. Chris Shuman at NASA Goddard. Daily SSM/I brightness temperatures and corresponding Ski Hi AWS surface temperatures were tabulated in a Microsoft EXCEL spread sheet. The daily ratio of the SSM/I brightness temperature to the AWS surface temperature provided an emissivity trend from which to extrapolate surface temperatures The Ski Hi AWS operated from late February 1994 until late November 1998. The team will develop mathematical/statistical techniques to robustly estimate the surface emissivity trend at the Ski Hi site for the period January 1, 1995 through November, 1998, and use it to obtain a continuous estimate of surface temperature during data gaps in either the SSM/I or the AWS archive. Future work will establish emissivity trends at other AWS sites. These values will be combined with surface elevation data to extrapolate emissivity values beyond the locale of the AWS stations. Average surface temperatures can then be calculated from SSM/I brightness temperature records as well as data from other satellite sensors observing the Antarctic continent during the last 30 years.This work is thus a preliminary step to deriving a surface temperature trend across the entire Antarctic ice sheet from 1981 through to the present.

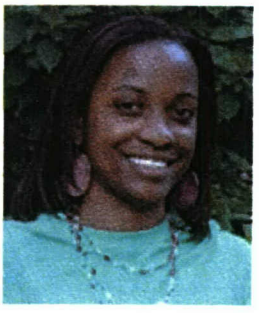
Anthony Anderson - Senior, Computer Scientist
Timothy Harrell - Senior, Computer Scientist
Mentor: Dr. David Stevenson, Dr. Kevin Chu
Internship: NOAA's Northeast Regional Office
Title: Massachusetts Young-of-the-Year Bottom Trawl Survey

Designating essential fish habits are important because they protect specific species of fish from becoming extinct. To help aid the process we took a look at young of the year species in the north east region of the United States.

We are interested in knowing anything that will affect the numbers of young-of-the-year (YOY) juveniles caught in each survey and the environmental variables that could be correlated with geospatial data on catch rates (number of fish per tow).

Mr. Antonio Rook, past ONR researcher and current faculty at ECSU talks with Demetrius Rorie

Karitsa Williams - Graduate, Computer Science
Mentor: Mrs. Keisha Wilkins, ECSU - CERSER
Internship: Undergraduate Research Experience in Ocean and Marine Science, ECSU
Title: Automating the TeraScan Image Process for Creation of NOAA AVHRR Data Products



During the summer of 2002 the Center of Excellence in Remote Sensing Education and Research (CERSER) was established on the campus of Elizabeth City State University. It is the intent of CERSER to develop innovative and relevant research collaboration focused on coastal, ocean, and marine research. The project represents a joint effort by the Office of Naval Research (ONR), the MU-SPIN Office of Goddard Space Flight Center (GSFC), the National Oceanic and Atmospheric Administration (NOAA) and SeaSpace.

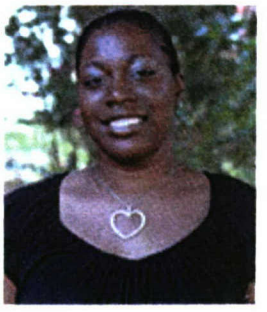
In addition to providing remotely sensed Advanced Very High Resolution Radiometer (AVHRR) and Sea Wide Field-of-View Sensor (SeaWiFS) data for research projects during the summer and academic year, CERSER maintains a website which displays and archives data that has been captured and processed. Since the establishment of the CERSER lab, data has been processed, annotated and converted into tiff files manually by using a series of TeraScan and LINIX commands. This process is time consuming and requires a person to physically be at the TeraScan Machine.

The objective of this project was to automate the process of creating NOAA AVHRR products. The TeraScan Product Generation System was utilized to create a visible and sea surface temperature image. This was accomplished by first creating a master of North Carolina and Virginia. A master is a TeraScan dataset that delimits a geographical area of the earth and specifies a map projection and a pixel resolution to the area. The master was used for the sea surface temperature product. Visible images were processed from the complete raw AVHRR data.

A script was created which processes raw AVHRR data from the passdisk. A script is a sequence of commands linked together to automatically run when initiated. A script can be initiated by running it from the command line or by linking the processing to TeraCapCon (TeraScan Capture Control).

Once passes are captured on the passdisk the script processes the image and generates a picture product. Each image, overlaid with a coastal boundary, gridlines, a wedge and a legend, is converted into a tagged image file format (tiff) file and automatically distributed to the server using file transfer protocol (ftp). Automating the image process eliminates the need for an individual to manually process images, and insures that the CERSER webpage is current.

TreAsia Fields - Sophomore, Math
Mentors: Dr. Raj Chaudhury & Dr. Lin Chambers
Internship: NASA SPHERE 2006 - Christopher Newport University (CNU)
Title: Data/Visualization Team



This summer the Data/Visualization Team was responsible for creating a google map of local and remote GLOBE sites and their data on environmental phenomena that are linked using Google Maps and GPS (Global Positioning Service). Also the team created a walking tour of CNU and the Shenandoah Valley. The LAS stores satellite data on cloud coverage, surface Temperature, tropospheric ozone and other parameters, which is monitored by ground stations. This information will be linked to the google map to display the climate factors of each specific area. This information is useful for everyone, it makes it easy to identify geographical locations and their associated data from both satellite and ground stations.

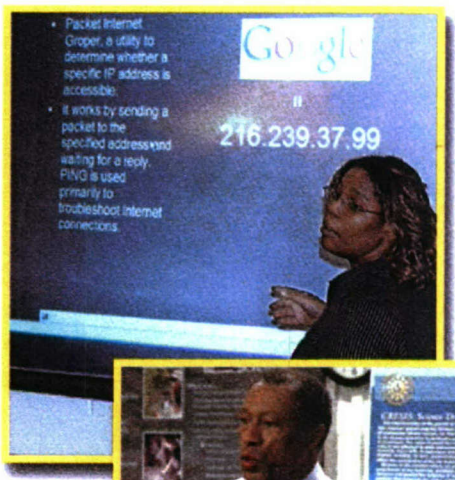
Unquiea Wade - Sophomore, Computer Science
Mentor: Dr. Prasad Gogengni
Internship: Center for Remote Sensing of Ice Sheets (CReSIS), University of Kansas
Title: Airborne Measurement of Snow Thickness Over Sea Ice

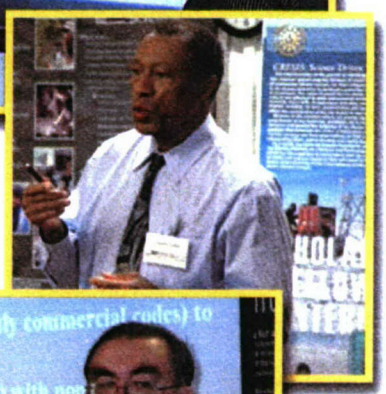
Snow cover on sea ice plays an important role in the climate of the polar regions. Snow on the sea ice reduces the heat exchange between the ocean and the atmosphere by its high albedo (reflectivity) and low thermal conductivity. The lower the albedo, the less solar energy is reflected back into the atmosphere. This energy is absorbed into the ocean. The warmer water will melt more sea ice, and eventually the warmer atmosphere above the warmer water will melt more of the sea ice in the polar regions. Better data on the extent and thickness of snow cover are therefore needed to understand the condition and future behavior of sea ice.

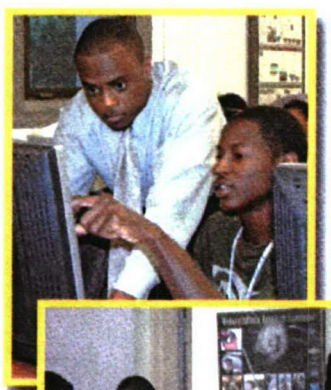
Up until recently, the only practical means of observing snow cover over sea ice was by satellite remote sensing. The Advanced Microwave Scanning Radiometer (AMSRE) onboard NASA's Aqua satellite does precisely this. To validate the measurements made by AMSR-E, the University of Kansas developed an ultra-wideband frequency-modulated continuous-wave (FM-CW) airborne radar to measure snow thickness over sea ice. This system was flown over the Arctic sea ice in March 2006 to measure the snow thickness.

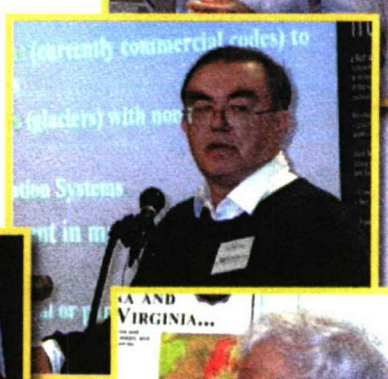
Photo Highlights

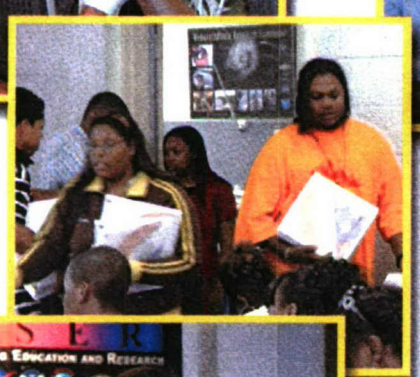
The Office of Naval Research Nurturing ECSU Research Talent program involves undergraduate mathematics and computer science majors in academic year team research activities. Research and training meetings began in early September and are held every Tuesday and Thursday 5-8 PM through mid April. Research meetings start with a 20-30 minute announcement period during which time students learn about internship opportunities, hear program announcements, give team reports, discuss travel logistics, and discuss goals of the program. Following the announcement period, students meet with faculty mentors or attend training on tools used for research. In addition, students spend 20 hrs/week in the undergraduate research computer laboratory completing task sheet requirements and research assignments. The closing program is held on two nights in April. During the closing program, students make oral presentations of their research activities. The research teams are also required to complete written reports and to maintain a team web page. Shown below are highlights from the academic year program.

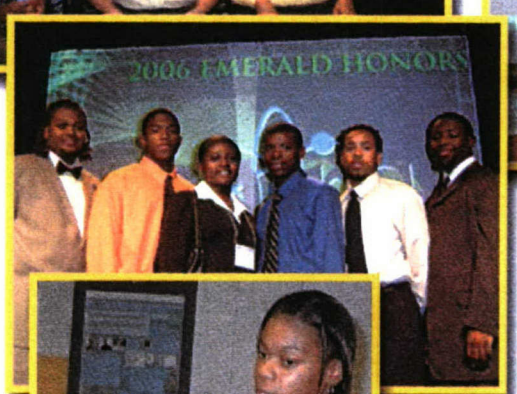


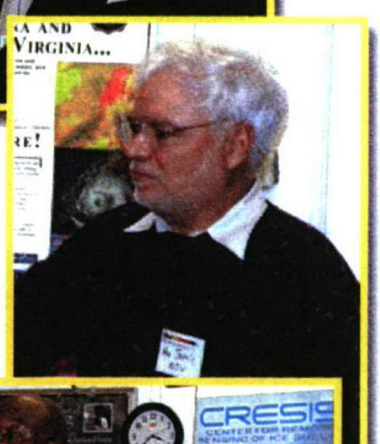


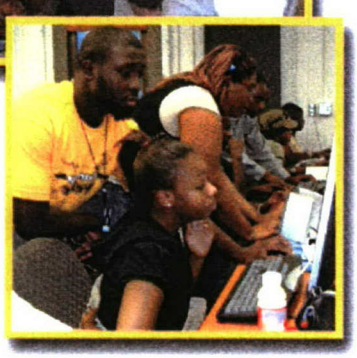




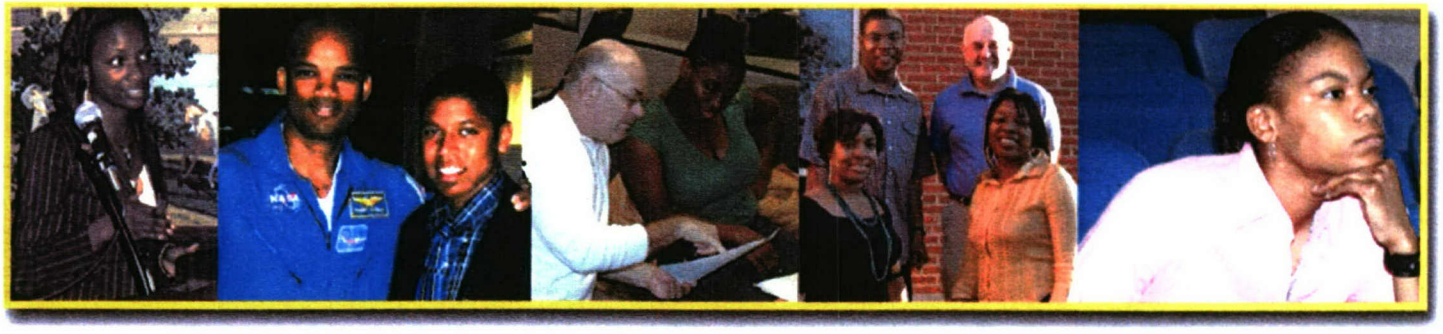


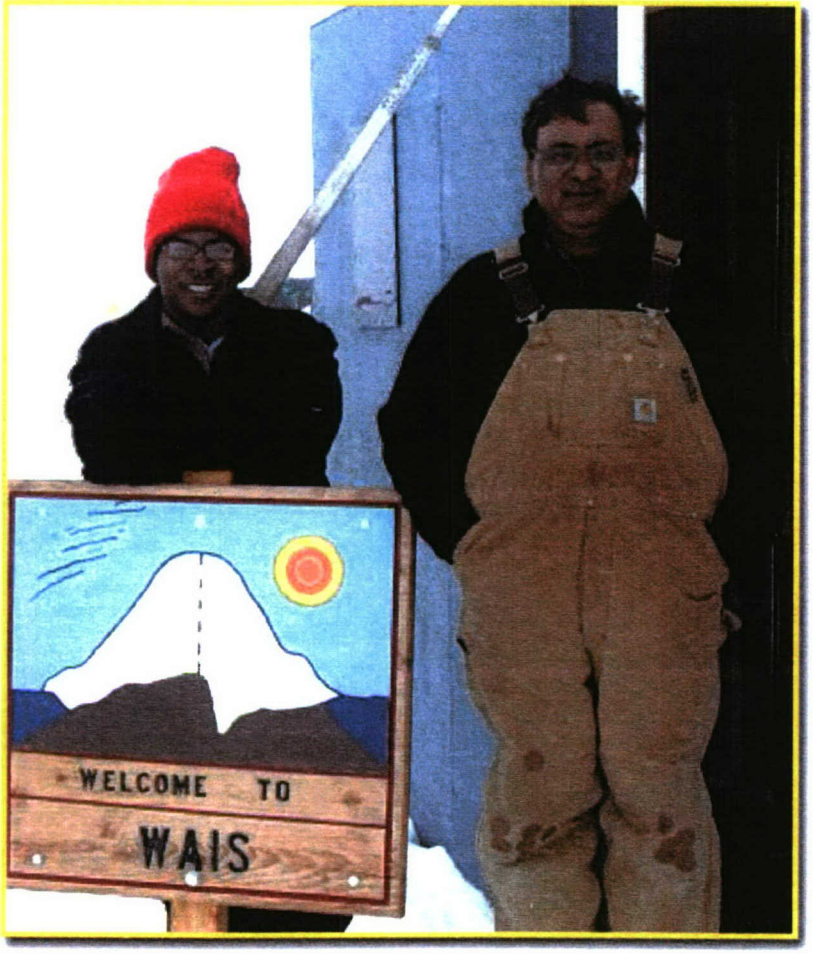






ONR student researchers Jerome Mitchell (L) and Kaiem Frink (R) deliver poster presentations during the ADMI 2005 Symposium entitled "Modeling Diversity in Computing and Engineering" in Rincon, Puerto Rico.





CReSIS
Center for Remote Sensing of Ice Sheets

ONR student researcher Jerome Mitchell (L) and Dr. Prasad Gogenini, Director of the Center for Remote Sensing of Ice Sheets (CReSIS) at the West Antarctic Ice Sheet (WAIS) field camp.

Jerome Mitchell was the only undergraduate researcher taking part in this research trip to Antarctica sponsored by the National Science Foundation to test theories on Global Warming.

The 2006 International Geoscience and Remote Sensing Symposium, "Remote Sensing - A Natural Global Partnership", took place in Denver, Colorado. The focus of the symposium was the widespread distribution and interoperability of remote sensing and environmental data and information as many countries begin launching remote sensing satellites.

Elizabeth City State University was represented by Dr. Linda B. Hayden, Director of the Center of Excellence in Remote Sensing Education and Research (CERSER). Dr. Hayden joined with Dr. Ali Omar of the NASA Langley Research Center in Hampton, Virginia in presenting "Collaborations Focused on Enhancing Undergraduate Involvement in Remote Sensing Applications to Atmospheric and Earth Science Research" a comprehensive look at the mentoring strategies used with groups of undergraduate physics, mathematics and atmospheric science majors to develop their ability to contribute to remote sensing investigations. The projects discussed were joint efforts of scientist and educators at NASA Langley Research Center, Hampton University in Virginia, ECSU, Stennis Space Center, and The Office of Naval Research. Also attending were Malcolm Mathis II (UAPB) and Brittany Green (SCSU).

Malcolm presented on the topic "Exploring the Migration of the Roanoke Colonists", research looking at tracking the "lost colony" on Roanoke Island using data from satellite based Optical and ISAR instruments and aerial LIDAR which were compared to observe and quantify the terrain and environment of the historical locales. Ground Penetrating Radar, and geologic core samples at the sites were also used during this research.

Brittany's research presentation was titled "Spatial-Explicit Growth Rate Model of Young Striped Bass in Albemarle Sound: Implications on Essential Fish Habitat (EFH) Using GIS." This research examined the growth rate potential of juvenile striped bass Morone saxatilis in Albemarle Sound, North Carolina, to identify essential fish habitat (EFH) for striped bass during the summer and early-fall months.

IGARSS 2006 Minority Student Program Attendees

HONORS CONVOCATION AWARDS

Center of Excellence in Remote Sensing Education and Research (CERSER)

CERSER "Research Program" Award
Criteria: Second Semester freshman or above, 3.0 current or cumulative GPA, attending research training seminars
Award: Certificate/$150.00
Recipients: Lovell Pendleton :: Jasmine Rivers :: Illiana Thomas :: Tiwana Walton :: Jermaine Moore :: Kaiem Frink

CERSER "Research Scholars" Award
Criteria: Sophomore or above, 3.0 current and cumulative GPA, attending research training seminars, completed at least one approved internship
Award: Certificate/$250.00
Recipients: Bryce Carmichael :: Treasia Fields :: Lee Smalls, Jr. :: Cheniece Arthur :: Brian Campbell :: Unquiea Wade

CERSER "Award of Excellence"
Criteria: Graduating Senior, 3.0 Current or cumulative GPA, attending research training seminars, admission into graduate school with financial support, completed at least two approved internships
Award: Certificate/$1500.00
Recipient: Jerome Mitchell

2006-2007 ONR Research Teams

Estimating Firn Emissivity on the West Antarctic Ice Sheet

Mentor: Dr. Malcolm LeCompte

Brian Campbell, Jerome Mitchell, Jamika Baltrop, TreAsia Fields, Fayana Graham

Case Study: Undergraduate Research Office Network Redesign

Mentor: Mr. Chris Edwards

Bryce Carmichael, Ebony Addison, Lovell Pendleton, Cheniece Arthur

Water Quality

Mentor: Mrs. Keisha Wilkins

Brandi Brehon, Lee Smalls, Jr., Kaiem Frink, Kevin Reynolds, Akeem Archer, Jermaine Moore

Correlations between the Concentrations of Chlorophyll a in Surface Waters and Dissolved Oxygen in Bottom Waters of the Northern Gulf of Mexico

Mentors: Dr. Jinchun Yuan / Ms. Karitsa Williams

Gregory Brown, Carrie Williams, Kodarius Berry

Developing Standards and Practices for Digitizing and Archiving Multimedia Material from the URE and Other Associated Programs

Mentor: Mr. Jeff Wood

Tiwana Walton, Brittney Lynch, Illiana Thomas, Jasmin Rivers

GIS Applications

Mentor: Dr. William Porter

Unquiea Wade, Travis Capehart

Office of Naval Research

One Liberty Center
875 North Randolph Street, Suite 1425
Arlington, VA 22203-1995

Dates to Remember

http://nia.ecsu.edu/events.html

January 11, 2007, 5:00 pm
Preparing for Graduate School
Room 229 Dixon Hall, ECSU

January 11–14, 2007
2007 FOCUS
Georgia Tech, Atlanta, Georgia

February 8–10, 2007
2007 ADMI Symposium
Atlanta, Georgia

February 12-16, 2007
ECSU Research Week

March 20, 2007
IEEE-GRSS Distinguished Lecture Series
229 Dixon Hall Elizabeth City State University
Dr. Robert Bindschadler, NASA GSFC
Understanding the West Antarctic Ice Sheet from Space: Beyond Dogsleds and Frozen Toes

Meeting of the Eastern North Carolina Chapter of the IEEE Geoscience and Remote Sensing Society (GRSS)

April 12, 2007, 2:00 pm
Watershed Watch Summer Program Briefing
Room 229 Dixon Hall, ECSU

May 29 - June 9, 2007
Watershed Watch Summer Program
Application
http://nia.ecsu.edu/ww/ww_0607_application.pdf

May 31 - July 18, 2007
Undergraduate Research Experience in Ocean and Marine Science
Application
http://nia.ecsu.edu/ureoms2007/2007_ureoms_application.pdf

July 23-27, 2007
IEEE - International Geoscience and Remote Sensing Symposium
Barcelona, Spain

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